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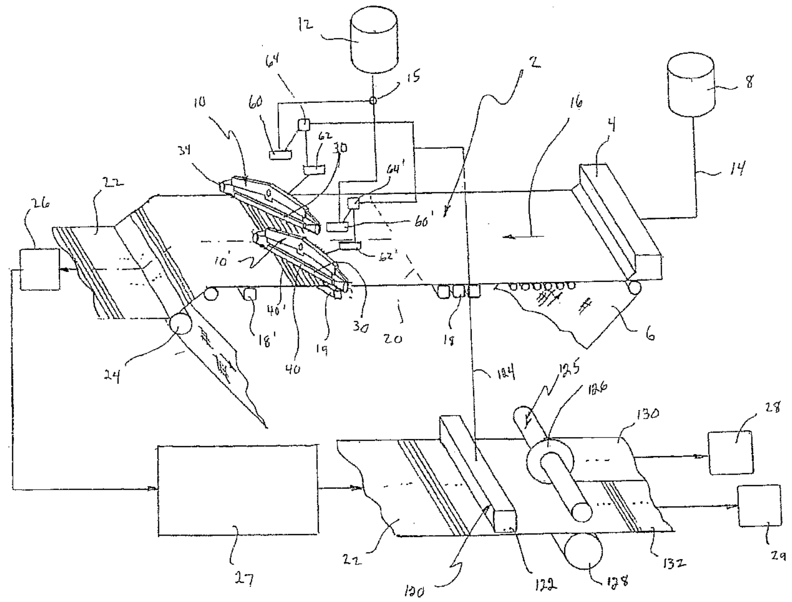
(54) **Title:** METHOD AND APPARATUS FOR APPLYING A MATERIAL TO A WIDE HIGH-SPEED WEB



(57) **Abstract:** A high-speed apparatus (2) for applying material to cigarette paper during manufacture uses at least two independently operable, moving orifice devices (10,10') , each positioned to deposit horizontal bands of material on a paper web (22) at the dry end of a Fourdrinier wire (6). The resulting web may be cut into multiple webs, each web having a width corresponding to the effective width of a moving orifice device. The apparatus can simultaneously produce both banded and unhanded paper for wrapping tobacco during cigarette manufacturing.

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METHOD AND APPARATUS FOR APPLYING A MATERIAL TO A WIDE HIGH-SPEED WEB

BACKGROUND OF INVENTION

The present invention relates to method and apparatus for applying a predetermined pattern of add-on material to a base web, preferably in the form of bands, and more particularly, to a high-speed method and apparatus for producing cigarette papers having banded regions of additional material.

SUMMARY

A method and apparatus are disclosed for the high-speed production of a web having banded regions of add-on material, more particularly a cigarette paper having stripes of additional cellulosic material added thereto. The method includes the steps of: preparing a first slurry of fibrous material and liquid and delivering that slurry to a moving wire of a paper-making machine, and draining liquid from the first slurry to form a fibrous web advancing at a first nominal linear speed. A second slurry of add-on material is prepared and delivered to at least one of a plurality of distribution devices, each having a moving belt with one or more orifices. The belt moves such that its velocity component in the direction of web movement is substantially the same as the nominal linear speed of the web. The second slurry is deposited as transverse stripes on the web through the orifice(s), with the length of each stripe corresponding to the width of the associated distribution device projected onto the transverse dimension of the web. After drying, the web may be divided or split into two or more narrower webs for subsequent use. The transverse stripes of the dry web may be optically inspected to evaluate width and spacing characteristics so that operation of the distribution devices can be dynamically adjusted to provide uniform width and spacing of the transverse stripes on the web.

The disclosed apparatus includes at least two applicators for applying a pattern of add-on material to the web produced by a paper-making machine. Each applicator is positioned at an angle to the direction of web movement so that each applicator covers a corresponding portion of the web width. Each applicator further

includes a continuous belt movable so as to regulate communication between a reservoir for add-on material and the top of the web. The continuous belt of the applicator is operable so that the component of its velocity parallel to the web surface in the direction of the web movement corresponds to the linear velocity of the web movement and each orifice deposits a transverse stripe on the web. The apparatus further includes means for selectively operating each of the applicators so that the pattern of stripes can be applied to the entire width of the web or to a portion of the width.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a paper-making machine constructed in accordance with a preferred embodiment;

FIG. 2 is a perspective view of a paper constructed in accordance with the methodologies and apparatus of the preferred embodiment;

FIG. 3 is a perspective view of a cigarette constructed with the paper of FIG. 2;

FIG. 4 is a side view of the moving orifice applicator constructed in accordance with the preferred embodiment;

FIG. 5 is a breakaway perspective view of the applicator of FIG. 4;

FIG. 6 is a top planar view of tracking control system of the applicator as viewed in the direction of the double pointed arrow B--B in FIG. 5;

FIG. 7 is a cross-sectional view of the chamber box taken at line VII--VII in FIG. 4;

FIG. 8 is a detail perspective view of the endless belt of the applicator shown in FIG. 4; and

FIG. 9 is a detail, partial sectional view of an alternate embodiment of a chamber box of the applicator of FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Existing paper-making machine installations do not have identical proportions, sizes, running speeds, and the like. To use such machines for making banded cigarette paper, the band applying apparatus must fit in within the existing physical arrangement to avoid significant additional capital investments. Moreover, occasions exist where cigarette paper machines are needed to produce not only banded paper but also unbanded paper. When a moving orifice device applies the add-on material to a web, the applicator offset angle becomes small for wider machines, which requires that the applicator operate at speeds that can be multiples of the nominal wire speed of the paper-making machine. When the paper-making machine operates at speeds of 7.5m/s (1500 ft./min) and above, the speed requirement for the applicator may cause non-uniformity of band width and non-uniformity of band spacing. Furthermore, current paper inspection techniques for banded paper commonly occur after the paper-making operation has been completed.

Referring to FIG. 1, a preferred embodiment comprises a cigarette paper making machine 2 which is operable to manufacture banded paper 3 (see FIG. 2) having uniform width bands 5 spaced from one another. Such banded paper 3 can be used in the manufacture of cigarettes (see FIG. 3) where the bands 5 comprise regions designed to self-extinguish the cigarette. The paper making machine 2 (FIG. 1) preferably includes a head box 4 operatively located at one end of a Fourdrinier wire 6, a feed stock slurry is prepared and delivered to a source of feed stock slurry such as a run tank 8 in communication with the head box 4. The machine 2 also includes at least two distribution devices, such as moving orifice applicators 10, 10', in operative communication with source of prepared add-on slurry such as a day tank 12.

The head box 4 can be one typically utilized in the paper making industry for laying down cellulosic pulp upon the Fourdrinier wire 6. In the usual context, the head box 4 communicates with the run tank 8 through a plurality of conduits 14. Preferably, the feed stock from the run tank 8 constitutes a refined cellulosic pulp such as a refined flax or wood pulp as is the common practice in the cigarette paper-making industry. That pulp normally constitutes a mixture of water, fibers, and additives including fillers such as chalk.

The Fourdrinier wire 6 moves in a longitudinal direction, has a width transverse to that longitudinal direction, and operates at a generally constant nominal linear speed. The first slurry from the run tank 8 is delivered through the head box 4 to the moving Fourdrinier wire 6.

The Fourdrinier wire 6 carries the laid slurry pulp from the head box 4 along a path in the general direction of arrow 16 in FIG. 1. As the wire 6 advances, liquid water drains from the pulp through the wire 6 under the influence of gravity to form a fibrous web. Vacuum boxes 18 may be provided at some locations along the Fourdrinier wire 6 to assist in removal of water from the slurry, as is the established practice in the art of cigarette paper-making. At some point along the Fourdrinier wire 6, sufficient water has drained and/or been removed from the base web pulp to establish what is commonly referred to as a dry line 20. At the dry line 20, the texture of the slurry transforms from one of a glossy, watery appearance to a surface appearance more closely approximating that of the finished base web (but in a wetted condition). At about the dry line 20, the moisture content of the pulp material is approximately 85 to 90%, which may vary depending upon operating conditions and the like. The surface of the web 22 is generally planar and is supported by the Fourdrinier wire 6.

Downstream of the dry line 20, the base web 22 separates from the Fourdrinier wire 6 at a couch roll 24. From there, the Fourdrinier wire 6 continues on the return loop of its endless path. Beyond the couch roll 24, the base web 22 continues on through the remainder of the paper making system including the drying section 27 which further dries and presses the base web 22 and surface conditions it to a desired final moisture content and texture. Such drying apparatus are well known in the art of paper making and may include drying felts 26 and the like.

At the very end of the paper-making machine, suitable conventional reeling apparatus 28, 29 is provided to collect the paper onto spools for subsequent processing and/or use. Such reeling apparatus 28, 29 is well known in the art of paper making.

During the paper-making process, it is sometimes desirable to apply a pattern to the web before the web is dried so that the pattern becomes part of the paper web itself rather than a surface treatment such as, for example, printing. A preferred pattern comprises a plurality of uniformly spaced, transverse bands on the base web. The bands may, for example, comprise an add-on material useful in affecting combustibility of the resulting paper web. Materials used to accomplish self-extinction of cigarettes are candidates for such patterns.

Paper-making apparatus currently used for making cigarette paper differ in many ways. Paper-making machines vary in terms of the transverse width of the Fourdrinier wire 6, the nominal speed of the Fourdrinier wire 6, longitudinal spacing between the headbox 4 and the couch roll 24, and longitudinal spacing between the dry line 20 and the couch roll 24, to name just a few. For example, paper-making apparatus may have wire widths ranging from less than 3 meters to greater than 5 meters. Similarly, machines may have Fourdrinier wire operating at linear speed less than 120m/s (400 ft./sec). to greater than 450m/s (1500 ft./sec). For purposes of this description, widths greater than 3 meters are considered wide and linear speeds exceeding 150m/s (500 ft./min) are considered high speed.

Processes and apparatus for applying patterns of add-on material to a web at the wet end of a paper-making machine are preferably to adaptable to accommodate idiosyncrasies of existing machine installations. To apply add-on material to wide and high speed paper-making machines, a plurality of distribution devices are used that apply a pattern of bands in zones across a base web. Each of the distribution devices can incorporate features of a moving orifice applicator for add-on material is described in commonly assigned US 5 997 691, issued December 7, 1999 to Gautam *et al.*, which is hereby incorporated herein by this reference thereto.

With reference to FIG. 1, two or more applicators, such as the moving orifice applicators 10, 10', are provided between the dry line 20 and the couch roll 24 to apply separate patterns of add-on material to the web 22. Each applicator is operable to apply the pattern to a corresponding portion of the width of the web. The applicators 10, 10' may be parallel to one another and offset as shown. The applicators 10, 10' may also be offset from one another longitudinally along the Fourdrinier wire 6 as necessary to accommodate existing obstructions in the site for the paper-making machine. The applicators 10, 10' may be positioned at the same or different angles with respect to the longitudinal direction of the machine, if desired.

Since the required length of such a moving orifice applicator 10, 10' is a function of (i) the width of the web, (ii) the longitudinal speed of the paper-making machine, and (iii) the angle between the applicator and the longitudinal direction at which the web advances along the Fourdrinier wire, the use of multiple applicators reduces the physical length needed along the Fourdrinier wire by the reciprocal of the number of applicators used. Thus, multiple applicators can be used to obviate limitations that might otherwise be imposed by the above-noted physical characteristics of paper-making machines.

An applicator offset angle can be defined as the acute angle between the longitudinal direction of movement of the Fourdrinier wire and angled direction of movement of the belt of the moving orifice device. Alternatively the applicator offset angle can be defined as the complement to the acute angle between the longitudinal direction of the machine and the plane within which the edge of the moving orifice belt operates. For low values of the applicator offset angle, the linear speed of the moving orifice belt becomes a multiple of the nominal linear speed of the Fourdrinier wire. For example, at an applicator offset angle of 30°, the belt speed is twice the nominal linear wire speed; for an applicator offset angle of about 19.5°, the belt speed is three times the nominal linear wire speed; and for an applicator angle of about 14.5°, the belt speed if four times the nominal linear wire speed. High-speed paper-making machine installations operate at nominal linear speeds of 420m/s to 450m/s (1400 ft/sec to 1500 ft/sec). At the required band speeds for low applicator offset angles, fluid mechanics characteristics of the add-on material and physical limitations of the applicator operation can combine to cause splatter and/or insufficient uniformity in the deposited pattern. Multiple applicators 10, 10′ can be employed allowing the applicator offset angle for each applicator to be increased thereby reducing the belt speed to acceptable levels so that splatter is avoided and the deposited pattern is uniform.

Moreover, where the applicators 10, 10′ are selectively operable, i.e., they can be used simultaneously, separately, or turned off, and the paper-making operation can produce a banded pattern across the web, a banded pattern on only a portion of the web, or unbanded paper across the web. For example, where both banded paper and non-banded paper are needed simultaneously for cigarette manufacture, the paper-making machine 2 can be operated with one of the two applicators 10, 10′ operating and the other applicator being idle. In this way, half the resulting cigarette wrapper product can be banded and the other half unbanded.

Details of the moving orifice applicator 10 will now be described. It will be understood by those of ordinary skill in the art that the details of each additional moving orifice applicator 10′ are substantially the same, with the possible exception of length. Referring now to both FIGS. 1 and 4, add-on slurry from the day tank 12 is delivered to the moving orifice applicator 10. Preferably, the moving orifice applicator 10 comprises an elongate chamber box 30 for establishing a reservoir of add-on slurry in an oblique relation across the path 16 of the Fourdrinier wire 6. That reservoir receives the add-on slurry from the day tank 12. The moving orifice applicator 10 also includes an endless continuous perforated steel belt 32, whose pathway is directed about a drive wheel 34 at the downstream end of the applicator, a guide wheel 36 at the apex of the moving orifice applicator 10, and a follower wheel 38 at the upstream end of the chamber box 30, i.e., opposite from the drive wheel 34. Upstream and downstream are viewed as being relative to movement of the Fourdrinier wire 6 and the web 22.

The endless belt 32 moves through a bottom portion of the chamber box 30 and, as it leaves the chamber box 30, the belt 32 moves through a cleaning box 42. Then, the belt 32 moves toward the drive wheel 34 and continues along the remainder of its circumlocution.

The belt 32 (see FIG. 8) preferably has a plurality of orifices spaced uniformly along the length thereof. As each perforation or orifice 44 (FIG. 8) of the belt 32 passes through the bottom portion of the chamber box 30, the orifice 44 communicates with the reservoir of add-on slurry established in the chamber box 30. At such time, a stream 40 (FIG. 4) of add-on slurry discharges from the orifice 44 as the orifice 44 traverses the length of the chamber box 30. The discharge stream 40 impinges upon the base web 22 passing beneath the moving orifice applicator 10 so as to deliver or create a transverse band of additional (add-on) material upon the base web 22. The operational speed of the belt 32 varies from one layout to another, but by way of example, the belt 32 is driven at approximately 1111 feet per minute when the Fourdrinier wire moves at approximately 500 feet per minute and the chamber box 30 is oriented with an offset angle of 27° relative to the direction of the wire. The spacing of the orifices 44 along the belt 32 and the operational speed of the belt 32 are selected such that a plurality of streams 40, 40' emanate simultaneously from beneath the chamber box 30 during operation of the moving orifice application. Because of the oblique orientation of the moving orifice applicator relative to the path 16 of the base web 22 and the relative speeds of the Fourdrinier wire 6 and the endless belt 32, each stream 40 of add-on material will create a band of add-on material upon the base web 22, where the band has a length corresponding to the operational length of the moving orifice applicator 10. That operational length is the length in the direction transverse of the wire 6 through which the orifice 44 can deposit add-on material. At the above speeds and angle, the moving orifice applicator 10 will repetitively generate or deposit transverse bands of add-on material that are oriented normal to a longitudinal edge of the base web 22 and uniformly spaced from one another along the web 22. In combination, the multiple applicators 10, 10′ are operable to deposit aligned or offset bands substantially across the entire width of the Fourdrinier wire 6. If desired, the angle and/or relative speeds may be altered to produce bands which are angled obliquely to the edge of the base web 22.

After the belt 32 exits from the chamber box 30, the portions of the belt 32 adjacent each orifice 44 are cleansed of entrained add-on slurry at the cleaning station 42. The belt 32 and each associated orifice then proceed along the circuit of the endless belt 32 to reenter the chamber box 30 to repeat an application of a band upon the base web 22.

Referring particularly to FIG. 1, the moving orifice applicator 10 is preferably situated obliquely across the Fourdrinier wire 6 at a location downstream of the dry line 20 where condition of the base web 22 is such that it can accept the add-on material without the add-on material dispersing itself too thinly throughout the local mass of the base web slurry. The applicator 10 is uniformly spaced above the web 22 such that the stream 40, 40′ of add-on material emanating from the orifices 44 falls through the same distance between the applicator 10 and the planar upper surface of the web 22. At that location of the applicator 10, the base web 22 retains sufficient moisture content (approximately 85 to 90%) that the add-on slurry is allowed to penetrate (or establish hydrogen bonding) to a degree sufficient to bond and integrate the add-material to the base web 22.

Preferably, a vacuum box 19 located beneath the chamber box 30 of the moving orifice applicator 10 extends coextensively with the applicator providing local support for the Fourdrinier wire 6 as well as facilitating the bonding/integration of the add-on slurry with the base web 22. The vacuum box 19 is constructed in accordance with designs commonly utilized in the paper making industry (such as those of the vacuum boxes 18) The vacuum box 19 operates at a relatively modest vacuum level, preferably at approximately 60 inches of water or less. Optionally, additional vacuum boxes 18' may be located downstream of the moving orifice applicator 10 to remove the additional quantum of water that the add-on slurry may contribute. It has been found that much of the water removal from the add-on material occurs at the couch roll 24 where a vacuum is applied of approximately 560mm to 640mm (22 to 25 inches) mercury.

The moving orifice applicator 10 is supported in its position over the Fourdrinier wire 6 in a suitable conventional way so that the moving orifice applicator 10 may be lowered consistently to a desired location above the Fourdrinier wire 6, preferably such that the bottom of the chamber box 30 clears the base web 22 on the Fourdrinier wire 6 by approximately one to two inches, preferably less than 40mm (1.5 inch).

Preferably, the chamber box 30 has a length selected such that the chamber box 30 covers a portion of the width of the web 22, measured transverse to the paper-making machine. The multiple applicators 10, 10′ are arranged such that the adjacent ends of their respective chamber boxes 30 lie above a common longitudinal line in the web 22 so that transverse bands of adjacent applicators 10, 10′ do not overlap. The applicators 10, 10′ are also arranged such that the outermost end of the applicator adjacent to the corresponding web edge extends beyond the edge of the base web 22. When there are three or more applicators, the edges of the outermost applicators have an overlapping relationship with the web edges. Ends of interior applicators can overlap or not overlap in the transverse direction across the base web. The over-extension of the chamber boxes 30 at the web edges assures that any fluid discontinuities existing or arising at the end portions of the chamber box 30 do not affect the discharge streams 40 as the streams 40 deposit add-on material across the base web 22. By such arrangement, any errant spray emanating from the ends of the chamber box 30 occurs over edge portions of the base web 22 that are trimmed away at or about the couch roll 24. Likewise, overlapping or non-overlapping of the bands across the base web can be trimmed to provide continuous reels of uniformly banded paper.

The vertical support framework for the moving orifice applicators 10, 10′ may be pivotal about the other so as to adjust applicator offset angle for the applicators 10, 10′ relative to the Fourdrinier wire 6. However, the preferred practice involves fixing the vertical support framework and only adjusting the speed of endless belt 32 in response to changes in operating conditions of the paper making machine 2.

The chamber box 30 receives add-on slurry from the day tank 12 at spaced locations along the chamber box 30. The reservoir of the chamber box 30 may also include a plurality of linearly arranged compartments through which the endless belt 32 passes. Uniform pressure is preferably maintained along the length of the chamber box 30 by the interaction of a flow distribution system 60, a pressure monitoring system 62 and a programmable logic controller 64 such that the pumping action of the belt 22 and other flow disturbances along the length of the chamber box 30 are compensated locally and continuously to achieve the desired pressure uniformity throughout the length of the chamber box 30. A main circulation pulp 15 delivers add-on slurry from the day tank 12 to the flow distribution system 60.

Details regarding how the controller initiates and maintains uniform pressure along the chamber box 30 are known, see, *e.g.*, commonly assigned US 5 997 691.

A selectable speed motor drives the drive wheel 34 and is operatively connected therewith by a suitable conventional drive belt. Preferably, the motor is supported by the framework of the moving orifice applicator 10, and both the motor and the drive belt are encased within a housing so as to capture any extraneous material (such as bits of slurry) that may find its way to and be otherwise flung from the drive system for the drive wheel 34.

The drive wheel 34 is advantageously positioned at the downstream end of the chamber box 30 along the pathway of the belt 32 so that the belt 32 is pulled through the chamber box 30. A significant degree of the directional stability is achieved by the close fit between the belt 32 and the elongate chamber box 30 throughout the length of the box 30. However, precise control of the tracking for the belt 32 about its pathway circuit is effected by placement of an infrared proximity sensor 54 at a location adjacent the guide wheel 36. The infrared proximity sensor 54 comprises an emitter 56 and a sensor 58 which are mutually aligned relative to one of the edges of the belt 32 such that if the belt strays laterally from its intended course, a signal from the sensor is affected by a relative increase or decrease in the interference of the edge with the emitter beam. A controller 59 communicates with the sensor 58, interprets changes in the signal from the sensor 58 and adjusts the yaw of the guide wheel 36 about a vertical axis so as to return the edge of the belt 32 to its proper, predetermined position relative to the beam of the emitter 56.

Referring now also to FIG. 6, the guide wheel 36 rotates about a horizontally disposed axle 36a, which itself is pivotal about a vertical axis at a pivotal connection 57 by the controlled actuation of a pneumatic actuator 61 The actuator 61 is operatively connected to a free end portion 36*b* of the axle 36*a* and is responsive to signals received from the controller 59. Preferably, both the pivotal connection 57 and the actuator 61 are fixed relative to the general framework of the applicator 10 during operation the applicator 10; and a connection 54*a* is provided between the sensor 54 and the free end 36*b* of the axle 36*a* so that the sensor 54 rotates as the yaw of the guide wheel 36 is adjusted. The connection 54*a* assures that the sensor 54 remains proximate to the edge of the belt 32 as the guide wheel 36 undergoes adjustment.

Preferably, the actuator 61 and the pivotal connection 57 are affixed on a plate 39*a* which is vertically displaceable along fixed vertical guides 39*b* and 39*c*. Preferably, releasable, vertical bias is applied to the plate 39*a* so as to urge the guide wheel 36 into its operative position and to impart tension in the endless belt 32.

Along the return path of the endless belt 32, from the drive wheel 34 over the guide wheel 36 and back to the follower wheel 38, the belt 32 is enclosed by a plurality of housings, including outer housings 68, 68' and a central housing 70 which also encloses the infrared proximity sensor 54 and the controller 59 of the tracking system 55. The housing 68, 68' and the housing 70 prevent the flash of errant slurry upon the base web 22 as the belt 32 traverses the return portion of its circuit.

Referring particularly to FIG. 4, the housings 70 and various other components of the applicator 10 (such as the wheels 34, 36 and 38; the chamber box 30; the cleaning box 42; and the motor 52) are supported by and/or from a planar frame member 72. The planar frame member 72 itself is attached at hold-points 73, 73' to a cross-member (an I-beam, box beam or the like), which cross-member is supported by the vertical support framework. In the alternative, an I-beam member or a box beam member may be used as a substitute for the frame member 72, with the chamber box 30 and other devices being supported from the beam member.

Referring to FIG. 5, in either support arrangement, the chamber box 30 is preferably hung from the support member with two or more, spaced apart adjustable mounts *77a*, *77b* that permit vertical and lateral adjustment (along arrows *y* and *x* in FIG. 5, respectively) of each end of the chamber box 30 so that the chamber box 30 may be accurately leveled and accurately angled relative to the Fourdrinier wire, and so that the chamber box 30 may be accurately aligned with the belt 32 to minimize rubbing.

Referring now to FIG. 7, the chamber box 30 includes at its bottom portion 76 a slotted base plate 78 as well as first and second wear strips 79 and 80, which cooperate with the base plate 78 to define a pair of opposing, elongated slots 81 and 82 that slidingly receive edge portions of the endless belt 32. Preferably, the elongate slots 81 and 82 are formed along a central bottom portion of the base plate 78, but alternatively, could be formed at least partially or wholly in the wear strips 79 and 80.

The central slot 84 in the base plate 78 terminates within the confines of the chamber box 30 adjacent to the end portions 50, 50' of the chamber box 30. Preferably, each terminus of the central slot 84 is scalloped so as to avoid the accumulation of slurry solids at those locations. The width of the central slot 84 is selected so as to minimize exposure of the fluid within the chamber box 30 to the pumping action of the belt 32. In the preferred embodiment, the slot is approximately 10mm (3/8 inch) wide, whereas the diameter of the orifices 44 in the endless belt 32 is preferably approximately 2.4mm (3/32 inch).

Each wear strip 79, 80 extends along a corresponding opposite side of the bottom portion 76 of the slurry box 30, co-extensively with the base plate 78. An elongate shim 86 and a plurality of spaced apart fasteners 88 (preferably bolts) affix the wear strips 79, 80 to the adjacent, superposed portion of the base plate 78. However, the orifices 44 can have any desired configuration such as symmetrical or asymmetrical non-circular openings.

The tolerances between the respective edge portions of the belt 32 and the slots 81, 82 are to be minimized so as to promote sealing of the bottom portion 76 of the chamber box 30. However, the fit between the belt 32 and the slots 81, 82 should not be so tight as to foment binding of the endless belt 32 in the slots 81, 82. In the preferred embodiment, these countervailing considerations are met when the slots 81, 82 are configured to present a 1.6mm 1/16 inch total tolerance in a width-wise direction across the endless belt 32. In the direction normal to the plane of the belt, the belt has preferably a thickness 0.508mm (0.020 inch), whereas the slots 81, 82 are 0.58mm (0.023 inch) deep. These relationships achieve the desired balance of proper sealing and the need for facile passage of the belt 32 through the bottom portion 76 of the chamber box 30.

Preferably, the wear strips 79, 80 are constructed from ultra high molecular weight polyethylene or Dalron.

Included within the confines of the chamber box 30 are beveled inserts 89, 90 which extend along and fill the corners defined between the base plate 78 and each of the vertical walls 91, 92 of the chamber box 30. The inserts preferably present a 45 degree incline from the vertical walls 91, 92 toward the central slot 84 of the base plate 78. This arrangement avoids stagnation of fluid in the confines of the chamber box 30, which would otherwise tend to accumulate the solid content of the slurry and possibly clog the chamber box 30 and the orifices 44 of the endless belt 32.

Near the bottom portion 76 of the chamber box 30, a plurality of spaced-apart pressure ports 94 communicate the pressure monitoring system 62 with the interior of the slurry box 30.

Along the upper portion of the chamber box 30, a plurality of spaced-apart feed ports 96 are located along the vertical wall 91. The feed ports 96 communicate the flow distribution system 60 with the interior of the slurry box 30. Preferably, the feed ports 96 are located close to the lid plate 31 of the chamber box 30. The flow distribution system 60 has been noted in reference to FIG. 1.

The feed ports 96 are spaced vertically by a distance *h* above the location where the endless belt 32 traverses through the bottom portion 76 of the chamber box 30. The feed ports 96 introduce slurry into the chamber box 30 in a substantially horizontal direction. The vertical placement and the horizontal orientation of the ports 96 dampens vertical velocity components in the fluid at or about the region of endless belt 32 at the bottom portion 76 of the chamber box 30. The arrangement also decouples the discharge flows 40 through the orifices 44 from the inlet flows at the feed ports 96.

The height *h* in the preferred embodiment is approximately 8 inches or more; however, the vertical distance *h* between the feed ports 96 and the endless belt 32 may be as little as 6 inches. With greater distances for *h*, there is less disturbance and interaction between the fluid adjacent the endless belt 32 and the fluid conditions at the feed ports 96.

In the preferred embodiment, twelve feed ports 96 are used, but the applicator is workable with as few as six inlet feed ports 96. Although not preferred, the applicator is expected to function with as few as four inlet feed ports 96. The number of feed ports 96 depends upon the portion of the web width the particular applicator must cover. The preferred spacing between the feed ports 96 is approximately twelve inches and preferably not greater than approximately 0.6m (twenty-four inches), although it is possible to operate with even greater separation.

Referring now to FIG. 8, each orifice 44 along the endless belt 32 includes a beveled portion 45 adjacent the side of the endless belt

44 facing into the chamber box 30. With such an arrangement, the solids content of the slurry is not allowed to collect at or about the orifices 44 during operation of the applicator 10. More particularly, slurry fiber is not allowed to collect about the orifice and deflect the jets of slurry being discharged. Accordingly, the beveled portions 45 of the orifices 44 promote consistent delivery of slurry from the applicator 10 and reduce malfunctions and maintenance.

Referring now to FIG. 9, in an alternate embodiment of the chamber box 30', the vertical walls 91', 92', together with the base plate 78' and inclined beveled elements 89', 90' cooperate with a retractable armature 100, which supports an elongate wear strip 102 at its operative end portion. The elongate wear strip 102 extends the length of the chamber box 30' and is supported at spaced locations along each side of the chamber 30' by a plurality of retractable armatures 100 and 101. In this embodiment, the wear strips 79' and 80' are mounted upon and are retractable with the armatures 100 and 101, respectively. In FIG. 9, the armatures 100 along one side of the chamber box 30 are shown in a retracted position, while the armatures 101 along the opposite side of the chamber box 30' are shown in an engaged position, where the respective wear strip 90' is biased against the base plate 78'. In actual operation, the armatures 100 and 101 are pivoted between the retracted and engaged positions simultaneously.

Each retractable armature 100, 101 is pivotally mounted upon one or a pair of vertical flanges 106, which preferably provides support for an actuator mechanism 107 for moving the retractable armature 100, 101 from an operative, engaging position where the wear strips 89', 90' are urged against base plate 78' to a retracted position where the wear strips 89', 90' are spaced away from the base plate 78' and the

The actuator mechanism 107 is preferably an air cylinder 108 which is operatively connected to the pivot arms 109, 110 of the armatures 100 and 101, respectively. Other mechanical expediencies could be selected for pivoting the retractable armatures 100 and 101, as would be readily apparent to one of ordinary skill in the art upon reading this disclosure.

An elastomeric seal 104 is provided between the lower portions of the chamber box walls 91', 92' and the base plate 78' so as to create a fluid-proof seal about the entire periphery of the base plate 78'.

In operation, all of the armatures 100, 101 along both sides of the chamber box 30' are pivoted simultaneously so that the wear strips 79', 80' are moved as units to and from their operative and engaged positions. The retractable armatures 100, 101 facilitate quick and speedy maintenance, repair and/or replacement of the endless belt 32', the wear strips 79', 80' and the base plate 78'.

As discussed above, after the web 22 leaves the couch roll 24 (see FIG. 1), the web advances through the dryer section 27 where additional moisture is removed and the cellulosic fiber web is dried to the desired moisture content level. As the web 22 leaves the dryer section 27, it passes through and optical inspection means 120 that examines the transverse bands of add-on material and evaluates the uniformity of band width and uniformity of spacing between adjacent bands or lines. To effect this optical inspection, the optical inspection system may include a plurality of suitable conventional cameras deployed in a linear array above the web 22 and directed downwardly at the top surface of the web within a housing 122. The cameras can be uniformly spaced from one another so that the camera position is indicative of the lateral location on the web, i.e., a longitudinal zone of the web. In addition, the field of view for adjacent cameras may slightly overlap to insure that the entire width of the web is subject to the optical inspection. By way of example, 16 cameras may be deployed in the array.

The optical inspection system 120 communicates its inspection signals through suitable conventional cabling 124 to the programmable controllers 64, 64′ of the applicators. The longitudinal zones of the web monitored by the cameras of the optical inspection system 120 correspond to regions of the applicators 10, 10′ fed by the feed ports 96. Thus, if lack of line-width uniformity is detected in a portion of a line, the programmable controllers use the feedback signal from the inspection system 120 to appropriately adjust the add-on material supplied to the feed port 96 corresponding to the longitudinal zone of the web where the lack of band-width uniformity was detected. This adjustment at the feed port 96 occurs dynamically, i.e., while the paper is being produced thereby avoiding production of large quantities of defective paper that must be discarded or reprocessed. In addition, the dynamic feedback adjustment and control can avoid the need for post-manufacture inspection of the paper.

If lack of band-spacing uniformity is detected by the optical inspection system 120, then the feedback signals are employed to appropriately adjust the linear speed of the moving orifice belt 32 of the appropriate applicator 10, 10′. In that manner, the band-spacing of the transverse bands on the web can be dynamically adjusted so to remain within the design tolerances for the band-to-band spacing. Again, the dynamic feedback adjustment and control for band spacing provided by the optical inspection system may be used to avoid post-manufacture inspection of the manufactured paper.

After passing through the optical inspection system 120, the web enters a splitter 125 for dividing the web 22 into two or more longitudinal web portions 130, 132. The splitter 125 may, for example, include an appropriate number of slitting disks 126 positioned laterally over the web 22 to cut the web into the desired longitudinal portions 130, 132. The splitters disk 126 may engage an anvil roll 128 so that the disk 126 and the roll 128 cooperate to sever the web at the position of the disk 126 as the web passes between the disk 126 and the anvil 128.

While a single splitting disk 126 is depicted, that arrangement would be appropriate for an installation using two moving orifice applicators 10, 10′. Where, for example, three applicators are used, it may be desired to split the web 22 into three longitudinal portions. In that instance, two splitter disks 126 would be used with the same anvil roll 128, the disks being spaced from one another to provide web portions with the desired width.

Downstream of the splitter 125, the individual web portions 130, 132 are collected by corresponding reeling apparatus 28, 29. Here again, while only two reeling apparatuses are shown, one would be provided for each longitudinal web portion in applications where the original web 22 is divided into more than two portions.

In manufacturing scenarios where both banded and unbanded papers are needed, the paper manufacturing machine can be operated with one of the applicators 10, 10′ being inactive. As a result, one longitudinal portion 132 of the web may be banded and collected while the other longitudinal portion 130 of the web is unbanded and collected simultaneously. This capability increases the manufacturing flexibility of the paper making apparatus.

The general method of making patterned paper according to the disclosure has been described in conjunction with the foregoing description of the apparatus. Further, the operation of the cigarette paper-making machine and method of the preferred embodiment typically uses flax feedstock. Nevertheless, the apparatus and associated methodologies are readily workable with other feedstocks such as hardwood and softwood pulps, eucalyptus pulps and other types of pulps used in the paper making industry. The alternate pulps may have different characteristics from flax, such as differences in average fiber length, which may necessitate adjustment of the degree of refining in the preparation of the base sheet slurry with some pulps. Regardless what type of pulp is used, add-on slurry must be processed sufficiently to avoid fiber build-up at or about the orifices 44 of the belt, which in turn avoids jet deflections at the orifices 44.

Because the flow of the fluid stream 40 emanating from each orifice 44 as the orifice 44 passes along the bottom portion of the chamber box 30 is proportional to the pressure differential across the orifice 44, it is desirable that fluid pressure be established and then held as uniformly as possible along the entire journey of each orifice 44 along the bottom portion 76 of the chamber box 30.

A new high speed method and apparatus for applying a material to a web has been described in this specification. It will be apparent to those skilled in the art that numerous modifications, variations, substitutions, and equivalents exist for various features of the inventions recited in the appended claims. Accordingly, all such modifications, variations, substitutions and equivalents that fall within the spirit and scope of the invention as set forth in the appended claims are intended to be embraced by the appended claims.

CLAIMS:

1. A method of manufacturing a web having an applied pattern of add-on material, the method comprising the steps of:

preparing a first slurry of fibrous material and liquid;

delivering the first slurry to a moving wire having a longitudinal direction, a wire width transverse to that longitudinal direction, and a nominal linear speed;

draining the liquid from the first slurry through the moving wire to form a fibrous web;

preparing a second slurry of add-on material;

operating at least one of a plurality of distribution devices, each device having a continuous belt with a plurality of spaced-apart orifices therethrough, a reservoir, a principal length, and angled with respect to the longitudinal direction such that each distribution device covers a corresponding portion of the wire width;

delivering the add-on slurry to the reservoir of at least one distribution device;

moving the continuous belt with a nominal band speed having a velocity component in the longitudinal direction substantially the same as the nominal linear speed; and

depositing transverse bands of the add-on slurry onto the fibrous web through the orifices, where the length of each transverse band is no greater than the portion of the wire width corresponding to the distribution device.

2. The method of manufacturing of Claim 1 including:

delivering the add-on slurry to the reservoir of each distribution device; and

depositing transverse bands of add-on slurry in a plurality of longitudinally extending zones which are parallel to each other and together extend substantially across the wire width.

3. The method of manufacturing of Claim 1 further including the step of slitting the web into at least two narrower webs, each narrower web having a width corresponding to the distribution device which deposited transverse stripes thereon.

4. The method of manufacturing of Claim 3, including the further step of independently reeling each of the narrower webs for subsequent use.

5. The method of manufacturing of Claim 1 further including the steps of:

optically inspecting the transverse stripes on the web to determine width, and spacing characteristics; and

dynamically adjusting operation of at least one of the distribution devices in response to the optical inspection step to provide uniform width and uniform spacing of the transverse stripes on the web.

6. The method of manufacturing of Claim 1, further including the steps of:

supplying the add-on slurry to a plurality of linearly arranged compartments in the reservoir; and

advancing the at least one orifice sequentially through the plurality of linearly arranged compartments.

7. The method of manufacturing of Claim 6, further including the steps of:

optically inspecting the transverse stripes on the web to determine width and spacing characteristics as a function of lateral location on the web;

dynamically adjusting the pressure in each compartment of the distribution devices in response to the optical inspection step to provide uniform width and uniform spacing of the transverse stripes on the web.

8. The method of manufacturing of Claim 1, wherein the first slurry and the add-on material are ingredients of cigarette paper.

9. The method of manufacturing of Claim 1, wherein the wire has a width greater than three meters and the linear speed is more than 2.5m/s (500 ft./min0.

10. Apparatus for manufacturing a web having an applied pattern of add-on material comprising:

a Fourdrinier wire operable to prepare a continuous web of fibrous material which moves in a longitudinal direction at a nominal linear speed, has a width transverse to that longitudinal direction, and a generally planar surface;

at least two distribution devices, each operable to deposit a stream of add-on material on the generally planar surface of the web, each having a reservoir for add-on material, a principal length, and a continuous belt operable to move between the reservoir and the planar surface at a belt speed, including at least one orifice, such that when the orifice aligns with the reservoir a stream of add-on material is deposited on the generally planar surface,

each distribution device being angled with respect to the longitudinal direction such that each distribution device covers a corresponding portion of the web width,

the belt speed having a longitudinal component generally parallel to the longitudinal direction and a transverse component generally perpendicular to the longitudinal direction, the longitudinal component being substantially equal to the nominal linear speed; and

a control system selectively operating each of the distribution devices.

11. The apparatus of Claim 10, wherein:

each distribution device covers a portion of the width of the web; and

each distribution device deposits a plurality of generally horizontal bands of add-on material on the surface of the web.

12. The apparatus of Claim 10 further including a cutting device to longitudinally slit the web into parallel narrower webs, each narrower web having a width corresponding to a banded region formed by the respective distribution device.

13. The apparatus of Claim 10 further including:

a drying system operable to dry the web, positioned downstream of the distribution devices;

an optical inspection system operable to determine the width of the bands of add-on material, positioned downstream of the drying system, operably connected with the distribution devices; and

a control system responsive to the optical inspection system to adjust add-on material supply to the distribution devices to provide bands with uniform width and/or thickness.

14. The apparatus of Claim 10 further including:

a drying system operable to dry the web, positioned downstream of the distribution devices;

an optical inspection system operable to determine the spacing between the bands of add-on material, positioned downstream of the drying system, operably connected with the distribution devices; and

a control system responsive to the optical inspection system to adjust operation of distribution device belt speed to provide bands of uniform spacing.

15. The apparatus of Claim 10 further including:

a drying system operable to dry the web, positioned downstream of the distribution devices;

an optical inspection system operable to determine the uniformity and spacing of the bands of add-on material, positioned downstream of the drying system and operably connected with the distribution devices; and

a control system responsive to the optical inspection system to adjust operation of the distribution devices to provide bands with uniform width and spacing.

16. The apparatus of Claim 10 wherein the distribution devices are parallel to one another and laterally offset.

17. The apparatus is a cigarette paper making machine.

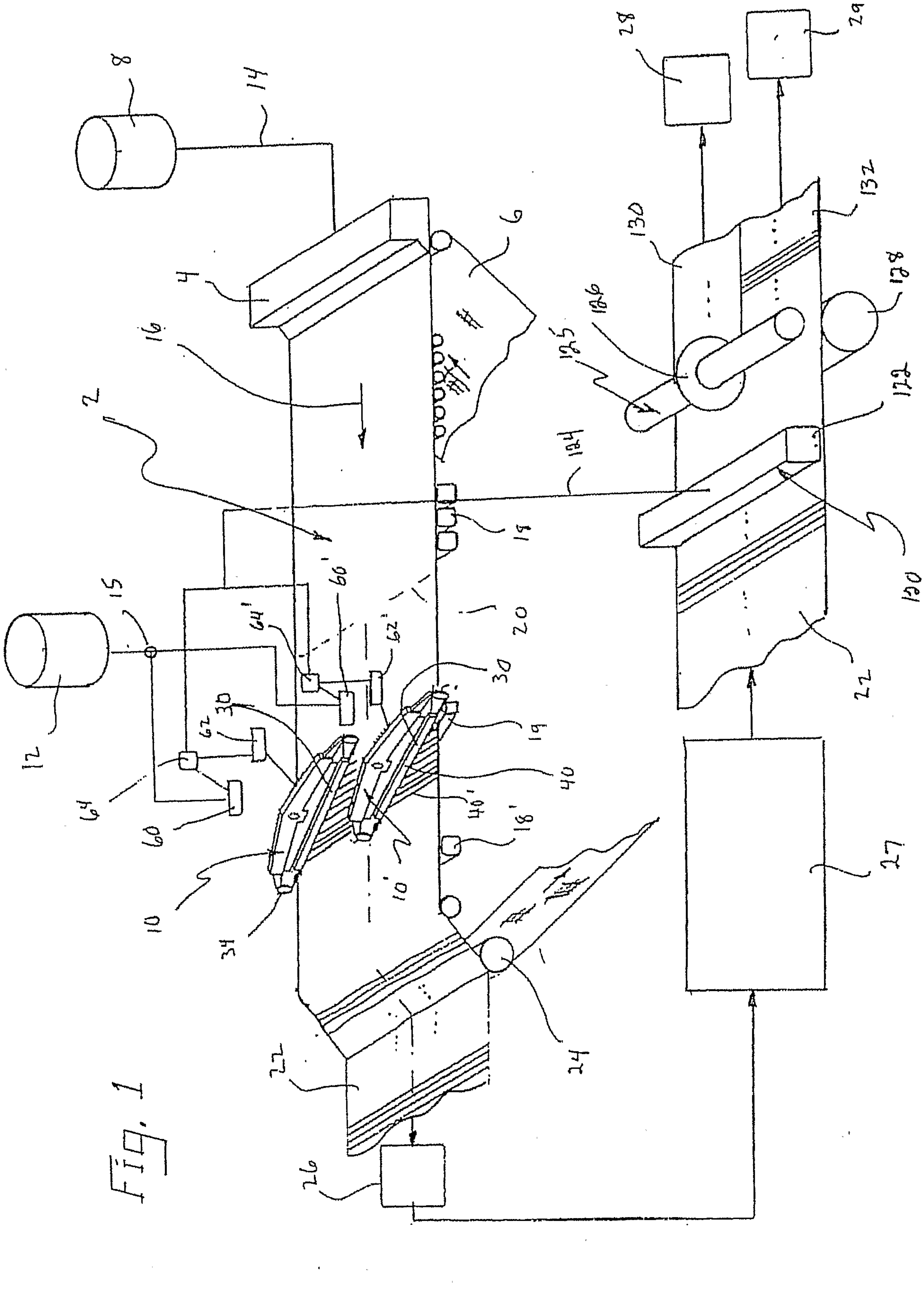


Fig. 1

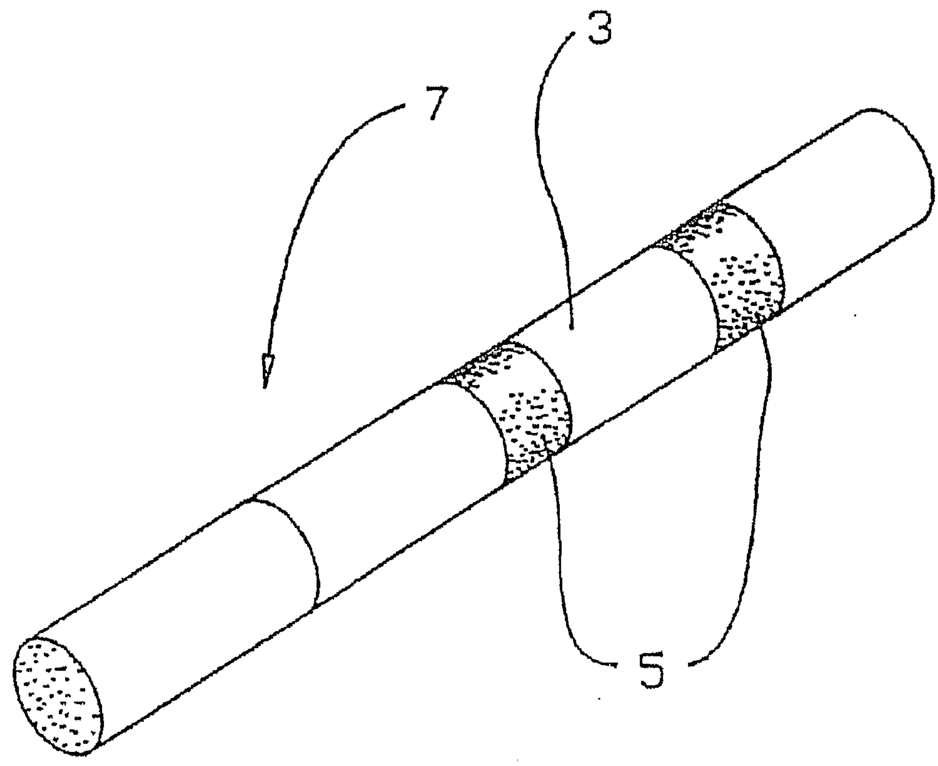
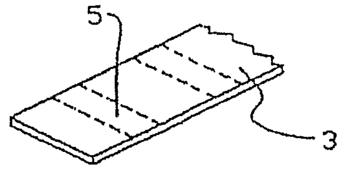
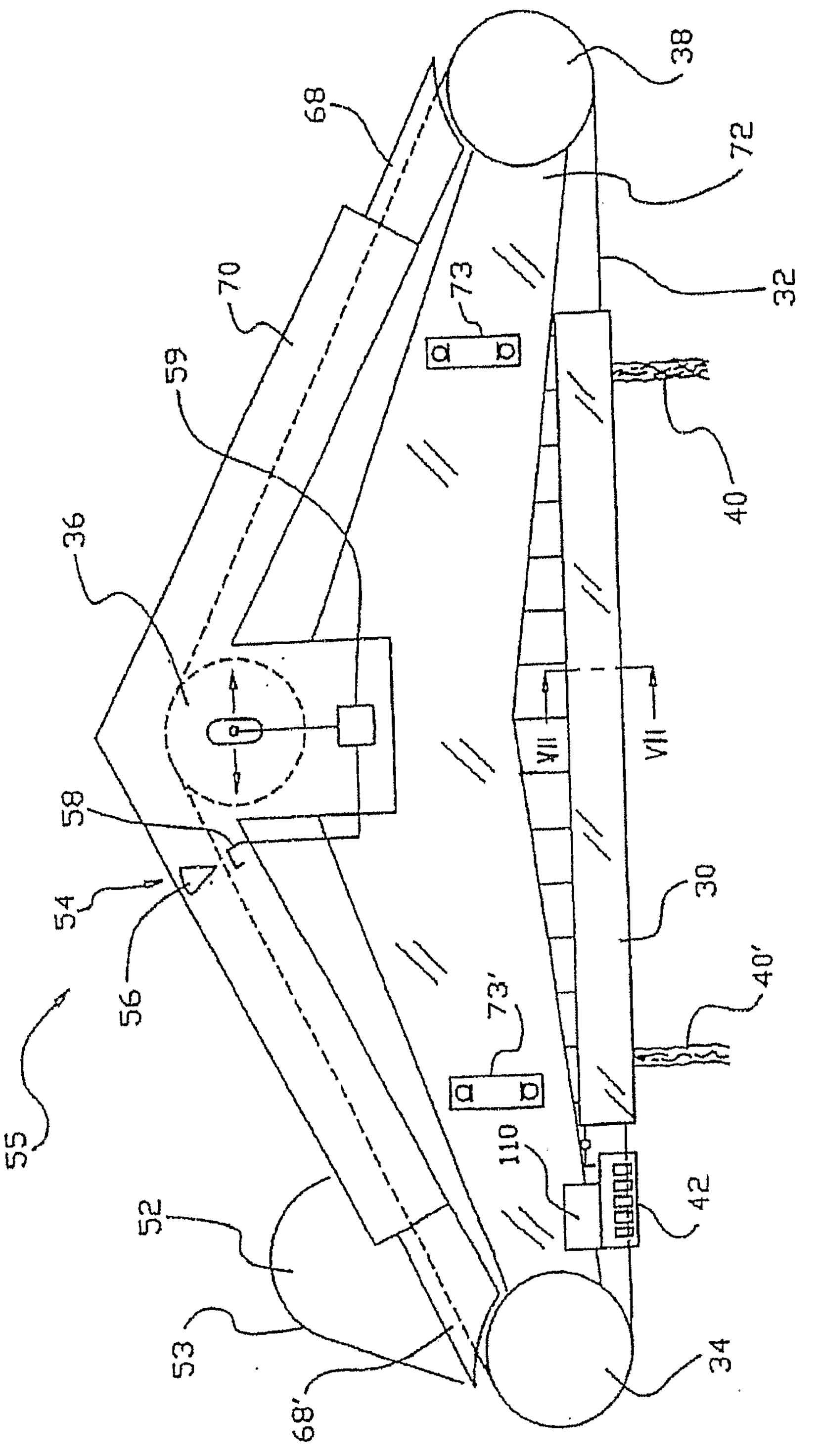


Fig. 3

Fig. 2

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68
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73
a
b
59
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VII
VII
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54
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110
52
42
53
34
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Fig. 4

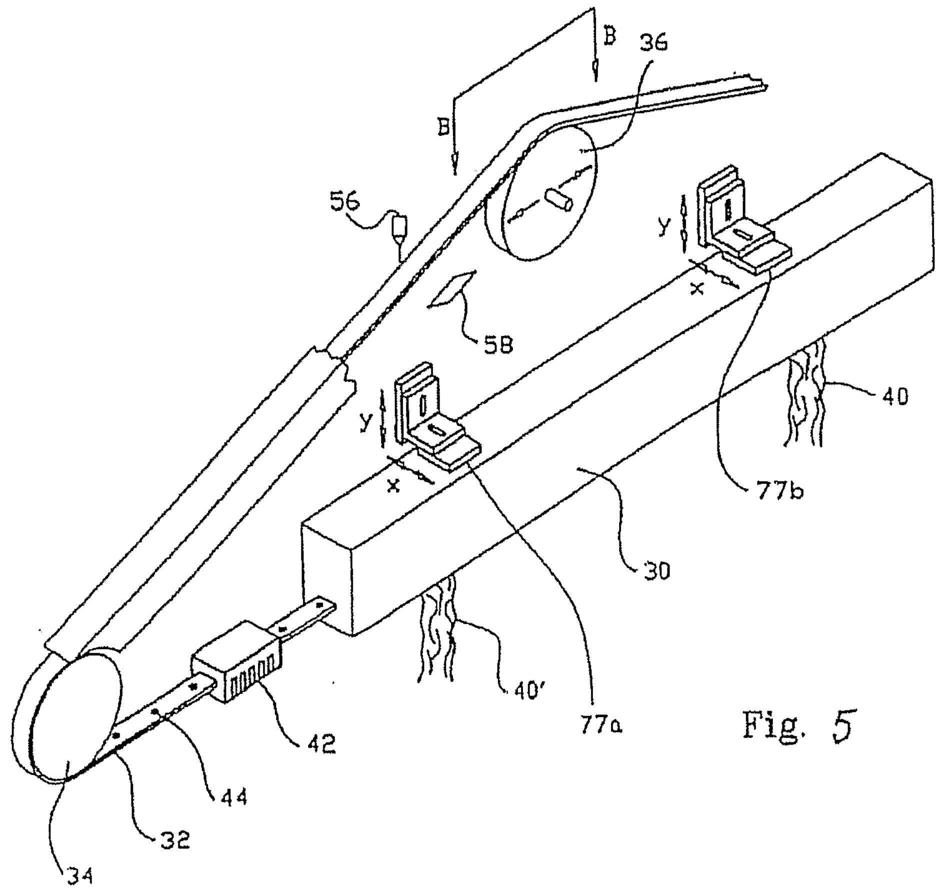


Fig. 5

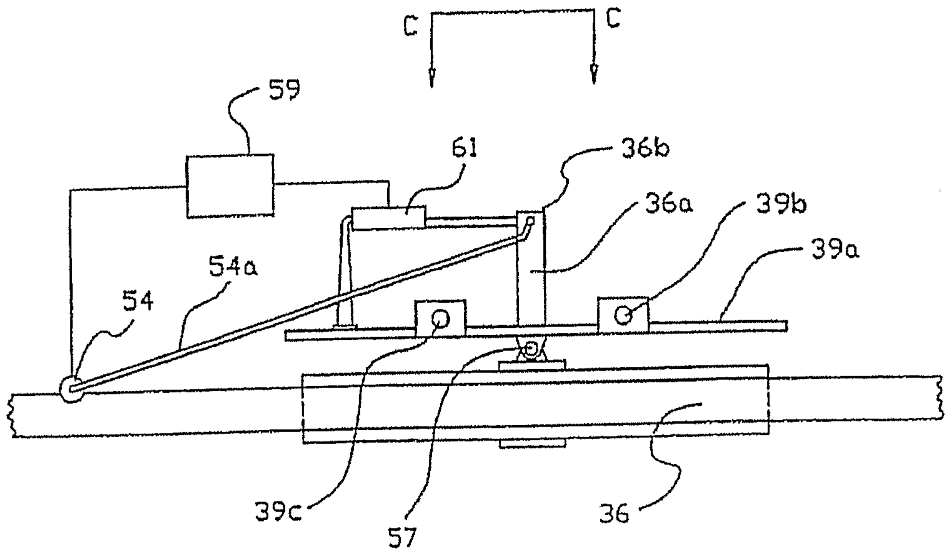
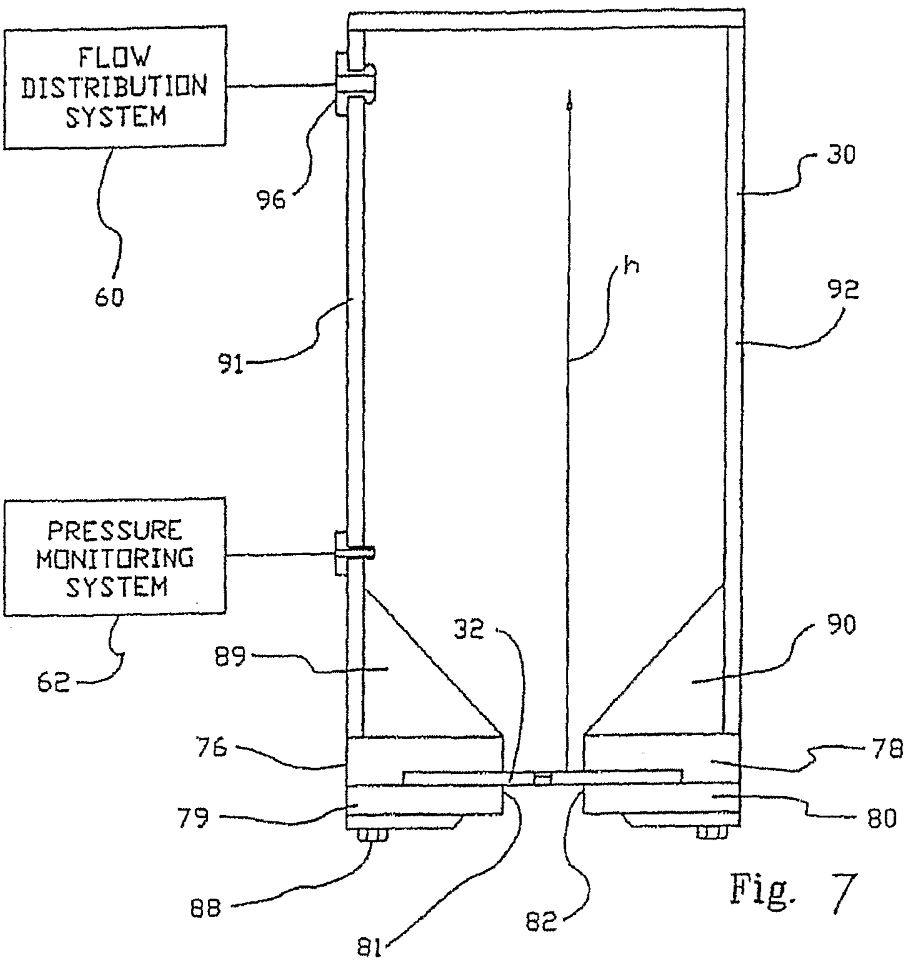


Fig. 6


FLOW
DISTRIBUTION
SYSTEM
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96
30
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92
91
PRESSURE
MONITORING
SYSTEM
62
32
90
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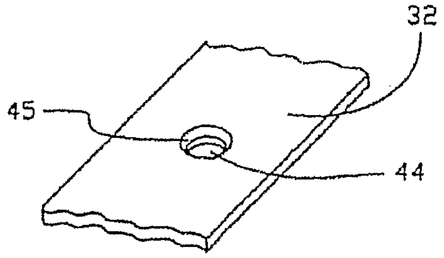
76
78
79
80
88
81
82

Fig. 7


32
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44

Fig. 8

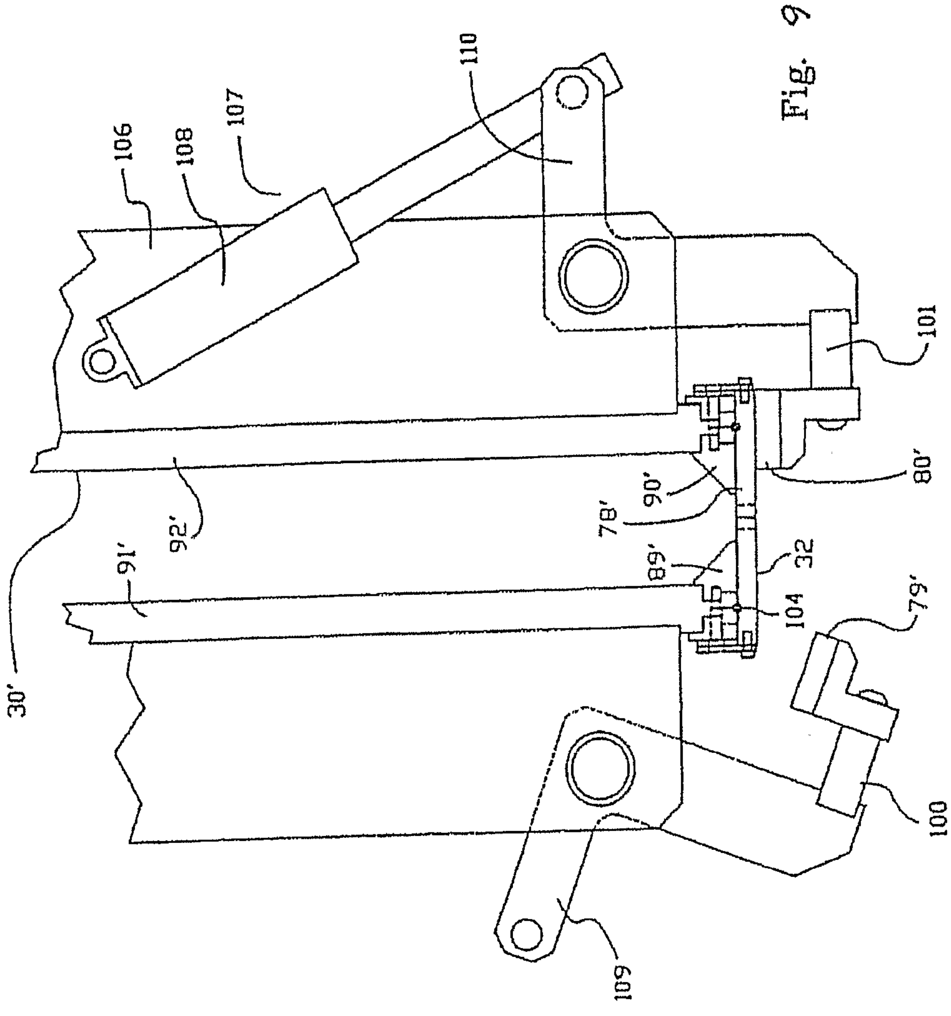

Fig. 9