Jan. 8, 1963 R. M. JODREY 3,072,180

FLEXIBLE FLOW STABILIZER

Filed Sept. 3, 1959 2 Sheets-Sheet 1

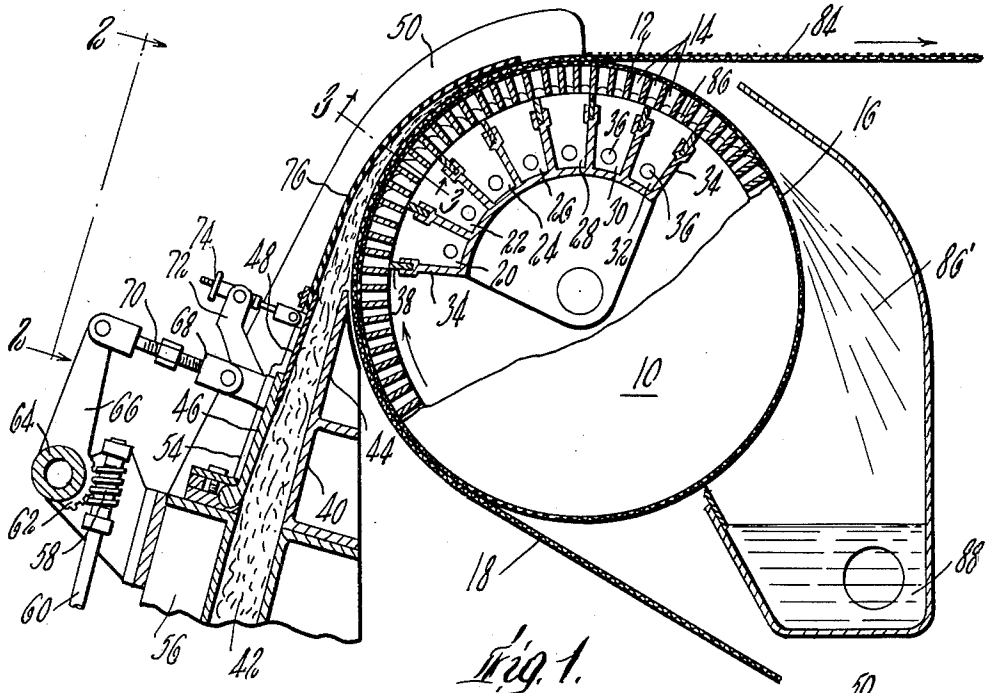

Fig. 1.

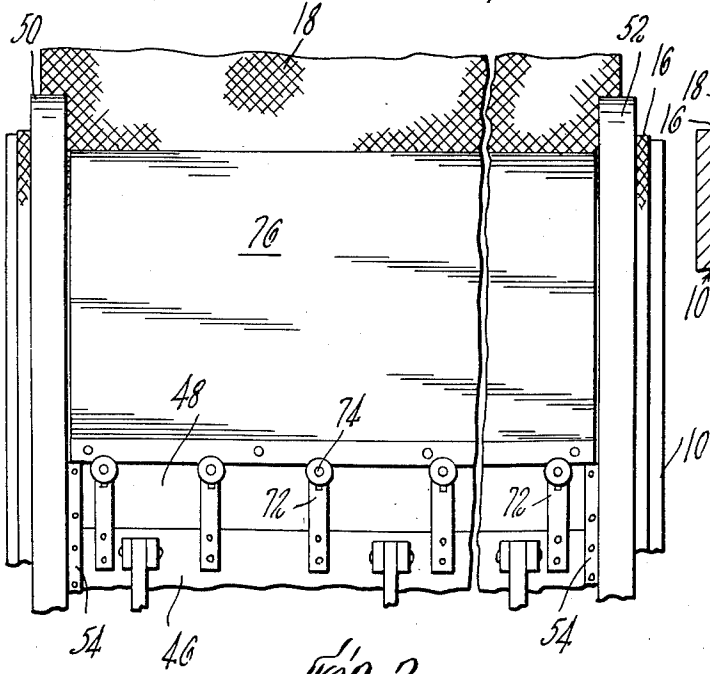

Fig. 2.

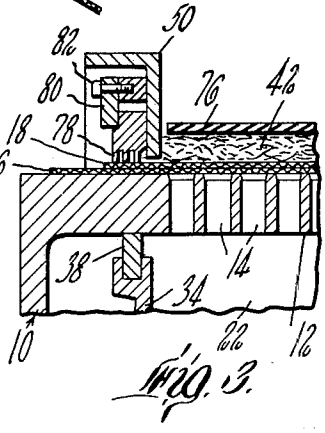

Fig. 3.

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FLEXIBLE FLOW STABILIZER

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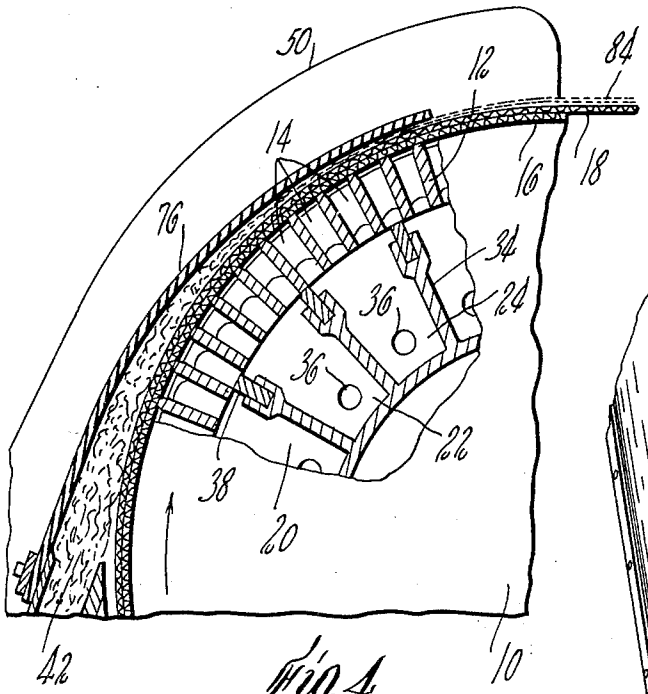

Fig. 4.

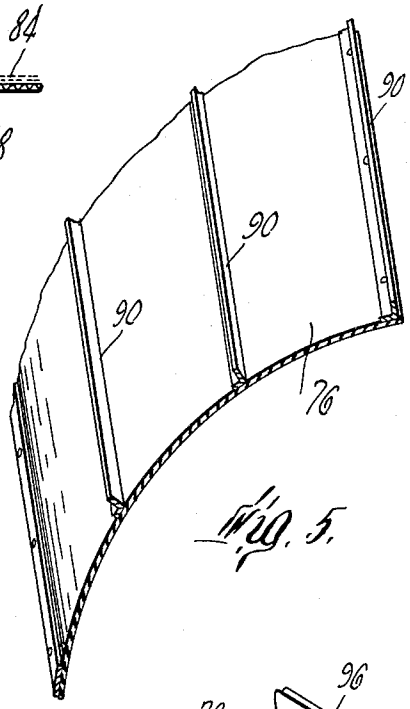

Fig. 5.

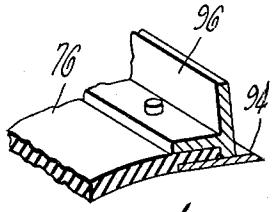

Fig. 6.

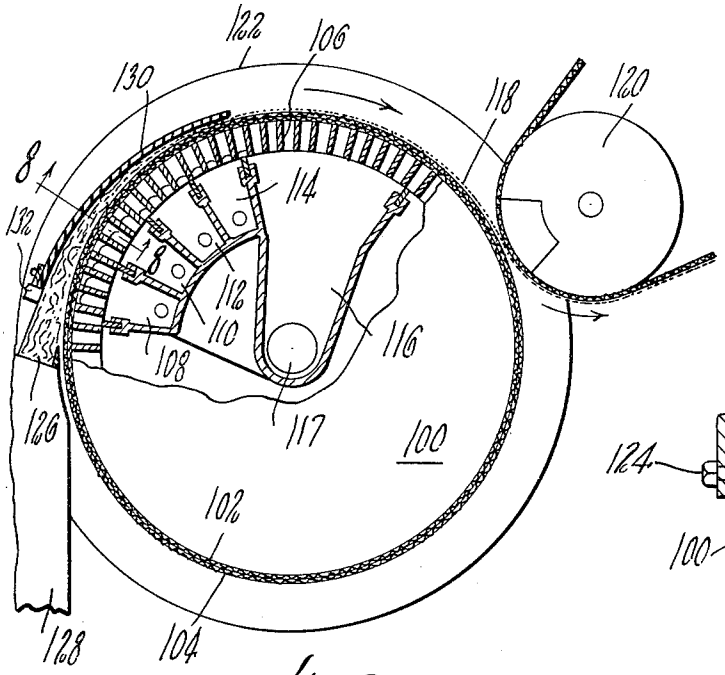

Fig. 7.

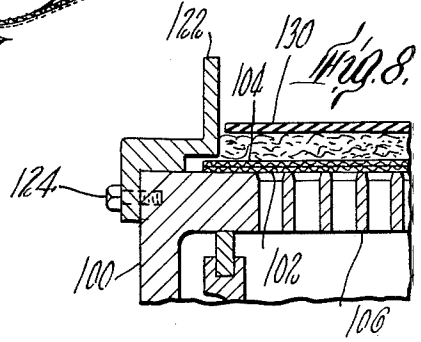

Fig. 8.

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3,072,180
FLEXIBLE FLOW STABILIZER

Robert M. Jedrey, Marlboro, Mass., assignor to Rice Barton Corporation, Worcester, Mass., a corporation of Massachusetts

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10 Claims. (Cl. 162—319)

This invention relates to paper making machines and the like and more particularly to a method and apparatus for providing control of the paper web formation process. This invention may be used with either high or low speed paper making machines but embodies principles particularly advantageous in high speed operation.

In the typical paper making process a liquid fiber mixture is spouted onto a moving wire or other similar foraminous surface in a flat stream of uniform thickness. A pressure differential across the stream and the surface causes the liquid to be extracted from the mixture and the fibers to be deposited in a web on the surface. The relative arrangement of fibers in the web formed on the foraminous surface is a function in part of the velocity difference between the foraminous surface and the mixture applied to that surface. If the stock is moving at a velocity substantially different from the velocity of the surface, a combing action results which tends to align the fibers along the direction of the surface movement and imparts to the sheet different properties in the machine direction than in the transverse direction. However, if the stock is applied to the surface with a velocity substantially equal to that of the surface, a more random fiber orientation is achieved which produces a sheet having substantially the same characteristics in both the machine and transverse directions. Thus the relative velocity between the stock and the foraminous surface plays an important role in obtaining desired sheet characteristics.

The free surface of the stock stream, which is exposed to the atmosphere, as flowed onto the foraminous surface often has a certain degree of turbulence or agitation so that the stream tends to be of somewhat uneven thickness. Where the velocity of this stock stream is high and the stock is flowed onto a wire trained about a suction roll, for example, the centrifugal force tends to exaggerate the turbulent characteristics of the free surface and further impair the evenness of deposition and thus the quality of the sheet being formed.

In order to maintain the proper velocity characteristics for desirable web formation in high speed paper making machines, there have been provided in prior art apparatus enclosures which overlie the suction forming zone of the paper making machine. Enclosure devices for this purpose have often taken the form of rigid plate structures which are carefully and critically designed to achieve a suitably smooth surface of accurate curvature for conformance to the desired radial drainage profile of the apparatus. Usually adjusting means are associated with the enclosure so that the dimensions of the forming zone may be varied somewhat depending on the type of stock being used. These adjustment means must be complex and massive as it is essential to provide highly accurate positioning of the rigid enclosure device so as to avoid harmful interference with the smooth flow of the stock stream and even deposit of the fiber web.

It is an object of this invention to provide an improved method and apparatus for achieving desirable control of the stock flow in the formation zone of a paper forming machine.

Another object of the invention is to provide a stock flow and web formation device capable of operation without necessity of mechanical adjustment of its position relative to the foraminous surface for a variety of stock types.

Another object of the invention is to provide a stock flow control device which facilitates the obtaining of the desired drainage rate and fiber deposition in the forming zone regardless of the stock furnish.

A further object of the invention is to provide an apparatus suitable for use with high speed paper making machines which improves the flow stability of the free surface of a stock stream moving in conjunction with a foraminous forming surface.

The apparatus according to a preferred embodiment of the invention is adapted to be associated with a paper making machine in which the stock stream is applied to the foraminous forming surface under control of an adjustable nozzle mechanism. In this paper making machine, the liquid fiber stock mixture is flowed into a channel, the floor of which is a moving foraminous surface. A pressure differential, impressed across the stock and the surface, causes the liquid to be separated from the fibers and extracted through the surface and the fibers to be deposited on the surface in a mat. In general, it is desirable that the rate of drainage of liquid from the mixture be controlled by varying the pressure differential along the forming zone such that a slow initial drainage rate will prevent the excessive loss of fines or filler material through the foraminous surface before a sufficient mat is deposited. As the mat gradually increases in thickness, a greater pressure differential is employed to overcome the resulting increase in the drainage resistance offered by the mat. In accordance with one embodiment of the invention a flexible sheet member, attached to the nozzle mechanism, is adapted to overlie the stock mixture in the forming zone. This sheet member extends substantially across the width of the channel and is supported solely by the moving stock stream where it is not supported by the nozzle. Thus the sheet member encloses the forming zone and imparts a smoothing and stabilizing action to the uppermost surface of the stock mixture as the liquid is drained therefrom and a mat of fiber is formed on the foraminous surface.

When forming a paper web on a suction breast roll, it has been the practice to locate the nozzle or slice close to the apex of the roll and to utilize vacuum to prevent the residual drainage from prematurely discharging radially adjacent the apex. It has been considered impractical to discharge a slice jet onto an ascending surface of a cylinder in a relatively open zone where the flow on the wire is exposed to the atmosphere. With apparatus according to the invention it now becomes possible to discharge a high velocity jet onto an ascending surface of a suction breast roll.

Other objects and advantages of the invention will be seen as the following detailed description of preferred embodiments thereof progresses in conjunction with drawings, in which:

FIG. 1 is a side elevational view, in section, illustrating the apparatus according to a preferred embodiment of the invention associated with a portion of a paper making machine;

FIG. 2 is an endwise view of the apparatus shown in FIG. 1 taken along the line 2—2 thereof;

FIG. 3 is a fragmentary sectional view taken along the line 3—3 of FIG. 1;

FIG. 4 is an enlarged sectional view of a portion of the apparatus as shown in FIG. 1;

FIG. 5 is a perspective view of a modification of a portion of the apparatus incorporating principles of the invention;

FIG. 6 is an enlarged sectional perspective view of a portion of apparatus incorporated in a modified embodiment of the invention;

FIG. 7 is a side elevational view, in section, of a portion of a second paper making machine embodying principles of the invention; and

FIG. 8 is a fragmentary sectional view along line 8—8 of FIG. 7.

With reference to FIG. 1, a rotating suction breast roll 10 is used as a cylindrical forming means for a web of paper. This breast roll comprises a cylindrical metal shell 12 through which have been drilled a multitude of countersunk apertures 14 and around the outer surface of which may be attached a conventional backing wire 16. A wire 18, moving at the same speed as the roll 10, is trained about the periphery of the roll and is associated with other components of the paper making machine which do not necessarily form a part of the invention and therefore are not shown. Within the shell 12 and opening against the inner surface thereof is a series of stationary suction boxes 20–32 having common walls 34 and mounted in a conventional manner. The individual boxes have apertures 36 which are connected, by means of pipes through hollow journals on which the roll 10 may be mounted, or by other means to independently controllable sources of fluid pressure. Thus the pressure in the drilled apertures 14 of the shell 12 may be controlled as the apertures pass over successive suction boxes. The partitions 34 have sealing strips 38 which bear against the inner surface of the shell in a conventional manner.

An adjustable nozzle 40 is disposed adjacent the roll 10 and a stock stream 42 is forced under pressure through this nozzle and is spouted in a flat wide jet onto the ascending surface of the wire 18. The nozzle is formed on the bottom by an apron 44 and on the top by a rigid nozzle plate 46 and a semi-flexible trimmer lip 48. The apron, nozzle plate and trimmer lip extend the entire width of the machine as indicated in FIG. 2.

Disposed on either end of the nozzle are pond plates 50, 52 which enclose the ends of the nozzle and extend along the periphery of the forming roll 10 defining the sides of the channel into which the stock stream is spouted. Conventional seal strips 54 prevent leakage of stock at the junction of the nozzle plate 46 and trimmer lip 48, and the pond plates 50, 52.

The nozzle plate 46 is pivotally mounted on the nozzle frame 56 and is adjustable to vary the spouting velocity of the stock for any given rate of stock flow into the nozzle. A worm pinion 58, adapted to be rotated by shaft 60, is supported from the frame 56 and coacts with a worm gear segment 62 mounted on shaft 64 to rotate that shaft and the rocker arms 66 that are mounted thereon. The rocker arms are connected to the plate by means of pivot links 68 and the turnbuckles 70 which are provided for initial alignment. Thus the position of the plate may be adjusted by rotation of the shaft 60 which acts to pivot the plate to the desired opening. A plurality of rocker arms and pivot links are employed to give sufficient rigidity to the nozzle plate.

A fine adjustment of the nozzle opening is provided by the adjustment means associated with the trimmer lip 48 which is secured at the forward end of the nozzle plate 46. The interior nozzle surface that is formed by the nozzle plate and the trimmer lip is smooth so that there is no interference with the proper flow of stock through the nozzle. Brackets 72, mounted on the nozzle plate 46, and associated trimmer links 74, which are secured to the forward edge of the trimmer lip 48, provide a fine adjustment of the position of that trimmer lip so that any minor velocity variations, inherent in the stock delivery devices connected to the nozzle, may be corrected.

Attached to the forward edge of the trimmer lip and positioned so as to overlie the stock discharged from the nozzle is a flexible sheet enclosure device 76. This enclosure device may be manufactured from rubber or rubber-like material and may be reinforced with canvas, for example, if desired. Other similar semiflexible materials such as certain plastics may be also suitably employed. The lower or interior surface of this enclosure 76 should be smooth so that it does not interfere with the smooth flow of stock and the material should have the general characteristics to resist permanent deformation. The flexible enclosure device extends substantially the entire distance between the pond plates 50, 52 so that the channel provided by the pond plates and the moving foraminous surface is substantially completely enclosed in the zone in which liquid is drained from the mixture and fibers are formed into a mat on the wire. The free end of the flexible sheet member therefor extends well beyond the end of the apron 44 and other elements of the nozzle 40.

The enclosure 76 is spaced a small distance from the pond plates as shown in FIG. 3 to prevent undue friction and is supported in position by the moving stock stream so that it is free to conform to the radial drainage profile of the stock on the wire. Associated with the pond plates 50, 52 in this embodiment are seal strips 78 which are adjusted to bear lightly against the moving wire 18 and are held in place by clamp strips 80 secured by bolts 82, as shown in FIG. 3. Thus in this embodiment the pond plates define fixed walls of the channel and the wire floor and roll move relative to them.

The vacuums maintained in the suction boxes 20–32 as shown in FIG. 1 create a pressure differential across the enclosure 76, the stock stream 42, and the wire 18 which holds the stock stream in contact with the roll 10, produces drainage of liquid from the stock, and deposits the fiber in a web 84 on the wire. The vacuums also maintain the filtrate 86 inside the apertures in the forming roll until the wire 18 carrying the web 84 has been separated from the roll. The filtrate 86 is then discharged by centrifugal action into the save-all 88 in a conventional manner as shown by 86.

It will be understood that the dimensions and proportions of the various parts shown in the drawings are not intended to be to scale but have been chosen for the convenience of explaining the principle and mode of operation of the invention. Although FIG. 1 shows the flexible enclosure 76 covering substantially one fourth of the circumference of the forming roll 10, where circumstances warrant, the length of the enclosure may be reduced or increased as necessary depending on the type of forming machine and the stock being utilized. Those skilled in the art will have no difficulty in selecting the relative dimensions of the components for accomplishing the desired results in any particular installation. It should also be noted that, even though the forming roll 10 as shown in FIG. 1 is a drilled shell containing stationary suction boxes, the flexible forming zone concept of the invention is readily adapted to machines in which the entire interior of the forming roll is evacuated and to other types of suction forming structures.

In operation, stock issues from the nozzle opening formed between the trimmer lip 48 and the apron 44 and flows onto the ascending surface of the wire 18. The flexible enclosure 76 overlies the stock stream and, together with the channel, encloses the stock stream in that portion of the web formation area where liquid is being drawn from the stock mixture under the influence of the pressure differential created across the enclosed stock stream and the wire by means of the suction boxes 20–32. This pressure differential is varied along the drainage zone so that the liquid is drained off at the preferred rate and the thickness of the mixture on the forming surface decreases at a substantially constant rate as indicated in FIG. 4.

It should be noted that if air pressure is used to accelerate a liquid by direct contact, considerable surface instability is encountered at the interface of the air and the liquid when large accelerations are effected. High speed operation of suction forming rolls on which the stock stream moves in an arcuate path necessitates large radial accelerations. By employing the flexible enclosure as described herein, atmospheric pressure is caused to

act on the relatively stable enclosure rather than on an unstable free liquid stream, thus making it possible to keep the stock stream suitably intact relative to the roll and effect the desired drainage. The enclosure guides the stock stream and stabilizes the upper surface thereof, thereby insuring the even deposition of fibers. The fact that there is very little leakage of the stock stream through the gaps between the enclosure and associated pond plates is due in part to the fact that the gaps are comparatively small and in part to the fact that the stock stream pressure immediately adjacent the enclosure is substantially atmospheric.

Throughout the forming zone there is a certain degree of friction between the moving stock stream and the stationary enclosure. However, the magnitude of this friction is such that no deleterious effects on formation are produced. In the final stage of formation where all of the liquid has been drained from the stock stream, it is preferred that there remain sufficient liquid in the formed mat to provide a film of liquid on that surface of the mat against which the enclosure bears. Thus there is a minimum of friction between the enclosure and the formed mat and a resulting absence of deleterious effects.

Further, this enclosure device by its flexible nature readily conforms to the contour of the stock stream as determined by the drainage characteristics of the stock furnish being used and the pressure differentials applied to effect the drainage. Thus the complex mechanical adjustment devices required in conjunction with the rigid enclosure devices of the prior art are avoided.

The peripheral velocity of the stock being drained remains substantially constant throughout most of the forming zone, its magnitude at any point being dependent on the initial jet velocity with which the stock stream was delivered to the forming roll, the peripheral velocity of the forming roll, and the cumulative friction effects on the stock stream prior to the point in question.

Certain modified embodiments of the invention and portions thereof are shown in FIGS. 5 through 8. In FIG. 5 the flexible enclosure **76** is shown with a plurality of lateral stiffening bars **90** secured thereto. These stiffening bars extend across the entire width of the enclosure and serve to eliminate any possible lateral wave like configurations in the enclosure so that a uniform depth of stock stream at any point across the machine is assured. The addition of such stiffening bars, which are preferably manufactured of a light weight material such as aluminum, does not impair the ability of the flexible enclosure **84** to conform to the radial drainage profile as determined by the type of stock furnish being employed in the paper making process and the pressure differentials applied to effect drainage.

In some cases where the stock emerging from beneath the flexible enclosure **76** still contains an appreciable amount of undrained liquid it may be desirable to ensure that the stock stream has no variation in depth across the width of the machine at this point. In such cases a stiffening lip of the type shown in FIG. 6 may be utilized. This stiffening lip comprises a smooth plate **94** secured to the bottom of the flexible enclosure member **76** and a stiffener **96** in the form of a laterally extending angle which coacts with the smooth plate to provide the desired rigidity of this edge of the flexible enclosure. The material from which this lip is fabricated should also be light in weight so that undue increases of the stock stream pressure beneath the flexible enclosure are avoided.

FIGS. 7 and 7 show a portion of a second paper making machine which utilizes certain modified embodiments of the invention. The forming roll **100** comprises a conventional backing wire **102** and top wire **104** both of which are attached to the periphery of the shell **106** of similar type to that of the embodiment shown in FIGS. 1 through 4. Stationary suction boxes **108–114** of the conventional type are associated with the shell and the liquid extracted from the stock mixture is ultimately drawn into a sufficiently sized suction chamber **116** by the vacuum maintained therein and subsequently removed through a pipe **117** which extends outward through the hollow journals on which the forming roll **100** rotates. In pulling the liquid through the forming roll, air is also caused to flow through the web **118** affording additional moisture removal from the web. A conventional suction pickup **120** is used to remove the web from the forming roll **100**.

In this embodiment end flanges **122** are provided which are secured to the roll **100** by bolts **124** and are adapted to rotate with the forming roll as shown in FIG. 8. Thus the necessity of having long pond plates to enclose the ends of the forming zone is eliminated. The nozzle **126** may be of substantially the same type as shown and described in conjunction with FIGS. 1 and 2 with the modification that the pond plates **128** as shown in FIG. 7 need only extend to some point within the confines of the end flanges **122** and be positioned in close proximity thereto.

A flexible sheet enclosure member **130** which functions in the same manner as the enclosure **76** shown and described in conjunction with FIGS. 1–4, is secured to the forward edge of the nozzle structure **132** such that a smooth transition between the nozzle and the enclosure is provided. In this embodiment the flanges **122** move relative to the enclosure. As shown in FIG. 8 there is provided a small gap between each flange and the enclosure **130** of dimensions similar to that of the first embodiment so that there is little friction between those elements.

Thus there is provided in a paper making machine a novel enclosure device adapted for use within a channel which has a foraminous floor surface. This enclosure is attached preferably to the nozzle structure and is a flexible sheet member adapted to be positioned within the channel and to be supported by the moving stock stream which is flowed from the nozzle into the channel. Means for applying a pressure differential across the stock stream and the foraminous surface are associated with this channel. The pressure differential may be varied along the length of the channel and may at points be positive, negative or neutral depending on the application. In some cases it may be desirable to apply pressure to the enclosure itself. The flexible enclosure functions in such a manner that the peripheral velocity of the stock in the channel during the web deposition process is maintained substantially constant for almost the entire length of the web forming zone. This result is achieved regardless of the velocity difference between the stock stream and the foraminous surface and is unaffected by the rate at which drainage takes place through that surface. The enclosure is in part responsive to the position of the adjustable portion of the nozzle on which it is mounted and operates to provide the desired uniform deposition of fiber over a wide range of types and consistencies of stock mixtures and variations in drainage rate throughout the formation zone. The substantial throw-off and other causes of non-uniform deposits of solids which frequently occur in high speed machines of this type are avoided without the use of complex and massive mechanically adjustable enclosure devices. When used with a suction roll the enclosure may extend over approximately one-half the circumference of the roll where such operation is necessitated by the stock furnish being utilized and permits stock to be spouted onto the ascending roll surface without impairing the quality of the web deposited. Further, the enclosure device has the distinct advantage of being compartively inexpensive and of permitting ease of accessibility to the channel and foraminous surface where such is necessary. While the invention has been shown and described in conjunction with suction forming rolls, it will be understood that the principles are also applicable to certain other types of similar web forming apparatus.

It will thus be seen that the invention provides an improved flow control device whereby the deposition of solids upon a foraminous surface in a uniform manner

is greatly improved. While preferred embodiments of the invention have been shown and described it will be understood that the invention is not intended to be limited thereto or to the details thereof and departures may be made therefrom without departing from the scope and spirit of the invention defined in the claims.

I claim:

1. In a paper making machine the combination comprising a foraminous surface, a wall disposed on either side of said surface such that a channel is defined by said walls and said surface, means for flowing a liquid fiber mixture into said channel, means for creating a pressure differential across said surface and said mixture for extracting liquid from said mixture and depositing a mat of fibers on said surface, and a flexible, flow stabilizing member disposed above said surface and adapted to be positioned between said walls so that it overlies said liquid fiber mixture in said channel and is supported solely by the flowing liquid fiber mixture in said channel.

2. The apparatus claimed in claim 1, and further including a plurality of spaced laterally extending stiffening members secured to said flow stabilizing member.

3. The apparatus as claimed in claim 1 wherein said flow stabilizing member is a flat sheet of rubber reinforced with textile fibers and has a smooth surface adapted to contact said liquid fiber mixture.

4. In a paper making machine a channel comprising two spaced substantially parallel walls and a foraminous floor surface, means including a stock inlet adapted to introduce a liquid fiber stock mixture into said channel, a flexible sheet member secured to said stock inlet and adapted to overlie said channel, said sheet member extending across substantially the entire width of said channel between said walls, said sheet being adapted to be supported solely by said mixture, and means for applying a pressure differential across said foraminous surface and said mixture in the vicinity of said enclosure for draining the liquid from said mixture and depositing fibers in a layer upon said surface.

5. A paper making machine comprising a suction breast roll mounted for rotation, a wire trained about said roll and adapted to move with said roll, a pair of spaced substantially parallel walls disposed adjacent said roll, said walls together with said wire forming a channel, a nozzle structure disposed adjacent said roll, said nozzle being adapted to discharge a thin wide jet of stock into said channel, a flexible flow stabilizing member secured to said nozzle and adapted to overlie and contact said stock in said channel and to be maintained in spaced relationship from said wire solely by said stock, said flow stabilizing device extending substantially the entire distance between said walls, and means for applying a pressure differential across said stock in the vicinity of said flow stabilizing device for draining liquid from said stock and depositing fibers in a web upon said wire.

6. The apparatus as claimed in claim 5 and further including a plurality of stiffening members secured to said flow stabilizing device and disposed parallel to one another and extending substantially the entire width of said flow stabilizing device.

7. The apparatus as claimed in claim 5 and further including a stiffening lip structure secured to the edge of said flow stabilizing device opposite said nozzle, said lip including a flat plate having a surface lying in the same plane as the lower surface of said flow stabilizing device, and means to secure said plate to said flow stabilizing device.

8. In a paper making machine the combination comprising a foraminous surface, said surface being adapted to be moved at a substantially constant velocity, a channel wall disposed on either side of said surface such that a channel is defined by said walls and said surface, means including a stock introducing device for introducing a liquid fiber mixture into said channel at approximately the velocity of said surface, means for creating a pressure differential across said surface for extracting liquid from said mixture and depositing a mat of fibers on said surface, and a flexible member disposed above said surface and adapted to be positioned between said walls so that it overlies said liquid fiber mixture in said channel and is supported solely by the moving liquid fiber mixture on the surface thereof.

9. A paper making machine comprising a suction breast roll mounted for rotation, a wire trained about said roll and adapted to move with said roll, a pair of spaced substantially parallel pond plates secured to said nozzle and disposed adjacent said roll, said plates together with said wire forming a channel, seal means associated with said pond plates and adapted to coact with said roll in liquid sealing relationship, an adjustable nozzle structure disposed adjacent said roll, said nozzle being adapted to discharge a thin wide jet of paper stock into said channel, a flexible enclosure member secured to said nozzle and adapted to overlie and contact said stock in said channel and to be maintained in spaced relationship from said wire solely by said stock, said enclosure device extending substantially the entire distance between said pond plates, and means for applying a pressure differential across said wire and said stock in the vicinity of said enclosure for draining liquid from said paper stock and depositing fibers in a web upon said wire.

10. A paper making machine comprising in combination, a roll structure having a plurality of apertures in the cylindrical surface thereof, said roll being mounted for rotation, a foraminous surface wrapped about said cylindrical surface and adapted to move with said roll, a pair of spaced substantially parallel walls secured to said roll, said walls together with said surface adapted to form a channel, an adjustable nozzle structure disposed adjacent said roll, said nozzle being adapted to discharge a thin wide jet of stock onto said surface at an ascending point in its movement, a flexible enclosure member secured to said nozzle and adapted to overlie and contact said stock in said channel and to be maintained in spaced relationship from said foraminous surface solely by said stock, said enclosure device extending substantially the entire distance between said walls, and a plurality of suction boxes positioned within said roll and adapted in cooperation with said apertures to apply a pressure differential across said surface in the vicinity of said enclosure for draining liquid from said stock and depositing fibers in a web upon said surface.

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