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(54) **METHOD FOR OPTIMIZING EVAPORATION DRYING OF PAPER, RUNNABILITY, AND PAPER QUALITY AS WELL AS DRYER SECTION THAT MAKES USE OF THE METHOD IN A PAPER MACHINE**

VERFAHREN ZUR OPTIMIERUNG VON VERDAMPFUNGSTROCKNUNG VON PAPIER, GESCHWINDIGKEIT, UND PAPIERQUALITÄT SOWIE EINE TROCKENPARTIE EINER PAPIERMASCHINE ZUR DURCHFÜHRUNG DES VERFAHRENS

PROCEDE PERMETTANT D'OPTIMISER LE SECHAGE PAR EVAPORATION DU PAPIER, SON APTITUDE AU PASSAGE SUR MACHINE ET SA QUALITE, ET SECTION DE SECHAGE D'UNE MACHINE A PAPIER UTILISANT CE PROCEDE

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(73) Proprietor: **Metso Paper, Inc.**
00130 Helsinki (FI)

(72) Inventors:
• **LIPPONEN, Juha**
FIN-40270 Palokka (FI)

- **SALMINEN, Martti**
FIN-40200 Jyväskylä (FI)
- **KAIHOVIRTA, Juha**
FIN-40700 Jyväskylä (FI)
- **KERTTULA, Reima**
FIN-40950 Muurame (FI)

(74) Representative: **TBK-Patent**
Bavariaring 4-6
80336 München (DE)

(56) References cited:
WO-A-89/04890 **WO-A-97/13031**
US-A- 4 882 855

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Description

[0001] The invention concerns a method for evaporation drying of the paper web that comes from the press section of a paper machine from a dry solids content of $k_0 \approx 35...55\%$ to a dry solids content of $k_1 = 90...98\%$.

[0002] Also, the invention concerns a dryer section of a paper machine for carrying out the method.

[0003] 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, in twin-wire draw, the web has free and unsupported draws, which are susceptible of fluttering, which may cause web breaks, in particular so in the stages of the drying in which the web is still relatively moist and, therefore, of low strength. This is 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. From the prior art, dryer sections are known that comprise so-called normal groups with single-wire draw only, in which the drying cylinders are placed in the upper row and the reversing cylinders or rolls are in the lower row.

[0004] The highest web speeds in paper machines are to-day up to an order of 25 metres per second and slightly higher, but before long the speed range of 25...40 metres per second will be taken to common use. In such a case, a bottleneck for the runnability of a paper machine will be the dryer section, whose length with the prior-art multi-cylinder dryers would also become intolerably long. If it is imagined that a present-day multi-cylinder dryer were used in a newsprint machine at a web speed of 40 mps, it would include about 70 drying cylinders ($\phi \approx 1800$ mm), and its length in the machine direction would be ~ 180 metres. In such a case, the dryer section would comprise about 15 separate wire groups and a corresponding number of draws over group gaps. It is probable that, in a speed range of 30...40 mps, the runnability of normal prior-art multi-cylinder dryers is no longer even nearly satisfactory, but web breaks would occur abundantly, lowering the efficiency of the paper machine.

[0005] In a speed range of 30...40 mps and at higher speeds, the prior-art multi-cylinder dryers would also become uneconomical, because the cost of investment of an excessively long paper machine hall would become unreasonably high. It can be estimated that the cost of a paper machine hall is at present typically about 1 million

FIM per metre in the machine direction.

[0006] It is known from the prior art to use various impingement-drying/through-drying units for evaporation drying of a paper web, which units have been employed in particular in the drying of tissue paper. With respect to this prior art, reference is made, by way of example, to the following patent literature: *US-A-3,301,746*, *US-A-3,418,723*, *US-A-3,447,247*, *US-A-3,541,697*, *US-A-3,956,832*, *US-A-4,033,048*, *CA-A-2,061,976*, *DE-A-2,212,209*, *DE-A-2,364,346*, *EP-A2-0,427,218*, *FI-B-57,457* (equivalent to *SE-C-7503134-4*), *FI-B-87,669*, and *FI-A-931263* (equivalent to *EP-0.620,313-A1*).

[0007] *US-A-4882855* discloses a multi-cylinder dryer section which is divided into an initial part for heating up the web and into a second part in which the region of the maximum evaporation rate of the moisture contained in the web is reached at each drying cylinder. In the initial part all drying cylinders have the same diameter. The drying cylinders of the second part are divided into two groups, the drying cylinders of the first group having a relatively large diameter and the drying cylinders of the last group having a relatively small diameter.

[0008] *WO-A-97/13031* discloses a dryer section which comprises after the press section of the paper machine an impingement drying unit in which the paper web runs along a linear path, the impingement drying unit being followed by several single-wire groups in which contact drying is effected.

[0009] One object of the invention is, in connection with increasing of paper machine speeds and with modernizations, to permit fitting of a new dryer section in the place of an existing multi-cylinder dryer. In relation to this, it is a further object of the invention to provide a dryer section concept that permits ever shorter dryer sections compared with the prior-art dryer sections.

[0010] It is a further object of the invention to make it possible to provide a dryer section concept in which different evaporation devices and techniques can be applied optimally in the different stages of drying so that a short construction of the dryer section, a good quality of the paper and a runnability sufficiently free from disturbance are achieved.

[0011] The main object of the invention is to provide a novel drying module for a paper web and dryer sections that make use of said module/modules, which are suitable for use at high web speeds of $v > 25$ metres per second, which speeds can be up to an order of $v \approx 30...40$ metres per second or even higher.

[0012] It is a further object of the present invention to increase the drying capacity by means of impingement drying and/or through-drying and in this way to make the length of the dryer section shorter, which contributes to an improvement of the runnability of the dryer section.

[0013] It is a further object of the invention to provide such a drying method and drying equipment by whose means, in said high speed range, the length of the dryer section in the machine direction can, nevertheless, be-

come reasonable so that its length does not, at least not substantially, exceed the length of the cylinder dryers currently in operation. An achievement of this objective would permit renewals and modernizations of paper machines in existing paper machine halls up to, and even beyond, a web speed of $v \approx 40$ metres per second.

[0014] It is a further object of the invention to provide a drying method and a dryer section that applies said method wherein the web is reliably affixed to the drying wire over the entire length of the dryer section so that cross-direction shrinkage of the web can be substantially prevented.

[0015] It is a further object of the invention to provide a drying method and a dryer section that applies said method wherein the web is prevented from sticking to the cylinders in the initial end of the dryer section and to improve both the paper quality and the runnability of the paper machine.

[0016] With respect to the prior art most closely related to the present invention, reference is made to the applicant's *FI Patent 93, 876 (equivalent to US-pat. 5,553,393)* in which a dryer section of a paper machine is described which is composed of cylinder groups with single-wire draw and in which dryer section it is considered novel that, in view of optimizing the drying capacity calculated per unit of length of the dryer section in the machine direction, as the drying makes progress, different ratios $k = D/d$ of the drying-cylinder diameter D to the reversing-roll diameter d are employed, so that, in the first group or groups in the initial end of the dryer section, said ratio $k = k_1$ is higher than the ratio $k = k_2$ in the groups in the middle area of the dryer section, $k_1 > k_2$, and that in the group or groups in the final end of the dryer section, a diameter ratio k_3 is used that is higher than said ratio k_2 , $k_3 > k_2$. In said FI patent an effort has been made to choose the diameter ratio D/d of drying cylinder to reversing roll optimally taking into account the different evaporation curves that are carried into effect in different areas of the dryer section. In said FI patent, in the initial end of the dryer section, preferably in one group, said diameter ratio D/d that is used is higher than average, compared with the middle area of the dryer section, for example in the second, third and fourth wire groups. The last mentioned wire groups are in the area where the main evaporation of water takes place from the web. Said higher diameter ratio D/d is also employed in the final end of the dryer section, in which a significant proportion of the evaporation takes place on the curve sectors of the wire and the web on the drying cylinders.

[0017] In said FI patent, owing to the optionally chosen and varied diameter ratio $k = D/d$ of drying cylinder to reversing roll, the length of the drying section is estimated to be shortened, at the maximum, by about 10 per cent in comparison with a situation in which said ratio k is used as invariable over the entire length of the dryer section. It has been understood in said FI patent that, as the drying proceeds, the nature of the drying process will change substantially. However, only the diameter ratio of the dry-

ing cylinder to the reversing roll, $k = D/d$, has been varied in order to optimize the drying, which does, however, not take it far enough from the point of view of optimizing the drying process and the drying configuration, especially since the speeds of paper machines become ever higher and the quality requirements imposed on the paper become ever stricter.

[0018] An object of the present invention is further development of the evaporation drying and the dryer sections in paper machines so that the drying process in different parts of the dryer section, in different phases of the drying process, and the dryer section configuration can be optimized and the length of the dryer section shortened or kept unchanged while the speeds become higher.

[0019] It is a further object of the invention to optimize the runnability of the paper machine in different phases of the drying procedure so that the efficiency of the paper machine is improved while breaks are fewer. It is a further object of the invention to take advantage of the different structures/methods/processes in the different phases of the paper drying process so that the quality properties of the paper can be optimized.

[0020] The nature of the drying procedure has been clarified further in the applicant's recent research and in dryer sections that are in operation and in test runs on a test device. The invention is partly based on the observation that in the dryer section of a paper machine the drying process can be divided into three process stages that are different from each other:

(I) heating stage, in which evaporation does not take place to a substantial extent, but the water present in the web is mainly heated,

(II) main evaporation area, in which the rate of evaporation remains substantially invariable when cylinder drying alone is used and in which the main evaporation of water from between the fibres and from their surface takes place, and

(III) final evaporation area, in which the rate of evaporation becomes lower and the proportion of the evaporation that takes place on the drying cylinders is increased, and in this stage mainly evaporation of water present inside the fibres takes place.

[0021] It has also been a problem in the prior-art multi-cylinder dryers that in said first stage (I) it has not been possible to use a temperature high enough in view of optimizing the drying, because, when the paper web is in direct contact with the hot faces of the drying cylinders, at temperatures higher than a certain figure, sticking of the web to the hot surface of the cylinder occurs, from which web breaks and standstills follow. It has been noticed that excessively hot contact drying cylinders also have detrimental effects on the quality properties of the paper.

[0022] An object of the present invention is further development of said prior art, elimination of drawbacks of

the prior art that were mentioned above and of those that will come out later, and implementation of other objectives of the invention.

[0023] In view of achieving the above objectives, the method of the invention comprises the features defined in claims 1.

[0024] On the other hand, the dryer section in accordance with the invention comprises the features defined in claim 8.

[0025] In the first stage I in the method in accordance with the invention, such a construction of the dryer section is used as also has optimal runnability properties so that in this stage, when the web is still moist and relatively weak, web breaks can be minimized. The final stage III of the method of the invention is carried out with such solutions of equipment as also permit control of quality properties of paper, such as brightness, curl, etc.

[0026] With the method in accordance with the present invention and with a dryer section concept that carries out the method it is possible to achieve the objectives mentioned above and to eliminate said drawbacks substantially. In accordance with the invention it is possible to provide a dryer section that is shorter and more compact than in the prior art also at high machine speeds so that the operating quality of the dryer section still remains good.

[0027] In the method and the dryer section in accordance with the invention the web is preferably dried so that in the first stage I the drying energy is at least mainly applied from the side of and through the upper surface of the web, in the second stage II the drying energy is applied to the web from the side of and through its lower surface, and in the third stage III the drying energy is applied to the web from and through its both surfaces.

[0028] In the following, the invention will be described in detail with reference to some exemplifying embodiments of the invention illustrated in the figures in the accompanying drawings, the invention being by no means strictly confined to the details of said embodiments.

[0029] Figure 1A is a schematic side view of a dryer section in accordance with the invention in which the method in accordance with the invention can be applied favourably.

[0030] Figure 1B shows a preferred contact-drying/impingement-drying unit used in a dryer section in accordance with the invention, of which units there are three in the dryer section shown in Fig. 1, separated from one another by single-wire groups.

[0031] Figure 1C shows the last wire group of the dryer section in a scale larger than Fig. 1A, in which group the stage III of the method in accordance with the invention is carried out.

[0032] Figure 2 is a graphic illustration of the different stages of the method in accordance with the invention in a system of coordinates of dry solids content of the web.-length of the dryer section in the machine direction, compared with a prior-art multi cylinder dryer.

[0033] Figure 3 is a graphic illustration similar to Fig.2

of the drying method in accordance with the invention and of a prior-art drying method in a system of coordinates of evaporation capacity - length of the dryer section in the machine direction.

[0034] Figure 4 is an illustration similar to Figs. 2 and 3 of the distribution of paper web temperature in the machine direction of the dryer section.

[0035] Figure 5 illustrates the evaporation capacity of stage III in accordance with the invention as a function of the dry solids content percentage of the web in the method in accordance with the invention and in a prior-art dryer section.

[0036] Figure 1A shows a particularly favourable overall concept of a dryer section in accordance with the invention. As is shown in Fig. 1A, the paper web W is passed from the press section 10 of the paper machine at a dry solids content of $k_0 \approx 35...55\%$ and at a temperature of $T_0 = 30...60^\circ\text{C}$ on the bottom face of the transfer fabric 11 and supported by a *PressRun*TM box 11a onto the top face of the drying wire 12 over its guide roll 13. The first planar drying unit R_1 comprises a blow hood 15, under which the web W to be dried runs on the horizontal run of the wire 12, which is supported by the rolls 14. Said horizontal run of the wire 12 forms a plane consisting of grooved rolls and/or of suction boxes or blow boxes to support the web W. In the unit R_1 , an intensive drying energy impulse is applied to the web W, in which connection, after the unit R_1 , the temperature of the web W is $T_1 \approx 60...85^\circ\text{C}$. In the unit R_1 , primarily heating of the web W and of the water contained in it takes place, but no substantial evaporation of water as yet. The length L_1 of the unit R_1 in the machine direction is typically of an order of $L_1 \approx 3...10\text{ m}$.

[0037] In the unit R_1 , the paper web runs on support of the upper run of the drying wire 12 along a linear path in the horizontal plane so that it has no major changes in the direction and that, thus, no high dynamic forces are applied to it which might produce a web break in the web, which is still relatively moist and, thus, of low strength. In the interior of the blow hood 15, there is a nozzle arrangement, by whose means hot drying gases, such as air or steam, are blown against the top face of the web. Additionally or alternatively, it is possible to employ infrared heaters. Said blow devices and/or radiators in the unit R_1 can be arranged so that their output in the cross direction of the web W is adjustable so as to provide profiling of the web W in the cross direction.

[0038] In Fig. 1A, the unit R_1 is followed by the first so-called normal (not inverted) single-wire unit R_2 , onto whose drying wire 22 the web W is transferred as a closed draw in the area of the first reversing suction roll 21. The single-wire unit R_2 , and so also the subsequent single-wire units R_4 , R_6 and R_8 that are open towards the bottom comprise steam-heated contact-drying cylinders 20 fitted in the upper row and reversing suction rolls 21 fitted in the lower row, for example the applicant's said *VAC-rolls*TM. Below the cylinders 20, there are doctors and ventilation blow devices 25. The paper web W to be

dried enters into direct contact with the faces of the steam-heated drying cylinders 20, and on the reversing suction rolls 21 the web W remains on the drying wire 22 at the side of the outside curve.

[0039] In Fig. 1A, after the group R_2 with single-wire draw, there follows a drying unit R_3 in accordance with the invention, which, in accordance with Fig. 1B, comprises two contact-drying cylinders 30 and a large-diameter D_1 impingement-drying/through-drying cylinder 31 with a perforated mantle, which cylinder will be called a large cylinder in the following. Around the contact-drying cylinders 30 and around the large cylinder 31, a drying wire 32 is fitted to run, which wire is guided by the guide rolls 33. The impingement-drying/through-drying hood module M_1 of the drying unit R_3 is fitted in the basement space KT underneath the floor level K_1-K_1 of the paper machine hall on support of the floor level K_2-K_2 of said space. The central axes of the contact-drying cylinders 30 in the unit R_3 and in the corresponding following drying units R_5 and R_7 in accordance with the present invention are placed substantially in the floor plane of the paper machine hall or in the vicinity of said plane K_1-K_1 , preferably slightly above said plane. The paper web W to be dried is passed from the single-wire unit R_2 as a closed draw onto the first drying cylinder 30 in the drying unit R_3 (R_n), after which the web W is passed on the wire 32 of the unit R_3 over the large cylinder 31 of the first module M_1 on a remarkably large sector $b \approx 220 \dots 280^\circ$ on support of the drying wire 32 and further onto the second drying cylinder 30 in the unit R_3 (R_n). From this drying cylinder 30 the web W is transferred as a closed draw into the next normal unit R_4 with single-wire draw, which unit is substantially similar to the unit R_2 described above. After this, there follows the second drying unit R_5 (R_n), which unit is similar to the drying unit R_3 described above and whose large cylinder 31 is also placed in the basement space KT. After the drying unit R_5 the web W is passed as a closed draw into the next single-wire unit R_6 , which is followed by the third drying unit R_7 (R_n), whose large cylinder 31 is likewise placed in the basement space KT. The unit R_7 is followed by a particular single-wire unit R_8 , from which the web W_{out} is passed to the reel-up or into a finishing unit (not shown). The construction and operation of the particular unit R_8 will be described in more detail later with reference to Fig. 1C.

[0040] In the basement space, besides the modules M_1 , M_2 and M_3 , Fig. 1A also shows the pulpers 40a and 40b, between which there is the broke conveyor 41, which carries the paper broke into the pulper 40a and/or 40b. In the event of a web break, the web W can be passed after the unit R_1 directly into the pulper 40a placed underneath. The single-wire units R_4 , R_6 , and R_8 are open towards the bottom, and therefore the paper broke falls from them by the effect of gravity onto the broke conveyor 41 placed underneath or directly into the pulpers 40a, 40b. Also the modules M_1 , M_2 and M_3 are open or openable towards the bottom so that the paper broke falls out of connection with them, substantially by the ef-

fect of gravity, without major manual operations, onto the broke conveyor 41 placed underneath.

[0041] Underneath the modules M_1 , M_2 and M_3 , above the floor level K_2-K_2 of the basement space KT, there is still space KT_0 for various devices, such as ducts through which the heating medium, such as heated air or steam, is passed into the interior of the hoods 35 of the modules M_1 , M_2 and M_3 . Said lower space KT_0 is defined from below by the floor level K_2-K_2 of the basement space and from above by the partition wall 42 placed below the broke conveyor 41. On the drying units $R_2 \dots R_8$ there is an air-conditioned hood 50 in itself known.

[0042] Figure 1B is a more detailed illustration of the impingement-drying/through-drying hood module M in accordance with the invention. As is shown in Fig. 1B, the wire 32a which runs around the large cylinder 31 is first passed around the last lower cylinder 21a in the preceding group R_{n-1} with single-wire draw onto the first contact-drying cylinder 30 in the unit R_n , from it further as a short straight run over the sector $b = 220 \dots 280^\circ$ of the large cylinder 31 onto the second contact-drying cylinder 30 in the group R_n and over said cylinder on a sector of about 90° . After this the web W follows the face of the cylinder 10 and is transferred as a closed draw onto the drying wire 22 of the next group R_{n+1} . The hood of the large cylinder 31, which consists of two parts 35, covers the cylinder substantially over the entire curve sector b of the wire 32a and the web W. On the sector b the web W remains on the wire 32a at the side of the outside curve, so that its outer face is free. The large cylinder 31 is mounted on its axle journals 36, through which a communication is arranged with vacuum devices (not shown), by whose intermediate a suitable vacuum is produced in the interior of the cylinder 31, which vacuum is of an order of $p_0 \approx 1 \dots 3$ kPa. This vacuum p_0 keeps the web W on the wire 32a when the web W is at the side of the outside curve, and, at the same time, the vacuum p_0 also promotes possible through-drying taking place through the web W and the wire 32a. The sector $360^\circ - b$ that remains outside the sector b on the large cylinder 31 is covered by a cover plate 34 placed in the gap between the drying cylinders 30, and so also the last cylinder 21a in the group R_n , which can also be called the reversing cylinder of the group R_n , is covered by an obstacle plate 29. As to its more detailed embodiment, the perforated and grooved outer mantle 31a of the large cylinder 31 is, for example, similar to that described in said *FI Pat. Appl. 931263* and illustrated above all in Fig. 11 of said patent application, so that the construction will not be described again in this connection.

[0043] In accordance with figure 1B, the large cylinder 31 is mounted by means of its axle journals 36 on support of the frame construction 37. In this frame construction, both at the driving side and at the tending side, there are horizontal and machine direction beams 37a, on whose top face, or on rails provided on said top face, the hood halves 35 are arranged to be movable on wheels 39, which hood halves are illustrated in the open position

35a, in which the module M can be serviced. The hood halves 35 are displaced into the open and closed positions by actuating cylinders 38. The module M and its hood 35 are open towards the bottom, so that broke can be removed in the direction of the arrows WA substantially by the effect of gravity onto the broke conveyor 41 placed underneath without substantial manual operations. The top face of the hood 35 has been shaped as smoothly downwards inclined so as to improve the removal of broke.

[0044] Further, in the open position 35a of the hood 35, the module M can also be serviced and cleaned easily in other respects. The diameter D_1 of the large cylinder 31 is, as a rule, chosen in the range of $D_1 > 2$ m, as a rule in the range of $D_1 \approx 2...8$ m, preferably $D_1 \approx 2...4$ m. The diameter D_2 of the drying cylinders 30 in the group R_n is, as a rule, chosen in the range of $D_2 \approx 1.5...2.5$ m, preferably in the range of $D_2 \approx 1.8...2.2$ m. In the groups R_{n-1} and R_{n+1} with single-wire draw, the diameter of the drying cylinders 20 is preferably $= D_2$. The diameter D_3 of the reversing suction cylinders 21,21a is, as a rule, chosen in the range of $D_3 \approx 0.6...1.8$ m, preferably $D_3 \approx 1.0...1.5$ m. The top face of the hood 35 has been shaped as smoothly downwards inclined to improve the removal of broke.

[0045] The wire 32a guide roll 33a placed above the latter drying cylinder 30 can be stationary or displaceable. Between the groups R_{n-1} , R_n and R_{n+1} a little difference in speed can be employed, which is, typically, about 0.1...0.2 %, so that, on the wires 22,32a,22, the speed becomes higher when the web W moves forwards. In the final end of the dryer section, the difference in speed can also be reversed.

[0046] The more detailed construction of the hood 35 of the module M and the circulation arrangements of the drying gases that are blown through it are described in detail in the *FI Patent Application No. (971713)* to be filed on the same day with the present application by the applicant, especially in its Fig. 3 and the related specification part, to which reference is made in this connection.

[0047] Fig. 1C shows, in a larger scale than Fig. 1A, the last group R_8 with single-wire draw in the dryer section in accordance with the invention, in which group the third stage of the invention is carried out. The paper web W to be dried is brought into the group R_8 from the last contact-drying cylinder 30 of the module M_3 shown in Fig. 1A as a closed draw onto the first reversing suction roll 61 of the group R_g . There are five of these reversing suction cylinders inside the wire loop 62 in the group R_8 . The group R_8 includes five contact drying cylinders 60,60A. Two middle ones 60A of these cylinders are contact drying cylinders whose diameter, which is larger than that of the other cylinders 60, is $D_4 = 1.8...2.5$ m, whereas the diameter of the smaller cylinders 60 is $D_5 \approx 1.0...1.8$ m, and the diameter of the reversing suction cylinders 61 is $D_6 \approx 1.0...1.5$ m. Between the reversing suction cylinders 61 there are blowing devices 65 to ventilate the spaces between the cylinders 60,60A and 61 and to pro-

mote the drying. There is a blow box 64 above the upper sectors of the reversing suction cylinders 61 free from the web W and from the wire 62, which promotes maintenance of the vacuum inside cylinders 61.

[0048] In order that it should be possible to carry out the stage III of the method in accordance with the invention and to achieve a sufficiently high evaporation capacity and an increase in the web W temperature T_w in accordance with the curve T_I of Fig. 4 by means of the group R_8 shown in Fig. 1C, a drying effect is applied to the web W by means of contact drying cylinders 60A with large diameter also from the top face of the web W, i.e. from the drying wire 62. For this purpose ventilation hoods 66 are provided above the cylinders 60A, into which hoods sufficiently hot and dry drying air gases are passed through the intake pipe 67. Out of the pressurized interior of the ventilation hoods 66, the humidified ventilation air is discharged into the hood 50 around the dryer section, from where it is removed in a way known from the prior art. These drying gases are blown against the drying wire 62 in the sector d of the cylinders 60A, said sector being preferably $d \approx 180^\circ$ or even larger. Thus, evaporation of water is promoted through the upper face of the web W through the wire 62. The ventilation hoods 66 are shown in their open position 66a, as well as their air intake pipes are shown in their open position 67a. In this position 66a it is possible to clean and service the ventilation hoods, and the web W threading is also carried out most favourably then. In respect of their construction the ventilation hoods 66 can be similar to those that are described in more detail in the *FI Patent Application (971713)* to be filed on the same day with the present application.

[0049] In respect of the various details of the construction and the operation of the ventilation hoods 66, reference is made to the prior art coming out from the applicant's *FI Patent Application 951746* and from the *FI Patent 83, 679 of Teollisuusmittaus Oy*.

[0050] Fig. 2 shows the development of the dry solids content KA of the paper over the length L of the dryer section in the machine direction as a function. The curve K represents an optimized method in accordance with the invention, and the curve K_{PA} represents the development of the dry solids content with a method and a dryer section of prior art. The curves K and K_{PA} have been obtained by means of computer simulation using the applicant's dryer section process model. The basis for the curve K_{PA} is the applicant's prior-art *SymRun™* dryer section concept, which consists of N pcs. of successive groups with single-wire draw that are open towards the bottom, and the curve K is based on a dryer section concept in accordance with Fig. 1.

[0051] It can be noticed immediately from Fig. 2 that it has been possible to shorten the length of the dryer section from the length L_{PA} to the length L_I , i.e. in practice by about 15...40 percent. In accordance with Figs. 1...4 the method in accordance with the invention is divided into three different stages I, II and III. As is seen in Fig. 2, in the first stage I the rate of increase in dry solids

content K_A of the web W becomes higher from the initial value K_0 more steeply in accordance with the curve K , in comparison with the curve K_{PA} , because the initial temperature of the web W is higher, which becomes clear from a comparison of the temperature curves T_I and T_{PA} of the stage I in the figure. Also, in the first stage I, as is shown in Fig. 3, the evaporation efficiency PE is, in accordance with the curve PE_I , substantially higher than in the prior-art method, curve PE_{PA} of stage I (Fig. 3). In the invention the first phase I is carried out on a horizontal dryer unit R_1 where the web W temperature T_W is raised to about 55...85°C, preferably to about 70°C, as comes out from Fig. 4. In the invention this raising of the temperature can be carried out very quickly, because in the unit R_1 a highly energy-intensive impingement stage and/or infra radiation can be used, because heating of the web W takes place free of contact so that there is no risk of sticking.

[0052] Stage II, shown in Figs. 1...4, is the main evaporation area where, in accordance with Fig. 2, the dry solids content K_A of the web increases more steeply than in stage I as the drying proceeds. Fig. 3 shows the three successive evaporation peaks PE_1 , PE_2 and PE_3 of stage II, at which the maximal evaporation efficiency PE is of an order of $PE \approx 60 \text{ kg/m}^2/\text{h}$ (kilograms per square meter in an hour). These evaporation peaks are achieved by the hood modules M_1 , M_2 and M_3 in the dryer section shown in Fig. 1. Depending on the mode of operation of the modules M_1 , M_2 and M_3 or equivalent, the maximal evaporation efficiency can be even higher. Between said peaks PE_1 , PE_2 and PE_3 , the evaporation efficiency PE is of an order 20 $\text{kg/m}^2/\text{h}$, i.e. of the same order of magnitude as the evaporation efficiency in accordance with the curve PE_{PA} in Fig. 3 on the average.

[0053] In the exemplifying embodiment of Fig. 4, the web temperature T_W stays substantially invariable in the stage II in accordance with the curves T_I and T_{PA} in a range of about 60...70°C. As was stated, the stage II is the main evaporation area where the water is evaporated from between the fibres in the web W and from the fibre surfaces.

[0054] In the third stage III in accordance with the invention, the steepness of the increase in the dry solids content decreases in comparison with stage II. The evaporation efficiency also decreases in accordance with Fig. 3, whereas the web W temperature T_W starts rising from about 70°C to 100...110°C. In the corresponding location in the dryer section in the machine direction, in prior-art methods, the evaporation efficiency still remains invariable, in accordance with the curve PE_{PA} in Fig. 3, and so also the temperature in accordance with the curve T_{PA} in Fig. 4. In the dryer section in accordance with the invention, the stage III is carried out in the last cylinder group R_8 , where the evaporation is made more intensive by means of the hoods 66 that are placed above the cylinders 60 A with large diameter, in which hoods sufficiently powerful and hot drying gases are applied to the web W placed under the drying wire 62 and to the envi-

ronment of the wire 62, so that the web W temperature T_W can be raised very steeply in the stage III, in accordance with Fig. 4, in which connection also the water present inside the fibres in the paper web W can be efficiently evaporated on a sufficiently short length L of the dryer section in the machine direction. Fig. 5 illustrates the evaporation efficiency PE in the stage III of the invention, i.e. the dry solids content K_A in the area K_A 80...98 %. The curve PR_I represents the method in accordance with the invention, and the curve PE_{PA} a corresponding curve carried out by means of the prior-art *SymRun™* concept. Fig. 5 shows that in the beginning of the stage III, in accordance with the curve PE_I , in the dry solids content area 80...82 the evaporation efficiency is substantially higher than in the prior-art concept and somewhat higher than in the dry solids content area 84...91 and in the dry solids content area 93...98. This improvement has mainly been carried out in the particular group R_8 by means of the drying cylinders 60A with large diameter and by means of the blowings from their ventilation hoods 66. Thus, in the drying method and in the dryer section in accordance with the invention, the ultimate dry solids content of the web W , $k_1 \approx 96...98 \%$, is achieved in the machine direction length L_I of the dryer section, whereas in the prior art a substantially longer length L_{PA} was needed.

[0055] As comes out from the above and especially from Fig. 1A, the method stage I in accordance with the invention is carried out by applying drying energy mainly through the upper face of the web W . As is shown in Fig. 1, in the second stage II of the method, drying energy is applied to the web mainly through the lower face of the web only by means of the wire groups R_3 , R_4 , R_5 , R_6 , R_7 and R_8 and by means of the hood modules M_1 , M_2 and M_3 , whereas in the group R_8 (Fig. 1C) and in the stage III drying energy is applied to the web W through its both faces by applying drying energy through the lower face of the web W by means of the contact drying cylinders 60 and 60A and through the upper face of the web by means of the ventilation hoods 66 on the sectors d of the cylinders. This arrangement provides a short dryer section in which, at the same time, it is possible to control the paper quality, for example its curl.

[0056] In this context it should be emphasized that the method in accordance with the invention can also be carried out with many other dryer section concepts and solutions of equipment besides those of Figs. 1A and 1B. Examples of these other dryer section concepts are some dryer section concepts described in the applicant's *FI Patent Applications Nos. (971713 and 971715)* to be filed on the same day with the present application. It is an essential feature of the dryer section in accordance with the invention that in said different drying stages I, II and III exactly a sort of a solution of equipment is used in which it is possible to carry out heating of the web and evaporation in accordance with the invention optimally. This inevitably has the consequence that, unlike the prior-art, in the different stages I, II and III of the invention,

solutions of equipment different from one another have to be used, which is illustrated in Fig. 1.

[0057] In the following, the patent claims will be given, and the various details of the invention can show variation within the scope of the inventive idea defined in said claims and differ from the details described above by way of example only.

Claims

1. A method for evaporation drying of the paper web that comes from the press section (10) of a paper machine from a dry solids content of $k_0 \approx 35 \dots 55\%$ to a dry solids content of $k_1 \approx 90 \dots 98\%$, wherein the method consists of three successive stages I, II and III that are carried out in the direction of progress of the web (W) in the sequence given as follows:

I in the first stage, the paper web coming from the press section (10) of the paper machine is heated in a section of the paper machine having a length of 3 ... 10 m in the machine direction to a temperature of 55 ... 85°C, preferably to a temperature of about 70°C, and in this section the web is passed along a linear path while it is supported so that web breaks of the relatively moist and, thus, weak web (W) are minimized, wherein the heating is carried out by applying, free of contact, to the paper web (W) an energy-intensive heating effect of a drying gas and/or of electromagnetic radiation,

II after the first stage (I), the drying is continued as contact drying and impingement drying, wherein in this second stage (II) the main evaporation drying of the web (W) is carried out in such a way that the evaporation efficiency (PE) and rate of increase in dry solids content (KA) per unit of length of the dryer section in the machine direction are substantially higher than in the first stage or in the final stage (III), and the web temperature (T_w) does substantially not rise in the second stage (II) while the drying proceeds,

III in the third and final stage, the drying is continued with a decreasing evaporation efficiency as contact drying and, in addition to contact drying, by evaporation drying which is carried out in a multi-cylinder dryer by during the contact drying, applying to the web (w) outside a drying wire (62), drying gas flows that increase the evaporation substantially, in which connection also the water present in the fibers in the web (W) is evaporated, wherein the drying in the third stage is continued with an average rate of increase in the dry solids content (KA) of the web (W) in the machine direction that is lower than in the preceding stage (II) so that the paper qual-

ity can be controlled at the same time.

2. A method as claimed in claim 1, **characterized in that** in said stage II, the main evaporation from between the fibres in the web (W) and from the fibre surfaces takes place so that evaporation efficiency peaks (PE_1 , PE_2 , PE_3) are applied to the web (W), at which peaks the evaporation efficiency is substantially higher than between the peaks, preferably about 2 to 4 times as high as between the peaks.
3. A method as claimed in claim 2, **characterized in that** said evaporation efficiency between said peaks is dimensioned in the range of 10 ... 30 kg/m²/h, and that said evaporation efficiencies at said peaks (PE_1 , PE_2 , PE_3) are dimensioned in the range of 50 ... 90 kg/m²/h.
4. A method as claimed in any of the claims 1 to 3, **characterized in that** in the second stage (II) the dry solids content (KA) of the web (W) is increased from about 50% to about 80%.
5. A method as claimed in claim 2 or 3, **characterized in that** the evaporation efficiency peaks (PE_1 , PE_2 , PE_3) in the second stage (II) are achieved by means of contact-drying/impingement-drying units (R_3 , R_5 , R_7) having a single looped drying wire (32), an impingement-drying/through-drying cylinder (31) that is partially covered by a hood (35) and is placed inside the drying wire loop, and contact-drying cylinders (30) that are located at both sides above said impingement-drying/through-drying cylinder (31) and are placed outside the drying wire loop, in which contact-drying/impingement-drying units energy-intensive drying gas jets are applied to the web (W) placed on the impingement-drying/through-drying cylinder (31) with the drying wire (32) being located between the web (W) and the impingement-drying/through-drying cylinder (31).
6. A method as claimed in any of the claims 1 to 5, **characterized in that** in the third stage (III) drying is mainly carried out by means of one or several contact-drying cylinders (60, 60A) so that on at least one of said contact-drying cylinders (60A), while the web (W) is pressed on the contact-drying cylinder (60A) by a drying wire (62) against the heated face of the contact-drying cylinder (60A), drying gas flows that promote the evaporation efficiency are applied to said drying wire (62) so that the water present inside the fibres in the web (W) is substantially evaporated.
7. A method as claimed in any of the claims 1 to 6, **characterized in that** the first stage (I) of the method is carried out by applying drying energy to the web (W) to be dried mainly through its upper face, that the second stage (II) of the method is carried out by

applying drying energy to the web (W) to be dried through its lower face, and that the third stage (III) is carried out by applying drying energy to the web (W) to be dried through its both faces.

8. A dryer section of a paper machine for carrying out the method as claimed in any of the claims 1 to 7, wherein after the press section (10) of the paper machine, the dryer section comprises the following dryer units that are placed in the given sequence in the machine direction:

in order to carry out the first stage (I) of the method, the first dryer unit (R_1) is a drying wire unit in which the paper web (W) runs along a linear path supported by a drying (12) past blow boxes and/or radiation dryer units, by whose means the web is heated without a direct contact with heated faces to a temperature of 55 ... 85°C, the first dryer unit (R_1) having a length of 3 ... 10 m in the machine direction,

in order to carry out the second stage (II) of the method, dryer units (R_2 ... R_7) that comprise at least one single-wire group (R_2 , R_4 , R_6) and at least one contact-drying/impingement-drying unit (R_3 , R_5 , R_7), said at least one single-wire group having a single looped drying wire (22), one upper row of heated contact-drying cylinders (20) placed outside the drying wire loop and a lower row of reversing suction cylinders (21) placed inside the drying wire loop, so that removal of broke can take place downwards by the effect of gravity, and said at least one contact-drying/impingement-drying unit having a single looped drying wire (32), an impingement-drying/through-drying cylinder (31) that is partially covered by a hood (35) and is placed inside the drying wire loop, and contact-drying cylinders (30) that are located at both sides above said impingement-drying/through-drying cylinder (31) and are placed outside the drying wire loop, and

in order to carry out the last stage (III) of the method, the dryer section comprises at least one single-wire unit (R_8) with decreasing evaporation efficiency, said single wire unit (R_8) having a single looped drying wire (62), one upper row of heated contact-drying cylinders (60, 60A) placed outside the drying wire loop, a lower row of reversing suction cylinders (61) placed inside the drying wire loop, and at least one hood structure (66) that increases the evaporation through the drying wire (62), wherein the hood structure (66) is mounted above one of the contact-drying cylinders in said single-wire unit (R_8) and wherein drying gases are supplied from the hood structure (66) to the drying wire (62) while the web (W) is pressed by the drying wire (62) against

the contact-drying cylinder(s) (60A) above which the hood structure (66) is mounted.

9. A dryer section as claimed in claim 8, **characterized in that**, in order to carry out the last stage (III) of the method, one or several contact-drying cylinder(s) (60, 60A) of said single-wire unit (R_8), preferably contact-drying cylinder(s) (60A) with the hood structure (66), is/are dimensioned so that its/their diameter is larger than the diameters of the other contact-drying cylinders (60) in said single-wire unit (R_8) and/or of the contact-drying cylinders (20) in the single-wire groups preceding the single-wire unit (R_8) concerned.
10. A dryer section as claimed in claim 8 or 9, **characterized in that** the dryer section comprises two or three of said single-wire groups (R_2 , R_4 , R_6) between and/or after which said contact-drying/impingement-drying unit(s) (R_3 , R_5 , R_7) is/are located, wherein the web (W) is brought from the preceding single-wire group (R_{n-1}) to one of the contact-drying cylinders (30) of said contact-drying/impingement-drying unit and is passed from the latter one of said contact-drying cylinders (30) to the following single-wire group (R_{n+1}) or said single-wire unit (R_8) as a closed draw.
11. A dryer section as claimed in claim 10, **characterized in that** said impingement-drying/through-drying cylinder(s) (31) is/are placed in the basement space (KT) below the floor level (K_1 - K_1) of the paper machine hall while the single-wire groups (R_2 , R_4 , R_6) and the single-wire unit(s) (R_8) are placed above said impingement-drying/through-drying cylinders (31) and above the floor level (K_1 - K_1) of the paper machine hall.
12. A dryer section as claimed in claim 11, **characterized in that** said single-wire groups (R_2 , R_4 , R_6), said single-wire unit(s) (R_8) and the hood(s) (35) of the impingement-drying/through-drying cylinder(s) (31) permit removal of broke to take place towards the bottom by the force of gravity onto a broke conveyor (41) placed underneath.
13. A dryer section as claimed in anyone of the claims 8 to 12, **characterized in that**, after the first dryer unit (R_1) that carries out the first stage (I), the dryer section comprises a first one of said single-wire groups (R_2) and after that a first one of said contact-drying/impingement-drying units (R_3), after that a second one of said single-wire groups (R_4), after that a second one of said contact-drying/impingement-drying units (R_5), after that a third one of said single-wire groups (R_6), after that a third one of said contact-drying/impingement-drying units (R_7) and, in order to carry out stage III of the method, one or

several of said single-wire units (R_8) in which at least two contact-drying cylinders (60A) have larger diameters (D_4) than the other contact-drying cylinders (60) thereof and are provided with said hood structures (66).

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Patentansprüche

1. Verfahren zum Verdampfungstrocknen der Papierbahn, die von der Pressenpartie (10) einer Papiermaschine kommt, von einem Trockengehalt von $k_0 \approx 35 \dots 55\%$ auf einen Trockengehalt von $k_1 \approx 90 \dots 98\%$, wobei das Verfahren aus drei aufeinander folgenden Stufen I, II und III besteht, die in der Richtung des Voranschreitens der Bahn (W) in der nachfolgend dargelegten Abfolge ausgeführt werden, bei der:

I bei der ersten Stufe die von der Pressenpartie (10) der Papiermaschine kommende Papierbahn in einem Abschnitt der Papiermaschine mit einer Länge von 3 ... 10 m in der Maschinenrichtung auf eine Temperatur von 55 ... 85°C, vorzugsweise auf eine Temperatur von ungefähr 70°C, erwärmt wird, und in diesem Abschnitt die Bahn entlang einer linearen Laufbahn tritt, während sie so gestützt ist, dass ein Bahnreißen der relativ feuchten und somit schwachen Bahn (W) minimal gestaltet ist, wobei das Erwärmen ausgeführt wird, indem ohne Kontakt auf die Papierbahn (W) ein energieintensiver Erwärmungseffekt eines Trocknungsgases und / oder elektromagnetischer Strahlung aufgebracht wird, II nach der ersten Stufe (I) das Trocknen fortgesetzt wird als ein Kontakttrocknen und Aufpralltrocknen, wobei bei dieser zweiten Stufe (II) die Hauptverdampfung, die die Bahn (W) trocknet, in einer derartigen Weise ausgeführt wird, dass die Verdampfungseffizienz (PE) und die Rate der Zunahme des Trockengehaltes (KA) pro Längeneinheit der Trockenpartie in der Maschinenrichtung wesentlich höher als bei der ersten Stufe oder bei der letzten Stufe (III) sind, und die Bahntemperatur (T_w) im Wesentlichen bei der zweiten Stufe (II) während des Voranschreitens des Trocknens nicht ansteigt, III bei der dritten und letzten Stufe das Trocknen mit einer abnehmenden Verdampfungseffizienz als ein Kontakttrocknen und zusätzlich zu dem Kontakttrocknen durch ein Verdampfungstrocknen fortgesetzt wird, das in einem Mehrzylindertrockner ausgeführt wird, indem während des Kontakttrocknens, das auf die Bahn (W) aufgebracht wird, außerhalb eines Trocknungssiebes (62) Trocknungsgas strömt, das die Verdampfung wesentlich steigert, wobei in diesem Zusammenhang auch das in den Fasern in der

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Bahn (W) vorhandene Wasser verdampft, wobei das Trocknen in der dritten Stufe fortgesetzt wird bei einer durchschnittlichen Erhöhungsrate des Trockengehalts (KA) der Bahn (W) in der Maschinenrichtung, die geringer als bei der vorherigen Stufe (II) ist, so dass die Papierqualität gleichzeitig gesteuert werden kann.

2. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** bei der Stufe II die Hauptverdampfung von einem Ort zwischen den Fasern in der Bahn (W) und von den Faseroberflächen so stattfindet, dass Verdampfungseffizienzspitzen (PE_1 , PE_2 , PE_3) auf die Bahn (W) aufgebracht werden, wobei an den Spitzen die Verdampfungseffizienz wesentlich höher als zwischen den Spitzen ist, vorzugsweise ungefähr 2 bis 4 mal so hoch als zwischen den Spitzen.
3. Verfahren gemäß Anspruch 2, **dadurch gekennzeichnet, dass** die Verdampfungseffizienz zwischen den Spitzen in dem Bereich von 10... 30 kg/m²/h dimensioniert ist, und dass die Verdampfungseffizienzen bei den Spitzen (PE_1 , PE_2 , PE_3) in dem Bereich von 50... 90 kg/m²/h dimensioniert sind.
4. Verfahren gemäß einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** bei der zweiten Stufe (II) der Trockengehalt (KA) der Bahn (W) von ungefähr 50% auf ungefähr 80% zunimmt.
5. Verfahren gemäß Anspruch 2 oder 3, **dadurch gekennzeichnet, dass** die Verdampfungseffizienzspitzen (PE_1 , PE_2 , PE_3) bei der zweiten Stufe (II) erreicht werden mittels Kontakttrocknungseinheiten / Aufpralltrocknungseinheiten (R_3 , R_5 , R_7) mit einem Einzelschleifentrocknungssieb (32), einem Aufpralltrocknungszyylinder / Durchtrocknungszyylinder (31), der teilweise durch eine Haube (35) bedeckt ist und innerhalb der Trocknungssiebschleife angeordnet ist, und Kontakttrocknungszyindern (30), die an beiden Seiten oberhalb von dem Aufpralltrocknungszyylinder / Durchtrocknungszyylinder (31) angeordnet sind und außerhalb von der Trocknungssiebschleife angeordnet sind, wobei bei den Kontakttrocknungseinheiten / Aufpralltrocknungseinheiten energieintensive Trocknungsgasstrahlen auf die Bahn (W) aufgebracht werden, die an dem Aufpralltrocknungszyylinder / Durchtrocknungszyylinder (31) angeordnet ist, wobei das Trocknungssieb (32) zwischen der Bahn (W) und dem Aufpralltrocknungszyylinder / Durchtrocknungszyylinder (31) angeordnet ist.
6. Verfahren gemäß einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass**

bei der dritten Stufe (III) ein Trocknen hauptsächlich ausgeführt wird mittels einem oder mehreren Kontakt-trocknungs-zylindern (60, 60A) in derartiger Weise, dass an zumindest einem der Kontakt-trocknungs-zylinder (60A), während die Bahn (W) an den Kontakt-trocknungs-zylinder (60A) durch ein Trocknungs-sieb (62) gegen die erwärmte Oberfläche von dem Kontakt-trocknungs-zylinder (60A) gepresst wird, Trocknungsgasströmungen, die die Verdampfungseffizienz unterstützen, auf das Trocknungs-sieb (62) so aufgebracht werden, dass das im Inneren der Fasern in der Bahn (W) vorhandene Wasser im Wesentlichen verdampft.

7. Verfahren gemäß einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die erste Stufe (I) von dem Verfahren ausgeführt wird, indem Trocknungsenergie auf die zu trocknende Bahn (W) hauptsächlich durch ihre obere Fläche aufgebracht wird, dass die zweite Stufe (II) von dem Verfahren ausgeführt wird, indem Trocknungsenergie auf die zu trocknende Bahn (W) durch ihre untere Fläche aufgebracht wird, und dass die dritte Stufe (III) ausgeführt wird, indem Trocknungsenergie auf die zu trocknende Bahn (W) durch ihre beiden Flächen aufgebracht wird.
8. Trockenpartie einer Papiermaschine für ein Ausführen des Verfahrens gemäß einem der Ansprüche 1 bis 7, wobei nach der Pressenpartie (10) der Papiermaschine die Trockenpartie die folgenden Trocknereinheiten aufweist, die in der vorgegebenen Abfolge in der Maschinenrichtung angeordnet sind:

zum Ausführen der ersten Stufe (I) des Verfahrens die erste Trocknereinheit (R_1) eine Trocknungs-siebeinheit ist, in der die Papierbahn (W) entlang einer linearen Laufbahn gestützt durch ein Trocknungs-sieb (12) an Gebläsekästen und / oder Strahlungstrocknereinheiten vorbeiläuft, wobei durch diese Einrichtungen die Bahn ohne einen direkten Kontakt mit den erwärmten Flächen auf eine Temperatur von 55 ... 85°C erwärmt wird, wobei die erste Trocknereinheit (R_1) eine Länge von 3 ... 10 m in der Maschinenrichtung hat,

zum Ausführen der zweiten Stufe (II) des Verfahrens Trocknereinheiten (R_2 ... R_7), die zumindest eine Einzelsiebgruppe (R_2 , R_4 , R_6) und zumindest eine Kontakt-trocknungseinheit / Aufprall-trocknungseinheit (R_3 , R_5 , R_7) aufweisen, wobei die zumindest eine Einzelsiebgruppe ein Einzelschleifentrocknungs-sieb (22), eine obere Reihe an erwärmten Kontakt-trocknungs-zylindern (20), die außerhalb von der Trocknungs-siebschleife angeordnet sind, und eine untere Reihe an Umkehrsaugzylindern (21), die inner-

halb der Trocknungs-siebschleife angeordnet sind, hat, so dass ein Entfernen von Fertigungsabfall nach unten durch die Wirkung der Schwerkraft stattfinden kann, und die zumindest eine Kontakt-trocknungseinheit / Aufprall-trocknungseinheit, die ein Einzelschleifentrocknungs-sieb (32), einen Aufprall-trocknungs-zylinder / Durch-trocknungs-zylinder (31), der teilweise durch eine Haube (35) bedeckt ist und innerhalb der Trocknungs-siebschleife angeordnet ist, und Kontakt-trocknungs-zylinder (30) hat, die an beiden Seiten oberhalb von dem Aufprall-trocknungs-zylinder / Durch-trocknungs-zylinder (31) angeordnet sind und außerhalb von der Trocknungs-siebschleife angeordnet sind, und zum Ausführen der letzten Stufe (III) von dem Verfahren die Trockenpartie zumindest eine Einzelsiebeinheit (R_8) mit einer abnehmenden Verdampfungseffizienz aufweist, wobei die Einzelsiebeinheit (R_8) ein Einzelschleifentrocknungs-sieb (62), eine obere Reihe an erwärmten Kontakt-trocknungs-zylindern (60, 60A), die außerhalb von der Trocknungs-siebschleife angeordnet sind, eine untere Reihe an Umkehrsaugzylindern (61), die innerhalb der Trocknungs-siebschleife angeordnet sind, und zumindest einen Haubenaufbau (66), der die Verdampfung durch das Trocknungs-sieb (62) verstärkt, hat, wobei der Haubenaufbau (66) oberhalb von einem der Kontakt-trocknungs-zylinder in der Einzelsiebeinheit (R_8) montiert ist, und wobei Trocknungsgase von dem Haubenaufbau (66) zu dem Trocknungs-sieb (62) geliefert werden, während die Bahn (W) durch das Trocknungs-sieb (62) gegen den Kontakt-trocknungs-zylinder (gegen die Kontakt-trocknungs-zylinder) (60A) gepresst wird, oberhalb von dem (denen) der Haubenaufbau (66) montiert ist.

9. Trockenpartie gemäß Anspruch 8, **dadurch gekennzeichnet, dass** zum Ausführen der letzten Stufe (III) von dem Verfahren ein oder mehrere Kontakt-trocknungs-zylinder (60, 60A) von der Einzelsiebeinheit (R_8), vorzugsweise ein Kontakt-trocknungs-zylinder (mehrere Kontakt-trocknungs-zylinder) (60A) mit dem Haubenaufbau (66), so dimensioniert ist / sind, dass ihr / deren Durchmesser größer als die Durchmesser der anderen Kontakt-trocknungs-zylinder (60) in der Einzelsiebeinheit (R_8) und / oder der Kontakt-trocknungs-zylinder (20) in den Einzelsiebgruppen ist, die der betreffenden Einzelsiebeinheit (R_8) vorangehen.
10. Trockenpartie gemäß Anspruch 8 oder 9, **dadurch gekennzeichnet, dass** die Trockenpartie zwei oder drei von den Einzelsiebgruppen (R_2 , R_4 , R_6) aufweist, zwischen und / oder nach denen die Kontakt-trocknungseinheit(en) / Auf-

pralltrocknungseinheit (en) (R_3 , R_5 , R_7) angeordnet ist / sind, wobei die Bahn (W) von der vorherigen Einzelsiebgruppe (R_{n-1}) zu einem der Kontakttrocknungszyylinder (30) von der Kontakttrocknungseinheit / Aufpralltrocknungseinheit gebracht wird und von letztgenannter der Kontakttrocknungszyylinder (30) zu der folgenden Einzelsiebgruppe (R_{n+1}) oder der Einzelsiebeeinheit (R_8) als ein geschlossener Zug tritt.

11. Trockenpartie gemäß Anspruch 10,

dadurch gekennzeichnet, dass

der / die Aufpralltrocknungszyylinder / Durchrocknungszyylinder (31) in dem Fundamentraum (KT) unterhalb der Bodenebene (K_1 - K_1) der Papiermaschinenhalle angeordnet ist / sind, während die Einzelsiebgruppen (R_2 , R_4 , R_6) und die Einzelsiebeeinheit(en) (R_8) oberhalb von den Aufpralltrocknungszyindern / Durchrocknungszyindern (31) und oberhalb der Bodenebene (K_1 - K_1) von der Papiermaschinenhalle angeordnet sind.

12. Trockenpartie gemäß Anspruch 11,

dadurch gekennzeichnet, dass

die Einzelsiebgruppen (R_2 , R_4 , R_6), die Einzelsiebeeinheit(en) (R_8) und die Haube(n) (35) von dem(den) Aufpralltrocknungszyylinder(n) / Durchrocknungszyylinder(n) (31) ermöglichen, dass ein Entfernen des Fertigungsabfalls zu dem Boden hin durch die Schwerkraft zu einem Fertigungsabfallförderer (41), der unterhalb angeordnet ist, stattfindet.

13. Trockenpartie gemäß einem der Ansprüche 8 bis 12,

dadurch gekennzeichnet, dass

nach der ersten Trocknereinheit (R_1), die die erste Stufe (I) ausführt, die Trockenpartie eine erste Gruppe der Einzelsiebgruppen (R_2) aufweist und nach dieser eine erste der Kontakttrocknungseinheiten / Aufpralltrocknungseinheiten (R_3), nach dieser eine zweite Gruppe der Einzelsiebgruppen (R_4), nach dieser eine zweite Einheit der Kontakttrocknungseinheiten / Aufpralltrocknungseinheiten (R_5), nach dieser eine dritte Gruppe der Einzelsiebgruppen (R_6), nach dieser eine dritte der Kontakttrocknungseinheiten / Aufpralltrocknungseinheiten (R_7) und zum Ausführen der Stufe III von dem Verfahren eine oder mehrere der Einzelsiebeeinheiten (R_8), bei denen zumindest zwei Trocknungszyylinder (60A) größeren Durchmesser (D_4) als die anderen Kontakttrocknungszyylinder (60) von ihnen haben und mit den Haubenaufbauten (66) versehen sind.

Revendications

1. Procédé de séchage par évaporation de la bande de papier en continu qui arrive depuis la section de pressage (10) d'une machine à papier depuis une

teneur en matière sèche de $k_0 \approx 35 \dots 55 \%$ à une teneur en matière sèche de $k_0 \approx 90 \dots 98 \%$, dans lequel le procédé comprend trois phases successives I, II et III qui sont accomplies dans le sens de la progression de la bande de papier en continu (W), selon la séquence précisée ci-dessous :

I - au cours de la première phase, la bande de papier en continu qui arrive depuis la section de pressage (10) de la machine à papier est chauffée dans une section de la machine à papier ayant une longueur de 3 ... 10 m dans la direction machine, à une température de 55 ... 85°C, de préférence à une température de 70°C environ et, dans cette section, la bande de papier en continu est amenée à progresser le long d'un trajet linéaire tandis qu'elle est supportée de façon à ce que des cassures de la bande de papier en continu dues à l'humidité relative et, partant, une faiblesse de la bande de papier en continu (W) soient minimisées, dans lequel le chauffage est exécuté en appliquant sur la bande de papier en continu (W), en évitant tout contact avec elle, un effet de chauffage à forte intensité énergétique d'un gaz de séchage et / ou d'un rayonnement électromagnétique ;

II - au terme de la première phase (I), le séchage se poursuit, sous la forme d'un séchage par contact et d'un séchage par impact, dans lequel au cours de cette deuxième phase (II), la plus grande partie du séchage par évaporation de la bande de papier en continu (W) est accomplie de telle façon que l'efficacité d'évaporation (PE) et le taux d'augmentation de la teneur en matière sèche (KA) par unité de longueur de la section de séchage dans la direction machine soient sensiblement plus élevés qu'au cours de la première phase ou de la phase finale (III), et que la température (T_w) de la bande de papier en continu n'augmente pas sensiblement au cours de la deuxième phase (II) tandis que le séchage se poursuit ;

III - au cours de la troisième et dernière phase, le séchage se poursuit avec une efficacité d'évaporation réduite sous la forme d'un séchage par contact et, en plus du séchage par contact, sous la forme d'un séchage par évaporation qui est réalisé dans un sécheur multicylindre en appliquant sur la bande de papier en continu (W), pendant le séchage par contact, à l'extérieur d'une toile de séchage (62), des flux de gaz de séchage qui augmentent sensiblement l'évaporation, moyennant quoi également l'eau présente dans les fibres de la bande de papier en continu (W) est évaporée, dans lequel le séchage au cours de la troisième phase se poursuit avec un taux d'augmentation moyen de la teneur en matière sèche (KA) de la bande de papier en

continu (W) dans la direction machine qui est moins élevé qu'au cours de la phase précédente (II) de façon à ce que la qualité du papier puisse être contrôlée en même temps.

2. Procédé selon la revendication 1, **caractérisé en ce que**, au cours de ladite phase II, la plus grande partie de l'évaporation entre les fibres de la bande de papier en continu (W) et les surfaces des fibres se produit de telle sorte que des pics d'efficacité d'évaporation (PE_1 , PE_2 , PE_3) sont appliqués sur la bande de papier en continu (W), qui sont des pics d'efficacité d'évaporation au niveau desquels l'efficacité d'évaporation est sensiblement plus élevée que entre les pics, de 2 à 4 fois environ plus élevée de préférence que entre les pics. 5
3. Procédé selon la revendication 2, **caractérisé en ce que** ladite efficacité d'évaporation entre lesdits pics se situe dans la plage de 10 ... 30 kg / m² / h, et **en ce que** lesdites efficacités d'évaporation au niveau desdits pics (PE_1 , PE_2 , PE_3) se situent dans la plage de 50 ... 90 kg/m²/H. 10
4. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que**, au cours de la deuxième phase (II), la teneur en matière sèche (KA) de la bande de papier en continu (W) augmente de 50 % environ à 80 % environ. 15
5. Procédé selon la revendication 2 ou 3, **caractérisé en ce que**, au cours de la deuxième phase (II), les pics d'efficacité d'évaporation (PE_1 , PE_2 , PE_3) sont atteints au moyen d'unités de séchage par contact / de séchage par impact (R_3 , R_5 , R_7) dotées d'une 20
toile de séchage à boucle simple (32), un cylindre de séchage par impact / de séchage à coeur (31) qui est partiellement recouvert par un capot (35) et qui est placé à l'intérieur de la boucle de la toile de séchage, et des cylindres de séchage par contact (30) qui sont disposés des deux côtés au-dessus dudit cylindre de séchage par impact / de séchage à coeur (31) et qui sont placés à l'extérieur de la boucle de la toile de séchage, des unités de séchage par contact / de séchage par impact à l'intérieur des- 25
quelles des flux de gaz de séchage à forte intensité énergétique sont appliqués sur la bande de papier en continu (W) qui est placée sur le cylindre de séchage par impact / de séchage à coeur (31), la toile de séchage (32) se trouvant située quant à elle entre la bande de papier en continu (W) et le cylindre de séchage par impact / de séchage à coeur (31). 30
6. Procédé selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que**, au cours de la troisième phase (III) la plus grande partie du séchage est accomplie au moyen d'un ou plusieurs cylindres de séchage par contact (60, 60A) de telle sorte que, sur 35

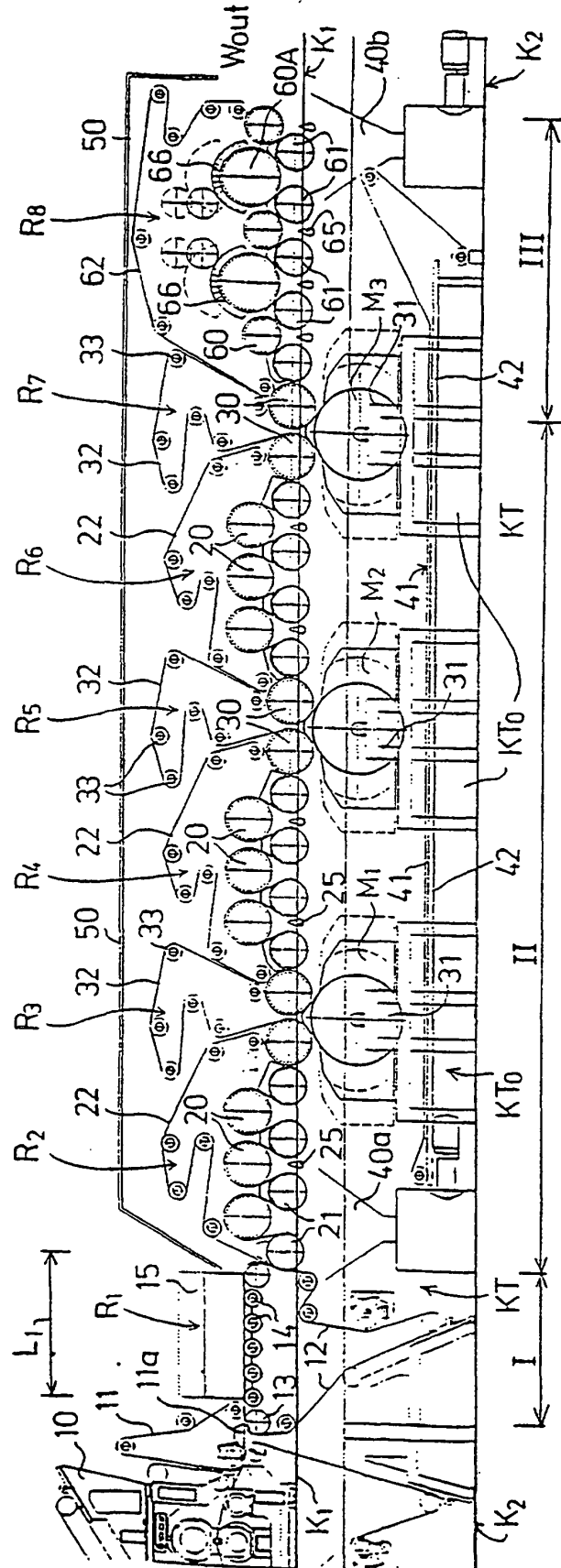
au moins un desdits cylindres de séchage par contact (60A), tandis que la bande de papier en continu (W) est pressée sur le cylindre de séchage par contact (60A) par une toile de séchage (62) contre la face chauffée du cylindre de séchage par contact (60A), des flux de gaz de séchage favorisant l'efficacité d'évaporation sont appliqués sur ladite toile de séchage (62), de telle sorte que l'eau présente à l'intérieur des fibres de la bande de papier en continu (W) s'évapore sensiblement.

7. Procédé selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** la première phase (I) du procédé est accomplie en appliquant une énergie de séchage sur la bande de papier en continu (W) de façon à ce qu'elle soit séchée principalement à travers sa face supérieure, que la deuxième phase (II) du procédé est accomplie en appliquant une énergie de séchage sur la bande de papier en continu (W) de façon à ce qu'elle soit séchée à travers sa surface inférieure, et **en ce que** la troisième phase (III) est accomplie en appliquant une énergie de séchage sur la bande de papier en continu (W) de façon à ce qu'elle soit séchée à travers ses deux faces. 40
8. Section de séchage d'une machine à papier destinée à accomplir le procédé selon l'une quelconque des revendications 1 à 7, dans laquelle, après la section de pressage (10) de la machine à papier, la section de séchage comprend les unités de séchage suivantes qui sont disposées selon l'ordre indiqué dans la direction machine : 45

de façon à accomplir la première phase (I) du procédé la première unité de séchage (R_1) est une unité formant toile de séchage dans laquelle la bande de papier en continu (W) est amenée à passer le long d'un trajet linéaire tandis qu'elle est supportée par une toile de séchage (12) en dépassant des enveloppes de soufflage et / ou des unités de séchage par rayonnement, au moyen desquelles la bande de papier en continu est chauffée sans contact direct avec les faces chauffées à une température de 55 ... 85°C, la première unité de séchage (R_1) ayant une longueur de 3 ... 10 m dans la direction machine ; de façon à accomplir la deuxième phase (II) du procédé, des unités de séchage (R_2 ... R_7) qui comprennent au moins un groupe de toiles de séchage simples (R_2 , R_4 , R_6) et au moins une unité de séchage par contact / de séchage par impact (R_3 , R_5 , R_7), ledit au moins un groupe de toiles de séchage simples comprenant une toile de séchage à boucle simple (22), une rangée supérieure de cylindres de séchage par contact (20) chauffés placée à l'extérieur de la boucle de la toile de séchage et une rangée inférieure de cylindres d'aspiration réversibles 50

- (21) placée à l'intérieur de la boucle de la toile de séchage, de telle sorte que le retrait de cassés de fabrication puisse se faire vers le bas sous la force de la gravité, et ladite au moins une unité de séchage par contact / de séchage par impact comprenant une toile de séchage à boucle simple (32), un cylindre de séchage par impact / de séchage à coeur (31) qui est partiellement recouvert par un capot (35) et qui est placé à l'intérieur de la boucle de la toile de séchage, et des cylindres de séchage par contact (30) qui sont disposés des deux côtés au-dessus dudit cylindre de séchage par impact / de séchage à coeur (31) et qui sont placés à l'extérieur de la boucle de la toile de séchage ; et de façon à accomplir la dernière phase (III) du procédé, la section de séchage comprend au moins une unité formant toile de séchage simple (R_8) ayant une efficacité d'évaporation réduite, ladite unité formant toile de séchage simple (R_8) ayant une toile de séchage à boucle simple (62), une rangée supérieure de cylindres de séchage par contact (60, 60A) chauffés placée à l'extérieur de la boucle de la toile de séchage, une rangée inférieure de cylindres d'aspiration réversibles (61) placée à l'intérieur de la boucle de la toile de séchage, et au moins une structure de capot (66) qui renforce l'évaporation à travers la toile de séchage (62), dans lequel la structure de capot (66) est montée au-dessus de l'un des cylindres de séchage par contact dans ladite unité de toile de séchage simple (R_8) et dans lequel des gaz de séchage sont injectés depuis la structure de capot (66) vers la toile de séchage (62) tandis que la bande de papier en continu (W) est pressée par la toile de séchage (62) contre le(s) cylindre(s) de séchage par contact (60A) au-dessus duquel (desquels) est montée la structure de capot (66).
9. Section de séchage selon la revendication 8, **caractérisée en ce que**, de façon à accomplir la dernière phase (III) du procédé, un ou plusieurs cylindres de séchage par contact (60, 60A) de ladite unité formant toile de séchage simple (R_8), de préférence un ou plusieurs cylindres de séchage par contact (60A) munis de la structure de capot (66), est / sont dimensionné(s) de telle sorte que son / leur diamètre soit (soient) plus large(s) que les diamètres des autres cylindres de séchage par contact (60) dans ladite unité formant toile de séchage simple (R_8) et / ou des cylindres de séchage par contact (20) dans les groupes de toiles de séchage simples qui précèdent l'unité formant toile de séchage simple (R_8) concernée.
10. Section de séchage selon la revendication 8 ou 9, **caractérisée en ce que** la section de séchage comprend deux ou trois desdits groupes de toiles de séchage simples (R_2, R_4, R_6) entre et / ou à la suite desquels ladite / desdites unité(s) de séchage par contact / de séchage par impact (R_3, R_5, R_7) est / sont disposée(s), dans laquelle la bande de papier en continu (W) est amenée en provenance du précédent groupe de toiles de séchage simples (R_{n-1}) vers un des cylindres de séchage par contact (30) de ladite unité de séchage par contact / de séchage par impact, et elle est transférée depuis le dernier desdits cylindres de séchage par contact (30) vers le groupe de toiles de séchage simples suivant (R_{n+1}) ou ladite unité formant toile de séchage simple (R_8) sous la forme d'un tirage fermé.
11. Section de séchage selon la revendication 10, **caractérisée en ce que** ledit (lesdits) cylindre(s) de séchage par impact / séchage à coeur (31) est / sont placé(s) dans l'espace de fondement (KT) situé en dessous du niveau du sol (K_1-K_1) du hall de la machine à papier tandis que les groupes de toiles de séchage simples (R_2, R_4, R_6) et la ou les unité(s) formant toile(s) de séchage simple(s) (R_8) sont placés au-dessus desdits cylindres de séchage par impact / séchage à coeur (31) et au-dessus du niveau du sol (K_1-K_1) du hall de la machine à papier.
12. Section de séchage selon la revendication 11, **caractérisée en ce que** lesdits groupes de toiles de séchage simples (R_2, R_4, R_6), ladite (lesdites) unité(s) formant toile(s) de séchage simple(s) (R_8) et le ou les capot(s) (35) du ou des cylindre(s) de séchage par impact / séchage à coeur (31) permettent au retrait de cassés de fabrication de pouvoir se faire vers le bas sous la force de la gravité sur un convoyeur de cassés de fabrication (41) placé en dessous.
13. Section de séchage selon l'une quelconque des revendications 8 à 12, **caractérisée en ce que**, à la suite de la première unité de séchage (R_1) qui accomplit la première phase (I) du procédé, la section de séchage comprend un premier desdits groupes de toiles de séchage simples (R_2) et, après cela, une première desdites unités de séchage par contact / de séchage par impact (R_3), après cela un deuxième desdits groupes de toiles de séchage simples (R_4), après cela une deuxième desdites unités de séchage par contact / de séchage par impact (R_5), après cela un troisième desdits groupes de toiles de séchage simples (R_6), après cela une troisième desdites unités de séchage par contact / de séchage par impact (R_7) et, de façon à accomplir la phase III du procédé, une ou plusieurs desdites unité(s) formant toile(s) de séchage simple(s) (R_8) dans lesquelles au moins deux cylindres de séchage par contact (60A) ont des diamètres plus larges (D_4) que les autres cylindres de séchage par contact (60) de celles-ci et sont dotés desdites structures de capot (66).

FIG. 1A



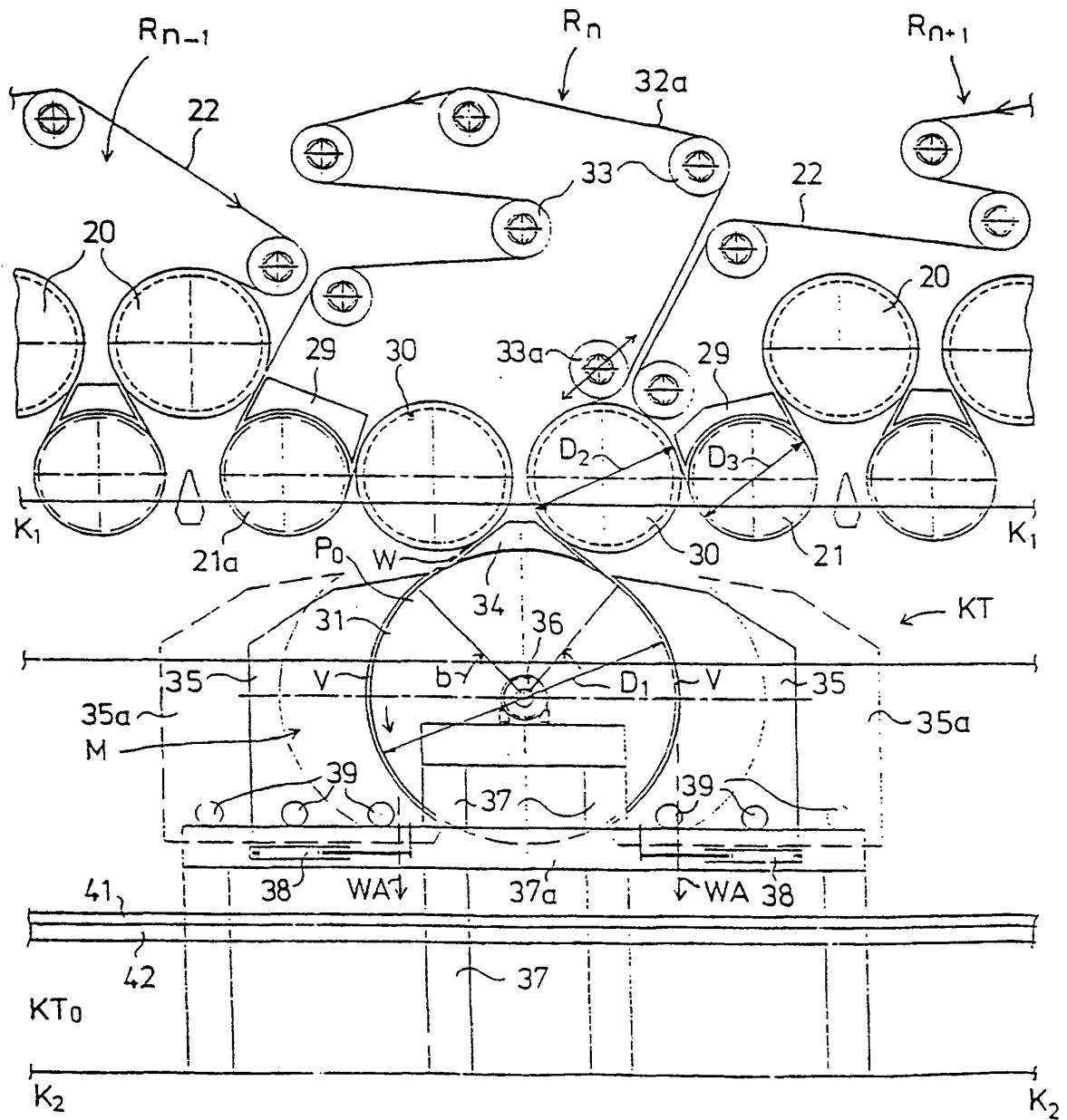
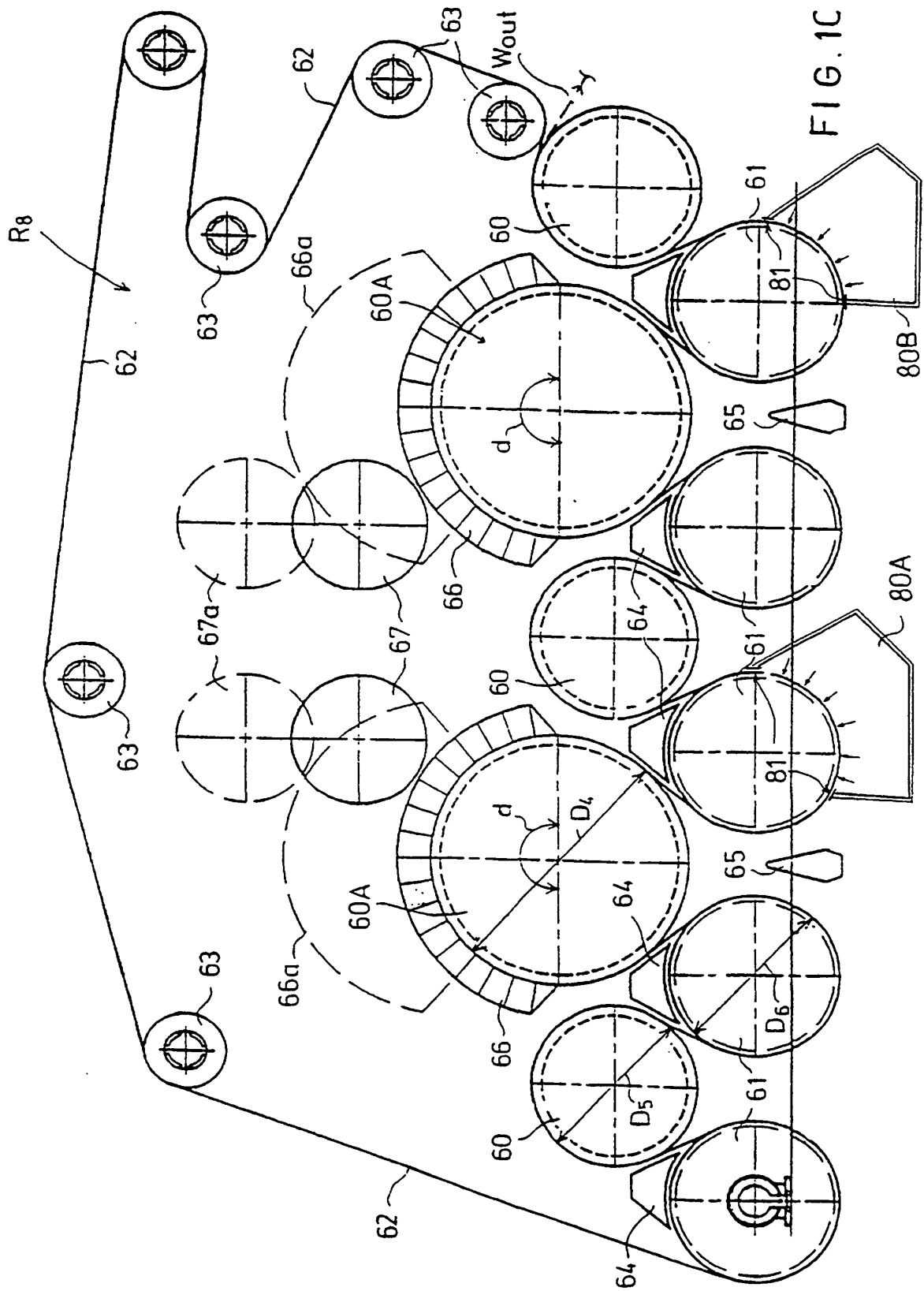


FIG. 1B



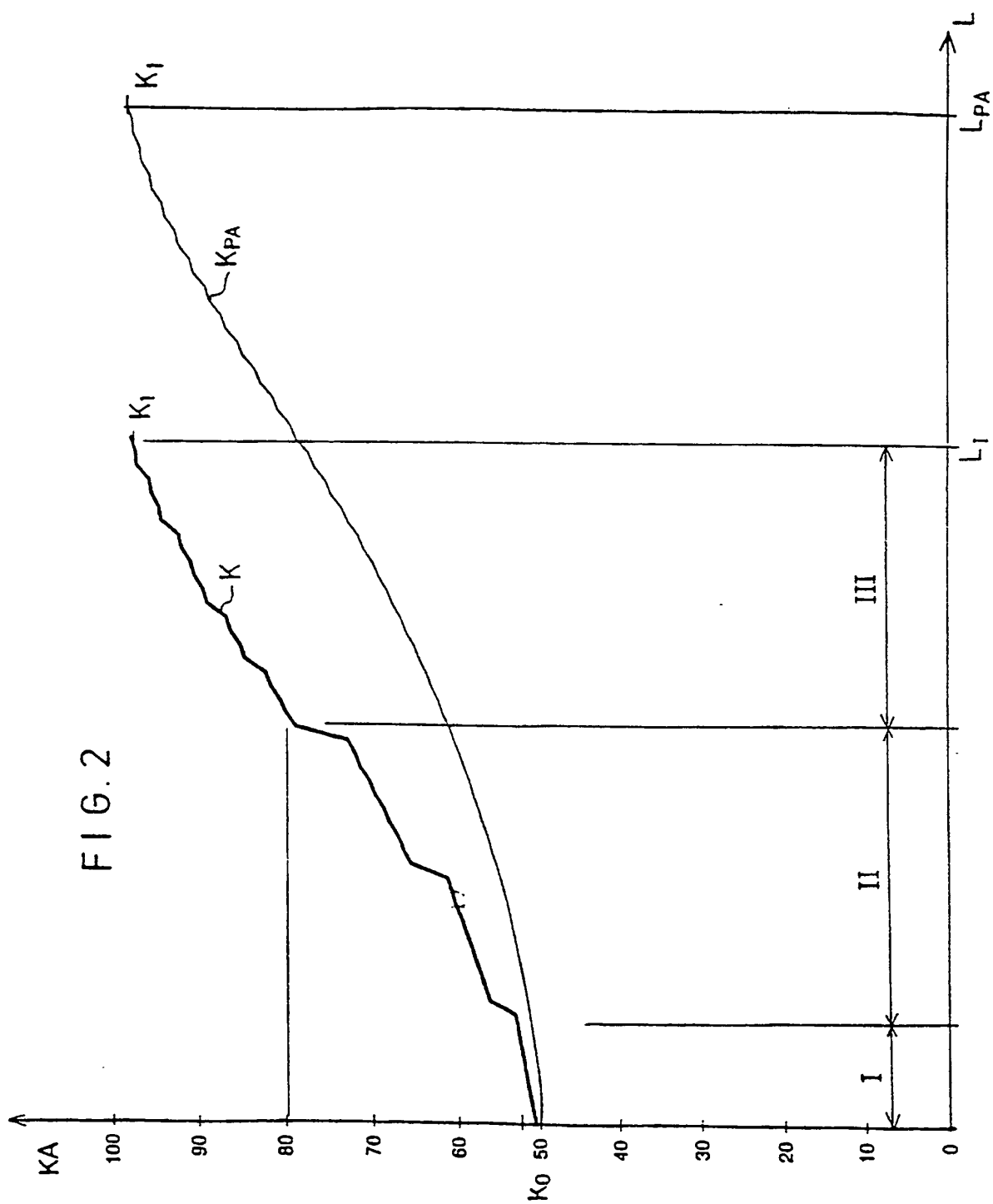


FIG. 3

