MULTI-PLY PAPER FORMATION
Jerome P. Brezinski, Neenah, Wis., assignor to Beloit Corporation, Beloit, Wis.
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ABSTRACT OF THE DISCLOSURE

This invention relates to a paper making machine for forming a plural or multi-ply web using more compact and efficient ply-forming sequences than are ordinarily employed in conventional cylinder machines. This is done in each such sequence by the use of a single web ply-forming zone defined between a main felt carrying a pre-formed ply and a converging forming web wrapped over a web guide or suction box designed for efficient and rapid water removal via the wire, with quality incipient web formation in the ply so formed, followed immediately by merging of such ply into the desired multi-ply moist web of good quality. In this arrangement, the felt carries the resultant multi-ply web from sequence to sequence thereby allowing for intermediate dewatering at press nips receiving the felt carrying the resultant web in each instance.

In the conventional cylinder mold-type of board machine, there will be a plurality of cylinder mold devices aligned in longitudinal succession, and each of these devices has certain limitations as to overall capital expenditure, speed of operation, flow control of stock and the like. In such arrangement, however, a large top felt is employed to pick-up successive plies of multi-ply paper web from each of the successive cylinder mold devices.

In certain more recent developments involving web formation between pairs of forming wires, there has been developed a machine involving the use of a substantial bottom wire which is operated with a plurality of top wires and top stock guide or suction boxes mounted in longitudinal succession, so that each stock inlet device may feed stock onto the bottom wire (or onto a preformed paper ply carried by the bottom wire) and one of the top shorter forming wires is then pressed down against the stock on the bottom wire and dewatering of such stock is effected primarily through the short top wire that is associated with the specific stock inlet in question. In this way, successive superimposed plies of web are applied onto the main bottom forming wire. In disclosures relating to the plural wire paper formers of this general type, there are various suggestion concerning both suction and pressure mechanisms for dewatering the stock and also in U.S. Pat. No. 2,881,676, for example, there is at least a general suggestion that the location of the various wires could be reversed with the main wire serving as a top wire and the shorter wires serving as bottom wires.

In the instant invention, a number of extremely practical advantages are achieved by the particular arrangement employed, which involves the use of a top main felt (as contrasted to a wire) in combination with a plurality of bottom short wires which are mounted in conjunction with certain specific guiding and dewatering devices in order to effect most efficiently the formation of the individual incipient web plies and their merger with and into a main multi-ply web carried on the top main felt. In this arrangement the top main felt may be subjected to a number of treatments which would not be practical for a conventional forming wire, e.g., subjecting such felt with the multi-ply web thereon to the pressures of a conventional press nip or simply causing such felt to pass through a number of comparatively abrupt turns or directional changes. Likewise, the present invention provides for very simple travel paths for each of the comparatively short forming wires used in each ply-forming sequence of the device, so that the advantages of web formation on a forming wire may be obtained without many of the disadvantages or increased expenses that might be incurred relative to the use of forming wires (or plastic wires for that matter) which are expensive per se and are also expensive in terms of lost production when it is necessary to replace the same. Still another extremely important advantage of the present invention resides in the felt and wire arrangements and each of the sequences which make possible the most advantageous control and handling of the water that is necessarily involved in the movement and the dewatering of stock.

Other features and advantages of the present invention will become apparent to those skilled in the art from the following detailed disclosure thereof and the drawings attached hereto and made a part hereof.

On the drawings:
FIGS. 1A and 1B show, in sequence, an essentially schematic elevational view of a paper machine embodying the instant invention; and
FIG. 2 shows a schematic elevational view of essential parts of another embodiment of the instant invention.

As shown on the drawings:
In FIGS. 1A and 1B, it will be noted that FIG. 1B is a continuation from the right hand side of FIG. 1A; and in the views of FIGS. 1A and B it will be seen that there is certain of the main framing 10 in terms of a succession of longitudinally spaced upright frames 11a, 11b, 11c, and 11d which are secured in conventional manner to the operating floor F and which carry a main top cross beam 12 and sections of a central cross beam structure 13a, 13b, 13c, and 13d being shown connected to a secondary upright frame 11e which in turn is connected by a cross beam 13e to the main upright 11d. It will be appreciated that the framing 10, 11, 12, and 13 is only a skeleton for the overall structure (not shown) for mounting bearings thereon in longitudinal roll shown and similar other drive and tensioning equipment conventional to paper making machines and not shown herein.

At the outset it should be pointed out that the main top felt 14 is not shown in its entirety; but the main portion of its top run 14b is indicated as moving from right to left in the views of FIGS. 1A and B (as indicated by arrowheads) and it will be appreciated that in a region (not shown) to the left of FIG. 1A the main top felt 14 will pass through conventional felt conditioning, pressing and tensioning devices (not shown) and it will then return again in the direction indicated by the arrows as the bottom run 14c through each of the longitudinally successive ply-forming sequences indicated at S1, S2, S3, and S4, respectively. In each such sequence S1, etc. the bottom felt 14a will pick up an additional ply of web, here indicated in the case of the very first ply as P1 at the first sequence S1; after the second sequence S2, here indicated as the composite of the first two plies P12; at the end of the third sequence S3 here indicated as the composite of the three plies P123; and at the exit of the fourth sequence S4 here indicated as the ultimate composite of the four plies P1234, which is actually the integral or emergent web ultimately formed in the four sequence machine here indicated and it then passed upwardly into a pasting and dewatering nip N4 between a rubber covered roll 49 and a suction drum 48. At the nip N4 it will be noted that the composite web is covered with a press felt 15 which is essentially conventionally mounted on guide rolls 15a through 15d, a tensioning roll 15e, and passes through wringer rolls 15f, 15g. This felt 15 remains over
the top of the composite web as it passes on through a second dewatering nip N4a between the suction drum 48 and another rubber covered roll 49a, then on through a plain pressure nip N11 between a rubber covered roll 16a and 16b and on through a suction primary press nip N11 between a rubber covered roll 17a and a suction roll 17b, at which location the press felt 15 separates from the top run 14f of the previously described main upper felt 14c of the machine. The resulting pressure-sensitive composite web W1234 is then ordinarily carried away on the top of the felt run 14b and taken from there by conventional pickup means (not shown).

Referring now to the operation of the instant machine at a single sequence, as the sequence S2 shown in FIG. 1A, it will be noted that there is shown a short looped forming wire 24 which may be made of the conventional woven forming wire structure but is preferably formed of a plastic wire structure that is well known in the trade. In any event the wire 24 is functionally a paper-forming wire and it is mounted more or less conventionally on guide rolls 21a through 21f, which indicate 21f is a driven roll by the drive M2 (indicated schematically), the roll 21c as a guide roll and the roll 21b as a tensioning roll. Also guiding the travel of the forming wire 24 and defining a portion of its travel is a suction box 23 having a forward curved portion 23a top guide roll 25 and the roll wire 24 smoothly as it approaches the active or water-permeable surface or top 23a of the suction box 23. The suction box top 23a is preferably formed of a plurality of longitudinally closely spaced transversely extending blades presenting thin edges to the wire for defining the water-permeable surface 23a. These blades are shown essentially schematically at the location 23a, but it will be understood that they are longitudinally spaced from perhaps ½ to 1½ inches and the longitudinal dimension of the blade tops is substantially ½ to 1 inch, with the overall curvature of the top guide roll 25 and blade tops substantially greater than 50%, and preferably at least about 75% at the cover 23a. Additionally, the use of such blades at the cover 23a permits the selective positioning thereof so as to define in the longitudinal contour of the wire contacting blade edges the elongated non-circularly contoured corrugation which results in the expanded substantially to the drainage characteristics of the stock being fed onto the wire 24 approximately at the lip 22 or at the oncoming edge of the suction box 23 through the stock feed device 25 indicating a slice in this position. Actually, the stock feed device 25 opens at a slice 25a just upstream of the suction box 23 top guide roll 25 so as to form the dilute aqueous suspension of entangled co-moving fibers at a comparatively high speed in a substantially unidirectional ribbon-thin jet stream between the converging top run 24a of the wire 24 and the bottom run 14a of the main felt 14.

In effect such convergence, it will be seen that the bottom felt run 14a with the initial ply P1 on the underside thereof passes over the first guide in the form of the roll 26, while the top wire run 24a passes over what constitutes a second guide in succession in the form of the suction box 23, and the top wire run 24a and bottom felt run 14a are thus brought into convergence at the off-running side of the suction box 23 as they proceed together in substantial parallelism to the roll 27 which functions as a third guide in succession for both the wire 24 and the felt 14, plus the moist web merged plies P12 therebetween. The bottom felt run 14a between the rolls 26 and 27 is mounted, of course, under tension but is free from restraining means in contact therewith opposed the actual ply-forming area F2 (indicated as an approximate dimension). Because the felt 14a is carrying at least one ply of web (in this case the initial ply P1) as it passes opposite the forming wire 24, it will be appreciated that the bulk of the dewatering of the stock fed from the inlet 25 will occur through the water-permeable top 23a of the suction box 23, i.e., so as to form an incident ply on the wire top run 24a in the forming zone F2, which incident ply merges with the web P1 carried on the underside of the felt 14a to form an ultimate composite web P12 in which dewatering continues through the comparatively brief generally parallel travel between the felt 14a and the wire top 24a at least to the third guide or roll 27. The roll 27 is a rubber covered solid roll which supports web P12 and carries the underside of the traveling felt 14a and away from the off-running wire 24 turning about the guide roll 21f.

The guide rolls 26 and 27 will actually hold the felt 14a in tension down against the wire top run 24a in a generally yieldable manner, because the felt with the initial ply P1 thereon will tend to yield some to the internal forces in the jet initially fed into the large end of the converging forming area F2. But at the off-running side of such forming area F2 the felt 14a and wire run 24a are squeezed together sufficiently to effect a certain amount of dewatering and the merging of the plies in the manner hereinbefore described.

It will also be noted that the composite multi-ply web P12 traveling from the second sequence S2 on the underside of the felt 14a is then fed through a dewatering nip N2 between a rubber covered roll 29 and an open roll 28 provided with a savell 28a. In the arrangement for this nip N2 the roll 28 is preferably a closely woven, plain rubber covered nip 29 which will cooperate with the backside of the felt 14a to assure continued travel of the web away from the off-running surface of the open roll 28 and with the downstream felt reach 14b feeding into the next sequence S3.

Referring briefly to the third sequence S3 here shown, it will be seen that parts having substantially the same function as those in the second sequence S2 are designated by the same reference numerals in the 70, 80 and 90 series, with the possible exception that the forming zone here indicated by the symbol F3 and the off-running dewatering nip is indicated by the symbol N3, and the preformed plies entering the sequence S3 on the underside of the felt 14a represent the composite of plies from the first two sequences and are thus designated P12; whereas the off-running composite web is designated P123 to represent the integration of the third ply into the composite web leaving the third sequence S3.

The fourth sequence S4 functions similarly to the third sequence and it will be recognized that corresponding elements are designated by the same reference numerals in the 100 series.

With respect to the first sequence S1 shown at the left hand side of FIG. 1A, it will be understood that there is an operating difference in that the bottom run 14a of the felt does not carry a preformed ply on its underside as it is fed into the forming area F1. All of the other elements shown in the initial sequence S1 which correspond substantially to previously described elements in the other sequences are designated, however, by the same reference numeral in the 110 series. Additionally, it might be noted that there is shown a conventional upright 116a extending up from the cradle 13a and provided with adjusting means 116b for the bearing mountings 116c for the initial guide roll 116. This arrangement is indicated generally in sequence S1 to indicate the advantages in simplicity that are afforded in connection with the mounting and operation of the various sequences here shown.

Referring now briefly to FIG. 2, it will be seen that there are shown two sequences which might correspond to those designated in FIGS. 1A and B, except for certain differences which will be explained, and for the sake of consistency such sequences will be designated S7 (shown partially), S8 and S9. Parts in these parts in these sequences substantially to parts already shown in FIGS. 1A and 1B are designated by the same reference numerals in the 70, 80 and 90 series, respectively. It will
be noted that the main felt top run here designated 200 has a somewhat simplified travel in the embodiment of FIG. 2 by virtue of the elimination of some of the elements shown in the embodiment of FIGS. 1A and B. Thus, in sequence S8 the felt 200 travels around an initial guide roll 86 with a ply P7 on the underside thereof and into gradual convergence with the top run 84a of the wire 84 over the forming zone F8 between the wire run 84a and the felt 200. After passing beyond the suction box 83 the wire and felt 84a, 200 traveling in parallelism with the composite web P78 therebetwen pass on up to a nip N8 between a wire guide roll 81f and a conventional rubber covered roll 89. This arrangement for the nip N8 does serve to avoid rolls corresponding to reference numerals 87 and 88 in the sequence S8 here shown, since the rubber covered roll 89 carries out the essential function already described in connection with the sequence S2 for the rolls 27 and 28. On the other hand, the wire 84 must pass through the nip N8 and this requires a certain amount of additional care in the operation of the nip N8 to avoid the possibility of damage to the wire 84.

In connection with the use of press nips to carry out substantial or limited dewatering of the moist web carried on a felt, it will be appreciated that by the use of the plastic forming wires known in the trade in the positions for the short wires 84 and 94 of FIG. 2, the operation of the nips N8 and N9 can be carried out more easily without possible concern about damage to a typical woven metal forming wire. In this respect, it will also be appreciated that the main top felt 14 of FIGS. 1A and B or 200 of FIG. 2 could be a plastic forming wire also, at least in the sense of using the same in press nips for dewatering of the web, but the practicality of this type of arrangement may be questioned since the forming wire function is actually not required for the top felt 14 or 200 in the embodiments here shown. Instead, the top felt 14 and 200 will in each case carry plies of web thereon such that formation of new webs or plies by drainage through such felts with pre-formed paper webs thereon will not occur to any significant extent, and, there would be no practical advantage to attempting to use a fabric wire in this position in most instances. In fact the much less expensive felt in the positions 14 and 200 affords distinct advantages in the practice of the instant invention.

In FIG. 2 the alignment of the various elements is shown so that the main felt 200 may travel with a minimum of abrupt changes in direction and also the advantages generally afforded in the practice of the instant invention of employing devices which are capable of being shifted to some extent in their relative positions becomes apparent. Thus, the suction boxes 83 and 93 may be tilted upwardly as shown or downwardly, if desired, in a particular arrangement to suit the convenience of the particular operation. The main felt 14 or 200 offers a primary advantage with respect to its ability to conform to various configurations in ordinary use and travel, but, because of the short wires used in each of the sequences in order to achieve certain advantages, as will become apparent to those skilled in the art. In the typical sequence S8 shown in FIG. 2, the convergence of the felt 200 and the wire 84 will occur primarily as the guide roll 86 brings the felt 200 into closely spaced relation with the wire traveling over the guiding top surface of the suction box 83, and the cooperation between the two rolls 89 and 81f at the off-running side will effect convergence and substantially parallelism between the top wire run 84 and the felt 200 with the wet web sandwiched therebetween.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

I claim as my invention:

1. A device for forming a multi-ply web comprising in combination, spaced first guides at a first forming zone, a felt run for carrying a web ply wrapping one of said first guides, a forming wire run opposing said felt run wrapping the other of said first guides, first slice means for delivering a dilute aqueous suspension of entangled comoving fibers exiting from the slice as a high-speed substantially unidirectional ribbon-thin jet stream with said runs traveling substantially at the jet stream speed (a) over said guides and through initially close spacing for receiving therebetween the jet stream and (b) immediately thereafter through gradual divergence in a web forming zone and into general parallelism with a resultant fibrous formed web therebetween in which parallelism said runs are maintained as they travel downstream together, a second forming wire opposing the felt at a second forming zone, second guides for the felt and the second wire at said second forming zone, a second slice means at the second forming zone delivering a dilute aqueous suspension of entangled co-moving fibers exiting from the second slice means as a high-speed substantially unidirectional ribbon-thin jet stream, and press means receiving said felt and the first web ply formed thereon from fibers from said first slice means and means supporting the ply and the web separated from the first wire in advance of said press means.

2. The device of claim 1 wherein the guides for the wires comprise suction boxes for maintaining subatmospheric pressure across the wire runs in said forming zones to accelerate dewatering therethrough.

3. The device of claim 1 wherein the guides for the wire runs are constructed with a plurality of longitudinally closely spaced transversely extending blades presenting top thin edges to the wires for defining the water-permeable surfaces of the guides.

4. The device of claim 3 wherein the longitudinal contour of loci of wire contacting blade edges of the wire guides define an elongated non-circular convex curve.

5. The device of claim 4 wherein such blades are mounted in suction boxes for accelerating water drainage through the wires at such forming zones.

6. The device of claim 1 wherein the guides for the felts comprise rotary felt supporting rolls.

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REUBEN FRIEDMAN, Primary Examiner
T. A. GRANGER, Assistant Examiner

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