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APPARATUS AND METHOD FOR DRYING A FIBROUS WEB

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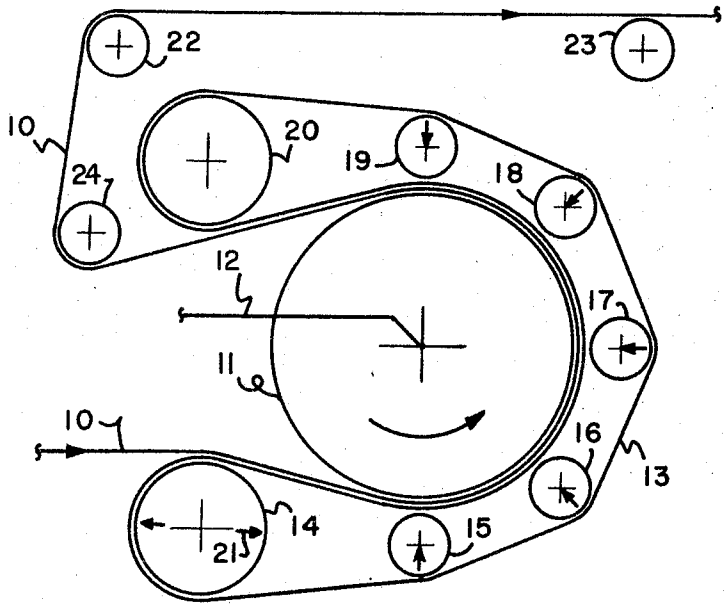


FIG. 1

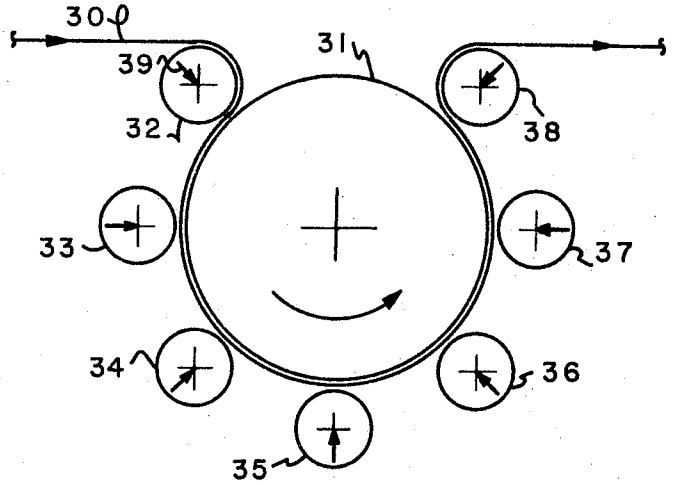


FIG. 2

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APPARATUS AND METHOD FOR DRYING A FIBROUS WEB

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This invention relates to an apparatus and method for drying a fibrous web material. More specifically, this invention relates to an apparatus and method for the high rate removal of water from a continuous web material.

Paper making machines generally comprise three main sections, namely a formation section, a press section, and a dryer section. A paper web after being formed is fed to the press section which it generally leaves saturated with a minimum of about 60 to 70 percent water. In this condition it is thereafter fed to the dryer section. The dryer section generally comprises a series of heated cylinders, usually in combination with a system of dryer felts. The dryer felts serve a dual function, first, to hold the web in reasonably close contact with the drum drying cylinders and second, to provide a vehicle for the transfer of water emanating from the web. The dryer felts, which are endless and continuous, are then dried separately by passage over heated cylinders constituting part of the felt conveying means. After contact with the heated cylinders, the semi-dried felt is then reapplied to the web undergoing treatment.

Heretofore, the practice in the art has been to apply an amount of tension to the dryer felt corresponding to a normal pressure against the cylinder of about 0.05 pound per square inch. To the best of my knowledge, no felt system has been reported in the literature operating at a pressure higher than about 1 pound per square inch. The use of such operating pressures has in turn limited the use of high temperatures, especially in the initial drying stage since excessive heat will cause the water at the surface of the web to boil thereby blowing the web away from the drying surface.

In present day conventional paper making machines operating under the above conditions, it has also been found that very little water removal occurs on the first several dryers in the cylinder dryer section even though these dryers are heated to at least the boiling point of water. The water in the web does not begin to evaporate until after the first several dryers, part of the water reconsidering and being absorbed in the felt and the remaining portion being removed from the environment as steam and discharged into the atmosphere. Thus, in light of the above limitations it can be understood why the drying rate of a paper web varies along the length of the drying section of present day papermaking machines. Specifically, the drying rate starts off rather low, usually at about 1 to 2 pounds/hour/square foot of drying surface and gradually increases as the paper serpentines through the section, reaching a maximum of generally from about 7 to 8 pounds/hour/square foot at which point it holds constant for a period whereafter it gradually decreases toward the dry end of the section. Overall drying rates will vary to some extent depending upon the type of stock being manufactured, however, seldom does it exceed more than 5 pounds/hour/square foot, even with very effective vapor removal means. For example, average drying rates for kraft paper and board will usually be from about 3 to about 5 pounds/hour/square foot under the best conditions.

To overcome the above deficiencies, the art has resorted to more and more dryers in order to increase production rates. That is, for a given present day machine,

there exists a maximum production rate, the exceeding of which will result in the production of paper exceeding the specification level of moisture content. The simple solution of just adding more and more dryers and auxiliary equipment has not been a panacea for all of the paper makers' problems in this regard since other troublesome factors have thereby been introduced. For example, besides the additional cost, there is the additional amount of effort required in operating larger machines. Additionally, more operating utilities are required. Therefore, a means and method overcoming this problem, that is, a means and method whereby the drying rate can be vastly increased employing much simpler equipment, would be a welcome contribution to the art.

An object of this invention is to provide novel means for the removal of moisture from a web material at a high rate generally not realized in present day paper making machines.

Another object of this invention is to provide a simplified high rate method for drying a web material containing moisture.

A specific object of this invention is to provide an apparatus and method for the high rate removal of water from a fibrous web material at production rates and efficiencies heretofore unobtainable by conventional paper making equipment.

An even more specific object of this invention is to provide a means and method for drying continuous paper stock at high rates whereby a glazed and shiny surface is realized thereby minimizing or even eliminating the need for subsequent special treatment to achieve such results.

These and further objects will come to light as the discussion proceeds.

The drawing depicts two embodiments of the novel apparatus of this invention in schematic form.

Referring to the drawing, the above objects are accomplished by the present invention in accordance with FIGURE 1 which depicts a preferred apparatus for drying a fibrous web comprising: the rotatable drum means **11**; the drum means **11** further comprising suitable heating means, e.g., steam injection means **12**; pressure belt means **13**; multiple roller means **14–20**; and tensioning means **21**. The fibrous web **10** is conveyed into contact with the dryer drum **11** and compressed upon its circumferential surface by the pressure belt means **13**. The belt **13** exerts a pressure upon the web **10** by placing the belt under tension, such as by hydraulic means, e.g. element **21**, acting upon one of the belt conveying rollers, e.g. the roller **14**. The roller **14** together with the rollers **15–20** comprise the conveying system for the belt **13**. Rollers **15–19** are mounted to move in a radial direction toward the center axis of drum means **13** and provide an additional function in that the tensioned belt **13** urges these rollers toward the drum **11** so as to provide a series of pressure nips to which the web undergoing treatment is subjected. It is clear that rollers **15–19**, or any one or more of the rollers, may be urged toward the dryer drum **11** by suitable additional actuating means such as a hydraulic means or other, if desired. The fibrous web **10** as it passes through the system is compressed at several pressures alternatively by the tensioned pressure belt means **13** and the pressure roller means **15–19**. Afterwards, the web **10** is fed to windup over rollers **22–24**.

The dryer drum or can **11** is preferably around 4 to 6 feet in diameter. The pressure rollers **15–19** are preferably of a diameter anywhere from about 6 to about 18 inches. While the drawing depicts 5 pressure rollers, any number of rollers from 2 on up can be employed, however only between 3 to 5 are preferred. The pressure belt means **13** preferably comprises a smooth porous felt-like fibrous belt capable of withstanding the necessary

forces, however conventional papermaker's felt reenforced with foraminous metal mesh or belt, either embedded therein, or as a backup member is also suitable. Moreover, papermarker's felt having a non-porous backing material or backup felt, e.g. rubber or metal (which can be perforated), can likewise be employed advantageously. For example, a belt comprising ½ inch thick felt combined with a ⅜ inch thick rubber belt is suitable.

In the operation of the apparatus shown in FIGURE 1, the pressurizing means **13** is at least tensioned sufficiently to keep the paper web **10** against the dryer drum **11**, the minimum tension required depending upon the temperature to which the web **10** is subjected. Or in other words, the pressure belt means **13** is tensioned to at least that pressure necessary to overcome the tendency of the web to "blow." The porous means **13** picks up liquid driven from the web **10**, especially in the initial stage of contact. Most of the liquid in the belt **13** thereafter escapes, as it does in the web **10**, by vaporization due to heating by the drum **11**, the effect of which is magnified for both the web **10** and the belt **13** as they pass through the series of pressure nips or pressure zones created by the rollers **15–19**. Within these zones, particularly at the latter stage of the drying operation, for example starting at around roller **17**, the liquid in both the web **10** and the belt **13** is superheated whereby a large portion thereof flashes from these members upon exit from each respective pressure nip. While not shown in the drawing, the pressure belt means **13** can be treated separately for removing liquid picked up during the operation by separate heating and/or pressing means. Thus it can be seen that the pressure belt means **13** serves many functions, namely, aids in pressing the web **10** whereby high liquid removal rates are realized as well as promoting strength development in the web **10**, prevents the web **10** from blowing or moving away from the surface of the drum **11** whenever high temperatures are employed, and serves as a medium for receiving liquid removed from the web **10**.

In certain instances, it is possible to eliminate the pressure belt means **13**, e.g. where the web itself is strong enough to be tensioned so as to withstand "blowing," where the web is porous to the extent that vapors can readily pass therethrough whereby "blowing" does not occur, where low drum temperatures are employed, or for any other similar reason. Accordingly, if this be the situation then the second embodiment of the apparatus of this invention as depicted in FIGURE 2 can be advantageously employed. Referring to FIGURE 2, the web **30** is fed into contact with the heated dryer drum **31**. As the web **30** is conveyed upon the circumferential surface of the dryer drum **31** it is contacted by the series of pressure rollers **32–38**. These rollers are preferably covered with a resilient material, e.g. rubber or the like. During operation the rollers **32–38** are urged toward the dryer drum **31** by suitable actuating means, for example, element **39** which can be hydraulic means or the like. Accordingly, as the web **30** is conveyed over the circumferential surface of the dryer drum **31** it is subjected to the series of pressure nips or pressure zones defined by the respective rollers **32–38**. Here as in the embodiment of FIGURE 1, the dryer drum or can **31** is preferably around 4 to 6 feet in diameter and preferably has a highly polished surface which can be steel, cast iron, chromium plated, polytetrafluoroethylene coated, or the like. The pressure rollers **32–38** are preferably of a diameter anywhere from about 6 to about 18 inches. Moreover, while the drawing depicts seven pressure rollers, any number of rollers from 2 on up can be employed, however only between 5 and 7 are preferred. During its passage through the pressure nips, the web **30** is subjected to considerable pressure which can be varied from roller to roller, that is, the individual pressure rollers can be independently loaded. This embodiment, as the previous one, allows the application of high pressures to the paper web as it passes through the series of pressure nips whereby liquid contained therein is

superheated which consequently flashes off upon exit from each respective pressure nip. Moreover, this embodiment allows for the realization of varying degrees of surface finish as well as strength development. Additionally, the pressure rollers **32–38** when independently loaded permit the application of variable pressures to the web as it is conveyed over the dryer drum.

While the apparatus of this invention can be employed alone as means for drying a wet web, that is, as the entire drying section in a paper making machine, it is preferred to employ it in conjunction with a number of conventional dryer drums. When doing so, it is preferred to position the conventional dryer drums upstream of the present apparatus to serve in their customary manner, that is, merely as means for preheating a wet web since very little moisture is removed in the initial stage of the drying section in a conventional paper making machine.

It can thus be seen that this invention is in essence an exceptionally high pressure and temperature apparatus and method for drying a fibrous web material. By exceptionally high pressures is meant an increase over that normally employed in the art by a factor as much as 100, viz, the use of pressures on the order of 5 p.s.i. and even upwards to 150 p.s.i., however the pressure always being less than the corresponding vapor pressure for the specific operation temperature of the dryer drum.

In accordance with the preferred method of this invention high drying rates for fibrous web material are realized by passing the wet web **10** around and in direct contact with a substantial portion of the circumferential surface of the drum **11** which surface is heated to a temperature at least equivalent to the boiling point of the liquid in the web while continuously compressing the web at different pressures throughout the time the web is in contact with the drum surface, said compression being applied by the porous pressure means **13** urging the web **10** against the drum surface so as to exert a pressure of at least about 5 p.s.i. but less than the vapor pressure of the liquid at the temperature employed and alternately applying a corresponding higher pressure to the web by passing it through multiple pressure zones or nips created by the roller means **15–19** which are urged against the web **10** by the porous pressure means **13**. It is preferred to compress the web by the porous pressure means **13** to a pressure within the range of from about 10 to about 30 p.s.i., the pressure always being less than the corresponding vapor pressure for the specific operating temperature of the dryer drum **11**. When operating at a felt pressure of at least about 5 p.s.i. and employing a preferred apparatus arrangement as disclosed above, the web **10** is generally subjected to a pressure in the pressure nips in excess of 100 p.s.i., in fact, usually in excess of 300 p.s.i. For most operations it is preferred to subject the web in the pressure nips to a pressure within the range of from about 200 p.s.i. to about 600 p.s.i. Paper produced by the instant method is characterized by having a high machine glaze as well as being very shiny making it extremely suitable for subsequent coating or laminating operations.

Pursuant to the process of this invention drying rates of 50 lbs./hr./sq. ft. are easily obtained when working with paper stock having a moisture range of 60 to 40 percent after pressing as compared to drying rates of 5 to 7 lbs./hr./sq. ft. realized today by conventional paper making machines when drying paper having a moisture content within this range. Moreover, by the instant invention higher temperatures are employed than heretofore employed in the art, specifically, temperatures above 250° F., preferably between 300 to 500° F., around 400° F. being most preferred. Thus, by the combination of higher pressures and temperatures in the practice of this invention, drying rates much higher than normally employed in the art are easily realized.

By way of example, the apparatus of FIGURE 1 when positioned approximately ⅔ downstream in the drying section of an 80 inch wide Fourdrinier paper machine al-

lows a considerable number of the conventional dryer drums to be dispensed with while providing greater drying rates. The dryer drum **11** is 6 feet in diameter and is heated by 200 p.s.i. steam having a temperature of around 387° F. The pressure belt **13** is constructed of a temperature resistant Dacron fabric capable of withstanding a tension of at least 1000 pounds per linear inch of width. The specific apparatus configuration as shown in the drawing is employed with the 5 pressure rollers (e.g. elements **15–19**) being of 6 inch diameter. The belt **13** is tensioned sufficiently to provide a compressive force of at least 5 p.s.i. which dictates a pressure in the nips defined between the drum **11** and the rollers **15–19** of about 360 pounds per inch width of web. A 150 pound kraft paper board web (3000 sq. ft. basis) traveling at 200 feet per minute is fed into the system. The web, having an initial moisture content of 35 percent, after passing through the system is found to have a moisture content of about 15 percent. An overall drying rate of better than 19.7 lbs./hr./sq. ft. of drying surface is realized. Kraft paper board thus produced is found to have a Mullen strength increase of 25 percent over that realized when operating the same paper making machine employing its conventional drying section arrangement. The kraft paper board thus produced is found to be very shiny and possessing a high degree of machine glaze which minimizes or even eliminates subsequent calendering.

While the present invention has been described and demonstrated with particularity to drying a wet paper web, it is to be understood that many apparatus arrangements different from those depicted in the drawing can now be made by one skilled in the art without departing from the spirit and scope of this invention. Moreover, the present invention can also be employed in other types of web materials. The high pressure and temperature apparatus of this invention is ideally suited for cast coating operations. For example, an uncalendered board prepared from 50 percent kraft and 40 percent Groundwood and having a density of 7 lbs./ream/mil and a thickness of 18 mils is given a 20 lbs./ream dry coating composed of 90 parts clay, 10 parts titanium dioxide, 9 parts protein, 9 parts styrene-butadiene latex, and sufficient water to make 55 percent solids and passed through the apparatus arrangement of FIGURE 1. The end result is a very smooth and high gloss cast coated paper. For such operations, the drum **11** should have a very smooth surface, e.g. a polished chromium surface. Since the apparatus of this invention makes possible the use of high temperatures coupled with pressure selectivity, especially the embodiment of FIGURE 2, it can also be utilized in the treatment and/or production of other types of web, e.g. plastic webs such as Textryls which are composed of synthetic fibers and fibrids and which may or may not contain cellulosic fibers and which may also be woven or nonwoven.

I claim:

1. An apparatus for drying a fibrous web comprising, in combination,

(a) at least one rotatable heated drum means having an axis and providing a substantially rigid heated cylindrical surface,

(b) an endless belt means having an outer face and an inner face, a portion of said outer face being in contact with a substantial portion of said substantially rigid heated cylindrical surface,

(c) at least four roller support means in contact with substantially opposing portions of said inner face,

(d) at least three of said at least four roller support means being movably mounted for changing their location in reference to said drum means,

(e) at least two of said at least three roller support means being movable radially toward said axis to press said outer face against said cylindrical surface, and

(f) at least one of said at least three roller support means being a tension means for pressing said outer face against said cylindrical surface and causing said inner face to force said at least two roller support means radially toward said axis.

2. The apparatus of claim **1** further characterized by additional pressure means being provided to force at least one of said at least two of at least three roller support means radially toward said axis at a pressure greater than that provided by said tension means.

References Cited by the Examiner

UNITED STATES PATENTS

1,689,743	10/1928	Mullen	34—117 X
1,873,949	8/1932	Williams	34—116
1,951,710	3/1934	Schorger.	

FOREIGN PATENTS

3,196	1893	Great Britain.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,319,352 May 16, 1967

John M. Haigh

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

In the heading to the printed specification, lines 4 and 5, for "Albemarle Paper Manufacturing Company" read -- Albemarle Paper Company --.

Signed and sealed this 1st day of October 1968.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents