(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 0 943 034 B2**

(12) **NEW EUROPEAN PATENT SPECIFICATION**
After opposition procedure

(45) Date of publication and mention of the opposition decision:
03.12.2008 Bulletin 2008/49

(45) Mention of the grant of the patent:
23.10.2002 Bulletin 2002/43

(21) Application number: **97946772.7**

(22) Date of filing: **02.12.1997**

(51) Int Cl.:
D21F 5/04 *(2006.01)*

(86) International application number:
PCT/FI1997/000745

(87) International publication number:
WO 1998/027273 (25.06.1998 Gazette 1998/25)

(54) METHOD FOR DRYING OF PAPER AND DRY END OF A PAPER MACHINE

VERFAHREN ZUR TROCKNUNG VON PAPIER UND TROCKENPARTIE EINER PAPIERMASCHINE

PROCEDE DE SECHAGE DU PAPIER SECTION SECHE D'UNE MACHINE A PAPIER

(84) Designated Contracting States:
AT DE ES FR GB IT PT SE

(30) Priority: **03.12.1996 FI 964830**

(43) Date of publication of application:
22.09.1999 Bulletin 1999/38

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EP 0 943 034 B2

Description

[0001] The invention concerns a method for drying of paper, which method comprises the following steps:

a) the paper web to be dried is passed from the press section into a forward dryer section, in which the paper web is dried from the side of its bottom face in dryer groups that apply a normal single-wire draw, said forward dryer section comprising exclusively single-wire groups with normal single-wire draw,

b) from the forward dryer section the paper web is passed into a finishing section, in which the paper web is coated/surface-sized by means of a coating/surface-sizing equipment, dried in an after-dryer section, in which the paper web is dried in at least one dryer group that applies a normal single-wire draw, after which the paper web is calendered in a calender and passed to a reeling station, in which the paper web is reeled into a machine reel, and

c) the curling of the paper web is controlled by means of elements and/or by means of assemblies and combinations formed out of said elements and by means of at least one steam box at least in the area of the finishing section.

[0002] Further, the invention also concerns a dry end of a paper machine, which comprises a forward dryer section and a finishing section, which finishing section comprises a coating/surface-sizing equipment, an after-dryer, a calender, and a reeling station, and the dry end of the paper machine further comprises elements and/or assemblies and combinations formed out of said elements and at least one steam box in view of controlling the curling of the paper web at least in the area of the finishing section.

[0003] With respect to the prior art related to the invention, reference is made to the publication EP-A2-726353 which discloses a method of the type described above for drying paper, and a dry end of a paper machine.

[0004] As is known from the 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 comprise two wires, which press the web one from above and the other one from below against 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 cause web breaks, in particular so when the web is still relatively moist and, therefore, of low strength. This is

[0005] why, in recent years, ever increasing use has been made of said single-wire draw, in which each group of drying cylinders includes just one drying wire, 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.

[0006] From experience it is known that, if paper is dried one-sidedly, the result is a tendency of curling of the sheet. When paper is dried by means of normal groups with single-wire draw from the side of its bottom face and if such asymmetric drying is extended over the entire length of the forward dryer section, the drying takes place so that first the bottom-face side of the paper web is dried and, when the drying makes progress, the drying effect is also extended to the side of the top face of the paper web. Under these circumstances, the dried paper is usually curled and becomes concave, seen from above.

[0007] As is known from the prior art, the tendency of curling of paper is already affected in connection with the web formation, in particular at the sheet formation stage (for example, the applicant's Sym-Former™) by means of selection of the difference in speed between the slice jet and the wire, and by means of other running parameters. As is known from the prior art, for example, in the case of copying paper, by means of unequalsidedness of drying in the after-dryer a suitable initial curl form is regulated for the sheet in order that the curling of the paper after one-sided or double-sided copying could be optimized. In the case of copying paper, the reactivity of curling, i.e. the extent to which curling occurs per unit of change in moisture content, is affected to a greater extent by means of a multi-layer structure of the paper, which is produced in connection with the web formation in the wet end.

[0008] The most recent prior-art technology related to the present invention in high-speed paper machines has been based on dryer sections in which there is single-wire draw over the major part of the length of the dryer section; and in view of controlling the tendency of curling, an inverted group has also been used in order that the drying could be made sufficiently symmetric in the z-direction. However, it has come out that an inverted group produces obvious drawbacks in view of the runnability and the overall efficiency of the machine and in view of the profitability of the paper machine investment. Thus, from the point of view of the runnability of the paper machine, a dryer section fully supported over its entire length and based on normal groups with single-wire draw with no inverted groups would be a highly justified solution. People skilled in the art have, however, not had the courage to introduce this solution in operation, because it has been considered that it would result in solutions uncontrollable and unfavourable from the point of view of the tendency of curling of paper. One problem involved in the prior-art solutions that include inverted dryer groups is the removal of broke in the event of web breaks, for inverted groups are not self-cleaning by the effect of grav-

ity.

[0009] Thus, the object of the present invention is to provide a dry end of a paper machine in which no inverted groups are needed at all, but which, however, meets all other requirements that are imposed.

[0010] Thus, the object of the present invention is to approach these problems from a new point of view and to suggest novel solutions for said problems, which solutions are contrary to conventional modes of thinking.

[0011] With respect to the prior art related to the present invention, reference is made to the applicant's FI Patent No. 91,900 (equivalent to US Pat. No. 5,416,980), in which a method is described in the dryer section of a paper machine in particular for reducing the tendency of curling of paper, in which method the paper web is dried by means of drying cylinders, against whose heated faces the paper web is pressed by means of a drying wire, and in which dryer section groups of drying cylinders are used in which twin-wire draw and/or single-wire draw is/are applied. In this method it has been considered novel that in the dryer section, substantially across the entire width of the paper web, hot water steam is fed, by whose means the strains that arise or tend to arise in the fibre mesh in the paper web are relaxed by means of heat and moisture in, or substantially directly after, the area of formation of said strains.

[0012] With respect to the prior art related to the present invention, reference is made further to the applicant's FI Patent No. 93,876 (equivalent to US Pat. No. 5-,553,393) and to the applicant's FI Patent Applications No. 925942 (equivalent to US Pat. No. 5.465,505), 935340, 951746, and to the applicant's, so far non-published, FI Patent Applications Nos. 963024, 963734, and 963735.

[0013] In the applicant's FI Patent No. 93,876 a dryer section of a paper machine is described in which there are dryer groups provided with single-wire draw. In this dryer section it has been considered novel that, in order to optimize the drying capacity calculated per unit of length of the dryer section in the machine direction, with the progress of the drying different ratios of the diameters of the drying cylinders to the diameters of the reversing rolls have been employed so that in the first group or groups in the initial end of the dryer section said ratio is higher than in the groups in the middle area of the dryer section, and in the group or groups in the final end of the dryer section a diameter ratio higher than said ratio is used.

[0014] In the applicant's FI Patent Application No. 935340, methods in the drying of a paper web and dryer sections for a paper web are described, wherein, after the press section, the paper web is dried in a number of successive groups with single-wire draw, and according to one embodiment the paper web is dried from the side of its bottom face over the entire length by means of said contact drying cylinders, and the paper web is dried from the side of its top face on the draw or draws of the paper web free from the wire, and/or the paper web is dried from the side of its top face by to the top face of the paper web applying a drying air flow through the drying wire.

[0015] In the applicant's FI Patent Application No. 925942 a so-called inverted dryer group with single-wire draw for a multi-cylinder dryer of a paper machine is described, in which a support wire is arranged to be in contact with the reversing cylinders over a substantially large sector, which wire is guided by its guide rolls fitted in the gaps between the reversing cylinders and by other necessary rolls, and the web is pressed by means of the tension of the support wire on said sectors against the drying wire.

[0016] In the applicant's FI Patent Application No. 951746 a dryer-section concept and a method in the drying of a paper/board web are described, wherein impingement blowing units or equivalent have been arranged in connection with at least some of the drying cylinders, through which units a heated medium, preferably air or steam, is passed through the wire into connection with the web so as to produce a two-sided drying effect and to increase the drying capacity.

[0017] In the applicant's FI Patent Application No. 963734 a method is described for drying a surface-treated paper web or equivalent in an after-dryer of a paper machine as well as a dryer section of a paper machine for applying the method, wherein, in view of compensating for a tendency of curling of the paper web, in the after-dryer the paper web is dried in a dryer group/groups making use of a normal single-wire draw, and that, in connection with or after the drying, the paper web is treated by means of a device/devices in order to compensate for a tendency of curling of the paper web, which devices are, for example, a steam box, a blower unit, a moistening device, and/or a soft calender.

[0018] On the other hand, in the applicant's FI Patent Application No. 963735 a method for drying a surface-treated paper web or equivalent in an after-dryer of a paper machine as well as an after-dryer of a paper machine for applying the method are described, in which after-dryer the paper web is dried in at least one dryer group that makes use of single-wire draw, and at the same time the paper web is dried by means of an impingement drying equipment fitted in connection with at least one cylinder or roll in said dryer group.

[0019] In the applicant's FI Patent Application No. 963024 a method for drying a paper to be surface-treated, in particular fine paper, in an after-dryer in a paper machine is described as well as an after-dryer in a paper machine for carrying out the method, wherein, after the surface-sizing or coating, the paper web is dried by means of an upwards open inverted group with single-wire draw, in which connection the tendency of curling formed in the paper web in the forward dryer section can be substantially eliminated and/or compensated for.

[0020] The object of the present invention is further development of the earlier solutions described above so that the curling of the paper can be controlled more efficiently in the dry end of the paper machine.

[0021] It is a further object of the present invention to provide such a dry end of a paper machine with finishing devices in which the runnability can be brought to a particularly high level.

[0022] Further, it is an additional object of the invention to provide such a dry end of a paper machine with finishing devices in which unequalsidedness, roughness, glaze, etc. surface properties of the paper are controlled.

[0023] In view of achieving the objectives stated above and those that will come out later, the solution in accordance with the invention is mainly characterized by the combination of the features defined in the independent claims 1 and 13, respectively.

[0024] On the other hand, the dry end of a paper machine in accordance with the invention is mainly characterized in that the effect of said steam box is intensified by cooling the web prior to said steam box.

[0025] In the arrangement in accordance with the invention, the forward dryer section in the dry end of the paper machine is exclusively based on dryer groups with single-wire draw, in which case the removal of broke takes place all the time by the force of gravity and does, thus, not cause problems. Likewise, in the single-wire draw in the forward dryer section, the paper web is constantly supported by a wire, whereby the runnability is improved and it is possible to increase the running speed.

[0026] In view of controlling the unequalsidedness of paper and in particular of the curling arising from one-sided drying, in the forward dryer section and/or in the after-dryer in the dry end of the paper machine elements have been fitted for the control of the tendency of curling so that the desired curl form is obtained for the paper. For the purpose of controlling the curling, various elements are used, such as steam boxes, impingement blow units, dryer groups with twin-wire draw, a separate lower support fabric, ratio of drying cylinders to reversing cylinders, etc., fitted in a suitable way in the area of the whole dry end and as different combinations. Thus, in the present invention it has been realized to control the curling in a number of different ways in the dry end of the paper machine.

[0027] According to an exemplifying embodiment of the invention, both the forward dryer section and the after-dryer have been accomplished exclusively by means of dryer groups with normal single-wire draw. In the forward dryer section, blowing through the wire is employed for regulating the curling; from above the different cylinders hot air is blown out of impingement blow devices, and evaporation takes place through the wire and affects the drying and, thus, the curling of the paper. On the other hand, in the after-dryer, for example, steam boxes and possibly blowings of moist air taken from the forward dryer section are employed for controlling the curling.

[0028] According to an essential feature of a second exemplifying embodiment of the invention, in which both the forward dryer section and the after-dryer are accomplished exclusively by means of dryer groups with normal single-wire draw and in which, where applicable, in view of increasing the capacity and compensating for the curling, impingement blow equipments have been added in connection with the drying cylinders in the dryer groups, and in view of controlling the curling, a lower support belt has also been added to a dryer group, which belt circulates against the lower faces of the reversing rolls while guided by its own guide rolls, and which support belt is so impermeable that it prevents evaporation of water out of the web from its lower face, whereby the tendency of curling can be controlled.

[0029] According to a further exemplifying embodiment of the invention, the forward dryer section has been accomplished exclusively by means of dryer groups with single-wire draw, to which groups, where applicable, impingement blow equipments have been added for regulation of the curling and, if necessary, also in order to increase the capacity. The after-dryer has been accomplished so that it includes both dryer groups with single-wire draw and those with twin-wire draw, the curling being controlled by means of the dryer groups with twin-wire draw. According to a modification of this embodiment, impingement blow equipments can also be added to the groups with single-wire draw in the after-dryer.

[0030] According to an exemplifying embodiment of the invention, in which the forward dryer section is exclusively composed of dryer groups with single-wire draw, as is the after-dryer, in the after-dryer, in order to control the curling, a higher ratio of the diameter of a drying cylinder to the diameter of a reversing roll has been used than in the forward dryer section, in which case a more equal evaporation is obtained from the top side and from the bottom side. Moreover, if necessary, in the dryer group it is possible to use airborne type hoods fitted in connection with the reversing cylinders in order to increase the capacity and/or to compensate for the curling, both in the after-dryer and in the forward dryer.

[0031] According to a further exemplifying embodiment of the invention, between the dryer section and a calender, there can also be an additional steam box in view of controlling the curling. In stead of a steam box it is also possible to use moist air or any other, equivalent medium, such as a device that blows moist air that is brought from the forward dryer, or, for example, a separate water atomizing box, by whose means water is sprayed by means of air as small drops towards the web, or an airborne type hood to be placed underneath. Further, in the after-dryer, it is possible to arrange a what is called "spreader bar" at one side or both sides of the paper web in order to work the curling of the paper web mechanically. In this way in particular the curling of the web in the longitudinal direction is affected. The spreader bar can also be of a spreader roll type, in which case the effect on cross-direction curling can be enhanced.

[0032] In the following, the invention will be described in more detail with reference to the figures in the accompanying drawing, the invention being, however, in no way supposed to be strictly confined to the details of said illustrations.

[0033] Figures 1 to 4 are schematic illustrations of the dry end of the paper machine which is shown from the forward dryer up to the machine reel-up.

[0034] Figure 5 is a schematic illustration of in part of the after-dryer of a paper machine.

[0035] Figure 6A is schematic illustration of an exemplifying embodiment of the invention, in which figure the last dryer group in the after-dryer and the machine reel-up are shown.

[0036] Figures 6B to 6E are schematic illustrations in which figures the dry end of a paper machine is shown from the forward dryer section to the machine reel-up.

[0037] As is shown in Figs. 1 to 4 and 6D to 6E, the paper web W is brought into the forward dryer section D1 from the press section onto the drying wire 15 of the first group R_0 with single-wire draw, to which wire the web is attached by the effect of the vacuum in the suction boxes 13. The forward dryer section includes 7 groups $R_0...r_6$ with single-wire draw, and the web W has closed draws over the group gaps between said groups. In the figures the machine direction, i.e. the direction of progress of the of the web W is denoted with the arrow S. In the forward dryer section D1 in accordance with the invention, all the groups $R_0...R_N$ with single-wire draw are so-called normal groups, in which the, for example, steam-heated smooth-faced drying cylinders 10 are placed in the upper horizontal row and the reversing suction cylinders 11 are placed in the lower horizontal row. The number of the dryer groups $R_{0...N}$ is, as a rule, N = 4...12, most appropriately N = 6...8.

[0038] Each normal group $R_0...R_N$ has a drying wire 15 of its own, which is guided by the guide rolls 18. The drying wires 15 press the web W to be dried on the drying cylinders 10 against the smooth heated faces of the cylinders, 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 the support of the wire 15 against the effect of centrifugal forces by the effect of the vacuum present on the grooved faces 12 of the reversing cylinders 11 or on the perforated mantle of an equivalent suction roll, whereby cross-direction shrinkage of the web W is also counteracted. As reversing suction cylinders 11, particularly favourably are used the suction cylinders which are marketed by the applicant with the *trade mark* **"VAC-ROLL"™** and which have no inside suction boxes, and with respect to the details of the constructions of said suction cylinders reference is made to the applicant's FI Patent No. 83,680 (equivalent to US Pats. Nos. 5,022,163 and 5,172,491).

[0039] In a forward dryer D1, the support contact between the web W and the drying wire 15 is kept adequate also on the straight draws between the drying cylinders 10 and the reversing cylinders 11 by, at least on the runs from the drying cylinders 10 to the reversing cylinders 11, making use of blow-suction boxes 17, by means of which boxes formation of pressures induced by the wire 15 is also prevented in the closing wedge-shaped nip spaces between the wire 15 and the cylinder 11 mantles. Blow-suction boxes 17 are understood as blow boxes whose air blowing produces a vacuum, and said boxes 17 do not communicate with sources of vacuum. With respect to the details of the constructions of these blow-suction boxes 17, which are marketed by the applicant with 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.Patents Nos. 4,441,263, 4,516,330 and 4,905,380. Blow-box solutions of other types, in themselves known, are also included in the scope of the overall concept of the present invention.

[0040] In the forward dryer section D1, in the groups $R_0...R_N$ with single-wire draw, blow boxes 16 are also employed in the gaps between the reversing cylinders 11, by means of which boxes 16 said gap spaces are air-conditioned and evaporation from the web W is promoted. The faces of the drying cylinders 10 are kept clean by doctors 14.

[0041] It is a further substantial advantage of the forward dryer section D1 used in the invention that in the groups $R_0...R_N$ with single-wire draw, which extend over the entire length of the dryer section, removal of broke by the effect of gravity can be applied, for the single-wire groups $R_0...R_N$ are open towards the bottom, so that the paper web W that becomes broke can be removed without any special arrangements onto the broke conveyor (not shown) placed in the basement spaces of the paper machine and on said conveyor further into the pulper or pulpers.

[0042] In view of prevention of cross-direction shrinkage of the web W, it is of particular importance that, in the forward dryer section D1, the web W is kept in reliable contact with the drying wires 15 all the time. This holding effect is produced on the reversing cylinders 11 by means of a vacuum present in the grooved mantle 12 or equivalent on said cylinders and, on the straight runs between the cylinders 10 and the reversing cylinders 11, by means of pressure levels arranged by means of the blow-suction boxes 17 and partly also by means of the tension T of the web W in the machine direction, which tension produces a contact pressure $p_k = T/R$ (R = radius of the cylinders 11) between the web W and the wires 15.

[0043] As was stated above, as the reversing cylinders 11 in the forward dryer D1, favourably the applicant's VAC™ rolls are used. This vacuum effect is spread through the perforations on the reversing cylinders 11 onto the grooved mantle 12 so that the wedge-shaped nip spaces between the reversing cylinders 11 and the drying wire can also be evacuated efficiently, so that pressures cannot be induced into these wedge spaces, which pressures would attempt to separate the web W from the drying wire when the web W is placed outside. If suction rolls provided with inside suction boxes are used as the reversing cylinders 11 in the forward dryer section D1, the suction zone should preferably be extended over an area wider than the turning sector of the drying wire 15 and the web, so that the suction effect and the free flow

of air can be extended into said wedge spaces, for the purposes mentioned above.

[0044] Besides the forward dryer section D1 described above, the dry end of a paper machine in accordance with the invention includes a finishing unit D2 placed after the forward dryer D1, which finishing unit includes a machine reel-up 50, for example a Pope-type reel-up. A machine reel that is being produced on-line by means of the reel-up 50 is denoted with the reference MR_0, and one complete machine reel is denoted with the reference MR. The web W is brought to the machine reel-up 50 through the calender 40 from an after-dryer 30, which is placed after the coating device 20 in the finishing section D_2.

[0045] As is shown in the figures, after the forward dryer section D1 the paper web W, which has been dried to a dry solids content of $k_2 \approx 96...99$ %, is passed over paper guide rolls 25 and over a measurement beam 26, which is placed between said guide rolls 25 and which measures the property profiles of the paper, into a coating device 20, which is, for example, a coating device marketed by the applicant with the name Sym-Sizer™. The coating device 20 includes two coating rolls 21 and 22 placed one opposite to the other, and size feed devices 23 and 24 are placed in connection with both of said rolls so that the paper web W is coated from both sides in the coating nip NS between the rolls 21 and 22. Owing to the water-containing coating agent, the web W is partly moistened in the coating nip NS from both sides. Then, the web W, which was dried in the forward dryer D1 asymmetrically from the side of its bottom face W and which has a tendency of curling, is treated into such a state that its internal strains are partly relaxed or at least substantially reduced.

[0046] In Fig. 1, the forward dryer section D_1 is exclusively composed of dryer groups $R_0...R_6$ with single-wire draw; in which the paper web W runs meandering from a drying cylinder 10 onto a reversing roll 11 and onto a drying cylinder 10 and so on. In the dryer groups $R_0...R_6$, in connection with some of the drying cylinders 10 in the groups, upper impingement blow equipments 19 have been fitted in order to regulate the curling, by means of which impingement blow equipments 19 hot air is blown towards the web W, and evaporation takes place through the wire 15 thus regulating the curling. The after-dryer 30 in the finishing section D_2 is also exclusively composed of dryer groups R_{21},R_{22},R_{23} with single-wire draw, in connection with which groups an option has been arranged for an impingement blow equipment 19A for possible requirement of additional regulation of curling. In the other respects, in the after-dryer 30, the curling is controlled by means of steam boxes 31. In view of achieving uniform drying, in connection with the last drying cylinder 10 in the last group R_{23} an infra dryer 32 has been fitted. Further, for regulation of curling, one steam box 31 has been fitted before the web W is passed to the calender 40.

[0047] By means of the impingement blow device 19 blowing takes place through the wire 15, whereby it is possible to affect the regulation of curling when hot air or steam is blown, whereby evaporation takes place through the wire 15. Impingement drying can be used in the forward dryer section D_1 also for requirements of additional capacity, for example for increased running speed and for two-sided drying. The blowings from the impingement blow devices 19 also affect the regulation of curling so that ventilation is provided in the web area, in which case the evaporation is less one-sided. When such an arrangement is used, the wire 15 must be as open as possible, and when the web runs, for example, at a speed of 25 metres per second, the blow velocity of the blow air must be 25 to 150 metres per second, optimally about 100 metres per second. The blow angle of the nozzles of the impingement blow devices 19 is chosen optimally based on the wire properties that are used, on the running speed of the machine, and on other parameters. The blow air can be outdoor air or heated air, up to 400 °C, preferably of a temperature of 70...200 °C.

[0048] In Fig. 2 the forward dryer section D_1 is similar to that shown in Fig. 1, but here the after-dryer 30 is also provided with impingement blow devices 19. In connection with the last dryer group R_{23} in the after-dryer 30 a lower support belt 33 has been arranged, by means of which belt evaporation of water out of the bottom face of the web W is prevented, whereby the curling is regulated.

[0049] The lower support belt 33 is a tight belt, which prevents removal of moisture through the bottom face, in which case the moisture is removed from the opposite side of the web W; thus, since the belt 33 prevents evaporation from the bottom face, the web W is curled towards the bottom face. It is a further advantage of the support belt 33 that here the web runs between two belts 33,15, in which case the web W is supported particularly well. When a support belt 33 is used, its guide rolls 33A are placed at a lower level, approximately at the same level as the bottom edges of the reversing cylinders, in which case the removal of broke is easy as the belt 33 operates as a broke conveyor at the same time. The support belt 33 is preferably provided with a drive of its own, in which case its tension can be regulated as required. The support belt 33 is preferably a dense wire, whose permeability is low, or a smooth-faced belt. The temperature of the belt 33 can be adjusted, it can be cooled and/or heated as required when the curling is controlled. In this connection it is also favourably possible to introduce moist air into the area between the belt 33 and the reversing cylinders 11, whereby the process can be made more efficient.

[0050] The forward dryer section D_1 in Fig. 3 is similar to those shown in Figs. 1 and 2, but here the last two dryer groups R_{32},R_{33} in the after-dryer 30 have been formed as dryer groups with twin-wire draw, by means of which groups, thus, the curling is regulated. In the dryer groups R_{32},R_{33} with twin-wire draw, the dryer cylinders 10A, 10B are fitted in two rows, and the cylinders in each row have a wire circulation 15A, 15B of their own guided by the guide rolls 18A,18B, and between the rows the

web W has free unsupported draws. Impingement blow devices 19 have been fitted in the forward dryer section in connection with the drying cylinders 10 in the upper row in view of regulating the curling, increasing the capacity, and providing two-sided drying.

[0051] In Fig. 4, in view of controlling the curling, impingement blow equipments 19 have been provided additionally in connection with the first dryer group R_{21} in the after-dryer. In this case, as is usual after a Sizer, the steam temperature in the cylinders 10 is rather low, in which case the impingement blow devices 19 also provide additional capacity for heating the web W. It is a particular advantage of the impingement blow devices 19, that their temperatures can be regulated quickly, in which case, for example, change of the machine from one paper grade to another is quicker, whereby additional production is achieved.

[0052] As is shown in Fig. 5, in the after-dryer 30 a larger ratio of diameter of drying cylinder to diameter of reversing roll (D_{syl}/D_{tela} in Fig. 5) is employed, compared with the forward dryer section D_1, in which case a more uniform evaporation is provided at the top/bottom side, and thereby the curling can be controlled. The after-dryer 30 in the finishing section D_2 is composed of two dryer groups R_{21},R_{22} with single-wire draw. In connection with the reversing rolls 11 in the latter group R_{22}, steam boxes 31 have also been arranged in order to control the curling. The after-dryer 30 as shown in Fig. 5 can be fitted in connection with the forward dryers D_1 illustrated in the figures described above.

[0053] By means of this arrangement, the direction of evaporation is reversed, in which connection the web W has a longer passage to run on the drying cylinder 10, where the evaporation takes place primarily. The drying cylinders 10 have preferably adjustable steam pressures, and, if necessary, it is possible to use impingement blow devices 19 also in connection with these drying cylinders 10 in order to increase the capacity. At the side of the reversing cylinders 11, if necessary, it is possible to provide additional moisture, for example, by bringing moist air from the forward dryer section D_1, by using a water atomizing equipment, support belts, or equivalent arrangements that have been described above and will be described later.

[0054] In the exemplifying embodiment of the invention shown in Fig. 6A, in connection with the last dryer group R_{23}, with single-wire draw, in the after-dryer 30, steam boxes 31 have been fitted, by whose means steam is blown onto the web W on the reversing cylinder 11, and in this way the curling is regulated. Further, a spray moistener 35 is provided, by whose means water is also sprayed onto the web W in order to regulate the curling. Of the drying cylinders 10, three cylinders are cylinders C with adjustable temperature, so that they can be used as cooling or heating cylinders.

[0055] In Fig. 6B, after the last dryer group R_{23} in the after-dryer, an infra dryer 32 is fitted, by whose means the web W is dried intensively from the top side.

[0056] In Figs. 6A to 6C, a what is called spreader bar 34 has been fitted also in connection with the web, by means of which bar 34 the longitudinal curling of the web W is worked mechanically. The spreader bar 34 is a profiling roll, for example of the spreader roll type, in which case, in order to work the longitudinal curling, by its means it is also easy to act upon the cross-direction curling by means of mechanical working. A spreader bar 34 can be fitted at either side of the web or at both sides.

[0057] In Fig. 6C, in connection with the last dryer group R_{23} in the after-dryer 30, on the reversing cylinders 11 airborne type hoods 36 are provided, by whose means hot, moist air is blown towards the web W in view of controlling the curling.

[0058] Fig. 6D comprises a forward dryer section D_1 with single-wire draw, in which options have been arranged for possible impingement blow devices 19A. In this case the regulation of curling has been arranged by means of steam boxes 31 and a water spray device 35 fitted in connection with the last dryer group R_{23} in the after-dryer 30. Also in the after-dryer, there are optional provisions for impingement blow equipments 19A.

[0059] In Fig. 6E, which is substantially similar to Fig. 6D, in view of regulation of curling, the last two groups R_{22},R_{23} in the after-dryer 30 are provided with lower support belts 33, which prevent evaporation of water, and, moreover, in connection with the last dryer group, steam boxes 31 and a water spray device 35 have been fitted.

[0060] In the exemplifying embodiment shown in Fig. 6A, the emphasis is in particular on the control of curling before the calender 40 while the web W is cool. By means of a combination of steam boxes 31 and adjustable-temperature cylinders C, a particularly efficient combination is achieved, because, the hotter the web W is, the less readily is the steam condensed, in which connection, when cooling cylinders are used, efficient condensation of the steam is obtained. In view of compensating for the tendency of curling, it is also important to be able to make the web W as dry as possible before steam treatment, to condense the steam, and to make the web W warm by the effect of the steam, in which case the water remains at one side of the web W and provides elimination of curling. In the control of curling, it is to be taken into account that the web W tends to be curled towards the side at which drying takes place last. As comes out from the exemplifying embodiments of the invention described above, the curling can be affected at different stages in different ways so as to obtain an optimal application.

[0061] The exemplifying embodiment illustrated in Fig. 6A is optimal when both the forward dryer and the after-dryer D_1,30 are accomplished exclusively by means of dryer groups $R_0...R_6$,$R_{21}...R_{23}$ with single-wire draw and when the tendency of curling is controlled mainly by means of the last dryer group R_{23} in the after-dryer 30. When a tendency of curling is compensated for, a steam with a content of energy is blown out of the steam boxes 31, the superheating degree of said steam being preferably low in order that a condensation of maximal efficien-

cy could be achieved. Thus, the temperature of the steam is typically 2...10 °C above the dew point temperature. In such a case, a joint effect of moistening and thermal energy is achieved in the control of curling. The steam box 31 extends substantially across the entire width of the web, and it is, of course, fitted as adjustable and as profiling.

[0062] The web W can be moistened so that, in the final end of the dryer section, the face(s) of one or several drying cylinders is/are moistened, for example, by means of a water atomizing device fitted preferably in connection with a doctor 14, and the water fed out of said atomizer is vaporized and enters efficiently into contact with the web by the effect of the pressure caused by the wire. In the place of a cylinder, there can, of course, also be some other roll, in which case the water film applied to the face of the roll enters into contact with the web W when the wire presses the web against the roll.

[0063] The patent FI 70,275 related to the present invention instructs to control the temperature of the drying wire so that the drying efficiency can be affected. Similarly, by means of the temperature of the drying wire it is possible to control the unequalsidedness of drying. According to the present invention, in the after-dryer there are devices by whose means the temperature of the drying wire or wires and, thereby, the curling are affected. The wire can be heated, for example, by means of a steam box. For cooling, it is possible to use, for example, the methods and devices known from said FI Patent 70,275.

[0064] The curling can also be controlled by adjusting the humidity and temperature of the air blown through **UNORUN™** blow boxes. Similarly, unequalsided evaporation and curling of the web can be affected by means of the humidity of the air in the hood surrounding the web from different sides. Thus, by regulating the state of the air blown out of ventilation boxes 16, possibly together with the air blown through the wire or with the air used in **UNORUN™** boxes, it is possible to act upon the curling efficiently.

[0065] In the Patent US 5,557,860 mentioned in the introductory part of the present patent application, a steam box has been employed before the calender, after the forward dryer section exclusively provided with single-wire draw. If exclusively such an arrangement is used, there is a high risk that the surface properties of the final product are no longer as desired when the curling is under control. The scope of the present invention includes a combination in which the curling is controlled by means of blowing of steam or humid air before the calender, together with the control devices placed in the dryer section.

[0066] Above, the invention has been described with reference to a preferred exemplifying embodiment of same only, the invention being, however, not supposed to be in any way strictly confined to the details of said embodiment. Many modifications and variations are possible within the scope of the inventive idea defined in the following patent claims.

Claims

1. A method for drying of paper, which method comprises the following steps:

   a) the paper web (W) to be dried is passed from the press section into a forward dryer section (D_1), in which the paper web (W) is dried from the side of its bottom face in dryer groups (R_1... R_N) that apply a normal single-wire draw, said forward dryer section (D_1) comprising exclusively single-wire groups (R_1...R_N) with normal single-wire draw,
   b) from the forward dryer section (D_1) the paper web (W) is passed into a finishing section (D_2), in which the paper, web (W) is coated/surface-sized by means of a coating/surface-sizing equipment (20), dried in an after-dryer section (30), in which the paper web (W) is dried in at least one dryer group (R_{21}) that applies a normal single-wire draw, after which the paperweb (W) is calendered in a calender (40) and passed to a reeling station (50), in which the paper web (W) is reeled into a machine reel (MR), and
   c) the curling of the paper web is controlled by means of elements (19;32;33;34;38;36;D_{syl}, D_{tela}) and/or by means of assemblies and combinations formed out of said elements and by means of at least one steam box (31) at least in the area of the finishing section (D_2),

   characterized in that, in the method, the condensation of the steam fed by said steam box is intensified by cooling the web prior to said steam box, by using a cooling cylinder with adjustable temperature.

2. A method as claimed in claim 1, **characterized in that**, in the method, the curling of the paper web (W) is affected by means of impingement blow devices (19) placed in the forward dryer section (D_1) above a drying cylinder (10)/cylinders, by means of which devices (19) preferably - hot, moist air is blown towards the paper web (W).

3. A method as claimed in any one of the claims 1 and 2, **characterized in that** in the after-dryer (30) the curling of the paperweb (W) is controlled by means of steam boxes (31), by whose means steam with a content of energy is blown onto the paper web (W) which runs in connection with the reversing cylinders (11) in at least one dryer group (R_{21}, R_{23}) with single-wire draw in the after-dryer (30).

4. A method as claimed in any one of the claims 1 to 3, **characterized in that**, in the method, the curling

of the paper web is controlled by means of a lower support wire or belt (33) fitted in at least one dryer group (R_{21},R_{22},R_{23}) in the after-dryer (30), by means of which support wire/belt evaporation of moisture downwards from the paperweb (W) is prevented.

5. A method as claimed in claim 1, **characterized in that**, in the method, in an after-dryer (30) with at least three dryer groups, the curling of the paper web (W) is controlled in the last two dryer groups in the after-dryer (30), which groups have been ar ranged as dryer groups (R_{23},R_{33}) that apply twin-wire draw, the paperweb (W) being dried both from the side of its top face and from the side of its bottom face.

6. A method as claimed in any one of the claims 1 to 5, **characterized in that** in the after-dryer (30) the curling of the paper web (W) is controlled by means of an impingement blow equipment (19) placed above a drying cylinder (10) / cylinders (10) in at least one dryer group (R_{21},R_{22},R_{23}) with a normal single-wire draw in the after-dryer (30).

7. A method as claimed in any one of the claims 1 to 6, **characterized in that**, in the method, the curling of the paper web (W) is controlled in the dryer groups in the after-dryer (30) so that the paper web (W) is guided over such drying cylinders (10) and reversing rolls (11) whose diameter ratio (D_{syl};D_{tela}) has been made larger as compared with the forward dryer section (D_1) in orderthat a more uniform drying could be achieved.

8. A method as claimed in any one of the preceding claims, **characterized in that**, in the method, the curling of the paper web is affected by spraying water mist into connection with the paper web (W) by means of a water atomizing device/devices (35) in the after-dryer (30).

9. A method as claimed in any one of the preceding claims, **characterized in that**, in the method, the curling of the paper web (W) is affected by means of through drying of the paper web (W) by means of an infrared dryer (32) before the paper web (W) is passed into the calender (40).

10. A method as claimed in any one of the preceding claims, **characterized in that**, in the method, the curling of the paperweb (W) is controlled by blowing moist air towards the paper web (W), which air has preferably been brought from the forward dryer section (D_1), by the intermediate of hoods (36) placed in connection with at least one dryer group (R_{21}, R_{22}, R_{23}) in the after-dryer.

11. A method as claimed in any one of the preceding claims, **characterized in that**, in the method, the curling of the paper web (W) is controlled by means of a spreader bar (34), by whose means the paper web (W) is worked mechanically.

12. A method as claimed in any one of the claims 1 to 3 or 5 to 11, characterizecl in that the forward dryer section is exclusively composed of normal groups with single-wire draw that are open towards the bottom, and/or that, in the method, in the after-dryer (30), the paperweb (W) is dried substantially exclusively by means of dryer groups (R_{21}, R_{22}, R_{23}) with normal single-wire draw.

13. A dry end of a paper machine, which comprises a forward dryer section (D_1) and a finishing, section (D_2), wh ich finishing section (D_2) comprises a coating/surface-sizing equipment (20), an after-dryer (30), a calender (40), and a reeling station (50), and the dry end of a paper machine further comprises elements (19;32;33;34;35;36;D_{syl},D_{tela}) and/or assemblies and combinations formed out of said elements and at least one steam box (31) in view of controlling the curling of the paperweb (W) at least in the area of the finishing section (D_2), **characterized in that** said dry end of a paper machine comprises a cooling cylinder of adjustable temperature for lowering the temperature of the web (W) prior to said steam box in orderto intensify the condensation of the steam fed by said steam box.

14. A dry end of a paper machine as claimed in of the claim 13, **characterized in that** the dry end comprises an impingement blow equipment (19) fitted in connection with at least one dryer group above a drying cylinder (10) /cylinders (10) in the forward dryer section (D_1) and/or in the after-dryer (30).

15. A dry end of a paper machine as claimed in any one of the claims 13 and 14, **characterized in that** the dry end comprises at least one steam box (31) fitted in the, after-dryer (30) in order to blow steam towards the paper web (W) in connection with the groups (R_{21},R_{22},R_{23}) with single-wire draw in the after-dryer (30).

16. A dry end of a papermachine as claimed in any one of the claims 13 to 15, **characterized in that** the dry end comprises at least one support wire or belt (33) fitted in a dryergroup (R_{21},R_{22},R_{23}) in the after-dryer (30) in order to prevent evaporation of moisture from the paper web (W) downwards.

17. A dry end of a papermachine as claimed In any one of the claims 13 to 16, **characterized in that** the last two dryer groups in the after-dryer (30) are dryer groups (R_{32},R_{33}) with twin-wire draw.

18. A dry end of a papermachine as claimed in any one

of the claims 13 to 16, **characterized in that** in the after-dryer the ratio (D_{syl}; D_{tela}) of the diameter of the drying cylinders is higher than said ratio in the forward dryer section.

19. A dry end of a paper machine as claimed in any one of the claims 13 to 18, **characterized in that** the dry end includes a water atomizing device / devices (35) for the purpose of spraying water mist into connection with the paper web (W) in view of controlling the curling.

20. A dry end of a papermachine as claimed in any one of the claims 13 to 19, **characterized in that** the after-dryer includes an infra dryer (32), which is placed before the paper web is passed into the calender (40).

21. A dry end of a paper machine as claimed in any one of the claims 13 to 19, **characterized in that** the dry end comprises hoods (36) fitted in connection with at least one dryer group in the after-dryer (30) in view of blowing moist air brought from the forward dryer section (D_1) towards the paper web.

22. A dry end of a paper machine as claimed in any one of the claims 13 to 21, **characterized in that** in the after-dryer a spreader bar (34) is fitted for working the paper web mechanically and for controlling the curling-of the paper web.

23. A dry end of a paper machine as claimed in any one of the claims 13 to 16 or 18 to 22, **characterized in that** the after-dryer (30) comprises exclusively dryer groups (R_{21},R_{22},R_{23}) with a normal single-wire draw.

24. A method as claimed in any one of the claims 1 to 12 or a dry end of a paper machine as claimed in any one of the claims 13 to 23, **characterized in that** said dryer section and auxiliary devices are controlled based on on-line or off-line measurements of curling and quality in view of achieving an optimal ultimate overall quality.

Patentansprüche

1. Verfahren zum Trocknen von Papier mit den folgenden Schritten:

a) die zu trocknende Papierbahn (W) tritt von der Pressenpartie zu einer Vorwärtstrockenpartie (D_1), bei der die Papierbahn (W) von der Seite ihrer Bodenfläche in Trocknergruppen (R_1...R_N) getrocknet wird, die einen normalen Einzelsiebzug anwenden, wobei die Vorwärtstrockenpartie (D_1) ausschließlich Einzelsiebgruppen (R_1...R_N) mit normalem Einzelsiebzug aufweisen,

b) von der Vorwärtstrockenpartie (D_1) tritt die Papierbahn (W) zu einer Finishingpartie (D_2), bei der die Papierbahn (W) mittels einer Beschichtungs-Oberflächenleim-Anlage (20) beschichtet /oberflächengeleimt wird, bei einer Nachtrockenpartie (30) getrocknet wird, bei der die Papierbahn (W) in zumindest einer Trocknergruppe (R_{21}) getrocknet wird, die einen normalen Einzelsiebzug anwendet, wobei danach die Papierbahn (W) in einem Kalander(40) kalendriert wird und zu einer Aufrollstation (50) tritt, bei der die Papierbahn (W) zu einer Maschinenrolle (MR) aufgerollt wird, und

c) das Rollen der Papierbahn mittels Elementen (19; 32; 33; 34; 35; 36; D_{syl}; D_{tela}) und / oder mittels Baugruppen und Kombinationen, die aus den Elementen ausgebildet sind, und mittels zumindest einem Dampfkasten (31) zumindest in dem Bereich der Finishingpartie (D_2) gesteuert wird,

dadurch gekennzeichnet, dass
bei diesem Verfahren die Wirkung des Dampfkastens verstärkt wird, indem die Bahn vor dem Dampfkasten unter Verwendung eines Kühlzylinders mit einer einstellbaren Temperatur gekühlt wird.

2. Verfahren gemäß Anspruch 1,
dadurch gekennzeichnet, dass
bei diesem Verfahren das Rollen der Papierbahn (W) mittels Aufprallblasvorrichtungen (19) beeinflusst wird, die in der Vorwärtstrockenpartie (D_1) oberhalb eines Trocknungszylinders (10) / oberhalb von Trocknungszylindern angeordnet sind, wobei mittels der Vorrichtungen (19) vorzugsweise heiße feuchte Luft zu der Papierbahn (W) geblasen wird.

3. Verfahren gemäß einem der Ansprüche 1 und 2,
dadurch gekennzeichnet, dass
bei dem Nachtrockner (30) das Rollen der Papierbahn (W) mittels Dampfkästen (31) gesteuert wird, wobei durch diese Einrichtungen Dampf mit einem Energiegehalt zu der Papierbahn (W) geblasen wird, die in Verbindung mit den Umkehrzylindern (12) in zumindest einer Trocknergruppe (R_{21}, R_{23}) mit einem Einzelsiebzug in dem Nachtrockner (30) läuft.

4. Verfahren gemäß einem der Ansprüche 1 bis 3,
dadurch gekennzeichnet, dass
bei dem Verfahren das Rollen der Papierbahn mittels eines unteren Stützsiebes oder -riemens (33) gesteuert wird, der in zumindest einer Trocknergruppe (R_{21}, R_{22}, R_{23}) in dem Nachtrockner (30) sitzt, wobei mittels dieses Stützsiebes / Stützriemens verhindert wird, dass Feuchtigkeit von der Papierbahn (W) nach unten verdampft.

5. Verfahren gemäß Anspruch 1,
dadurch gekennzeichnet, dass
bei dem Verfahren bei einem Nachtrockner (30) mit zumindest drei Trocknergruppen das Rollen der Papierbahn (W) in den letzten beiden Trocknergruppen in dem Nachtrockner (30) gesteuert wird, wobei die Gruppen als Trocknergruppen (R_{23}, R_{33}) eingerichtet sind, die einen Zwillingssiebzug anwenden, wobei die Papierbahn (W) sowohl von der Seite ihrer Oberfläche als auch von der Seite ihrer Bodenfläche getrocknet wird.

6. Verfahren gemäß einem der Ansprüche 1 bis 5,
dadurch gekennzeichnet, dass
bei dem Nachtrockner (30) das Rollen der Papierbahn (W) mittels einer Aufprallblasanlage (19) gesteuert wird, die oberhalb eines Trocknungszylinders (10) / oberhalb von Trocknungszylindern (10) in zumindest einer Trocknergruppe (R_{21}, R_{22}, R_{23}) mit einem normalen Einzelsiebzug in dem Nachtrockner (30) angeordnet ist.

7. Verfahren gemäß einem der Ansprüche 1 bis 6,
dadurch gekennzeichnet, dass
bei diesem Verfahren das Rollen der Papierbahn (W) in den Trocknergruppen in dem Nachtrockner (30) so gesteuert wird, dass die Papierbahn (W) über derartige Trocknungszylinder (10) und Umkehrwalzen (11) geführt wird, deren Durchmesserverhältnis (D_{syl}; D_{tela}) im Vergleich zu der Vorwärtstrockenpartie (D_1) größer gestaltet ist, damit ein gleichmäßigeres Trocknen erzielt werden kann.

8. Verfahren gemäß einem der vorherigen Ansprüche,
dadurch gekennzeichnet, dass
bei diesem Verfahren das Rollen der Papierbahn beeinflusst wird, indem ein Wassernebel in Verbindung mit der Papierbahn (W) mittels einer Wasserzerstäubungsvorrichtung / mittels Wasserzerstäubungsvorrichtungen (35) in dem Nachtrockner (30) gesprüht wird.

9. Verfahren gemäß einem der vorherigen Ansprüche,
dadurch gekennzeichnet, dass
bei diesem Verfahren das Rollen der Papierbahn (W) mittels eines Durchtrocknens der Papierbahn (W) mittels eines Infrarottrockners (32) beeinflusst wird, bevor die Papierbahn (W) in den Kalander (40) tritt.

10. Verfahren gemäß einem der vorherigen Ansprüche,
dadurch gekennzeichnet, dass
bei diesem Verfahren das Rollen der Papierbahn (W) gesteuert wird, indem feuchte Luft zu der Papierbahn (W) geblasen wird, wobei die Luft vorzugsweise von der Vorwärtstrockenpartie (D_1) gebracht worden ist, wobei Hauben (36) zwischenwirken, die in Verbindung mit zumindest einer Trocknergruppe (R_{21}, R_{22}, R_{23}) in dem Nachtrockner angeordnet sind.

11. Verfahren gemäß einem der vorherigen Ansprüche,
dadurch gekennzeichnet, dass
bei diesem Verfahren das Rollen der Papierbahn (W) mittels einer Ausstreichleiste (34) gesteuert wird, wobei durch diese Einrichtung die Papierbahn (W) mechanisch bearbeitet wird.

12. Verfahren gemäß einem der Ansprüche 1 bis 3 oder 5 bis 11,
dadurch gekennzeichnet, dass
die Vorwärtstrockenpartie ausschließlich aus normalen Gruppen mit Einzelsiebzug besteht, die zu dem Boden hin offen sind, und / oder
bei diesem Verfahren in dem Nachtrockner (30) die Papierbahn (W) im Wesentlichen ausschließlich mittels der Trocknergruppen (R_{21}, R_{22}, R_{23}) mit normalem Einzelsiebzug getrocknet wird.

13. Trockenende einer Papiermaschine mit einer Vorwärtstrockenpartie (D_1) und einer Finishingpartie (D_2), wobei die Finishingpartie (D_2) eine Beschichtungs-Oberflächenleim-Anlage (20), einen Nachtrockner (30), einen Kalander (40) und eine Aufrollstation (50) aufweist, und das Trockenende einer Papiermaschine des weiteren Elemente (19; 32; 33; 34; 35; 36; D_{syl}; D_{tela}) und / oder Baugruppen und Kombinationen, die aus diesen Elementen ausgebildet sind, und zumindest einen Dampfkasten (31) im Hinblick auf das Steuern des Rollens der Papierbahn (W) zumindest in dem Bereich der Finishingpartie (D_2) aufweist,
dadurch gekennzeichnet, dass
das Trockenende einer Papiermaschine einen Kühlzylinder mit einstellbarer Temperatur zum Senken der Temperatur der Bahn (W) vor dem Dampfkasten aufweist, die Kondensation des von dem Dampfkasten gelieferten Dampf zu verstärken.

14. Trockenende einer Papiermaschine gemäß Anspruch 13,
dadurch gekennzeichnet, dass
das Trockenende einer Aufprallblasanlage (19) aufweist, die in Verbindung mit zumindest einer Trocknergruppe oberhalb eines Trocknungszylinders (10) /oberhalb von Trocknungszylindern (10) in der Vorwärtstrockenpartie (D_1) und / oder in dem Nachtrockner (30) sitzt.

15. Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 und 14,
dadurch gekennzeichnet, dass
das Trockenende zumindest einen Dampfkasten (31) aufweiset, der in dem Nachtrockner (30) sitzt, um Dampf zu der Papierbahn (W) in Verbindung mit den Gruppen (R_{21}, R_{22}, R_{23}) mit Einzelsiebzug in dem Nachtrockner (30) zu blasen.

16. Trockenende einer Papiermaschine gemäß einem

der Ansprüche 13 bis 15,
dadurch gekennzeichnet, dass
das Trockenende zumindest ein Stützsieb oder einen Stützriemen (33) aufweist, der in einer Trocknergruppe (R_{21}, R_{22}, R_{23}) in dem Nachtrockner (30) sitzt, um zu verhindern, dass die Feuchtigkeit von der Papierbahn (W) nach unten verdampft.

17. Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 bis 16,
dadurch gekennzeichnet, dass
die letzten beiden Trocknergruppen in dem Nachtrockner (30) Trocknergruppen (R_{32}, R_{33}) mit Zwillingssiebzug sind.

18. Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 bis 16,
dadurch gekennzeichnet, dass
in dem Nachtrockner das Verhältnis (D_{syl}; D_{tela}) des Durchmessers der Trocknungszylinder größer als das Verhältnis in der Vorwärtstrockenpartie ist.

19. Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 bis 18,
dadurch gekennzeichnet, dass
das Trockenende einer Wasserzerstäubungsvorrichtung / Wasserzerstäubungsvorrichtungen (35) zum Zwecke des Sprühens von Wassernebel in Verbindung mit der Papierbahn (W) im Hinblick auf das Steuern des Rollens hat.

20. Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 bis 19,
dadurch gekennzeichnet, dass
der Nachtrockner einen Infrarottrockner (32) hat, der angeordnet ist, bevor die Papierbahn in den Kalander (40) tritt.

21. Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 bis 19,
dadurch gekennzeichnet, dass
das Trockenende Hauben (36) aufweist, die in Verbindung mit zumindest einer Trocknergruppe in dem Nachtrockner (30) im Hinblick auf das Blasen von feuchter Luft eingesetzt sind, die von der Vorwärtstrockenpartie (D_1) zu der Papierbahn gebracht wird.

22. Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 bis 21,
dadurch gekennzeichnet, dass
in dem Nachtrockner eine Ausstreichleiste (34) sitzt, um die Papierbahn mechanisch zu bearbeiten und um das Rollen der Papierbahn zu steuern.

23. Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 bis 16 oder 18 bis 22,
dadurch gekennzeichnet, dass
der Nachtrockner (30) ausschließlich Trocknergruppen (R_{21}, R_{22}, R_{23}) mit einem normalen Einzelsiebzug aufweist.

24. Verfahren gemäß einem der Ansprüche 1 bis 12 oder Trockenende einer Papiermaschine gemäß einem der Ansprüche 13 bis 23,
dadurch gekennzeichnet, dass
die Trockenpartie und die Hilfsvorrichtungen auf der Grundlage von in der Produktionslinie stattfindenden oder außerhalb der Produktionslinie stattfindenden Messungen des Rollens und der Qualität im Hinblick auf ein Erzielen einer optimalen Endgesamtqualität gesteuert werden.

Revendications

1. Procédé de séchage de papier, lequel procédé comprend les étapes suivantes:

a) on fait passer la bande de papier (W) à sécher de la section de presse dans une section de séchoir avant (D_1), dans laquelle la bande de papier (W) est séchée du côté de sa face inférieure dans des groupes de séchoirs (R_1... R_N) qui appliquent une tension de toile unique normale, ladite section de séchoir avant (D_1) comprenant exclusivement des groupes à toile unique (R_1...R_N) avec une tension de toile unique normale,
b) on fait passer la bande de papier (W) de la section de séchoir avant (D_1) dans une section de finition (D_2), dans laquelle la bande de papier (W) est enrobée/gélatinée par le biais d'un équipement d'enrobage/de gélatinage (20), séchée dans une section post-séchoir (30), dans laquelle la bande de papier (W) est séchée dans au moins un groupe de séchoirs (R_{21}) qui applique une tension de toile unique normale, suite à quoi la bande de papier (W) est calandrée dans une calandre (40) et transmise à une station d'enroulage (50), où la bande de papier (W) est enroulée dans une enrouleuse de machine (MR), et
c) le roulage de la bande de papier est commandé par le biais d'éléments (19; 32; 33; 34; 35; 36; D_{syl}, D_{tela}) et/ou par le biais d'assemblages et de combinaisons formé(e)s à partir desdits éléments et par le biais d'au moins une boîte à vapeur (31) au moins dans la zone de la section de finition (D_2),

caractérisé en ce que, dans le procédé, la condensation de la vapeur alimentée par ladite boîte à vapeur est intensifiée en refroidissant la bande avant ladite boîte à vapeur, en utilisant un cylindre de refroidissement avec une température ajustable.

2. Procédé tel que revendiqué dans la revendication 1, **caractérisé en ce que**, dans le procédé, le roulage de la bande de papier (W) est affecté par le biais de dispositifs de soufflage par impact (19) placés dans la section de séchoir avant (D_1) au-dessus d'un ou de cylindres (10) de séchage, dispositifs (19) par le biais desquels de l'air humide, chaud, de préférence, est soufflé vers la bande de papier (W).

3. Procédé tel que revendiqué dans l'une quelconque des revendications 1 et 2, **caractérisé en ce que** dans le post-séchoir (30) le roulage de la bande de papier (W) est commandé par le biais de boîtes à vapeur (31), au moyen desquelles de la vapeur avec une teneur en énergie est soufflée sur la bande de papier (W) qui avance en relation avec les cylindres inverseurs (11) dans au moins un groupe de séchoirs (R_{21}, R_{23}) avec une tension de toile unique dans le post-séchoir (30).

4. Procédé tel que revendiqué dans l'une quelconque des revendications 1 à 3, **caractérisé en ce que**, dans le procédé, le roulage de la bande de papier est commandé par le biais d'une toile ou d'une courroie de soutien inférieure (33) installée dans au moins un groupe de séchoirs (R_{21}, R_{22}, R_{23}) dans le post-séchoir (30), toile/courroie de soutien par le biais de laquelle on empêche l'évaporation d'humidité vers le bas à partir de la bande de papier (W).

5. Procédé tel que revendiqué dans la revendication 1, **caractérisé en ce que**, dans le procédé, dans une post-séchoir (30) avec au moins trois groupes de séchoirs, le roulage de la bande de papier (W) est commandé dans les deux derniers groupes de séchoirs dans le post-séchoir (30), lesquels groupes ont été agencés en tant que groupes de séchoirs (R_{23}, R_{33}) qui appliquent une tension de toile double, la bande de papier (W) étant séchée à la fois du côté de sa face supérieure et du côté de sa face inférieure.

6. Procédé tel que revendiqué dans l'une quelconque des revendications 1 à 5, **caractérisé en ce que** dans le post-séchoir (30), le roulage de la bande de papier (W) est commandé par le biais d'un équipement de soufflage par impact (19) placé au-dessus d'un ou de cylindres (10) de séchage dans au moins un groupe de séchoirs (R_{21}, R_{22}, R_{23}) avec une tension de toile unique normale dans le post-séchoir (30).

7. Procédé tel que revendiqué dans l'une quelconque des revendications 1 à 6, **caractérisé en ce que**, dans le procédé, le roulage de la bande de papier (W) est commandé dans les groupes de séchoirs dans le post-séchoir (30) de sorte que la bande de papier (W) soit guidée sur de tels cylindres de séchage (10) et des rouleaux inverseurs (11) dont le rapport de diamètres (D_{syl} ; D_{tela}) est plus grand en comparaison avec la section de séchoir avant (D_1) pour qu'un séchage plus uniforme puisse être réalisé.

8. Procédé tel que revendiqué dans l'une quelconque des revendications précédentes, **caractérisé en ce que**, dans le procédé, le roulage de la bande de papier est affecté en pulvérisant une brume d'eau en relation avec la bande de papier (W) par le biais d'un dispositif/de dispositifs d'atomisation à l'eau (35) dans le post-séchoir (30).

9. Procédé tel que revendiqué dans l'une quelconque des revendications précédentes, **caractérisé en ce que**, dans le Procédé, le roulage de la bande de papier (W) est affecté par le biais d'un séchage à fond de la bande de papier (W) par le biais d'un séchoir à infrarouge (32) avant que la bande de papier (W) ne soit transférée dans la calandre (40).

10. Procédé tel que revendiqué dans l'une quelconque des revendications précédentes, **caractérisé en ce que**, dans le procédé, le roulage de la bande de papier (W) est commandé en soufflant de l'air humide vers la bande de papier (W), air qui a été amené de préférence de la section de séchoir avant (D_1), par l'intermédiaire de capots (36) placés en relation avec au moins un groupe de séchoirs (R_{21}, R_{22}, R_{23}) dans le post-séchoir.

11. Procédé tel que revendiqué dans l'une quelconque des revendications précédentes, **caractérisé en ce que**, dans le procédé, le roulage de la bande de papier (W) est commandé par le biais d'une barre déplisseuse (34) par l'intermédiaire de laquelle la bande de papier (W) est travaillée mécaniquement.

12. Procédé tel que revendiqué dans l'une quelconque des revendications 1 à 3, **caractérisé en ce que** la section de séchoir avant est composée exclusivement de groupes normaux avec une tension de toile unique qui sont ouverts vers le fond, et/ou **en ce que**, dans le procédé, dans le post-séchoir (30), la bande de papier (W) est séchée essentiellement exclusivement par le biais de groupes de séchoirs (R_{21}, R_{22}, R_{23}) avec une tension de toile unique normale.

13. Train de séchage d'une machine à papier, qui comprend une section de séchoir avant (D_1) et une section de finition (D_2), laquelle section de finition (D_2) comprend un équipement d'enrobage/de gélatinage (20), une post-séchoir (30), une calandre (40), et une station d'enroulage (50), et le train de séchage d'une machine à papier comprend en plus des éléments (19; 32; 33; 34; 35; 36; D_{syl}, D_{tela}) et/ou des assemblages et des combinaisons formé(e)s à partir desdits éléments et au moins une boîte à vapeur (31)

en vue de commander le roulage de la bande de papier (W) au moins dans la zone de la section de finition (D_2), **caractérisé en ce que** ledit train de séchage d'une machine à papier comprend un cylindre de refroidissement à température ajustable pour réduire la température de la bande (W) avant ladite boîte à vapeur afin d'intensifier la condensation de la vapeur alimentée par ladite boîte à vapeur.

14. Train de séchage d'une machine à papier tel que revendiqué dans la revendication 13 **caractérisé en ce que** le train de séchage comprend un équipement de soufflage par impact (19) installé en relation avec au moins un groupe de séchoirs au-dessus d'un ou de cylindres (10) de séchage dans la section de séchoir avant (D_1) et/ou dans le post-séchoir (30).

15. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 et 14, **caractérisé en ce que** le train de séchage comprend au moins une boîte à vapeur (31) installée dans le post-séchoir (30) afin de souffler de la vapeur vers la bande de papier (W) en relation avec les groupes (R_{21}, R_{22}, R_{23}) avec une tension de toile unique dans le post-séchoir (30).

16. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 15, **caractérisée en ce que** le train de séchage comprend au moins une toile ou une courroie de soutien (33) installée dans un groupe de séchoirs (R_{21}, R_{22}, R_{23}) dans le post-séchoir (30) afin d'empêcher l'évaporation vers le bas d'humidité à partir de la bande de papier (W).

17. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 16, **caractérisé en ce que** les deux derniers groupes de séchoirs dans le post-séchoir (30) sont des groupes de séchoirs (R_{23}, R_{33}) avec une tension de toile double.

18. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 16, **caractérisée en ce que** dans le post-séchoir le rapport (D_{syl} ; D_{tela}) du diamètre des cylindres de séchage est supérieur audit rapport dans la section de séchoir avant.

19. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 18, **caractérisée en ce que** le train de séchage inclut un dispositif/des dispositifs de pulvérisation d'eau (35) dans le but de pulvériser une brume d'eau en relation avec la bande de papier (W) afin de commander le roulage.

20. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 19, **caractérisé en ce que** le post-séchoir inclut un séchoir à infrarouge (32), qui est placé avant que la bande de papier ne soit transférée dans la calandre (40).

21. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 19, **caractérisé en ce que** le train de séchage comprend des capots (36) installés en relation avec au moins un groupe de séchoirs dans le post-séchoir (30) en vue due souffler de l'air humide amené de la section de séchoir avant (D_1) vers la bande de papier.

22. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 21, **caractérisé en ce que** dans le post-séchoir une barre déplisseuse (34) est installée pour travailler la bande de papier mécaniquement et pour commander le roulage de la bande de papier.

23. Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 16 ou 18 à 22, **caractérisé en ce que** le post-séchoir (30) comprend exclusivement des groupes de séchoirs R_{21}, R_{22}, R_{23}) avec une tension de toile unique normale.

24. Procédé tel que revendiqué dans l'une quelconque des revendications 1 à 12 ou un Train de séchage d'une machine à papier tel que revendiqué dans l'une quelconque des revendications 13 à 23, **caractérisé en ce que** ladite section de séchoir et des dispositifs auxiliaires sont commandés sur la base de mesures en ligne ou hors ligne du roulage et d'une qualité en vue d'accomplir une qualité globale finale optimale.

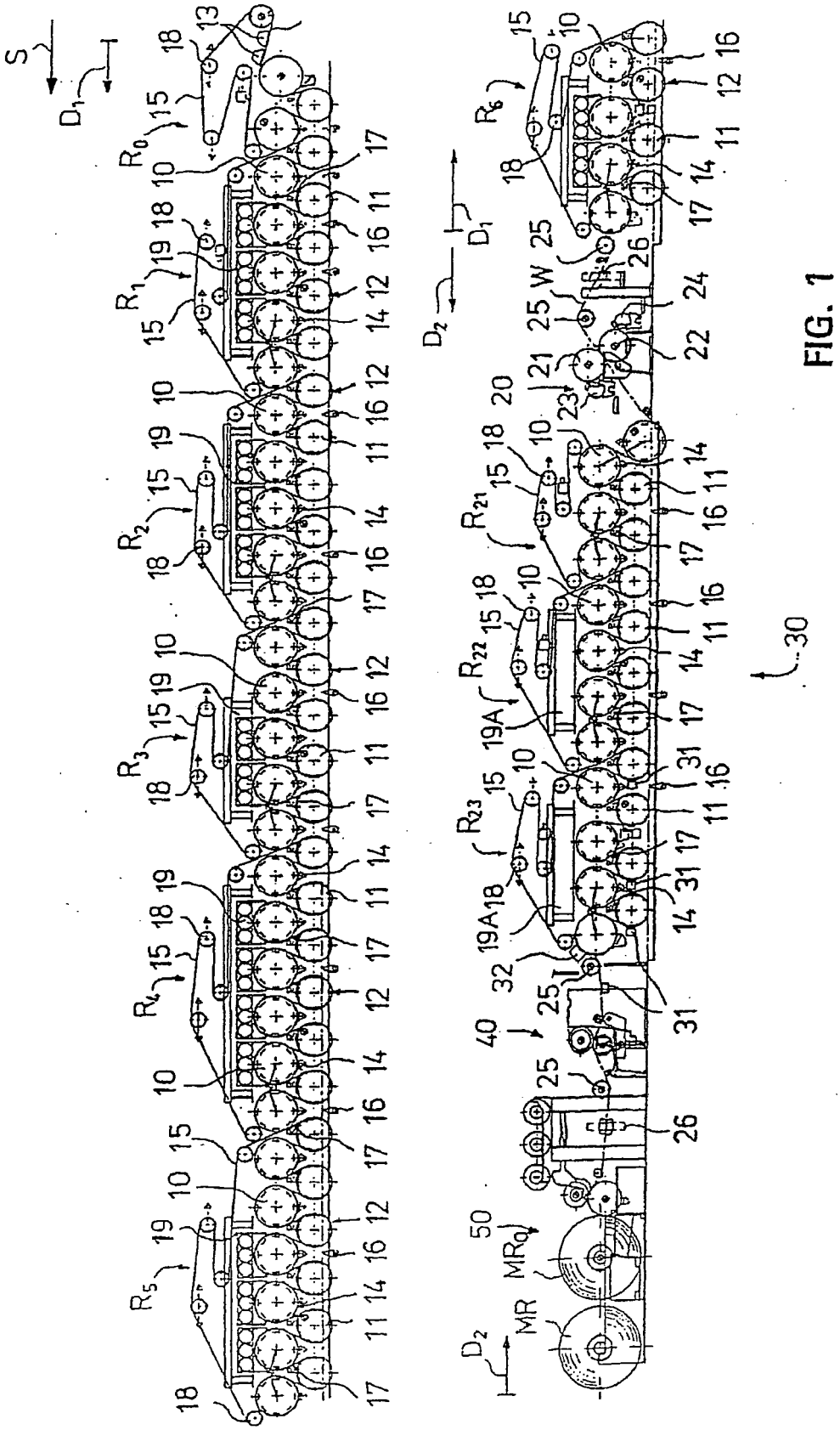


FIG. 1

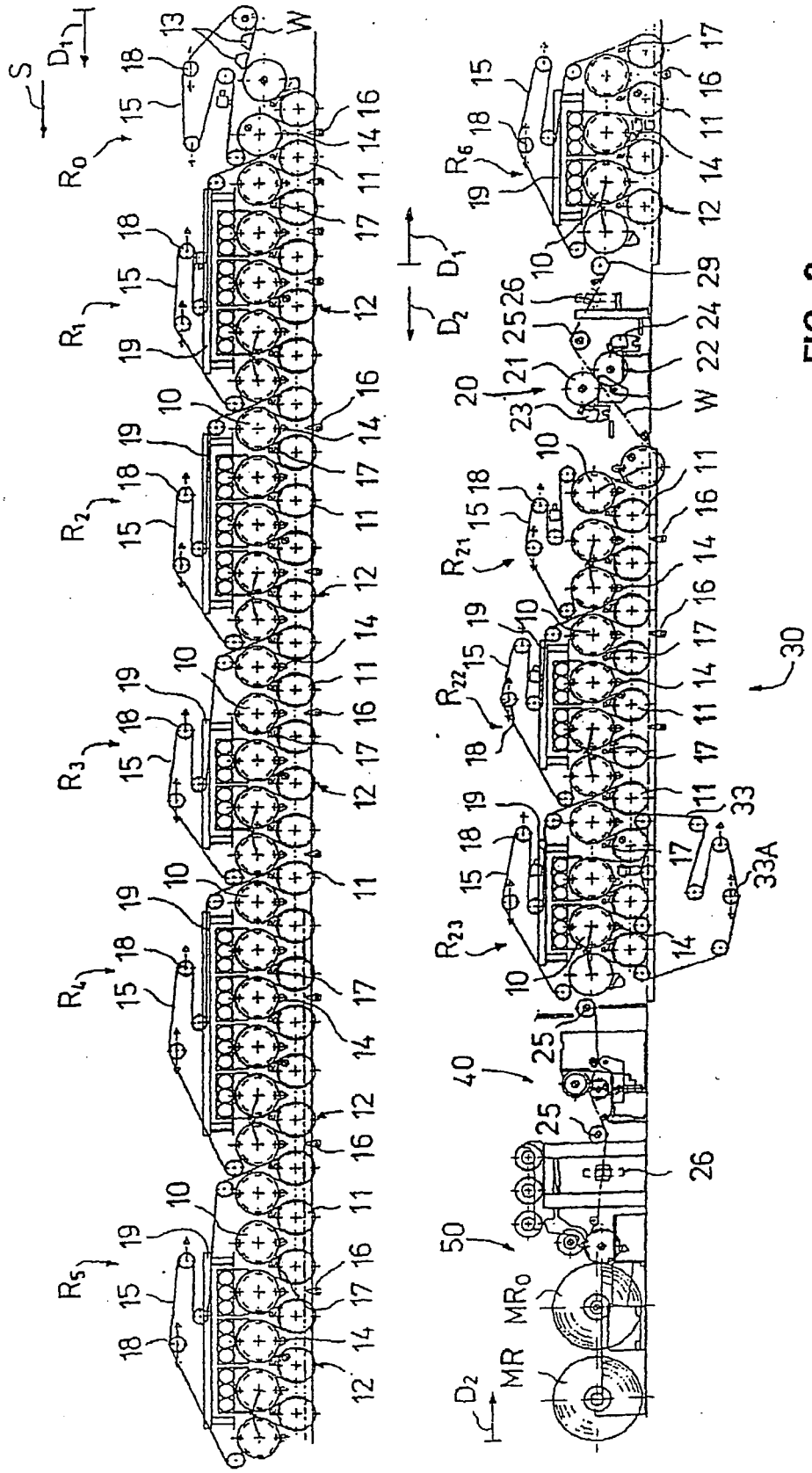
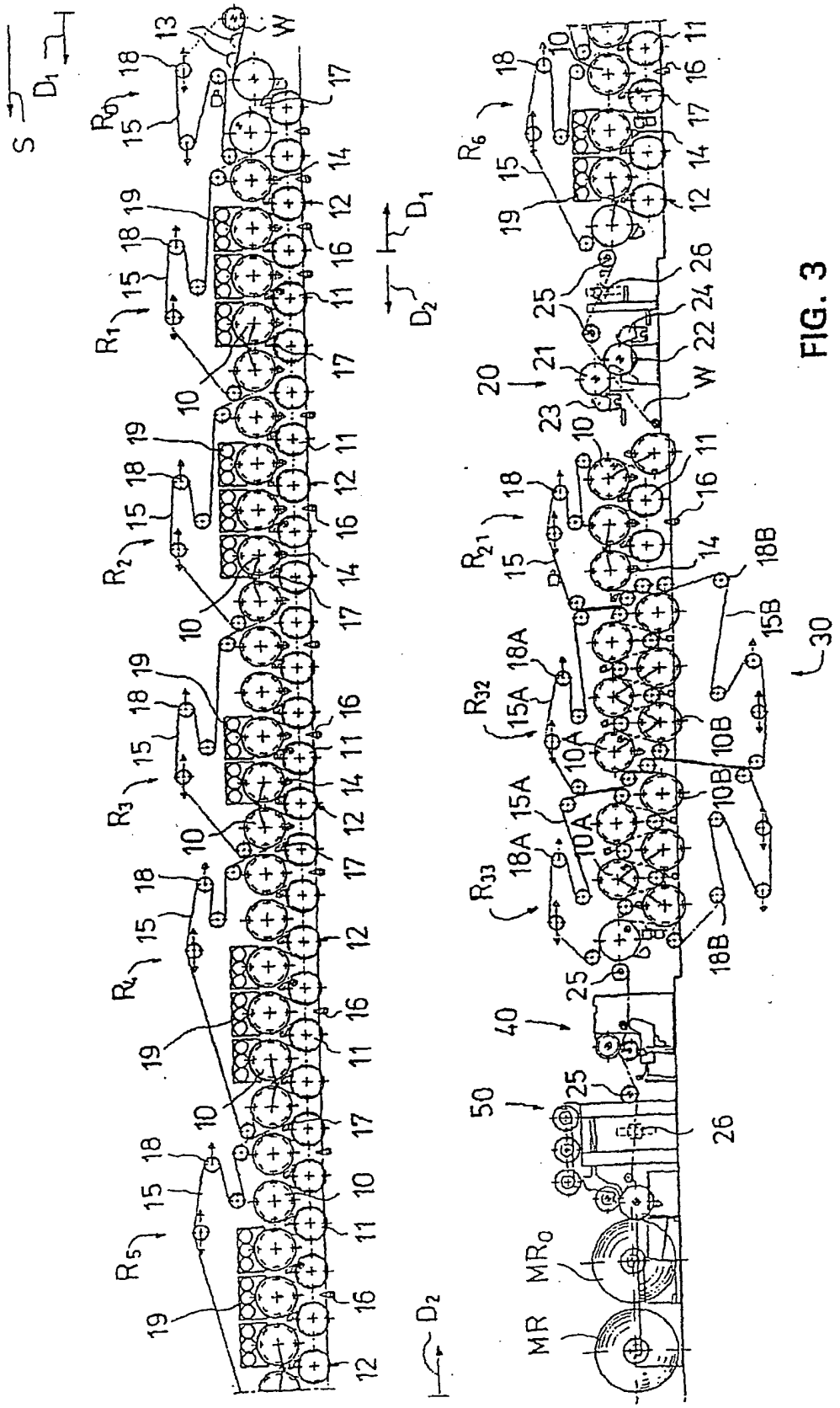


FIG. 2


S
D1
D2
W
R0
R1
R2
R3
R4
R5
R6
R21
R32
R33
MR
MR0
10
10A
10B
11
12
13
14
15
15A
15B
16
17
18
18A
18B
19
20
21
22
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24
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26
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40
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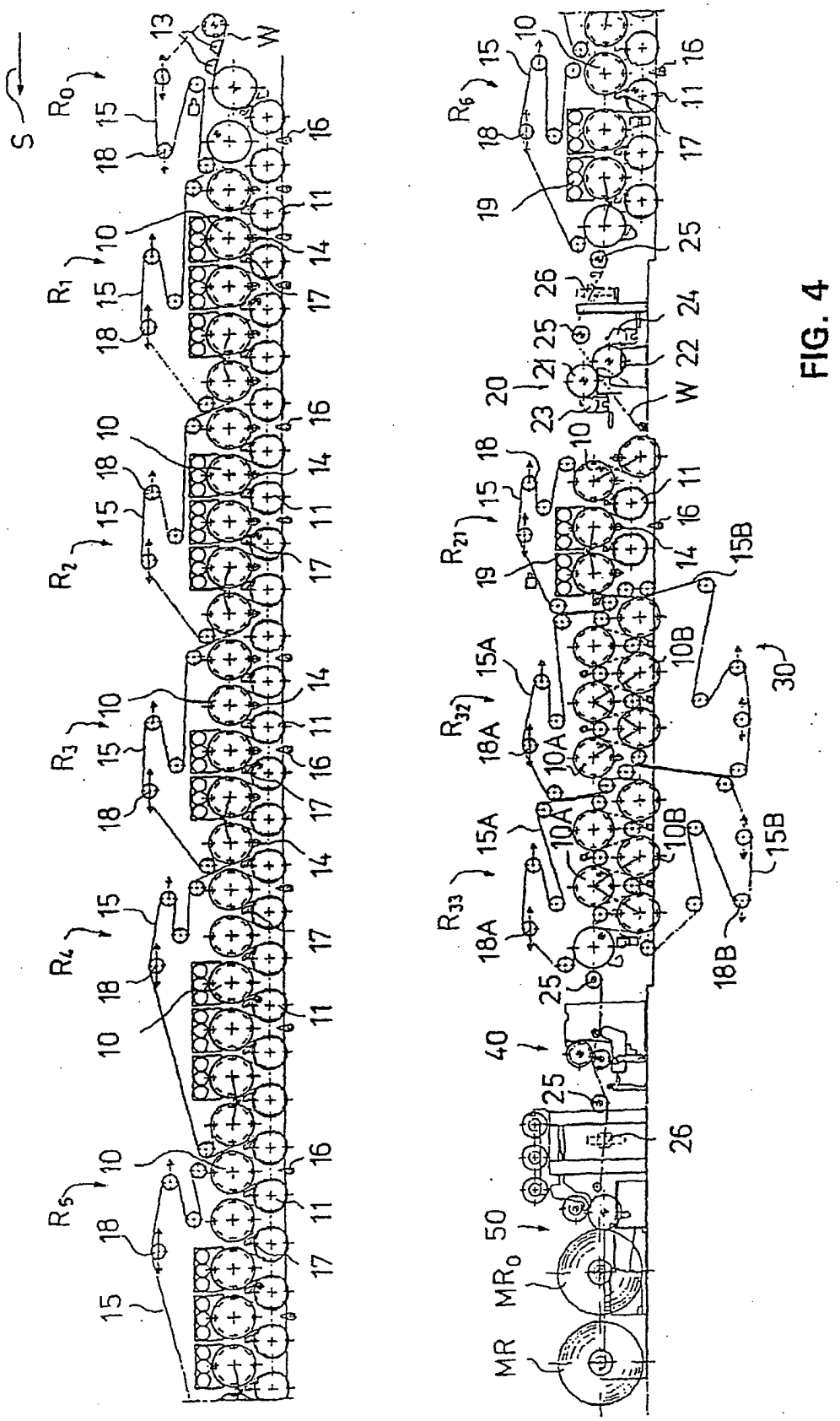
FIG. 3


S
W
MR
MR0
R0
R1
R2
R3
R4
R5
R6
R21
R32
R33
10
10A
10B
11
13
14
15
15A
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22
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FIG. 4

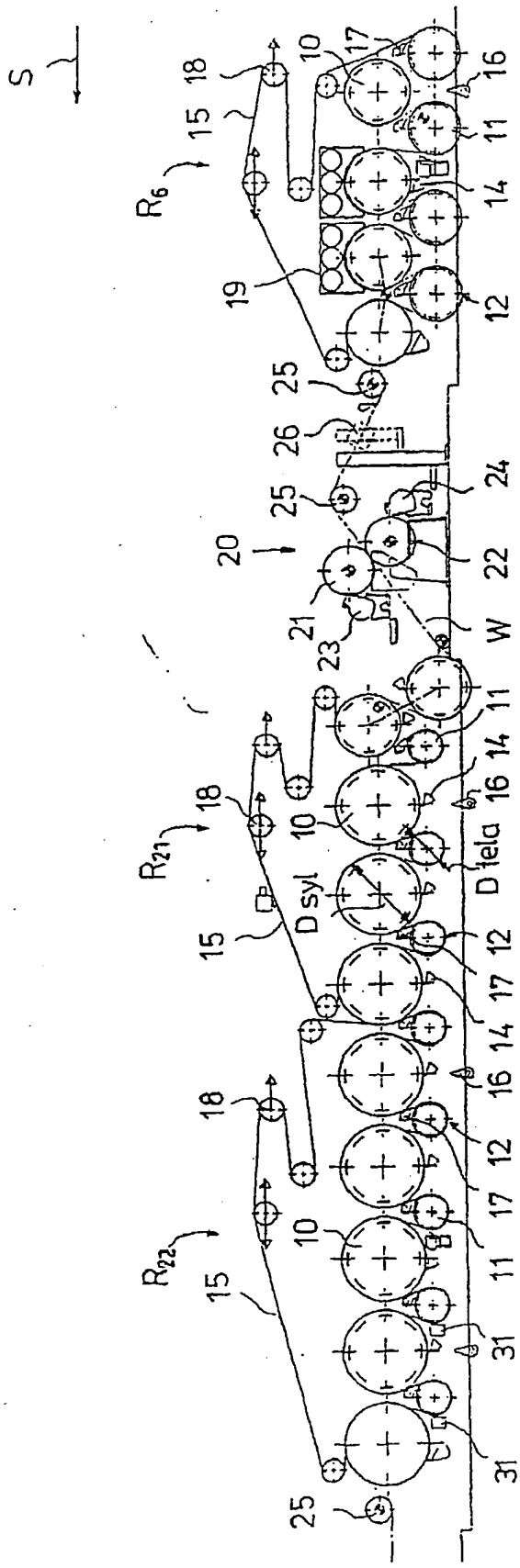

FIG. 5

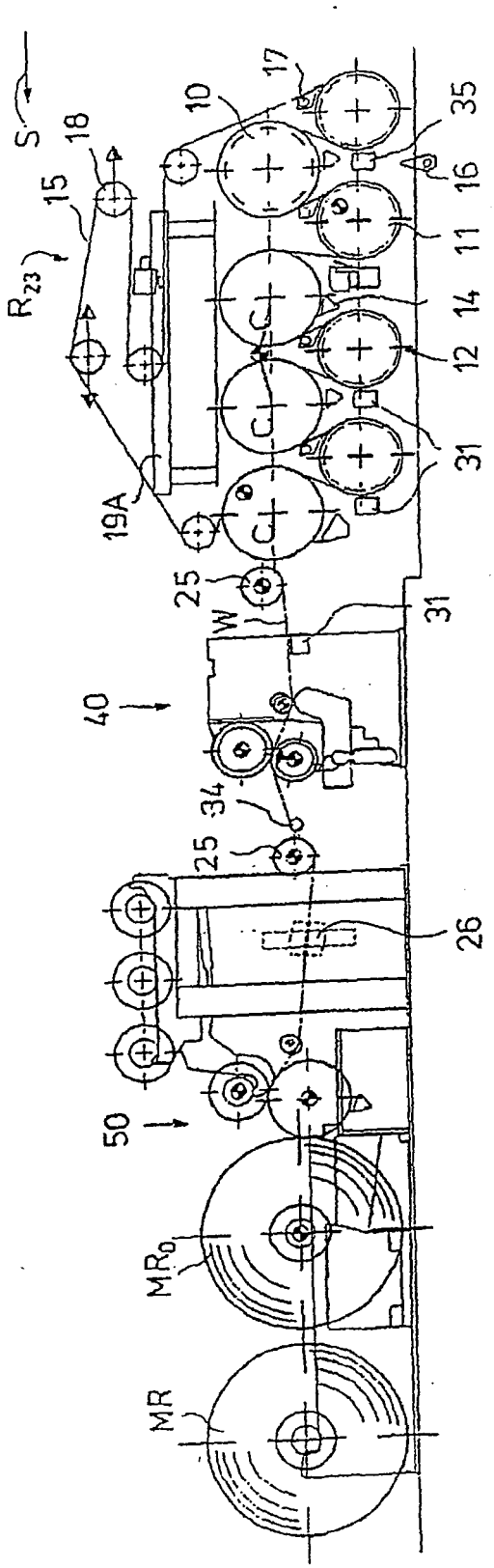
S
R23
15
18
10
17
35
16
11
14
12
31
19A
25
W
40
34
26
50
MRo
MR

FIG. 6A

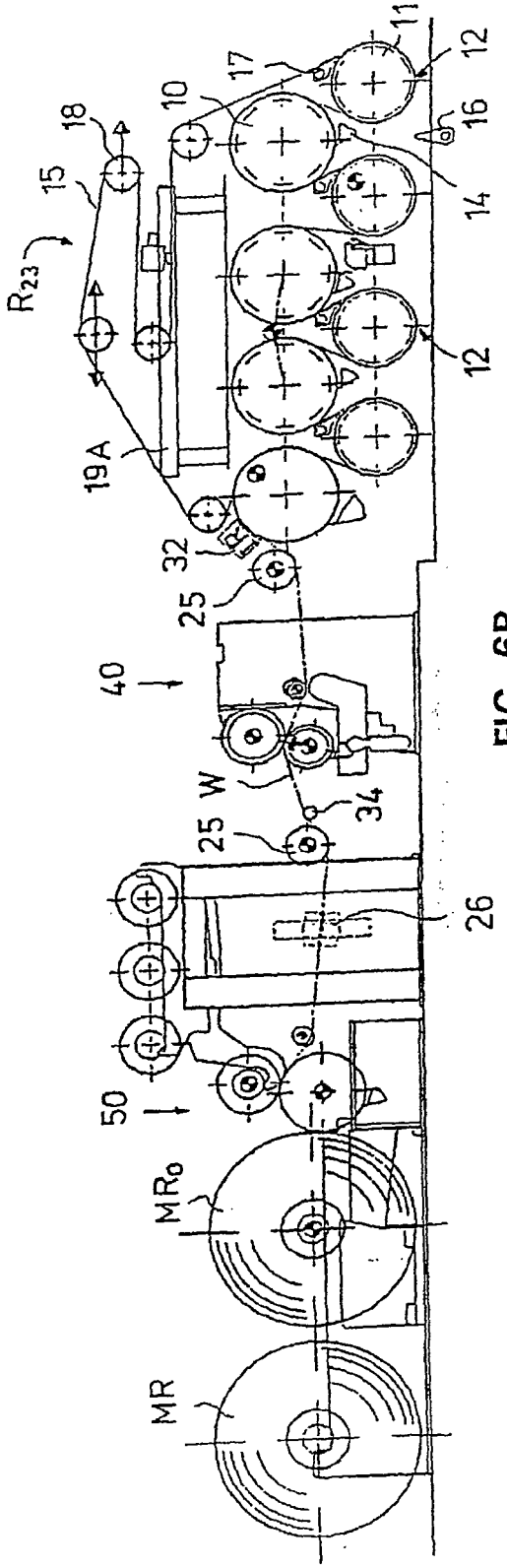
S
R23
15
18
10
17
11
12
16
14
12
19A
32
25
40
W
34
26
50
MRo
MR

FIG. 6B

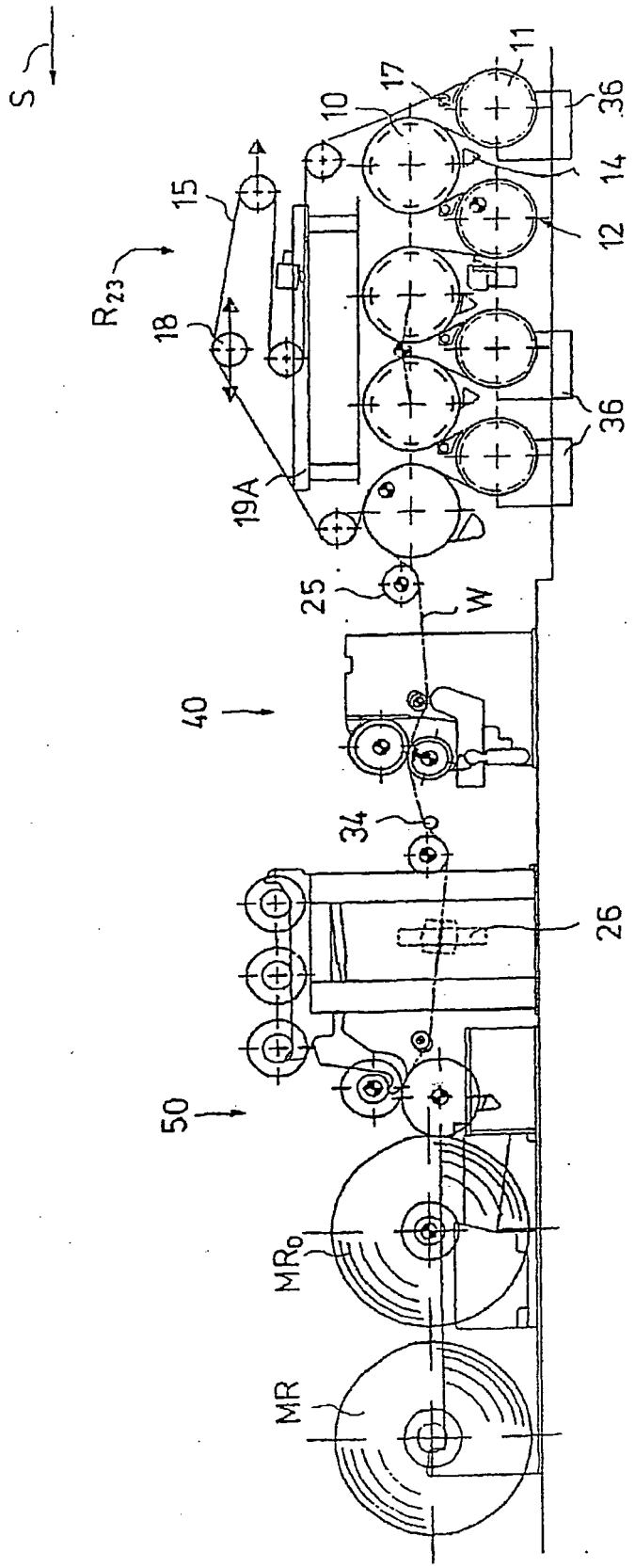

FIG. 6C

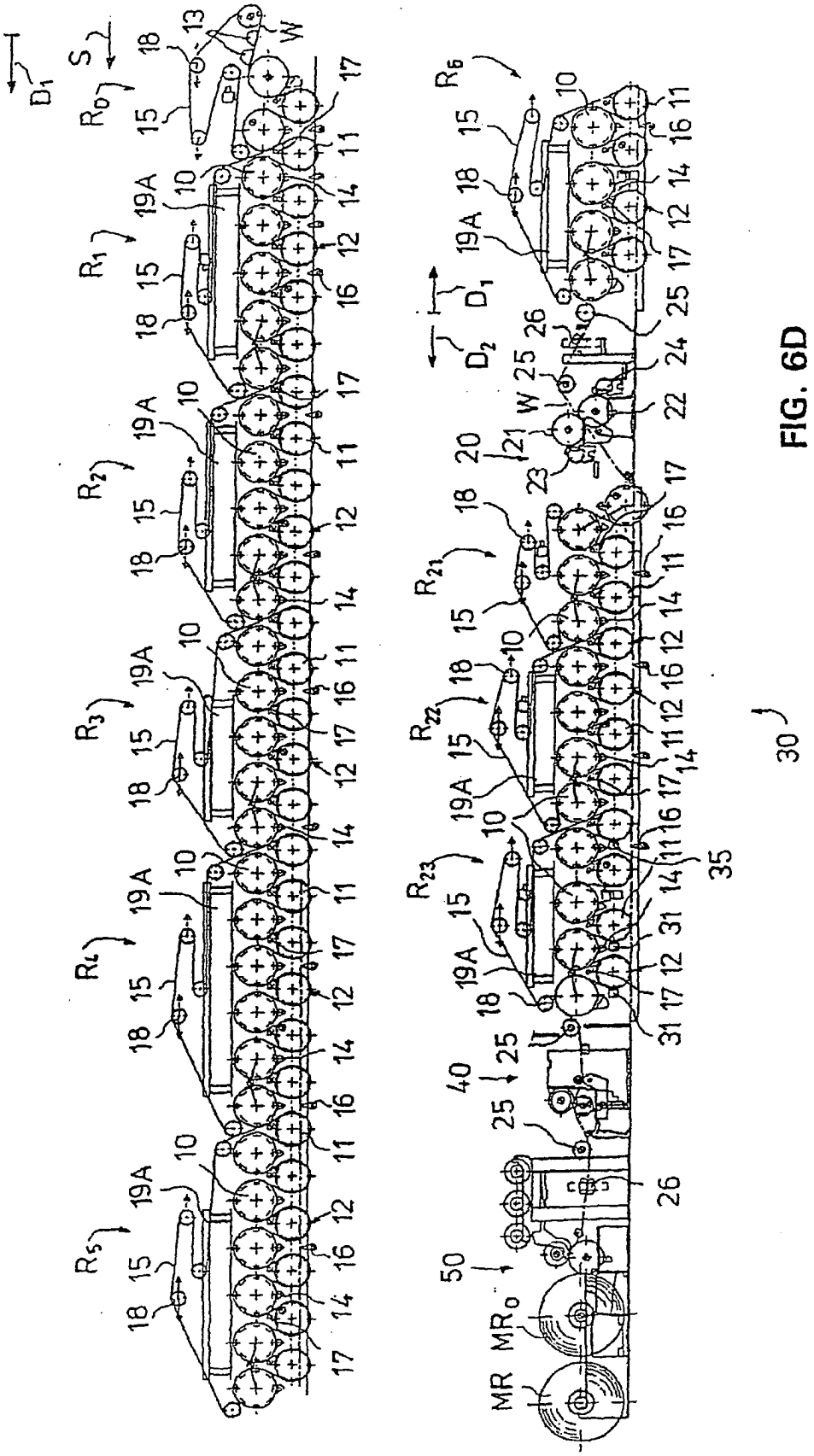

FIG. 6D

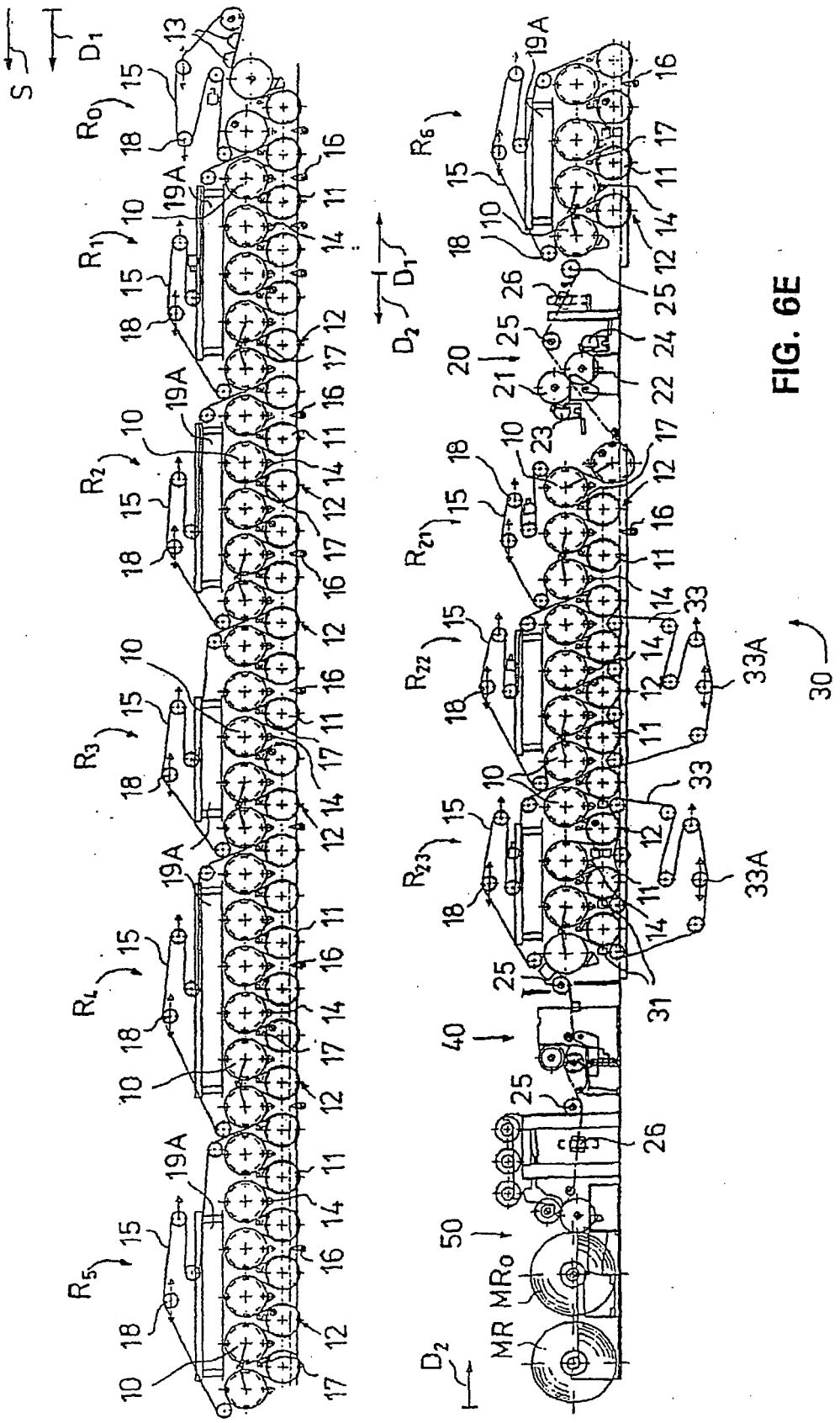
S
D1
D2
R0
R1
R2
R3
R4
R5
R6
R21
R22
R23
MR
MR0
10
11
12
13
14
15
16
17
18
19A
20
21
22
23
24
25
26
30
31
33
33A
40
50

FIG. 6E

REFERENCES CITED IN THE DESCRIPTION

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