March 19, 1974 L. H. BUSKER ET AL 3,798,121

WRAPPED ROLL PRESS

Filed Oct. 28, 1971 3 Sheets-Sheet 1

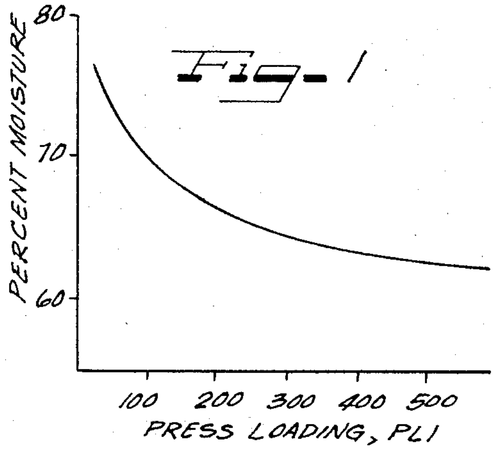
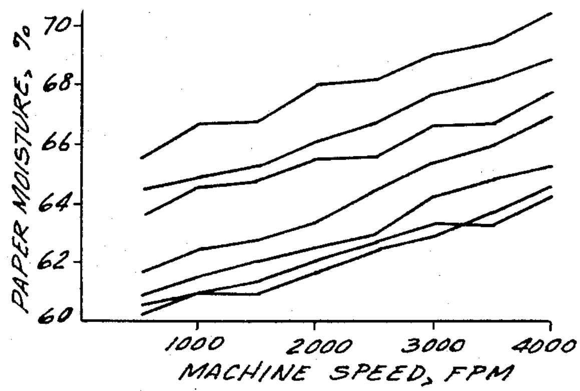
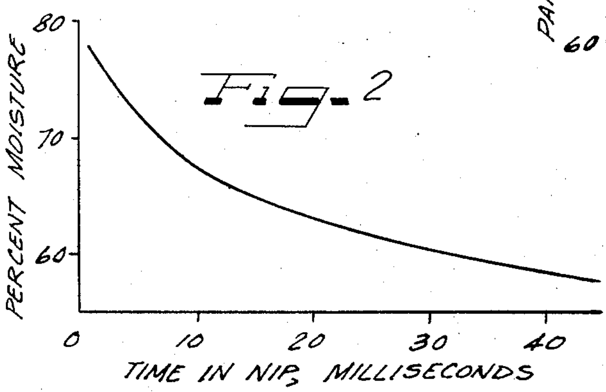


Fig-8





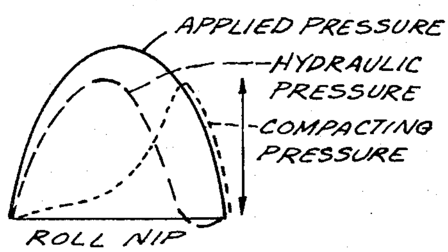


Fig-3

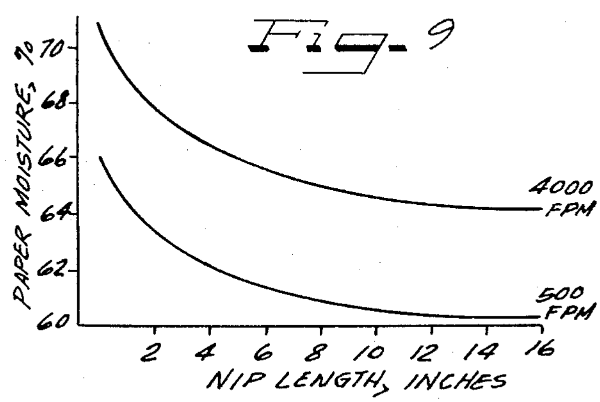
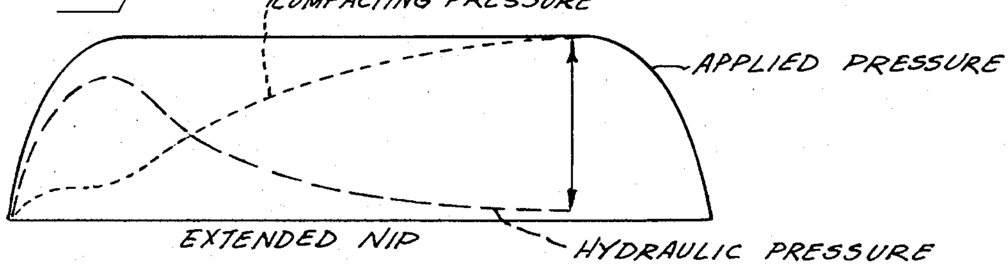


Fig-4



WRAPPED ROLL PRESS

Filed Oct. 28, 1971 3 Sheets-Sheet 2

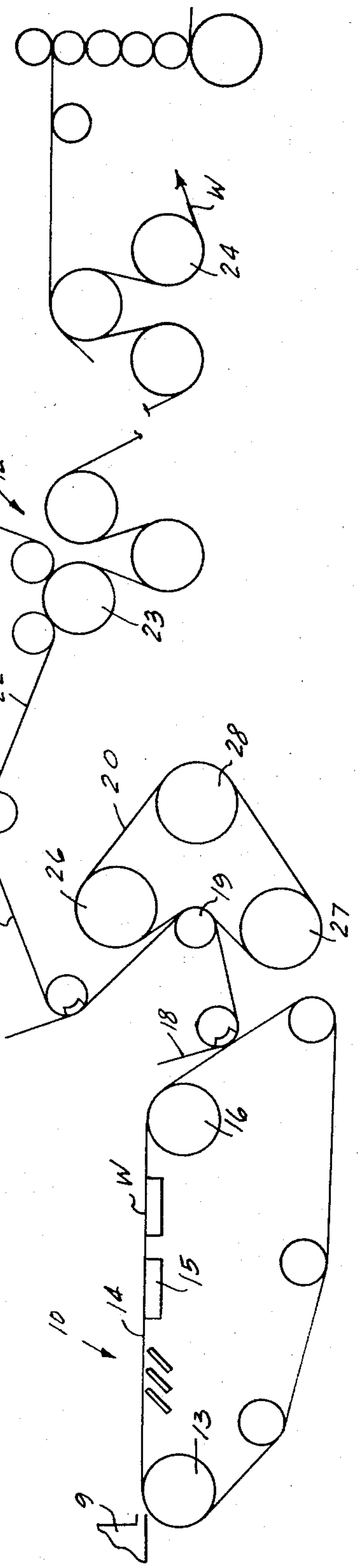


Fig. 5

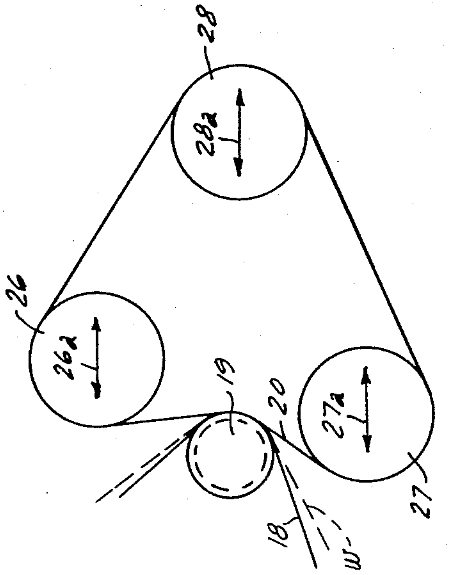


Fig. 7

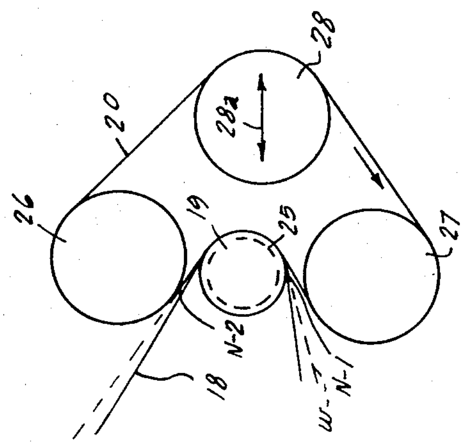
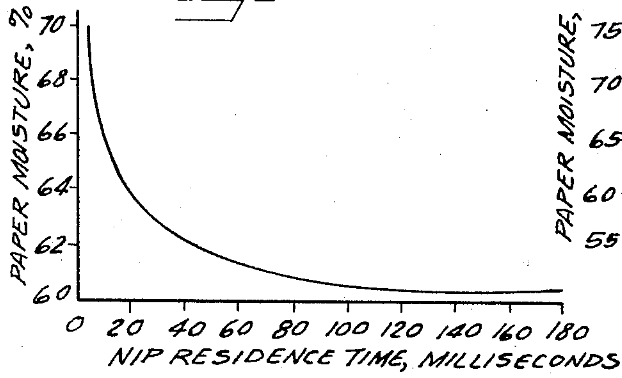


Fig. 6

WRAPPED ROLL PRESS

Filed Oct. 28, 1971 3 Sheets-Sheet 3

Fig. 10



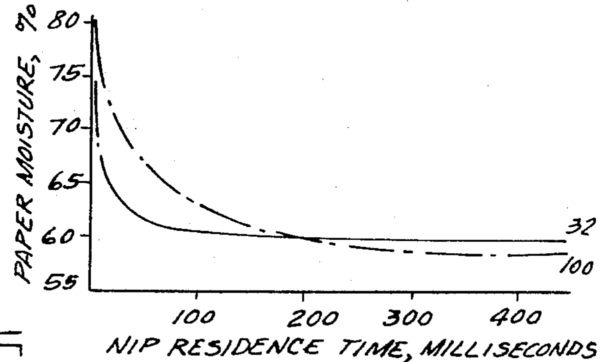
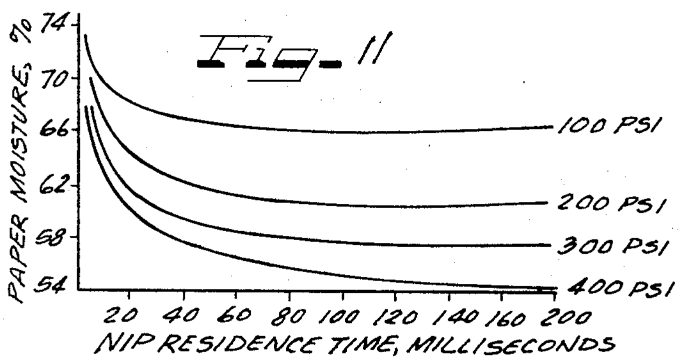


Fig. 13

Fig. 11



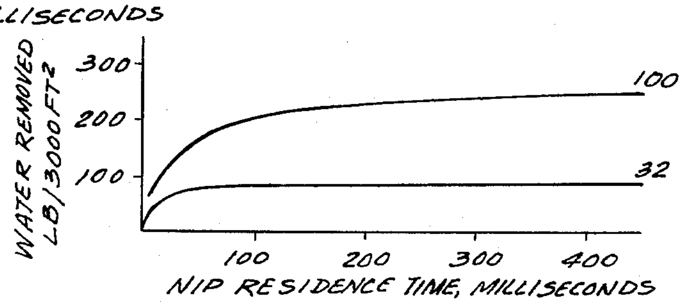
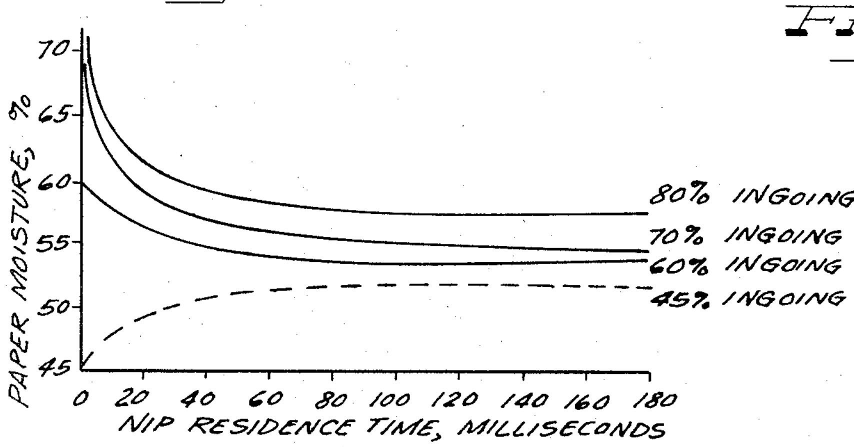


Fig. 14

Fig. 12



United States Patent Office

3,798,121

Patented Mar. 19, 1974

1

2

3,798,121

WRAPPED ROLL PRESS

Leroy H. Busker, Rockton, and Carl J. Francik, Roscoe, Ill., assignors to Beloit Corporation, Beloit, Wis.

Filed Oct. 28, 1971, Ser. No. 193,272

Int. Cl. D21f 3/06

U.S. Cl. 162—205 12 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus and method for forming a fibrous web and particularly for removing water therefrom by a compressing action which includes passing the web over a portion of the outer surface of a revolving roll and applying a belt to the outer surface to define a pressing zone in which the web is pressed due to the linear tension on the belt with a felt or other means passed through the pressing zone to receive water pressed from the compacted web and the belt being imperforate and equal atmospheric pressures existing on both sides of the pressing zone so that the water is expressed solely by the application of mechanical pressure which is at least as great as 100 pounds per square inch.

RELATED APPLICATIONS

The concepts of the invention of the instant application relate to certain of the principles expressed in our copending application, Ser. No. 90,921 filed Nov. 16, 1970 now U.S. Pat. No. 3,748,225.

BACKGROUND OF THE INVENTION

The invention relates to improvements in paper machine press sections for pressing water from a newly formed paper web and particularly to methods and structures which will provide an improved press section and eliminate the need for a conventional paper machine press which employs a sequence of press nips between press roll couples.

As will be appreciated from the teachings of the disclosure, the features of the invention may be employed in the dewatering in other forms of webs. For convenience, a preferred embodiment of the invention will be described in the environment of a paper making machine which conventionally forms a web by depositing a slurry of pulp fibers on a traveling Fourdrinier wire, transfers the web to a press section where the web passes through a number of press nips formed between roll couples, and then the web passes over a series of heated dryer drums and usually through a calender and then wound on a roll. Many modifications can be made in this type of machine to the forming section, the press section or the dryer section, and it can be employed in forming webs of various synthetic fibers.

The present invention relates to improvements in the press section in making a paper web. The web usually arrives at the section with about 80 percent wet basis moisture (ratio of water to fiber plus water) and leaves the dryer section with approximately 60 percent moisture, with the remaining moisture being removed by thermal evaporation as the web passes over a series of dryer drums. Because of various inherent ilmitations in the operation of roll couples forming press nips for the press section, only a given amount of water can be removed in each nip and, therefore, in the conventional paper machine, a series of three press nips are employed. It has been found impractical to attempt to remove a significant amount of additional water by increasing the number of press nips although the further removal of water by pressing can greatly reduce the expense and size of the dryer section. It is estimated that if the water removed in the press section can be reduced from 60 to 50 percent, the length of the dryer section can be reduced by ⅓. This is significant in a typical 3000 feet per minute newsprint machine which employs approximately 100 dryer drums. This significance can be appreciated in considering that dryer drums are each expensive to construct and to operate in requiring the provision of steam for each drum. The relative importance of the removal of water in the press section is further highlighted by the fact that one of the most important economic considerations in justifying a satisfactory return on investment in the operation of a paper machine is to obtain the highest speed possible consistent with good paper formation and better pressing will shorten the necessary time in the dryer section and permit higher speeds.

It is accordingly an object of the present invention to provide an improvement in the press section of the paper machine which makes it possible to remove an increased amount of water in the press section and makes it possible to provide a press section having only a single pressing nip of a unique elongated nature which does not have the performance limitations of conventional roll couple presses and which requires far less space in terms of requirements as to length of the press section. By increasing the amount of water removed from the web in the press section, increased speeds are possible with existing equipment, i.e., a given length of dryer section can operate at higher speeds since it is required to remove less water. Also, new equipment can be constructed requiring less machine length and expense.

The invention employs a principle which may be referred to as the extended nip concept wherein the time the paper is subjected to a pressing action is greatly extended, i.e., a single pressing nip is provided having a residence time which exceeds that of the web in a number of conventional roll couple press nips. With the reduction to a single pressing operation, the compound effects of rewetting the web leaving a plurality of nips are avoided.

A factor which presently limits water removal from paper by mechanical web pressing is the flow property of water within the paper sheet. We have found that other factors are not of dominant significance, for example, the effects of the moisture in the felt which travels with the web are small. We have further found that the length of time that the web is in the nip, or in other words, the residence in the nip can have a significant effect in overcoming the difficulties created by the flow properties of the water within the sheet. We have found in experiments that merely by increasing the residence time of the web in the nip, the water content of the sheet coming out of a press can be decreased so that the web will have 46 percent dryness rather than 40 percent dryness with other variables remaining constant. Further, with long-term static application of mechanical pressure to a wet paper mat, the moisture can be reduced to below 40 percent. As is evident, the residence time of a web in a conventional press nip is limited and can only be increased by decreasing the speed of travel of the web, or can be increased slighly by increasing the diameter of the press rolls, but these factors are indeed limiting. It has been found, for example, that by applying a 1300 pound per square inch pressure on a web for 5 minutes, a moisture level of less than 30 percent can be attained. Yet, under the dynamic short-term mechanical pressing of the paper machine press section, even with a plurality of nips, a great deal of effort is required to maintain moisture levels below 60 percent. Inspection of moisture versus press loading curves for the typical paper machine reveals that a plateau has been approached where major increases in roll loading to increase nip pressure result in relatively small decreases in moisture. This is illustrated by the curve of FIG. 1 (for a conventional two roll press) where it is shown that the curve flattens out so that moisture is not reduced significantly with increase in nip load.

However, as illustrated in FIG. 2, when time in the nip is increased, the moisture curve continues on downwardly showing an appreciable moisture decrease with increase in nip residence time.

It has been found that significant losses in dryness occur at higher speeds and that a loss in dryness of over 5 percent is experienced in going from 300 feet per minute to 1000 feet per minute with typical press loadings in a suction press. It has been found that a hydraulic pressure or wedge effect develops during the passage of the wet mat through the wet press nip. The hydraulic pressure that develops subtracts from the applied load and reduces the mechanical compacting pressure. The result is a loss in dryness. As machine speed increases, the compacting rates are higher resulting in higher hydraulic pressures within the paper mat. These hydraulic pressures react against the pressure of the rolls and prevent the moisture from being squeezed from the web. The exact value of hydraulic pressure is difficult to determine either by direct measurement or analysis because of the space and speeds involved. It is believed, however, that hydraulic pressure predominately determines press performance on machines operating at the high speeds.

Accordingly, the instant invention relates to avoiding disadvantages encountered with high speed press nips of the type used in most commercial applications today and provides a substantial increase in residence time within a press nip to allow time for flow to occur within the mat and for the hydraulic pressure to dissipate.

Some insight into the flow of water in paper is provided by Darcy's law. One form of the equation neglecting gravitational force is

$$v=\frac{K\Delta P}{\mu L}$$

where v is a superficial velocity defined as volumetric flow rate per unit area and

ΔP=pressure drop or difference between static pressures at the external boundaries of the paper mat.
L=thickness of the paper mat (distance across which pressure drop occurs)
μ=viscosity of water
K=specific permeability of the paper to water with dimensions of length squared.

The average velocity of flow, $\bar{v}$, over the nip of length N is

$$\bar{v}=\frac{1}{N}\int_0^N v\,dx=\frac{1}{\mu N}\int_0^N \frac{K\Delta P}{L}\,dx$$

Since permeability, pressure drop, and length of flow path are all interdependent, no direct solution can be made in this form. However, if an average value of these terms is introduced, then

$$\bar{v}=\frac{1}{\mu}\left(\overline{\frac{K\Delta P}{L}}\right)$$

Furthermore, the velocity of the flow of water out of the paper averaged over a nip of length N is

$$\bar{v}=(W_i-W_o)\cdot\frac{F}{\rho_w}\cdot\frac{U}{N}$$

where

W_i=ingoing moisture ratio, lb. water/lb. dry fiber
W_o=outgoing moisture ratio, lb. water/lb. dry fiber
F=basis weight, lb. dry fiber/unit area
ρ_w=density of water
U=machine speed

Combining the two relationships for average flow velocity gives

$$\left(\overline{\frac{K\Delta P}{L}}\right)\cdot N=\frac{\mu\cdot\Delta W.F.U.}{\rho_w}$$

where W=moisture removed, (W_i-W_o).

An explicit solution for pressure drop would be desirable to study factors which contribute to it and which ultimately subtract from the applied load resulting in less compaction and less dryness. Such a solution is not readily achieved; however, some insight into the effect of other variables on the pressure drop term $(\overline{K\Delta P/L})$, can be gained from the above relationship.

Assuming that a constant moisture removal, ΔW, is to be maintained, consider the following changes of variable upon the hydraulic pressure drop term.

The viscosity of water at 20° C. (68° F.) is very near to 1.0 centipoise. At 55° C. (131° F.) it is near 0.5 centipoise. If other variables are held constant, this increase in temperature could effectively halve the hydraulic pressure drop term. This concept has been applied in paper making but is limited by damage to the fibers, and the large expenditure of fuel required to heat the large volume of stock.

Doubling the basis weight doubles the hydraulic pressure drop term. In practice, increasing basis weight also increases the thickness, L, and the affect on pressure drop term is less certain. Past experimental results would indicate that an increase in thickness would require an increase in pressure drop for equality, but this is not a direct relationship. For purposes of wet pressing, basis weight is a specified variable not under control of the paper maker.

The hydraulic pressure drop term must increase directly with the machine speed. As limitations of speed in other parts of the paper machine are overcome, press speeds must increase correspondingly. Therefore, other variables must be changed in order to overcome or alleviate the increased hydraulic pressure so as to maintain the same moisture removal.

One interesting variable is the distance across which the hydraulic pressure drop occurs, L. In the conventional transverse flow press, this distance is considered to be the thickness of the paper mat at the given compacting pressure. If provision is made for flow to occur out of both surfaces of the paper mat, then the distance across which the hydraulic pressure drop occurs is reduced to half the thickness of the mat. Although actual conditions may be grossly oversimplified in the preceding example, double felting in a press provides for flow out of both surfaces and reduces flow path length and could be useful in some instances. Unfortunately, the effect on pressure drop cannot be reduced directly from the equation because of the interrelation of variables. In practice, most of its advantage is often lost due to other factors such as rewetting.

The effect of permeability change cannot be determined directly from the equation again because of the interrelation of variables. Permeability is somewhat under the control of the paper maker depending upon his choice of furnish and subsequent treatment, but this choice is limited by the requirements of paper properties and cannot be selected merely to optimize permeability for pressing.

The remaining variable affecting the hydraulic pressure drop term, according to the equation, is nip length. Inspection shows that an inverse relationship exists between the pressure drop term and nip length and if all other variables are held constant, a hyperbolic function results.

$$\left(\overline{\frac{K\Delta P}{L}}\right)\cdot N=\text{a constant}$$

It is of interest to consider that doubling the nip length reduces the average pressure drop term to one half. This does not mean that the hydraulic pressure drop also is reduced by half, but from experimental studies it can be concluded that it will be reduced thus increasing the proportion of the applied load giving mechanical compaction and causing further water removal.

If, now, instantaneous hydraulic pressure is considered, FIG. 3 illustrates the dynamic condition. First a roll press nip is considered and in this nip the applied load is divided between hydraulic pressure and mechanical compacting pressure. It is the maximum value of mechanical compacting pressure reached in the nip which is the major determining factor of final dryness achieved. A second and third roll press nip would have similar curves with possibly a slight reduction in hydraulic pressure as a result of lower total moisture. If then one could combine the 3 nips into 1 nip which gave a continuous application of pressure throughout its length, the flow out of the paper and felt could occur over a longer period of time and the hydraulic pressure could dissipate more completely during the interval giving a higher mechanical compacting pressure and higher dryness. Instantaneous values of hydraulic pressure for the extended nip may be as high as in the roll press for the applied load as shown, but the average hydraulic pressure is much reduced, and more importantly, near the nip exit all of the applied pressure results in mechanical compacting and water removal.

The present invention operates in accordance with the principles of providing an extended nip as shown in FIG. 4. This obtains continuous pressure for an extended time to allow the decrease of hydraulic resistance pressure and to allow compacting pressure to build up. It also has the effect of providing a period of time in drop of applied pressure which is no longer than with the roll nip of FIG. 3 so that the rewetting time has not changed. Yet, with the principles of FIG. 3, two or three nips are provided so that three rewetting periods are inescapable, and with the principles of FIG. 4, only one application of pressure is made so that only one rewetting time is necessary.

It is accordingly an object of the present invention to provide an improved web making machine with a mechanical pressing operation for dewatering that achieves advantages over structures heretofore provided by applying a pressure over an extended period of time to permit the hydraulic resistance pressure to decrease and attain more effective water removal.

Other objects and advantages and other forms of the invention will become more apparent from the teachings of the principles of the invention in connection with the disclosure of the claims, specification and drawings in which:

DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 are schematic illustrations of graphs, with FIG. 1 showing the relationship between moisture reduction and press load in a typical two roll press, and FIG. 2 showing the relationship between moisture reduction and residence time in a press;

FIG. 3 is a schematic illustration showing the pressure situations within the nip of a typical two roll press;

FIG. 4 is a schematic showing of the pressure conditions existing within an extended nip of the present invention;

FIG. 5 is a schematic showing of a paper making machine employing a structure in accordance with the present invention;

FIG. 6 is a schematic end elevational showing of a press constructed and operating in accordance with the present invention;

FIG. 7 is another view of the structure of FIG. 6 showing the parts in different adjustment;

FIG. 8 is a graph showing paper moisture versus speed of web travel;

FIG. 9 is a graph showing paper moisture versus nip length;

FIG. 10 is a graph showing paper moisture versus residence time in the nip;

FIG. 11 is a graph showing various curves for different nip pressures and illustrating paper web moisture as against nip residence time;

FIG. 12 is a graph illustrating the effects of incoming moisture of a paper web plotting nip residence time against paper moisture;

FIG. 13 is a graph showing basis weight effects, plotting paper moisture against nip residence time; and

FIG. 14 is a graph showing the amounts of water removed for different basis weights plotting water removed against nip residence time.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As illustrated in FIG. 5, a paper making machine has a forming section **10**, a press section **11** and a dryer section **12**.

In the forming section **10** a headbox **9** carried on a breast roll **13** and a couch roll **16** delivers a slurry of stock onto a traveling Fourdrinier wire **14** so that a web W is formed on the upper surface. Within the looped Fourdrinier wire are dewatering means such as foils and suction boxes **15**, and the web is formed and carried on the wire over the couch roll **16** to be picked off the downrunning Fourdrinier wire by a felt **18** to be carried into the extended press section **11**. After passing through the press in a manner which will be described in greater detail in connection with FIGS. 6 and 7, the dewatered web is received by a felt **21**, and transferred onto a felt **22** to be passed over a dryer drum **23** of the dryer section **12**. From the last drum **24**, the web is calendered and taken up on a windup roll.

In the press section of FIGS. 6 and 7, a single extended press nip is provided formed between a supporting roll **19** and a highly tensioned belt **20**. The belt is carried over rolls **26**, **27** and **28**. The web is carried on the belt **18** into the nip N–1 and is subjected to pressing action for the entire time that is between the belt and the support roll **19**. The belt is tensioned with sufficient linear tension to supply a compacting force to the web of at least 100 pounds per square inch and pressure substantially in excess of this i.e., on the order of 200 to 500 pounds per square inch are preferred.

No air pressure differentials are applied across the web so that the entire extraction of water is due to the application of the mechanical force normal to the web. This avoids the disruption of the paper mat which has been formed, and which at this time is fragile and can be disrupted by the sudden passage of water through the fibers that is caused by flushing water from the paper with air pressure differential as has been one of the suggestions of the art.

The nonpervious belt may take different constructions adequate to withstand the tension required to obtain the pressing forces, and in one form may be a fabric reinforced in layers and covered with rubber. Such structures are commercially available. In another form extruded nylon may be utilized. This nylon is linearally oriented and extruded in narrow widths which are ultrasonically welded together. The web also may contain coated steel wire but a uniform belt is required which does not create a problem of marking the web.

The web enters a pressing zone which extends from the time that it enters the nip between the belt **20** and a felt **18** and support roll **19** at N–1 until it leaves the nip N–2 on the outgoing side. During this time, the water is being transferred from the web to the moisture receiving means which in FIGS. 6 and 7 is the felt **18**. The felt may be provided with dewatering means to reduce its moisture before again entering nip, but as above stated while there are moisture contents which appear to give somewhat better results, the moisture content of the felt is not critical with the present arrangement. The support roll may be provided with recesses for receiving moisture for aiding the passage of moisture from the web into the felt. These recesses may be in the form of circumferentially extending narrow grooves **25** which are relatively narrow so as not to cause markings on the paper web through the felt **18**. Means may be provided for skimming the water from the grooves, such as by skimmer doctor or other well known means.

The tension in the belt **20** is controlled by the tension roll **28** which may be provided with a movable support **28***a*. The upper and lower support rolls **26** and **27** may also be horizontally movable to controllably change the arc of wrap of the support roll **19**. Thus, with the rolls **26** and **27** shifted to the right from their position of FIG. 6 to their position of FIG. 7, the arc is substantially reduced and the time of residence of the web in the nip is reduced. This residence time may be controlled in accordance with different paper machine speeds or in accordance with different types of papers being processed. Power means shown schematically at **26***a* and **27***a* are provided for shifting the rolls **26** and **27**.

Dependent upon the diameter of the support roll **19**, and the angle of wrap chosen, the length of the nip can be selected for the conditions of operation required. A support roll of sufficient strength to avoid any substantial deflection over the width of the paper machine should be employed. In substantially large machine, deflection control means may be employed to obtain a roll which does not bend under load.

Except during the regions of entry and exit, the pressure existing between the belt and roll is constant and given by the expression,

$$P=\frac{T}{R}$$

where P is the pressure, R is the roll radius and T is the tension existing in the belt per unit width.

In some circumstances it may be desirable to provide additional moisture receiving means in the form of a felt not shown, positioned between the web and the tensioned belt **20** so that the web will be sandwiched between felts. This will permit receiving moisture from both sides of the web as it is subjected to compacting pressure in the pressing zone.

As above stated, the moisture contained in the incoming felt does not have a large effect on the moisture removed during the extended nip. A set of data is shown on the following Table 1. This data indicates that the moisture of the outgoing paper web is only slightly dependent on the incoming felt moisture. There is some indication of an optimum felt moisture near 30 percent (wet basis) but this optimum point is not well defined. Over the range studied, varying felt moisture created a change of at most 2 percent moisture in the outgoing web.

The following Table I illustrates examples with different nip lengths, different nip pressures, different machine moisture.

TABLE I.—DATA RELATING FELT MOISTURE AND PAPER MOISTURE

	Nip pressure, p.s.i.	Machine speed, f.p.m.	Sample moisture In, percent	Sample moisture Out, percent	Felt moisture, percent
Nip length;					
2″	200	500	81.9	66.6	58
			81.8	65.8	50
			81.7	65.2	40
			79.7	64.0	30
			81.0	64.7	20
			79.0	65.1	10
2″	200	2,000	78.8	67.2	55.5
			78.2	67.1	50
			78.0	67.5	40
			80.9	67.9	30
			78.8	68.1	20
			78.4	68.6	10
18″	200	500	79.7	59.7	53.4
			80.6	59.3	50
			79.6	59.3	40
			79.3	57.7	30
			79.4	58.2	20
			79.0	59.6	10
18″	200	2,000	79.6	61.7	48.1
			79.6	61.4	40
			79.9	61.1	30
			79.0	61.7	20
			79.2	62.2	10

Another variable which has been considered is the relationship of the moisture contained in the felt relative to speed of travel of the web. Tests showed that the felt moisture leaving the nip remained essentially constant through a range of speed of 1500 to 4000 feet per minute. This implied that there was no significant development of hydraulic pressure in the felt. The significant relationship in accordance with the principles of the present invention is the necessity of providing an adequate nip pressure, i.e., at least 100 pounds per square inch and the necessity of providing an increased residence time over that afforded by the nip of the usual press couple.

It has been determined that there is a strong dependence of paper moisture on machine speed which reflects the need for residence time. FIG. 8 illustrates tests made with a web having a paper basis weight of 32 lbs./3000 square feet. The tests were made with a 200 pounds per square inch nip pressure and 80 percent ingoing web moisture. As will be observed the sample moisture out of the press increased with speed and decreased with increasing nip length. Data for the 14 inch nip length is almost indistinguishable from the 18 inch nip length. Data at 500 feet per minute was somewhat inconsistent, and this is believed to be because of felt rewetting occurring on the outgoing nip.

The foregoing demonstrates the effectiveness of the use of an extended nip in water removal. The nip residence time may be expressed as follows:

$$NRT=\frac{\text{nip length}}{\text{speed}}=\frac{N}{U}$$

For the web above referred to, FIG. 9 illustrates the relationship at 4000 feet per minute and at 500 feet per minute of the paper moisture coming from the nip versus nip length in inches. This chart illustrates for the paper tested that a long residence time as afforded by long nip length definitely yields an advantage but that the advantage diminishes as the nip length is made excessively long. Thus, a nip length should be chosen which affords maximum water removal within a convenient residence time, i.e., for a convenient size support roll and a convenient angle of wrap depending on machine environment.

FIG. 10 expresses the foregoing principles directly in terms of nip residence time milliseconds.

A 2 inch nip at 3000 feet per minute would give a residence time of 3.3 milliseconds as indicated by the arrowed line in FIG. 10. As illustrated if the time the nip could be extended by a factor of 10 beyond this point, a reduction of nearly 7 percent moisture is indicated.

FIG. 11 illustrates the same relationship as FIG. 10 for various nip pressures and as shown, the additional moisture removal which can be attained by increasing the nip pressure beyond 100 pounds per square inch is appreciable.

The following equation may be employed to describe press performance.

$$\frac{M_{in}-M_{out}}{M_{in}-M_{min}}=\frac{\Delta M}{\Delta M_{max}}=f(NRT$$

where

M_{in}=percent moisture before pressing

M_{out}=percent moisture after pressing

M_{min}=percent moisture relating to the estimated lowest moisture attainable at the given pressure

NRT=nip residence time, N/U

By employing these formulas, the following Table II correlates the data of FIG. 11 within approximately ±10 percent.

TABLE II.—NIP RESIDENCE TIME PER UNIT WATER REMOVED

	$\Delta M/\Delta M_{max}$. for various pressures of—			
	100 p.s.i.	200 p.s.i.	300 p.s.i.	400 p.s.i.
NRT, ms.:				
2	.342	.459	.489	.477
5	.585	.581	.593	.565
10	.715	.695	.706	.662
20	.827	.820	.820	.770
40	.935	.918	.909	.862
80	.985	.975	.960	.935
120	1.0	.990	.985	.970
180	1.0	1.0	1.0	1.0

A further consideration was to determine the effect of ingoing paper moisture on outgoing moisture. It might be expected that with sufficient time for flow to occur (with high residence time) and hydraulic pressure in the paper to become dissipated, the final moisture content would be the same regardless of entering paper moisture. FIG. 12 shows this relationship at a constant pressure of 300 pounds per square inch. The data at 80, 70 and 60 percent ingoing moisture tends toward a single constant outgoing moisture level at long residence times of 180 milliseconds. However, the higher moistures result in slightly higher outgoing moisture. Our theory for this result is that this difference is due to a rewetting action at the nip exit. This action is not likely to be controllable by time in the nip, but could be influenced by greater amounts of water available at the paper felt interface at higher values of input moisture. Although the felt is considered to be saturated with water, no doubt some air is trapped in the felt structure and carried into the nip. Water moving out of the paper into the felt may displace some of the entrained air near the felt paper interface.

An attempt was made to rewet samples from input moisture of 45 percent up to the equilibrium value of 54 percent outgoing moisture. These results are shown in the broken line curve of FIG. 12. Again, rewetting (or more exactly, a lack of rewetting) at the exit of the nip could explain the failure to reach 54 percent. Also, samples were brought to 45 percent moisture by pressing previous to use in obtaining data and, therefore, had been conditioned somewhat differently than the other samples.

Another factor which has been investigated is the effect of the basis weight upon the moisture residence time relationship. Again for a nip pressure of 200 p.s.i. with 80 percent ingoing moisture of the web, FIG. 13 shows that as the paper weight increases, longer residence times are required to achieve the same outgoing moisture levels. Although the percent reduction in moisture may be less at higher basis weights, the water removed is actually greater which is illustrated by the chart of FIG. 14.

Pressing is known to affect sheet properties as well as remove water. It is possible that with the extended nip principle of the present invention that the formation will be disturbed less for an improved web. It is also possible that an increase in tensile strength, bulk and other paper properties will be achieved.

With respect to the foregoing discussion of test results pertaining to the structure and method of the instant invention, it can be stated that a major important controlling variable in web pressing is the resistance to water flow out of the paper web itself. To achieve greater dryness out of the press, the resistance must either be alleviated or overcome to a greater extent. No improvement in paper dryness can be achieved by improving upon the initial water flow properties of a new unused felt since no development of hydraulic pressure in the felt can be demonstrated for the transverse flow arrangement. This is not the case on a paper machine where the life of the felt is determined by flow resistance of the felt as is affected by compaction and filling. However, if felt flow resistance is minimal, then paper flow resistance properties are a major factor limiting increased paper dryness.

While advantage should be taken of all the variables which minimize the development of hydraulic pressure within the paper web, countering the resistance to water flow by providing greater nip residence time has been found to be effective. A greater residence time is achieved in this instance by an extension of the nip length with the structure described and illustrated.

We claim as our invention:

1. A press structure for performing a dewatering operation in the steps of formation of a traveling fibrous web which comprises,
- a rotatable support roll having an outer supporting surface,
- a moisture impervious pressure belt defining with said support roll surface an arcuate pressing zone with the web being pressed normal to the web surface between the roll and belt throughout said zone,
- tensioning means for applying a tension to said belt to form a pressing force normal to the web of at least 100 pounds per square inch throughout said zone, and
- means in said zone for receiving moisture pressed from the web.

2. A press structure for performing a dewatering operation in the steps of formation of a traveling fibrous web constructed in accordance with claim **1** wherein said moisture receiving means includes a looped felt passing between the web and the surface of the support roll.

3. A press structure for performing a dewatering operation in the steps of formation of a traveling fibrous web which comprises,
- a rotatable radially imperforate support roll with an outer supporting surface,
- a moisture impervious pressure belt means defining with the surface of the roll an arcuate pressing zone wherein the web is pressed normal to the web surface between the surface of the roll and belt throughout said zone,
- tensioning means for applying a tension to said belt to generate a pressing force normal to the web of at least 100 pounds per square inch in said zone sufficient to press water from the web, and
- means in said zone for receiving moisture pressed from the web.

4. A press structure for performing a dewatering operation in the steps of formation of a traveling fibrous web constructed in accordance with claim **3** wherein the means for receiving moisture from the web is a felt positioned between the surface of the roll and the web.

5. A press structure for performing a dewatering operation in the steps of formation of a traveling fibrous web constructed in accordance with claim **4** wherein the surface of the roll has a plurality of water receiving recesses thereon.

6. A press structure for performing a dewatering operation in the steps of formation of a traveling fibrous web constructed in accordance with claim **5** wherein said recesses are in the form of circumferentially extending narrow grooves of a width sufficiently small so that the web will not be marked.

7. A press structure for performing a dewatering operation in the formation of a traveling fibrous web which comprises,
- a rotatable support roll having an outer supporting surface, an imperforate moisture impervious pressure belt defining with the surface of said roll an arcuate pressing zone in which the web is pressed,
- tensioning means for applying a linear tension to said belt to form a pressing force normal to the web of at least 100 pounds per square inch throughout the pressing zone, and
- means in said zone coextensive with the web for receiving moisture pressed from the web,
  - said zone formed solely by the normal reaction between the belt and the roll surface so that the

pressure of the belt forms the sole force for moving water from the web to the moisture receiving means.

8. A press structure for performing a dewatering operation in the formation of a traveling fibrous web constructed in accordance with claim **7** wherein the moisture receiving means includes a felt located between the belt and the web.

9. A press structure for performing a dewatering operation is the formation of a traveling fibrous web constructed in accordance with claim **7** wherein the moisture receiving means includes a felt positioned between the web and the belt and another felt positioned between the roll surface and the web.

10. A press structure for performing a dewatering operation in the formation of a traveling fibrous web constructed in accordance with claim **7** wherein the moisture receiving means includes a looped traveling felt passing between the web and the surface of the roll and the roll has a plurality of circumferentially extending narrow grooves in the surface thereof being sufficiently narrow to avoid marking the web.

11. A paper making machine comprising in combination,

a web forming section including means for delivering a stock slurry onto a traveling perforate dewatering surface,

a press section for receiving the web from the dewatering surface, a dryer section having a plurality of heated dryer drums for evaporating moisture from the web and receiving the web from the press section, and

means for receiving the dryed web from the dryer section, said press section comprising a rotatable support roll with a moisture impervious pressure belt defining with the outer surface of the roll a pressing zone through which the web is passed,

said pressing zone extending over a portion of the outer surface of the roll with the web being dewatered solely by the pressing force of the belt normal to the surface of the web in said zone,

tensioning means for applying a tension to the belt to generate said pressing force of at least 100 pounds per square inch, and

means in said zone for receiving moisture pressed from the web.

12. The method of removing water from a traveling web which comprises the steps of passing a web over a portion of the outer surface of a revolving roll, and while the inner surface of the web is passing over said portion of the outer roll surface,

applying a moisture impervious belt to the outer surface of the web to form an arcuate pressing zone with said roll and tensioning the belt to a linear tension sufficient to apply a compressing force normal to the web of at least 100 pounds per square inch and great enough to express water from the web while maintaining uniform atmospheric pressure on opposite sides of the web so that the water is expressed solely by the application of mechanical pressure to the web, and

passing a carrier for said web through the arcuate pressing zone, and receiving the water expressed from said web in said carrier as the web and the carrier pass therethrough.

References Cited

UNITED STATES PATENTS

3,257,268	6/1966	Wrist et al.	162—358 X
3,515,633	6/1970	Futch, Jr.	162—361 X
1,483,562	2/1924	Wagner	162—358
2,979,131	4/1961	Bentov	162—361
3,131,118	4/1964	Dabroski et al.	162—361
3,162,568	12/1964	Post	162—358
3,306,814	2/1967	McHugh	162—358

S. LEON BASHORE, Primary Examiner

R. V. FISHER, Assistant Examiner

U.S. Cl. X.R.

100—121, 155 R; 162—358, 361