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HIGH-SPEED PAPER MAKING SYSTEM AND METHOD

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FIG-1

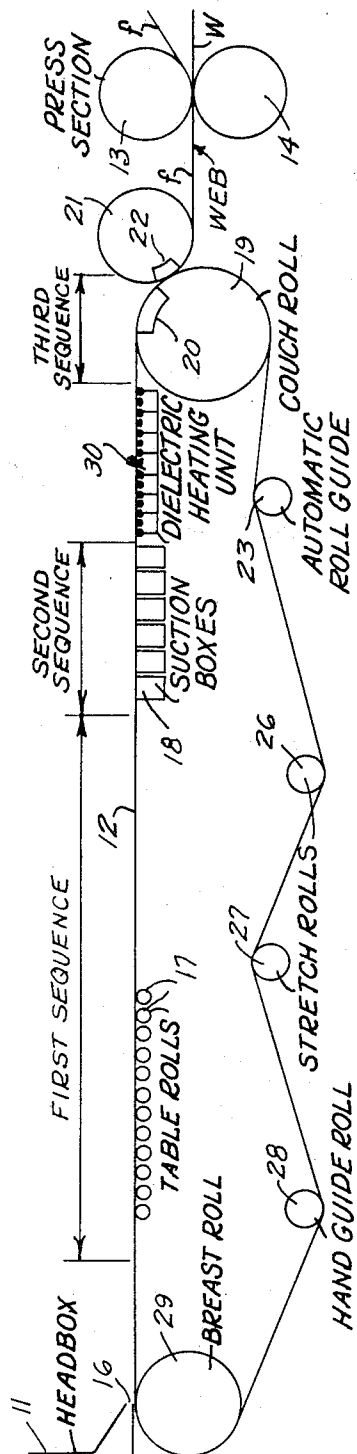


FIG-3

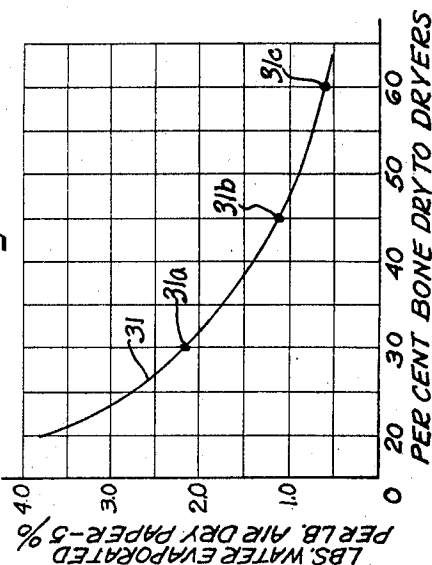
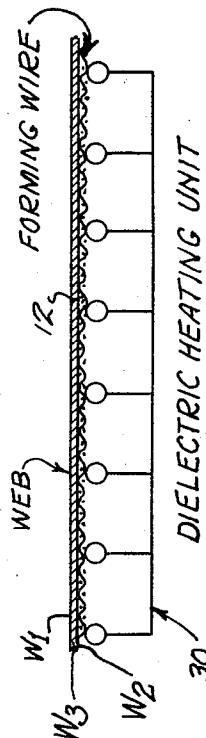


FIG-2



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**HIGH-SPEED PAPER MAKING SYSTEM
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ABSTRACT OF THE DISCLOSURE

This invention is directed to a method of heating a paper stock or slurry formed by a paper making machine while the slurry is on a forming surface. The forming surface is constructed of dielectrically transparent material so as to be not effected by dielectric heating means. Dielectric heating means are positioned adjacent the paper web formed by the slurry to raise the temperature of the web before the web leaves the forming surface.

This invention relates generally to paper making machines and more particularly to an improvement in the Fourdrinier section thereof. Specifically, this invention is directed to a new and novel method of heating a slurry of paper stock as the slurry is transported by the forming wire.

In the manufacture of paper, a slurry which consists essentially of water is applied to a continuously moving forming wire. Generally, the consistency of the slurry is between 0.1% to 3.0% pulp and 99.9% to 97% water by weight, and in some cases, the consistency may extend to either side of the general range depending upon the type of paper being formed. Therefore, the process of removing this large quantity of water from the slurry is an essential and very important part of the paper making process. Heretofore, various methods of removing water from the slurry and drying the web formed on the wire have been used. Heating the web prior to passing it through the press section greatly increases the efficiency of the drying operation of a paper making machine.

Methods of heating the stock or the web during the paper making process include using open flame heaters, heating the entire mass of the stock in the headbox before it is applied to the forming wire; applying steam showers to the surface of the stock as it passes the suction boxes, couch roll or the press section; or using infrared gas or electric heaters.

The method of heating the entire mass of the stock has the disadvantage of being relatively expensive in that large heating units are required to pump sufficient heat energy into the stock and the entire amount of water must be heated. Furthermore, much of the heat energy is lost from the stock as it is transported to the press section, where it is advantageous to have the stock at a higher temperature. Infrared and electric heaters, as well as the open flame heater, have the disadvantage in that they can only supply a certain amount of heat to the stock or to the web since the web itself acts as a heat insulator. This causes only the outer surfaces of the web to be heated sufficient to vaporize moisture therefrom while the interior of the stock remains at a relatively cool temperature.

Furthermore, the present day high speed paper making machines, with speeds of approximately 4,000 f.p.m., open flame heaters having a high B.t.u. rating are needed to supply sufficient heat energy to the stock as it passes through the heater at a high rate of speed.

Therefore, one of the primary objects of the present invention, particularly from the standpoint of increasing the efficiency of a paper making machine, is to completely and uniformly heat the web through the entire thickness thereof as it is being formed into a paper web.

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Another object of the present invention is to provide a method of heating the web which will increase the efficiency of a drying section of a paper making machine.

A feature of the present invention is the provision of a dielectric heating unit positioned in energy-transfer relation with a moving web as it passes through a paper making machine prior to the press section.

Briefly, there are three sections for removing water in order to form a paper web. These are the so-called wet-end, press and dryer sections. In addition, there are two main types of wet-end sections, the cylinder, of either the single or multiple type, and the Fourdrinier type.

In order to properly form a sheet of paper, it is necessary to dilute the paper making stock with water at a ratio of approximately 200 times by weight. The cost of removing this large quantity of water is determined greatly by the section at which it is removed. For example, the cost of removing the water is lowest at the wet-end section, considerably higher in the press section, and very much higher in the dryer section due to the use of steam. Removal of the water at the wet-end and at the press sections of a paper making machine is a function of water viscosity. That is, the lower the viscosity, the easier the water is removed. However, water viscosity is a function of temperature and, therefore, the higher the temperature, the lower the viscosity.

In the present day paper making machines, it is not economically feasible to maintain the slurry at maximum temperature as it passes through the wet-end of the machine due to the large volume of water associated with the slurry which has to be heated. However, after a considerable amount of water has been removed at the wet-end, applying heat to the slurry before it reaches the press section would greatly increase the efficiency of a paper making machine. Therefore, the present invention provides a dielectric heating unit which is positioned immediately before the couch roll in the Fourdrinier section of the machine.

The consistency of the web after it passes the wet-end of the machine has a relatively wide range of variation, as for example, 20% to 30% or more by weight. After it passes the press section the web consistency has a wide range of variation, as for example, 30% to 45% or more by weight. Generally, at the drying end of the paper making machine, it is desired that the paper have a moisture content of approximately 50% relative humidity with respect to the surrounding air. With different types of stock, this figure may vary from 4% to 9% or more depending upon the type of fiber and the amount of filler used. Typically, for purposes of illustration, the moisture may be 5% by weight.

Should the web entering the dryer of the machine have a consistency of 30%, it is necessary to evaporate 2.2 pounds of water for every pound of paper which retains 5% moisture. However, should the stock entering the dryer section of the machine have a consistency of 45%, it is necessary only to evaporate 1.1 pounds of water for every pound of paper which retains a 5% moisture content. Similarly, should the consistency of the web be 60%, it is necessary only to evaporate 0.6 pound of water per pound of paper. Therefore, if means were provided to increase the dryness from 30% to 45% prior to the dryers, the steam required for the drying process would be cut in half. This feature would also allow the paper making machine to increase its production rate or, in the case of a new machine, would require only half of the dryer sections presently necessary, thereby providing a tremendous savings in capital cost.

Presently it is not feasible to apply high steam pressure at the first drying cylinders of the dryer because the web will stick to the surface of the cylinder which will result in the formed sheet having a fuzzy appearance. In addition,

tion, the drying cylinder will acquire a coating which will reduce its efficiency. Therefore, it is highly desirable to heat the web prior to contact with the surface of the first dryer so that full or nearly full steam pressure can be used which, in turn, will increase the efficiency and the capacity of the dryer section.

Therefore, a feature of my invention is the use of a dielectric heating unit positioned in energy-transfer relation with moving web so as to increase the temperature of the entire volume of water associated therewith preferably without attempting to actually evaporate water from the web. By applying a dielectric current through the web, the velocity of the molecules of the water is increased to such an extent that internal friction causes an increase in temperature throughout the entire thickness of the web rather than only near the outer surface thereof. The application of this method of heating is feasible at the wet-end of the machine because of the use of synthetic non-conductive material which makes up the forming wire. The synthetic material of the forming wire is substantially not affected by the dielectric heating energy. Therefore, higher temperatures of the web are now made possible at the wet-end of the machine. This feature will enable the couch roll and the presses to perform more efficiently so that a less saturated web will be delivered to the dryer section of the machine. Although it will be understood that the application of dielectric heating units can be made before each press section, it is conceived that maximum efficiency is obtained when the dielectric heating unit is placed before the couch roll.

Other objects and features will be more fully realized and understood from the following detailed description when taken in conjunction with the accompanying drawings in which like reference numerals throughout the various views of the drawings are intended to designate similar elements or components and wherein:

FIGURE 1 is a diagrammatic representation of a Fourdrinier type wet-end of a paper making machine;

FIGURE 2 is an enlarged fragmentary view of a portion of a web passing over a dielectric heating unit; and

FIGURE 3 is a chart showing the relative increase in efficiency of a dryer section when a paper making machine is operated in accordance with the principles of this invention.

Shown in FIGURE 1 is a portion of a paper making machine which includes a Fourdrinier section designated generally by the reference numeral 10. A headbox 11 supplies a slurry of paper pulp to a forming wire 12. The slurry passes through the Fourdrinier section 10 to form a web on the wire and is subsequently delivered to a press section which includes a pair of press rollers 13 and 14.

The headbox 11 is provided with a slice 16 which delivers a slurry of $\frac{1}{2}$ % to 5% pulp consistency and 99 $\frac{1}{2}$ % to 95% water. As the slurry is carried by the forming wire 12 over a plurality of table rolls 17, a portion of the water associated with the slurry is separated therefrom and passes through the forming wire 12 and through the table rolls 17. Therefore, the first sequence of removing water from the slurry to form a web is provided by the forming wire 12 and table rolls 17. The table rolls 17 may be replaced with foils, suction foils or large volume suction boxes.

As the web is further transported by the forming wire 12 it is subjected to a plurality of suction boxes 18 which is considered a second sequence of removing water. A third sequence of removing water from the web may be provided by a couch roll 19 which can have a suction gland 20 extending the axial length thereof. The negative pressure applied to the gland 20 extracts water.

A web pick-off roll 21 is provided with a suction gland 22 which is placed in close proximity to the forming wire 12 and carries a felt *f*. The felt *f* picks off the web from the wire so that the web may be carried to the rolls 13 and 14 of the press section. Although the illustrated embodiment of my invention shows a suction pick-up roll

it will be understood that open draw may be used in the transfer of the web from the forming wire to the press section.

The return portion of the forming wire 12 is engaged by an automatic guide roll 23, a pair of stretch rolls 26 and 27, and a hand guide roll 28. A breast roll 29 is wrapped by the forming wire 12 immediately adjacent the slice 16.

To obtain maximum efficiency of the dryers of a paper making machine, it is desirable to heat the water associated with the web prior to the web passing between the press rolls 13 and 14. Furthermore, such heating should be of a character whereby all of the water throughout the entire thickness of the web is substantially uniformly heated. This facilitates or improves its flow into the felt *f*, and improves the efficiency of the first press section and succeeding press sections. It is also believed that in addition to improving water flow into the felt, heating the water reduces its tendency to flow from the felt back to the web on the offrunning side of the press nip. In other words, a region of reduced pressure is formed on the offrunning side tending to draw water back out of the felt. At increased water temperatures the water will flash to steam avoiding the formation of the suction which drains water out of the felt and rewets the web.

Therefore, the present invention has provided a dielectric heating unit 30 which is positioned in energy-transfer relation with the web as it is transported by the forming wire 12. In the preferred embodiment of the present invention the dielectric heating unit 30 is positioned between the suction boxes 18 and the couch roll 19. Therefore, after the web has passed over the forming wire 12 through the first and second sequences of removing water, the dielectric heating unit 30 may be used with great efficiency to heat the remaining portion of the water associated with the web prior to the third sequence of removing water. It will be understood that this heating unit 30 may be placed above or below the web as desired.

When the heating unit is placed above the web, it would be necessary to have the unit mounted on a device to move it away when necessary, for washups, for example.

The electrode units should be protected from open hoses and shielding provided to prevent the radiation of energy.

For a better understanding of the advantage obtained by using the dielectric heating unit 30, in accordance with the principles of this invention, reference is now made to FIGURE 2. As the web is carried by the forming wire 12 over the dielectric heating unit 30, high frequency energy is delivered to the web from the dielectric heating unit. The characteristic of dielectric heating is such that each water molecule associated with the web is set into motion thereby causing a considerable amount of heat due to friction between adjacent water molecules. Therefore, not only will the outer surfaces W_1 and W_2 of the web be heated, but so also will the interior W_3 of the web be heated to the same temperature.

The advantage of such uniform heating is that the web will not be cooled due to the transfer of heat energy from the outer surfaces W_1 and W_2 to the inner portion W_3 .

Seen in FIGURE 3 is a chart which indicates the amount of water, in pounds necessary to evaporate a pound of water from a paper web. The abscissa indicates the percent of dryness of the paper as it is delivered to the dryers. The ordinate indicates the pounds of water necessary to evaporate each pound of water from the web. For example, a point 31a on a curvilinear line 31 indicates that approximately 2.2 pounds of water must be evaporated for each pound of paper when the web is delivered to the dryer having a consistency of 30%. On the other hand, a point 31b on the curvilinear line 31 indicates that approximately 1.1 pounds of water must be evaporated for each pound of paper when the web is delivered to the dryer having a consistency of 45%. In

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addition, a point 31c indicates that approximately 0.6 pound of water must be evaporated for each pound of paper when the web is delivered to the dryer at 60% consistency.

By utilizing the dielectric heating method of the present invention, the temperature of the water associated with the slurry may be raised between a minimum of 5° F. to a maximum of 212° F. with a minimum or very small loss of heat energy in the heat of vaporization. To obtain this temperature range of heating, the dielectric unit 30 may be operated at a frequency between 2 to 90 megacycles, and preferably 5 to 15 megacycles, and more desirably at a frequency of approximately ten megacycles. The voltage range of the dielectric unit 30 may be between 5,000 and 25,000 volts. For a better understanding of dielectric heating units per se, reference is made to McGraw-Hill Encyclopedia of Science and Technology, copyright 1960, page 113.

Through the specification and claims, the term "consistency" or generally, the percent consistency is meant to be by weight.

Therefore, by the use of dielectric heating means positioned between the suction boxes 18 and the couch roll 19, the present invention has provided means which greatly increases the efficiency of a dryer section of a paper making machine. Although the dielectric heating unit 30 is preferably positioned in energy-transfer relation with the web prior to the web passing over the couch roll, it is not to be construed in a limiting sense. Variations and modifications may be effected without departing from the spirit and scope of the novel concept of this invention.

I claim as my invention:

1. A method of drying paper stock including the steps of:
 - applying a slurry of paper stock to the surface of a forming wire to form a web;
 - dielectrically heating the web on said forming wire; and
 - subsequently thereafter drying the web.
2. A method of drying paper stock including the steps of:
 - applying a slurry of paper stock to the surface of a forming wire so as to form a paper web thereon;
 - dielectrically heating said web; and
 - transferring said web from said forming wire to a drying station.
3. A method of transporting a slurry of paper stock to a dryer of a paper making machine comprising the steps of:
 - applying a slurry of paper stock to the surface of a forming wire to form a web;
 - subjecting the web to a first sequence for removing water therefrom;
 - immediately thereafter subjecting the web to a second

sequence for removing additional water therefrom; dielectrically heating the web; subjecting the web to a third sequence for removing the heated water therefrom; and transferring said web from said forming wire to a drying station.

4. In a paper making machine including:

- a forming wire;
- a headbox for supplying a slurry of paper stock to said forming wire to form a web;
- suction means positioned in proximity with said forming wire for removing a portion of the water associated with the web;
- a couch roll wrapped by said forming wire;
- a transfer roll positioned in close proximity with said couch roll for removing the web from said forming wire;
- a press roll for receiving the web from said transfer roll;

the improvement therein comprising:

said forming wire being constructed of dielectrically transparent material, and dielectric heating means positioned in energy-transfer relation with the web between said suction means and said couch roll.

5. A method of drying paper stock including the steps of:

- applying a slurry of paper stock to the surface of a forming wire to form a web;
- uniformly heating the web while on said forming wire through the entire thickness thereof to raise the temperature of the water therein a minimum of 5° F. and less than 212° F.; and subsequently thereafter, drying the web.

6. In a paper making machine including:

- a web forming surface;
 - means for supplying a slurry of paper stock to said forming surface to form a web;
 - a press section for receiving said web to press water from the web;
- the improvement therein comprising:
- said forming surface being constructed of dielectrically transparent material, and
 - dielectrical heating means positioned in energy-transfer relation with said web prior to the web passing through said press section.

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JOHN J. CAMBY, *Acting Primary Examiner.*