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VERTICAL TWIN-WIRE PAPER MACHINE

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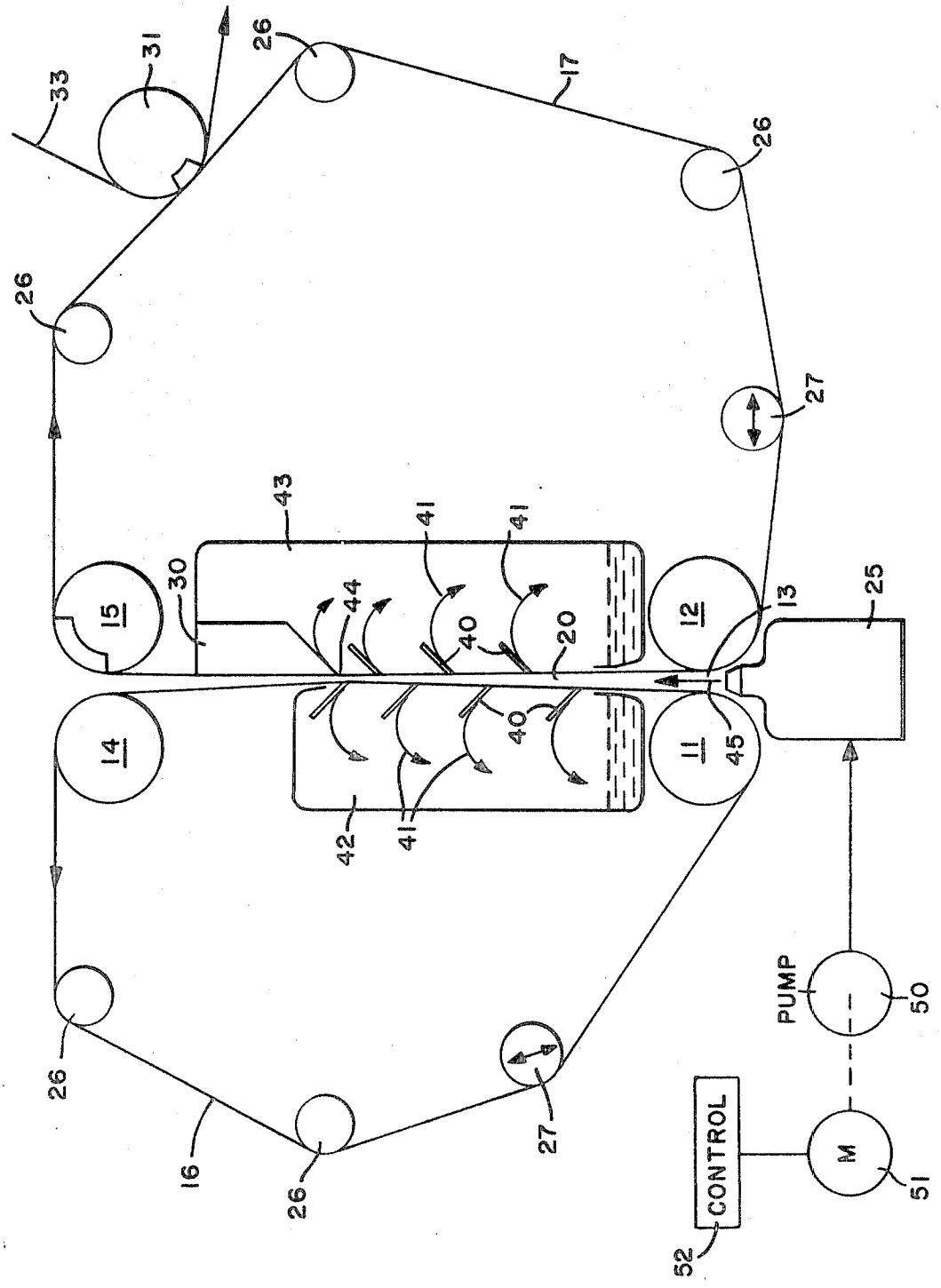

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VERTICAL TWIN-WIRE PAPER MACHINE

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The portion of the term of the patent subsequent to May 11, 1988, has been disclaimed
Int. Cl. D21f 1/00
U.S. Cl. 162—203 7 Claims

ABSTRACT OF THE DISCLOSURE

In a two-wire vertical paper machine, the opposed upwardly traveling reaches of the two wires are guided in converging relation to define a forming zone of predetermined dimensions, and a stock jet is discharged upwardly into this forming zone at a velocity sufficiently higher than wire speed to assure an upwardly directed pressure head on the liquid component of the stock substantially throughout the forming zone. The dimensions and direction of the stock jet are controlled such that the jet passes freely into the forming zone in spaced relation to each of the wires to impinge on the wires above the mouth of the forming zone defined between a pair of breast rolls.

REFERENCE TO COPENDING APPLICATIONS

Ser. No. 703,299, filed Feb. 6, 1968, Notbohm et al.
Ser. No. 706,514, filed Feb. 19, 1968, McCarrick et al.
Ser. No. 711,583, filed Mar. 8, 1968, McCarrick et al.
Ser. No. 755,602, filed Aug. 27, 1968, Notbohm et al.

BACKGROUND OF THE INVENTION

The invention relates generally to papermaking machines of the type shown in the above applications and in Baxter Pat. No. Re. 25,333 and Baxter et al. Pat. No. 3,215,594. Such paper machines may be characterized generally as incorporating a pair of endless forming wires arranged to wrap a corresponding pair of horizontally spaced abreast rolls in such manner as to provide a pair of opposed reaches which travel downwardly from the breast rolls in closely spaced converging relation to create a zone wherein the paper sheet is formed. Guidance of the wires along the forming zone is effected by multiple deflectors which support the traveling wires in the desired converging relation while skimming from their surfaces the liquid which is extruded therethrough from the forming zone as the fibers remaining therein are compacted in felted relation to form the paper sheet.

One of the outstanding advantages of a paper machine of the type summarized in the preceding paragraph lies in the fact that maximum use is made of the forces of gravity in achieving uniform drainage conditions through both forming wires and thereby eliminating the two-sided surface characteristics of paper formed on a conventional Fourdrinier machine. It has been found to be relatively simple in practice to operate such a machine at sufficiently high speed to eliminate the necessity for edge seals along the forming zone, because dewatering through the wires takes place before there is significant lateral spreading of the stock. The first commercial installation of such a machine by the assignee of the above patents and applications was greeted by the paper industry as a revolution in the art, and many additional installations are under construction.

The present invention is concerned with the provision of a vertical paper machine wherein the forming wires run upwardly in defining the forming zone and which is

capable of affording the significant advantages of vertical paper machines of the type outlined above along with additional advantages by reason of its upwardly directed forming zone. The invention has the further objective of accomplishing the result without the requirement of edge seals and other special equipment not necessary with vertical paper machines wherein the forming zone extends downwardly.

SUMMARY OF THE INVENTION

The invention lies in part in a two-wire paper machine wherein the forming zone extends vertically between two upwardly traveling converging reaches of the two wires, and wherein the velocity with which the stock is introduced into the forming zone is so controlled with relation to the speed of the forming wires that substantially all the free water in the stock is extruded through the wires and has minimum tendency to flow laterally of the wires within the forming zone. The invention further lies in delivering the stock into the forming zone at a discharge velocity which is sufficiently higher than the speed of the wires that even though the free water in the stock is continually subject to the decelerating action of gravity, an upward pressure head will continue to be effective thereon until it has been extruded through one of the wires from the interior of the forming zone.

The invention may be explained more readily by comparison with a vertical paper machine operating downwardly as in the above patents and applications. In such a machine, the stock is delivered to the forming zone with an initial downward velocity which is subject to the accelerating action of gravity. The length of the forming zone in the direction of wire travel in such a machine is so short, namely less than 48 inches in a commercial size machine, that if the wire speeds and stock velocity are relatively closely matched, formation of the sheet by dewatering through the wires will take place before there is any significant lateral flow of liquid in the forming zone.

If the forming action is visualized as commencing with the deposition of fibers on the inner surface of each wire from the essentially liquid suspension which fills the larger end of the forming zone, there is a progressive increase in the thickness of deposited fiber while the relatively liquid core in the center of the forming zone progressively decreases until it disappears as the deposited layers of fiber merge with each other at the small end of the forming zone. This forming action is a function both of the pressure exerted on the stock by the converging wires, and also of the accelerating action of gravity on the liquid component of the stock, which acts as a pressure head aiding in the extrusion of liquid through the wires as the converging wire reaches restrain the gravitational acceleration of the liquid.

As a more specific analysis of the forming conditions in a downward vertical paper machine, the forming zone is at all times filled with stock from its lowermost level where the wires are closest together up to the level at which the stock jet is in contact with both wires. The velocity of the stock is therefore essentially the same as wire speed throughout the forming zone, and any excess stock velocity derived from the accelerating effect of gravity and its discharge velocity will be converted into a downward pressure head providing kinetic energy which combines with the converging wires to force liquid through the wires and thereby to cause formation of the sheet.

It is important in the operation of a vertical paper machine to maintain the proper relationship between the kinetic energy of the stock and the force which opposes this energy. This opposing force is provided initially by

the bare wires, and it increases as fibers deposit on the surfaces of the wires and thereby provide increased resistance to further dewatering as a given particle of stock travels through the vertical extent of the forming zone. In order to maintain optimum forming conditions while eliminating lateral leakage of stock from between the wires, the kinetic energy of the stock should be greater than the forces opposing dewatering through the forming zone. Otherwise, namely if the forces opposing dewatering are greater than the kinetic energy of the stock, some of the stock will follow the liner of lesser resistance and seek to escape laterally from between the wires.

The present invention recognizes that the same conditions outlined in the preceding paragraph also apply to a vertical paper machine wherein the wires travel upwardly in defining the forming zone, and wherein gravity will therefore have a decelerating effect which must be taken into account. In accordance with the invention, therefore, the stock is supplied into the upwardly extending forming zone at a discharge velocity which is sufficiently greater than wire speed to assure conversion into an upward pressure head which will be effective so long as there is any free water within the forming zone. In other words, the relative speeds of the stock and the wires should be such as to provide an excess velocity component for the stock which will convert to an upward pressure head effective so long as there is an essentially liquid core in the forming zone. Under these conditions, just as in the downwardly operating machine, the upward pressure head will cooperate with the converging wires in effecting extrusion of the free liquid through both wires.

A vertical paper machine constructed in accordance with the principles of the invention outlined above is capable of operation over at least as wide a range of wire speeds as a downwardly operating vertical paper machine, especially at the lower end of the speed range, and it also offers other practical advantages. For example, if the two wires are arranged to diverge above the forming zone, the single wire carrying the sheet is readily directed into a horizontal or downwardly inclined run with the sheet on its upper surface for pickup and transfer to a press section by any of the pickup arrangements commonly used with conventional Fourdrinier machines. Further, a vertical forming section in accordance with the invention may be even more compact and require even less space than a downwardly operating paper machine, with attendant economies of both initial construction and maintenance, and by reason of the opposed force of gravity, it offers the possibility of different modes of operation. Other objects and advantages of the invention will be apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWING

The single view is a side elevation illustrating diagrammatically one form of downwardly operating paper machine constructed in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The figure shows the general construction of a vertical paper machine including a pair of breast rolls **11** and **12** supported in horizontally spaced relation to define a mouth or gap **13** therebetween, and a pair of couch rolls **14** and **15** are mounted above the breast rolls **11** and **12** A pair of forming webs or wires **16** and **17** are looped around the respective pairs of breast and couch rolls **11–14** and **12–15**, the term "wires" being used generically as including foraminous forming webs of any suitable material. The couch rolls **14** and **15** are provided with suitable drive means (not shown) to cause the wires to travel upwardly from the breast rolls **11–12** at regulated speeds toward and around the couch rolls **14** and **15**.

The reaches of the wires **16** and **17** directly above the breast rolls **11** and **12** are guided so that they converge upwardly to define therebetween a forming zone **20** of generally triangular section open at its larger end to the

gap **13** between the breast rolls to receive stock from headbox **25**, which is represented diagrammatically and is preferably of the construction shown in the above Notbohm et al. application Ser. No. 703,299. The remainder of the loop of each of the forming wires **16** and **17** is provided with suitable guide rolls **26** and **27**. A suction box **30** is mounted below the right-hand couch roll **15** for loosening the newly formed paper web from the wire **16** and causing it to adhere to the wire **17** as the latter wraps the couch roll **15**, which is shown as a suction roll, and travels away from the wire **16** to the pickup roll **31** by which it is transferred to the pickup felt **33**.

The wire reaches defining the forming zone are guided by deflectors **40** which engage the inner surfaces of these wires in supporting relation. These deflectors **40** are advantageously of the adjustable construction shown in the above application Ser. No. 706,514, but in contrast to their arrangement in a downwardly operating vertical paper machine, they are inclined upwardly away from their respective lines of engagement with the forming wires in order to skim off water expressed through the wires and guide this water away from the wires as indicated by the arrows **41**, so that it falls into the interior of the save-alls **42–43** by which the respective sets of deflectors are enclosed. An additional deflector **44** is provided along the lowermost edge of the suction box **30**, and this deflector **44** and the uppermost deflector **40** for the other wire cooperate to establish the station of minimum relative spacing of the wires, the wire **16** being guided away from wire **17** above this level by its couch roll **14**.

The spacing and arrangements of the deflectors **40** and **44** with respect to each other and to the gap **13** between the breast rolls are preferably determined in accordance with the principles described in Notbohm et al. application Ser. No. 755,602 and in combination with a headbox **25** of such characteristics that the stock is delivered as a sheet-like jet, represented by the arrow **45**, which passes freely through the gap or mouth **13** in spaced relation with both of the wires **16–17** so as to provide an air-stock interface on each side of the jet as it passes through the mouth **13** and then impinges on the wires **16–17** above the level at which the pumping action of the breast rolls **10–11** would tend to draw liquid through the wires, i.e. substantially above the line of tangency of each wire with its associated breast roll. Additionally, the stock supply to the headbox **25**, represented by the pump **50**, motor **51** and motor control **52**, is so regulated with relation to the speed of the wires that the initial discharge velocity of the stock toward the forming zone is greater than wire speed and is such that in the absence of the wires, the jet would rise at least as high as the deflector **44**, and preferably somewhat higher, before being overcome by gravity.

Under these relative speed and velocity conditions, stock will continuously fill the forming (zone while dewatering proceeds as described above, first with deposition of fibers on the inner surfaces of each wire, and thereafter by complete formation of the sheet as it travels out of the forming zone above the deflector **44**. With the discharge velocity of the stock in excess of wire speed, retardation of the stock by the wires will not only result in some dewatering by reason of the momentum of the liquid, but the velocity components capable of carrying the stock as a free jet above the deflector **44** will be converted into pressure head cooperating with the converging wires to extrude liquid through the wires while formation of the sheet is completed.

It is a relatively simple matter to calculate the discharge velocity necessary to achieve the optimum results of the invention for a given wire speed and given dimension of the forming zone. The essential condition is that the discharge velocity be sufficiently higher than wire speed to assure an upward pressure up to substantially the height of the deflector **44**, notwithstanding the decelerating action of gravity. Critically of this require-

ment is mitigated by the fact that moderately excessive speed has no disadvantage and affords a measure of safety. For example, if the vertical distance from the upper end of the headbox nozzle to the deflector **44** is 3 inches, and if wire speed is 1,000 feet per minute, then 1,500 feet per minute is a safe discharge velocity for the stock jet. A corresponding margin should be maintained for different wire speeds, always with relation to the vertical distance from the headbox nozzle to the uppermost level of the forming zone.

A vertical paper machine constructed in accordance with the invention offers significant advantages in several respects. Not only is it capable of operation at comparatively slow speeds, namely a few hundred feet per minute, but it is extremely compact, as is demonstrated by reference to the drawing on the basis of the above dimension of 32 inches from the headbox nozzle to the deflector **44**. Additionally, as shown in the drawing, the sheet is presented on the upper surface of the reach of wire **17** traveling away from its couch roll **15**, so that no special adaptation is necessary for the use of a conventional pickup mechanism.

While the method herein described, and the form of apparatus for carrying this method into effect, constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to this precise method and form of apparatus, and that changes may be made in either without departing from the scope of the invention.

What is claimed is:

1. The method of forming a fibrous sheet between a pair of looped forming wires which comprises the steps of continuously advancing said wires upwardly in closely spaced relation defining an upwardly extending forming zone, maintaining said wires in predetermined spaced relation at the lower end of said forming zone to define a mouth thereto of predetermined maximum width, continuously guiding said wires upwardly in maintained converging relation from said mouth toward a station of predetermined minimum relative spacing, continuously discharging in an upward direction into said zone through said mouth a jet of fiber-containing stock, maintaining the discharge velocity of said jet sufficiently higher than the speed of said wires to maintain the upward pressure head of the stock throughout substantially the vertical extent of said forming zone and thereby forcing liquid to be extruded through said converging wires by the action of said pressure head between said converging wires while the fibers remaining within said forming zone form the paper sheet, and removing said extruded liquid from within the loop of each of said wires.

2. A method as defined in claim **1** comprising the step of controlling the dimensions and direction of said jet to cause said jet to pass freely through said mouth in spaced relation with both of said wires providing an air-stock interface on each side of said jet through said mouth and to impinge on said wires above said mouth.

3. A method as defined in claim **1** wherein the discharge velocity of said jet is maintained sufficiently higher than the speed of said wires that the upward velocity of the stock is greater than the speed of said wires at said station of minimum spacing and is converted to pressure head urging the liquid component of the stock through said wires.

4. Apparatus for forming a paper sheet in a forming zone extending upwardly between traveling reaches of a pair of looped forming wires, comprising a pair of breast rolls each adapted to be looped by one of said wires, means supporting said breast rolls in such spaced relation that horizontally opposed portions of said wires define a mouth of predetermined width for said forming zone, guide means positioned within loops of said wires and guiding opposed reaches thereof upwardly in converging relation from said mouth to a station of minimum relative spacing thereby causing said wire reaches to define said forming zone, headbox means for supplying papermaking stock to said forming zone from below and including means for discharging upwardly through said mouth a stock jet of predetermined cross sectional dimensions smaller in thickness than said width of said mouth and for so directing said jet into said mouth that said jet impinges on each of said wires at a location spaced substantially above the line of tangency of said wire with its associated breast roll, means for controlling the discharge velocity of said jet at a velocity sufficiently higher than the speed of said wires to maintain a positive upward pressure head substantially throughout the vertical extent of said forming zone forcing liquid to be extruded through said converging wires while the fibers remaining within said forming zone form the paper sheet, and means for removing said extruded liquid from within the loop of each of said wires.

5. Apparatus as defined in claim **4** wherein said guide means include a plurality of deflectors engaging the surfaces of said wire reaches outside said forming zone to deflect the extruded liquid upwardly and away therefrom.

6. Apparatus as defined in claim **5** comprising a suction box above and in closely spaced relation with the uppermost said deflector for one of said wires for causing the sheet to adhere to said one wire, and means for guiding said wires in diverging relation away from said suction box.

7. Apparatus as defined in claim **4** comprising a pair of couch rolls located above said breast rolls and each positioned to be wrapped by one of said wires as it travels away from the other said wire, one of said couch rolls being a suction roll.

References Cited

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OTHER REFERENCES

Castagne, M. R.: "With the Verti-Forma" in Paper Industry, October 1965. pp. 40–49.

S. LEON BASHORE, Primary Examiner

R. H. TUSHIN, Assistant Examiner

U.S. Cl. X.R.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,597,315 Dated August 3, 1971

Inventor(s) Willard C. Notbohm and Paul M. Schaffrath

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 12, following "extends" insert --generally--.

Column 3, line 11, "liner" should be --line--.

Column 4, line 75, "Critically" should be Criticality--.

Column 5, line 5, "3 inches" should be --32 inches--.

Signed and sealed this 25th day of April 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents