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(54) Forming-gap arrangement in a twin-wire former of a paper machine.

(57) The invention concerns a forming-gap arrangement in a twin-wire former of a paper machine. The twin-wire former comprises forming wires (10,20) operating one against the other, which forming wires (10,20) define a wedge-shaped narrowing forming gap (G) between them. The forming-gap arrangement comprises two opposite support members (40, 41), whose inner sides have been arranged as direct extensions of the inner sides of the lip walls (31,32) of the headbox that define the discharge duct. The support members (40,41) have been arranged to extend into the forming gap (G) as parallel to one another, so that the free ends (42) of the support members (40,41) are placed at direct proximity of, or in contact with, the forming wires (10,20). The support members (40,41) have a plate-like, isotropic or anisotropic, at least to some extent resilient construction.

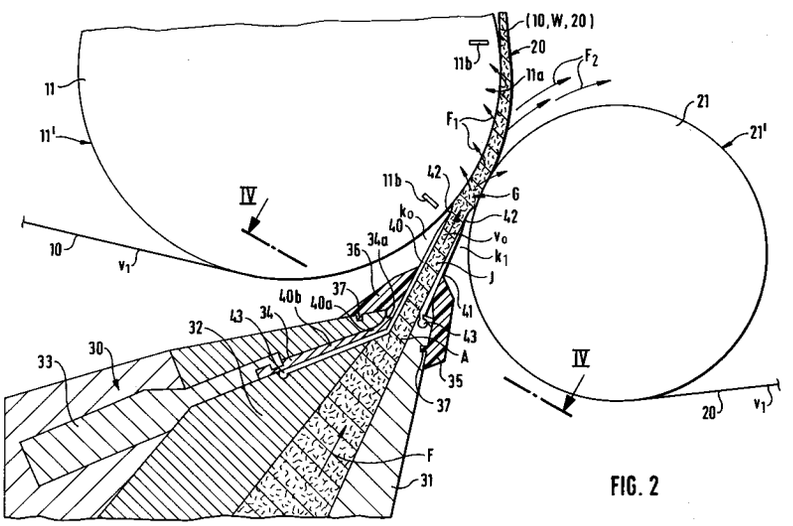

FIG. 2

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The invention concerns a forming-gap arrangement in a twin-wire former of a paper machine, which twin-wire former comprises forming wires operating one against the other, between which wires there is a twin-wire forming zone, on which dewatering and web-formation elements are provided and which forming wires define a wedge-shaped narrowing forming gap between them, into which the slice arrangement of the headbox of the paper machine is fitted to feed the pulp suspension jet from which the paper web is formed, and which said headbox comprises two lip walls placed one opposite the other, the discharge duct being placed between said lip walls, which duct preferably becomes narrower in the direction of flow of the pulp suspension so that, in the discharge duct, the flow speed of the pulp suspension is increased.

In prior-art gap formers of paper machines, the pulp suspension jet is fed into a wedge-shaped, narrowing gap between the forming wires. In several gap formers, such as, for example, the formers marketed by the applicant under the trade mark "Speed Former HS", the pulp suspension jet is directed at an unsupported outer wire at a certain impingement angle. A live pulp suspension jet produces instability in the unsupported wire, and above all transverse wrinkles, waves, and streaks in particular at the edges of the machine. Said tendency of formation of wrinkles and waves produces variation in grammage both in the machine direction and in the transverse direction in the finished paper or board.

In the prior-art gap formers, as a rule, either two forming rolls are used, which operate as breast rolls and are placed one opposite the other inside both of the wire loops, or one forming roll is used in the gap area, which roll is placed inside the loop of the inner wire, the outer wire being passed into contact with said roll by means of guide rolls. Owing to the large-diameter breast and forming rolls and owing to the guide rolls, the geometry of the forming gap usually becomes such that it is difficult to bring the discharge opening of the headbox sufficiently deep into the forming gap, for example, because the means of adjustment of the profile bar at the discharge opening require a considerably large space. These problems are emphasized further in multi-layer headboxes.

In gap formation, the distance of flight of the pulp suspension jet departing from the headbox is a factor critical in many respects. A relatively long distance of flight of the jet subjects the jet to effects of air flows in the gap, whereby the point of impingement of the jet may be changed and/or the surface of the jet may be disintegrated with resulting inferior formation and possibly deterioration of other properties of the paper. A long distance of flight of the jet in absence of the turbulence arising from the differences in velocity produced by walls increases a renewed flocculation of fibres in a detrimental way.

Since, in gap formers, the rolls placed near the headbox limit a locating of the headbox near the gap, even in the best case the shortest distance of the flight of the pulp jet, with the prior-art forming-gap arrangements, is at least about 100 mm. In constructions designed by several paper machine producers, attempts have been made to shorten the distance of the flight of the discharge jet by means of various "turning bar" constructions, in which cases the wire can be made to run at a location closer to the starting point of the jet. An example of this is the forming-gap arrangement described in the applicant's FI Pat. Appl. No. 894868 (dated Oct. 13, 1989), wherein it is considered novel that inside the lap of the outside wire, in the area of the bottom of the forming gap, an oblong stabilization rib is fitted, which stabilizes the running of the outer wire in the area of the bottom of the forming gap as well as removes water through the outer wire.

In respect of the prior art related to the present invention, we refer, by way of example, to the US Patents 3,619,362 (Beloit Corp.), 4,141,788 (Beloit Corp.), and 4,358,342 (Kimberly-Clark Corporation).

In the above US Pat. 4,358,342, a slice part of a headbox is described in which there are wedge-shaped rigid lip plates that extend deep into the forming gap but which do, however, not reach contact with the wires. In said US Pat. 4,141,788, a multi-layer headbox is described whose middle discharge duct is defined by lip plates, which extend deep into the forming gap, and the middle pulp jet is discharged from inside these lip plates into the forming gap, while the outer pulp jets are discharged outside said plates, so that the lip plates are not in contact with the wires, and the outer jets have free surfaces in contact with air before they reach contact with the wires.

Of the above publications, the construction of US Pat. 3,619,362 is most closely related to the present invention, in which construction a lip part of a headbox and a related forming gap are described, the forming gap being defined between two forming rolls. In said US patent, the walls of the headbox lip part are provided with extensions consisting of flexible lip plates, which are in contact with, and drag against, the forming rolls and the wires, which run over said rolls, within a remarkably large sector, and said flexible lip plates extend relatively deep into the forming gap over said contact sectors. One of the drawbacks of the forming-gap arrangement of this US patent is the fact that, owing to the wide contact sector and the pressure prevailing in the discharge duct, said lip plates are subjected to wear, and the lack of adjusting pos-

sibilities is another drawback.

The object of the present invention is to provide a novel forming-gap arrangement for use in connection with a twin-wire former so that the drawbacks discussed above can be substantially avoided.

It is a particular object of the invention to provide a forming-gap arrangement in which a free distance of flight of the pulp suspension jet does not have to be used at all, whereby the drawbacks discussed above and arising from said flight can be avoided.

A non-indispensable additional object of the present invention is to provide a forming-gap arrangement that can be adjusted in a versatile way.

A non-indispensable additional object of the invention is to provide a forming-gap arrangement in connection with which it is advantageously possible to measure the dimensions of the forming gap and the pulp suspension jet in the direction of thickness and, if necessary, also the velocity of the pulp suspension, and in connection with which arrangement it is possible, based on these measured quantities, to carry out versatile adjustments of the lip part of the head box and possibly also other adjustments.

In view of achieving the objectives stated above and those that will come out later, the invention is mainly characterized in that the forming-gap arrangement comprises two opposite support members, whose inner sides have been arranged as direct extensions of the inner sides of the lip walls that define the discharge duct, that said support members have been arranged to extend into the forming gap as substantially parallel to one another, so that the free ends of the support members are placed at direct proximity of, or in contact with, the forming wires, and that said support members are made of a plate-like, at least to some extent resilient material.

In the present invention, the pulp suspension jet is supported all the way to the wires by means of in such a way resilient support members that the members do not have to bear the forces arising from accelerating of the discharge jet. The support members can be placed so that they start after or before the profile bar or an equivalent profile regulation equipment, so that the constructions placed against the support member behind said member bear the forces arising from accelerating of the flow. The free outer ends of the support members are dimensioned preferably so that they drag against the wires in the forming gap, in which case it is also possible to regulate the magnitude of the back wave formed in the gap.

In the invention, by means of the resilient jet support members, the point of impingement of the jet at the nip between the wire and the former roll is also adjusted. By means of these adjustments, it is possible to act significantly upon the operation of the forming gap and upon the uniformity of the jet arriving in the gap, upon the turbulence and other significant parameters and, generally speaking, upon the coating process and its starting point in the initial end of the former.

By means of the invention, the following advantages, which are synergistic with one another, are carried into effect:

- more accurate point of impingement of the jet
- quieter jet face when it meets the wire
- higher intensity of turbulence when the jet meets the gap
- possibility of adjustment at the point of impingement of the jet
- better ratio of tensile strength, because more fibres in the transverse direction
- higher speed in gap formation
- possibility of adjustment of the back wave formed at the point of impingement of the jet
- improved control of the process
- versatile possibilities of measurement and adjustment of the jet.

The above circumstances permit development of gap formation to make it well suitable for different paper qualities, including such qualities for which it has not been possible to employ gap formation, which is in itself favourable, as well as for increased running speeds of paper machines.

The material of the support members must be, at the same time, both resilient and sufficiently rigid to prevent formation of detrimental extra oscillations. For example, a teflon-coated metal plate or fibre/composite structures can be concerned as support members. Materials that are rigid anisotropically, in different ways in the machine direction and in the transverse direction, are also suitable for the purpose. If a member is sufficiently rigid in the machine direction, the transverse rigidity can be lowered to facilitate the adjustment.

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 drawing, the invention being by no means strictly confined to the details of said embodiments.

Figure 1 is a schematic side view of an exemplifying embodiment of a gap former in which a forming-gap arrangement in accordance with the invention is applied.

Figure 2 is a schematic vertical sectional view in the machine direction of a gap arrangement in accordance with the invention and, at the same time, Fig. 2 is the detail D indicated in Fig. 1.

Figure 3 illustrates a second exemplifying embodiment of the invention in a way corresponding to Fig. 2.

Figure 4 is a schematic transverse sectional view along the line IV-IV in Fig. 2.

Fig. 1 is a schematic illustration of the invention as applied in connection with a gap former marketed by the applicant under the trade mark "Speed-Former HS". The former comprises a carrying wire 10 and a covering wire 20, which define a twin-wire forming zone between the forming rolls 11 and 13. The carrying wire 10 is guided by the forming roll 11,13 and by the guide rolls 14,15. On the run between the rolls 14 and 15, there is the pick-up point P, at which the web W is detached from the carrying wire 10 and transferred on the suction zone 17a of the roll 17 onto the pick-up fabric 18, which carries it into the press section (not shown) of the paper machine. The twin-wire forming zone starts from the forming gap G defined by the wires 10 and 20 guided by the rolls 11 and 21, and the gap is followed by a forming shoe 22, which is provided with a curved face and is placed inside the loop of the covering wire 20, and thereupon by a foil arrangement 12 placed inside the loop of the carrying wire. Hereupon there is the second forming roll 13, and by the effect of the suction prevailing in the interior of said forming roll 13, the web W follows the carrying wire 10 and is separated from the covering wire 20. The return run of the wire 20 is first guided by the leading roll 24a and then by the guide rolls 24. Inside the loops of the wires 10 and 20, there is a collecting arrangement 16,23 for the waters removed from the web.

The headbox 30 that is shown schematically in Fig. 1 comprises an inlet header 39, a distributor tube bank and a turbulence generator 38 as well as a discharge duct 32, from which the pulp suspension jet J is discharged into the forming gap G.

The former shown in Fig. 1 is illustrated just as an example of the environment of application of the forming-gap arrangement in accordance with the invention, and it should be emphasized that the invention can be applied in connection with highly different gap formers, which formers differ essentially from that shown in Fig. 1.

In Fig. 2, a first exemplifying embodiment of a forming-gap arrangement in accordance with the invention is shown. The wedge-shaped discharge duct 33 of the headbox is defined between the lip walls 31 and 32. In the discharge duct 33, a pulp suspension flow F flows, in which a suitable state of turbulence has been produced in the preceding turbulence generator 38. The pulp suspension flow F is accelerated to a suitable velocity in the narrowing discharge duct 33, which is provided with a discharge opening A. In the invention, after the discharge opening A, the pulp suspension jet J is not allowed to be discharged into the forming gap G freely, but at both sides of the jet J, plate-shaped support members 40 and 41 are employed, which have plane smooth inner faces. The material of the support members 40 and 41 is a resilient but sufficiently rigid plate material, which is made of metal sheets coated, e.g., with Teflon (TM) and/or of fibre/composite materials. The support members 40 and 41 extend across the entire transverse width of the pulp jet J as unified plate constructions. The support members 40,41 become preferably thinner towards their ends 42 in the flow direction F of the pulp suspension.

Within the scope of the invention, the support members 40 and 41 do not necessarily have to be made of a plate material of uniform strength and of one plate or of several layers, but in some cases the invention can be accomplished by using materials or wall constructions that have different rigidities in the machine direction and in the transverse direction. It is particularly advantageous to carry out the invention by means of a support member construction whose walls are substantially more rigid in the machine direction than in the transverse direction, which facilitates the profiling of the support plates for adjustment. Such an anisotropy of rigidity can be produced, e.g., by means of various layer constructions, rib constructions, and/or grooves, the latter formations being placed on the outer faces of the support members.

In a preferred embodiment of the invention, the length M of the support members 40 is, as a rule, in the range of M = 50...500 mm, preferably in the range of M = 100...350 mm. The average wall thickness S of the support members 40,41 is, as a rule, in the range of S = 1...10 mm, preferably in the range of S = 2...5 mm.

It is an essential feature of the forming-gap arrangement in accordance with the invention that only the free ends 42 of the support members 40,41, which ends are straight, reach contact with the forming wires 10,20 or become placed at their direct proximity, so that the gap between the support members 40,41 is of substantially equal width in the flow direction across the entire pulp suspension jet J. In such a case, no acceleration of the pulp flow takes place between the support members 40,41. After the end 42 of the support members 40,41, the faces of the pulp suspension do not meet eddying layers of air, but they enter directly into contact with the wires 10,20. Thus, no so-called back wave or similar disturbance can arise. As comes out from Fig. 2, between the support members 40 and 41 and the wires 10,20 that run over the rolls 11,21, there are wedge-shaped narrowing nip spaces K_0 and K_1 up to the ends 42 of the support members 40,41.

The gap arrangement shown in Fig. 2 is also advantageous in the respect that, after the free ends 42 of the support members 40,41, the pulp

suspension jet J enters between the wires 10,20 initially in an area where the wires are supported stably by the roll 11,21 faces 11',21', so that detrimental oscillations and other disturbance cannot be produced. In Fig. 3, after the ends 42 of the support members 40,41, the gap is supported by the roll face 21' at the side of the wire 20.

The fibre orientation and the formation can also be affected in away in itself known by setting the velocity v_0 of the pulp suspension jet discharged from between the ends 42 of the support members 40,41 at a suitable level in relation to the velocity v_1 of the wires. In order that the difference in velocity v_0-v_1 could be used as one of the regulation parameters, it is, of course, required that the velocity v_0 is known sufficiently precisely. The measurement of the velocity v_0 in connection with the invention will be returned to in more detail in connection with the description of Fig. 4.

According to Fig. 2, the forming gap G is defined between the wires 10,20 that run overthe forming roll 11 and the leading roll 21. The forming roll 11, over which the wire 10 runs, comprises a perforated mantle face 11'. In the interior of the forming roll 11, there is a suction zone 11a, which is defined by the ribs 11b of the suction box, which ribs operate against the inner face of the cylinder mantle of the roll 11. In the area of the suction zone 11, water is also removed into the suction box in the roll 11 in the direction of the arrows F_1. Also, considerable dewatering takes place into the hollow face 21' of the roll 21 and through the wire 20 in the direction of the arrows F_2.

The support members 40 and 41 are provided with fastening parts 43, by whose means the support members 40,41 are fixed across their entire width, one support member 40 to the lip wall 32 and the other support member 41 to the lip wall 31, to the grooves provided in said walls by means of the fastening parts 43. The support members 40,41 are supported from outside by backup pieces 35 and 36, which are attached to the lip walls 31 and 32 by means of groove-projection fittings 37. According to Fig. 2, the upper support member 40 goes on as a plane plate part 40b made of one piece and, by means of a fold 40a, joining the plane part of the support member 40 that guides the discharge jet. The smoothly curved fold 40a is placed at the level of the discharge opening A and regulates the magnitude of the discharge opening. For this regulation, placed against the outer face of the angle part 40a, there is a bent rib part 34a, whose position and shape are regulated by adjustment rods 34, which are connected with the profile regulation devices 33 fitted in connection with the lip wall 32 of the headbox. The profile regulation devices operate in a way similar to the prior-art devices that regulate the profile bar at the discharge opening of a headbox.

Fig. 3 shows a second exemplifying embodiment of the invention, wherein the support members 40 and 41 are attached to the front sides of the lip walls 31 and 33 by means of fastening parts 43. The support members 40,41 do not participate in the profiling of the discharge opening A, but for that purpose the lip wall 31 is provided with a profile bar 34b, regulating spindles 34, and profile regulation motors 33. The geometry of the forming gap G shown in Fig. 3 also differs to some extent from that shown in Fig. 2.

In Fig. 2, one support member 40 is also illustrated as operating as a member by whose means the profile of the discharge opening A is adjusted. The invention can also be accomplished so that the stationary support member 41 shown in Fig. 2 is replaced by a second adjustable support member similar to the adjustable support member 40, in which case two opposite adjustable support members are used for the profiling of the discharge opening A, both of which are provided with profile regulation devices 33,34,34a.

Fig. 4 is a schematic transverse sectional view along the liner IV-IV in Fig. 2. In Fig. 4, the series of regulation rods 34 are seen. The regulation rods 34 are at a transverse distance L_2 from one another. The distance L_2 is preferably within the range of L_2 = 50...200 mm. To the regulation rods 34, electric motors 33 are connected, which receive their control signal $c_1 ... c_N$ from the regulation system 53, which is illustrated just schematically. The outer ends of the regulation rods 34 are connected to said flexible rib part 34a by the intermediate of connecting parts 34b, which rib part 34a acts upon the profile of the support member 40 and, thereby, upon the thickness profile $h_1 ... h_n$ of the pulp suspension jet J in the way described above.

According to Fig. 4, a series of detector pairs 51a,51b; 52a,52b is arranged in connection with the support member 40. The distance between said detectors in the transverse direction is denoted with L_1. The distance L_1 between the pairs of measurement detectors is as a rule in the range of L_1 = 100...5000 mm. From the detector pairs 51a,51b; 52a,52b, etc., measurement signals $a_1, a_2 ... b_1, b_2 ...$ are passed to the regulation system 53, by means of which signals the thickness profile $h_1, h_2 ... h_N$ of the discharge jet is measured. Said detectors may be, e.g., contact detectors, capacitive detectors, ultrasonic detectors, or other, corresponding detectors. Moreover, measurement of the velocity v_0 and of the velocity profile of the discharge jet can also be connected to the detectors 51,52. In this measurement, it is possible to use, e.g., ultrasonic detectors, whose operation is based on the correlation technique. As an example of such a prior-art arrangement of ultrasonic detec-

tors based on the correlation technique for measurement of the flow velocity of pulp suspension, reference is made to the patents FI-67,627 and US-4,484,478.

In Fig. 4, it is suggested that the regulation system 53 be connected with a block 54, which represents the entire measurement and control system of the paper machine, from which the series of signals S of the set values is received, by whose means the thickness profile of the discharge duct is set at a suitable value. It should be emphasized that, in Fig. 4, the regulation and measurement system is illustrated just quite schematically and by way of example, and many variations from Fig. 4 are possible.

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

The invention concerns a forming-gap arrangement in a twin-wire former of a paper machine. The twin-wire former comprises forming wires (10,20) operating one against the other, which forming wires (10,20) define a wedge-shaped narrowing forming gap (G) between them. The forming-gap arrangement comprises two opposite support members (40, 41), whose inner sides have been arranged as direct extensions of the inner sides of the lip walls (31,32) of the headbox that define the discharge duct. The support members (40,41) have been arranged to extend into the forming gap (G) as parallel to one another, so that the free ends (42) of the support members (40,41) are placed at direct proximity of, or in contact with, the forming wires (10,20). The support members (40,41) have a plate-like, isotropic or anisotropic, at least to some extent resilient construction.

Claims

1. Forming-gap arrangement in a twin-wire former of a paper machine, which twin-wire former comprises forming wires (10,20) operating one against the other, between which wires there is a twin-wire forming zone, on which dewatering and web-formation elements (11,12,13,22) are provided and which forming wires (10,20) define a wedge-shaped narrowing forming gap (G) between them, into which the slice arrangement of the headbox of the paper machine is fitted to feed the pulp suspension jet (J) from which the paper web is formed, and which headbox comprises two lip walls (31,32) placed one opposite the other, the discharge duct (33) being placed between said lip walls, which duct (33) preferably becomes narrower in the direction of flow (F) of the pulp suspension so that, in the discharge duct (33), the flow speed of the pulp suspension is increased, **characterized** in that the forming-gap arrangement comprises two opposite support members (40,41), whose inner sides have been arranged as direct extensions of the inner sides of the lip walls (31,32) that define the discharge duct, that said support members (40,41) have been arranged to extend into the forming gap (G) as substantially parallel to one another, so that the free ends (42) of the support members (40,41) are placed at direct proximity of, or in contact with, the forming wires (10,20), and that said support members (40,41) are made of a plate-like, at least to some extent resilient material.

2. Forming-gap arrangement as claimed in claim 1, **characterized** in that, in the flow direction (F) of the pulp suspension, after the ends (42) of the support members (40,41), in the forming gap, a narrowing area defined by the forming wires (10,20) follows, in which area one wire (20) or preferably both wires (10,20) are supported by a roll face (11',21').

3. Forming-gap arrangement as claimed in claim 1 or 2, **characterized** in that outside the support members (40,41), wedge-shaped nip spaces (K_0,K_1) are formed, which are defined from the sides opposite to the support members (40,41) by the runs of the forming wires (10,20) running over the rolls (11,21) and the bottoms of which nip spaces (K_0,K_1) are formed at the level of the free ends (42) of the support members.

4. Forming-gap arrangement as claimed in any of the claims 1 to 3, **characterized** in that said support members (40,41) become narrower in the flow direction of the pulp suspension towards their free ends (42) so that the mutual distance between said support members (40,41), which distance determines the thickness of the pulp suspension jet (J), remains substantially invariable.

5. Forming-gap arrangement as claimed in any of the claims 1 to 4, **characterized** in that, by the ends opposite to their free ends (42), said support members (40,41) are attached to the lip walls (31,32) across their entire width by means of fastening parts (43).

6. Forming-gap arrangement as claimed in any of the claims 1 to 5, **characterized** in that outside the support members (40,41), there are backup pieces (35,36) which support them and

which are attached to the opposite lip walls (31,32) (Fig. 2).

7. Forming-gap arrangement as claimed in any of the claims 1 to 6, **characterized** in that one or both of the support members (40,41) operate(s) in the way of a prior-art profile bar as a member for profiling of the thickness dimension of the discharge opening (A) (Fig. 2).

8. Forming-gap arrangement as claimed in any of the claims 1 to 7, **characterized** in that in connection with the extension part (42b) of both or one of the support members (40), there is a flexible rib part (34a) acting upon the outer face of said extension part, a series of regulating spindles (34) being arranged to act upon said rib part so as to profile the discharge opening, which regulating spindles (34) are adjusted by actuator motors (33).

9. Forming-gap arrangement as claimed in any of the claims 1 to 8, **characterized** in that, in connection with both or one of the support members (40), a series of detectors (51a,51b, 52a,52b) is provided, by whose means the thickness profile (h_1,h_2...h_N) of the discharge opening and/or the velocity (v_0) of the discharge jet is/are measured.

10. Forming-gap arrangement as claimed in any of the claims 1 to 9, **characterized** in that the length M of said support members (40,41) in the flow direction of the pulp suspension is in the range of M = 50...500 mm, preferably in the range of M = 100...350 mm, and that the average wall thickness S of said support members is in the range of S = 1...10 mm, preferably in the range of S = 2...5 mm.

11. Forming-gap arrangement as claimed in any of the claims 1 to 10, **characterized** in that the material of the support members is a resilient but sufficiently rigid plate material which is made of plastic-coated metal sheets and/or of fibre/composite materials.

12. Forming-gap arrangement as claimed in any of the claims 1 to 11, **characterized** in that the rigidity of the support members is, in the machine direction and in the transverse direction, anisotropic, preferably so that the rigidity of the support members (40,41) in the machine direction is substantially higher than the rigidity in the transverse direction, which has been accomplished by means of multi-layer structures, ribbed constructions, and/or by means of grooves.

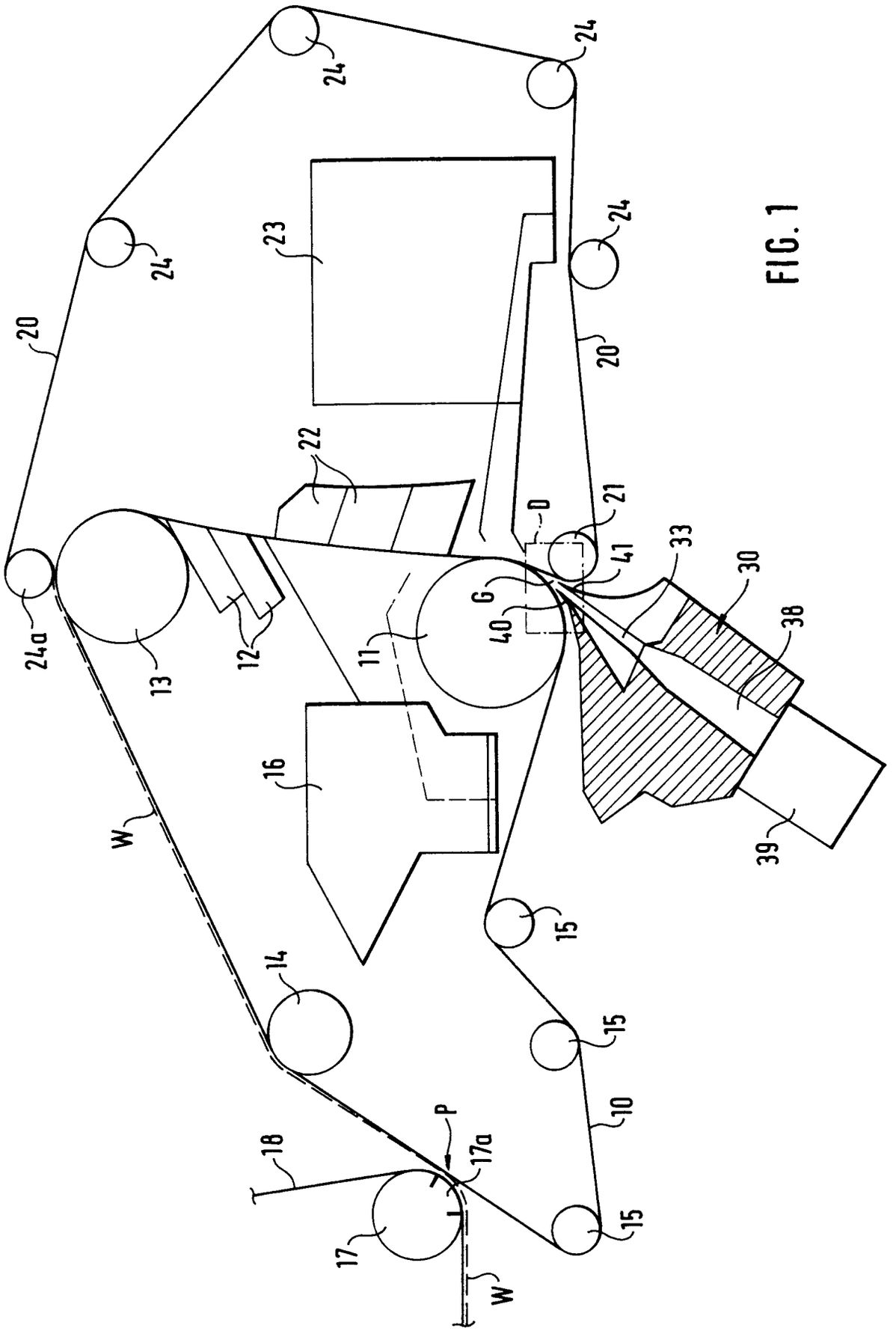
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FIG. 1

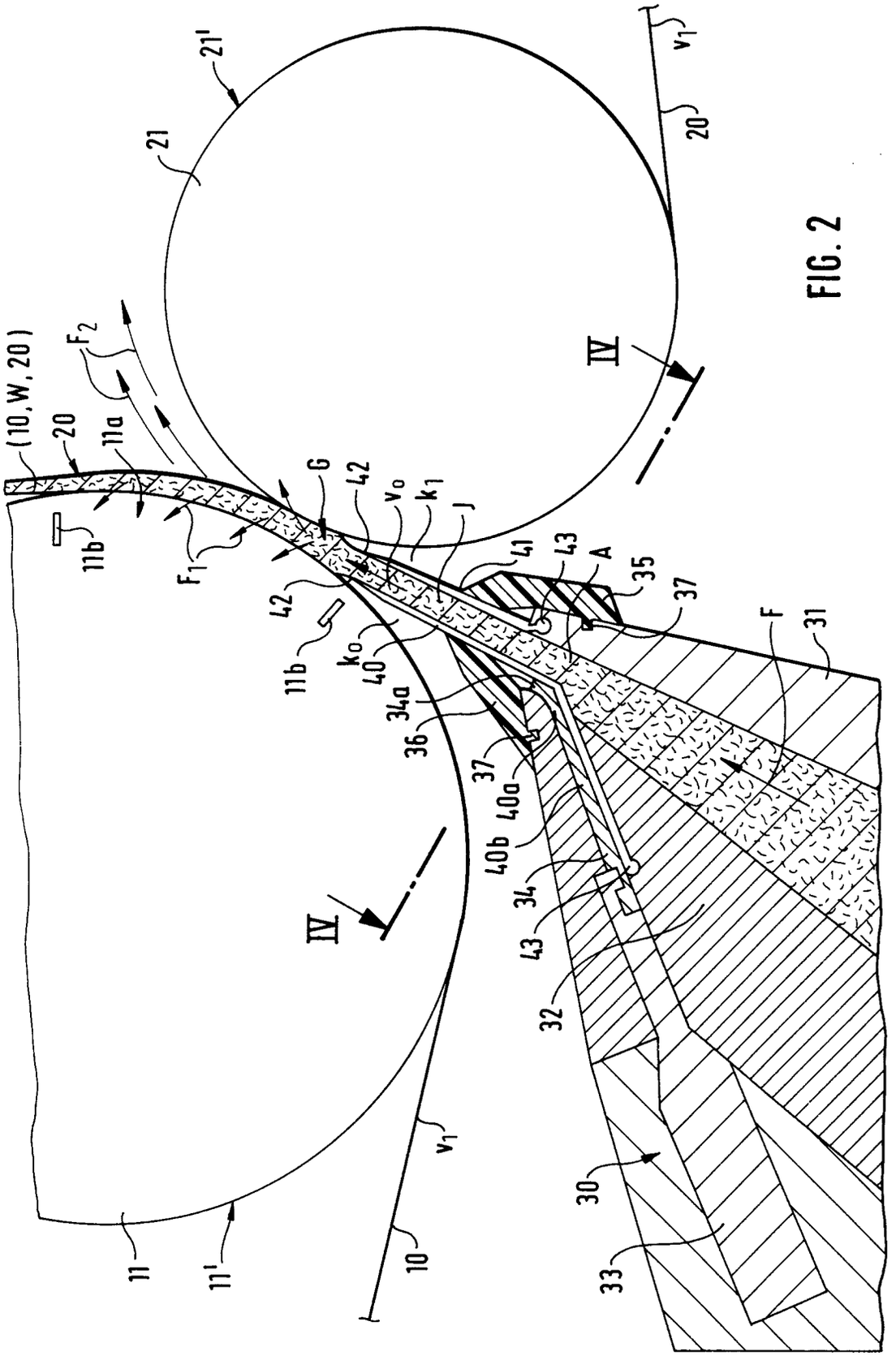
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FIG. 2

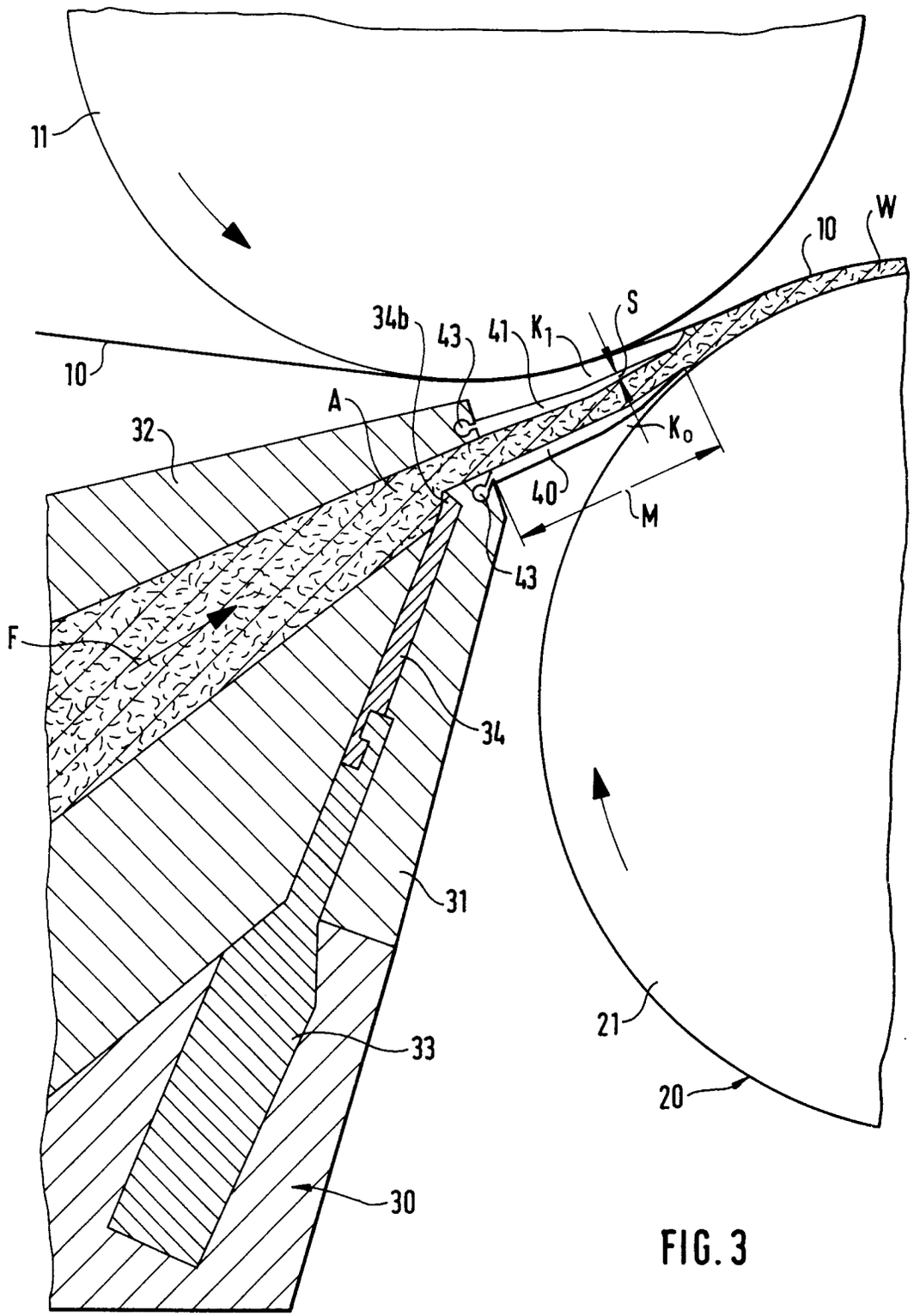
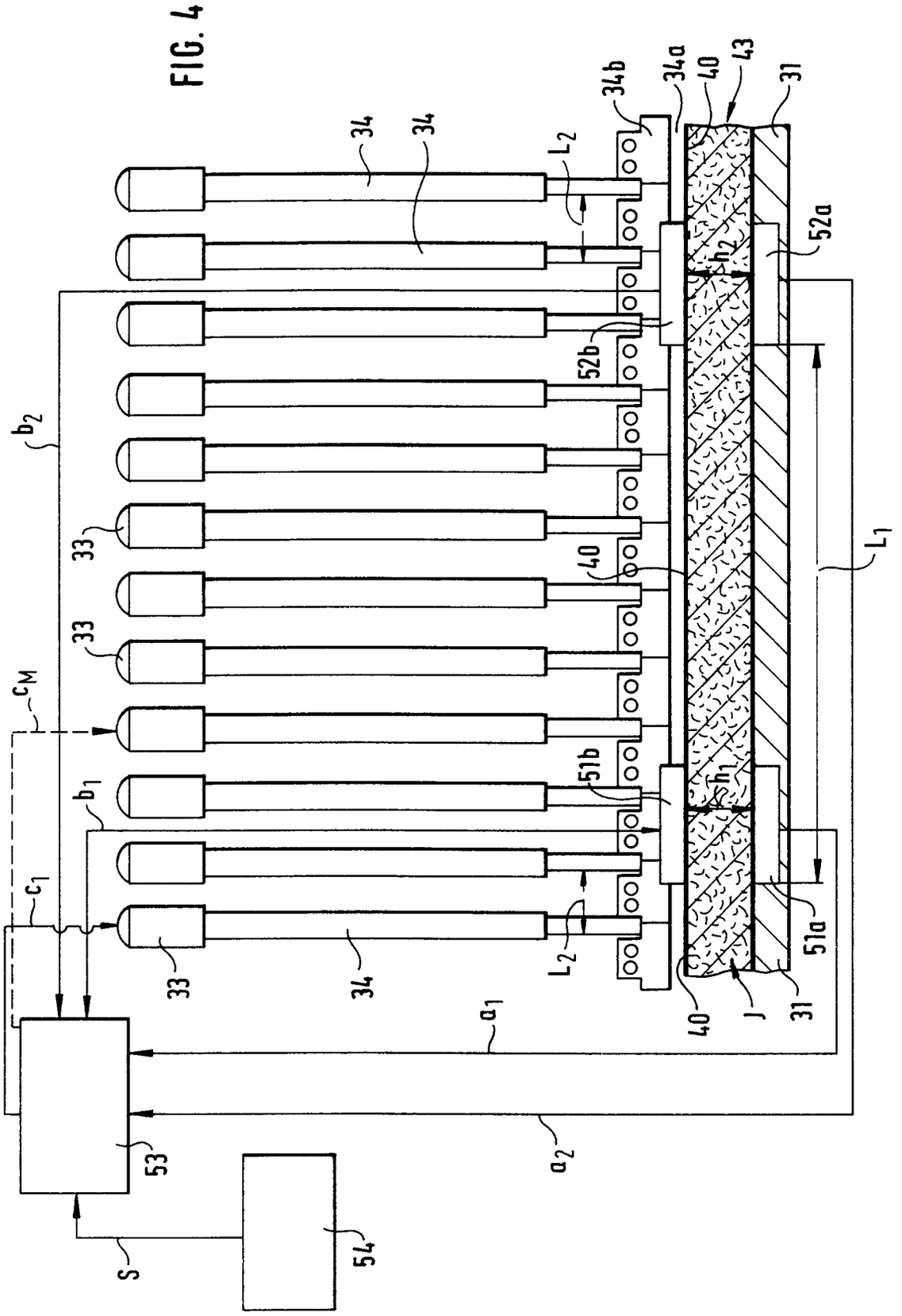


FIG. 3

FIG. 4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European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 11 9880

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	FR-A-2 014 192 (BELOIT) * page 16, line 12 - line 40; figure 2 *	1-6,11	D21F1/00 D21F9/00
X A	GB-A-1 015 841 (PAPER MACHINE COMPONENTS) * the whole document *	1-4,7,11 8	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 FEBRUARY 1992	DE RIJCK F.

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