Oct. 18, 1966 F. H. FREULER 3,279,091

APPARATUS FOR DRYING A MOVING WEB OVER A NON-ROTATING SHELL

Filed Dec. 23, 1963 2 Sheets-Sheet 1

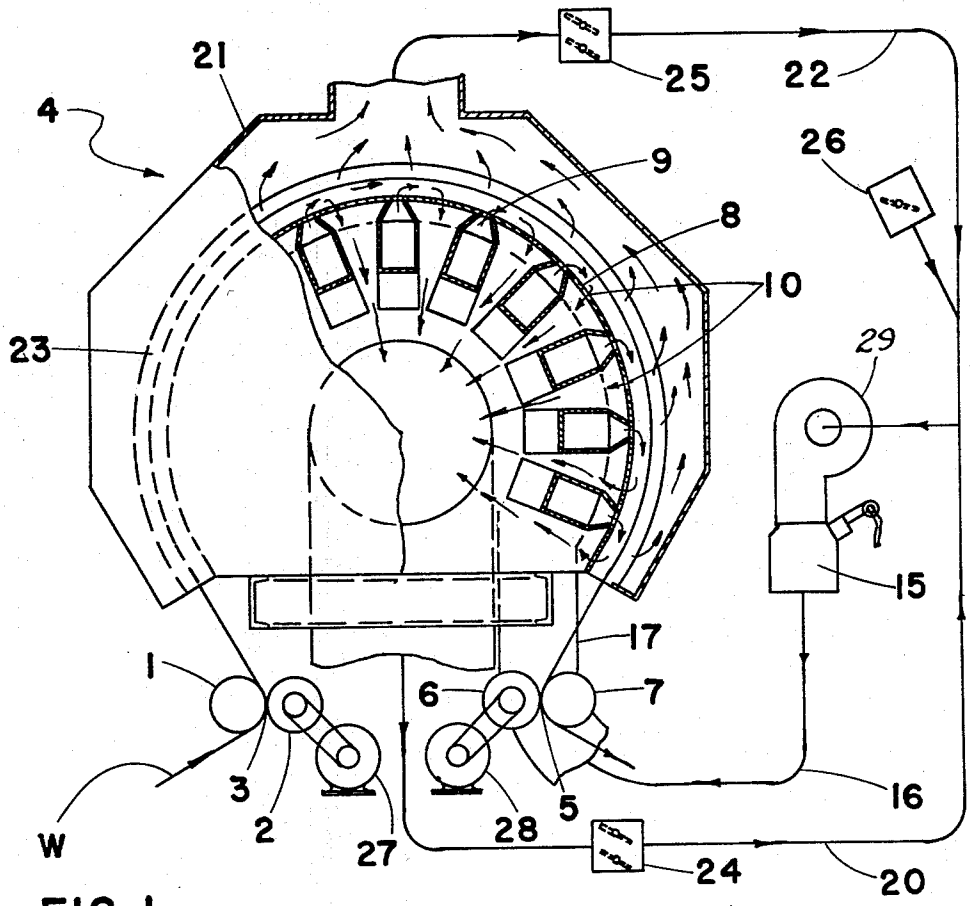


FIG 1

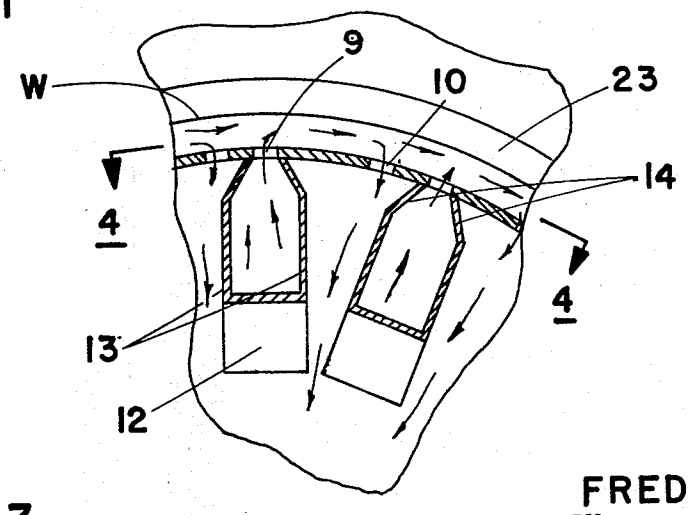


FIG 3

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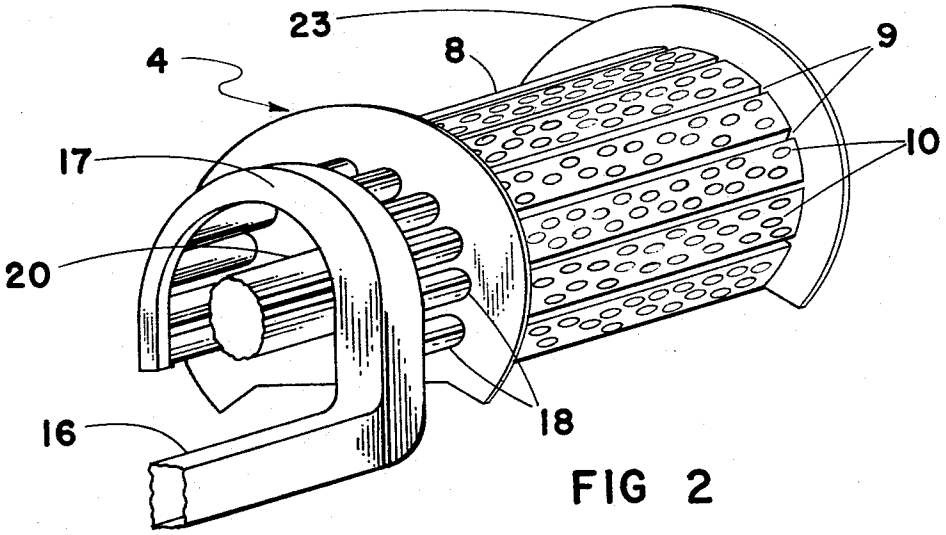


FIG 2

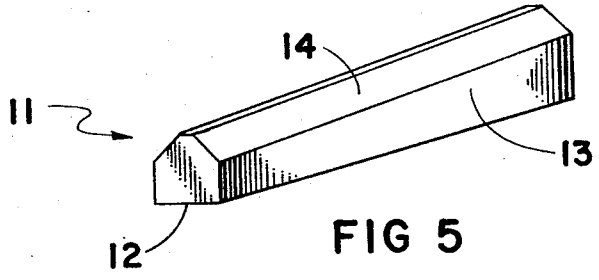


FIG 5

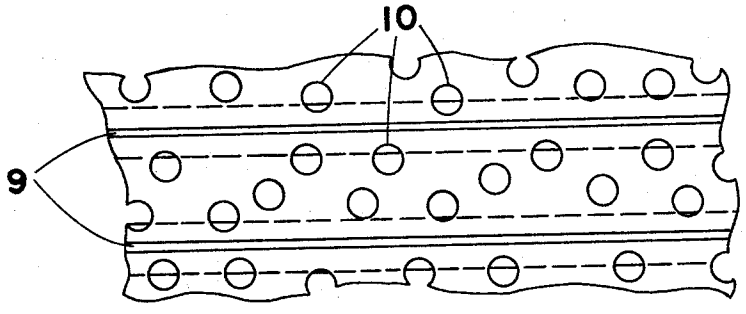


FIG 4

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3,279,091

Patented Oct. 18, 1966

3,279,091

APPARATUS FOR DRYING A MOVING WEB OVER A NON-ROTATING SHELL

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Filed Dec. 23, 1963, Ser. No. 332,779
4 Claims. (Cl. 34—156)

This invention relates to a method of drying a continuously moving web, free of cross direction restraint, and an apparatus for its practice.

Certain continuously formed webs, particularly paper webs, contain a high percentage of moisture immediately after their initial formation and must be subjected to a series of operations designed to remove a major portion of this moisure and obtain a stable, finished product. In removing this moisture, there is a tendency for the webs to shrink; and if allowed to occur, this shrinkage greatly enhances the ability of the finished web to resist rupture. This results because the amount of stress which a web will withstand before bursting is increased by its ability to stretch, and this ability to stretch is directly proportional to the amount of shrinkage which occurs in the web as it dries.

The usual method used in drying continuously formed webs is to pass the moving web around a rotating heated drum; the heated surface of the drum heating the web as they come into contact and driving a portion of the moisture from the web. Unfortunately, in this type of dryer, as the moisture is driven from the web, the tendency of the web to shrink is resisted by the friction between the drum surface and the web and only negligible shrinkage occurs.

A second method utilized in drying moving webs consists in passing the web along a long horizontal path while subjecting the web to jets of air from both sides. In this method, the web is usually either carried by an endless foraminous belt or supported by jets of air impinging on its lower surface. Both of these modifications are subject to the disadvantage that they require large areas to accommodate the long horizontal path necessary to effect appreciable drying. Further, where an endless belt is used to support the web, undesirable, shrinkage-inhibiting, friction between the belt and the web occurs; while supporting the web between jets of air generally results in an unstable condition causing wrinkles, web breaks, and excessive noise.

Applicant has overcome these disadvantages of prior art methods by devising a method and an apparatus wherein the moisture containing web is dried, free from cross direction restraint but under a balanced system of tensile forces, while the web is transported in a non-planar path. In carrying out his method, applicant uses a non-rotating, cylindrical shell of less than circular extent having a series of elongated slots formed in its outer surface and means forming an incoming or feed nip at one side of the shell and an outgoing nip at the other side thereof. A wet web is passed through the incoming or feed nip, around the shell and thence, through the outgoing nip. As the web passes around the shell, elongated jets of air impinge on its lower surface, maintaining it out of contact with the cylindrical shell while drying the web free from transverse restraint. In order to insure that the pressure imposed on the web as it passes through the incoming nip is not effective during the drying cycle, this nip is spaced from the beginning of the drying run a distance equal to at least a certain percentage of the width of the web. Further, the tension imposed on the web longitudinally thereof by the pull of the outgoing nip, the resistance to this pull exerted by the feed nip, and the pressure exerted on the web by the air jets, form a balanced system of

tensile forces which greatly enhances the stability of the moving web. Although the web is thus, under a limited amount of tension longitudinally thereof, some shrinkage may still occur in the direction of web travel. To account for this shrinkage, maintain a substantially constant space between the web and the surface of the dryer, and prevent excessive longitudinal tension in the web, the linear speed of the web as it passes through the outgoing nip may be regulated so as to be somewhat slower than its speed as it passes through the feed nip.

An advantage of the present invention is that shrinkage of the web as it dries is not inhibited by frictional contact with a supporting surface.

Additionally, because of its curved configuration, the long planar runs required by some prior art dryers is obviated with resultant savings in space.

Also, due to the fact that the web is maintained in tension longitudinally thereof by a balanced system of forces, vibration of the drying web is substantially eliminated along with the consequent web wrinkling, tearing, and excessive noise.

Further, because of its size and shape, the dryer of the present invention may be readily substituted for one or more conventional dryers of the heated drum type, thereby rendering the modification of existing installations relatively simple to attain.

These and other advantages and features of the invention will become apparent from the following description wherein:

FIGURE 1 is an end view of the dryer, in elevation, with portions broken away to more clearly show details thereof;

FIGURE 2 is a perspective view of the dryer with parts removed to more clearly show certain features of the air delivery and exhaust systems;

FIGURE 3 is an enlarged fragmentary sectional view of the dryer showing the cross-sectional configuration of certain elements thereof;

FIGURE 4 is a sectional view, taken on line 4—4 of FIGURE 3, and showing the configuration and arrangement of the air delivery slots and exhaust apertures; and

FIGURE 5 is a perspective view of a single nozzle chamber.

Referring more particularly to the drawings, in FIGURE 1 there is shown the apparatus of the present invention comprising rollers **1** and **2** forming an incoming or feed nip **3**, a drying section, indicated generally by the reference numeral **4**, and an outgoing nip **5** formed by the rollers **6** and **7**. While members **1**, **2**, **6**, and **7** are shown as simple rollers for purposes of illustration, it will be apparent that they may take the form of conventional drum dryers in a drying run.

The drying section **4**, as shown in FIGURES 1 and 2, is provided with a shell **8** of arcuate cross-sectional configuration extending in an arc of less than 360° but more than 180°. Formed in the surface of cylindrical shell **8** are a series of openings **9** and **10** for the delivery and exhaust, respectively, of heated, drying air.

Referring to FIGURES 2 and 4, it will be seen that openings **9** take the form of elongated slots extending axially of the dryer section in spaced parallel relation. Intermediate each pair of elongated slots **9**, apertures **10** are randomly distributed to provide an exit or exhaust path for the heated air delivered through slots **9**. Nozzle chambers **11**, tapered longitudinally throughout their extent, are provided for each slot **9** for the delivery of heated, drying air therethrough. Each nozzle chamber **11**, as best seen in FIGURES 3 and 5, comprises a base wall **12**, side walls **13** and inwardly extending walls **14**. The terminal portions of the walls **14** are spaced apart to provide an exit from the chamber **11** in communication with

the slots 9. In order to insure an air flow of substantially constant pressure through each slot 9 throughout its length, the side walls 13 of the nozzle chambers 11 are tapered from a largest dimension adjacent the entry to each chamber, seen at the right hand side of FIGURE 5, to a smallest dimension adjacent the opposite end.

A fan 29 drives air through a heating unit 15 and a connecting duct 16 to a manifold 17 of curvilinear configuration. At spaced intervals around the manifold, conduits 18 tap off heated air for delivery under pressure to the nozzle chambers 11. The manifold 17, as best seen in FIGURE 2, is tapered from a largest dimension adjacent the connecting duct 16 to a smallest dimension adjacent its opposite end to insure the delivery of air at a substantially constant pressure to each of the nozzle chambers 11.

Connected adjacent one end of the dryer section 4 is an exhaust duct 20 in communication with the hollow interior of dryer section 4. Air passing through apertures 10 is collected in the interior of the dryer section and is carried off by the exhaust duct 20 and thence, back to fan 14 for reheating and recirculation.

At each end of the cylindrical shell 8, upstanding guide flanges 23 extend coextensive with, and with their outer edges in parallel relationship to the curved surface of cylindrical shell 8. As will presently be seen, this construction not only serves to maintain the moving web centered on the drying section 4 but tends to equalize the pressure beneath the web transversely thereof.

While the major portion of the heated air passes through apertures 10 and exhaust duct 20, a smaller percentage will ordinarily be allowed to escape to the atmosphere. If it is deemed desirable for purposes of economy to collect these gases for recirculation, auxiliary exhaust means may be provided in accordance with the present invention. As seen in FIGURE 1, this auxiliary exhaust system may take the form of a polygonal hood 21, surrounding and approximating the contour of the dryer section 4. Attached adjacent the top of hood 21, a hood duct 22 may be provided for withdrawing air collected in the hood for recirculation to the fan 14. Optionally, the exhaust hood and its associated equipment may be dispensed with for easier access to the dryer section 4.

Dampers 24 and 25 may be provided in ducts 20 and 22, respectively, if desired, to control the flow of air through these two lines. Alternatively, the air flow through ducts 20 and 22 may be controlled by exhaust fans or simply made dependent on the output of fan 14. A fresh air supply regulator 26 may also be provided to control the supply of fresh air to fan 14 to compensate for air lost during circulation.

In operation, the web W, as seen in FIGURE 1, passes through the nip 3 formed by members 1 and 2 in the direction indicated by the arrows, thence, to the dryer section 4, around dryer section 4, and through the nip 5 formed by members 6 and 7. As the web travels in a curved path about the dryer section, air is pumped from fan 14, through heater 15 and connecting duct 16 to manifold 17. The heated air delivered to manifold 17 is tapped off at intervals along the manifold by conduits 18 for delivery to nozzle chambers 11 in communication with elongated slots 9. Because of its tapered configuration, the air pressure at all points along the manifold 17 is substantially equal, thereby insuring equal distribution through each of the conduits 18. Similarly, nozzle chambers 11, being tapered from a largest dimension adjacent conduits 18 to a smallest dimension adjacent their opposite ends, insure that the air pressure in the chambers will be substantially equal at all points along their length; thereby providing a substantially constant air flow at all points along elongated slots 9. The heated air, at temperatures of from 400°–650° F., issues from the slots 9 in the form of elongated jets having a velocity of from 12,000–20,000 f.p.m. and impinges on the bottom surface of the moving web W, simultaneously drying it and supporting it out of contact with the cylindrical shell 8. It has been found that the greatest rate of shrinkage occurs as the web dries from 50%–10% moisture content. Therefore, the web, as it passes over the dryer is preferably dried between these limits. In order to insure that the moisture content of the web is reduced the desired amount during passage around the arcuate shell, the speed of web travel, the velocity of the heated air and the temperature of the air may be varied as appears necessary. After contact with the web, the major portion of the drying air passes through exhaust apertures 10 into the hollow interior of dryer section 4 and is drawn off by exhaust duct 20 back to fan 14. In order to promote flow through the apertures 10 and prevent excessive pressure between the web and the shell 8, the total area of the exhaust apertures is preferably at last as great as the total area of slots 9. Upstanding guide flanges 23 serve to maintain web W centered over shell 8 as the elongated jets of drying air are directed against the undersurface of the web. More importantly however, flanges 23 act as boundaries to retard the flow of air around the edges of the moving web. By thus limiting edge flow to a minimum, the air pressure at all points across the web is maintained substantially constant, resulting in greater web stability and more uniform drying.

While edge flow is thus, greatly limited, it is not completely eliminated, and if it is desired to return this flow, and any flow through the web itself, to the fan 14, this may be accomplished through the use of an auxiliary exhaust system as previously described. The pattern of air flow described above is represented in FIGURES 1 and 3 by the small arrows.

Referring again to FIGURE 1, it will be noted that separate drive means 27 and 28 are provided for pairs of rollers 1 and 2 and 6 and 7, respectively. As mentioned previously, shrinkage may occur to some extent longitudinally of the web as it passes through the dryer. To compensate for this decrease in length between nips 3 and 5, the linear speed of the web W may be decreased as it moves through nip 5 by regulating the speed of drive means 27 and 28 relative to each other. This may be done manually or through the use of a control system (not shown) responsive to signals from a conventional sensing mechanism, such as a photoelectric device, measuring the distance between web W and shell 8. Thus, the pull exerted by the nips 3 and 5 and the pressure exerted on the undersurface of the web by the air jets forms a balanced system of forces. By maintaining the pressure on the web undersurface substantially constant by means of the tapered manifold and nozzle chamber, elongated slots 9 and flanges 23, this balance is maintained and instability in the web, along with consequent web wrinkling and breaks and excessive noise is substantially eliminated.

As the web passes through the nip 3, the pressure exerted by the nip will cause a cross direction restraint on the web. This restraint, though imposed at only one localized area, will be effective for a certain distance downstream of the nip 3. Applicant has found that this nip restraint will be evidenced up to a distance of about .65 of the width of the web downstream from its point of application. Thus, in order to obtain the maximum rate of shrinkage possible with a given air flow, temperature and drying area, the incoming or feed nip should be spaced from the beginning of the drying zone a distance of, approximately, at least .65 of the web width.

From the foregoing it will be apparent to those skilled in the art that applicant has devised a method and apparatus for its practice which permits stable, restraint free drying of a continuous moving web with consequent web shrinkage and enhanced strength qualities. While a specific embodiment has been disclosed, it is to be understood that various changes may be made within the scope of the appended claims.

I claim:

1. Apparatus for drying a moving web comprising:

(a) A non-rotating, arcuate shell,

(b) portions of said shell defining elongated slots extending axially of said shell throughout substantially the entire length thereof,
(c) other portions of said shell defining apertures intermediate said elongated slots,
(d) a plurality of nozzle chambers,
(e) said nozzle chambers being tapered from a largest cross-sectional area adjacent one end of a smallest cross-sectional area adjacent their opposite end,
(f) portions of said nozzle chambers defining exits extending longitudinally of said nozzle chambers,
(g) said nozzle chambers extending axially of said arcuate shell with the elongated slots of said shell and the exits of said nozzle chambers being in substantial registration,
(h) a manifold of curvilinear configuration,
(i) said manifold extending generally parallel to said arcuate shell,
(j) said manifold being tapered from a largest cross-sectional configuration adjacent one end to a smallest cross-sectional configuration adjacent its opposite end,
(k) said nozzle chambers each communicating with said manifold adjacent said one end of said nozzle chambers,
(l) an exhaust duct in communication with the interior of said arcuate shell,
(m) means for delivering heated air to said one end of said manifold, and

(n) means for withdrawing exhaust air through said exhaust duct.

2. The apparatus of claim 1 wherein:
the total area of said aperture is substantially equal to the total area of said elongated slots.

3. The apparatus of claim 1 further comprising:
(a) upstanding flanges adjacent each end of said arcuate shell,
(b) a first nip adjacent said shell,
(c) said first nip being spaced from said shell a distance equal to at least .65 of the axial length of said shell, and
(d) a second nip extending in spaced parallel relation to said first nip.

4. The apparatus of claim 3 further comprising:
(a) means for driving said first nip at a first speed, and
(b) means for driving said second nip at a speed slower than said first speed.

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