A multi-ply paper forming system wherein a vertically-oriented twin-wire papermaking machine having horizontal stringers leading to a converging vertical gap is utilized. Multiple fibrous plies are formed on the horizontal stringers and additional stock is discharged from a headbox between the plies as they pass down the converging vertical gap. Suction devices function to withdraw the liquid phase of the additional stock and thereby cause a uniform felting of this inner ply with the outer plies. Pivotal panels connected to the support rolls which guide the two forming wires function to adjust the orientation of either the horizontal or vertical runs thereof.
Fig. 2

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TWIN-WIRE MULTI-PLY PAPER MAKING MACHINE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a division of our application Ser. No. 164,060, filed on July 19, 1971 and now abandoned, which was a division of application Ser. No. 858,899, filed Nov. 17, 1969 and now abandoned, and which in turn was a continuation-in-part of application Ser. No. 630,605, filed Apr. 13, 1967 and now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to an apparatus for making paper or the like. More particularly, the invention relates to an apparatus for making laminated paper, cardboard, paperboard, and fiberboard consisting of two or more layers of fibrous material.

It is already known to produce paper sheet stock by the so-called wet felting method. Such method involves one-sided filtration and compression of fibers on an elongated or round screen of the paper making machine. A serious drawback of this method is that the felting of sheets is not uniform because all relatively long and coarse fibers and impurities, filling agents, bonding agents and dyes tend to settle at the underside, i.e., at the screen side of the layer, whereas the exposed or top side mainly contains short and fine fibers. Therefore, the bending strength, appearance and printability (capacity to absorb ink) of the ultimate product is not the same at both sides, the product tends to curl, and its physical properties are not satisfactory.

Attempts to improve the quality of paper sheets have led to a method according to which the filtration is carried out at both sides of the fibrous layer.

However, it has been found—particularly in the production of coarse packing or wrapping paper, cardboard, boards consisting of wood fibers and panels consisting of mineral fibers—that the longer fibers accumulate in the neutral axis of the product and are ineffective if the product is subjected to bending stresses. In such products, the longer fibers should settle at the exposed surfaces to offer satisfactory resistance to bending. Furthermore, the presently known equipment for producing multiple-layer sheets of paper or the like cannot insure symmetrical deposition of longer and shorter fibers and satisfactory spatial felting of fibers while the filtration is in progress.

SUMMARY OF THE INVENTION

Accordingly, it is an important object of the present invention to provide an improved paper-making apparatus which is not possessed of the aforementioned disadvantages.

Another object of the invention is to provide such an apparatus which assures that adjacent laminae of laminar paper products manufactured with this apparatus are uniformly inter-felted with one another.

In pursuance of the above and other objects, one feature of the invention resides in an apparatus for making multiple-layer paper products, which, briefly stated, comprises first means for forming two discrete juxtaposed travelling outer fibrous layers which define with one another a gap. Second means is provided for introducing into this gap a fibrous dispersion in a liquid phase. Third means causes the liquid within the gap to be withdrawn therefrom through the outer fibrous layers whereas the fibers of the dispersion are retained within the gap, and for thereby causing the retained fibers to bond said outer fibrous layers together.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved apparatus itself, however, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic elevational view of the novel paper making machine; and FIG. 2 is an enlarged fragmentary transverse horizontal section as seen in the direction of arrows from the line II—II of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, there is shown a paper making machine which is assembled of two halves disposed mirror symmetrically with reference to a vertical plane X—X which is normal to the plane of FIG. 1. Each half of the machine comprises an elongated foraminous band 1 which is constituted by an endless flexible screen and includes a horizontal or nearly horizontal stringer 1a and a substantially vertical stringer 1b. The bands 1 constitute one pair of pervious supports. The drive means for the bands 1 comprises two sets or groups of rolls 2, 4, 6, 7 at least one of which is driven to advance the stringers is toward the symmetry plane X—X and to advance the stringers 1b downwardly. The stringers 1b are preferably inclined with reference to each other to form a channel 8 which tapers downwardly. The drive means further includes a prime mover 100, for example, a suitable electric motor, and variable-speed transmissions 101, 102 which drive the rolls 6 at a desired speed. The band-engaging cylindrical walls of the rolls 4 and 6 are perforated and travel around stationary suction chambers or boxes 4a, 6a. Additional suction chambers or boxes 3 and 5 are provided below the stringers 1a and adjacent to the stringers 1b opposite the channel 8. The conduits which connect the suction boxes 3, 4a, 5, 6a with suction generating devices 24 are shown at 24a, and each such conduit is preferably provided with a valve 24b which can be operated to regulate the suction in the respective box or to disconnect the respective box from the source 24. Each source 24 may be constituted by a suitable pump or fan.

The rolls 7 serve to regulate the tension of the respective bands 1 and are adjustable in directions indicated by double-headed arrows. All of the rolls and the suction boxes 3, 5 are mounted on a suitable frame 28 and the rolls 2 are movable in arcuate paths about the axes of the corresponding rolls 4 to pivot the stringers 1a about their inner end portions, namely, about such end portions which are nearest to the symmetry plane X—X. The arrangement may be such that the left-hand rolls 2, 4, 6 and 7 are mounted on a panel 28a which is adjustable toward and away from the plane X—X and can be fastened to the frame 28 by bolts, screws or analogous fasteners. The panel 28a is further pivotally about the axis of the left-hand roll 6 by the diagrammatically illustrated means M' to change the inclination of the left-hand stringer 1b with reference to a ver-
tical plane. The panel 28a carries a further panel 28b which supports the left-hand roll 2 and is movable therewith in an arc about the axis of the left-hand roll 4 to change the inclination of the left-hand stringer 1a. In this way, the personnel in charge can select the taper of the channel 8 and the inclination of the left-hand stringer 1a with reference to a horizontal plane which is tangential to the topmost portion of the left-hand roll 4. The right-hand rolls 2, 4, 6, 7 and the right-hand suction boxes 3, 5 are supported in similar fashion (see means M) to allow for a large number of adjustments of the inclination of right-hand stringers 1a, 1b with reference to the left-hand stringers 1a, 1b and for adjustment of the distance between the bands 1.

The rolls 6 perform a plurality of functions, namely, they transmit motion to the respective bands 1, they draw the liquid phase from the ultimate product which issues from the lower end of the channel 8, and they also compress the solid phase of such product to further promote evaporation of the liquid phase and to treat the exposed surfaces of the continuous multiple-layer sheet 5 which is formed in the channel. If desired, the rolls 4 and/or 2 may be driven in addition to or instead of the rolls 6.

The angles alpha indicate the extent to which the stringers 1a may be pivoted about the axes of rolls 4 with reference to a horizontal plane. It was found that the angles alpha need not exceed 40°, i.e., that each of the stringers 1a need not pivot through more than about 20° above or below a horizontal plane which is tangential to and touches the uppermost points of the rolls 4. As stated above, such adjustability of the stringers 1a is due to placeability of panels 28b with reference to the panels 28a. The panels 28a can be pivoted about the axes of the rolls 6 to vary the angle beta between the stringers 1b. This angle beta is the apex angle of the wedge-like channel 8 and the panels 28a are preferably pivotable through angles of 30°, i.e., each of the stringers 1b can be moved through 15° to the opposite sides of a vertical plane which is tangential to the respective roll 6.

In the illustrated embodiment, the machine comprises three feeds including a centrally located feed 9 which is disposed at a level above the upper end of the channel 8 and two outer feeds which are disposed above the stringers 1a. Each outer feed includes a primary feeding device 10 and a secondary feeding device 13. The feeding device 10 contains a supply of fibrous suspension or dispersion and its outlet 10a can discharge the suspension directly onto the upper stringer 1a of the left-hand band 1. The left-hand suction box 3 draws the liquid phase of the suspension through the adjacent stringer 1a and the solid phase forms a fibrous layer which travels with the stringer 1a and enters the channel 8. Such layer will form one of the two surface layers of the multiple-layer sheet 5 which issues from the lower end of the channel 8. Each feeding device 10 further comprises a settling trough 11 which collects the heavier ingredients of the solid phase (mainly impurities) and can be evacuated continuously or at regular intervals in a manner well known from the art of paper making machines. For example, each settling trough 11 may be provided with a feed screw which is driven by a motor to expel the solids in a direction at right angles to the plane of Fig. 1. Each feeding device 10 can be mounted on the adjoining panel 28b to share all movements of the respective roll 2. By changing the inclination of the left-hand stringer 1a, the personnel in charge can change the rate at which the machine withdraws liquid phase from the suspension which is discharged by the outlet 10a of the left-hand feeding device 10. Adjustments in the position of the left-hand roll 2 about the axis of the left-hand roll 4 will be carried out in dependency on the consistency of suspension in the feeding device 10 and in dependency on the desired thickness of the surface layer on the band 1.

Filtration of the surface layer which travels with the left-hand stringer 1a is continued during travel along the suction box 4a in the left-hand roll 4 and thereupon during travel along the left-hand suction box 5 and suction chamber 6a in the left-hand roll 6. The right-hand part of the machine forms a second surface layer consisting of fibers discharged by the outlet 10a of the right-hand feeding device 10. The two surface layers travel along the stringers 1b and are of moisture which is withdrawn by the suction boxes 5 and 6a. The centrally located feed 9 discharges a third suspension or dispersion through an outlet 9a, and the liquid phase of such suspension is withdrawn by the suction boxes 4a, 5 and 6a, irrespective of whether or not the formation of surface layers on the stringers 1a, 1b is already completed. Evacuation of liquid phase from the channel 8 is promoted by the mutually inclined stringers 1b so that the liquid phase enters the suction boxes 4a, 5, 6a not only in response to suction but also due to mechanical compression of material travelling in the channel 8. Maximum compression of the solid phase takes place between the rolls 6 and such solid phase leaves the gap 15 between the rolls 6 in the form of a continuous coherent multiple-layer sheet, carpet or mat S which is caused to advance along an arcuate deflector 25 to move into a substantially horizontal plane. The sheet S is then ready for further processing, such as additional pressing, drying, subdivision into plates of desired size or shape, packaging, stacking and/or others. The just outlined operations can be carried out with greater convenience if the sheet S is maintained in a horizontal or nearly horizontal plane.

Each secondary feeding device 13 includes a settling trough 14 for heavier parts of the solid phase and a driven forming roller 12 having a suction chamber or box 12a serving to withdraw at least some liquid matter from the suspension discharged through the outlet 12a. The forming rollers 12 constitute a second pair of pervious supports and can form two layers of fibrous material which deposit on the surface layers travelling with the stringers 1a and form two intermediate layers of the ultimate sheet S. The structure of (i.e., the distribution of fibers in) layers produced by forming rollers 12 is different from that of the surface layers on the stringers 1a and 1b for reasons which will be explained hereinafter. The direction of rotation of forming rollers 12 is such that the intermediate layers are advanced in the same direction as the adjoining stringers 1a, namely, toward the rolls 4. Furthermore, the rotational speed of rollers 12 is preferably such that the layers furnished thereby advance at the exact speed of the adjacent surface layers. The drives for the forming rollers 12 may derive motion from the prime mover 100 or from separate prime movers. The machine may have variable speed drive means for the rollers 12. Furthermore, the conduits which connect the suction boxes 12a with the suction generating devices 24 preferably include valves to permit for regulation of the rate at which the liquid
phase is being withdrawn from the suspension discharged by the outlets 13a.

The primary feeding devices 10 may be used simultaneously with or independently of the secondary feeding devices 13 and feed 9. In other words, the machine may be used to produce a two-layer sheet composed of fibers discharged by the feeding devices 10 or 13, a three-layer sheet from fibers discharged by the feed 9 and devices 10 or by the feed 9 and devices 13 (or even by two devices 10 and one device 13 or vice versa), a four-layer sheet from fibers furnished by the devices 10 and 13 (or by feed 9 and three of the devices 10, 13), or a five-layer sheet by operating the feed 9 simultaneously with all of the feeding devices 10 and 13.

The frame 28 further supports reels 20, 21, 22 which respectively constitute sources of tapes or webs 23 serving to reinforce or to otherwise enhance the quality or appearance of the sheet 5. Such webs 23 may consist of metallic or plastic netting, fabric, finished fiber carpets and/or others which can improve the appearance and/or the quality of the ultimate product. Thus, by operating the machine in such a way that the feeds 10, 13 and 9 are on simultaneously, and that the webs 23 are being paid out by the reels 20–22, the ultimate product may contain as many as eight layers whereby the webs 23 issuing from reels 20, 21 separate the surface layers from the intermediate layers and the web 23 issuing from the reel 20 halves the layer formed by fibers which issue from the outlet 9a of the feed 9. As a rule, the webs 23 will be used to reinforce the ultimate product by improving its tensile strength, its resistance to bending, its resistance to breakage, or another characteristic. The extent to which the various layers and webs in the channel 8 will be caused to adhere to each other will depend on the nature of their ingredients, on the taper of the channel, on the minimal distance between the stringers 1b, on the extent of suction in the boxes 4a, 5, 6a, and on certain other factors. As stated above, the taper of the channel 8 may be varied by pivoting the panels 28a about the axes of the rolls 6, and the minimal width of the channel may be regulated by moving the left-hand band 4 with reference to the right-hand band, or vice versa. Such movements of an entire band with reference to the other band change the width of the gap 15 between the rolls 6. All such adjustments are carried out in dependency on the desired thickness and unit weight of the ultimate product and also in dependency of the thickness of webs 23, the rate at which the feeds 9, 10 and/or 13 deliver suspensions, and the composition of such suspensions.

Successive increments of bands 1 are preferably cleaned during travel from the rolls 6 toward the rolls 2. Such cleaning may be effected by revolving brushes or by other known devices which are not shown in the drawing, and its purpose is to prevent clogging of interstices in the bands.

FIG. 1 further shows two reels 26 which are located upstream of the rolls 2 and each of which contains a supply of web or tape 27. Such webs 27 may be fed onto the upper stringers 1a to form the outermost layers of the ultimate product and preferably consist of a material which is sufficiently permeable to permit for evacuation of liquid phase which is supplied by one or more feeds. For example, the webs 27 may consist of metallic or plastic netting, of textile or other flexible which is to constitute the exposed layer of the ultimate product to improve its strength characteristics, its appearance or both. It is further clear that the webs 27 may replace the bands 1, i.e., that such webs will constitute the bands of our machine if the bands 1 are removed or omitted. The operation is then the same as described above, with the exception that the bands do not travel from the rolls 6 and back toward the rolls 2 but adhere to the sheet which is guided along the deflector 25 and travels on toward the next processing station.

FIG. 2 shows in horizontal sectional view such parts which define and enclose the channel 8. The front and rear sides of the channel 8 are bounded by vertical side walls 16 (only one shown). These side walls are adjustable and/or exchangeable and are detachably supported by the frame 28 to allow for convenient adjustments of the angle beta. The side wall 16 shown in FIG. 2 is supported along its edges by rails 17 which are directly or indirectly affixed to the frame 28 and carry sealing strips 18 of rubber or the like to prevent leakage of liquid phase. Such liquid matter which escapes along the edges of the stringers 1b is sucked in by auxiliary suction chambers or boxes 19 connected to the suction generating devices 24 and disposed at both sides of each suction box 5. The conduits 24c shown in FIG. 1 are arranged to connect the suction boxes 19 with the suction generating devices 24 and are provided with regulating valves 24d. It is to be understood that the suction box may comprise two or more compartments in each of which the suction is adjustable independently of the other compartments to regulate the withdrawal of liquid phase along the respective stringer. This is shown, by way of example, for the right-hand suction box 3. The suction generating devices 24 may but need not be mounted on the frame 28; in the illustrated embodiment, the devices 24 are remote from the frame.

The suction boxes 19 can be said to constitute separate compartments of the respective suction boxes 5. The feeding devices 13 supply suspensions or dispersions whose solid phases respectively produce two individual surface layers. For this purpose the suction chambers 12a of the former rollers withdraw sufficient moisture to assure that the solid phases of the suspensions furnished by the outlets 13a will form the required two surface layers which are entrained by the adjoining stringers 1a and deflected by the rolls 4 with the upper end of channel 8.

The surface layers on the stringers 1a are of course wet as they move through the channel 8.

In the conventional production of laminated paper products these surface layers would be dried and bonded together in dry state. Alternately, a single layer might be formed and suspension for a second layer be passed onto the single layer from one side thereof, or alternately from opposite sides, with dewatering—i.e. removal of the moisture—taking place in direction toward the outer side of the one layer.

The present invention departs from these prior-art concepts by providing first for the simultaneous production of the two surface layers, and by thereupon providing for the introduction of additional suspension or dispersion between these surface layers. This may be accomplished, in the illustrated apparatus, by supplying the additional suspension via the feed 9 which discharges into the space between the surface layers in the channel 8. There is thus formed a middle layer from the solid phase of the additional suspension discharged by feed 9, while moisture resulting from the additional sus-
pension is withdrawn outwardly through the surface layers by the suction chambers 12a and, primarily, by the suction chambers 4a, 5 and 6a.

As a result of the introduction of the additional suspension and withdrawal of the moisture from the additional suspension, outwardly through the already formed surface layers, the fibers of outer surface layers are first released again and then perfectly felted with the fibers of the middle layer which is being formed from the solid phase of the additional suspension. This felting takes place concomitantly with, and is the result of the filtration effect caused by the withdrawing of the moisture from the additional suspension outwardly through the outer surface layers.

It should be understood that a three-layer product as described above may itself serve as the surface layer of a further laminated product. In other words, two three-layer products, made as discussed above, may be arranged in the manner described above with reference to the surface layers, and suspension be introduced between them to form between them an additional layer which becomes interfelted with them. Removal of moisture again takes place, of course, in direction outwardly through the respective three-layer product.

Normally, more valuable—i.e. better grade—stock is used for the outer surface layers than for the inner layer, but the stock may of course also be differently chosen, for instance identical in all layers.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. Apparatus for making paper products composed of multiple interfelted fibrous plies, comprising a pair of travelling forming wires; means supporting each of said forming wires to provide a substantially horizontal run followed by a downwardly inclined run, said downwardly inclined runs of said forming wires being juxtaposed and defining between themselves a downwardly converging narrow gap; means depositing stock on each of said horizontal runs for forming thereon respective first fibrous plies of deposited fibers which travel to the respective inclined runs; travelling forming means for forming from fibrous stock a pair of second fibrous plies each having a first side facing said travelling forming means, and for depositing each of said second plies on one of said horizontal runs so that the second side faces the first ply on the respective horizontal run; means for depositing fibrous stock on said travelling forming means for forming thereon said second fibrous plies which are deposited on said horizontal runs and travel to the respective inclined runs, so that said first sides become juxtaposed in said gap; headbox means for admitting into said gap and between the formed second fibrous plies a fibrous dispersion in a liquid phase; and means for withdrawing the liquid phase of said fibrous dispersion from said gap through the respective formed first and second fibrous plies so that the deposited fibers of said plies are first released again due to the filtration of the liquid phase through said first and second fibrous plies, and thereupon become interfelted with the fibers of said dispersion which are retained within said gap and form between said second fibrous plies an additional ply which is interfelted with and bonds said first and second fibrous plies together.

2. Apparatus as defined in claim 1, including suction means for withdrawing the liquid phase of said stock through the respective horizontal runs.

3. Apparatus as defined in claim 1; and further comprising means for varying the orientation of said substantially horizontal runs.

4. Apparatus as defined in claim 1, wherein each of said substantially horizontal runs has an upstream end remote from and a downstream adjacent to the associated inclined run; and further comprising means for varying the orientation of said substantially horizontal runs by pivoting them about the respective downstream end through substantially 20° with reference to a horizontal plane.

5. Apparatus as defined in claim 1; and further comprising means for varying the orientation of said inclined runs relative to one another so as to change the degree of convergence of said gap.

6. Apparatus as defined in claim 1, wherein each of said inclined runs has an upper end and a lower end; and further comprising means for varying the orientation of said inclined runs by pivoting them about the respective lower ends through substantially 15° with reference to a vertical plane.

7. Apparatus as defined in claim 1; and further comprising means for continuously delivering a pre-formed material of netting into substantially the central plane of the suspension-filled gap, whereby said suspension will permeate said material from both sides thereof.

8. Apparatus as defined in claim 7, wherein said means for delivering said material is arranged substantially centrally above said gap.

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