

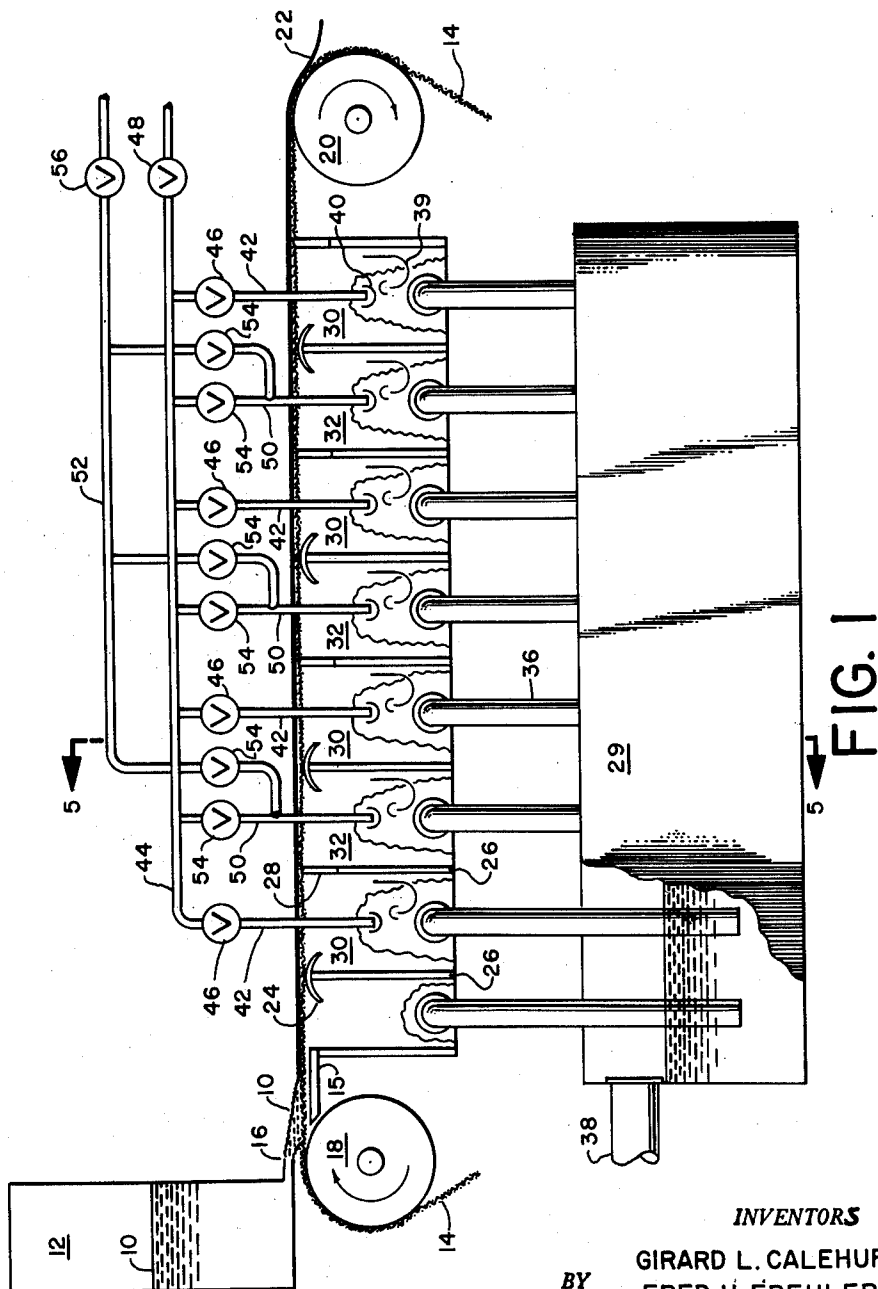
Nov. 27, 1962

G. L. CALEHUFF ET AL
MEANS FOR AND METHOD OF IMPROVING DRAINAGE
ON FOURDRINIER MACHINES

3,066,068

Filed Sept. 8, 1960

3 Sheets-Sheet 1



INVENTORS

BY GIRARD L. CALEHUFF
FRED H. FREULER

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3 Sheets-Sheet 2

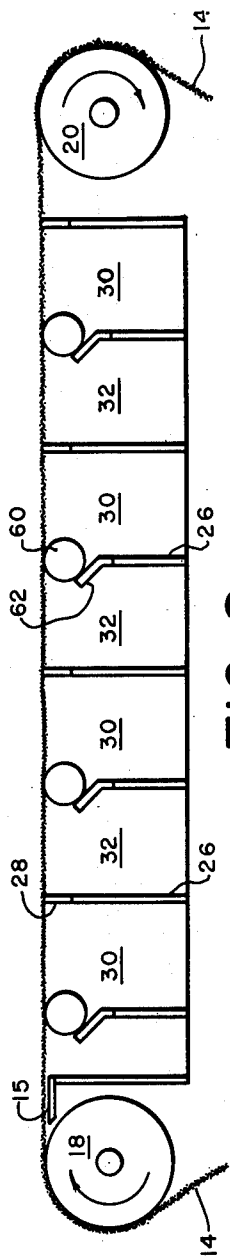


FIG. 2

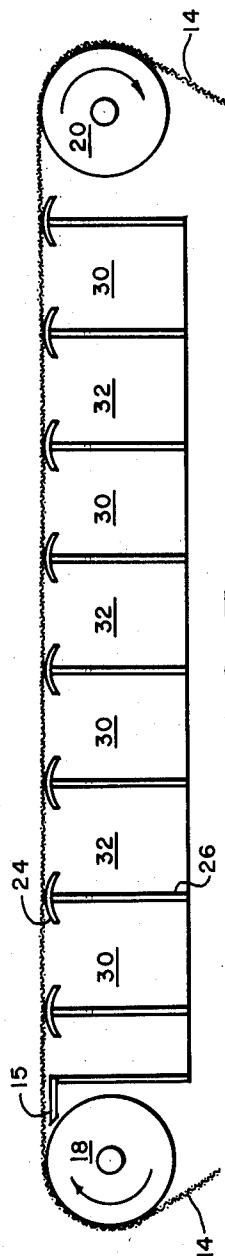


FIG. 3

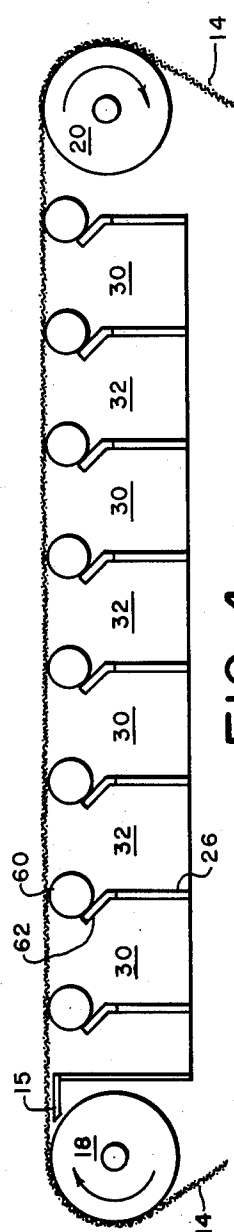


FIG. 4

INVENTORS

BY GIRARD L. CALEHUFF
FRED H. FREULER

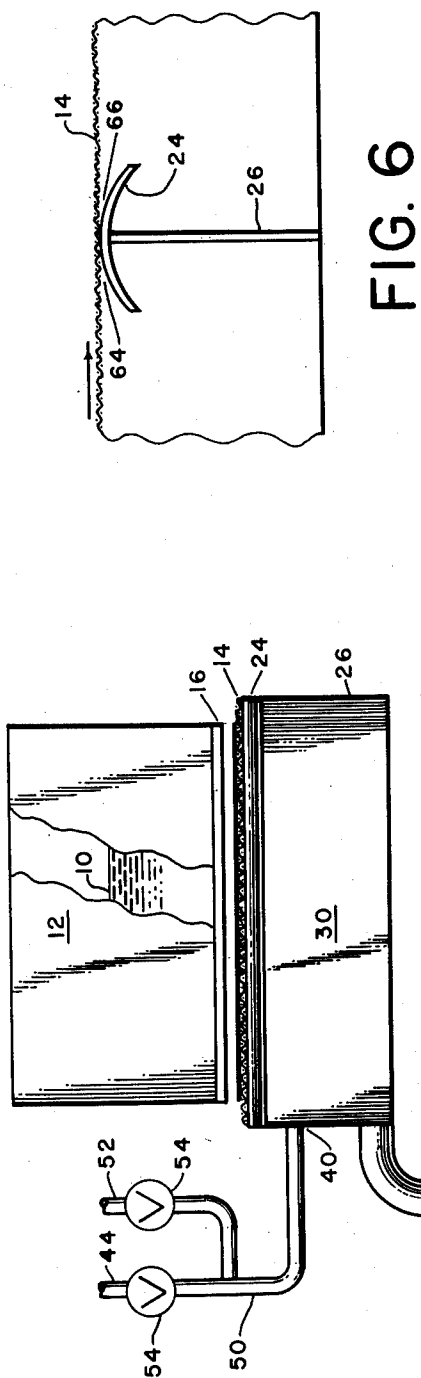
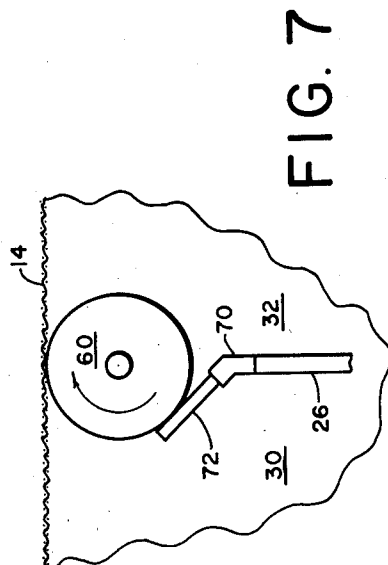
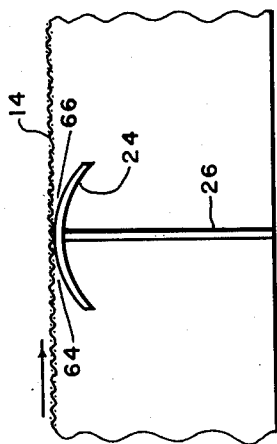
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INVENTORS
GIRARD L. CALEHUFF
FRED H. FREULER

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MEANS FOR AND METHOD OF IMPROVING DRAINAGE ON FOURDRINIER MACHINES

Girard L. Calehuff and Fred H. Freuler, Covington, Va., assignors to West Virginia Pulp and Paper Company, New York, N.Y., a corporation of Delaware

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9 Claims. (Cl. 162-208)

This invention relates generally to paper making on a Fourdrinier machine from paper pulp stock, and more specifically to an improved apparatus for efficiently removing liquid from the stock.

On conventional Fourdrinier paper making machines, the paper web is formed on the upper reach of an endless foraminous drainage support, commonly called a Fourdrinier wire, which is supported by a breast roll at the wet end and a couch roll at the dry or discharge end. Normally, paper pulp stock is introduced on the Fourdrinier wire from a headbox, which is positioned adjacent to the breast roll and above the Fourdrinier wire. The stock is drained of its suspending liquid as it progresses from the wet end of the machine to the dry end of the machine, and is finally compacted by the application of high vacuum before it leaves the Fourdrinier wire. It is essential that the stock be drained thoroughly prior to final compaction by the high vacuum.

It is well known in the art of paper making that a relatively low consistency or relatively highly diluted stock provides a more uniform formation of paper fibers, with consequent increase in strength and quality of the paper web. In the past, poor liquid drainage from the stock in the early stages of formation has prevented the use of sufficiently dilute stock to form a paper web of maximum strength and quality.

On conventional Fourdrinier machines, difficulty has been encountered in the efficient removal of liquid from the stock quickly and uniformly while the paper web is being formed. Insufficient removal of liquid from the stock in the early stages of formation permits the fibers of the stock to cluster together into a non-uniform paper formation. Furthermore, the paper making process is slowed down because the Fourdrinier wire must be moved at a speed slow enough to allow sufficient time for the liquid to be drained from the web and through the Fourdrinier wire.

In previously employed Fourdrinier machines, the wire is moved over a series of rotatable table rolls located between the breast and couch rolls, which maintain the wire substantially level to permit formation of a paper web as the wire progresses from the wet end of the machine to the dry end of the machine. In addition to supporting the wire and maintaining it level, the rolls aid in the removal of liquid from the web. Drainage is induced by a vacuum created in the outgoing nip of the table rolls. The effective drainage area is but a small fraction of the total area encompassed by the table rolls because drainage induced by the table rolls is only effective for a very short distance beyond top dead center of each roll. Liquid tends to adhere somewhat to the surface of the rolls, and due to centrifugal forces created by the rotating rolls, most of the liquid is thrown downward away from the wire. However, some of the liquid is retained on the rolls for a longer period of time and is thrown back against the underside of the wire, causing a non-uniform disruption of the partially matted fibers and loss of strength and quality of the finished web.

Conventional Fourdrinier machines using table rolls as a means of inducing drainage provide zones of relaxation for the web between rolls. Also, positive pressures are created in the ingoing nip of the rolls. These zones

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of relaxation and zones of positive pressure are needed for proper web formation, because during the passage of the web over these regions, the interstices between fibers expand, allowing the liquid from the top layers of the web to drain down to the bottom layers of the web to a position for removal during the next application of suction. If there is no period for relaxation of the web, the fibers in the bottom layers tend to become tightly matted and depleted of tiny fibers, which are commonly called "fines," and resist drainage from the top layers. This leaves only the top layers of the web with an excess of moisture and fines.

Unfortunately, conventional Fourdrinier machines lack flexibility in the sense that drainage induced by the table rolls cannot be independently controlled, but is dependent upon machine speed, the magnitude of induced suction varying as the square of the machine speed. Accordingly, the time for relaxation of the web varies inversely with the wire speed and distance between table rolls. In order to better control web moisture content and fines retention, the suction and relaxation zones of the Fourdrinier machine table roll area should be independent of wire speed and roll spacing. Where the suction and relaxation can be controlled over a wide range of operation, a fine quality web can be produced on a relatively short machine and at a high wire speed. It can be seen that under such circumstances, a positive pressure under the wire may be needed to produce sufficient relaxation of the web between applications of suction.

In the past, efforts have been made to increase the rate of drainage from the web on a Fourdrinier machine in a number of ways. Included in these efforts have been attempts to increase liquid drainage by increasing the hydrostatic head on the wire along its entire length. High vacuum suction boxes spaced along the entire length of the Fourdrinier table roll area have also been proposed in efforts to increase drainage. However, these attempts have not proved entirely successful. Other efforts to efficiently remove the liquid from the stock include the proposal to use light vacuum under the wire in conjunction with narrow slats supporting the wire which act as shearing devices to scrape the liquid from the underside of the wire.

In efforts to increase the rate of drainage, the desirable features of the table roll induced drainage principle have been overlooked. Contrary to the theories which brought about the above efforts to improve drainage characteristics of a Fourdrinier machine, present research indicates that suction applied to the underside of the wire tends to drain the liquid and fines from the bottom layers of the web and then tightly mat these fibers together, preventing drainage from the upper layers of fibers in the web.

Where the proper relationship between suction and relaxation does not exist, a web condition sometimes known as two-sidedness will exist. This condition may be observed when the finish and reflectance of the two sides of the web do not match, and is caused by the felt side of the web having a smoother and closer fiber formation than the wire side. The closer fiber formation on the felt side of the web is due to larger concentrations of fines on this side, resulting from improper relationship of suction and relaxation during web formation.

The present invention provides an improved method and apparatus for removing the liquid quickly from the web and provides uniform drainage for the entire cross section of the web in a relatively short distance by moving the web through alternate zones of controlled suction and relaxation. Thus, the present invention will enable a strong, uniform paper web to be produced quickly on a relatively short Fourdrinier machine.

The present invention further provides an apparatus which is relatively simple and inexpensive, and may be applied to old Fourdrinier machines as well as new machines.

This invention utilizes the rapid application of suction and relaxation, applied alternately, to remove liquid from the web and immediately open up the fibers that were tightly matted during suction so that drainage will occur more freely during the next application of suction. In addition to providing uniform drainage to the web, the rapid application of suction and relaxation produces web perturbations, which agitate the fibers and tend to break up any lumps which may have formed. Also, due to the rapid drainage, additional lumps do not tend to form while the web is being formed on the wire.

In the present invention, the space beneath the upper reach of the Fourdrinier wire is arranged into a series of sealed pressure chambers, whereby chambers containing a relatively high vacuum may be alternated with chambers containing a substantially higher pressure. The chambers are completely enclosed except for a drainage outlet which has a liquid seal, so that the only outlet to the atmosphere is through the Fourdrinier wire, which defines the top side of the chambers. The chambers are separated by partitions, and means for supporting the wire are provided at the tops of the partitions. The chambers are connected to sources of pressure or vacuum, or both, whereby the absolute pressure in each chamber may be adjusted to optimum degrees for a wide range of operating conditions.

In addition to the pressure differences in adjacent chambers, the above mentioned wire supports are preferably designed and arranged in a manner to cause the absolute pressures in the chambers to be supplemented. Convexly curved plates are mounted on top of the partitions, preceding a vacuum chamber, or conventional table rolls are mounted above these partitions with adequate seals between the rolls and partitions. The partitions succeeding the vacuum chambers merely have flat-top configurations which provide support for the wire between the curved plates or table rolls. In this arrangement, chambers which provide suction to the web are preceded by the outgoing nip of the curved plate or table roll where a negative pressure is known to exist, and chambers which provide relaxation to the web are succeeded by the ingoing nip of the curved plate or table roll where a positive pressure is known to exist. This arrangement and other possible arrangements will be explained in more detail in the descriptions of the accompanying drawings in which:

FIGURE 1 is a schematic side elevation view of a Fourdrinier paper making machine, illustrating a preferred form of the present invention;

FIGURE 2 is a schematic side elevation view of a Fourdrinier table, illustrating another form of the present invention;

FIGURE 3 is a schematic side elevation view of a Fourdrinier table, illustrating further form of the present invention;

FIGURE 4 is a schematic side elevation view of a Fourdrinier table, illustrating still another form of the present invention;

FIGURE 5 is a schematic sectional view taken in a plane of line 5—5 of FIGURE 1 in the direction of the arrows;

FIGURE 6 is an enlarged side elevation view of a convexly curved wire support between pressure chambers as shown in FIGURE 1; and

FIGURE 7 is an enlarged side elevation view of a table roll mounted above a partition having a pressure seal therebetween.

Referring to FIGURE 1, liquid pulp stock 10 from a conventional stock headbox 12 at the wet or infeed end of the machine is introduced onto Fourdrinier wire 14, the rate of stock flow from the headbox 12 being con-

trolled in conventional fashion by using an adjustable gate (not shown) normally positioned at the outlet 16 of the headbox 12. The Fourdrinier wire 14 comprises the usual endless wire mesh conveyor which is mounted for continuous movement at a uniform rate of speed by conventional drive means (not shown) over a breast roll 18 at the wet or infeed end of the machine, and a couch roll 20 at the dry end of the machine where the paper web 22 is removed and handled in the customary manner by the usual pressing, drying, and calender rolls (not shown). In conventional Fourdrinier machines, the wire 14 is supported between the breast roll 18 and couch roll 20 by a series of table rolls. However, in the embodiment of the present invention as shown in FIGURE 1, the table rolls are replaced by four stationary convexly curved plates 24 mounted on top of the chamber partitions 26, and four flat top portions 28 of the partitions 26 in alternate arrangement with each other. The top portions 28 of the partitions 26 may be integral with the partitions, or they may be separate to insure easy removal for replacement. A conventional forming board 15 is placed under the wire immediately downstream from the breast roll 18.

Although not shown in the drawings, a wire pit, which is simply an open end collecting sump, is positioned below the entire conveyor assembly extending from the wet end to the dry end of the wire. In conventional practice, liquid from such a sump is continuously mixed with fresh measured amounts of pulp and recirculated to the headbox 12 in a well known manner.

In conventional machines, a drainage tray (not shown) is usually positioned under the upper reach of the Fourdrinier wire 14 in spaced relation thereto, and extending from the wet end to the dry end of the machine. However, in the present invention, a relatively narrow and high vacuum seal box 29 replaces this drainage tray. The vacuum seal box 29 is positioned below the suction chambers, so that gravity will cause drainage from the chambers 30, 32 into the vacuum seal box 29, which extends for the length of the pressure chambers 30, 32. The vacuum seal box 29 is made narrow and high to permit a greater head of water to be built up, thereby maintaining a vacuum seal in the downcomers 36. Normally, liquid which drains into the vacuum seal box 29 is pumped out through outlet 38 and mixed with a concentrated suspension of pulp stock to give a desired consistency and recirculated to the headbox 12.

Conventional deckle straps or deckle boards (not shown) may be mounted in the usual manner adjacent opposite side edges of the Fourdrinier wire 14 to provide longitudinally extending guide member to confine paper pulp stock deposited there-between on the wire 14. However, the use of resilient deckle straps of a material such as rubber is desirable, as it enhances the seal between chambers 30 and chambers 32, and the underside of the wire 14 at the sides thereof.

The preferred apparatus of the present invention for effecting drainage under the wire comprises a plurality of individual chambers 30 and 32, and convexly curved plates 24 positioned on alternate partitions 26, or preceding the suction chambers. The top portion of the remainder of the partitions provide support for the wire, but do not contribute to the pressure differential between chambers. The chambers 30 and 32 are provided with an air-tight seal on all sides except the top. Thus, air may only be admitted to or dismissed from the chambers through the wire 14 which forms the top side of the chamber. The partitions and wire supports should be spaced close enough to prevent sagging of the wire.

Chambers 30 and 32 are provided with differential pressures. As shown in FIGURE 1, a preferred arrangement is for chambers 30 to be provided with a relatively high vacuum, say between 3" and 12" Hg, while chambers 32 are provided with a higher pressure which may be slightly below atmospheric, atmospheric, or slightly

above atmospheric, depending on operating conditions. Manometers 39 provide easy determination of the absolute pressure in each chamber.

The partitions 26 serve the purposes of defining each individual pressure chamber and supporting the curved plates 24 or directly supporting the wire 14, whichever the case may be. The curved wire supports 24 are rigidly mounted on the tops of alternate partitions and serve the dual purpose of supporting the wire and creating hydrodynamic forces on the web.

A typical piping arrangement supplying pressure or vacuum to the chambers is shown in FIGURES 1 and 5. The chambers 30 and 32 are provided with connections 40 to which leads from pressure and vacuum manifolds are connected. Alternate chambers 30 are supplied with vacuum through leads 42 from vacuum manifold 44. The leads 42 are provided with regulator valves 46 which provide means for individually controlling the degree of vacuum in each chamber. Manifold 44 is equipped with valve 48 which provides means for completely shutting off the vacuum to the chambers, or centrally controlling the degree of vacuum to the chambers as a group. Alternate chambers 32 are supplied with pressure or vacuum through leads 50, branches of which are connected to pressure manifold 52 and to vacuum manifold 44. The branches of leads 50 are supplied with valves 54, whereby pressure or vacuum may be selected for chambers 32, the valve 54 in the branch selected being adjusted for the desired degree of pressure or vacuum, and the valve in the branch not selected being completely shut off. Pressure manifold 52 is provided with valve 56 for completely shutting off pressure to all chambers, or for centrally controlling the degree of pressure to alternate chambers 32.

Although the construction and mounting of various elements such as framework, supporting members and other elements common to conventional Fourdrinier machines are not described here in detail, it is to be understood that the present invention is a modification and improvement of conventional machines, and the elements and methods of operation not described here are common to conventional Fourdrinier machines.

FIGURE 2 illustrates another form of the present invention. Actually, this arrangement has very nearly the same effect on the formation of the web as the arrangement shown in FIGURE 1. However, in the arrangement shown in FIGURE 2, table rolls 60 replace the convexly curved plates 24 as shown in FIGURE 1. The table rolls 60 are mounted for rotary motion above the partitions 26, and pressure seals 62 are provided between the table rolls 60 and partitions 26 to prevent pressure leakage between the chambers.

Since the pressure fluctuations produced by an arrangement as shown in FIGURE 2 are substantially the same as for the arrangement shown in FIGURE 1, the operation of the invention in the form of FIGURE 1 as described will be understood to be generally applicable to both arrangements.

As shown in FIGURE 1, the liquid pulp stock 10 is introduced directly onto the wire 14 from the headbox 12. The wire immediately passes over forming board 15 after deposition of the stock 10 onto the wire 14, where drainage is inhibited for a short distance. After leaving the forming board, the wire passes over a short open space before contacting the first curved plate 24. Immediately before the wire 14 reaches the crest of the curved plate 24, the pressure build up in the leading nip of the curved plate is relieved through the wire 14 and into the web, which at this point has only been slightly drained by natural drainage between the forming board 15 and the curved plate 24. The web then passes over the neutral zone directly above the crest of the curved plate and into the first suction zone above the outgoing nip of curved plate 24. The suction on the web provided by this outgoing nip is supplemented and main-

tained by the vacuum in chamber 30. The vacuum in chamber 30 is in the range of approximately 3" to approximately 12" Hg. During the time the web is passing through this suction zone, liquid is being drained from the web into the chamber 30 and at the same time, fibers in the lower layers of the web are becoming tightly matted. The web then passes through a very short neutral zone over the top portion 28 of partition 26. Immediately after the web passes this neutral zone, it is subjected to a substantially higher pressure (relative to the absolute pressure in chamber 30) as it passes over chamber 32. This higher pressure, supplemented by the positive pressure in the ingoing nip of the succeeding curved plate 24, causes the web to relax. After this relaxation, liquid in the upper layers of the web is allowed to drain freely to the bottom layers, where it is extracted by the next application of suction. When this pressure fluctuation cycle is repeated for a number of times down the machine, a uniform web, free from the two-sidedness hereinbefore described, may be formed in a relatively short distance. Fiber flocculations which formed in the headbox are more effectively broken up due to the agitation of the web, and the tendency toward additional flocculation on the wire is diminished because the liquid is removed very rapidly from the web.

Another form of the present invention is illustrated in FIGURE 3 which is similar to the apparatus illustrated in FIGURES 1 and 2 in the respect that the space under the upper reach of the wire is divided into a plurality of independent pressure chambers. This form of the invention is different only in that all the wire supports on top of all the partitions 26 are curved plates 24, and the pressure or vacuum in the chambers 30 or 32 is not always supplemented by the pressure or vacuum created in the nips between the wire 14 and the curved plates 24. Therefore, to accomplish the same job as the apparatus in FIGURES 1 and 2, the intensity of the pressure or vacuum in the chambers 30 or 32 will have to be greater. However, there is an advantage in this type of arrangement in that the curved plates 24 do not tend to wear as quickly as the top portions 28 of the partitions 26 as illustrated in FIGURES 1 and 2.

FIGURE 4 illustrates basically the same form of the invention as FIGURE 3, but as in FIGURE 2, the curved plates 24 are replaced by table rolls 60 mounted above the partitions 26. Again, sufficient pressure seals 62 must be provided between the table rolls 60 and partitions 26, to prevent pressure leakage between chambers.

The piping arrangement for the forms of the invention illustrated in FIGURES 2, 3, and 4 are similar to the arrangement shown in FIGURE 1.

The pressure fluctuations caused by an arrangement as illustrated in FIGURES 3 and 4 are slightly different from those caused by an arrangement as shown in FIGURES 1 and 2; however, the arrangement illustrated in FIGURE 3 produces pressure fluctuations which are similar to the arrangement illustrated in FIGURE 4, and the operation of the invention in the form of FIGURE 3 as described will be generally applicable to the arrangement of FIGURE 4.

Referring to FIGURE 3, the liquid pulp stock first passes over forming board 15 after being introduced on the wire 14. After passing over forming board 15, the wire 14 passes over a short open space before contacting the first curved plate 24. Immediately, before the wire 14 nad into the web. The web then passes over the pressure built up in the ingoing nip is relieved through wire and into the web. The web then passes over the neutral zone directly above the crest of curved plate 24, and into the first suction zone above the outgoing nip of curved plate 24. The suction of the web provided by this outgoing nip is supplemented and maintained by the vacuum in chamber 30. The vacuum in chamber 30 is in the range of approximately 3" to approximately 12" Hg. Liquid is drained from the web

as it passes this suction zone, and fibers in the lower layers become tightly matted. The web is next relaxed somewhat as it passes over the pressure zone above the ingoing nip of the succeeding curved plate 24. The web is subjected to a vacuum as it passes over the outgoing nip of this curved plate 24. The pressure in the chamber 32 is substantially higher than the pressure in chamber 30, and in the zone above chamber 32 the fibers in the web are again relaxed. When these pressure fluctuations are repeated for a number of times as the web passes down the machine, a web uniform in moisture content and fines distribution will result.

FIGURE 6 best shows how hydrodynamic forces are created as the wire passes over the curved plates. The convexly curved plate 24 is mounted on top of partition 26 by any known means. A short distance ahead of the point of contact between the wire 14 (traveling from left to right) and plate 24, an ingoing nip at 64 is created. A positive pressure occurs in this nip, which builds up to a maximum intensity at the actual point of contact between the wire and plate. As the wire passes over the crest of the curved plate, and is in direct contact with it, the pressure on both sides of the wire is neutral. As the wire 14 passes the crest of the curved plate 24, contact is broken between the wire and plate, and an outgoing nip 66 is created, where a vacuum occurs. It is preferred to construct the faces of the curved plates 24 with a material having a low coefficient of friction such as Teflon in order to reduce frictional forces between the plates 24 and wire 14.

FIGURE 7 demonstrates one way of providing a pressure seal between the partitions 26 and table rolls 60 which are illustrated in FIGURE 2 and FIGURE 4. This seal may be accomplished by any known means. In FIGURE 7, the partitions 26 are terminated a short distance below the bottom of the roll 60 and an inclined bracket 70 is mounted on top of this partition 26. A strip of flexible material 72, such as rubber, is inserted into the top of this bracket 70 and positioned to contact the surface of the roll. The roll rotates in a clockwise direction, therefore, the frictional force between the roll 60 and strip 72 is not excessive since the top of the strip 72 is free. The pressure in chamber 32 is greater than the pressure in chamber 30, thereby insuring contact between the strip and the roll and providing the necessary seal.

It is to be understood that the invention may be applied to existing Fourdrinier machines as well as new machines, and that various changes may be made by one skilled in the art without departing from the scope of the invention. We claim:

1. In a Fourdrinier machine having a breast roll, a couch roll spaced apart from said breast roll, an endless foraminous Fourdrinier wire about said rolls having an upper reach on which a web is formed, means adjacent said breast roll for feeding pulp stock onto the upper reach of said wire, a plurality of substantially rectangular chambers arranged contiguously in series directly under the upper reach of the wire and coextensive with the full width of the web forming portion of the wire, and a partition between each of said chambers, the improvement consisting of means for removing the liquid from the web by alternately subjecting the web to controllable suction and relaxation comprising, in combination,

- (a) suction means for providing alternate chambers with absolute pressure substantially below atmospheric pressure,
- (b) means for providing the remaining chambers with a controllable substantially higher absolute pressure, and
- (c) a convexly curved inflexible wire support above each partition immediately preceding a chamber having an absolute pressure substantially below atmospheric pressure, whereby the increased pressure in the ingoing nip of said convexly curved wire supports supplements the substantially higher absolute pres-

sure in the preceding chamber and the decreased pressure in the outgoing nip of said convexly curved wire supports supplements the absolute pressure substantially below atmospheric pressure in the succeeding chamber.

2. Apparatus according to claim 1 in which wire supports with flat tops are mounted on top of the partitions following the chambers having an absolute pressure substantially below atmospheric pressure.

3. In a Fourdrinier machine having a breast roll, a couch roll spaced apart from said breast roll, an endless foraminous Fourdrinier wire about said rolls having an upper reach on which a web is formed, means adjacent said breast roll for feeding pulp stock onto the upper reach of said wire, a plurality of substantially rectangular chambers arranged contiguously in series directly under the upper reach of the wire and coextensive with the full width of the web forming portion of the wire, and a partition between each of said chambers, the improvement consisting of means for removing the liquid from the web by alternately subjecting the web to controllable suction and relaxation comprising, in combination,

- (a) suction means for providing alternate chambers with absolute pressure substantially below atmospheric pressure,
- (b) means for providing the remaining chambers with a controllable substantially higher absolute pressure, and
- (c) a table roll mounted above each partition immediately preceding a chamber having an absolute pressure substantially below atmospheric pressure, whereby the increased pressure in the ingoing nip of each table roll will supplement the substantially higher absolute pressure in the preceding chamber and the decreased pressure in the outgoing nip of each table roll will supplement the absolute pressure substantially below atmospheric pressure in the succeeding chamber.

4. Apparatus according to claim 3 in which wire supports with flat tops are mounted on top of the partitions following the chambers having absolute pressure substantially below atmospheric pressure.

5. In a Fourdrinier machine having a breast roll, a couch roll spaced apart from said breast roll, an endless foraminous Fourdrinier wire about said rolls having an upper reach on which a web is formed, means adjacent said breast roll for feeding pulp stock onto the upper reach of said wire, a plurality of substantially rectangular chambers arranged contiguously in series directly under the upper reach of the wire and coextensive with the full width of the web forming portion of the wire, and a partition between each of said chambers, the improvement consisting of means for removing the liquid from the web by alternately subjecting the web to controllable suction and relaxation comprising, in combination,

- (a) suction means for providing alternate chambers with absolute pressure substantially below atmospheric pressure,
- (b) means for providing the remaining chambers with a controllable substantially higher absolute pressure,
- (c) a table roll mounted above each partition immediately preceding a chamber having an absolute pressure substantially below atmospheric pressure, and
- (d) sealing means between each such table roll and each said partition, whereby the increased pressure in the ingoing nip of each table roll will supplement the substantially higher absolute pressure in the preceding chamber and the decreased pressure in the outgoing nip of each table roll will supplement the absolute pressure substantially below atmospheric pressure in the succeeding chamber.

6. In a Fourdrinier machine having a breast roll, a couch roll spaced apart from said breast roll, an endless foraminous Fourdrinier wire about said rolls having an upper reach on which a web is formed, means adjacent

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said breast roll for feeding pulp stock onto the upper reach of said wire, a plurality of substantially rectangular chambers arranged contiguously in series directly under the upper reach of the wire and coextensive with the full width of the web forming portion of the wire, and a partition between each of said chambers, the improvement consisting of means for removing the liquid from the web by alternately subjecting the web to controllable suction and relaxation comprising, in combination,

- (a) suction means for providing alternate chambers with absolute pressure substantially below atmospheric pressure,
 - (b) means comprising a pressure manifold and a vacuum manifold for providing the remaining chambers with a controllable substantially higher absolute pressure ranging from slightly below atmospheric up to slightly above atmospheric, and
 - (c) a convexly curved inflexible wire support above each partition immediately preceding a chamber having an absolute pressure substantially below atmospheric pressure, whereby the increased pressure in the ingoing nip of said convexly curved wire supports supplements the substantially higher absolute pressure in the preceding chamber and the decreased pressure in the outgoing nip of said convexly curved wire supports supplements the absolute pressure substantially below atmospheric pressure in the succeeding chamber.
7. The method of removing drainage from a web formed on an endless Fourdrinier wire comprising the steps of
- (a) subjecting the web to an absolute pressure substantially below atmospheric pressure by, firstly, pass-

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ing the web over the outgoing nip of a convexly curved surface to create by action of hydrodynamic forces a suction under the web at said outgoing nip, and, secondly, supplementing such suction by immediately applying a vacuum to the web from a vacuum chamber under the web adjacent to the said outgoing nip of the convexly curved surface, and

- (b) then subjecting the web to a controlled substantially higher absolute pressure to permit some relaxation of the web by, firstly, passing the web over a chamber having therein a higher absolute pressure than that in the first mentioned vacuum chamber, and, secondly, supplementing such higher absolute pressure by passing the web over the incoming nip of another convexly curved surface adjacent to said second mentioned chamber to create by action of hydrodynamic forces a positive pressure under said incoming nip.

8. The method of claim 7 wherein the pressure to which the web is subjected in step (b) is an absolute pressure slightly below atmospheric pressure.

9. The method of claim 7 wherein the pressure to which the web is subjected in step (b) is slightly above atmospheric pressure.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,066,068

November 27, 1962

Girard L. Calehuff et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, lines 66 to 68, for "wire 14 nad into the web. The web then passes over the pressure built up in the ingoing nip is relieved through wire and into the web." read -- wire 14 reaches the crest of the curved plate 24, the pressure built up in the ingoing nip is relieved through wire 14 and into the web. --.

Signed and sealed this 18th day of June 1963.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents