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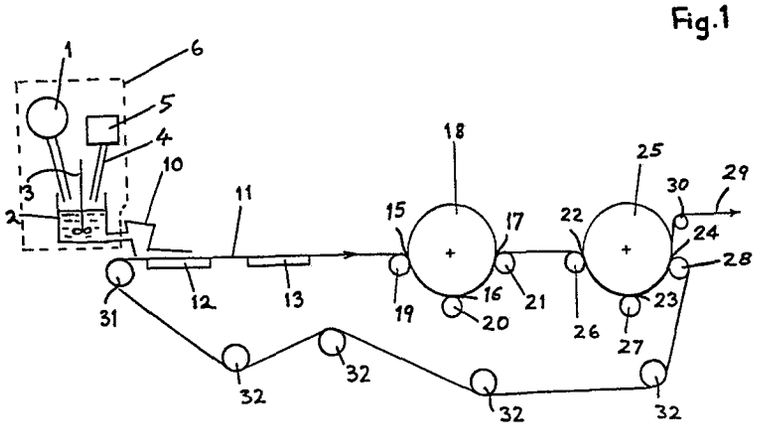
(54) Method and apparatus for use in the manufacture of paper and paperboard.

(57) In the manufacture of paper or paperboard from a non-woven web of fibrous cellulosic material, which is wet-formed on a travelling foraminous forming band (11), the aqueous paper-making stock is prepared in a defibering and mixing unit (6) from dry mechanical wood pulp. Water is added to the dry fibrous pulp produced in the unit (6) and mixed to form a stock which, preferably, has a water content of 99% by weight. The resulting stock is wet-laid on the forming band (11) to form the web which is thereafter partially dewatered by vacuum dewatering boxes (12, 13), for example, to a solids content of 10-20% by weight, and then consolidated in two press-drying stages (15-21, 22-28) to form a paper web. The web is supported by the forming band (11) during its travel through the press-drying stages and the band presses the web into contact with the drying cylinders (18, 25) between the pressure nips (15-17, 22-24) of the two stages.

Fig.1



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METHOD AND APPARATUS FOR USE IN THE MANUFACTURE OF PAPER AND PAPERBOARD

The present invention relates to the manufacture of paper and paperboard or boxboard from non-woven webs of fibrous cellulosic material and, more particularly, to the manufacture of such non-woven webs from dry mechanically prepared wood pulp.

In the conventional wet-forming process for the manufacture of paper and board, there is inevitably a large consumption of water in the preparation of the aqueous cellulosic stock. This not only results in a high overall consumption of energy, but also in potential pollution of water supplies by effluent, unless expensive preventive action is taken.

It is an object of the present invention to reduce the quantity of water required in the manufacture of paper web and to reduce the overall energy requirements of the paper-making process.

The invention consists in a method of manufacturing paper or paperboard in which a non-woven web of fibrous cellulosic material is wet-formed on a travelling foraminous forming band and dewatered, characterised by the steps of providing dry mechanically prepared pulp, adding water thereto and mixing to form an aqueous stock, wet-laying the stock onto the forming band to form the web, partially dewatering the web, and consolidating the partially dewatered web by the application of heat and pressure thereto.

The invention also consists in apparatus for manufacturing paper or paperboard in which a non-woven web of fibrous cellulosic material is wet-formed on a travelling foraminous forming band and dewatered, characterised by defibering and mixing means for providing dry mechanically prepared pulp and mixing water therewith to produce an aqueous stock, means for wet-laying said stock onto the band to produce the web thereon, dewatering means for partially dewatering said web, and consolidating means for consolidating the partially dewatered web by means of the application of heat and pressure thereto.

The dry mechanical pulp used in the method of this invention may include waste paper. Preferably, water is added to the dry pulp and mixed to form an aqueous stock containing about 99% by weight of water. The web wet-laid on the forming band or wire may be partially dewatered to a solids content of about 10-20% by weight by vacuum dewatering. It may be consolidated by advancing the partially dewatered web, supported by the forming band, through one or more pressure nips provided between one or more heated drying cylinders and cooperating pressure rollers, whilst retaining the web in contact with the or each cylinder, for at least a part of the circumference thereof, by means of the forming band. Preferably, the web is advanced through a plurality of pressure nips spaced around the or each drying cylinder, whilst supported by the forming band, the linear pressure applied by these nips being in the range from 8.5-180 kg/cm and the temperature of the or each drying cylinder being in the range from 65-250°C.

The invention enables a drying rate of 50-300 kg/sq m of effective drying surface per hour to be attained, thus providing a substantial overall reduction in energy requirements for drying the web and in the space required for drying compared with the drying arrangements in presently known paper machines. The fast drying at high temperatures and nip pressures obtainable with the invention improves web characteristics, including strength and formation. The reduced water usage in the preparation of the stock alleviates effluent pollution. In this regard, water is only added to the dry mechanical pulp immediately prior to the wet-forming process.

In order that the present invention may be more readily understood, reference will now be made to the accompanying drawings, in which:-

Fig. 1 is a diagrammatic side elevation of a first embodiment of paper-making machine in accordance with this invention for producing a single-ply wet-formed paper web;

Fig. 2 is a diagrammatic side elevation of a second embodiment for producing a three-ply wet-formed web;

Fig. 3 is a diagrammatic side elevation of a third embodiment for producing a three- ply composite web of both wet-formed and dry-formed layers; and

Fig. 4 is a block diagram illustrating the steps of the process of this invention.

Referring to Fig. 1 of the drawings, dry wood pulp is disintegrated and defibered in dry pulping apparatus, such as, breaker equipment, i.e. a hammer mill, followed by a refiner or hammer mill. Such apparatus is diagrammatically illustrated at 1 in Fig. 1. The dry particulate/or fibrous pulp thus produced is fed to a mixer unit, diagrammatically illustrated at 2, where it is mixed with water, which is delivered to the mixer by a pipe 4 leading from a water supply 5, by means of a stirrer 3. The aqueous stock produced by the mixer may, for example, have a consistency of about 99% by weight of water. The dry pulping apparatus 1, mixer unit 2, stirrer 3, pipe 4 and water supply 5 are collectively represented by a box 6, which is shown in broken outline in Fig. 1 and which will henceforth be used in Figs. 2 and 3 to indicate the equipment for defibering dry pulp and mixing it with water to form aqueous cellulosic stock, preferably, having the aforesaid consistency. Hereinafter, the equipment diagrammatically represented by the box 6 will be referred to as the "defibering and mixing unit".

Stock is supplied from the defibering and mixing unit 6 to an explosion chamber flowbox 10, which may, for example, be of the type described in British Patent No.

1548924 issued to St. Anne's Board Mill Company Limited, and is wet-laid from the flowbox onto an endless travelling foraminous forming band or wire 11 to form a web of, for example, 120 gms/sq m in weight. Disposed immediately beneath the flowbox outlet is a vacuum dewatering box 12 which reduces the water content of the stock, for example, from 99% to about 90%. A second vacuum dewatering box 13 disposed downstream of the dewatering box 12 further reduces the water content of the web, for example, to about 85% by weight, that is, about 15% solids.

Downstream of the dewatering box 13, the web, together with the forming band 11 which travels, for example, at a speed of about 70 m/min, is advanced through a first press-drying stage comprising a series of pressure nips 15,16,17 spaced around the circumference of a rotating heated drying cylinder 18 and defined by pressure rollers 19,20,21 co-operating with the drying cylinder. The latter may, for example, be 1.5 m in diameter and be heated by steam at a pressure of 2.1 kg/sq cm to give a surface temperature of about 115°C. The pressure exerted on the web and band by the nips 15,16,17 may, for example, be arranged to increase progressively from a linear pressure of 0 kg/cm at the nip 15 to 35 kg/cm at the nip 17. Over the parts of the circumference of the drying cylinder between the pressure nips, the web is retained pressed in contact with the cylinder by the forming band 11.

Upon leaving the nip 17, the web and band are guided about the pressure roller 21 to a similar second press-drying stage comprising a series of pressure nips 22,23,24 provided between a second rotating heated drying cylinder 25 and cooperating pressure rollers 26,27,28 spaced about the circumference of the drying cylinder. The forming band 11 retains the web in contact with the parts of the circumference of the drying cylinder 25 between the pressure nips 22,23,24. The drying cylinder 25 may be similar to the cylinder 18 and, likewise, be heated to a surface temperature of 115°C. The

pressure rollers 26,27,28 may be arranged to exert a linear pressure of 35 kg/cm on the web.

Upon leaving the final pressure nip 24, the resultant web 29 may have a solids content of, for example, 25-40% by weight. It is removed from the nip 24 and separated from the forming band via a take-off roller 30, whereupon it is fed to further drying equipment which may, for example, be in the form of press-driers as described in British Patent No. 1424682 issued to St. Anne's Board Mill Company Limited. The forming band 11 is removed from the nip 24 about the pressure roller 28 and is returned to the head roller 31 adjacent the flowbox 10 via guide and tensioning rollers 32.

Fig. 2 illustrates a three-ply paper making machine including a main forming and press-drying section of similar construction to the apparatus described with reference to Fig. 1. In Fig. 2, fibrous cellulosic stocks produced in defibering and mixing units 6 from dry pulp are wet-laid from explosion chamber flowboxes 40,41,42 onto endless travelling foraminous forming bands 43,44,45, respectively, to form wet-laid plies on these forming bands. The latter travel, respectively, about vacuum forming or dewatering rollers 46,47,48, disposed immediately underneath the outlets from the associated flowboxes. These vacuum forming rollers reduce the water content of the respective webs, for example, to about 85% by weight. Downstream of the forming rollers 47,48, the web on forming band 44 is transferred onto the web on the forming band 45 by transfer rollers 49 and a vacuum box 50. The band 44 is thereafter returned to the vacuum forming roller 47 via guide and tensioning roller 51. The resultant two-ply web supported on the band 45 is advanced about a roller 52 and is transferred from the band 45, onto the web laid on the forming band 43, by transfer rollers 53 and a vacuum box 54, whereafter the forming band 45 is returned to the vacuum roller 48 via guide and tensioning rollers 55.

Downstream of the transfer apparatus 53,54, the three-ply web is consolidated by advancing it, together with the band 43, through a press-drying stage comprising a series of pressure nips 56,57,58 spaced around the circumference of a rotating heated drying cylinder 59 and defined by pressure rollers 60,61,62. Between the pressure nips, the web is pressed into contact with the drying cylinder by the forming band 43. As in the previous embodiment, the drying cylinder 58 may, for example, be 1.5 m in diameter and be steam heated to a surface temperature of about 115°C. Also, the linear pressure exerted by the nips may increase progressively from 0-35 kg/cm. The resultant three-ply web 63 is removed from the nip 58 and separated from the band 43 by a take-off roller 64 and may, for example have a solids content of 25-40% by weight. It may then be fed to further drying equipment which may be in the form of press-driers of the type described in the aforementioned British Patent No. 1424682. The forming band 43 is returned to the vacuum forming roller 46 associated with the flowbox 40 via guide and tensioning rollers 64.

Fig. 3 illustrates a paper-making machine for forming a three-ply composite cellulosic web of both wet-laid and dry-laid fibrous cellulosic material and incorporates apparatus similar to that described with reference to Fig. 1. Referring to Fig. 3, wet fibrous cellulosic stock, which is prepared in a defibering and mixing unit 6 from a dry pulp, is laid from a first explosion chamber flowbox 70 onto a main endless foraminous forming band 71 to form a first ply which is immediately dewatered by a vacuum dewatering box 72. It may be partially dewatered by the box 72 to a solids content of, for example, about 15% by weight. Wet cellulosic stock, also prepared in a defibering and mixing unit 6 from dry pulp, is laid from a second explosion chamber flowbox 73 onto a second endless forming band 74 to form a second ply, which is immediately dewatered by a vacuum dewatering

box 75 to a solids content, for example, of about 15% by weight. Dry cellulosic fibres are dry-laid from a distributor 76, which may be of the construction shown in either of British Patents Nos. 1424682 or 1516573 issued to St. Anne's Board Mill Company Limited, onto an endless forming band 77 to form a third, dry-laid ply. Deposition of this dry-laid ply is assisted by suction box 78 disposed beneath the distributor 76.

The dry-laid ply is transferred from the band 77 onto the wet-ply on the band 74, downstream of the flowbox 73 and a guide roller 79, by means of transfer rollers 80 and a vacuum box 81. The band 77 is then returned to the distributor 76 via guide and tensioning rollers 82. The composite two-ply web supported on the band 74 is advanced about a guide roller 83 and is transferred onto the wet-laid web on the band 71 by means of transfer rollers 84 and a vacuum box 85 to form a three-ply web comprising the dry-laid ply sandwiched between the two wet-plies. This three-ply web may have a weight, for example, of about 250 gms/sq m. The band 74 is returned to the flowbox 73 via guide and tensioning rollers 86.

The three-ply web deposited on the forming band 71, which may, for example, travel at a speed of 50 m/min, is consolidated by advancing it successively through two press-drying stages comprising pressure nips 87-91 spaced about the circumferences of two heated drying cylinders 92,93. The construction of these press-drying stages is similar to that of Fig. 1 and between the pressure nips the web is retained in contact with the associated drying cylinders by the band 71. The drying cylinder 92 may, for example, have a diameter of 1.5 m and be steam heated to give a surface temperature of 130°C. As in the previous embodiments, the linear pressure exerted by the pressure nips associated with the cylinder 92 may be arranged to increase progressively from 0-35 kg/cm. In these circumstances, the three-ply web

leaving the nip 89 has a moisture content of about 85%. The drying cylinder 93 may, for example, be heated to a temperature of 110°C for further drying of the web to a moisture content of about 70%. The web 94 is removed from the final nip 91 and separated from the band 71 via a take-off roller 95 for further drying, as required. The forming band 71 is returned to the head roller 96 via guide and tensioning rollers 97.

In a modification of Fig. 3, a further eight pressure nips on two drying cylinders (not shown) heated to similar temperatures and employing similar pressures may be disposed downstream of the cylinder 93 to reduce the moisture content of the web, for example, to about 15%.

Instead of the dry-laid web formed on the band 77, a further wet-laid web may be produced using an explosion chamber flowbox instead of the dry-laying distributor 76. Alternatively, systems such as foam-forming or high consistency forming can be used.

The process of this invention is diagrammatically illustrated in Fig. 4. It comprises preparing dry cellulosic fibre in a first stage 100, mixing the dry fibre with water in a second stage 101 to produce an aqueous fibrous cellulosic stock having a consistency of 99% water, wet-forming a non-woven web of the stock in a third stage 102, and consolidating the web in a fourth stage 103 by press-drying to produce a self-supporting paper web.

In one specific example, dry prepared fluting medium was mixed with water to produce an aqueous stock having a consistency of 99% water, and then the stock was wet-formed and press-dried to give a fluting medium product. In a second specific example, thermo-mechanical pulp was prepared in the dry state, mixed with water, as in the first example, and then the resulting stock was wet-formed and press-dried to give a sheet of paperboard.

This invention, as well as economising on the use

of water in the preparation of stock, provides a single dewatering system with high dewatering capacity. The web produced can exhibit essentially square characteristics, that is, its strength and stiffness in the machine direction is substantially in a 1:1 ratio with the strength and stiffness in the cross-machine direction. Subsequently press-drying can result in the web characteristics described in the aforementioned British Patent No. 1424682.

Whilst particular embodiments have been described, it will be understood that modifications can be made without departing from the scope of the invention, as defined by the appended claims. For example, for special purposes, the number of pressure rollers associated with an individual drying cylinder may be increased to four, five or even six and the range of linear nip pressures may extend to 180 kg/cm. Likewise, the temperature of the drying cylinders may be varied from 65-250°C depending on the furnishes provided and the desired characteristics of the final web.

CLAIMS

1. A method of manufacturing paper or paperboard in which a non-woven web of fibrous cellulosic material is wet-formed on a travelling foraminous forming band (11) and dewatered, characterised by the steps of providing dry mechanically prepared pulp, adding water thereto and mixing to form an aqueous stock, wet-laying the stock onto the forming band (11) to form the web, partially dewatering the web, and consolidating the partially dewatered web by the application of heat and pressure thereto.

2. A method according to claim 1, characterised in that the water is added and mixed with the dry pulp to form an aqueous stock containing about 99% by weight of water, and the web is partially dewatered to a solids content of about 10-20% by weight.

3. A method according to claim 1 or 2, characterised in that the partial dewatering step comprises subjecting the web to at least one vacuum dewatering stage (12,13).

4. A method according to claim 1, 2 or 3, characterised in that the consolidating step comprises advancing the web through at least one pressure nip (15) provided between a heated drying cylinder (18) and at least one cooperating pressure roller (19) whilst supported by the forming band (11), said web being retained in contact with the drying cylinder by the forming band for at least a part of the circumference of the cylinder.

5. A method according to claim 4, characterised in that the web is advanced through a plurality of pressure nips (15,16,17) provided between said at least one drying cylinder (18) and a plurality of cooperating pressure rollers (19,20,21), and the web is retained in contact with said at least one cylinder between the pressure nips by the forming band (11).

6. A method according to claim 4 or 5, characterised in that the linear pressure applied at said at least one pressure nip (15,16,17) is in the range from about 8.5-180

kg/cm and the temperature of said at least one drying cylinder (18) is in the range from about 65-250°C.

7. A method according to any preceding claim, characterised by the steps of forming a second web of fibrous cellulosic material on a second travelling forming band (44,77), transferring said second web onto said first-mentioned web on the first-mentioned forming band (43,71) upstream of the consolidating step, and consolidating said combined webs in the consolidating step.

8. The method according to claim 7, characterised by the steps of wet-forming a third web of fibrous cellulosic material on a third travelling forming band (45,74) by providing dry mechanically prepared pulp, adding water thereto and mixing to form an aqueous stock and, wet-laying said stock on the third forming band and partially dewatering the web thereon, transferring the second web formed on the second band (44,77) onto said third web so as to combine said second and third webs together on said third band, transferring the two combined webs onto the first web upstream of the consolidating step so as to combine said three webs together on the first band (43,71), and consolidating said three combined webs in said consolidating step.

9. A method according to claim 7 or 8, characterised by the step of dry-forming the second web on the second forming band (77).

10. Apparatus for manufacturing paper or paperboard in which a non-woven web of fibrous cellulosic material is wet-formed on a travelling foraminous forming band (11) and dewatered, characterised by defibering and mixing means (6) for providing dry mechanically prepared pulp and mixing water therewith to produce an aqueous stock, means (10) for wet-laying said stock onto the band (11) to produce a web thereon, dewatering means (12,13) for partially dewatering said web, and consolidating means

(15-28) for consolidating the partially dewatered web by means of the application of heat and pressure thereto.

11. Apparatus according to claim 10, characterised in that the consolidating means comprises press-drying means disposed downstream of the partial dewatering means (12,13), said press-drying means including at least one heated drying cylinder (18) and at least one cooperating pressure roller (19) defining at least one pressure nip (15) with the cylinder, and said forming band being guided through said at least one pressure nip and about at least a part of the circumference of the cylinder (18), whereby the web is advanced through said at least one pressure nip and is retained in contact with at least a part of the circumference of the cylinder (18).

12. Apparatus according to claim 11, characterised in that the press-drying means includes at least one second drying cylinder (25) and at least one second pressure roller (26) cooperating therewith to define at least one second pressure nip (22), said forming band (11) being guided from said first-mentioned cylinder (18) through said at least one second pressure nip (22) and about at least a part of the circumference of the second cylinder (25), whereby the web is also advanced through said at least one second pressure nip and is retained in contact with at least a part of the circumference of the second cylinder.

13. Apparatus according to claim 10,11 or 12, characterised by means (41,76) for forming a second web of fibrous cellulosic material on a second travelling foraminous forming band (44,77), and means for transferring said second web onto said first-mentioned web upstream of the consolidated means (56-62,87-93).

14. Apparatus according to claim 13, characterised by means (6,42,73) for wet-forming a third web of fibrous cellulosic material on a third travelling foraminous

forming band (45,74), in which dry mechanically prepared pulp is mixed with water to form an aqueous stock which is wet laid on the third band and is partially dewatered, means (49,50 or 80,81) for transferring the second web onto the partially dewatered third web on the third band (45,74), and means (53,54 or 84,85) for transferring the combined second and third webs onto the first partially dewatered web on the first band (43,71) upstream of the consolidating means.

15. Apparatus according to claim 14, characterised in that the means for forming the second web on the second band (77) comprises means (76) for dry-laying said web on the second band.

Fig.1

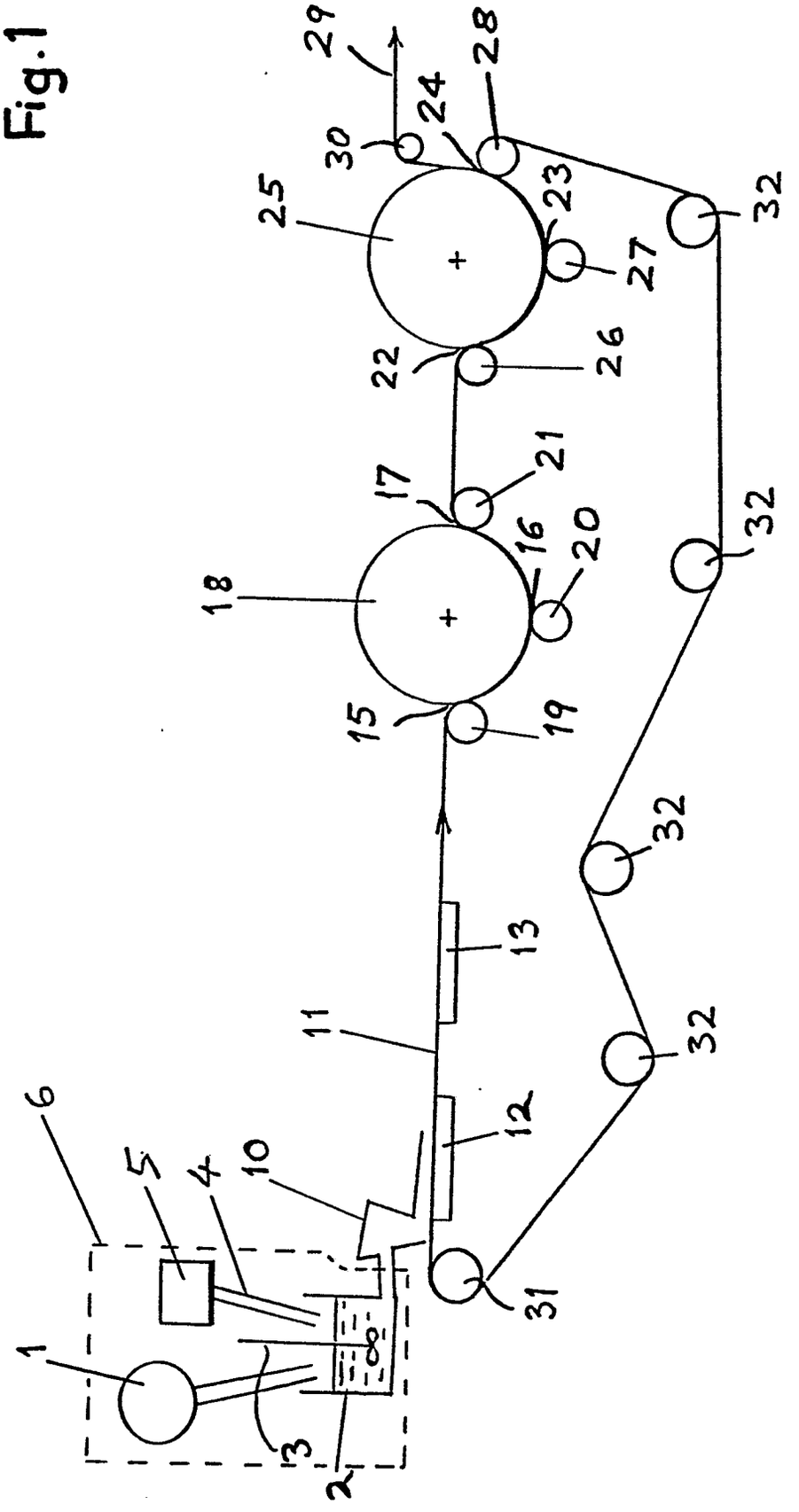
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Fig.2

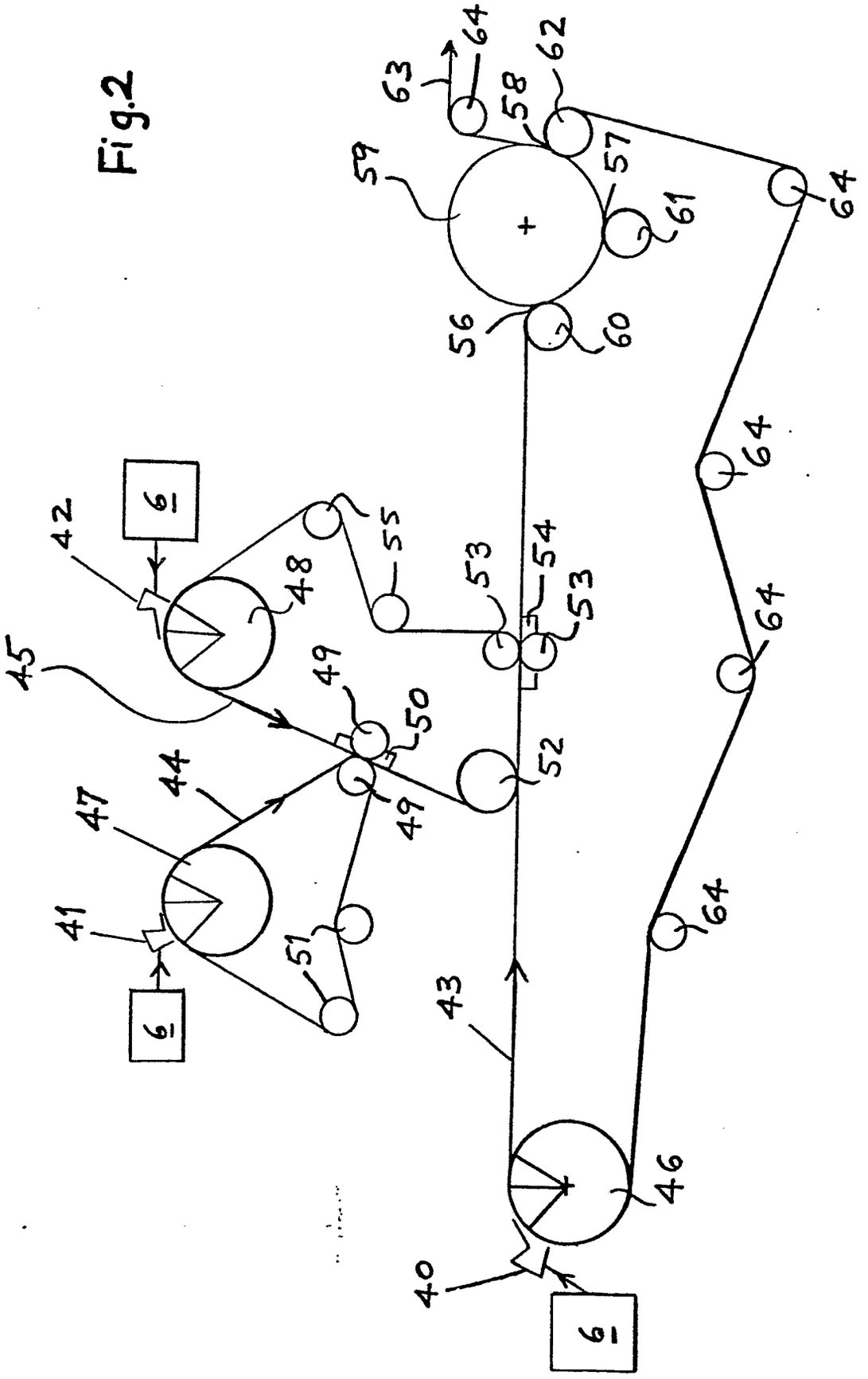
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Fig.3

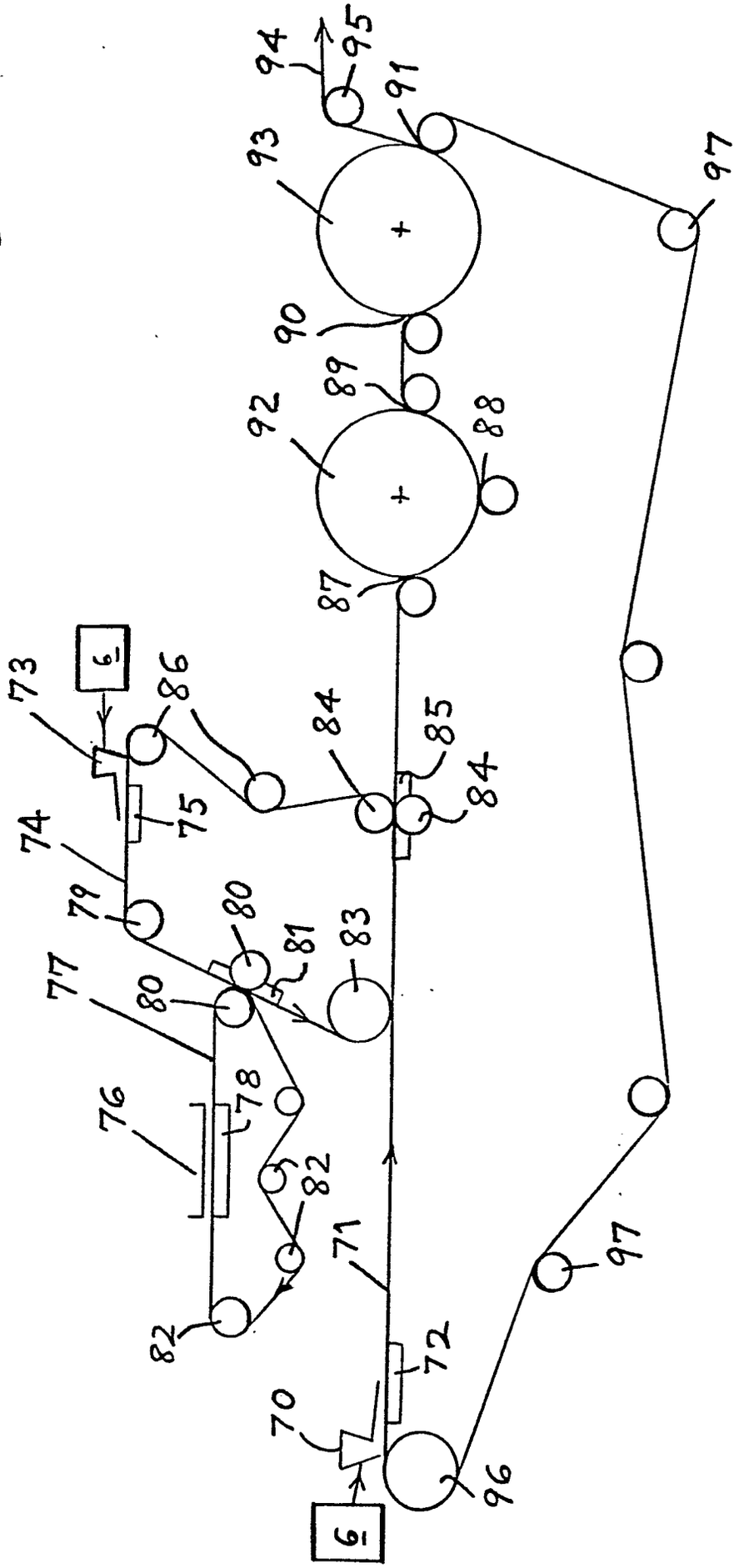
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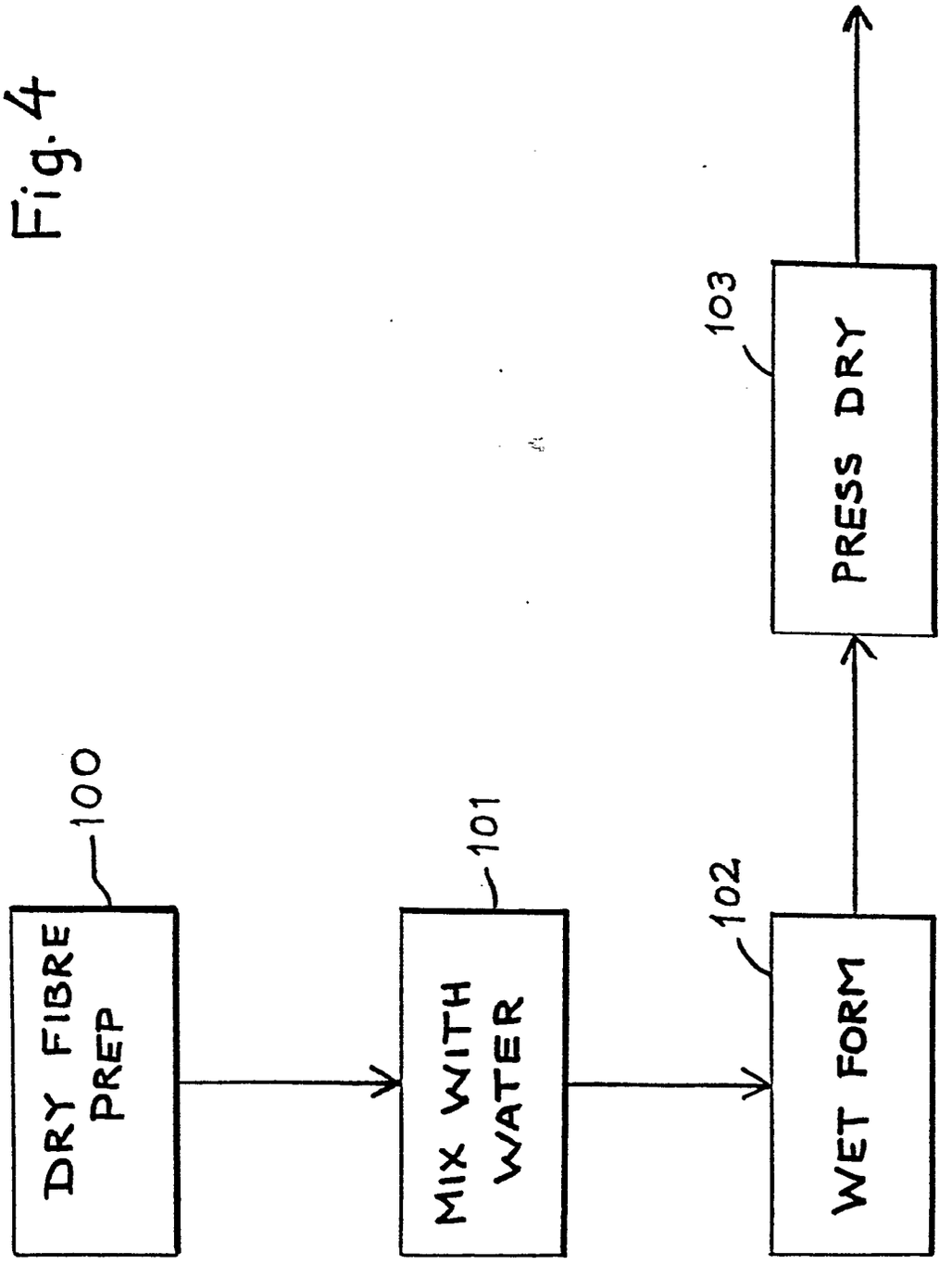
Fig. 4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