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(54) METHODS AND APPARATUS FOR DEWATERING PAPER WEBS

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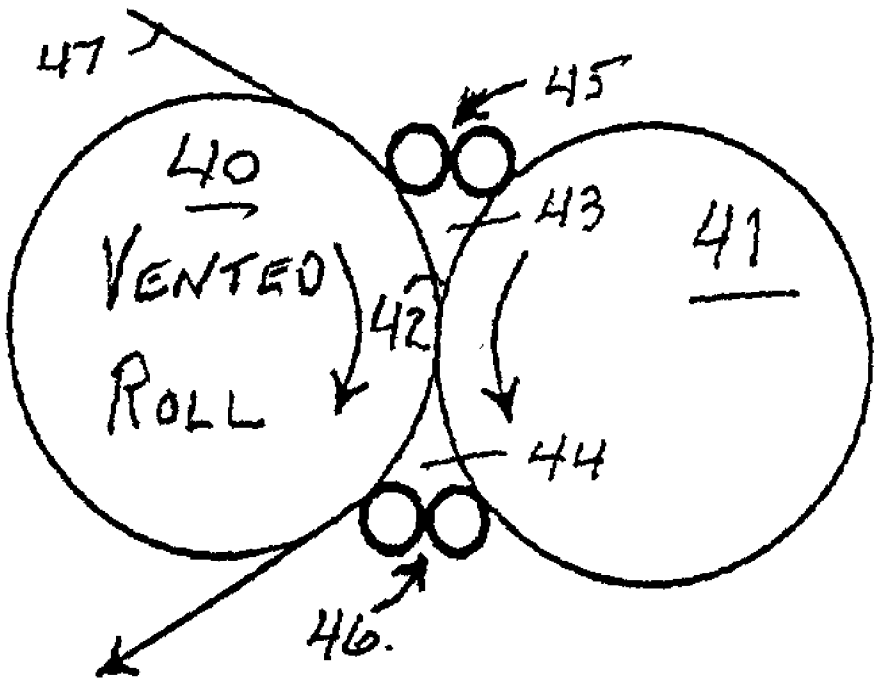
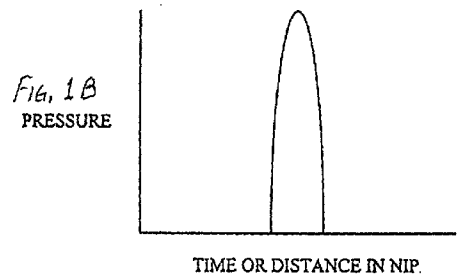
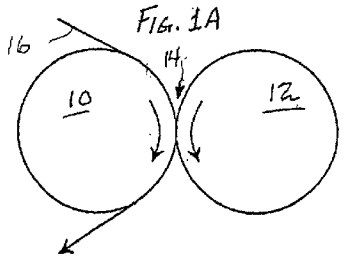
(57) ABSTRACT

A wet paper web or other wet porous web exiting a web former is supported on a vented press roll and sequentially subjected to a relatively high pressure mechanical nip pressing force and a relatively low pressure water displacement-pressing force. The combination of the two diverse pressing forces applied in sequence to the web is very effective in efficient and economical de-watering of the web and at the same time provides a de-watered web having high bulk, high solids content and high mechanical strength. The low pressure fluid displacement pressing force is applied immediately contiguous to the high pressure mechanical nip pressing force and may be applied upstream or downstream or both upstream and downstream of the mechanical nip pressing force.

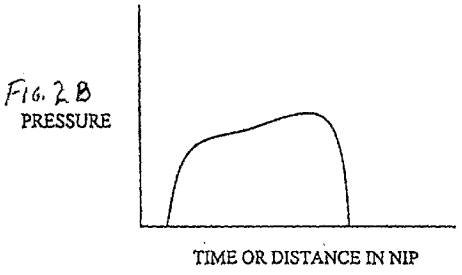


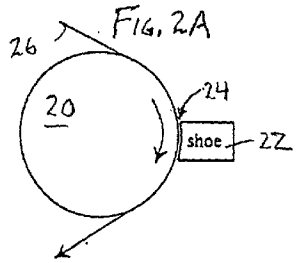
PRIOR ART
Figure 1. ROLL NIP PRESS



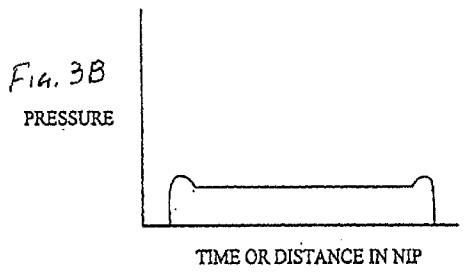


PRIOR ART
Figure 2. SHOE PRESS





PRIOR ART
Figure 3. DISPLACEMENT PRESS



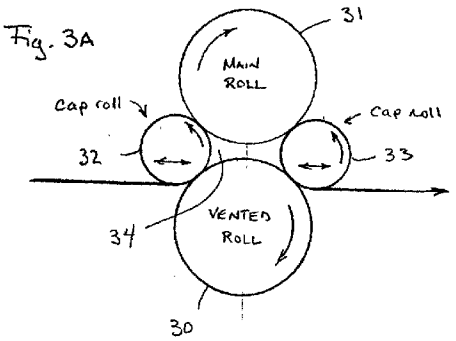
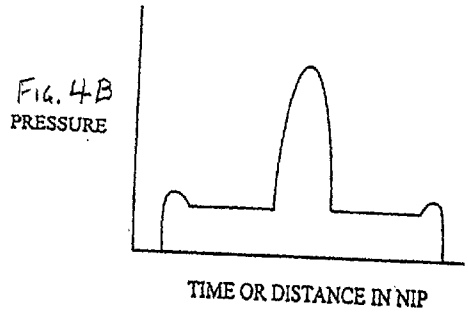


Figure 4. ROLL NIP/DISPLACEMENT PRESS



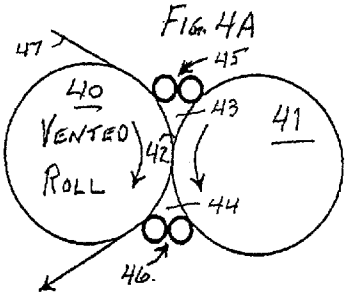
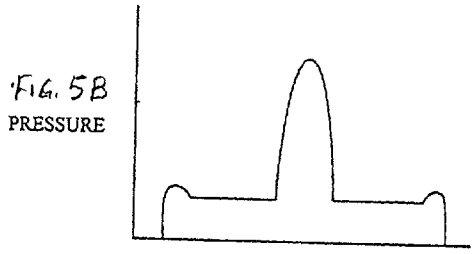


Figure 5. ROLL NIP/DISPLACEMENT PRESS WITH INTERMEDIATE PRESS ROLL



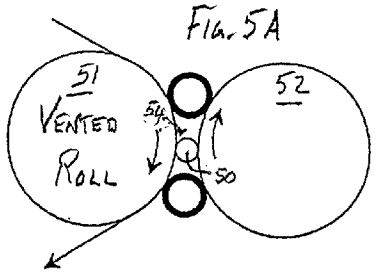
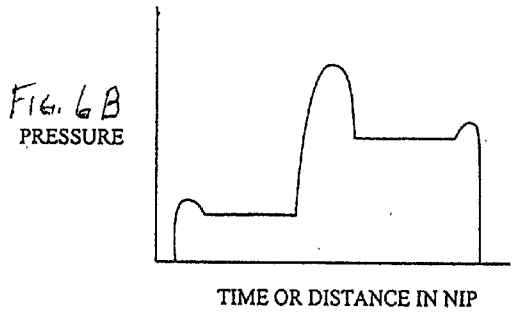


Figure 6. ROLL NIP/DISPLACEMENT PRESS WITH DIFFERENTIAL PRESSURE ZONES



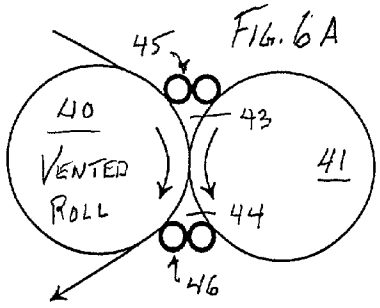
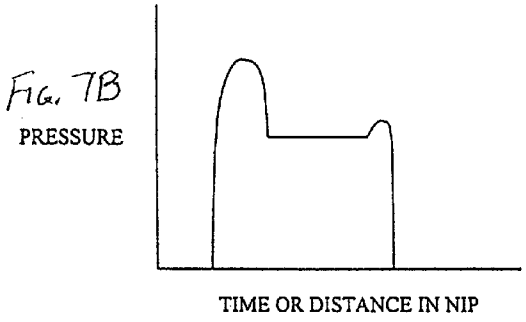


Figure 7. ROLL NIP/DISPACEMENT PRESS



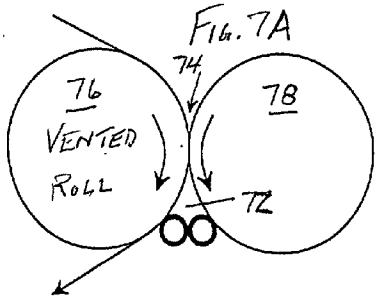
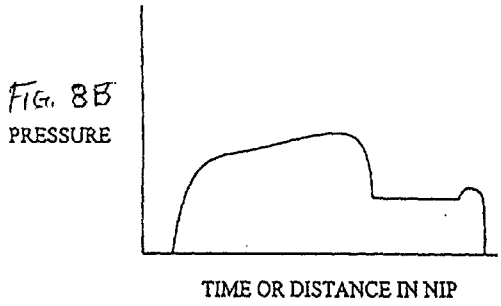


Figure 8. SHOE/DISPLACEMENT PRESS



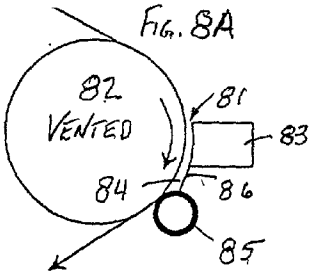
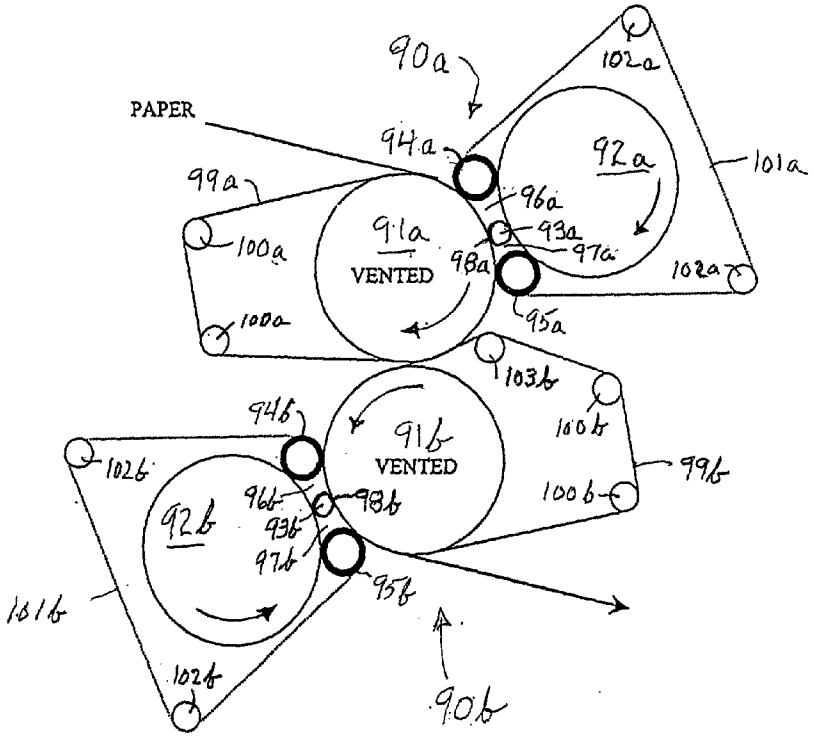


Figure 9. TWO-SIDED DISPLACEMENT PRESS



METHODS AND APPARATUS FOR DEWATERING PAPER WEBS

FIELD OF THE INVENTION

[0001] The present invention is directed to the art of dewatering wet paper webs and other wet porous webs as the webs exit from a wet web-forming machine, such as a fourdrinier wire. The invention relates particularly to the press section of papermaking machines.

BACKGROUND OF THE INVENTION

[0002] Paper is conventionally formed on a fourdrinier wire or other wet web former from a stock or furnish comprised of cellulose fibers and a binder, such as starch, and appropriate selected additives, suspended in an aqueous solution comprised of ninety percent (90%) or more parts of water. Most of the water is drained or otherwise expelled from the aqueous solution at the wet end of the paper machine, that is, on the wire or within the former, thereby to form a wet but coherent fibrous web. The wet web then passes to a press section where additional water is expelled from the web, conventionally by densification and reduction in the bulk of the web under mechanical pressure, e.g., by squeezing the web between one or more pairs of high pressure press rolls. The web then passes to a dryer section where an extensive series of heated rolls or cans vaporize additional water from the web and dry the web to the desired final moisture content.

[0003] The dryer section is the most costly and largest energy consuming part of the water removal sections of the paper machine. It has been estimated that the cost ratio of removing a unit of water from the web on the wire, in the presses and in the dryers of a paper machine (calculated for newsprint) is 1:67:325. Manifestly, improvements in water removal at the press section that will reduce the load on the dryer section are welcome in the art.

[0004] Paper machine press sections in current use are comprised of one or more roll nip presses and/or one or more extended nip shoe presses. A roll nip press, which is illustrated in **FIG. 1**, is comprised of a pair of rolls biased toward one another to define a pressure nip through which the web is passed and within which the web is mechanically densified. Typically, a roll nip press applies a force of 300 to 1200 pounds per lineal inch (pli) over a one-half to four inch long nip. A shoe press, which is illustrated in **FIG. 2**, is comprised of a web-supporting roll and a cooperating shoe, which is biased toward the roll to provide a pressure nip of extended length through which the web is passed and within which the web is mechanically densified. Typically, a shoe nip press applies a force of 1400 to 7000 pli over an eight to fourteen inch long nip.

[0005] In conventional pressing, the web is dewatered by compressing and thereby reducing the volume of the web. As the web enters the nip it rapidly becomes saturated, after which further reduction of web volume in the nip results in water being expelled. As the web exits the nip it tends to expand or rebound, restoring a portion of its original volume. As volume increases, the web will draw back in some of the water that had been expelled, rewetting itself. The web exiting the nip remains essentially saturated.

[0006] An advantage of mechanical presses is that both "free" water (water between fibers and fillers) and "bound" water (water contained within the lumens of the fibers) is removed. However, the dewatering comes at the expense of bulk. While a degree of mechanical densification of the web is desirable to enhance fiber bonding and increase the mechanical strength of the paper, excess densification decreases the bulk of the paper, which is a significant disadvantage.

[0007] For a number of years, considerable attention has been devoted to experimentation with a fluid pressure method of dewatering webs in which a pressurized fluid, e.g., air or steam, is employed to displace free water from the web. U.S. Pat. No. 3,974,026 to Emson et al discloses an apparatus for displacement dewatering. In Emson et al a wet web is confined between a vented roll and a guide belt. The guide belt can be permeable to water, such as felt or fabric, or can be impermeable, such as rubberized fabric. An arcuate shaped pressure member is disposed adjacent the guide belt and includes a chamber for applying a pressurized fluid such as air to the belted web. The fluid presses the guide belt uniformly towards the cylinder so that water can be removed from the web. If the pressure medium is a gas such as air and the guide belt is permeable to air, an advantageous air flow can be formed from the pressure member, through the web, and into the cylinder. Some water is displaced from the web as a result of the exterior belt being pressed against the web. Additional water is expelled by the gas passing through the web.

[0008] Another apparatus for displacement dewatering is disclosed in an article, Kawka, W., Stepien, K., Ingielewicz, H., "*Intensification of Paper Web Dewatering and Drying*" Przeglad Papier, 35, No. 11, pp. 402-404 (Nov. 1979). Kawka et al. disclose an apparatus comprising a belted paper web supported on a vented cylinder. A solid, non-vented cylinder is radially spaced above the vented cylinder. Two cap rolls are biased against both cylinders, on each respective side. A pressure chamber is defined between the cylinders and cap rolls. The volume is pressurized with a gas. The gas pressure acts to compress the web and cause water to be displaced by the gas passing through the web and into the vented cylinder.

[0009] Displacement dewatering is far more effective at removing free water from the web than either roll nip or shoe nip press, and it does not significantly densify the web. Consequently, a web dewatered by this process has high bulk and a high percentage of solids, both advantages. On the other hand, the process requires an extensive length or time duration of air pressure application. Further, whereas displacement dewatering is effective in removing free water between fibers, it does not remove bound water, i.e., water within the fiber lumen.

SUMMARY OF THE INVENTION

[0010] The object of the present invention is to provide methods of and apparatus for dewatering wet webs that incorporate the advantages, with few if any of the disadvantages, of mechanical nip pressing and displacement dewatering.

[0011] It is in particular an object of the invention to provide methods of and apparatus for dewatering wet webs wherein the web is subjected, in combination and in sequence, to both mechanical nip pressing and displacement dewatering.

[0012] In accordance with the invention, a belted wet paper web or other wet porous web exiting a web-former is supported on a vented press roll and sequentially subjected to a mechanical nip press and displacement dewatering. The displacement dewatering is applied contiguous to the mechanical nip and maybe applied upstream or downstream or both upstream and downstream of the mechanical nip press. By "contiguous" it is meant that one press substantially immediately follows the other press. In the present application both the mechanical nip press and the displacement dewatering press are adjacent on another on the same support roll, and as such they are contiguous. Although to be contiguous they need not be on the same support roll. It is necessary only that the fluid dynamic effects of one press (e.g., the mechanical nip) are not full dissipated before the web enters the second press (e.g., the displacement dewatering zone).

[0013] The displacement dewatering is effective, even over a relatively short arc of vented roll movement, to remove free water from the web and the mechanical nip press is effective to remove both bound and free water and to enhance web strength by a desired degree of densification. Also a displacement dewatering immediately down stream of the mechanical press is effective to remove formerly bound water that the mechanical press converted to free water and thereby to mitigate re-wetting of the web and the web fibers.

[0014] By virtue of the sequential, contiguous application of both displacement dewatering and mechanical nip pressing, the length or duration of displacement dewatering can be foreshortened without loss of effectiveness. Similarly, the application pressure at the mechanical nip can be maintained at lower pressing limits to minimize web densification, again without loss of effectiveness.

[0015] The combination of the two diverse dewatering techniques, applied in contiguous sequence to the web is very effective in efficient and economical dewatering of the web and at the same time provides a dewatered web having high bulk, high solids content and high mechanical strength.

[0016] The foregoing and other objects and advantages of the invention will become apparent to those skilled in the art from the following detailed description, as considered in conjunction with the accompanying drawings.

Brief Description of the Drawings

[0017] **FIG. 1A** is a schematic illustration of a conventional prior art mechanical roll nip web press comprised of a pair of press rolls defining a pressure nip through which the wet web is passed;

[0018] **FIG. 1B** is a pressure-time graph representative of the amount and duration of the pressure applied to the web by the apparatus of **FIG. 1A**;

[0019] **FIG. 2A** is a schematic illustration of a conventional prior art extended nip mechanical shoe press comprised of a web-supporting press roll and a cooperating pressure shoe defining an elongated pressure nip through which the web is passed;

[0020] **FIG. 2B** is a pressure-time graph representative of the amount and duration of the pressure applied to the web by the apparatus of **FIG. 2A**;

[0021] **FIG. 3A** is a schematic illustration of a prior art displacement dewatering press comprised of a pair of spaced-apart main rolls, one of which is vented, and a pair of cap rolls which seal off the space between and define a pressure chamber between the two main rolls within which fluid pressure may be applied to a web supported by the vented main roll;

[0022] **FIG. 3B** is a pressure-time graph representative of the amount and duration of the pressure applied to the web by the apparatus of **FIG. 3A**;

[0023] **FIG. 4A** is a schematic illustration of a first embodiment of the apparatus of the present invention which provides for application to the web of a mechanical press nip and displacement dewatering both before and after application of the mechanical nip;

[0024] **FIG. 4B** is a pressure-time graph representative of the amount and duration of the pressures applied to the web by the apparatus of **FIG. 4A**;

[0025] **FIG. 5A** is a schematic illustration of a second embodiment of the apparatus of the invention similar to the first embodiment but employing a small diameter press roll between the two main rolls;

[0026] **FIG. 5B** is a pressure-time graph representative of the amount and duration of the pressures applied to the web by the apparatus of **FIG. 5A**;

[0027] **FIG. 6A** is a schematic illustration of a third embodiment of the apparatus of the invention which is structurally the same as the first embodiment but which provides for application to the web of different fluid displacement pressures in the two pressure chambers defined by the press and cap rolls;

[0028] **FIG. 6B** is a pressure-time graph representative of the amount and duration of the pressures applied to the web by the apparatus of **FIG. 6A**.;

[0029] **FIG. 7A** is a schematic illustration of a fourth embodiment of the apparatus of the invention which is similar to the first embodiment but provides for the application of a fluid displacement pressure to the web only on the downstream side of the press roll pressure nip;

[0030] **FIG. 7B** is a pressure-time graph representative of the amount and duration of the pressures applied to the web by the apparatus of **FIG. 7A**;

[0031] **FIG. 8A** is a schematic illustration of a fifth embodiment of the apparatus of the invention comprising an extended nip mechanical press and a displacement dewatering press contiguous to and downstream from the extended nip;

[0032] **FIG. 8B** is a pressure-time graph representative of the amount and duration of the pressures applied to the web by the apparatus of **FIG. 8A**; and

[0033] **FIG. 9** is a schematic illustration of a sixth embodiment of the invention which effectively combines two presses for first applying dewatering pressure to one side of the web and subsequently applying dewatering pressure to the other side of the web to mitigate against two-sidedness, i.e., differences between the two sides, of the de-watered web.

DETAILED DESCRIPTION OF THE BEST MODE OF CARRYING OUT THE INVENTION

[0034] The following is a detailed description of several embodiments of the invention, which are presently deemed by the inventor to be best suited to convey to persons reasonably skilled in the art the best mode of carrying out the invention.

[0035] It is to be understood that the drawings are schematic illustrations intended to convey knowledge to the skilled artisan in such clear and concise manner as to enable any person skilled in the art to make and use the invention. Conventional components of web presses, such as dewatering felts, water disposal equipment, and the like, have been omitted for the sake of clarity. Also, it is to be understood that each embodiment of the invention as illustrated in the drawings may be employed in series or in tandem with additional ones of the same or other embodiments of the invention and/or other dewatering devices.

[0036] Referring to the drawings, **FIG. 1A** illustrates a conventional roll nip mechanical press comprised of a pair of rolls **10** and **12** defining a nip **14** through which a wet paper web **16** is passed as it exits from a wet web-former, such as a fourdrinier wire. The nip **14** may have an arcuate extent in the order of about one-half to four inches and the rolls are forced against one another by adjustable hydraulic and/or mechanical jacks in order to apply to the wet web **16** a mechanical pressing force in the order of about 300 to 1200 pounds per lineal inch (pli) of web width. Typically, the web is supported on one or both sides by endless belts or felts, which have not been shown for clarity.

[0037] The theoretical amount and duration of pressure applied to a web by a roll nip press is depicted graphically in **FIG. 1B,** i.e., a very high pressure of very short duration.

[0038] **FIG. 2A** depicts a conventional extended nip or shoe press comprised of a web supporting roll **20** and a shoe **22** defining an arcuately extended nip **24** between itself and the roll and through which a wet paper web **26** is passed. The nip formed by the shoe may have an arcuate length on the order of about eight to fourteen inches and the shoe may be pressed against the web at a pressure of from about 1400 to about 7000 pli.

[0039] **FIG. 2B** depicts the theoretical amount and duration of the pressure applied to the web by the shoe, i.e., as compared to **FIG. 1B** a lower pressure over a longer period of time.

[0040] The conventional pressing techniques of **FIGS. 1 and 2** remove free and bound water from the web. Mechanical pressing also produces a desired amount of densification of the web. However, increased dewatering comes at the price of reduced bulk, a disadvantage. Further, as the web exits the mechanical press, it expands somewhat, and as a result tends to rewet.

[0041] **FIG. 3A** schematically depicts a prior art fluid displacement press. Here, a pair of main rolls **30** and **31** are spaced apart and a pair of cap rolls **32** and **33** are sealingly engaged with both of the main rolls at arcuately spaced locations, thereby to define an arcuately extended pressure chamber **34** between the four rolls and appropriate end seals. A wet paper web **36**, supported at least one belt **37**, is carried into the pressure chamber **34** by the main roll **30**, which is a vented roll. A pressurized gas is introduced into and maintained at a pre-determined pressure within the chamber **34**. Water is displaced from the web into the vented roll by compressing the web against the vented roll and by causing an airflow from chamber **34**, through the web, into vented roll **30**.

[0042] A theoretical pressure time profile of the displacement dewatering press is depicted graphically in **FIG. 3B**. As illustrated, there is a small pressure peak at the front or upstream end caused by the nip defined between the vented roll **30** and the upstream cap roll **32**, a long, low pressure displacement zone, and another small peak at the back or downstream end due to the nip between the vented roll and the downstream cap roll **33**. Displacement pressing is very effective at removing free water from the web at a relatively low applied pressure, which results in paper with high solids and high bulk, which are advantages. However, to be effective, the low pressure displacement zone must be very long, for example four feet long, which necessitates the use of extremely large diameter main rolls and is a distinct disadvantage.

[0043] In accordance with the present invention, a novel press that incorporates a mechanical press nip contiguous with a displacement dewatering press, as herein described, achieves the benefits of both mechanical pressing and displacement dewatering producing a paper web of high solids and relatively high bulk.

[0044] **FIG. 4A** illustrates a first embodiment of the dewatering apparatus of the invention. In this configuration, two main press rolls **40** and **41** form a mechanical press nip **42**. Nip **42** is preferably loaded at a lower lineal force and correspondingly lower nip pressure than conventional mechanical nips. Although optimal loading conditions may be determined by those skilled in the art for any given application, and will necessary vary for particular conditions and grades, it is believed that the benefits of the invention may be realized at loads of 300 to 1200 pli, over a nip length of one-half to four inches.

[0045] Roll **40** is a vented roll. The term "vented roll" as used in this application includes hollow perforated rolls with or without suction boxes, solid rolls with grooves for the removal of water, or any other type roll or cylinder having a permeable peripheral surface that allows for the escape of water emerging from the web. In addition, the vented roll functions to maintain a pressure on the vented roll side of the web that is lower than the pressure in chambers **43** and **44**, as discussed below.

[0046] Displacement zones or pressure chambers **43** and **44** are formed before and after the roll nip **42** by respective pairs of cap rolls **45** and **46** which are sealingly engaged with one another and the main rolls. Chambers **43,44** are pressurized with a fluid, preferably a gas, such as air or steam. Optimal pressures may be determined by those skilled in the art for particular operating conditions. It is believed that fluid pressures of about 20 to 300 psi over an arcuate displacement pressing zone of about ½ to 50 inches, preferably 20-40 inches can achieve the benefits of the invention.

[0047] The web **47** is supported by at least one belt (not shown), and is preferably sandwiched between two belts or felts (not shown). The belt adjacent the vented cylinder is

preferably permeable to water and air. The belt adjacent the pressure chambers **43,44** is preferably permeable to air (or other gas used to pressurize chambers **43,44**).

[**0048**] The web **47** enters the press passing through the nip formed between vented roll **40** and cap roll **45**, entering displacement dewatering zone **43**. In zone **43** the web is compressed under comparatively low fluid pressure. In addition, some of the fluid (air or steam) passes though the web as the vented roll functions to maintain a lower surface pressure that the pressure in chamber **43**. The fluid flow through the web acts to displace free water from the web, which is carried away via the vented cylinder.

[**0049**] The web then proceeds directly into roll nip **42**. Nip **42** mechanically compresses the wet sheet forcing bound water out of the fiber lumens and forcing additional free water from the sheet. However, the sheet is still saturated with free water at the exit of the pressure nip.

[**0050**] Displacement dewatering zone **44** that follows the roll nip removes most of the remaining free water from the sheet in the same manner as displacement dewatering zone **43**. As discussed above, the web exiting nip **42** will have a tendency to expand somewhat, which normally causes water to be drawn back into the web. However, rewetting is reduced if not eliminated altogether in displacement dewatering zone **44**. The displacement fluid (air or steam) flow through the web keeps free water moving out of the web and thereby counteracts any rewetting action. As the displacement zone **44** is contiguous with nip **42** there is no time for the web to rewet after leaving nip **44**.

[**0051**] Accordingly, this combination of a roll nip and contiguous displacement zone(s) accomplishes what neither of the two could do alone: Bound water is removed from within the fibers at a reduced nip pressure, and free water is removed from around the fibers without unduly densifying the web. This results in a higher bulk, higher solids web than could otherwise be achieved.

[**0052**] Alternatively, mechanical nip **42** could be loaded to conventional levels. In such event, subjecting the web to contiguous displacement dewatering will produce a web with higher solids, and reduce the energy requirements to dry the web.

[**0053**] A theoretical pressure time profile of the press of the first embodiment illustrated in **FIG. 4A** is graphically portrayed in **FIG. 4B**. As compared to the graphs of **FIG. 1B** lower mechanical pressure is applied at the nip, causing less web densification and preserving better paper bulk. The two types of presses in the contiguous, sequential relationship of **FIG. 4A** produce highly effective removal of water, both bound and free.

[**0054**] **FIG. 4A** shows a pair of cap rolls **45,46** on each side of the mechanical nip **42** to form pressure chambers **43,44**. As will be apparent to those skilled in the art, cap rolls are only one means for forming displacement pressing zone(s) contiguous to a mechanical nip. The following FIGS. **5-8** illustrate alternative embodiments. Further variations will be apparent to those skilled in the art, all of which are to be construed as within the spirit and scope of the invention as defined by the appended claims.

[**0055**] **FIG. 5A** depicts an alternative arrangement wherein an intermediate press roll **50** is introduced between the two main rolls **51** and **52** to define a roll nip **54** between the rolls **50** and **51**. With this arrangement, the main rolls are rotated in the same direction as one another thereby permitting use of single cap roll seals **55** and **56**, rather than requiring dual cap roll seals as in the embodiment of **FIG. 4A**. However, the pressure profile remains unchanged, as is revealed by a comparison of **FIGS. 4B and 5B**.

[**0056**] **FIG. 6A** depicts the same combination of press elements as shown in **FIG. 4A**, but in this instance, different fluid displacement pressures are employed in the two pressure chambers **43** and **44**, as is graphically depicted in **FIG. 6B**. In this case, where the web has been partially dewatered, partially compressed and densified, and has attained good mechanical strength, the fluid pressure employed in the downstream displacement chamber **44** may be greater than might otherwise be the case so as to facilitate removal from the web of the formerly bound water that was converted to free water by the mechanical pressure nip **42**. Obviously, the first or upstream displacement zone could be operated at a higher pressure than the second displacement zone if that were found to be beneficial.

[**0057**] In the embodiment of **FIG. 7A, a** displacement dewatering zone **72** is provided only on the downstream side of the nip **74** between a pair of press rolls **76** and **78**. As above described, the advantages of the downstream displacement zone are such that the downstream zone by itself, in combination with the pressure nip, may in many cases suffice for efficient de-watering. The pressure profile is illustrated in **FIG. 7B**.

[**0058**] **FIG. 8A** depicts an extended nip press **81** and a downstream displacement dewatering press. Manifestly, the combination could be provided with an upstream displacement press as well. In the illustrated combination, an extended nip mechanical press **81** is defined between a vented web-supporting press roll **82** and a pressure shoe **83**, and a displacement zone pressure chamber **84** is defined by a cap roll **85** sealingly engaged with the press roll **82** and a pressure chamber-forming wall or shield **86** extending between and sealed to the shoe **83** and the roll **85**. A theoretical pressure-time graph, **FIG. 8B**, illustrates that this arrangement imposes on the web a fairly long and progressively increasing mechanical nip pressure, followed by a fairly long fluid displacement pressure, with a small ending peak due to the nip between the cap roll **85** and press roll **82**. As with the other embodiments of the invention, the web is efficiently dewatered by mechanical pressing and contiguous displacement dewatering.

[**0059**] In the embodiments of the invention above-described, dewatering is carried out from one side of the web. This can result in so called "two-sidedness," i.e., a condition wherein one side of the web is perceptively different from the other. To mitigate two-sidedness, two of any of the presses illustrated in FIGS. **1-8** may be used in tandem to apply dewatering forces first to one side of the web and then to the other side of the web. By way of example, **FIG. 9** illustrates a tandem arrangement of two of the presses shown in **FIG. 5A** to dewater the web from both sides. **FIG. 9** also supplements **FIG. 5A** and the other previously described embodiments of the invention by illustrating the manner in which de-watering felts may be associated with the nip and displacement presses of the invention.

[0060] Referring to **FIG. 9, a** first nip-displacement press **90***a* is comprised of a pair of main rolls **91***a* and **92***a,* an intermediate nip press roll **93***a,* a pair of arcuately-spaced cap rolls **94***a* and **95***a* sealingly engaged with the main rolls and defining with the main rolls, the press roll and suitable end seals a pair of water-displacement pressure chambers **96***a* and **97***a* contiguous to the press nip **98***a* defined between the press roll **93***a* and the web-carrying and vented main roll **91***a.* A first dewatering belt or felt **99***a* wraps about the vented roll **91***a* between the surface of the roll and the adjacent side of the web and is guided by rolls **100***a* through a conventional felt dewatering path. A second dewatering belt or felt **101***a* wraps about the cap rolls **94***a* and **95***a,* the press roll **93***a* and the opposite side of the web and is guided by guide rolls **102***a* through a felt dewatering path. The two belts **99***a* and **101***a* assist in carrying away water removed from the web by the displacement and nip presses. Additionally, they tend to equalize over the width of the web the application of fluid pressure to the web in each of the pressure chambers **96***a* and **97***a,* and also to equalize over the width of the web the mechanical pressure applied at the press nip **98***a.*

[0061] The nip-displacement press **90***a* thus applies dewatering forces to one side of the web, namely, the upper side of the web as it appears entering the press assembly at the top of **FIG. 9** and as it appears existing the press assembly at the bottom of **FIG. 9**.

[0062] The press assembly of **FIG. 9** additionally includes a second nip-displacement press **90***b* of the same construction as the press **90***a,* with the exception that it is arranged, i.e., reversed, so as to apply dewatering forces to the opposite or lower side of the web. The components of the press **90***b* are the same as those of press **90***a* and are indicated by the same reference numerals but with the substituted suffix "b."

[0063] With the press assembly of **FIG. 9**, both sides of the web are symmetrically subjected, in sequence, to relatively low displacement dewatering pressure, relatively high mechanical nip pressure and either low or immediate displacement dewatering pressure, so as to mitigate the problem of two-sidedness.

[0064] The press assembly of **FIG. 9** also provides the advantage that the web passes through the press with no open draws. Specifically, an added guide roll **103***b* guides the belt **99***b* into engagement with the web while the web is carried on vented roll **91***a,* and then transfers it to vented roll **91***b* without open draw. Consequently, the web can travel at high speed through the press assembly with little if any risk of breakage or damage.

[0065] Considered in light of the foregoing description and the accompanying drawings, it is to be appreciated that the objects and advantages of the invention have been attained in a convenient, economical, practical and facile manner.

[0066] While several presently preferred embodiments of the invention have been herein illustrated and described, it is to be appreciated that various changes, rearrangements and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A method of dewatering a moving wet paper web comprising the steps of contiguous application of mechanical pressing and displacement dewatering to the web.

2. A method as set forth in claim 1 wherein the web is subjected to the displacement dewatering prior to the mechanical pressing.

3. A method as set forth in claim 1 wherein the web is subjected to the displacement dewatering after the mechanical pressing.

4. A method as set forth in claim 1 wherein the web is subjected to the displacement dewatering both prior to and after the mechanical pressing.

5. A method as set forth in claim 1 wherein the mechanical pressing is applied at a nip formed between two press rolls.

6. A method as set forth in claim 5 wherein the mechanical pressing is applied over a nip length of from about one-half to about four inches and at a load of from about 300 to about 1200 pounds per lineal inch.

7. A method as set forth in claim 1 wherein the mechanical pressing is applied at the nip between a press roll and an extended nip press shoe.

8. A method as set forth in claim 7 wherein the mechanical pressing force is applied over a nip length of from about 8 to about 14 inches at a load of from about 1400 to about 7000 pounds per lineal inch.

9. A method as set forth in claim 1, wherein the displacement dewatering is applied over a length of from about 0.5 to about 50 inches at a fluid pressure of from about 20 to about 300 pounds per square inch.

10. A method as set forth in claim 1 wherein the mechanical pressing is applied at the nip of a vented roll and an associated mechanical press element, and the displacement dewatering is applied over an arc of the vented roll contiguous to the nip.

11. A method as set forth in claim 1 wherein the mechanical pressing and contiguous displacement dewatering of the moving web are first applied to one side of the web and subsequently applied to the other side of the web, without open draw, to mitigate two-sidedness of the web.

12. A method of dewatering a wet paper web comprising the steps of:

supporting the wet web on a vented roll;

passing the wet web through a mechanical press nip formed between the vented roll and an associated press element; and

passing the web through a displacement dewatering zone formed between the vented roll and an associated pressure chamber.

13. A method as set forth in claim 12 including the step of passing the web through the mechanical press nip and immediately thereafter passing the web through the displacement dewatering zone.

14. A method as set forth in claim 12 including the steps of sequentially passing the web through a first water displacement zone, a mechanical press nip, and a second displacement dewatering zone, all on the one vented roll.

15. Apparatus for dewatering a wet paper web comprising,

means for mechanically pressing the wet web, and

means defining a displacement press for applying fluid pressure to the web, said displacement press means being contiguous to said mechanical press means.

16. Apparatus as set forth in claim 15 wherein said mechanical pressing means and said displacement press means are located on a single roll.

17. Apparatus as set forth in claim 15 wherein

said mechanical pressing means comprises a vented roll and an associated mechanical press element defining a press nip there between, and

said displacement press means comprises a pressure chamber extending over an arc of said vented roll contiguous to said nip and means for applying fluid pressure within said chamber.

18. Apparatus as set forth in claim 17 wherein said pressure chamber is located upstream of said nip.

19. Apparatus as set forth in claim 17 wherein said pressure chamber is located downstream of said nip.

20. Apparatus as set forth in claim 17 wherein said press nip is within said pressure chamber.

21. Apparatus for dewatering a wet paper web comprising,

a vented roll for supporting the web,

a press member loaded on said vented roll forming a press nip there between, and

a pressure chamber on said vented roll, said pressure chamber being pressurized with a fluid and applying a displacement dewatering pressure on the web.

22. Apparatus as set forth in claim 21, wherein said pressure chamber is contiguous with and downstream of said press nip.

23. Apparatus for dewatering a wet paper web comprising,

a vented roll for supporting the web,

a press roll loaded on said vented roll forming a press nip there between, and

a pair of cap rolls on at least one side of said press nip, one said cap roll engaged with said vented roll and the other said cap roll engaged with said first cap roll and said press roll, said pair of cap rolls, vented roll and press roll defining a pressure chamber.

24. Apparatus for dewatering a wet paper web comprising,

a vented roll for supporting the web,

a non-vented roll radially spaced from said vented roll,

a press roll between and engaged with both said vented and non-vented rolls, said vented roll and said press roll forming a press nip there between, and

a cap roll on at least one side of said press nip, said cap roll engaged with said vented roll and said non-vented roll, said cap roll, vented roll, non-vented roll and press roll defining a pressure chamber.

25. Apparatus for dewatering a wet web comprising,

a vented roll for supporting the web,

an extended nip press loaded against said vented roll forming an extended press nip there between,

a cap roll engaged with said vented roll and spaced from said extended nip press, and

a member extending between said extended nip press and said cap roll, said vented roll, extended nip press, cap roll, and said member defining a pressure chamber.

26. Apparatus for dewatering a wet web comprising,

a first press for dewatering the web having a first set of endless belt runs, said web being carried between said first set of endless belts, said first press having at least one displacement dewatering zone for applying fluid pressure to a first side of the web; and

a second press for dewatering the web having a second set of endless belt runs, said web being carried between said second set of endless belts, said second press having at least one displacement dewatering zone for applying fluid pressure to a second side of the web.

27. Apparatus as set forth in claim 26, further comprising a belt guide roll on one of said belt runs of one of said presses, said guide roll urging said one belt run into contact with the web as the web is being carried on the other said press, whereby said web is transferred from said first press to said second press without open draw.

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