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(54) Method and apparatus for manufacturing paper and paperboard.

(57) In the manufacture of paper or paperboard, a web of fibrous cellulosic material is wet-formed on an endless foraminous forming band (11), is partially dewatered in a vacuum dewatering stage (13) and is then dried. In order to improve drying of the web and reduce energy consumption and space utilization, the partially dewatered web is subjected to a press-drying stage whilst supported by the forming band (11). In this press-drying stage, the web and band are advanced through a plurality of pressure nips (15-24) provided between two rotating heated drying cylinders (18,25) and a plurality of cooperating pressure rollers (19-28), and the web is pressed into contact with the circumferences of the cylinders between the pressure nips by the forming band (11).

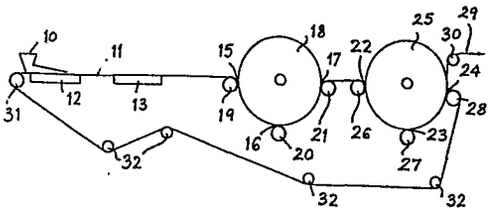

Fig.1

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METHOD AND APPARATUS FOR MANUFACTURING PAPER AND PAPERBOARD

The present invention relates to the manufacture of paper and paperboard from wet-formed webs of fibrous cellulosic material and, more particularly, to the drying or dewatering of such webs.

In the conventional wet-forming process for the manufacture of paper and paperboard, the largest single consumption of energy occurs in the drying of the wet-formed web. Typically, drying is achieved by feeding the web over a large number of drying cylinders, which are usually steam heated, and the drying section of a paper-making machine may extend over many tens of metres. In this conventional process, the rate of removal of water from the web during the drying stage is of the order of 14kgs per sq metre of effective drying surface per hour. Such a drying rate is expensive and inefficient in terms of energy consumption, utilisation of space, and rate of production of the final web or sheet.

Objects of the present invention are to provide a method and apparatus for manufacturing paper and paperboard which produce improved drying or dewatering of a wet-formed web of fibrous cellulosic material, which reduce energy consumption, and which enable the construction of more compact paper-making machines occupying less space than hitherto known machines.

From one aspect, the invention consists in method of manufacturing paper or paperboard, including wet-forming a web of fibrous cellulosic material on a travelling foraminous forming band and partially dewatering the web on the band, characterised by the steps of press-drying the partially dewatered web by advancing the web through one or more pressure nips provided between one or more rotating heated drying cylinders and one or more cooperating pressure rollers, and retaining the web in contact with the or each drying cylinder by means of the forming band for at least a part of the

circumference of the or each cylinder.

From another aspect, the invention consists in apparatus for manufacturing paper or paperboard, including means for wet-forming a web of fibrous cellulosic material on a travelling foraminous forming band, and means for partially dewatering the web on said band, characterised by press-drying means disposed downstream of the partial dewatering means and comprising one or more rotatable heated drying cylinders and one or more cooperating pressure rollers defining one or more pressure nips, said forming band being guided through the pressure nip or nips and about at least a part of the circumference of the or each drying cylinder, whereby the web is advanced through the pressure nip or nips and is retained in contact with at least a part of the circumference of the or each cylinder.

The web may be partially dewatered on the forming band by a vacuum dewatering stage to a solids content of 10-20% by weight in order to provide it with sufficient strength and integrity to withstand the treament in the press-drying stage. In the press-drying stage, it may be fed through a plurality of pressure nips spaced around the drying cylinder whilst supported by the band, the linear pressure applied by these nips being in the range from 8.5-180kg/cm and the temperature of the cylinder being in the range from about 65-250°C.

In one preferred embodiment of the press-drier, the web is successively advanced through a plurality of pressure nips provided between a single set or series of drying cylinders and cooperating pressure rollers, whilst supported by the forming band, and the band retains the web pressed in contact with a part of the circumference of each cylinder of the series. With this arrangement, the same side of the web is pressed against each drying cylinder.

In another embodiment for pressing opposite sides

of the web against successive drying cylinders, the web is alternately advanced about the drying cylinders and through the associated pressure nips of two sets of cylinders, the web being supported in contact with the cylinders of one set by the forming band and the cylinders of the other set by a second, separate, travelling foraminous band.

The invention enables a drying rate of better than 200kgs per sq metre of effective drying surface per hour to be achieved, thus providing a substantial overall reduction in energy consumption for drying the web and in the space required for drying compared with the drying or dewatering arrangements of hitherto known paper-making machines. The fast drying at high temperatures and nip pressures achievable with the invention improves web characteristics, such as, strength and formation.

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 one embodiment of paper-making machine constructed in accordance with this invention for manufacturing paper from a single ply wet-formed web;

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

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

Fig. 4 is a diagrammatic side elevation of a forth embodiment in which both sides of a wet-formed web are pressed against heated drying cylinders during the press-drying stage.

Referring to Fig. 1 of the drawings, solid bleach cellulosic fibre stock is wet-laid from an explosion chamber flowbox 10, of the type described in British Patent No. 1548924 issued to St. Anne's Board Mill Company Limited, onto an endless travelling foraminous forming band or wire 11 to form a web, for example, of 120gms/sq m in weight. Disposed immediately beneath the explosion chamber outlet is a vacuum dewatering box 12 which reduces the water content of the stock, for example, from about 99% to about 90%. A second vacuum dewatering box 13 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 band 11, which travels for example at a speed of about 70m/min, are advanced through 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 cooperating with the drying cylinder. The latter may, for example, be 1.5 metres in diameter and be heated by steam at 2.1kg/sq cm pressure 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 nip 15 to 35kg/cm at nip 17. Over the parts of the circumference of the drying cylinder between the pressure nips, the web is retained 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 second series of similar 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 about 115°C. The pressure rollers 26,27,28 may be arranged to exert a linear pressure of 35kg/cm on the web and band passing through the associated pressure nips.

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 band via a take-off roll 30, whereupon it is fed to further drying equipment which may be in the form of press driers as described in British Patent No. 1424682 issued to St. Anne's Board Mill Company Limited or British Specification No. 2052586A assigned to the present assignee. The 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 machine described with reference to Fig. 1. In Fig. 2, cellulosic fibrous stocks 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 about vacuum forming or dewatering rollers 46,47,48, respectively, disposed immediately underneath the outlets from which the flowboxes 40,41,42. 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 the band 44, is transferred onto the web on the 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 rollers 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 deposited on the forming band 43 by transfer rollers 53 and a vacuum box 54.

Downstream of the transfer apparatus 53,54, the three-ply web together with the band 43 is advanced through a press-drying section comprising a series of pressure nips 55,56,57 spaced around the circumference of a rotating heated drying cylinder 58 and defined by pressure rollers 59,60,61 cooperating with this drying cylinder. Between the pressure nips the web is retained in 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 metres 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 62 is removed from the nip 57 and separated from the band 43 by a take-off roller 63 and may, for example, have a solids content of 25-40% by weight. It is then fed to further drying equipment which may be in the form of press-driers as described in the aforementioned British Patent No. 1424682 or British Specification No. 2052586A. 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 cellulosic fibrous material and incorporates apparatus similar to that described with reference to Fig. 1 as the main wet-forming and press-drying sections. Referring to Fig. 3, wet cellulosic stock 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 partially dewatered by a vacuum dewatering box 72 to a solids content, for example, of about 15% by weight. Wet cellulosic stock is also wet-laid from a second explosion chamber flowbox 74 onto a second endless forming

band 75 to form a second ply, which is immediately partially dewatered by a vacuum dewatering box 76 to a solids content, for example, of about 15% by weight, and dry cellulosic fibres are dry-laid from a distributor 77, 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 78 to form a third, dry-laid ply. Deposition of this dry-laid ply is assisted by a suction box 79 disposed beneath the distributor 77.

The dry-laid ply is tranferred from the band 78 onto the wet-ply on the band 75 downstream of the flowbox 79 and a guide roller 80 by means of transfer rollers 81 and a vacuum box 82. The band 78 is then returned to the distributor 77 via guide and tensioning rollers 83. The composite two-ply web supported on the band 75 is advanced about guide roller 84 and is transferred onto the web on the band 71 by means of transfer rollers 85 and a vacuum box 86 to form a three-ply web which may, for example, be about 250gms/sq m in weight. The three-ply web thus supported on the band 71, which may, for example, travel at a speed of 50 metres/min, is press-dried by advancing it through pressure nips 87-91 spaced about the circumferences of two successive drying cylinders 92,93. The construction of this press-drying section is similar to that of Fig. 1, and between the pressure nips the web is retained in contact with the associated drying cylinders 92,93 by the band 71. The drying cylinder 92 may, for example, have a diameter of 1.5 metres 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 0-35kgs/cm. In these circumstances, the three-ply web leaving the nip 89 has a moisture content of about 75%. 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, a further eight pressure nips on two drying cylinders (not shown) heated to similar temperatures and pressures may be disposed downstream of the take-off roller 95 to reduce the moisture content of the web, for example, to about 15%.

Instead of the dry-laid web formed on the band 78, a further wet-laid web may be produced using an explosion chamber flowbox instead of the dry-laying distributor 77. Alternatively, systems such as foam-forming or high consistency forming may be used.

In the embodiments described above, only one side of the web of fibrous cellulosic material supported on a forming band is pressed against the drying cylinders. Fig. 4 illustrates a paper-making machine according to the invention in which opposite sides of the web are successively pressed against drying cylinders during the press-drying stage. In the machine illustrated in Fig. 4, cellulosic fibrous stock is wet-laid from an explosion chamber flowbox 100 onto an endless travelling foraminous forming band 101 to form a web of cellulosic fibrous material. Disposed immediately beneath the explosion chamber outlet is a vacuum dewatering box 102 and a second vacuum dewatering box 103, is disposed downstream thereof for futher reducing the water content of the web before it is advanced to the press-drying section. Downstream of the box 103, the forming band 101 is advanced through a series of pressure nips 104-112 spaced about the circumference of a first set of three rotating heated drying cylinders 113,114,115 similarly to the machine illustrated in Fig. 1. Upon leaving the final pressure nip 112, the band 101 is guided

about the associated pressure roller and returned to the head roller 117 via guide and tensioning rollers 118. The press-drying section also includes a second set of two rotating heated drying cylinders 119,120, each of which is provided with two pressure nips 121,122 formed by co-operating pressure rollers 123,124 and a separate endless foraminous backing band 125 which is fed through the nips 121,122 and about the cylinders 119,120 between the nips. Between the cylinders 119,120 the band 125 is guided by a guide roller 126.

In operation, the web 127 supported on the band 101 is advanced through the pressure nips 104,105,106 spaced about the drying cylinder 113 and, upon leaving the nip 106, the web is separated from the forming band 101 and is fed to the drying cylinder 119 where it is advanced through the associated pressure nips 121,122 and is supported on the cylinder 119 between the nips by the backing band 125. After passing through the pressure nip 122 on cylinder 119, the web is separated from the backing band 125 and is fed to the drying cylinder 114, where it is again supported by the band 101 during travel through the pressure nips 107,108,109, and so on. In this manner, the web 127 is alternately advanced about the drying cylinders of the two sets until it is eventually removed from the final nip 112 on the drying cylinder 115 and separated from the band 101 via a take-off roller 128 for further drying or dewatering treatment, as required. Hence, both sides of the web are pressed against drying cylinders during the press-drying process. Moreover, the web is retained in contact with each cylinder, between the associated pressure nips, by the associated band 101,125 but is unsupported in its travel between successive drying cylinders. These free runs of the web between successive drying cylinders, which may, for example, be two metres or more in length, facilitate evaporation from the web 127 and reduce

delamination problems. Nip pressures and temperatures are typically similar to those described with reference to Fig. 1, but can be varied in accordance with individual web requirements.

This invention provides a single dewatering system with high dewatering capacity. The web produced by the invention 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. Subsequent press-drying can result in the web characteristics described in the aforementioned British patent No. 1424682. A further advantage of the invention is that strength can be developed in the web from various fibrous furnishes having little previous mechanical treatment, such as, refining.

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 appending 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 nip pressures may extend up to 180kgs/cm. Likewise, the temperature of the drying cylinders may be varied from 65-150°C depending on the furnishes provided and the desired characteristics of the final web.

CLAIMS

1. A method of manufacturing paper or paperboard, including wet-forming a web (29) of fibrous cellulosic material on a travelling foraminous forming band (11) and partially dewatering the web on the band, characterised by the steps of press-drying the partially dewatered web by advancing the web through one or more pressure nips (15-24) provided between one or more rotating heated drying cylinders (18-25) and one or more cooperating pressure rollers (19,28), and retaining the web in contact with the or each drying cylinders by means of the forming band (11) for at least a part of the circumference of the or each cylinder.

2. A method as claimed in claim 1, characterised in that the press-drying step includes advancing the forming band (11) together with the web (29) successively through a plurality of pressure nips (15-24) provided between a plurality of drying cylinders (18,25) and cooperating pressure rollers (19,28), the arrangement being such that the same side of the web is pressed against each of the drying cylinders.

3. A method as claimed in claim 1, characterised in that the press-drying step includes alternately advancing the web (127) about the cylinders and through the associated pressure nips of two sets (113-115 and 119,120) of drying cylinders, and retaining the web in contact with the cylinders of one set by means of the forming band (101) and the other set by means of a separate travelling foraminous band (125), the arrangement being such that opposite sides of the web (127) are alternately pressed against the drying cylinders.

4. A method as claimed in claim 1, 2 or 3, characterised in that the web is advanced through a plurality of pressure nips provided between the or each drying cylinder and a plurality of cooperating pressure rollers.

5. A method as claimed in claim 1, 2, 3 or 4,

characterised in that the partial dewatering step dewaters the web to a solids content of about 10-20% by weight.

6. A method as claimed in any preceding claim, characterised in that the partial dewatering step comprises subjecting the web at ambient temperature to a region of reduced atmospheric pressure.

7. A method as claimed in any preceding claim, characterised in that the linear pressure applied at the or each pressure nip is in the range of from 8.5-180kg/cm and the temperature of the or each drying cylinder is in the range from 65-250°C.

8. A method as claimed in any preceding claim, characterised by the steps of forming a second web of fibrous cellulosic material on a second travelling forming band (44 or 45, 75 or 78), transferring the second web onto the first-mentioned web on the first-mentioned forming band (43,71) upstream of the press-drying stage, and press-drying the combined webs in said press-drying step.

9. A method as claimed in claim 8, characterised by the step of dry-forming the second web on the second forming band (78).

10. A method as claimed in claim 8 or 9, characterised by the steps of wet-forming a third web of fibrous cellulosic material on a third travelling forming band (45,75), partially dewatering the third web on the third band, transferring the second web formed on the second band (44,78) onto the third web so as to combine said second and third webs together, transferring the two combined webs onto the first web upstream of the press-drying stage, and press-drying the three combined webs in said press-drying step.

11. Apparatus for manufacturing paper or paperboard, including means (10) for wet-forming a web of fibrous cellulosic material on a travelling foraminous forming

band (11), and means (13) for partially dewatering the web on said band, characterised by press-drying means disposed downstream of the partial dewatering means (13) and comprising one or more rotatable heated drying cylinders (18,25) and one or more cooperating pressure rollers (19,28) defining one or more pressure nips (15-24) said forming band being guided through the pressure nip or nips and about at least a part of the circumference of the or each drying cylinder, whereby the web (29) is advanced through the pressure nip or nips and is retained in contact with at least a part of the circumference of the or each cylinder.

12. Apparatus as claimed in claim 11, characterised in that the drying cylinders and cooperating pressure rollers are arranged in two sets (113,114,115 and 119,120), the forming band (101) is guided about the cylinders (113,114,115) and through the associated pressure nips (104-112) of one set, and a separate foraminous band, is guided about the cylinders (119,120) and through the associated pressure nips (121,122) of the other set, whereby the web (127) can be alternately advanced about the cylinders and associated pressure nips of the two sets so that the opposite sides of the web are alternately pressed against successive drying cylinders.

13. Apparatus as claimed in claim 11 or 12, characterised by means (41,47 or 77,79) for forming a second web of fibrous cellulosic material on a second travelling foraminous band (44,78), and means (45,53,54 or 75,85,86) for transferring the second web onto the first-mentioned web upstream of the press-drying means.

14. Apparatus as claimed in claim 13, characterised by means (42,48 or 74,76) for wet-forming a third web of fibrous cellulosic material on a third travelling foraminous band (45,75), means (48,76) for partially dewatering the third web, means (49,50 or 81,82) for transferring the

second web onto the partially dewatered third web on the third band, and means (53,54 or 85,86) for transferring the combined second and third webs onto the first partially dewatered web on the first band (43) upstream of the press-drying means.

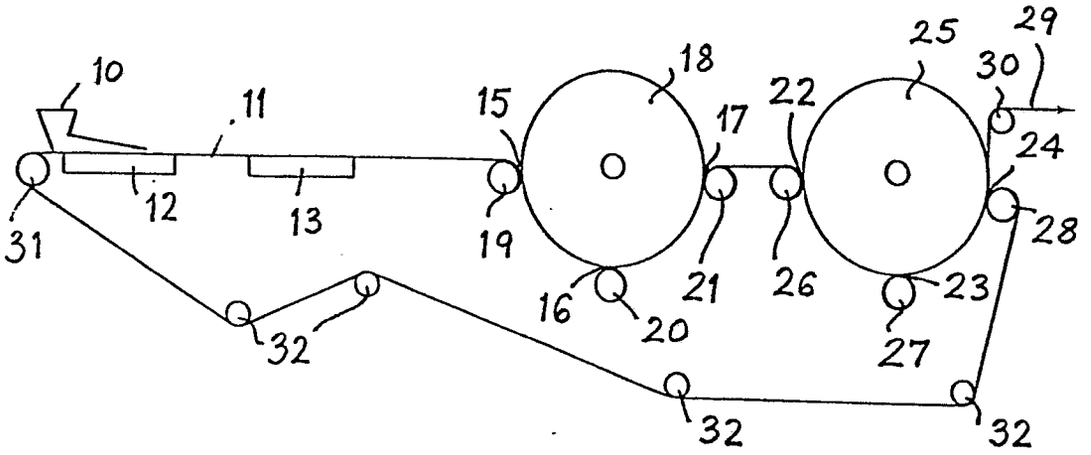
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Fig.1

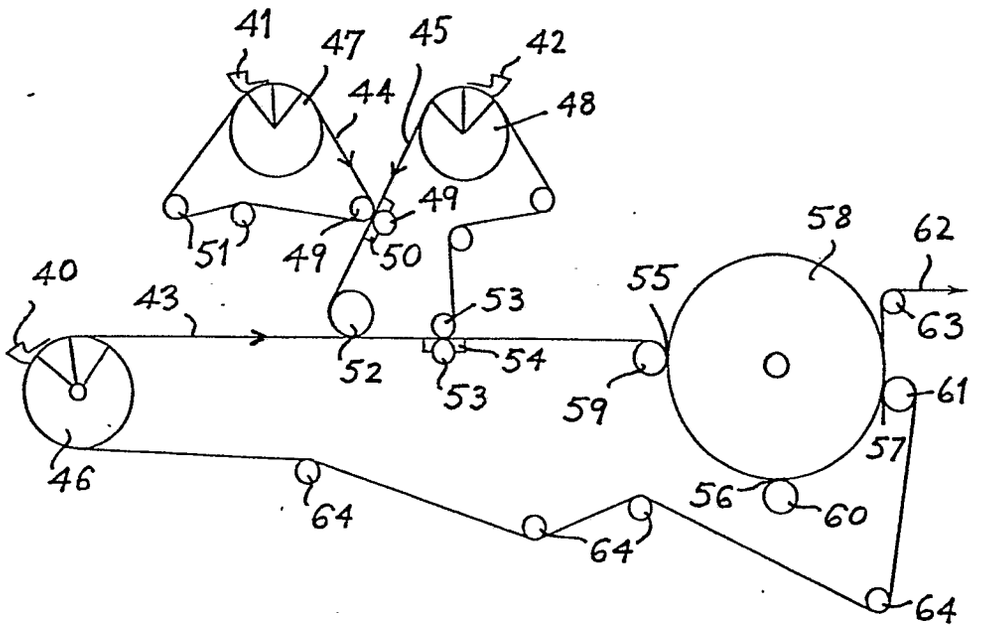
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Fig.2

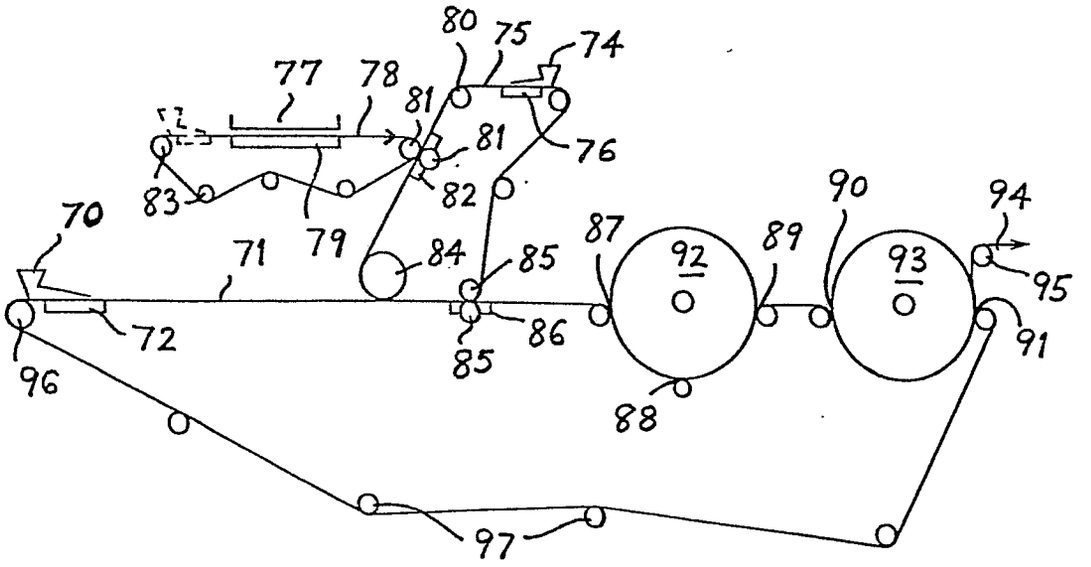
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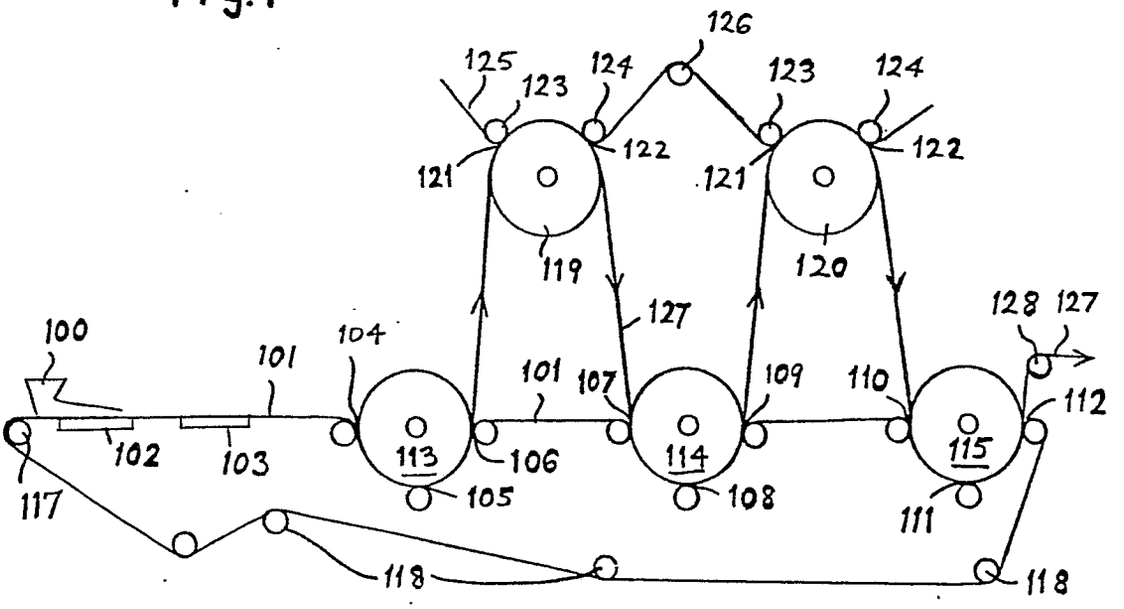
Fig.3

Fig.4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