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R. H. SNOW

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METHOD AND APPARATUS FOR WEB DRYING

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FIG. 1

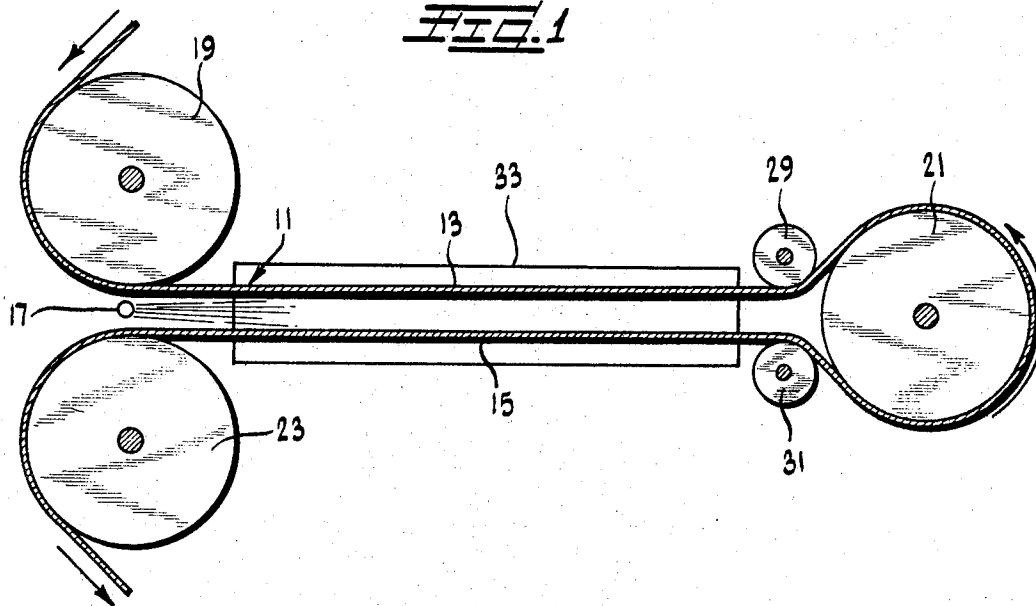
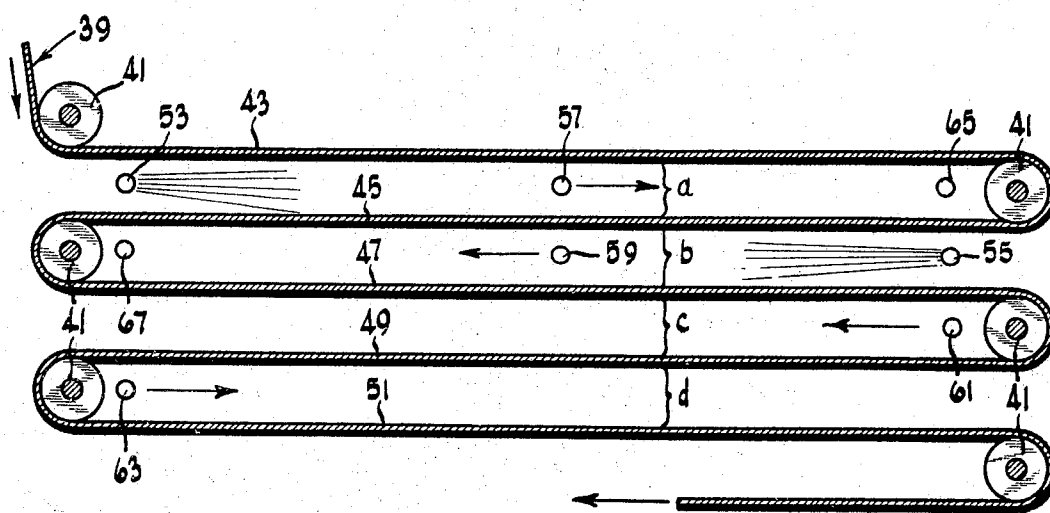


FIG. 2



INVENTOR
Richard H. Snow

BY *Anderson, Quedeka, Fitch, Egan & Tabin*
ATTORNEYS

1

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METHOD AND APPARATUS FOR WEB DRYING
Richard H. Snow, Chicago, Ill., assignor to Boxboard
Research and Development Association, Kalamazoo,
Mich.

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7 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus for drying web material by means of a flame heater in which a web is supported for movement in a path defining an open ended loop, and the flame heater is disposed within the loop for directing a flame generally parallel to the web.

This invention relates generally to web drying, and more particularly it relates to a method and apparatus for drying a web utilizing a flame heater.

For the purposes of this invention, a web may be defined as a sheet of finite width and indefinite length, for example, a continuous running length of paper, paperboard, textile or other material. Although the present invention is described in connection with the drying of paperboard webs, it is understood that other web materials may be dried using the method and apparatus of the invention. The term "flame heater" may be defined as a heater which utilizes the heat of combustion of an open flame for drying. In most instances the fuel for flame heaters is gas, but the use of other fuels is contemplated.

Various methods and apparatus are known for drying paper webs. The most common means of drying a wet paper web after formation of the wet web on the paper making machine is by means of a number of steam heated cylinders or rolls around which the wet web is passed. This form of drying apparatus is generally referred to as a cylinder dryer. The wet paper web in a paper making operation has a usual moisture content of between about 60 percent and about 70 percent by weight, and in order to dry the paper web without adversely affecting its properties the roll dryer may contain as many as one hundred steam heated rolls. It is apparent that this large number of steam heated rolls requires a large space in the paper making plant and increases the expense of the paper making operation. The drying rate of the cylinder dryer may also be the limiting factor in the speed of the web in the paper making operation, particularly in the manufacture of high basis weight paperboard.

In order to reduce the time required for drying the paper web, and to reduce the number of steam heated rolls necessary to accomplish drying of the paper web, it has been proposed to utilize additional drying means in conjunction with a roll dryer. Examples of additional heating means which might be used include radiant burners, hot gases, a fluidized bed, such as hot sand, and flame heaters.

Drying of a wet paper web by means of a flame heater offers several advantages in that it does not require expensive or complicated apparatus, and the burner itself does not become heated so that when the heater is not in operation there is less chance of accidents to operating personnel than with other types of burners. However, in previous attempts to utilize flame heaters for drying paper

2

webs it was found that it was difficult to obtain a reasonable degree of efficiency in the drying operation. In this connection, a typical flame heater for drying a paper web is arranged so that the burner extends transversely of the web substantially across the entire width thereof. The flame issuing from the burner is directed parallel to the web and the fuel pressure in the heater is adjusted so that the flame extends from the burner for a distance of a few inches up to several feet, depending upon the amount of moisture to be removed from the wet web. Drying of the wet web is accomplished by the heat of combustion of the fuel, and by contact of the hot combustion products with the wet web. In a typical gas flame heater, the maximum flame temperature that can be obtained is about 3500° F., although maximum flame temperatures as low as 1000° F. may be obtained depending upon the combustion mixture and the degree of dilution of the flame by ambient air. The maximum temperature of the combustion products is approximately equal to the maximum flame temperature.

Calculations have indicated that only about 16 percent of the available heat generated by a conventional flame heater is absorbed by the wet web. The reason for this is that the flame entrains cool air, thus lowering the flame temperature before a sufficient amount of heat is transferred to the web. In addition, the rate of moisture diffusion within the wet web is sufficiently slow that although the surface of the web may be sufficiently dried by exposure to the flame, the speed of travel of the web in the paper making operation is such that when the web is removed from the region of the flame the remaining moisture in the web equilibrates through the web by capillary action and re-establishes a moisture content in the web which is higher than would be desired.

It is an object of the present invention to provide a method and apparatus for drying web material. Another object is to provide a method and apparatus for drying web material utilizing a flame heater.

These and other objects of the invention will become apparent from the following detailed description and from the drawing in which:

FIGURE 1 is an elevational schematic view of one embodiment of the invention; and

FIGURE 2 is an elevational schematic view of another embodiment of the invention.

Generally, and having reference to FIGURE 1, the present invention is directed to a method and apparatus for drying web material by means of a flame heater which includes means for supporting and moving a web 11 to be dried in a path defining an open end loop formed by segments, i.e., runs, 13, 15 of the web disposed generally parallel to and spaced from one another. A flame heater 17 is disposed intermediate the runs 13 and 15 for directing a flame generally parallel to the web.

In a preferred embodiment of the invention, and as shown in FIGURE 1, the flame and combustion products are constrained between the runs and the runs have a length two to five times the visible length of the flame. In a still further embodiment of the invention, and as shown in FIGURE 2, the path of the web includes several loops and a plurality of flame heaters are employed. Further, ambient air is mixed with the hot combustion products from the flame heater in order to lower the moisture content thereof, and the hot combustion products are maintained in contact with the wet web to achieve further drying.

In accordance with the herein described method and apparatus, the efficiency of a flame heater used to dry a wet web may be significantly increased by confining the

flame between two runs of web to be dried. By confining the flame in this fashion escape of heat to the ambient surrounding and dilution of the flame with ambient air to an extent which would reduce the available heat for drying is substantially prevented. When the flame heater is positioned within a loop formed in the web, for example, by looping the web around a roll or cylinder, up to 40 percent or more of the heat of combustion may be delivered to the web for drying. Alternately, the flame may be confined between two independent webs traveling in the same or opposite directions.

There is shown in FIGURE 1 a schematic, elevational view of one embodiment of an apparatus for drying a wet web in accordance with the invention. As seen in FIGURE 1, a paper web 11 is guided about a series of spaced apart cylindrical rolls 19, 21 and 23. The rolls 19, 21 and 23 have parallel axes and are arranged so that the web 11 is caused to travel in a path around the rolls forming generally parallel runs 13 and 15.

It will be seen that the arrangement of the rolls and the guiding of the web around the rolls results in the creation of a loop in the web 11. Idler rolls 29, 31 may be provided, if desired, in order to space the runs 13 and 15 at a desired distance from each other, which may be from about 1 inch to 4 inches.

A flame heater 17, extending transversely of the web, is positioned within the loop formed by the runs 13 and 15 adjacent the open end thereof. As seen in FIGURE 1, the heater may be in the form of a pipe having a series of spaced apart orifices (not shown) along one side thereof. The orifices are arranged so the flame issuing from the pipe extends generally parallel to the runs of the paper web. However, any other means, such as baffles may be employed to direct the flame in the desired direction parallel to the runs of the web. Means, not shown, are provided for supplying a combustible fuel mixture to the flame heater 17. Alternately, the flame heater may be positioned adjacent the closed end of the loop, but care must be taken that the flame does not damage the web surface.

The orientation of the flame heater 17 and the runs 13 and 15 is arranged so that the web is directly exposed to the flame issuing from the heater and so that the flame grazes the surface of the web and the combustion products intimately contact the web.

As shown in FIGURE 1, a baffle 33 may be provided adjacent one or both of the longitudinal edges of the web 11 in the region of the runs 13 and 15. In this fashion escape of combustion products and excessive dilution of the flame and combustion products by ambient air is minimized, thereby preserving the heat of combustion of the flame and making this heat available for drying of the web 11.

In the embodiment illustrated in FIGURE 1, the runs 13 and 15 of the web 11 are substantially parallel and this configuration is generally preferred. However, the runs may diverge or converge slightly in order to obtain a desired drying effect, and where the term "generally parallel" is used herein it is intended to include orientation of the runs of the web which are converging or diverging to some extent.

The spacing between the runs is determined by the type of web being dried and the amount of moisture in the web. These in turn determine the amount of heat to be transferred, the flow rate of combustion gases, and the gas velocity and heat transfer rate. It has been determined that in most instances the space between the runs of the web should be at least about 0.5 inch. If the space between the runs is greater than 4 inches, drying may be reduced or an excessive flow of combustion gases may be required.

The web is preferably exposed to the flame for a distance of at least about 8 feet in order to obtain good drying. Of course, this distance may be altered depending upon the amount of moisture included in the web, and the

temperature of the flame. In the embodiment of FIGURE 1, the exposed surface of the web in run 13 is heated by the gas flame to a surface temperature of, for example, 240° F. The web is then passed about the roll 21, which may be either a heated or unheated roll, and into the second run 15 where it is again exposed to the flame and is further heated to a surface temperature of, for example, 300° F. The web 11 is then passed around the roll 23 and may then be further dried or processed, as desired.

In some instances, and particularly in drying paper, the drying of the web in the second run may be drastic, for example, to a surface moisture content of one percent or less. If the surface temperature of the web is raised too high, properties of the paper might be damaged. In such cases it is quite desirable to provide ventilation to the web and to allow for equilibration of the moisture content within the web before further heating of the web occurs. This may be accomplished, as seen in FIGURE 1, by positioning the heater 17 adjacent the open end of the loop and by extending the runs 13, 15 so that they have a length of two to five times the visible flame length, thereby allowing the moisture in the web to equilibrate through the thickness in the web before exposure to the flame a second time.

The combustion products constrained between the runs 13 and 15 contain large amounts of heat, which can be used for further drying of the web during the portion of the run where the moisture within the web is equilibrating. However, the moisture content of the combustion gases is high due to the initial drying effect mentioned above, and the drying afforded by the combustion products is not as great as would be desired. In order to maximize the drying effect of the combustion gases in the region of the runs where the moisture content is allowed to equilibrate, it is desirable to controllably dilute the combustion gases with air so as to reduce the moisture content of the combustion gases to an acceptable level for drying purposes. Of course, if the amount of moisture removed from the web is low, and the moisture content of the combustion gases is low, it may not be necessary to add air to the combustion gases.

The moisture content of the combustion gases may be reduced by controlled injection of cool, dry air into the combustion products in order to provide a hot dry mixture of combustion products and air which is suitable for drying of the web. The amount of air injected into the combustion products is controlled so that the water vapor content of the mixture of air and combustion products is relatively small compared to the vapor pressure of water at the temperature of the web. In practice, sufficient air is introduced so as to lower the water vapor partial pressure of the mixture of air and combustion products to below about 0.2 atmosphere, preferably below about 0.1 atmosphere.

There is shown in FIGURE 2 a second embodiment of the invention which incorporates the desirable features of using the combustion products to further dry the web. A series of opposed, spaced apart, stacked cylindrical rolls 41, which may be heated or unheated as desired, are arranged in a usual fashion and a web 39 is passed around the rolls. The spaced apart, stacked rolls cause the web to travel in a path defining a plurality of loops formed by a series of generally parallel segments, i.e., runs 43, 45, 47, 49, and 51. The organization and arrangement of the stacked rolls and the manner of passing the web about the rolls and driving the web may be in accordance with the prior art.

The series of loops formed in the web 39, for purposes of explanation may be identified as *a*, *b*, *c*, and *d*. Each of the loops *a*, *b*, *c* and *d* has an open end and a closed end, the closed end being defined by a cylinder 41 around which the web 39 passes, and it can be seen that the loops are arranged so that adjacent loops have their open ends facing in opposite directions. Transverse gas burners 53,

55 substantially as described above, are positioned transversely of the web within the loops *a* and *b* and the flame issuing from the burners is constrained between the webs and extends generally parallel thereto for a suitable distance, preferably about one-third of the total length of the run. Air injecting means 57 and 59 are provided for injecting cool air into the combustion products for reducing the moisture content thereof.

In order to achieve rapid and substantially complete drying of the web without causing damage to the web due to severe surface drying, the flame heaters 53, 55 should be arranged in a preferred manner in relation to the loops formed in the web. In this connection, the flame heaters are positioned adjacent the open end of the loop rather than the closed end, so that the flame issues from the heater in a direction toward the closed end of the loop. It will be seen that this orientation, in which the flame heater is positioned at the open end of a loop, provides a configuration in which a web surface does not travel directly around a roll and immediately back into contact with the flame, regardless of the direction in which the web is traveling.

As indicated, it is preferred that the runs of the web forming the loops extend for a distance greater than that which is exposed to the flame. For most purposes the total length of the run should be about 2 to 3 times as long as the visible length of the flame, and in a specific embodiment runs of about 30 feet in length, and a flame of about 10 feet in length has been found to provide good results.

Cool dry air is injected into the combustion products by means of the pipes 57, 59 in order to reduce the moisture content of the combustion products to a level whereby the mixture of air and combustion products can be used to further dry the web. Combustion products having a water vapor partial pressure of about 0.4 atmosphere, and a temperature of about 2200° F. can be diluted with about five volumes of cool, dry air thereby providing a hot diluted gas stream having a temperature of about 500° F. and a water vapor partial pressure of 0.08 atmosphere. These diluted combustion gases are sufficiently hot to provide good drying to the web, and such drying is accomplished during the time that the moisture in the web is equilibrating.

A suitable exhaust outlet 65, 67 may be provided adjacent the closed end of the loops *a* and *b* for exhausting the combustion gases, and such outlet may be in the form of a suction pipe. Alternately the hot gases may be allowed to flow laterally outwardly of the loop without having a suction outlet.

Baffles, similar to those shown in FIGURE 1, may be provided, if desired, to constrain the flame and the combustion products with the loops.

It will be seen that the configuration illustrated in FIGURE 2 alternately exposes opposite faces of the traveling web to the flame. This configuration has been found to be the most desirable and provides for uniform drying of the web with maximum moisture removal without undesirable severe surface drying.

It is contemplated that the web may be further dried by exposure to additional flame heaters similarly arranged to those shown in FIGURE 2. In such configurations it is generally desirable to allow one or more runs 47, 49 between each pair of flame heaters in order to allow the moisture within the web to substantially equilibrate before the web is again exposed to the flame. If desired, dry air may be passed in contact with the surface of the web in runs 49, 51, by means of pipes 61, 63.

In an example of the use of the method and apparatus to dry paper board, a wet paper web 10 feet wide having a weight of 77 lbs. per 1,000 sq. feet, and having a moisture content of 67 percent by weight was passed about a series of rolls such as illustrated in FIGURE 2 and was dried by means of two flame heaters. The rolls about which the web was passed were about 30 feet apart and

the flame heater was adjusted so that the flame had a visible length of about 10 feet. The temperature of the combustion products adjacent the end of the flame was about 3500° F. About 3,000 cubic feet of air per minute was injected into the hot combustion products in order to reduce the water vapor partial pressure of the combustion gases to about 0.08 atmosphere. The combustion gases were exhausted from the closed end of the loops by means of a suction outlet.

The paperboard web after being dried in accordance with the foregoing was found to have a moisture content of about 64 percent so that each flame was equivalent to two conventional dryer cylinders. An efficiency of about 43 percent utilization of heat energy in the flame was achieved with the flame dryer.

It will be seen that a flame dryer for drying a web of paper, textile or other material, has been described which has increased efficiency and which allows for rapid drying of the web without affecting the properties of the web. The apparatus is compact and is readily utilizable in connection with conventional paper making equipment.

The method and apparatus of the invention are particularly useful in drying web having high moisture content. It is contemplated that wet web material can first be partially dried using the described flame heater, followed by further drying with a conventional cylinder dryer. The use of a flame heater in combination with a cylinder dryer has been found to materially increase the overall drying rate, and allows the speed of the web to be increased. In addition it has been found that the subsequent steam-heated dryer cylinders could be operated at higher temperatures than usual, without picking of fibers occurring. Such picking frequently occurs when wet fibers contact a metal surface which is hotter than about 212° F. The partial surface drying of the web by the flame heater eliminated this difficulty and allowed the dryer cylinders to be operated at a higher capacity.

Although certain features of the described method and apparatus have been set forth with particularity, alternate embodiments within the skill of the art are contemplated.

Various features of the invention are set forth in the following claims.

What is claimed is:

1. An apparatus for drying a traveling web comprising, means for supporting a web for movement in a predetermined path defining a loop having an open end formed at least partially by segments of the web disposed in generally parallel relation to one another, and flame heater means positioned so as to be within said loop adjacent the open end thereof for directing a flame toward the closed end of the loop generally parallel to and in grazing contact with the segments of the web, the web segments having a length of about two to five times the visible length of the flame issuing from the flame heater.

2. An apparatus in accordance with claim 1 wherein means are provided for injecting air into the combustion products of the flame heater.

3. An apparatus for drying a traveling web comprising, means for supporting a web for movement in a predetermined path defining at least two open ended loops arranged so that adjacent loops have their open ends facing in opposite directions, the loops being formed at least partially by web segments disposed generally parallel to one another, flame heater means disposed within adjacent loops adjacent the open end of the loop for directing a flame generally parallel to and in grazing contact with the web, the web segments having a length of two to five times the visible length of the flame issuing from the flame heater.

4. An apparatus in accordance with claim 3 wherein means are provided within the loops for introducing air into the flame heater combustion products.

5. An apparatus in accordance with claim 4 wherein means are provided adjacent the closed end of the loops for exhausting combustion products.

6. A method of drying a traveling web comprising, causing a web to travel along a predetermined path defining an open ended loop, directing a flame from the open end of the loop toward the closed end of the loop in grazing contact with the web segments forming the loop, constraining the flame and its combustion products within said loop for drying of the web, and contacting the web segments with the combustion products over a distance at least equal to the visible length of the flame.

7. A method in accordance with claim 6 further comprising diluting the combustion products with air to reduce the water vapor content thereof to a partial pressure below 0.2 atmosphere.

References Cited

UNITED STATES PATENTS

	3,057,610	10/1962	Timson et al.	263—3
5	3,178,831	4/1965	Howlett	34—115 XR

KENNETH W. SPRAGUE, Primary Examiner

U.S. Cl. X.R.

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