Nov. 22, 1966 C. W. E. WALKER 3,286,360

DIVIDED TEMPERATURE CONTROLLED PRESS

Filed Oct. 16, 1963 5 Sheets-Sheet 1

FIG. 1

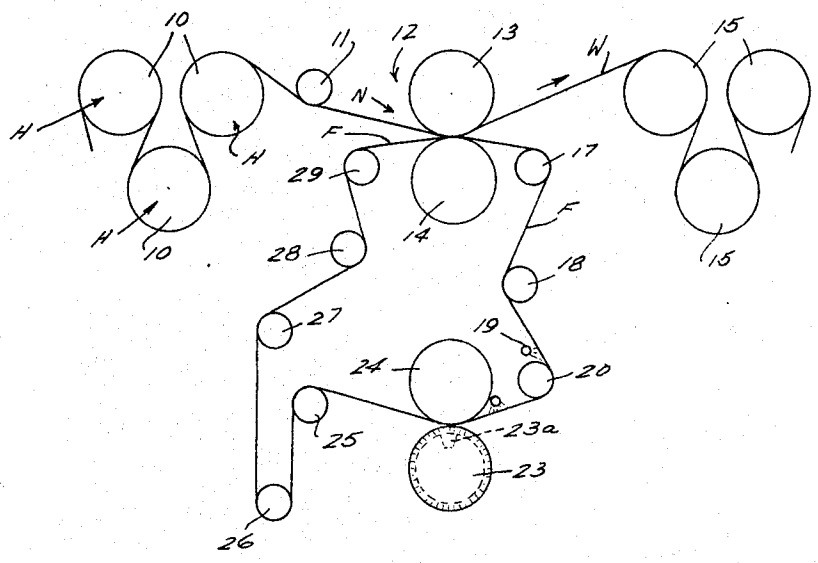
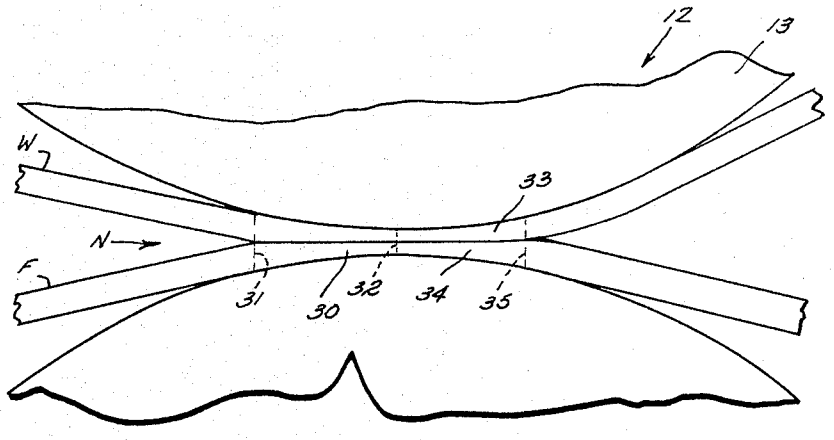



FIG. 2




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Nov. 22, 1966 C. W. E. WALKER 3,286,360

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FIG. 3

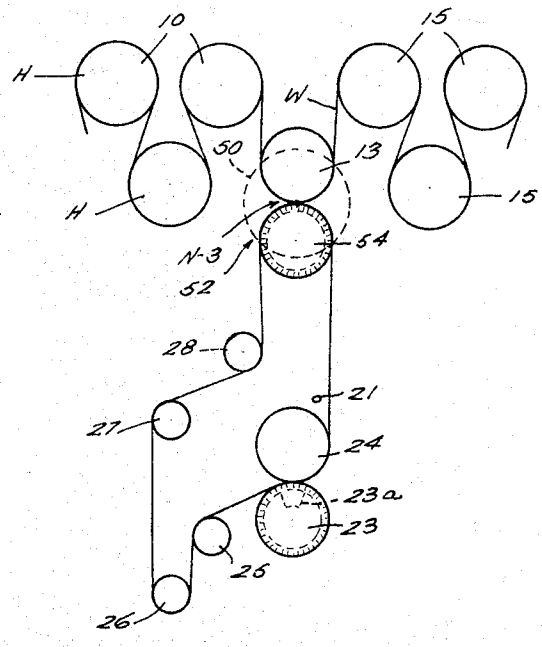
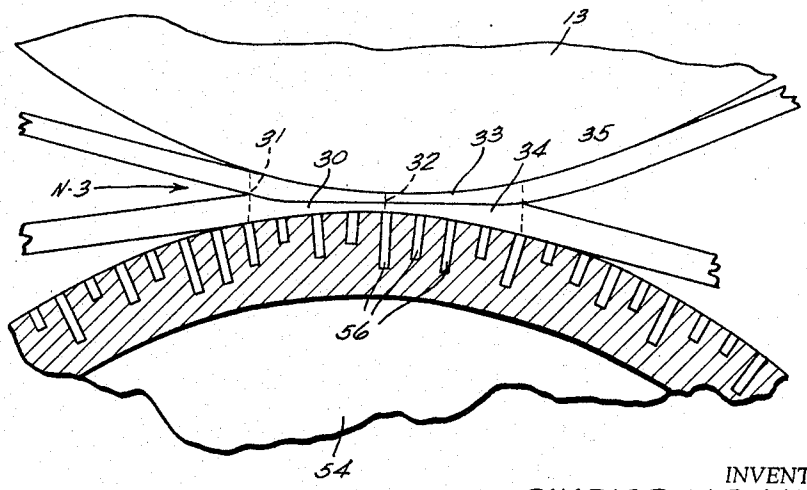



FIG. 4




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Filed Oct. 16, 1963 5 Sheets-Sheet 3

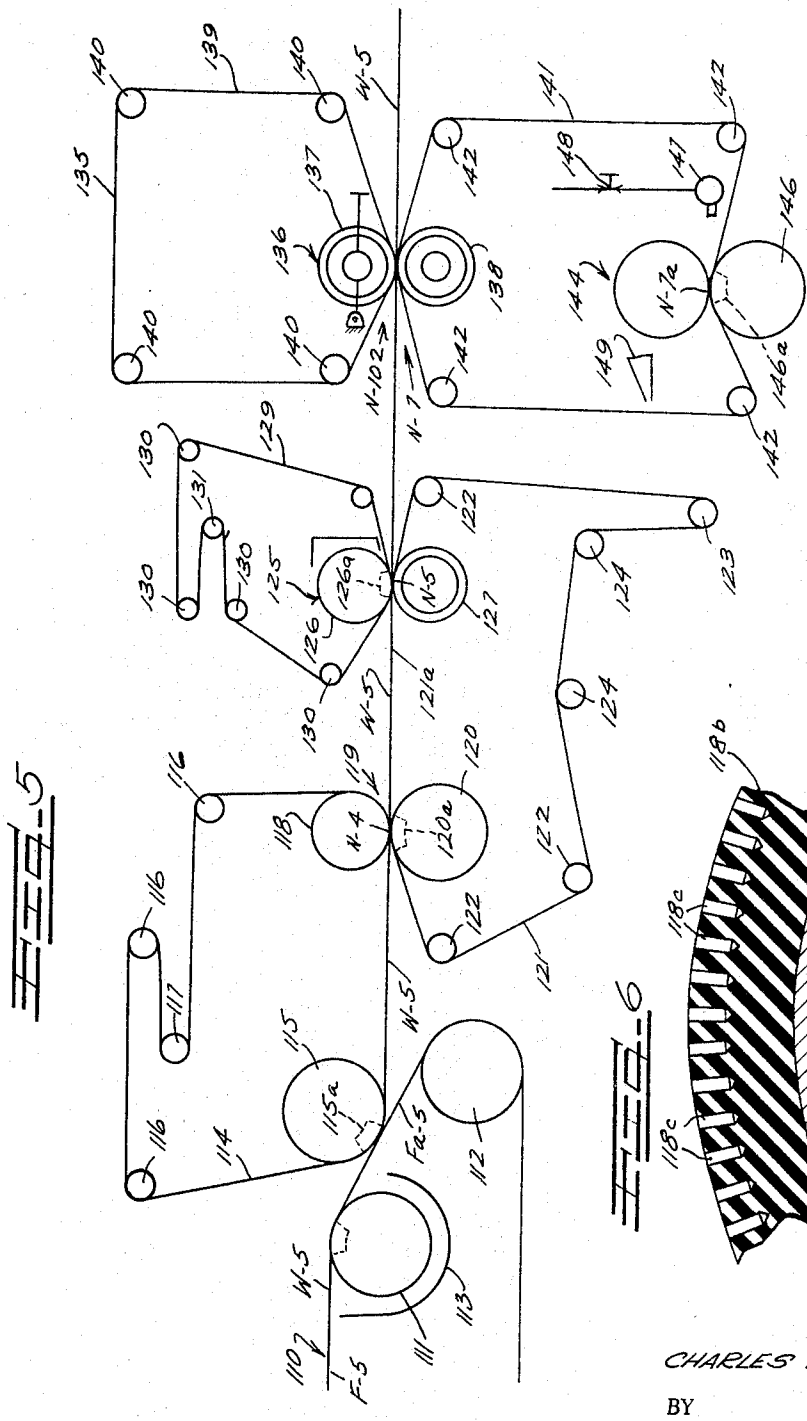



FIG-5

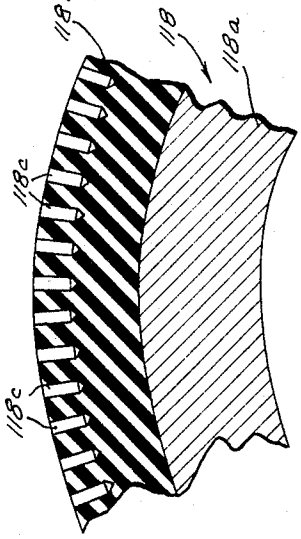


FIG-6

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Nov. 22, 1966 C. W. E. WALKER 3,286,360

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FIG. 7

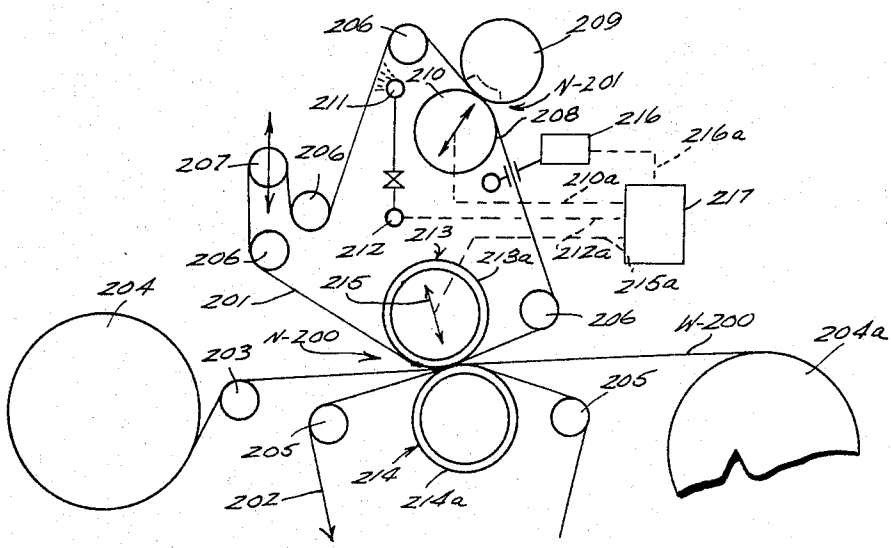
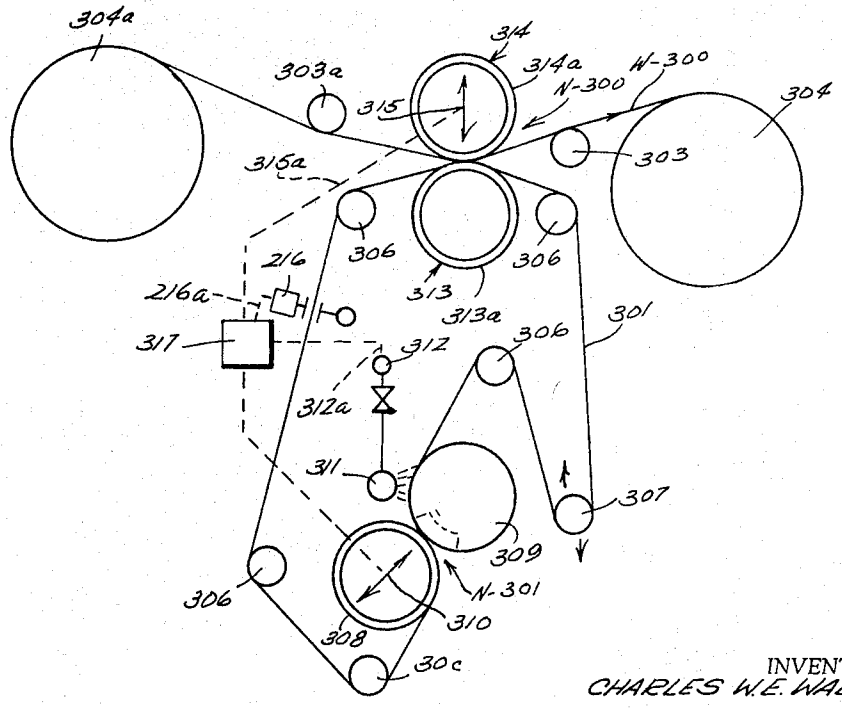



FIG. 8




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FIG. 9

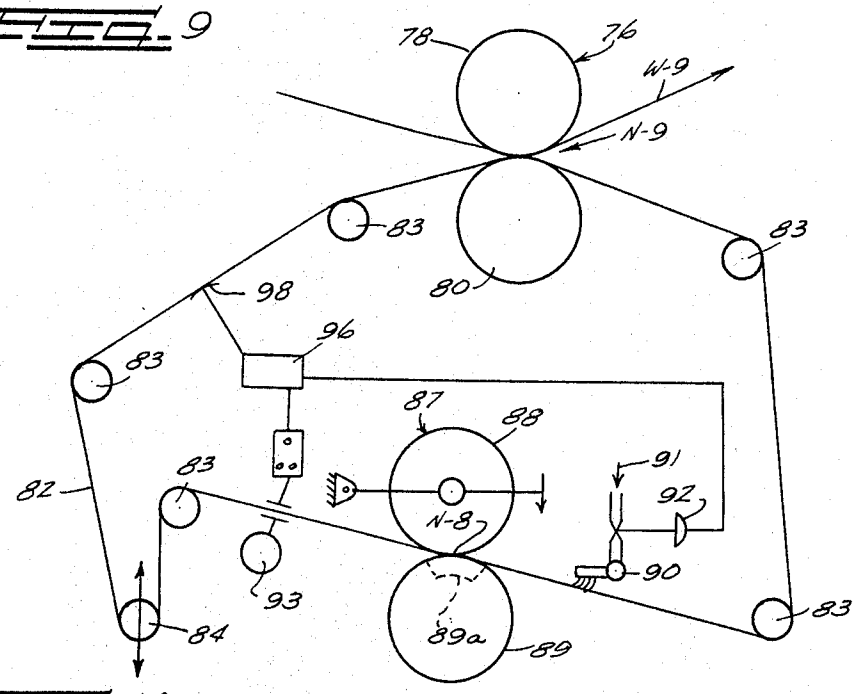
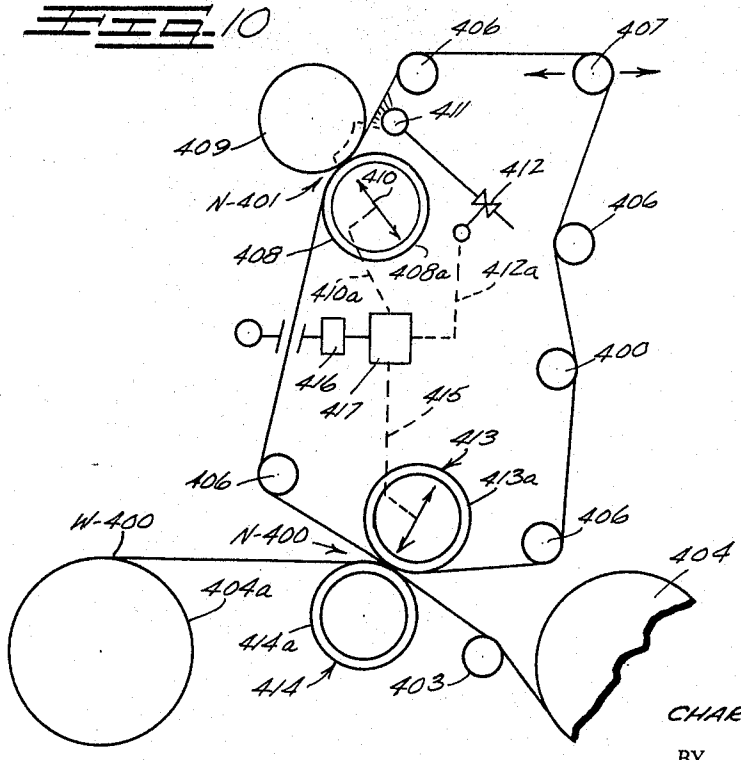



FIG. 10




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United States Patent Office 3,286,360 Patented Nov. 22, 1966



3,286,360

# DIVIDED TEMPERATURE CONTROLLED PRESS

Charles W. E. Walker, Beloit, Wis., assignor to Beloit Corporation, Beloit, Wis., a corporation of Wisconsin

Filed Oct. 16, 1963, Ser. No. 316,646
2 Claims. (Cl. 34—23)

This is a continuation-in-part of application Serial No. 107,691, filed May 4, 1961, now abandoned; and it also incorporates subject matter of my present invention disclosed in my joint application with Messrs. E. J. Justus and E. D. Beachler, Serial No. 275,764, filed April 25, 1963, now Patent No. 3,215,592; both applications are incorporated herein by reference.

The present invention relates to an improved paper machine press and particularly to an improved press mechanism and method for removing the moisture content of a traveling paper web.

The invention contemplates the provision of a press felt drying device for a paper machine wherein the conditions at the press nip are controlled and in particular wherein means are provided at the oncoming side of the nip for heating the web and cooling the felt.

In a felt press roll as used in a paper machine, a nip is formed between opposed press rolls and a traveling web of paper in engagement with a drying felt is passed through the nip. The press rolls may be plain or the roll on the felt side may be perforated and may be subject to a vacuum on the interior for aiding in the removal of moisture from the web to the felt.

As the felt and web enter the press nip the web reaches a condition of saturation at some point before the maximum compression of the nip is reached. Further compression of the web by the pressure of the rolls then transfers a substantial amount of moisture to the felt. If the press roll on the felt side is perforated, the felt may similarly reach saturation condition and moisture be similarly transferred from the felt into the perforations. If, on the other hand, both press rolls are plain and unperforated the felt must contain sufficient void space to accept the water expressed from the sheet at the point of maximum compression, or if both sheet and felt are compressed beyond saturation condition some water must move backwards out of the nip. At high speed of operation (when the sheet is traveling at more than a few hundred feet a minute through the nip) the water cannot move backwards fast enough through the compressed felt and web and damage to the sheet structure results. This damage is commonly referred to in the industry as "crushing." At high speed the felt must therefore be dried sufficiently so that it does not reach saturation in the nip. In the off-running or outgoing half of the press nip both the web or sheet and the felt expand as the surfaces of the rolls separate. This tends to create a vacuum in both the sheet and the felt. The pressure drops to that of the partial pressure of water vapor at the prevailing temperature in the sheet and felt. At 130° F., this 2.5 p.s.i. and there is normally a vacuum developed of about 25" Hg. This vacuum is, however, lessened in the felt either by expansion of air trapped in the voids mentioned above or by entry of air from the perforations in the press roll on the felt side, or by both. In all types of press previously known and particularly plain and divided presses, rewetting of the web thus occurs due to the partial vacuum developed in the web being greater than that existing in the felt and so creating an expansion suction which draws water into the web. The rewetting will also be due to the other factors acting on the moisture such as capillary forces and the centrifugal force on the moisture in the felt. This rewetting effect is not only substantially eliminated but additional transfer of water from the web to the felt is effected in accordance with the invention by heating the sheet and cooling the felt.



The terms heating and cooling and/or hot and cold are used herein in the conventional sense, meaning essentially hot or cold to the touch or to the human being. Thus, the stock temperatures in the head box area are approximately 130° F. or more and this stock is thus hot to the touch. As the stock passes onto the wire water flows therefrom through the forming wire and into the wire pit and this water is called "white water" and it also is hot to the touch having a temperature in the neighborhood of approximately 120° F. The paper web formed on the forming wire, likewise, remains hot to the touch, e.g., at 120° F. to 130° F. and in this hot condition then passes into the press section of the paper machine. In the press section substantial pressures are applied to the web and the application of such pressures will tend to increase the web temperature above ambient atmospheric temperature (if any temperature change at all is effected therein) because of the pressing "energy" applied to the web at the various press nips. The web then passes on to the dryer section where it is heated to still higher "hot" temperatures on substantially 150° F. to 212° F. (which is the boiling point of water).

It will be appreciated that the various showers which are ordinarily operated in paper machines to clean and/or recondition the felts in the press section are preferably operated using the aforesaid "white water" which has a temperature of approximately 120° F., which is definitely hot. In fact, some manufacturers of felt conditioning equipment specify the use of warm water or a mixture of water and steam which would probably be still hotter. In general, warm water is water which is merely warm to the touch and this has a relatively limited temperature range of about 90 to 100° F. Hot water would thus be over 100° F. and up to about the boiling point of water which is 212° F., and it does not require a skilled worker in this art to recognize that water in this temperature range is definitely hot to the touch. Likewise, the ordinary swimmer will recognize that water is cold to the touch in an approximate range of about 32° F. to 80° F. Even water at 80° F. is quite cold to the touch. At water temperatures of below about 70° F., water is so cold to the touch that even vigorous swimming therein is uncomfortable, and swimming is substantially prohibited in water that is less than about 60° F. in temperature. It will thus be seen that using the terms hot, warm and cold in the conventional manner, referring generally to sense of human touch, since the human operators do operate paper machines and human beings do experience these sensations when touching hot, warm and/or cold water, we find that the general definitions of the instant invention may be considered merely in the light of the human touch. It will be appreciated that the cold water referred to herein is preferably below about 70° F. and still better results are obtained if such water is below about 60° F.

As previously mentioned, the use of showers in paper making machinery involves recommendations by manufacturers and other authorities that warm or hot water should be used. Quite often it is "white water" which has a temperature in the neighborhood of about 120° F. and is definitely hot. In referring to certain authorities on the subject, attention is directed to volume 3 of "Pulp and Paper Manufacture" and the following quotation from page 205:

Section 244: "washing devices consist of a shower to distribute warm water, soap, or a chemical solution, and a suction box to draw dirty water and loosened dirt. On some machines a pair of squeeze rolls is employed to remove the water used for washing felt."

Section 425: "the conditioning box is provided with means for passing hot water through the felt and a suction means to withdraw the water from the felt together with the dirt that has been loosened by it."

In other instances when it may be desirable to use fresh water for wire and felt showers to avoid plugging of shower nozzles, it will be appreciated that steam condensate from the dryer section is ordinarily used, the temperature of such condensate is substantially 120 to 130° F. or higher.

With respect to heating of the web, it has been pointed out that in conventional machines, the web will pass through the press section maintaining a temperature of at least about the stock temperature of 130° F. or more, which temperature is substantially that of the shower water temperature used in the prior art, no matter what source was being selected for water for use in the prior art showers. It will further be appreciated that momentary contact of the web with the heated drum in a conventional press nip, e.g., perhaps one inch in peripheral dimension, will involve such a brief contact of the web with the heated drum at such nip (i.e. at a machine speed of about 2000 ft. per minute, such contact time being in the neighborhood of $2\times10^{-3}$ seconds or less) that the heating effect of the drum will be insignificant and the pressure "energy" added to the web at such a nip will be also only sufficient to effect a nominal increase in temperature, if at all, so that such operating conditions will not ordinarily increase the web temperature substantially above the recommended shower temperatures using "white water," steam condensate, etc. It will, likewise, be appreciated that the prolonged contact between the web and a conventional dryer drum or a series of conventional dryer drums in a conventional dryer section will increase the web temperature to distinctly hot temperatures in the range of about 160–170° F. up to substantially 212° F. Such type of heating does not occur, however, in the conventional press section and occurs only after the web has been passed on into the dryer section.

The sheet is heated, preferably to a temperature of from substantially 150° F. to 212° F. in the practice of the invention which eliminates the expansion suction and the creation of a partial vacuum. The boiling point of water at one atmosphere is 212° F. Because of the temperature of the water in the web the internal vapor pressure is at atmospheric pressure and no partial vacuums are created when the web expands in the outgoing side of the nip. Inasmuch as the moisture in the felt has been cooled, expansion suction will occur with a drop in pressure as the felt expands in the outgoing side of the nip. This difference in pressure between the web and the felt causes additional water to transfer from the web to the felt. Some expansion suction occurs in the cold felt even if it is dried beyond its normal optimum dryness so that some air is trapped in the felt and passed through the nip. The pressure difference due to expansion suction also counters any capillary effects which in any event appear to be small. The cooling of the moisture in the felt also increases its viscosity thereby reducing the tendency of centrifugal force and other actions carrying it from the felt to the web on the outgoing side of the nip while heating of the web reduces the viscosity of the water in the web thereby aiding the transfer of water from the web to the felt throughout the nip. Because of the high pressures in the separate felt drying press nip the increase in viscosity of the water in the felt does not appreciably adversely affect the removal of moisture from the felt.

It is accordingly an object of the invention to provide an improved mechanism for reducing the moisture content of a traveling paper web in the press felt nip.

Another object of the invention is to provide an improved method for removing moisture from a traveling paper web in a press nip preventing the transfer of moisture from the felt to the web in the outgoing side of the nip.

A still further object of the invention is to provide an improved press mechanism for a dryer wherein the felt does not have to be dried to optimum dryness between leaving and entering the nip.



A further object of the instant invention is to provide an improved mechanism and method of dewatering a web comprising receiving a web on a traveling felt and subjecting the web and felt to pressure to squeeze water therefrom in a press nip and heating the web and cooling the felt at the oncoming side of the nip.

Other objects and advantages will become more apparent with the teaching of the principles of the invention in connection with the disclosure of the preferred embodiment thereof in the specification, claims and drawings, in which:

FIGURE 1 is a side elevational view shown in schematic form of a dryer section of a paper machine; and

FIGURE 2 is a fragmental, greatly enlarged, view showing the press nip between the press rolls of the mechanism; and

FIGURE 3 is another modification shown in schematic form of the dryer section of a paper machine;

FIGURE 4 is a fragmental, greatly enlarged, view showing the press nip between the press rolls one of which is a blind drilled roll; and

FIGURES 5 through 10 show diagrammatic side elevation views of various press assemblies embodying the instant invention.

As shown on the drawings:

In FIGURE 1 a web W is shown guided through a dryer section of a machine. While features of the invention will have usefulness in other environments, the invention is especially well adapted to use in a paper machine and the web will be referred to as a traveling sheet of paper and will be received as it is normally delivered from the wet section of a paper making machine.

The web W passes over predryer rolls **10** which are supplied with heat energy as indicated by the arrows H. The predryer rolls are heated primarily to elevate the temperature of the travelling paper web W and (i.e. to about 180° F.) preferably the web is heated to a temperature from 150° F. to 212° F. so that it will be at that temperature when it reaches a press nip N of a press assembly **12** comprising a pair of plain press rolls **13** and **14**. A guide roll **11** may be positioned between the predryer rolls **11** and the press assembly **12**.

The web W passes through the press assembly and proceeds to a dryer section of the machine including dryer rolls **15**.

In the press nip N, the web W is brought into surface contact with a looped felt F which is illustrated as leaving the nip N then separating from the web W at the immediate off-running side of the nip D by passing downwardly over guide rolls **17** and **18** to be subject to a cold water (i.e. 60° F.) shower spray **19**. The felt passes over another guide roll **20** and is subjected to a second cold (i.e. 60° F.) water shower spray **21**, after which it passes between rolls **23** and **24**, which comprises the felt drying press. Roll **23** (outside the felt loop) is perforated and includes a vacuum box **23***a* to remove water from the felt. The felt is cooled (to about 60° F.) by the cold water shower sprays **19** and **21** (inside the felt loop) and is cold as it emerges from between the rolls **23** and **24** and passes up to enter the press assembly **12**. A series of guide rolls **25, 26, 27, 28,** and **29** direct the felt upwardly to the nip N.

Thus, the web W and the felt F have been respectively heated (to about 180° F.) and cooled (to about 60° F.) before entering the press nip and by heating and cooling means in the form of the predryer rolls **10** and the cold water shower sprays **19** and **21**. It will be understood that two showers are not essential and that either one may be used alone, it being essential only to cool the felt by some suitable means, such as cold air blasts and/or evaporation cooling for example. Essentially, a web and felt temperature differential of at least 50° F., as a minimal, is thus created; but preferably the temperature differential is 60°–100° F. or more.

As illustrated in FIGURE 2, the web W entering the

nip N between the rolls **13** and **14** is compressed with the felt F.

At some point in the zone **30** between the dotted lines **31** and **32** the web is compressed to saturation. Beyond this point and up to the point of maximum compression as indicated by dotted line **32**, further compression of the web forces water out of the web W and into the felt F.

At the off-running portion of the nip in the zones **33** and **34** respectively for the web W and felt F, between the dotted lines **32** and **35**, the surfaces of the rolls **13** and **14** start to separate. The pressure on the water which was present in zone **30** drops and in fact a reduced pressure tends to form as the felt and web expand. At the immediate off-running side of the nip N (beyond the line **35**) where the nip pressure is substantially completely removed, the web and felt are separated as shown.

Measurements have shown that in a cold felt (e.g. 50°–70° F.) essentially minimum subatmospheric (vacuum) pressure can develop. In the hot web, however, since its temperature and that of the moisture (preferably, 180°–212°, in the dryer section) therein is close to 212° F., the internal vapor pressure is close to atmospheric pressure so that little or no vacuum develops. There is, thus, a vacuum difference which may amount to nearly a full atmosphere between the web and felt in zones **33** and **34** respectively, drawing water from the web into the felt.

With plain unperforated press rolls as illustrated in FIGURES 1 and 2 and to avoid "crushing" the web at high operating speed as explained above, the felt must not be compressed to saturation before the point of maximum compression at dotted line **32**. In practice this means that some air will be trapped in voids in the felt and pass in a highly compressed state into zone **34** and thereby reduce the vacuum developed in the felt in this zone. If the web and felt were at the same temperature, whether both hot or both cold, a higher vacuum would be developed in the web in zone **33** than in the felt in zone **34** and there would be a vacuum difference between zones **33** and **34** such as to cause rewetting of the web. This is the normal condition resulting from overdrying the felt beyond its optimum dryness. With a hot web, and a cold felt, however, in accordance with the invention, the pressure in the web in zone **33** remains close to atmospheric pressure while some degree of vacuum exists in the felt in zone **34** despite the expanding air trapped in its voids. Rewetting of the web is therefore avoided and any movement of water is from the web into the felt.

In FIGURE 3 is illustrated another embodiment of the invention in which the press assembly **52** replaces and is fitted into the same space as would be occupied by a single dryer roll shown dotted at **50**. Also illustrated is the use of a blind drilled roll **54** as one of the press rolls comprised in the press assembly **52**. The other parts in the figure which fulfill the same functions as corresponding parts in FIGURE 1 are similarly numbered. As is apparent from FIGURE 4, the structure of the roll **54** is comparable to that of the blind drilled surfaced roll of my U.S. Patent No. 3,023,805 which was copending herewith and which roll comprises an imperforate press roll shell of conventional structure mounting on elastomeric cover having a myriad of fine blind holes drilled therein. As is shown in FIGURE 4 the blind holes **56** have varying (but limited) depths which further minimizes any uniform shadow marking effect on the paper web.

The operation in the press nip N–3 between the press rolls **13** and **54** as illustrated in FIGURE 4 is similar to that illustrated in and described for FIGURE 2 except for the following significant differences. At some point in the zone **30** between the dotted lines **31** and **32** the felt may be compressed to saturation as well as the web and beyond this point and up to the point of maximum compression at dotted line **32** the further compression of the felt forces water out of the bottom of the felt F–3 into the perforations **56**. Because of the void space available in the perforations "crushing" of the web is much less likely to occur so that the dryness of the felt is less critical. At the off running side of the nip, however, the pressure of air in the perforations will act to reduce the expansion vacuum developing in the felt which, if the felt and web were at the same temperature, would cause considerable rewetting of the web but with a hot web and cold felt, in accordance with the invention, still leaves a higher vacuum in the felt so that dewatering of the web continues. It is, however, advantageous to use a felt having low air porosity to reduce the extent to which air in the roll perforations enters the felt.

A further advantage accrues from chilling or cooling the felt in that the viscosity of the water in the felt is increased thereby reducing the effect of forces of the water which would cause it to pass outwardly from the felt to the web. Centrifugal force for example acts on the water as the felt follows the periphery of the roll **14** or the roll **114** and the increased viscosity will decrease the tendency of the water to leave the felt.

The diameters of the capillaries in a paper web are in general smaller than those in the felt used in paper making and since there is capillary attraction for water in paper the capillary forces tend to transfer water from the felt to the web. The action is relatively slow but under some conditions produces appreciable rewetting of the web. (Hence the separation by the web and the felt at the immediate off-running side of the nip N to minimize the capillary action rewetting effect.) The expansion suction developed in a cold (60° F.) felt can counter this capillary action and the higher viscosity of the cold (60° F.) water in the felt can further slow the action.

Accordingly rewetting of the paper by suction action can be eliminated and further drying of the web achieved in the outgoing portion of the nip. With plain unperforated rolls it is advantageous to dry the felt beyond the normal optimum and the method and apparatus has eliminated the loss of drying of the web otherwise associated with such overdrying of the felt.

In brief summary, the traveling paper web W is preheated by predryer rolls **10** to a temperature of from 150° F. to 212° F. and the felt F is cooled (to 32° to 60°–70° F.) by cold water shower sprays **19** and/or **21** and then dried by press rolls **23** and **24**, before they enter the press nip N. At the outgoing side of the nip N an expansion suction in the heated web will not be created although an expansion suction in the cooled felt will occur, thereby causing additional transfer of water from the web to the felt. Also the viscosity of the water in the felt is increased which under some circumstances can reduce or prevent rewetting of the paper from the felt without affecting the transfer of water from the web.

It has heretofore been believed that heating of the felt was advantageous because of the reduction of water viscosity. This is true in a standard (not divided) press in which water has to be removed from the felt in the same press nip and at the same time that water is transferred from the web to the felt. In such presses heating the felt can help to dry the felt to its optimum dryness although I have discovered that the effect on press drying due to reduction in water viscosity by heating is quite small. For example, at a normal paper stock temperature of 130° F. the viscosity of water $\eta$ is 0.50 centipoise. At 212° F. (boiling point) the viscosity is 0.28 centipoise. Thus, there is a maximum possible reduction by a factor of $f=1.78$. The effect of this on press operations can be calculated. Resistance to water movement in the sheet and in the felt can be expected to obey Poisseuille's law exactly and will be proportional to $v\eta$ where $v$ is the velocity of the water movement and $\eta$ is the viscosity. Thus, if $\eta$ is reduced by the factor $f$ then $v$ would increase by the factor $f$ under the action of the same driving force. The effect of increase in the velocity of water movement in the nip is the same as the effect of increasing the time in the nip. Therefore the effect of viscosity change due to the maximum possible increase of temperature will be the same as increasing the time in the nip by a factor of $f=1.78$. It should be noted that this change is effective

both in the removal of water in the ingoing half of the press nip and in the rewetting of the sheet in the outgoing half of the press nip by water moving from the felt to the sheet. I have discovered that if the time in the nip is increased by a factor $f$ the change in percent dryness of the outgoing sheet will be increased by

$$\sqrt[4]{f}$$

The maximum effect of viscosity change can therefore be computed to be

$$\sqrt[4]{1.78}=1.15$$

However, the effect may be greater in a first press when a larger volume of water must move.

In a divided press the expression of water from the web in press assembly **12** or **52** will be directly affected by the viscosity of the water in the web only and not by the viscosity of the water in the felt. For the removal of water from the felt in the nip between the press rolls **23** and **24** a small adverse effect due to increased viscosity by cooling of the felt can readily be offset by an increase in the pressure applied between the two rolls.

Referring now to FIGURE 5, there is shown a paper machine generally designated by the numeral **110** and comprising a forming wire F–5 looped over a suction couch roll **111** and a turning roll **112**, the couch roll having a suction area **111***a*, and if desired, a saveall **113** in association therewith. The forming wire F–5 supports a paper web W–5 thereon over the couch roll **111** and along a downwardly inclined wire run F*a*–5.

The paper web W–5 is removed from the downwardly inclined wire run F*a*–5 by a looped pickup felt **114** which is urged against the web W–5 by a suction pickup roll **115** having a suction area **115***a*. The pickup felt **114** is also trained around a plurality of guide rolls **116**, a tension roll **117** and a press roll **118** of a transfer press assembly, generally designated at **119**, and further comprising a suction press roll **120** having a suction area **120***a*. By action of the pickup felt **114** and suction pickup roll **115**, the paper web W–5 is carried along the underside of lower run **114***a* of the pickup felt to the transfer press assembly **119**.

If desired, the top press roll **118** may be constructed in the manner of FIGURE 2, comprising a cylindrical metal shell **118***a* to which is suitably secured an elastomeric covering **118***b* provided along its outer diameter with an array of blind drilled holes **118***c* of predetermined depth, diameter and spacing (more specifically described in Walker U.S. Patent No. 3,023,805, incorporated herein by reference). The blind holes **118***c* are effective to receive water from the relatively wet pickup felt **114** upon entry of the felt into nip N–4, to hold the water, in the blind holes during passage of the felt through the nip, and to release the water to felt upon its exit from the nip, whereby there is eliminated crushing occasioned by the presence at the nip of excessive volumes of water in both the pickup felt and the paper web. If this type press roll is employed, the rubber covering **118***b* is desirably of relatively low deformability, so that substantial volumes of air are not entrained in the blind holes to spew the water from said holes when the pickup felt advances beyond the nip N–4 to the off-running side thereof. As will be later noted, generally the structure of FIGURE 6 may be utilized with an anti-deflection roll in the improved divided press assembly of this invention.

At the transfer nip N–4 the paper web W–5 is transferred to a press felt **121** within the loop of which is a plurality of guide rolls **122** and a tensioning roll **123**, while outside of the loop are additional guide rolls **124**.

Downstream of the transfer or first press **119** is a second press **125** it which the paper web W–5 is directed and carried by the upper surface of the top run **121***a* of the press felt **121**. The second press section **125** is comprised of a top suction roll **126**, having a suction area **126***a*, and a lower press roll **127** (which may be rubber covered) within the loop of the press felt **121**. The top suction roll **126** may have in association therewith a saveall **128**, and wrapping the suction roll **126** is an upper looped press felt **129** trained around a plurality of guide rolls **130**, and if desired, around a tensioning roll **131**.

It is, of course, appreciated that wide variety of pickup and press sections are known to the art, and it will therefore be understood that the arrangement of FIGURE 5 with respect to the felts **114**, **121** and **129** is intended to be merely illustrative of an exemplary environment for the divided press assembly of this invention, generally designated in FIGURE 5 by the numeral **135**. This assembly **135** is illustratively indicated in FIGURE 5 as downstream of the second press **125**, although it will be readily apparent as the descripition proceeds that the divided press **135** could as well be at the second press section, or at other locations benefitted by the novel results obtained through use of this improved press assembly. Additionally, while in FIGURE 5 both top and bottom press felts are shown, this is not necessary in all applications, as will be more fully appreciated when reference is made to succeeding views of the drawings (e.g. FIGURE 8). As well, while in FIGURE 5 a suction pressing couple is indicated in a bottom position, a modification is to have the suction pressing couple in a top position, which also will be specifically described in connection with other views of the instant application drawings (e.g. FIGURE 12).

Extensive investigations have demonstrated that markedly more effective water removal at the web press nip is obtained when the press felt is presented to the nip in a particular condition of dryness or in a less than saturated condition, and as a corollary, when the felt upon entry to the web press nip is controlled as to its moisture content, substantially greater nip pressures can be applied without markedly effecting the web bulk or encountering the crushing condition to which earlier reference was made. Desirably, precise control of the pressure at the web press nip is obtained by utilization at said nip of at least one anti-deflection roll, so that the nip pressure can be adjusted in accordance with the character of the web being processed, and thereby the roll crown and nip pressure variation obtained without the necessity of press roll removal for regrinding purposes. The instant invention further features separation of the functions of web water removal and felt water removal, and to assure that the felt is presented to the web press nip at optimum dryness, water may be added thereto either manually or in response to a signal provided by a web moisture content measuring device located in sensing relation with the felt. This same measuring device may control the nip pressure at the felt pressing couple, and the instant description will note with an explanatory theory that the nip pressure at the felt press is preferably at least equal to or in excess of the nip loading at the web press to assure that the felt is delivered to the web press at an effective optimum dryness.

More specifically, it has been discovered that as the moisture in the felt is reduced, the web is more effectively dried, subject, however, to the limitation that if the felt is dried beyond its particular optimum range, its affinity for water appears to be reduced and the effectiveness of the instant method is diminished. In the extreme, of course, damage to the felt may occur as a result of overdrying. Up to the particular indicated optimum dryness, the removal of free moisture from the felt provides additional void space for the water expressed from the web by the nip pressures. This avoids the damaging backflow or crushing earlier noted.

As will be seen in FIGURE 5, a cold water shower **47** is employed at the oncoming side of the felt only nip N–7A of the divided press assembly. In this instance the cold water employed is preferably at a minimum practical available temperature of 50° F. and not more than about 60° F., which temperature would be available cooling with river water or well water, particularly in the

winter time. Likewise, a cold air blast or jet **149** may be used to cool the felt **141**, and in such instances, again, cold winter air may be used, the felt **141** will be traveling so fast that even freezing temperatures would not actually effect any freezing of the water in the felt **141**, whereas it would be possible to reduce the felt temperature to 40°–50° F. comparatively readily in such an arrangement.

The web W–5 has been formed from stock at about 140° F. in the embodiment of FIGURE 5 and this web W–5 passing through the various transfer and press nips N–4 and N–5, here shown, will not lose any of this temperature and, in fact, will probably undergo slight increase in temperature of 10 or more degrees F., particularly if the felts **114** and **121** do not have any cooling effect upon the web W–5 and are either untreated with shower water or are treated with the conventional "white water" or steam condensate shower water at approximately 130 to 140° F. It will thus be seen that the web W–5 in the press section shown in FIGURE 5 does not require significant preheating before the nip N–7, since it has maintained its relatively high temperature by virtue of the original stock temperature of 140° F.; whereas the felt **141** in this press section of FIGURE 5 has now been deliberately cooled to approximately 50° F., so that there is a temperature differential in the neighborhood of about 90° F. between the felt **141** and the web W–5 at the press nip N–7 here shown. This significant temperature differential effects the advantages of the invention hereinbefore described.

In the arrangement of FIGURE 9, water (at about 140° F.) in the web W–9 is effectively transferred to the press felt **82** at the nip N–9, and the press felt (at about 50° F.) is then directed to a felt or suction press couple **87** comprised of an upper plain press roll **88**, which may be of the anti-deflection type, and a lower suction press roll **89** having a suction area **89***a* and defining a nip N–8 with the upper plain press roll **88**. As is indicated in FIGURE 9, the top press roll **88** is suitably loaded so that the nip pressure at N–8 is in excess of the pressures at the nip N–9 whereby the press felt **82** is delivered to the nip N–9 at the effective optimum dryness.

It was noted in connection with FIGURES 1, 3 and 4 that in order that the felt be presented to the web press nip at its effective temperature and optimum dryness, particular circumstances may render it desirable that cold water (e.g. 40°–50° F.) be applied to the felt by means of a shower **90** located within the felt loop at the oncoming side of the felt press nip N–8 or somewhat upstream therefrom (so as to apply water to the felt on the side opposite to the side of the felt which engages the suction roll at the felt only nip N–3 in FIGURES 1 and 3, and N–8 in FIGURE 5). The amount of water removed from the felt at the suction press nip is of course relatively constant under fixed machine conditions, and will remain generally stable under the same conditions of felt composition, felt speed, felt nip pressure and amount of negative pressure applied to the suction area. Accordingly, to raise or lower the felt moisture content to a level desired at the web press nip, the water applied to the felt by the shower is either increased or decreased, and in the arrangements of FIGURES 1, 3 and 4, as well as 9, this is accomplished by the valve means described. The temperature control is even more simple, depending essentially upon the use of cold (40° F.–50° F.) water which remain in contact with the felt long enough to cool it.

However, there may occur a change in certain of the machine conditions and if the felt becomes more dry, it will then, as was noted, accept less water from the web thereby tending to become even more dry so that there appears to be a degree of instability in the felt at any point in its dryness curve between optimum and 100% bone dry condition, which includes the effective optimum dryness condition described earlier, and if for some reason the felt becomes more dry, the felt press will remove slightly less water from the felt, but not always sufficiently less to overcome the instability. If this effect continues, the felt will become overdried and damage may result thereto. On the other hand, if the felt tends to become more wet and hence more receptive to water in the web nip, and if the conditions at the felt press remain unchanged, the felt will become progressively more wet until crushing occurs.

In accordance with the novel concepts of this invention, means are also provided to control the moisture content of the felt coming from the felt press so as to overcome this instability. As appears in FIGURE 9, a water shower **90** to which cold water is supplied at **91** is under control of a modulating valve **92** which is in turn controlled by a measuring device **93**, which may take the form of a beta meter. The output from the measuring device **93** is fed to a control instrument **94**, which converts the signal from the beta meter **93** into an output signal which modulates the quantity of water delivered to the shower **90**.

It may be observed from FIGURE 9 that the measuring device **93** is located at the off-running side of the nip N–8, while the water shower **90** is in advance of or at the oncoming side of the nip. Application of cold water to the felt ahead of the nip has the important advantage of thoroughly cooling felt and distributing the water evenly throughout the felt and to a particular percentage per unit area of the felt. Additionally, the water shower **90** effectively assists in washing from the felt paper web fibers unavoidably removed from the web during pressing, and as well, by adding water to the felt it has been found that a greater volume of water can be removed at the suction press nip N–8. A sufficient total amount of cold water must be added at the shower **90** to effectively maintain the water in the felt **75** at about 40° F.–60° F. As for example, if $x$ gallons of water are added to the felt by the shower **90**, under particular conditions there can be removed from the felt the $x$ gallons, plus a percentage thereof. The measuring device **93** of course measures the felt moisture content at a value as near as possible to effective optimum dryness, or at a condition of dryness required for maximum water removal effectiveness at the web press nip N–6. Thus, the signal from the measuring device **93** modulates the valve **92** to add that volume of water which, when combined with the felt moisture level prior to passage under the shower **90**, will produce effective optimum dryness, adjusting also for variations in negative pressure at the suction area **89***a*, and other operating conditions, which include the desired cold felt temperature which can also be measured at **95** and used in part to control the flow valves **91–92** through a control box **96**.

In the embodiments of FIGURES 7, 8 and 10 similar elements are designated by the same reference numerals in the 200, 300 and 400 series, respectively.

In FIGURE 7, the web W–**200** passes over one dryer roll **204***a*, than through a web nip N–**200**, separating immediately after the nip N–**200** from press felts **201** and **202**, and then traveling over a guide roll **203** and on to the surface of a second conventional dryer drum **204**. The dryer **204***a* is part of a dryer section wherein the web W–**200** has been preheated to 190° F.–200° F. The press felt **202** is trained about guide rolls **205**, **205** and functions in substantially the manner described in connection with the felt **39** of FIGURE 1.

The felt **201** is mounted on a plurality of felt guide rolls indicated generally at **206**, **206**, etc., and a conventional felt tensioning roll **207**, which guide rolls **206** take the felt **201** away from the web W–**200** at the immediate off-running side of the nip N–**200** and then guide the looped felt **201** into a suction press nip N–**201** defined by a press roll **208** within the loop of the felt **201** and having an imperforate shell mounted on anti-deflection means of the type hereinbefore described, and specifically of a pre-

ferred type described in the aforesaid application Serial No. 102,571. The press roll **208** has a plain rubber cover and it cooperates with a conventional rubber covered suction roll **209** having the conventional suction roll perforate shell and mounted outside the loop of the felt **201**. Controlled pneumatic means indicated diagrammatically by the double headed arrow at **210** are provided for loading the press roll **208** against the suction roll **209** at the felt only nip N–**201** to obtain the pressure hereinbefore described for dewatering the felt **201**. A cold water (60° F.–70° F.) shower **211** is provided within the loop of the felt **201** with a control valve **212** for controlling the amount of water applied by the shower **211** to the felt **201**, and thus also assuring a sufficient amount to effectively cool the felt to the water temperature.

The web nip N–**200** is defined by a pair of press rolls **213**, **214** each having imperforate shells and each being equipped with anti-deflection means of the structure described in detail in the patents mentioned hereinbefore (but preferably of the structure described in the aforesaid application Serial No. 102,571). Controlled pneumatic means indicated diagrammatically by the two headed arrow at **215** cooperate with the anti-deflection means to load the press rolls **213** and **214** against each other to define the desired uniform pressure across the nip N–**200**. The press roll **213** within the loop of the press felt **201** is provided with a blind drilled solid elastomer cover **213***a*, such as the cover already described for the roll shown in FIGURE 4, and having blind drilled holes therein ranging from ½ to 1 inch in depth and having an average diameter of about ⅛ inch. The other web press roll **214** is provided with a micro-porous surface portion (designated in the trade by the name "Microrok").

It will be seen that the shower **211** applies cold water to the wet felt **201** at the oncoming side of the felt only suction press nip N–**201**, and water is removed from the felt **201** at this felt only press nip N–**201** to the extent desired to clean, dewater and condition the felt **201** but retain the cold temperature of the water therein for reentry into the web nip N–**200**. In the case of the all wool felt **201** here shown, the resulting moisture content at the off-running side of the nip N–**201** is held close to 65% (i.e. bone dryness), and within the range of 60% to 70%. The moisture at the off-running side of the felt only nip N–**201** is sensed by a beta gauge type of moisture sensing device **216** which sends a signal through the signal line **218***a* to a signal panel **217**. The signal panel **217** is provided with a pneumatic signal control line **210***a* for the pneumatic pressure loading means **210**, another pneumatic signal control means **215***a* for the pneumatic loading means **215** and still another pneumatic signal control line **212***a* for control of actuation of the water control valve **212** on the shower **211**. Control signals may be sent separately or simultaneously by manual controls at the control panel **217** for each of the control signal lines **210***a*, **212***a* and/or **215***a*; or the control panel **217** may be of a conventional type of control panel which will convert the moisture signal from the moisture signal line **216***a* to a control signal for one or more signals which the machine operator may select at the control panel **217** for automatically controlling the loading means **210**, the loading means **213** and/or the shower control means **212**, all in response to the moisture content and temperature in the web **201** at the off-running side of the nip N–**201**.

In FIGURE 8, elements which carry out substantially the same function as those already described in FIGURE 7 are designed by the same reference numeral in the 300 series. It will be noted that the web W–**300** here passes from one dryer **304***a* (at 210° F.) over a guide roll **303***a* and through the web nip N–**300** on over the guide roll **303** and onto another dryer drum **304**. The upper roll **314** of the roll couple **313**–**314** is provided with the microporous surface (having a sufficiently fine porosity on such surface **314***a* to function substantially as a plain surfaced roll); whereas the lower roll **313** is provided with the blind drilled elastomer cover **313***a*. At the nip N–**300** the web temperature is substantially 190° F. whereas the shower water temperature (e.g. 60° F.) cools the felt **301** entering the nip to substantially 60° F. for a temperature differential of 150° F.

It will be appreciated that in each of the embodiments of FIGURES 7, 8 and 10, the web press is the last press to which the web is subjected before being carried to the final dryer section, and the felt in each case is subjected to a press nip load only at the web press and at the felt only press. The pressures employed at the presses, for example N–**400** and N–**401**, and at the presses N–**200** and N–**201**, is in the range from about 300 pounds per inch to about 450 pounds per inch, which pressures are ideal for the second or third presses in paper machines using the instant divided press structures. In the embodiment of FIGURE 8, the nip pressures may be as high as 1000 pounds per inch of nip, since this divided press structure is employed between dryer sections. The high nip pressures described are used with great advantage using the instant divided press arrangement with anti-deflection rolls in the manner just described. Such high pressures are particularly effective in obtaining the desired "movement" of low viscosity, low temperature water in the felts (while still permitting minimum rewetting of the expanding web at the off-running side).

In FIGURE 12, it will be seen that the roll **408** is a plain rubber covered (**408***a*) roll, the roll **413** is a blind drilled rubber covered (**413***a*) roll and the roll **414** has a Microrok cover **414***a*. All of these rolls **408**, **413**, **414** have imperforate shells supported internally by rubber sandwiches appreciably axially inwardly from the shell ends on through shafts rotatably mounted, as more fully shown in the aforesaid Serial No. 102,571 so as to be anti-deflection rolls providing uniform nip pressures in this case at the felt only nip N–**401** slightly greater (e.g. approximately 425–450 pounds per linear inch) than at the web press nip N–**400** (e.g. approximately 400–425 pounds per linear inch).

It will be understood that modification and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

I claim as my invention:

**1.** A method of reducing the moisture in a traveling paper web which comprises passing the web through a drying nip in contact with a traveling felt, and contacting the web with a smooth heated surface, thereby contributing heat energy to the web ahead of the nip to bring the web to a temperature of substantially 212° F. to prevent the formation of a partial vacuum in the web at the off-running side of the nip, thereby maintaining a temperature differential between the web and felt of at least about 50° F.

**2.** A method of reducing moisture in a traveling paper web which comprises passing the web through a press nip in contact with a traveling felt, heating the web ahead of the nip to substantially 212° F. to prevent the formation of a partial vacuum in the web at the off-running side of the nip, and cooling the felt in advance of the nip, thereby maintaining a temperature differential between the web and felt at the nip of at least 100° F.

**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,438,511 | 3/1921 | Witham | 34—111 |
| 1,905,911 | 5/1932 | Kellett | 162—279 |
| 2,907,690 | 10/1959 | Hornbostel et al. | 162—358 |

FOREIGN PATENTS

| | | | |
|---|---|---|---|
| 483,483 | 2/1928 | Germany. | |

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