

Aug. 28, 1956

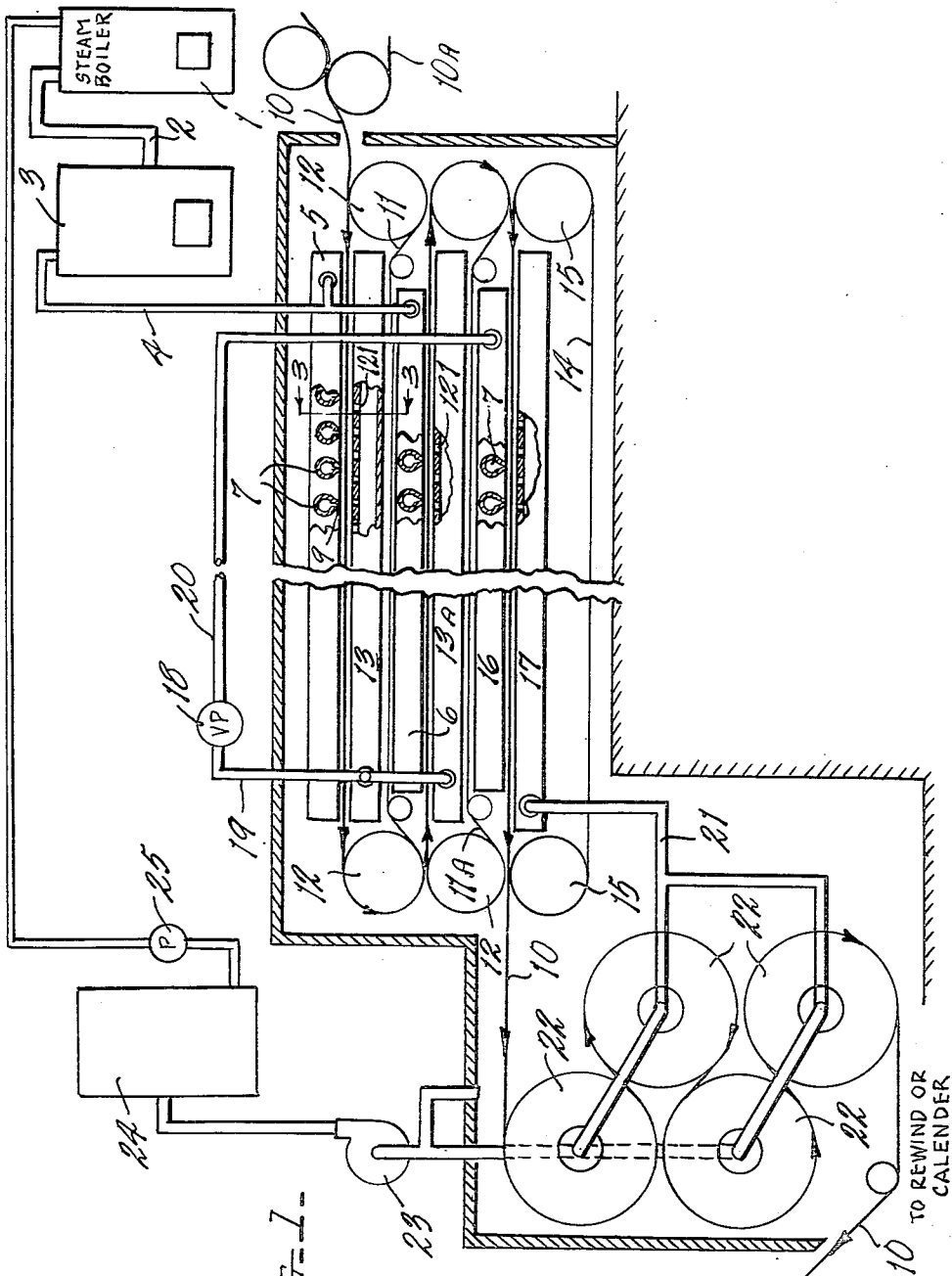
J. R. GILLIS

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METHOD AND APPARATUS FOR DRYING PAPER

Filed July 31, 1953

2 Sheets-Sheet 1



INVENTOR.
Joseph R. Gillis
BY
Otto A. Earl
Attorney.

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J. R. GILLIS

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2 Sheets-Sheet 2

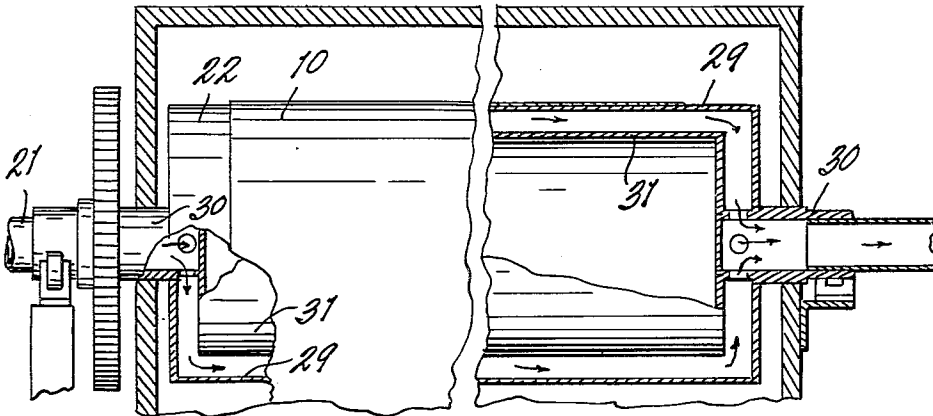


FIG. 2.

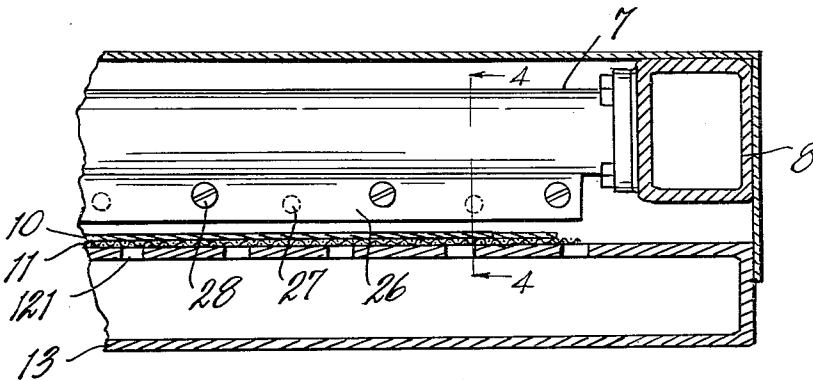


FIG. 3.

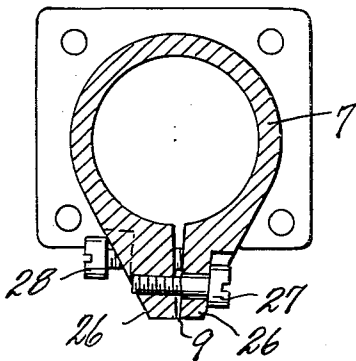


FIG. 4.

INVENTOR.
Joseph R. Gillis
BY *Otha Earl*
Attorney.

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METHOD AND APPARATUS FOR DRYING PAPER

Joseph R. Gillis, Kalamazoo, Mich.; Esther M. Gillis, administratrix of said Joseph R. Gillis, deceased

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15 Claims. (Cl. 92—38)

This invention relates to improvements in method and apparatus for drying paper.

The principal objects of this invention are:

First, to provide method and apparatus for removing moisture from newly formed paper which utilizes steam at extremely high temperatures to vaporize the water in the paper.

Second, to provide method and apparatus for drying paper which will remove the excess water content of newly formed paper in less time than has heretofore been possible.

Third, to provide paper drying apparatus which operates at relatively low pressures and which may consequently be of relatively light construction.

Fourth, to provide a method and apparatus for rapidly raising the temperature of a newly formed web of paper to an extremely high temperature without danger of damaging the paper.

Fifth, to provide paper drying apparatus that can be installed in a relatively small space as compared to the space required for existing drying apparatus.

Sixth, to provide drying apparatus that coacts with a paper making machine to provide an improved felting action in the newly and partially formed paper.

Other objects and advantages of the invention will be apparent from a consideration of the following description and claims:

The drawings illustrate a highly practical form of apparatus for performing the drying method. Fig. 1 is a somewhat schematic or diagrammatic elevational view of the paper drying apparatus, portions being broken away in a cross-section. Fig. 2 is a fragmentary longitudinal cross-sectional view through one of the drying rolls of the apparatus. Fig. 3 is a fragmentary transverse cross-sectional view through one of the dryer housings shown in Fig. 1 and taken along the plane of the line 3—3 in Fig. 1. Fig. 4 is a transverse cross-sectional view through one of the steam nozzles of the apparatus and taken along the plane of the line 4—4 in Fig. 3.

It is now the general practice to complete the manufacture of newly formed paper by advancing the newly formed web of very wet paper over a large number of heated drying rolls in order to evaporate or drive off the excess water content of the paper. These drying rolls are commonly heated by means of steam passed through their interiors and in order to obtain the desired temperature the drums and their connections must be relatively heavy to withstand the pressure of steam at the desired temperature. It has further been proposed to dry paper stock by passing the web of wet paper over a perforated drying roll and directing heated air to the surface of the web so that the air may be drawn through the web and into the roll by vacuum to remove excess water. This latter method has, however, generally required the prior use of conventional drying rolls to initially remove part of the water and thus stabilize the newly formed web.

The present invention differs from the foregoing prior

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art in that temperature far in excess of previously known instances are used to evaporate or boil off the water in the web. Temperatures ranging between 400° F. and 1500° F. may be used to rapidly raise the temperature of the web and the moisture therein. Dry super-heated steam is utilized as a heat medium and is also used as a vehicle for carrying away the steam thus evaporated from the paper.

The superheated steam used in the method and apparatus is employed at relatively low pressure and at relatively high superheats so that the apparatus for handling the steam may be of relatively light-weight inexpensive construction. The low pressure of the steam also permits the method to be performed on the new web of paper immediately after the web is formed without danger of damaging the web in its still fragile state. The same superheated steam is desirably passed successively through succeeding portions of the apparatus at progressively lower temperatures and pressures in order to efficiently utilize the heat content of the steam. It should be apparent however that separate steam supply and collection elements might be employed if that should appear desirable for special reasons. In its initial stages, the method and apparatus functions to assist and improve the felting of the paper.

As is more or less conventionally illustrated in Fig. 1 the apparatus which forms the present invention and on which the method is performed comprises a steam boiler 1 adapted to generate steam at relatively low pressure. While the exact pressure of the steam is not critical and may be raised as desired the increased pressure of the steam requires a corresponding increase in the strength of the steam handling apparatus and so is limited. Generally speaking it is believed that it would be uneconomical to raise the steam pressure above 60 pounds per square inch and pressures of 10 to 20 pounds per square inch are recommended. The boiler delivers through a pipe 2 to a superheater 3. The superheater 3 is a high heat capacity superheater that may be economically heated by gas or electricity to raise the temperature of the low pressure steam to between 400° F. and 1500° F. The superheater delivers through the steam pipe 4 to a pair of housings 5 and 6. The housings contain longitudinally spaced transversely extending series of steam nozzles 7. The nozzles 7 are tubular elements interconnected at their ends by headers 8 and are slotted as at 9 along their lower edges to deliver a sheet or jet of superheated steam downwardly against the advancing web of newly formed paper.

The web of newly formed paper 10 is taken from the belt or felt 10-A of the Fourdrinier paper-making machine as soon as the web of paper is self-sustaining. At this stage the paper may contain as much as 60% water and is very weak. The paper web is transferred to a woven wire belt 11 trained around a pair of rolls 12 and passing closely underneath the first housing 5 and the nozzles 7 therein. The upper reach of the belt 11 and the web thereon are supported on the top perforate surface 121 of a first suction chamber 13. After passing under the first steam housing 5 the web 10 is transferred to a second belt 11-A and desirably positioned underneath the first rolls 12 for economy of space. The web is advanced along with the belt 11-A in a reverse direction and in an inverted position underneath the second steam housing 6 and the nozzles therein. The second belt 11-A and the web thereon is supported by a second suction chamber 13-A identical in construction with the first suction chamber. The steam housings 5 and 6 and the suction chambers 13 and 13-A are in effect sections of a single primary heating and evacuating unit.

After leaving the belt 11-A the web is transferred to

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a third belt 14 trained around a pair of rolls 15. The belt 14 advances the web of paper underneath a secondary heating housing 16 and the web is then supported on the perforate top wall of a secondary suction chamber 17.

As was previously pointed out the primary heating housings 5 and 6 and the steam nozzles 7 therein are supplied directly from the superheater by the pipe 4. The steam delivered from the nozzles is directed closely adjacent the surface of the wet web 10 and the water in the web is heated and turned into steam. The mixture of primary steam and steam evaporated from the web is drawn off from the housings 5 and 6 and into the suction chambers 13 and 13-A. Part of the steam passes from the bottom of the web through the belts 11 and 11-A and the perforate top walls of the suction chambers. Particularly at the entrance end of the suction chamber 13 where the web 10 is still highly fluid in character, the action of the steam in being drawn through the web functions to aid or increase the felting action in the web that draws part of the fibers of the web downwardly in an interlocking action with the other fibers of the web. Part of the steam mixture is also drawn from along the sides of the web directly into the suction chambers as the perforate top walls of the suction chambers desirably extend beyond the side edges of the web as is illustrated in Fig. 3. The suction chambers 13 and 13-A are maintained at a pressure below the steam pressure in the nozzles 7 by means of a suction pump 18 acting through the pipe 19 connected to the suction chambers. The pump 18 delivers through a pipe 20 to the secondary steam housing 16 so that the housing 16 operates at a somewhat lower temperature than the housings 5 and 6. The mixture of initially supplied steam and steam evaporated from the web is still in a highly superheated state so that the secondary housing 16 functions to evaporate still further moisture from the advancing web. The steam drawn off in the suction chamber 17 is withdrawn through a pipe 21 and delivered to a series of tempering rolls 22. The web of paper which is now at a relatively high temperature and relatively low water content is advanced as indicated by the arrows around the rolls 22. The flow of vapor from the suction chamber 17 through the rolls 22 is maintained by a vacuum pump 23 which may reduce the pressure within the drums 22 to near or below atmospheric pressure to maintain the vapor state of the now greatly cooled steam. The pump 23 desirably delivers to a condenser 24 which condenses the steam vapors. A feed water pump 25 may return the condensed water to the boiler 1.

As is more particularly illustrated in Fig. 2 to 4 the steam handling elements of the system may be of relatively light weight construction as there is no necessity for containing high pressure steam. The nozzles 7 are desirably of cast construction because of the extremely high temperatures to which they are subjected. Depending flanges 26 on each side of the slots 9 are drilled and tapped for the reception of a first set of screws 27 that function to draw the sides of the slot together. A second set of screws 28 are threaded through the opposite flange 26 to bear against the side of the slot and tend to open the slot. The size of the slot and the amount of superheated steam delivered therethrough can thus be accurately controlled.

The tempering rolls 22 as shown in Fig. 2 may consist of relatively light steel plate drums 29 mounted on hollow axles 30. An inner drum 31 directs the vapors entering from the pipe 21 along the inner surface of the outer drum 29.

Having thus described the invention, what is claimed to be new and what is desired to be secured by Letters Patent is:

1. Paper drying apparatus comprising, a vapor pervious belt mounted to support and advance a web of wet paper, a vacuum chamber positioned under and sup-

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porting said belt, a housing substantially enclosing the opposite side of said belt from said chamber and opening to said chamber along the sides of said belt, a set of elongated nozzles positioned in said housing and directed toward said belt, a super heater connected to supply super-heated steam to said nozzles at between 400° to 1500° F. and at pressure not in excess of 60 pounds per square inch, a second pervious belt positioned to receive the web from said first belt, a second vacuum chamber positioned under and supporting said second belt, a second housing enclosing the opposite side of said second belt from said second chamber and opening to said second chamber along the sides of said second belt, a second set of nozzles in said second housing and directed toward said second belt, a conduit connecting said first vacuum chamber to said second set of nozzles, a pump in said conduit adapted to withdraw super heated vapor from said first chamber and deliver to said second set of nozzles, a plurality of hollow drums rotatably supported to receive and advance the web of paper from said second belt, a conduit connected to deliver superheated vapor from said second chamber to within said drums in series, and a vacuum pump connected to withdraw water vapor from said drums.

2. Paper drying apparatus comprising, a vapor pervious belt mounted to support and advance a web of wet paper, a vacuum chamber positioned under said belt, a housing substantially enclosing the opposite side of said belt from said chamber and opening to said chamber along the sides of said belt, a set of elongated nozzles positioned in said housing and directed toward said belt, a superheater connected to supply superheated steam to said nozzles at between 400° to 1500° F. and at pressure not in excess of 60 pounds per square inch, a second pervious belt positioned to receive the web from said first belt, a second vacuum chamber positioned under said second belt, a second housing enclosing the opposite side of said second belt from said second chamber and opening to said second chamber along the sides of said second belt, a second set of nozzles in said second housing and directed toward said second belt, a conduit connecting said first vacuum chamber to said second set of nozzles, a pump in said conduit adapted to withdraw superheated vapor from said first chamber and deliver to said second set of nozzles, a plurality of hollow drums rotatably supported to receive and advance the web of paper from said second belt, a conduit connected to deliver superheated vapor from said second chamber to within said drums, and a vacuum pump connected to withdraw water vapor from said drums.

3. Paper drying apparatus comprising, a vapor pervious belt mounted to support and advance a web of wet paper, a suction chamber positioned under and supporting said belt, a housing substantially enclosing the opposite side of said belt from said chamber, a set of longitudinally spaced transversely elongated nozzles positioned in said housing and directed toward said belt, a superheater connected to supply superheated steam to said nozzles at over 400° F. and at a pressure not in excess of 60 pounds per square inch, a second pervious belt positioned to receive the web from said first belt, a second suction chamber positioned under and supporting said second belt, a second housing enclosing the opposite side of said belt from said second chamber, a second set of nozzles in said second housing and directed toward said second belt, a conduit connecting said first suction chamber to said second set of nozzles, a pump in said conduit adapted to withdraw superheated vapor from said first chamber and deliver to said second set of nozzles, a plurality of hollow drums rotatably supported to receive and advance the web of paper from said second belt, a conduit connected to deliver superheated vapor from said second chamber to within said drums, and a pump connected to withdraw vapor from said drums.

4. Paper drying apparatus comprising, a vapor pervious

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belt mounted to support and advance a web of wet paper, a suction chamber positioned under said belt, a housing substantially enclosing the opposite side of said belt from said chamber, a set of nozzles spaced in said housing and directed toward said belt, a superheater connected to supply superheated steam to said nozzles at over 400° F. and at a pressure not in excess of 60 pounds per square inch, a second pervious belt positioned to receive the web from said first belt, a second suction chamber positioned under said second belt, a second housing enclosing the opposite side of said second belt from said second chamber, a second set of nozzles in said second housing and directed toward said second belt, a conduit connecting said first chamber to said second set of nozzles, a pump in said conduit adapted to withdraw superheated vapor from said first chamber and deliver to said second set of nozzles, a plurality of hollow drums rotatably supported to receive and advance the web of paper from said second belt, a conduit connected to deliver vapor from said second chamber to within said drums, and a vacuum pump connected to withdraw vapor from said drums.

5. Paper drying apparatus comprising, a vapor pervious belt mounted to support and advance a web of wet paper, a suction chamber positioned under said belt, a housing substantially enclosing the opposite side of said belt from said chamber and opening to said chamber along the sides of said belt, a set of elongated nozzles positioned in said housing and directed toward said belt, a superheater connected to supply superheated steam to said nozzles at over 400° F. and at pressure not in excess of 60 pounds per square inch, a plurality of hollow drums rotatably supported to receive and advance the web of paper from said belt, a conduit connected to deliver superheated vapor from said chamber to within said drums, and a vacuum pump connected to withdraw vapor from said drums.

6. Paper drying apparatus comprising, a vapor pervious belt mounted to support and advance a web of wet paper, a suction chamber positioned under said belt, a housing substantially enclosing the opposite side of said belt from said chamber, a set of elongated nozzles positioned in said housing and directed toward said belt, a superheater connected to supply superheated steam to said nozzles at between 400° to 1500° F. and at pressure not in excess of 60 pounds per square inch, a plurality of hollow drums rotatably supported to receive and advance the web of paper from said belt, a conduit connected to deliver superheated vapor from said chamber to within said drums, and a vacuum pump connected to withdraw vapor from said drums.

7. Paper drying apparatus comprising, a vapor pervious belt mounted to support and advance a web of wet paper, a suction chamber positioned under said belt, a housing substantially enclosing the opposite side of said belt from said chamber and opening to said chamber along the sides of said belt, a set of elongated nozzles positioned in said housing and directed toward said belt, a superheater connected to supply superheated steam to said nozzles at over 400° F. and at pressure not in excess of 60 pounds per square inch, a second pervious belt positioned to receive the web from said first belt, a second suction chamber positioned under said second belt, a second housing enclosing the opposite side of said second belt from said second chamber and opening to said second chamber along the sides of said second belt, a second set of nozzles in said second housing and directed toward said second belt, a conduit connecting said first chamber to said second set of nozzles, a pump in said conduit adapted to withdraw superheated vapor from said first chamber and deliver to said second set of nozzles, and a vacuum pump connected to withdraw vapor from said second chamber.

8. Paper drying apparatus comprising, a vapor pervious belt mounted to support and advance a web of wet

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paper, a suction chamber positioned under said belt, a housing substantially enclosing the opposite side of said belt from said chamber, a set of elongated nozzles positioned in said housing and directed toward said belt, a superheater connected to supply superheated steam to said nozzles at over 400° F. and at pressure not in excess of 60 pounds per square inch, a second pervious belt positioned to receive the web from said first belt, a second suction chamber positioned under said second belt, a second housing enclosing the opposite side of said second belt from said second chamber, a second set of nozzles in said second housing and directed toward said second belt, a conduit connecting said first chamber to said second set of nozzles, and a vacuum pump connected to withdraw vapor from said second chamber.

9. The method of paper making which comprises the steps of, subjecting a newly formed web of paper having a high water content to a jet of steam superheated to between 400° and 1500° F. and at a pressure not in excess of 60 pounds per square inch to evaporate part of the water in the web, withdrawing the steam and the evaporated water from said web in a superheated condition, directing the withdrawn steam and vapor in a still superheated condition and at a lower pressure to a preceding partially dried portion of the web to evaporate additional water, withdrawing the steam and additionally evaporated water from said web and still in superheated condition, advancing the web with the thus reduced water content and at increased temperature to a series of tempering rolls, directing the steam and water vapor withdrawn secondly from said web to the interior of said rolls and at decreased temperature, and withdrawing water vapor from said rolls to maintain the flow of steam and water vapor thereto.

10. The method of paper making which comprises the steps of, subjecting a newly formed web of paper having a high water content to a jet of steam superheated to between 400° and 1500° F. and at a pressure not in excess of 60 pounds per square inch to evaporate part of the water in the web, withdrawing the steam and the evaporated water through said web in a superheated condition, advancing the web with the thus reduced water content and at increased temperature to a series of tempering rolls, directing the steam and water vapor withdrawn from said web to the interior of said rolls and withdrawing water vapor from said rolls to maintain the flow of steam and water vapor thereto.

11. The method of paper making which comprises the steps of, subjecting a newly formed web of paper having a high water content to the action of a blanket of steam superheated to between 400° and 1500° F. and at a pressure not in excess of 60 pounds per square inch to evaporate part of the water in the web, withdrawing the steam and the evaporated water from said web in a superheated condition, directing the withdrawn steam and vapor in a still superheated condition and at a lower pressure to a preceding partially dried portion of the web to evaporate additional water, again withdrawing the steam and additionally evaporated water from said web and still in superheated condition, advancing the web with the thus reduced water content and at increased temperature to a series of tempering rolls, directing the steam and water vapor withdrawn secondly from said web to the interior of said rolls and at a decreased temperature, and maintaining a low pressure in said rolls to maintain the flow of steam and water vapor thereto.

12. The method of making paper which comprises the steps of, subjecting the newly formed web of paper having a high water content to the action of a blanket of steam superheated to between 400° and 1500° F. and at a pressure between 10 and 20 pounds per square inch to evaporate part of the water in the web, withdrawing the steam and the evaporated water through said web in a superheated condition, directing the withdrawn steam and vapor in a still superheated condition and at a lower pressure and temperature to a preceding partially dried

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portion of the web to evaporate additional water, and withdrawing the steam and additionally evaporated water through said web and still in a superheated condition.

13. The method of making paper which comprises the steps of transferring the newly formed web of wet paper to a traveling pervious belt, delivering super heated steam against the web on said belt to vaporize moisture in said web, withdrawing superheated steam and vapor through and from the surface of said web, repeating the steam delivering and withdrawing steps on the same portion of the web and utilizing the steam and vapor first withdrawn from the web, and tempering the web thus heated by passing the web over a heat transfer surface in heat transfer relation with said surface and using vapor withdrawn secondly from said web to condition said surface.

14. Paper making apparatus comprising, a paper making machine including a web translating felt for the web of wet paper, a vapor pervious belt mounted to receive and advance said web of wet paper from said felt, a suction chamber positioned under said belt and closely adjacent said felt, a housing substantially enclosing the opposite side of said belt from said chamber and opening to said chamber along the sides of said belt, a set of nozzles positioned in said housing and directed toward said belt and distributed over an area of the belt, a superheater connected to supply superheated steam to said nozzles at over 400° F. and at pressure not in excess of 60 pounds per square inch, a plurality of hollow drums rotatably supported to receive and advance the web of paper from said belt, a conduit connected to deliver superheated vapor from said chamber to within said drums, and a vacuum pump connected to withdraw vapor from said drums.

15. The method of making paper which comprises the steps of forming a web of wet paper and advancing the

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web on a continuously advancing felt while partially consolidating the web, removing the web from the felt and immediately subjecting the newly formed web of paper to the action of a blanket of steam superheated to over 400° F. and at a pressure not in excess of 60 pounds per square inch to evaporate water in the web, withdrawing the steam and the evaporated water through said web in a superheated condition, directing the withdrawn steam and vapor in a still superheated condition and at a lower pressure to a preceding partially dried portion of the web to evaporate additional water, again withdrawing the steam and additionally evaporated water from said web and still in superheated condition, advancing the web with the thus reduced water content and at increased temperature to a series of tempering rolls, directing the steam and water vapor withdrawn secondly from said web to the interior of said rolls and at decreased temperature, and maintaining low pressure in said rolls to maintain the flow of steam and water vapor thereto.

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