Oct. 9, 1962 D. R. WEBSTER 3,057,402

SILENT SUCTION ROLL ASSEMBLY

Filed Dec. 31, 1959 2 Sheets-Sheet 1

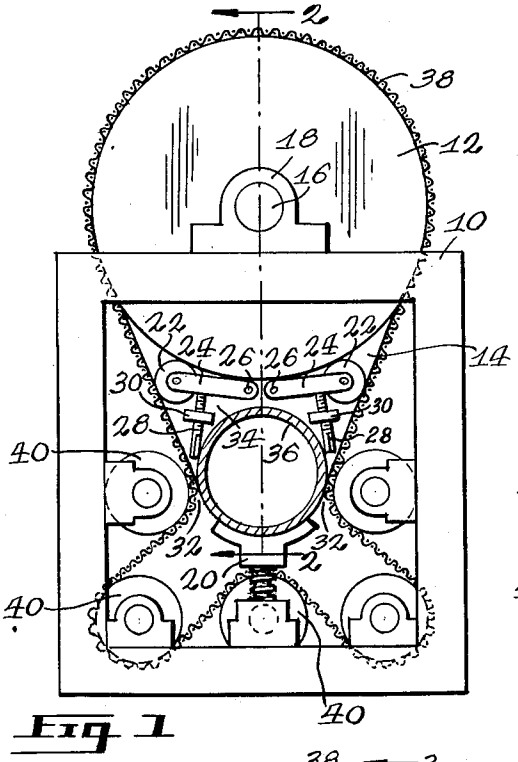



Fig. 1

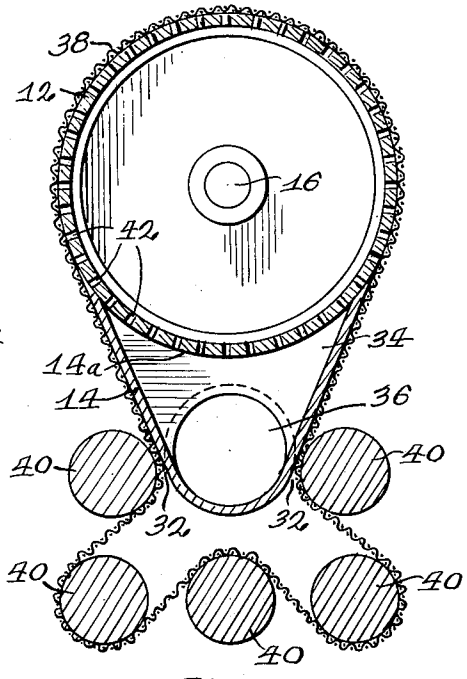



Fig. 3

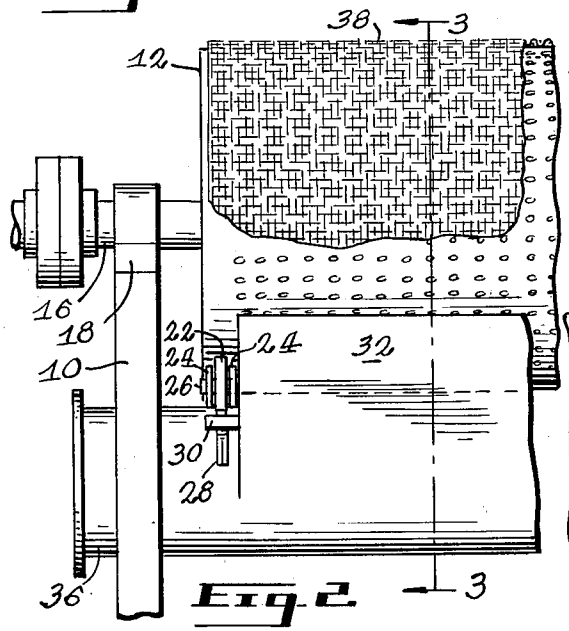
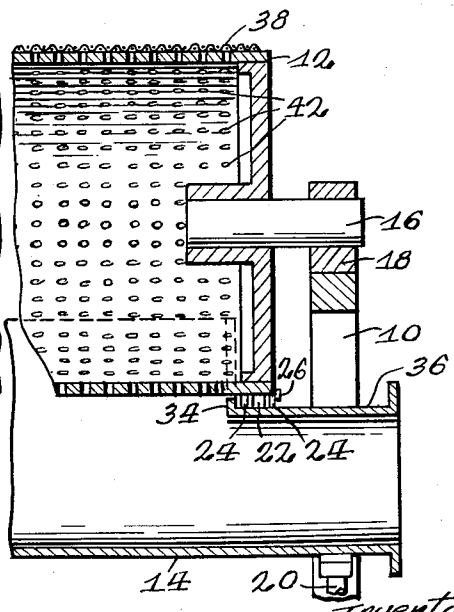



Fig. 2




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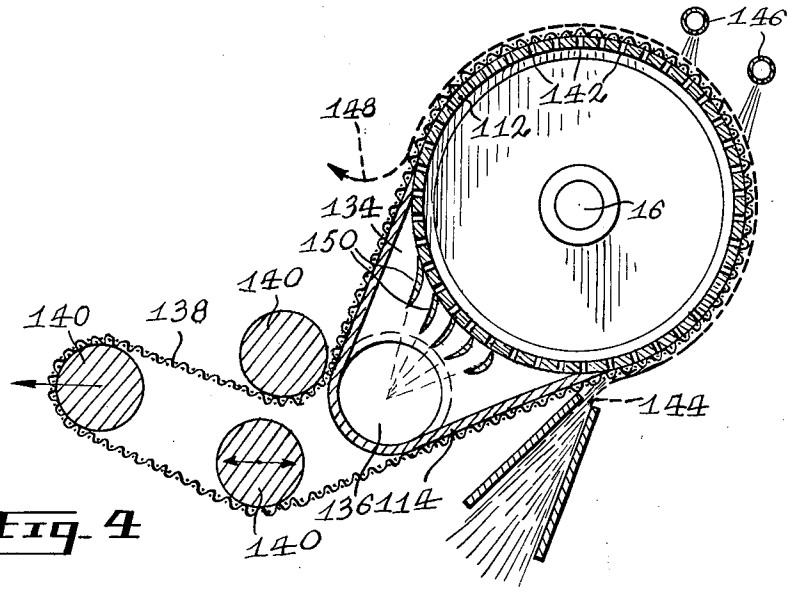



Fig. 4

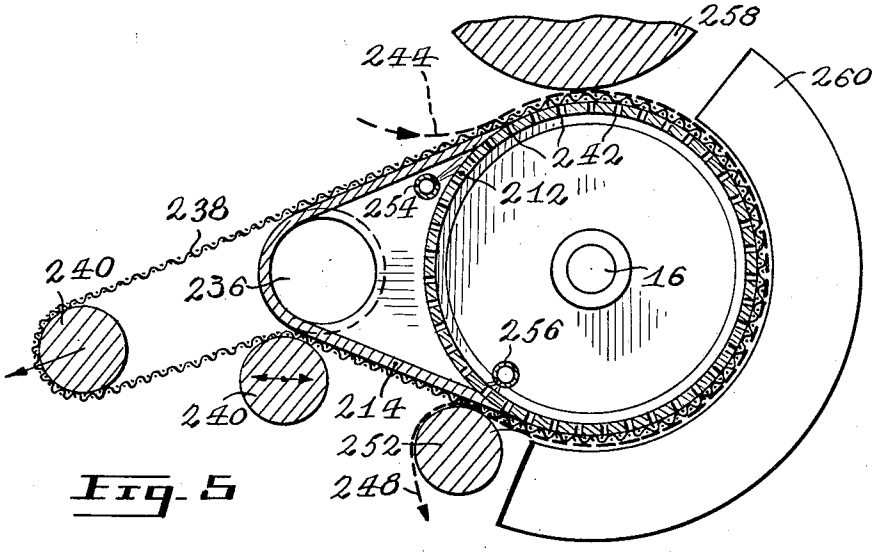



Fig. 5

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Patented Oct. 9, 1962



3,057,402

# SILENT SUCTION ROLL ASSEMBLY

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Filed Dec. 31, 1959, Ser. No. 863,332
4 Claims. (Cl. 162—368)

The present invention relates to papermaking equipment and more particularly to a silent suction roll assembly for a paper machine.

Suction rolls commonly are used singly or in combination with one another at paper-machine breast rolls, sheet formers, couch rolls, sheet transfers, pressers, and occasionally in dryers. There are two basic types of known suction rolls and both types exhaust through one or both ends of the roll.

One type has a multi-chambered shell exhausting through an end valve with sliding ports. That type is limited to low speeds, largely because the volume to be exhausted from each sub-chamber is large, and because the valve has troublesome friction and erosion at the sliding surfaces. This first type is called commonly a suction cylinder or suction filter.

The second type of suction roll has a thin-shelled perforated-roll with one or more stationary boxes in sliding contact with the inside peripheral surface of the roll. Vacuum is applied either inside the box, in which case the sheet is dehydrated during its passage across the box, or outside the box, in which case the sheet is dehydrated during its passage around the periphery remote from the box. Both forms of this second type are called commonly suction rolls.

There are gradations between these two basic types, and the gradation depends partly on how far along the radius of the roll the sliding surfaces are located, and partly on whether the stationary element is located only at the roll ends or extends through the length of the roll. If the sliding surfaces are located near the core or axis, the roll is referred to as chambered, if near the periphery it is referred to as perforated. If the stationary element is located only at the ends, that element is referred to as a valve; if it extends through the length of the roll, that element is referred to as a vacuum box.

The type of rotary suction-apparatus used almost universally in paper machines is the thin-shelled perforated-roll with vacuum inside the box. Such apparatus despite its advantages is plagued with three major disadvantages which all stem from the perforations being alternately exposed to atmospheric pressure and vacuum at each revolution.

Firstly, about as much power is used to re-evacuate the perforations as is used to do the useful work of drawing air through the paper. Thus only half the power used for vacuum is realized for useful work. Secondly, the release of the perforations to atmosheric pressure causes a staccato effect and thus an objectionable siren-like screech. Thirdly, the release of vacuum at the end of the vacuum zone releases water centrifugally either directly into the paper or into the travelling mesh carrying the paper, thereby hindering the dehydration. This third phenomenon is termed commonly "strike-back," and the spray comes not only from moisture in the sheet, but also from the necessary water shower used to lubricate the sliding surfaces.

The present invention is aimed to overcome the above-mentioned problems by providing a method of exhausting a suction roll from the periphery by an external vacuum arrangement instead of from the ends. The method sustains the vacuum throughout each revolution. Thus it eliminates the need to evacuate the perforations afresh



at each revolution thereby saving power, eliminating the staccato effect, and preventing "strike-back."

More specifically, the present invention is a suction roll assembly comprising in combination:

(1) A perforated roll mounted for rotation about a horizontal axis,

(2) Means to rotate the perforated roll,

(3) A stationary vacuum box having a concave side in air-tight sliding contact against a minor arc of the external peripheral surface of said perforated roll, the concave side is provided with air-inlet means, and another side of the box is provided with air outlet means,

(4) Means to evacuate the vacuum box,

(5) An endless mesh in frictional contact with a major arc of said roll which includes all the external-peripheral roll-surface subtending the vacuum box,

(6) Carrying-rolls disposed adjacent the vacuum box for a return circuit of the endless mesh.

These elements are combined to provide a suction roll assembly wherein a stock jet or a ready-formed sheet may be directed substantially at a tangent to the perforated roll, in the direction of rotation, and near the trailing edge of the vacuum box to ensure sealing this edge of the exposed vacuum zone.

The endless mesh is carried by the perforated roll across the exposed vacuum zone, in the direction of rotation, and the sheet at the same time is carried by the mesh, which results in the mesh travelling in frictional contact between the sheet and roll periphery. At the end of the exposed vacuum zone, or wrap-around of the mesh which may extend for about three-quarters of the roll periphery, the sheet is removed from the mesh by any of several conventional methods.

The leading edge of the vacuum box is located where the sheet leaves the exposed vacuum zone, and there the exterior surface of the roll meets and slides past one side of the leading edge of the vacuum box, and the endless mesh past the other side of the box. Then the mesh proceeds along a circuit over carrying rolls, disposed adjacent to the vacuum box, and returns to where the trailing edge of the vacuum box has a sliding departure from the perforated roll, and this completes the mesh circuit to where the fresh sheet enters.

Moisture is extracted from the sheet radially inwards through the mesh and roll perforations, for the entire roll-arc subtending the vacuum box, which arc comprises the exposed vacuum zone. It is essential that the sheet extend slightly beyond the extremities of this zone to effect a good vacuum seal. Thereby a strong differential pressure is provided across the thickness of a paper sheet, up to one atmosphere, which endures for a travel distance of several feet.

Moisture is extracted from the perforated roll radially outwards, through the roll perforations, and directly into the vacuum box which is in air-tight sliding contact with the roll periphery. The mesh is diverted around this roll evacuation-zone to avoid eroding the mesh, to enable having the necessary sliding surface durable and tight sealing, and to leave the perforations unobstructed during discharge.

Thus the roll perforations act as fluid inlets for the arc of the periphery subtending the vacuum box, and as fluid outlets for the arc adjacent the vacuum box. As a result, the vacuum is sustained throughout each revolution, and the perforations do not have to be evacuated afresh at each revolution.

Having thus generally described the nature of the invention particular reference will be made to the accompanying drawings, and in which:

FIGURE 1 is an end elevation of a suction roll assembly in accordance with the invention.

FIGURE 2 is a side-elevational broken view of the

perforated-roll and vacuum-box parts of the suction roll assembly of the invention with the righthand side shown in section corresponding to the line 2—2 of FIGURE 1.

FIGURE 3 is a section in end-elevation of the suction roll assembly along the line 3—3 of FIGURE 2.

FIGURE 4 is a section in end-elevation showing an example of this invention adapted to dehydrate a stock jet.

FIGURE 5 is a section in end-elevation showing an example of this invention adapted to dehydrate a ready-formed sheet.

Referring more specifically to the drawings, in FIGURES 1, 2 and 3, a frame **10** supports a perforated roll **12** and a vacuum box **14**. The perforated roll **12** is connected to the frame **10** through a shaft **16** and bearings **18** disposed at either end. Shaft **16** is in driven rotation, by drive means not shown, transmitting the rotation to perforated roll **12**.

Vacuum box **14** is connected to frame **10** through an adjustable support, for example a resiliently biased support assembly **20**, in which the extensible parts allow telescopic movement in a plane through the axes of the perforated roll **12** and vacuum box **14**, but allow no peripheral movement in the direction of rotation of the perforated roll **12**.

Vacuum box **14** is spaced from perforated roll **12** by means, such as trunnions **22**, which are adjustably mounted to allow a minimum friction between perforated roll **12** and vacuum box **14** consistent with a good vacuum seal between the roll **12** and the box **14**. The trunnions **22** may be adjustably mounted for example through levers **24** on pivots **26** loaded through set screws **28** threaded in lugs **30** on the vacuum box **14**.

The vacuum box **14** has two sides **32**, substantially tangential to the perforated roll **12**, which intersect each other and at this intersection merge into each other as a continuous surafce. Opposite this intersection the vacuum box **14** has a concave open side **14***a*, in sliding air-tight contact with a minor arc of the external peripheral surface of the perforated roll **12**, which open side serves as the inlet means to the vacuum box **14**. Vacuum box **14** has two ends **34** incorporating discharge means **36** at one or both ends of vacuum box **14**.

An endless mesh **38** lies in frictional contact with a major arc of the roll which includes all the exterior peripheral surface of the perforated roll **12** subtending vacuum box **14**, and which major arc comprises the exposed vacuum zone. This arc may extend for about three-quarters of the roll periphery. The balance of the endless mesh **38** comprises a return circuit disposed adjacent vacuum box **14** and which is diverted around vacuum box **14** on carrying rolls **40**. The carrying rolls **40** are mounted on frame **10**, in a conventional manner, and are driven by endless mesh **38** which in turn is driven by frictional contact with the peripheral surface of perforated-roll **12**.

Perforations **42** in the periphery of roll **12** serve as moisture inlets throughout all the major arc of roll **12** subtending vacuum box **14**. In turn, the perforations **42** serve as moisture outlets from roll **12** throughout all the minor arc of roll **12** between the leading and trailing edges of vacuum box **14**.

## OPERATION

The operation of the suction roll of the invention will be described with reference to examples, wherein the apparatus is adapted to receive a regulated jet as shown in FIGURE 4, and is adapted to receive an already-formed sheet as shown in FIGURE 5. As previously mentioned, other adaptations, for papermaking functions singly or combined in succession will be evident to persons skilled in the art.

In FIGURE 4 a driven roll **112**, with perforations **142**, is in sliding contact with a vacuum box **114** having discharge means **136**. An endless mesh **138** lies in frictional contact with all the major arc of the perforated roll **112** subtending vacuum box **114**. The balance of the mesh **138** comprises a return circuit which is diverted around vacuum box **114** on carrying rolls **140**.

### *Action Outside Roll*

A regulated jet **144** of fibers in fluid suspension is delivered substantially at a tangent to perforated-roll **112**, and in the direction of rotation, at the juncture where the roll surface leaves the trailing edge of the vacuum box **114**. At start-up, there is no sheet to cover the major arc of the roll **112** subtending the vacuum box **114**, and there is thus scant differential pressure to hold the jet against the underside of the perforated roll **112**.

Therefore "vacuum starters" in the form of stock showers **146** are preferably used which lay an initial sheet of fibers along the up-running side of the perforated-roll **112**. The resistance of this initial sheet to air-ingress limits the rush of air into the roll, to a portion of the major arc adjacent the jet **144**, and thus induces an initial skin of fibers to adhere to the mesh surface. Once this initial skin of fibers is formed, the vacuum within the perforated roll **112** increases rapidly, and prevents further escape of the main jet **144** from the mesh surface. Then the showers **146** can be closed.

Centrifugal force, combined with the force of gravity, at the under-side of perforated roll **112** is only a small fraction of the force exerted in the other direction by the vacuum. For example, a jet thickness of the order of 1″ common in papermaking, delivered to a 6 ft. dia. perforated roll having a surface speed of 2400 ft./min., exerts a pressure from centrifugal force of only about ⅔ lb./sq. in. As vacuum-pressure comon in suction rolls is of the order of 6 to 12 lb./sq. in., there is ample differential-pressure capacity for treating a jet thickness considerably beyond 1″, and for speeds well beyond the 2400 ft./min. of the above example.

The jet **144** is thus dehydrated on all the major arc of the perforated roll **112** subtending the vacuum box **114**, and ceases to be under vacuum and is removed from the apparatus the moment it reaches the juncture where the peripheral surface of roll **112** reaches the leading edge of the vacuum box **114**. The regulated stock jet **144** in that exposed vacuum zone thereby is transformed into a continuous paper sheet **148**.

### *Action Inside Roll*

Inside the perforated roll **112**, the drainage through the perforations **142** travels for example at a peripheral speed of 2400 ft./min. which equals 40 ft./sec. From the Torricelli theorem $v=\sqrt{2gh}$ the effect is that the drainage has a peripheral speed equal to that of an object which has dropped freely 25 ft. But the roll in this example is only 6 ft. dia., and thus the maximum speed possible from internal dropping is $v=\sqrt{2gh}=2.45$ ft./sec. Thus, the trajectories of droplets within the perforated roll **112** are at such great peripheral velocity (40 ft./sec.) that they hardly have time to be diverted by gravity before they impinge elsewhere against the interior of perforated roll **112**.

Besides this peripheral velocity, the drainage acquires a radial velocity, because it is accelerated by the vacuum through the perforations **142**. This radial velocity component near the delivery of the jet **144** to the roll **112** may derive from a vacuum pressure as great as the pressure in the headbox delivering the jet **144**. For example, at the above speed of 40 ft./sec., the headbox pressure would be 25 ft. which equals 10.8 p.s.i., and a suction inside the roll would need to be 22″ Hg to produce a similar 10.8 p.s.i. differential pressure across the sheet. Such a vacuum is well within the operating range of known suction rolls. Therefore the drainage may leave the initial perforations with two velocity components, approximately equal in the tangential and radial directions, thereby resulting in a trajectory about 45 degrees to the roll interior surface.

But as the stock drains, it offers increasing resistance to further flow through the forming sheet, and thus the radial velocity inwards through the perforations **142** decreases along the forming zone. Therefore the internal drainage path during the latter stages of formation tends to become more tangential than radial.

Also, internal drainage tends to hug the rim of the roll interior because it must impinge against the encircling roll interior, and once at the rim it tends to be held outward by centrifugal force. Near the delivery of the stock jet **144** to roll **112** the perforations **142** become filled solely with water. But as the stock progressively is drained some air percolates through the sheet, and although the drainage tends to rim the roll interior as described above, the percolating air keeps the drainage lifted off the formed sheet with a pressure greater than centrifugal force. The relative magnitudes of pressure from vacuum and from centrifugal force have been previously described. Thus the face of the paper sheet touching the mesh, and the mesh itself, are kept dry and out of contact with the passed drainage in the latter stages of the external vacuum zone.

*Examples*

In the use of this invention, given as an example and as shown in FIGURE 4, the jet **144** at perforated roll **112** acts something like a tangential jet against a water wheel. Usually in papermaking the jet speed is varied according to the paper grade to be either slightly faster or slower than the mesh speed. When this jet **144** lags the mesh speed, the drainage becomes accelerated tangentially by the perforated roll **112**, and therefore a small surplus of power capacity must be available at roll **112** to impart this acceleration. Conversely when this jet **144** leads the mesh speed, the drainage exerts a thrust at the perforations **142**, and therefore a small amount of power is then transmitted to the perforated roll **112**.

Just as the drainage flowing into the perforated roll **112** has a peripheral speed, so has the drainage leaving the roll **112** the same peripheral speed. Further, drainage leaving the roll **112** has a radial speed through the perforations. Therefore, in the arc adjacent the vacuum box **114**, the drainage leaves the roll **112** at a resultant angle to the peripheral surface.

To avoid having this high-speed drainage rebound off the inside walls of vacuum box **114** and back into the perforations **142**, a series of curved vanes **150** are fixed across the concave open side of vacuum box **114**, so that the drainage is diverted toward a central zone in the vacuum box where the separate drainage streams can dissipate their energy in turbulence. Also, the separate high-speed drainage streams impinge in the machine direction against the wall of vacuum box **114**, opposite the concave open side, and thereby their flow spreads forcibly and equally to the two vacuum box ends **134** which incorporate discharge means **136**. Thereby some of the entry velocity to the vacuum box is transmitted directly to exit velocity. These high-speed flows rinse all surfaces they touch thereby preventing slime growths in the roll **112**, in the perforations **142**, and in the vacuum box **114**.

The high-speed flow has more than speed at the perforations **142**, because it also reverses to act as a strong back-wash, and thereby eliminates the troublesome problem common at Fourdrinier flat boxes where slime periodically clogs and breaks loose from the perforations as little cylinders of slime. Thus in the present invention, the flow recirculation to any back-water or white-water showers is freed of slime lumps.

A further example of an embodiment of a suction roll assembly is shown in FIGURE 5 wherein a driven roll **212**, with perforations **242** is in sliding contact with a vacuum box **214** having discharge means **236**. An endless mesh **238** lies in frictional contact with all the major arc of the perforated roll **212** subtending vacuum box **214**. The balance of mesh **238** comprises a return circuit which is diverted around vacuum box **214** on carrying rolls **240**.

A paper sheet **244** containing moisture is delivered substantially at a tangent to the perforated roll **212**, and in the direction of rotation, at the juncture where the roll surface leaves the trailing edge of vacuum box **214**. At start-up, the sheet is held by gravity on the mesh surface, and as the sheet advances around the major arc of perforated roll **212** the entry of air to the roll is progressively obstructed. By the time the sheet has reached the down-running side of perforated roll **212**, the inrush of air is concentrated at the under-side of the roll, and the air current there becomes strong enough to hold the paper against the mesh in opposition to centrifugal force which is weak for such a light mass as one paper layer. As soon as the exposed vacuum zone is covered by the paper, the vacuum increases abruptly, thereby providing a strong dehydrating force.

The moist paper sheet **244** thus is dehydrated on all the major arc of the perforated roll **212** subtending the vacuum box, and ceases to be under vacuum and is removed as a dry sheet **248** around a paper-carrying roll **252**, the moment it reaches the juncture where the peripheral surface of roll **212** reaches the leading edge of the vacuum box **214**.

Less moisture is delivered to this apparatus by a paper sheet **244** than would be delivered by a jet, and thus the moisture in the apparatus of FIGURE 5 enters the perforated roll **212** more as a mist than as little streams. Accordingly, baffles are not used at the concave open-side of vacuum box **214**. Moisture is extracted from perforated roll **212** through the perforations **242** in all the minor arc adjacent the concave open side of vacuum box **214**, and then is ejected out discharge-means **236**.

Optional lubricating showers **254** and **256** for the sliding surfaces of vacuum box **214** may be fitted at the trailing and leading edges respectively of the vacuum box **214**. Shower **254** passes through the stationary vacuum box **214**, and shower **256** is supported through the shaft supporting perforated roll **212**.

Auxiliary paper-treatment means is provided in the form of a press roll **258**, against the surface of the moist sheet **244**, and in the form of a dryer hood **260** adjacent a major portion of the exposed vacuum zone of the perforated roll **212**. The arrangement of FIGURE 5 thus is a combined suction-press and dryer.

The present invention thus discloses means to sustain the vacuum in the perforations of a rotating roll with the new results of:

(1) Silently operating a perforated roll under vacuum.

(2) Reducing the power needed over conventional methods to dehydrate a sheet along a given arc of rotating perforated roll.

(3) Delivering the moisture of the perforations into the vacuum box, at the termination of the exposed vacuum zone, thereby avoiding "strike-back" into the sheet and carrying belt.

(4) Presenting already-evacuated perforations to the oncoming sheet, thereby avoiding the necessary vacuum lag which occurs when the perforations are full of air upon reaching the vacuum box, as occurs with conventional suction rolls.

(5) Increasing the capacity of a given width of paper machine beyond that possible in known art, by continuously exerting up to nearly one atmosphere differential pressure throughout an uninterrupted three-quarters approximately of a perforated-roll periphery, thereby increasing forming speed and drying capacity beyond that possible in known art.

(6) Improving mesh effectiveness, by combining an uninterrupted all-mobile support in the sheet zone with a slack tension in the sheet zone, thereby prolonging mesh life and permitting the use of fine non-metallic weaves.

(7) Removing entrained air from all drainage, with the same vacuum as used to squeeze the paper sheet, thereby avoiding the need for a separate de-aeration apparatus. Or alternatively directing the vacuum of an exist-

ing de-aeration apparatus also to squeeze the sheet. The vacuum box handles virtually all the discharge of the fan pump. This disclosure thus introduces means to make multiple use of a vacuum.

(8) Providing an air in-draft throughout the formation zone, to constrain the release of bothersome hot vapour to the machine room, by means of the same suction as used to squeeze the paper sheet.

(9) Enabling the use of a single basic design for the usually different designs of vacuum breast-roll, sheet former, couch, sheet transfer, press, and dryer, with the innovation that:

(*a*) Those units become interchangeable,

(*b*) Those units of a paper machine may be mass produced,

(*c*) Only a few spare parts are needed to serve the whole paper machine, thereby introducing spares where heretofore the cost has been prohibitive for some paper-machine sections.

(10) Simplifying the basic unit in a battery of units comprising a paper machine, thereby saving capital, maintenance, and operational costs.

(11) Concentrating, on a single continuous surface, two or more of the successive functions usually performed separately by the suction breast-roll, sheet former, couch, sheet transfer, press, and dryer, thereby saving space.

(12) In the product, minimizing the 2-sidedness of the paper by introducing the novel combination of a strong dehydration pressure with an uninterrupted rigid-support means, which enables the use of a slack and thus of a fine-weave mesh, if desired of fiber composition, thereby reducing weave imprint and retaining more stock fines than heretofore possible.

Other combinations of currently-separate paper-making functions are possible, such as including successively on a single perforated roll the operations of forming, pressing, coating and drying. Also, various additives can be sprayed on the paper along the arc of the perforated roll, and depending on how far along the vacuum zone the sprays are located, the penetration of the additives can be controlled.

Besides making paper, this apparatus can also be used for treating fibrous or finely-divided materials which are suspended in chemical liquors. Examples would be lime-mud recovery and back-liquor washing in making kraft pulp, and bleach-washing in general pulping.

From the foregoing, it is believed that the construction and advantages of the present invention may be readily understood by those skilled in the art without further description.

I claim:

1. A suction roll assembly consisting of a peripherally perforated, cylindrical roll mounted for rotation on its longitudinal axis, a vacuum box disposed at one side of said roll, said vacuum box including end walls having a concave edge substantially conforming to a minor arc area of said perforated roll and diverging side plates including terminal edges disposed tangentially at the terminal ends of said minor arc and defining the ends of a major arc area on said perforated drum, resilient means disposed at the outer surface of said suction box and engaged substantially equidistantly between a projection of said side plates for urging the terminal edges of said suction box toward said roll, adjustment means disposed between said suction box and said roll for adjusting a minimum clearance between said roll and the terminal edges of said suction box, said vacuum box including means for connection to a vacuum source for maintaining a constant vacuum in said box and roll, and a continuous, pervious web member for supporting a sheet of material thereon and including a loop portion entrained in juxtaposed relation over said major arc area and extending parallel to the outer surface of said side plates and tangential to the ends of said major and minor arcs whereby a sheet of material supported on said endless web member will overlie the juncture of said major and minor arcs and a substantially constant vacuum will be maintained in said suction box and perforated roll.

2. The structure of claim 1 wherein said suction box includes baffle means disposed intermediate of said minor arc within said suction box for preventing liquid "strike back" onto the inner surface of the sheet of material carried on said pervious loop.

3. The structure of claim 2 including a slurry emitting nozzle directed toward one of the ends of the major and minor arc areas in the direction toward which said roll is to be rotated, and a slurry shower directed toward an intermediate portion of said major arc area for forming an initial vacuum conserving skin.

4. The structure of claim 3 including lubricating showers within said roll and vacuum box and directed toward the terminal edges of said vacuum box side plates.

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