Aug. 26, 1969 D. B. BREWSTER ETAL 3,463,700

APPARATUS FOR IMPROVING DRAINAGE ON A FORMING WIRE

Filed July 13, 1966 2 Sheets-Sheet 1

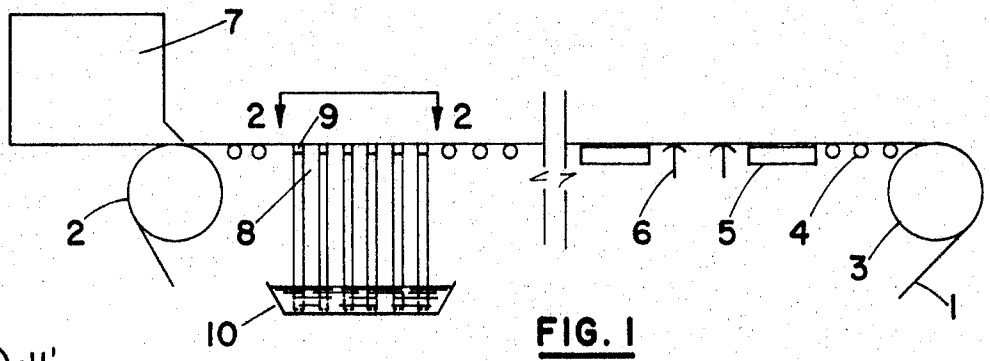


FIG. 1

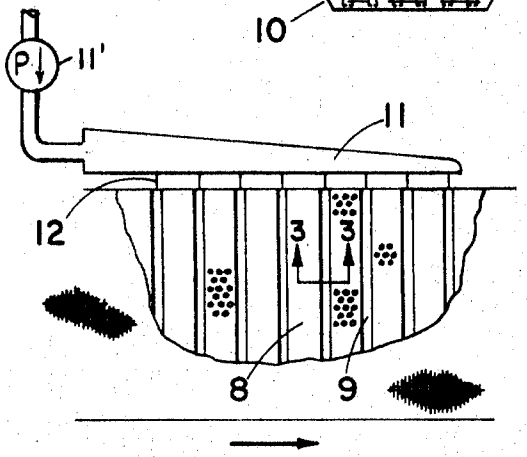


FIG. 2

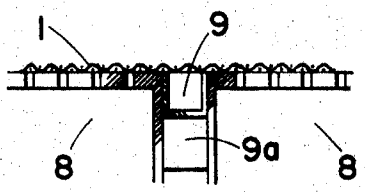


FIG. 3

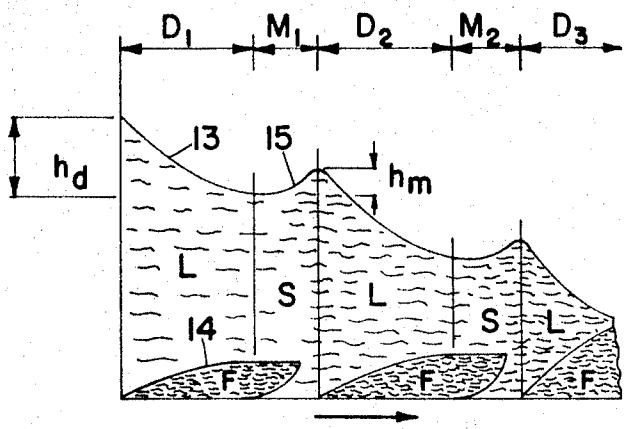


FIG. 4

INVENTORS
DONALD B. BREWSTER
WILLIAM H. BURGESS, JR.
BY Thomas W. Tyson
ATTORNEY

Aug. 26, 1969 D. B. BREWSTER ETAL 3,463,700

APPARATUS FOR IMPROVING DRAINAGE ON A FORMING WIRE

Filed July 13, 1966 2 Sheets-Sheet 2

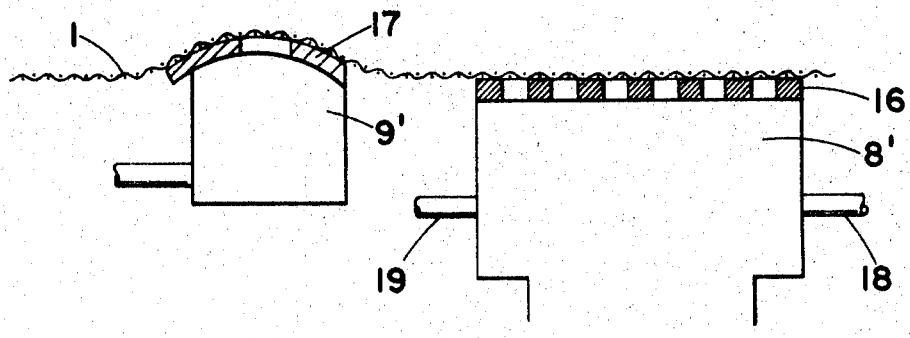


FIG. 5

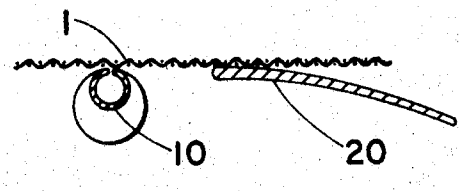


FIG. 6

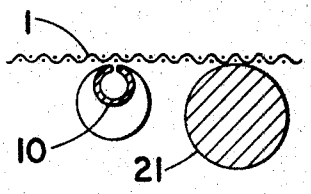


FIG. 7

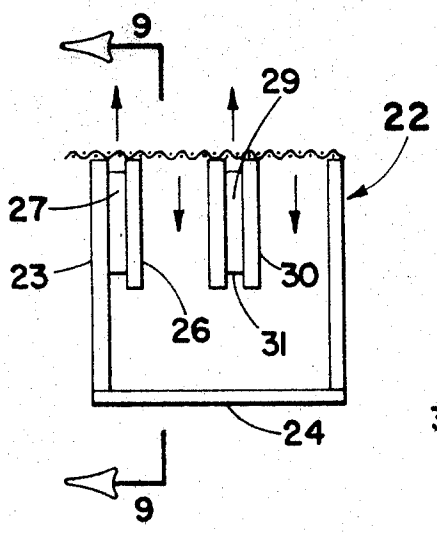


FIG. 8

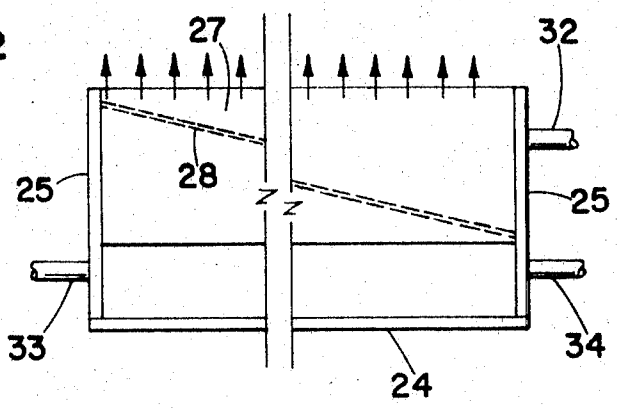


FIG. 9

INVENTORS
DONALD B. BREWSTER
WILLIAM H. BURGESS, JR.
BY Thomas W. Flynn
ATTORNEY

United States Patent Office 3,463,700
Patented Aug. 26, 1969

3,463,700

APPARATUS FOR IMPROVING DRAINAGE ON A FORMING WIRE

Donald B. Brewster and William H. Burgess, Jr., Covington, Va., assignors to West Virginia Pulp and Paper Company, New York, N.Y., a corporation of Delaware

Filed July 13, 1966, Ser. No. 564,796
Int. Cl. D21f 5/08, 11/08, 1/20
U.S. Cl. 162—308 3 Claims

ABSTRACT OF THE DISCLOSURE

A fluid such as steam is injected into the underside of a fourdrinier wire to remix a mat of fibers thereon and the liquid suspension overlying the mat. The injection is performed by a series of nozzles with water removal devices therebetween to partially remove the liquid upstream of the liquid dry line.

The present invention is directed to a method and apparatus for effecting the drainage of liquid from a liquid-fiber suspension and more particularly, to a method and apparatus for improving drainage on the fourdrinier wire of a papermaking machine.

In the conventional fourdrinier papermaking process, a suspension of liquid and fibers, generally referred to as stock, is deposited on an endless foraminous belt which is supported by rollers and the like to provide a substantially planar forming surface. One or more driven rollers are generally used to cause the wire to move continuously downstream from the area of stock deposition, or wet end, toward the downstream end of the planar surface, or dry end. As the deposited suspension of liquid and fibers moves downstream on the foraminous belt, a portion of the liquid of suspension drains through the forming surface leaving a layer of loosely felted fibers matted thereon, which is thereafter pressed and heated to provide a self supporting web. As is well known to those skilled in the art, drainage of the stock, as it moves downstream on the foraminous surface, is usually assisted by the use of suction boxes, table rolls, foils and the like.

It will be apparent, however, that as the liquid of suspension filters through the forming surface, the layer of fibers retained will tend to inhibit further drainage. Thus, while the initial rate of drainage through the foraminous surface is relatively high, the drainage rate rapidly decreases as the stock moves toward the dry end of the fourdrinier. Additionally, in the conventional papermaking process, there is a tendency for the fibers of the suspension to flocculate, and for the resulting flocs and fines to become unevenly distributed throughout the thickness of the resulting web.

These disadvantages of the conventional fourdrinier process have been the object of close scrutiny by the paper industry for many years and as a result, a number of remedies have been suggested. High vacuum suction boxes, for example, are often used toward the dry end of the forming surface in order to compensate for the increased drainage resistance encountered in that area. Additionally, grooved table rolls and variously configured foils have been proposed to modify the drainage rate through the wire and provide a more uniform mat of fibers.

With all of these prior art methods and apparatus, however, the problem of negating the effect of the fiber mat on drainage and formation is still unsolved. Furthermore, devices of this type are not readily adjustable and hence, do not provide the degree of flexibility needed in manufacturing webs of different grades of various speeds.

It is an object of the present invention, therefore, to

provide a method and apparatus for increasing the rate of drainage on a fourdrinier machine and improving the formation of the resulting paper web. This is accomplished by the injection of a liquid, such as water, white water or the like, or a readily condensible vapor such as steam, through the foraminous screen into the partially drained and matted layer of fibers adjacent the wire to cause a remixing of the fiber layer and the layer of stock overlying this fiber layer. By thus injecting liquid or steam under pressure through the wire at spaced locations in the machine direction, the retarding effect of the fiber mat on drainage rate is overcome and flocculation and uneven distribution of the fibers is substantially reduced. Thus, as the liquid-fiber suspension moves downstream on the fourdrinier wire it is alternately subjected to drainage, remixing, and drainage; whereby the high drainage rates which are ordinarily experienced only adjacent the upstream end of the wire are attained throughout a major portion of the length of the drainage area. Additionally, it will be apparent that by using liquid or steam jets to remix the fibers and layer of stock overlying the fibers, an apparatus of convenient and infinite adjustment is provided; whereby the method and apparatus of the present invention are adaptable to a wide variety of paper grades and machine speeds.

These and other objects and advantages of the present invention will become more readily apparent from the following detailed description wherein;

FIGURE 1 is a somewhat schematic showing of a conventional fourdrinier papermaking machine modified in accordance with the principles of the present invention;

FIGURE 2 is a sectional view taken on line 2—2 of FIGURE 1 with portions removed for clarity;

FIGURE 3 is a sectional view taken on line 3—3 of FIGURE 2;

FIGURE 4 is a somewhat diagrammatic showing of the alternating drainage and remixing steps as they occur along the length of the fourdrinier wire;

FIGURE 5 is a cross-sectional, elevational view showing one preferred embodiment of the invention;

FIGURE 6 is a second cross-sectional, elevational view showing a second preferred embodiment of the invention;

FIGURE 7 is a view similar to FIGURE 5 showing a third embodiment of the invention;

FIGURE 8 is a cross-sectional, elevational view of another embodiment of the invention; and

FIGURE 9 is a view taken on line 9—9 of FIGURE 8.

Turning to FIGURE 1 of the drawings, there is therein shown a fourdrinier paper machine comprising an endless foraminous belt 1 trained over a breast roll 2, a couch roll 3, several table rolls 4, suction boxes 5 and foils 6. A headbox or the like 7 is provided to deposit a suspension of fibers and liquid on the wire 1; the liquid from the suspension draining through the foraminous surface of the wire as the suspension is conveyed downstream towards the couch roll 3. Located upstream of the dry line of the machine is apparatus according to one embodiment of the present invention. As is well known to those skilled in the art, the dry line is a point along the wire, upstream of which, free liquid is visible above the surface of the partially drained and matted fibers on the wire.

As seen in FIGURES 1–3, the apparatus of the present invention may comprise a plurality of suction boxes 8 having apertured cover plates and separated by pressurized nozzles 9. The suction boxes are provided with drain means leading into a tray 10 wherein the liquid level is maintained above the outlet ends of the drain means to provide a seal in the suction boxes. Each of the nozzles 9 may be supplied with liquid or steam under pressure by a pump 11', feeding a manifold 11 suitably tapered to provide relatively constant pressure to each of the noz-

zle chambers **9**. Additionally, bottom wall **9***a* of nozzles **9** may be slanted upwardly toward wire **1** to provide a cross-sectional area that diminishes from a largest dimension adjacent manifold **11** to a smallest dimension adjacent its opposite end; thereby providing a substantially constant pressure along the length of each of the nozzles. If desired, adjustable valves may also be placed in the pipes **12** interconnecting the nozzles **9** and the manifold **11** in order to provide independent control of the pressure and velocity of the liquid or steam issuing from each of the nozzles **9**.

Turning now to FIGURE 4 of the drawings, the operation of the apparatus just described in accordance with the principles of the present invention will now be explained. In FIGURE 4, the horizontal axis represents the distance the stock travels as it moves downstream in the direction of the arrow and the vertical axis represents the total height of liquid and fibers on the wire.

It will be seen that as the stock moves downstream on the wire from the point of initial stock deposition and through the drainage zone D_1, the total height of the material on the wire, indicated by the line **13**, decreases as the liquid of suspension drains through the wire. Since this drainage causes a corresponding increase in the amount of fibers filtered out at the forming surface, the height of the fiber mat F increases, as indicated by the line **14**.

As the stock passes from drainage zone D_1, to mixing zone M_1, drainage of the stock is discontinued and the height of the mat F and the total height of the material on the wire remains fairly constant. As the mixing zone M_1 is traversed however, jets of liquid, such as water, white water, or the like, or a readily condensible vapor, such as steam, are directed through the wire against the lower surface of the fiber mat F. This causes a progressive eroding of the fiber mat until, adjacent the downstream end of zone M_1, the fiber mat is substantially destroyed and the fibers thereof remixed with the liquid and fibers immediately thereabove. Because some liquid is added to the material on the wire in the process of eroding the mat and remixing the liquid and fibers, either through the direct injection of liquid or through the condensation of the injected steam, there will be a slight increase in the total height of the material on the wire, as indicated at **15** in FIGURE 4. While this results in additional liquid to be drained from the stock, it will be seen that by controlling the velocity and volume of liquid or steam directed against the mat, the amount of liquid added in zone M_1, indicated as h_m, is maintained substantially less than the amount of liquid removed in zone D_1, reference h_d.

Most importantly, however, it will be noted that as the remixed stock moves once again into a drainage zone, such as zone D_2, the condition of the stock, and hence, its rate of drainage, approaches that found adjacent the upstream end of zone D_1. Therefore, as the stock moves through zone D_2, there will once again be a rapid decrease in the total height of the material on the wire and a rapid increase in the thickness of the fiber mat F. Since the consistency of the suspension resulting from the remixing the fiber layer and the layer of stock overlying the fiber layer is somewhat greater than the consistency of the stock at the upstream end of zone D_1, the rate of buildup of the mat F will be somewhat greater, and, other conditions being equal, the total thickness of the mat will be greater, at the downstream end of zone D_2 than at the corresponding position in zone D_1. Additionally, since the total height of the material on the wire is substantially less at the upstream end of zone D_2 than at the upstream end of zone D_1 and the rate of drainage in zone D_2 approaches that in D_1, the total height of the material on the wire at the downstream end of zone D_2 will be substantially less than the corresponding height in zone D_1.

As the partially drained stock moves from zone D_2 to zone M_2, the same sequence of events occurs as described for zones D_1 and M_1 above. Again, as the stock passes over another mixing nozzle, the liquid-fiber suspension and the fiber mat F underlying it are substantially remixed and ready to pass into the next drainage zone D_3. It will be noted that once again the amount of liquid added to the stock in the mixing zone M_2 is substantially less than the amount of liquid which drains from the stock in the preceding drainage zone D_2. In zone D_3 additional liquid is drained from the stock and the height of the fiber mat F may again be increased above the height of the mat in the previous drainage zone.

It will be seen that by alternately subjecting the stock to drainage and remixing, the height of the fiber mat eventually approaches the height of the free liquid surface. Depending upon a number of variables, such as the original consistency of the stock, its freeness, the speed of the process, etc., the number of alternating drainage and remixing zones can be calculated for any particular machine or grade being run thereon. It should also be noted that whereas conventional suction boxes are generally on the order of 1 to 2 ft. in width, it has been found that for best results the width of the suction boxes operated in accordance with the present invention should be on the order of 1 to 9 inches in width, with an optimum range of 1 to 3 inches, and spaced apart a distance sufficient to accommodate the width of the remixing nozzle.

From the above discussion and a consideration of FIGURE 4, it will be apparent that the overall formation of a web formed by the above described process will also be greatly improved over those formed by conventional methods. Thus, the remixing and redispersion of fibers within the liquid of suspension in each of the mixing zones insures that the fibers are uniformly dispersed throughout the suspension with a minimum of flocculation and segregation of fines. Additionally, it has been found that, despite the addition of liquid in each of the mixing zones, the overall drainage rate through the wire is substantially increased and allows a shorter drainage section on the machine. In fact, analysis of the system indicates that an increase in drainage rate on the order of 73% may be expected over a system which does not use mixing nozzles. This is, of course, because the fiber mat F, which in conventional processes lies next to the wire and retards the drainage of liquid through the wire, is substantially destroyed in each of the mixing zones, allowing the stock to drain in the succeeding drainage zone at a rate approaching that immediately adjacent the wet end.

It should also be noted that the material injected through the wire should be either a liquid or a vapor which readily condenses to a liquid form, such as steam. Thus, although if a relatively condensible gas, such as air, were used for remixing the stock there would be no increase in the amount of liquid on the wire, the use of air or the like would result in the formation of voids in both the fiber mat and the stock; which would not only deleteriously effect uniform web formation but would also retard the drainage rate of the stock.

Turning now to FIGURE 5 of the drawings, a second preferred embodiment of the invention is shown. As seen in FIGURE 5, a suction box **8'**, provided with an apertured cover **16**, a vacuum line **18**, and a relief line **19**, is proceeded by an injection nozzle **9'** having an apertured, adjustable cover **17**.

If desired, means may be provided for adjusting the size of the opening in the cover **17**. This provision, in conjunction with means, such as valves in the feed lines, will permit the volume and velocity of the liquid or steam issuing from the nozzle **9'** to be independently controlled. Of particular interest in the embodiment of FIGURE 5, is the fact that the remixing nozzle **9'** has a curved upper surface disposed above the level of the upper surface of the suction box **8'**. This causes the fourdrinier wire to traverse a curved path, inducing free surface turbulence in the stock. This free surface mixing,

together with the remixing created by the nozzle 9', helps control flocculation and fines distribution in the formed web.

Turning to FIGURE 6 of the drawings, a third embodiment of the invention is shown. In this embodiment of the invention, the suction box is replaced with a foil **20**, having a trailing surface diverging with respect to the wire **1**. As is well known in the art, this divergence between the foil surface and the wire creates a negative pressure area which promotes drainage through the wire. In order to enhance the drainage rate at each of the foils, a remixing nozzle **10** is provided just prior to the leading edge of each of the foils **20**. As seen in FIGURE 6, the cross-sectional area of the nozzle may be tapered throughout its length to insure uniform pressure and velocity.

A further embodiment of the invention is shown in FIGURE 7. In this embodiment, a conventional table roll is used in combination with a remixing nozzle **10**. The rotation of the table roll **21** causes an area of negative pressure on the downstream side of the nip between the wire and the roll. To assist in the drainage through the wire, the nozzle **10**, of tapered cross-sectional area, is provided to cause a redispersion of the fibers within the stock; thereby increasing the drainage rate in the downstream nip of the table roll.

In FIGURES 8 and 9 of the drawings, apparatus embodying the principles of the present invention is shown which is adapted to be manufactured in units for installation beneath the forming surface of a fourdrinier machine. Each unit **22** may comprise a pair of major side walls **23**, a bottom wall **24** and end walls **25**. A wall **26** extends in spaced, parallel relationship to one wall **23** and forms therewith a nozzle chamber **27** having a sloping bottom wall **28**. A second nozzle chamber **29** is also defined within the confines of the unit **22** by the side walls **30** and sloping bottom wall **31**. Each nozzle may be supplied with liquid or steam under pressure by means of a conduit or the like **32** and each unit is provided with vacuum and relief lines **33** and **34**, respectively.

In operation, a unit **22**, or preferably, a series of such units, are positioned beneath the forming surface of the papermaking machine with the nozzle chamber **27** positioned upstream of nozzle chamber **29**. As the partially drained stock passes over each nozzle, the stock is remixed in preparation for the succeeding suction chamber. As noted in connection with FIGURE 4, this alternate drainage and remixing results in both increased drainage rates and improved paper formation.

While the unit **22** is shown as having two remixing zones and two suction zones, it will be apparent that a unit can be constructed with any number of zones. Additionally, although the unit is illustrated as having a bottom wall **24**, it will be apparent that this wall may be dispensed with and a liquid seal provided in the manner of FIGURE 1; one liquid tray, as at **10**, serving several units **22**.

While several embodiments of the present invention have been described it will be seen that each has the common function of alternately draining and remixing the stock as it moves downstream on the forming surface.

We claim:

1. In web forming apparatus including an endless foraminous belt trained about a series of supporting members to provide a substantially planar forming surface having an upstream end and a downstream end, means for depositing a dilute suspension of liquid and fibers on said planar surface adjacent the upstream end thereof, whereby a portion of the said suspension tends to drain through said forming surface leaving a loosely felted layer of matted fibers on said forming surface and a layer of said suspension overlying said layer of fibers, and means positioned upstream of the dry line of said forming surface for applying fluid pressure to said liquid and fibers, the improvement comprising:

(a) a plurality of suction boxes extending transversely of said belt on the side thereof opposite said forming surface,

(b) a plurality of remixing nozzles extending transversely of said belt on the side thereof opposite said forming surface with each nozzle positioned adjacent to and upstream of a suction box,

(c) the upper surface of each of said nozzles being positioned above the upper surface of said suction boxes, and

(d) means for delivering fluid under pressure to said nozzles.

2. The apparatus of claim **1** wherein:

(a) each of said suction boxes is one to nine inches in length measured longitudinally of said belt.

3. The apparatus of claim **2** wherein:

(a) each of said suction boxes is one to three inches in length measured longitudinally of said belt.

References Cited

UNITED STATES PATENTS

3,149,026 9/1964 Hornbostel ------ 162—297 XR

FOREIGN PATENTS

610,708 12/1960 Canada.
666,214 7/1963 Canada.

S. LEON BASHORE, Primary Examiner
R. H. TUSHIN, Assistant Examiner

U.S. Cl. X.R.

162—209, 351, 363