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(54) **AIR EXHAUST MODULE, AIR SUPPLY MODULE AND METHOD OF PREVENTING DUST LADEN AIR FROM ESCAPING A LOCALIZED ZONE IN THE DRY END OF A FIBER WEB PROCESSING MACHINE**

LUFTABFÜHRUNGSMODUL, LUFTZUFÜHRUNGSMODUL UND VERFAHREN ZUM VERHINDERN DES AUSSTRÖMENS VON STAUBHALTIGER LUFT AUS EINER ÖRTLICH BEGRENZTEN ZONE IN DER TROCKENPARTIE EINER FASERSTOFFBAHNHERSTELLUNGSMASCHINE

MODULE D'ÉVACUATION D'AIR, MODULE D'ALIMENTATION EN AIR ET PROCÉDÉ POUR PRÉVENIR L'ÉCHAPPEMENT D'AIR CHARGÉ DE POUSSIÈRE D'UNE ZONE LOCALISÉE DANS LA PARTIE SÈCHE D'UNE MACHINE DE FABRICATION D'UNE BANDE FIBREUSE

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Description

TECHNICAL FIELD

[0001] The present invention relates to a system for transporting a fibre web through a dry end of a fibre web processing machine from a drying section to a reeling section of the machine. In particular, the invention relates to such a system in a tissue paper machine.

[0002] The invention also relates to an air supply module and an air exhaust module for use in such a system.

[0003] The invention also relates to method of preventing dust laden air from escaping a localized zone in a dry end of a fibre web processing machine.

BACKGROUND ART

[0004] US 3,775,806 (Olbrant et al.) discloses an apparatus for removing and collecting dust from a travelling sheet or web of material including a blow box having means for impinging jets of clean air against the sheet in directions both in the direction of travel of the sheet and opposite thereto. A suction box cooperates with the blow box to form suction gaps withdrawing the air after its engagement with the material to thereby remove the dust from the material. The suction in the suction box is sufficient to withdraw additional air from the surrounding atmosphere through the spaces which exist between the material and the suction box, and means is provided to remove the dust from the air withdrawn by the suction box. An alternate embodiment provides guide elements in the suction gaps which support the material at these points through a film of air.

[0005] US 5,991,964 (Baum) discloses a tissue web cleaner and method of cleaning tissue webs in a rewinder utilize the Coanda effect to produce an improved tissue product. The Coanda effect web cleaner utilizes the smooth flow of a thin layer of air to scrub off dust and lint embedded and entangled in the web surface while stabilizing the web in its travel. Two of these Coanda effect web cleaners arranged on opposite sides of a multiple-ply web in a rewinder are effective when operated according to the method of the invention to produce a rewound tissue with an unexpectedly low loose dust and lint count on its surfaces.

[0006] WO 97/10382 (Svanqvist et al.) discloses a method of and an apparatus for transferring a fast running ready-dried fibrous web, especially a tissue web, from one device and along a predetermined run to a subsequent device. To accomplish a web transfer, which in reliability is comparable to the one obtained with a closed draw, in any operating environment, but especially where it is desirable to transfer a fast running tissue web from the drying section of a tissue machine, e.g. a Yankee dryer, to a reel-up, a web support device extends across the width of the web and along a predetermined run of the web from the Yankee dryer to the reel-up. The web support device has a support surface formed by a series of plate member assemblies having means for creating a flow of air in the direction of the web run. Between the web and the support surface the flow of air forms an air layer of reduced static pressure, so as to stabilize the web against flutter. The predetermined run may extend through a calender and past scanner equipment. Pneumatic tail threading capabilities may be included.

[0007] WO 00/61264 (Courtney et al.) discloses an improved process and system for collecting and handling dust in a papermaking machine environment wherein dust-laden air is drawn into and moves along an elongated collector by way of a vacuum-generating source connected to the collector involves the introduction of water into the collector so that the introduced water becomes entrained by the dust-laden air moving through the collector and wet-scrubs the dust-laden air upon entering the collector. With the dust being wet-scrubbed upon exiting the collector, the likelihood of ductwork fouling is substantially eliminated, and the risk of fire in the ductwork downstream of the collector is appreciably reduced.

[0008] US 5,878,462 (Lindén et al.) discloses an apparatus for removing dust released, for instance, during the production of a soft crepe paper web which is creped off a Yankee cylinder and spread laterally. The apparatus comprises a dust suction box consisting of a housing with an inner suction chamber, said housing having a first inlet in the form of a suction gap, a main part and first and second parts which define said suction gap between them. According to the invention the main part is in the form of part of a cylinder to provide a corresponding curved inner side in the suction chamber, and the suction gap comprises an outer gradual throttling and an inner gradual enlargement, said throttling and enlargement merging at a transition where said throttling is maximal. The first inlet forming part preferably comprises a flat surface that defines its side of said enlargement whereas the second part forming the inlet comprises both a curved surface having a predetermined radius and such an arc length that it defines the whole of its side of the throttling and an initial part of the enlargement, and also an inner, flat surface extending at a tangent from the curved surface and forming an acute angle α with a tangent to the curved surface at said transition.

[0009] DE 199 40 980 A1 (Grabscheid) discloses an apparatus for cleaning a machine-wide run-off wedge in a paper or board manufacturing machine, which wedge is formed between a fabric or felt guiding roll and one of the fabric or the felt, wherein the following apparatus features are provided: in the run-off wedge, there is provided a machine-wide suction

box having a suction conduit;
a first deflector strip of the suction box is arranged across the fabric or felt guiding roll; and
a second deflector strip of the suction box is arranged at a distance from the fabric or the felt, and the suction box has in its part facing away from the run-off wedge a suction connection with at least one suction source as well as at least one liquid drain.

[0010] Regarding the dry end of a tissue machine, the conventional methods of controlling the web and containing dust are disappointing. The conventional methods are several layers of solutions. Each new successive solution (layer) has been devised without fully re-evaluating what has been previously done.

SUMMARY OF THE INVENTION

[0011] The present invention relates to a detailed outline of a dry end design that efficiently integrates the key processes and objectives of the dry end of a tissue or towel grade machine while using new and existing technology.

[0012] There are many aspects of the invention included herein that can be used as stand-alone devices or processes. However, they are more valuable when used in unison.

[0013] The objectives of sheet handling include sheet stability, preservation of the crepe in the sheet, and effective containment of dust. The present invention satisfies these needs.

[0014] According to the invention, careful attention is given to balancing of the airflows. Air is not only exhausted at critical locations, it is also supplied at strategic locations.

[0015] Experience has shown that systems that require intensive or complicated maintenance will eventually fail due to lack of maintenance. This new system is designed to have minimal maintenance requirements. Automated cleaning devices are incorporated where needed.

[0016] The majority of known dust control strategies are based on the premise that you cannot extract air from too close to the web. The majority of sheet handling solutions are based on "stabilize the sheet and don't worry about the dust".

[0017] The conventional strategies employed thus far are largely guess work based on misperceptions.

[0018] Scanners, glue turn-up at the reel drum, tail threading, sheet knockdown showers, calendering, etc. are poorly integrated with the key components of sheet handling and dust control.

[0019] Consequently, prior art techniques have the following drawbacks:

- Webs are not stable. Draw cannot be reduced.
- Dust leakage is considerable, although much more air is supplied and exhausted than what is really needed. Dust levels are unpredictable and "hit or miss" machine room dust level guarantees must be utilised.
- The intake slots of dust collectors of various types get plugged.
- There are web breaks caused by clumps of dust falling off of foils and beams and landing on the web.
- The paper machine operators have high capital, maintenance and operating costs.

[0020] A common problem associated with conventional systems is the sheet instability which occurs along the edges of the sheet run. This is a result of the incoming air flows.

[0021] The incoming air currents are intentional and are used for the purpose of containing the dust in the machine. Unfortunately, they result in edge instability. In areas where the web is unsupported, this inwards velocity normally cannot exceed a magnitude of 100 ft/min (0.5 m/s).

[0022] The incoming air currents will exist in certain areas without a dust collector present. When the web exits the creping doctor or exits a calender, air is pumped with the web's boundary layer and air must enter the sides of the machine to compensate. In these cases, exhausting from the zone only worsens the web stability problem.

[0023] In areas such as the entrance to a calender or the lead-in to a reel drum, air is pushed out of the sides of the machine. Simple containment velocities are not sufficient.

[0024] Another common issue is that conventional pulper exhaust systems are greatly oversized. Containment is attempted with high exhaust flowrates. In many cases, mist and vapour still escapes as variations in conditions occur. The conventional systems waste energy.

[0025] Another important issue is cleaning of the web. There are several variations of web cleaners available for tissue grades. They are all meant to be retrofit into a machine and there is no holistic approach in their concept. All known existing types may have one or more problems as specified in the following list:

1. The exhaust stream attempts to draw in the web and/or draw air through the web.

2. The exhaust point is too far away from the web in an attempt to prevent the web from being drawn in but with the drawback of an increased required exhaust air flow rate.

3. The design is overly complicated.

4. The exhaust intake slot is too narrow and this leads to plugging.

5. There are sharp edges that rub directly on the web thereby creating dust.

6. There is little or no scrubbing nozzle pressure that can be applied to the web.

7. The unit has many internal passages that plug and are difficult to clean.

8. The unit does not support the web very well.

[0026] In many cases, they function for a short period before they become plugged and the paper machine operator eventually removes them. Regardless if they work, there is little effort in preventing dust and debris from entering the nip at the reel. This renders useless any effort at web cleaning.

[0027] The objective of the present invention is to alleviate these problems.

[0028] According to some embodiments, an air exhaust module for use in a system for transporting a fiber web through a dry end of a fibre web processing machine from a drying section to a reeling section of the machine is presented. The module comprises a self-cleaning air exhaust slot, and is characterized in that the module comprises a rotatable section having an extending lip, which rotatable section is arranged to be rotated such that the lip traverses and clears the exhaust slot.

[0029] According to some embodiments, an air exhaust module for use in a system for transporting a fiber web through a dry end of a fibre web processing machine from a drying section to a reeling section of the machine is presented. The module comprises a self-cleaning air exhaust slot, and is characterized in that the module comprises two slot plates forming an air exhaust slot there-between, each slot plate displaying a zig-zag pattern having a pitch, wherein at least one of the slot plates is movably arranged in the air exhaust module such that it can move back and forth in the longitudinal direction of the slot with a length of stroke equal to or larger than said pitch.

[0030] According to some embodiments, an air supply module for use in a system for transporting a fiber web through a dry end of a fibre web processing machine from a drying section to a reeling section of the machine is presented. The module comprises a self-cleaning air supply slot, and is characterized in that the module comprises a cleaning blade having a toothed edge, the blade being movably arranged in the air supply slot in the longitudinal direction of the slot such that it can be oscillated longitudinally in the air supply slot.

[0031] According to some embodiments, an air supply module for use in a system for transporting a fiber web through a dry end of a fibre web processing machine from a drying section to a reeling section of the machine is presented. The module comprises a self-cleaning air supply slot, and is characterized in that the module comprises a cleaning blade having a linear edge, the blade being movably arranged in the air supply slot to follow a V-shaped path such that it can be oscillated longitudinally in the air supply slot and such that the cleaning blade is moved in and out of the slot during the longitudinal oscillation.

[0032] According to some embodiments, a system for transporting a fibre web through a dry end of a fibre web processing machine from a drying section to a reeling section of the machine is presented. The system comprises one or a plurality of groups of air modules, wherein each group of air modules is arranged for supplying and evacuating air from a predetermined, localized zone along the web run of the dry end, and wherein each group of air modules comprises:

- at least one air supply module being arranged for supplying air to the localized zone; and
- at least one air exhaust module being arranged for evacuating air from the localized zone,

wherein the air flow-rate of said at least one air supply module is balanced by the air flow-rate of said at least one air exhaust module such that dust-laden air is prevented from escaping the localized zone by other means than through said at least one air exhaust module; and
wherein said at least one air exhaust module is an air exhaust module as described above and/or said at least one air supply module is an air supply module as described above.

[0033] According to some embodiments, a method of preventing dust laden air from escaping a localized zone in a dry end of a fibre web processing machine is presented. The method comprises the steps of:

- placing within the localized zone at least one air supply module having an air supply slot;

- placing within the localized zone at least one air exhaust module; and
- balancing the air flow-rates of said at least one air supply module and said at least one air exhaust module such that the air flow-rate of said at least one air exhaust module is at least equal to the air flow-rate of said at least one air supply module;

wherein said at least one air exhaust module is an air exhaust module as described above and/or said at least one air supply module is an air supply module as described above.

[0034] Generally, the problems associated with web transportation in a dry end of a conventional tissue machine relate to the following technical areas: the handling of the boundary layer on a moving surface, the handling of flooded nip, the handling of linear free jets, the active airfoils, the passive air foils, sheet tensioning considerations, the spreading of the tissue web, the containment and removal of dust, wet scrubbing and the issue of containment at the pulper.

[0035] In the following, some of these areas will be discussed in more detail.

Boundary Layer on a Moving Surface

[0036] A moving surface carries air with it. There are theoretical correlations available for laminar flows and empirical correlations available for turbulent flows. The correlations used originate from those derived for applications involving a stationary plate and a moving airstream and are adopted for use in a given configuration. In a typical application, the vast majority of the boundary layer air is very close to the moving surface.

Flooded Nip

[0037] When two rotating rolls are in contact, a region of high pressure exists at the closing nip between them. Boundary layer air is carried into the nip area from the surfaces of both rolls. A larger roll will naturally have a stronger boundary layer flow. A jet of air exits the nip. The average angle of this jet is influenced by the relative magnitude of the two boundary layer flows.

[0038] It is possible to influence the magnitude of either boundary layer flow by using linear supply-air nozzles to augment their flows. In this way, it is possible to change the angle of the jet of air that exits the nip. This is useful when one roll carries a boundary layer that is clean while the other has a boundary layer that contains dust or debris. By augmenting the flow of the clean boundary layer flow, it is possible to prevent dust or debris from entering the nip.

Linear Free Jet

[0039] A linear free jet is a jet of air emerging perpendicularly from a slot in a surface.

[0040] Many of the important variables associated with linear free jets, e.g. the expansion angle, the core length zone, the transition zone length and the profile similarity zone length, can be determined using published correlations by scientists such as Baturin, Nielson and Rajaratnam.

[0041] Linear free jets can be used for air curtains. Some critical issues to consider include:

- The jet will induce the movement of adjacent air, Thus, the volumetric flow increases. Higher jet velocities result in greater induced flows.
- The maximum velocity of the jet decreases as the distance from the jet pole increases.
- Outside of the profile similarity zone, the flow patterns are difficult to predict. For air curtains, the effective reach of the curtain is within the profile similarity zone.

[0042] The effectiveness is roughly proportional to the nozzle velocity squared.

Active and Passive Foils

[0043] A foil comprising a nozzle releasing air along the foil surface in the direction of the travelling web in order to stabilize the web is called an active airfoil. A foil lacking such a nozzle is called a passive foil. Passive foils are the most common in the industry. They are low cost and adjustable.

[0044] Flat plates rely upon a slight wrap angle at it's trailing and leading edges to make sure that the web sticks to it.

[0045] Dust accumulation on the leading and trailing edges tends to fall off in large pieces. This usually results in web breaks. The dust accumulation on the leading edge is due to the impaction of dust particles that originate from the dust laden boundary layer that is above the web and upstream of the foil. The dust particles on the trailing edge originate

from the dust-laden air that is drawn into the zone at the trailing edge where the web's boundary layer causes air to be drawn in. The dust particles that accumulate on the leading edge will tend to be smaller as there are greater accelerations involved in the airstream and thus increased separation due to impaction.

[0046] The top surface of the web is exposed to allow for pressure relief upstream and downstream of the foil. This results in dust release above the web. In conventional configurations, dust is released between the foils.

[0047] The length of the foil surface in the direction of web travel is limited because air accumulates between the web and foil. The web is held to the underside of the foil due to the low pressure that is generated on the foil surface due to the movement of the web. It is also held to the foil due to the sheet tension coupled with the wrap on the leading and trailing edges of the foil. Web permeability contributes to the accumulation of air between the web and the foil.

[0048] The allowable foil length (in the machine direction) increases with:

- Increased sheet tension,
- Increased wrap angles,
- Increased machine speed,
- Smaller radius on leading edge, and,
- Lower web permeability.

[0049] Because of friction, a passive foil will induce a drag force on the web which results in increased sheet tension requirements.

[0050] Increased sheet tension results in increased drag on a passive foil.

Sheet Tension Considerations

[0051] The sheet tension can be predicted through-out the sheet run. A sheet handling system must be designed such that the sheet tension varies within an acceptable range through-out the sheet-run.

[0052] The sheet tension varies depending on the location in the dry end.

[0053] If the tension is too high at any particular location, the crepe will be pulled out or, worse yet, the web will be torn. If the tension is too low, the web will locally bag or drop off of the foils.

[0054] The following factors apply loads to the web along it's path and affect the sheet tension:

- An airfoil nozzle 'pushes' on the moving web.
- A passive foil will 'drag' on a web because of the friction.
- The weight of the sheet creates some tension.
- There is aerodynamic drag in the adjacent air.

[0055] Consider the following example. The start of the sheet run is at the creping doctor. The web is pulled at the end of the sheet run by the reel. Passive foils drag on the web while active foils push on the web. Consequently, there is a need for strategically locating passive and active foils in the sheet run.

[0056] The consequence of grouping too many passive foils at the start of the sheet run is that the sheet tension will become too high downstream of the passive foils.

[0057] The consequence of grouping too many active foils at the start of the sheet run is that the sheet tension will become too low downstream of the active foils. This configuration may also lead to sheet tensions that are too high at the start of the sheet run.

[0058] The frictional load on the passive foils can be predicted using experimentally determined friction factors. The 'push' provided by active foils can be predicted using experimentally determined correction factors and a simple energy balance.

[0059] Careful attention must be given to selecting the appropriate locations for the passive and active foils in order to achieve favourable tensions at certain locations while maintaining tensions within the acceptable range. Preferably, active and passive foils are alternately positioned along the sheet run.

[0060] Assuming that the web properties are uniform in the cross-machine direction and neglecting adverse air currents, cross-machine variations in sheet stability can be attributed to cross-machine variations in sheet tension. When sheet

tension is not high enough in the center of the machine, the web sags in the center of the machine. This is referred to as 'bagging'. When the web tension is too loose on the edges, it is referred to as 'edge flutter'.

[0061] Edge flutter is also caused by adverse air currents or cross-machine variations in the web's properties.

[0062] The sheet tension curve is affected by the crepe ratio. Variations in reel speed (crepe ratio) will shift the tension curve vertically.

[0063] The friction load on passive foils is partly a function of sheet tension. Increased sheet tension due to reduced crepe ratio will result in higher friction loads on the foils closest to the reel. The web massflow is of course constant as a function of location. The web acts as a linear tension spring. The velocity of the web varies as a function of sheet tension or location.

[0064] Sheet tension affects product quality and the runnability at the dry end. Consideration must be given to sheet tension in the design of the foils.

The Containment and Removal of Dust

[0065] Air conveys dust. This is an easy concept to accept when you consider transporting dust within ductwork.

[0066] Consider a short piece of duct with an inlet and an outlet. A certain volumetric flow of air is used to carry a certain massflow of dust with a minimum carrying velocity. Dust and air enter one end of the duct. The same dust and air exit the other end of the duct.

[0067] Now consider a point source of dust in a tissue machine near a moving tissue web. There are key considerations for effectively conveying the dust away:

- There must be an adequate carrying velocity past the dust source.
- The intake slots must be large enough so that they are not likely to plug.
- The intake slots must not be severely prone to intake of the sheet or broke.
- There must be some provision for cleaning of the slot.

[0068] Historically, the problem is that little consideration has been given to where the air comes from. If you simply evacuate the required amount of air from near the web, you will draw in the web. If you reduce the airflow to ensure that the web is stable, you can't capture all of the dust. The web is permeable, but it is not permeable enough.

[0069] A common approach is to install an exhaust hood over top of the sheet run and provide adequate containment velocity around the sheet run. However, sheet edge stability is always an issue. There is a limit to the inwards velocity at the edge of a moving web. This low containment velocity is not adequate to combat normally occurring air currents in the dry end. It also results in high exhaust flow requirements which is a waste of energy.

[0070] The answer to the problem is to strategically introduce the air that will be evacuated and account for airflows that exist due to moving surfaces. We need to supply some air to the source of dust and evacuate the same air along with the dust. Air is simply a tool for conveying the dust. There must be balance.

[0071] This invention takes web handling and dust control to a new level. In addition to controlling the evacuation of air, the supply of air is controlled and the natural airflows due to moving surfaces are favourably manipulated or allowed for.

Containment at the Pulper

[0072] The purpose of exhausting air from the pulper is to prevent a large bubble of hot humid air from escaping from the pulper. The required pulper exhaust flowrate is not only related to the volumetric flowrate of vapour that is being released by the hot agitated stock.

[0073] The air flow patterns near the pulper floor openings are difficult to predict. Conventional pulper exhaust systems achieve modest downwards air velocities at the floor openings. It is difficult to overcome other significant influences such as:

- buoyancy forces,
- air currents induced by pulper knockdown showers and dilution showers,
- air currents induced by stock flow in the pulper,
- trim system exhaust into the pulper, and,

- air currents induced by the full-width web entering the pulper at machine speed.

[0074] The aforementioned influences vary with time. The conventional answer has been to oversize the pulper exhaust system. This results in wasteful air scrubbing requirements and needless machine room make-up air requirements.

[0075] The buoyancy forces acting on the humid pulper air must be counteracted by the downwards velocity of air at the floor openings.

[0076] Neglecting localized high air velocities resulting from various forced air currents, buoyancy forces are the dominant factor that must be controlled. Theoretically, if there is no air forced into the pulper and it is completely sealed, no exhaust is required as the air will reach saturation and no more water vapour will be liberated from the stock or showers.

[0077] The required Pulper Exhaust varies depending on the operating condition. The following two steady state conditions must be considered.

- Normal Production
- Web directed to pulper at the Yankee floor opening.

[0078] The pulper exhaust flowrate must satisfy both conditions. In terms of Pulper Exhaust Flowrate requirement, the worst case condition occurs when the web is directed into the pulper. It is essentially the same as discharging air into the pulper and relying on the Pulper Exhaust to accommodate it. When the web is directed into the pulper from the Yankee, it carries boundary layer air with it on both of it's sides. This flow of additional air may be sufficient to overcome the predicted containment flowrate and spillage from the reel pulper opening would occur.

[0079] The following expression summarizes the various contributions to the required Pulper Exhaust Flowrate for a conventional system.

$$Q_{pulper} = Q_{containment} + Q_{vapour} + Q_{trim} + Q_{boundary\ layer\ air}$$

$Q_{containment}$	The flowrate of air required to achieve containment velocities at the floor opening(s) into the pulper to offset buoyancy effects.
Q_{vapour}	The flowrate of water vapour generated from the pulper liquid surface
Q_{tnm}	The flowrate of air into the pulper from other sources such as a trim conveying system
$Q_{boundary\ layer\ air}$	The flowrate of air that is carried with the web into the pulper when the web is diverted to the pulper from the Yankee at machine speed.

Water Vapour Generation

[0080] The flowrate of water vapour in the pulper due to the evaporation of water can be approximated using many methods. It is quite low in magnitude in comparison to the other contributing factors in the sizing of the required pulper exhaust flowrate.

[0081] In the following, the present invention will be disclosed with reference to the accompanying drawings, wherein:

Fig. 1 shows a dry end of a tissue paper machine comprising a dry end web transport system according to the invention;

Figs. 2 to 6 show air supply nozzles according to one aspect of the invention;

Figs. 7 and 8 show adjacent air foils according to one aspect of the invention;

Fig. 9 shows an air exhaust module having a self-cleaning air exhaust slot according to one aspect of the invention;

Figs. 10 to 12 show an air exhaust module having a self-cleaning air exhaust slot according to another aspect of the invention;

Fig. 13 shows a dry end enclosure according to one aspect of the invention;

Figs. 14 and 15 show air curtains according to one aspect of the invention;

Fig. 16 shows a creper lead-out foil according to one aspect of the invention;

Figs. 17 and 18 show second foil according to one aspect of the invention;

Fig. 19 shows a calender lead-in according to one aspect of the invention;

Fig. 20 shows a calender roll dust collector and a calender roll air deflector according to one aspect of the invention;

Fig. 21 shows a scanner passage according to one aspect of the invention;

Fig. 22 shows a reeling station comprising a reel drum according to one aspect of the invention;

Fig. 23 shows web or sheet pressurization at the reel drum according to one aspect of the invention;

Fig. 24 shows a reel shield with a dust collector and a nip flooding air curtain according to one aspect of the invention;

Fig. 25 shows a lower reel drum air curtain according to one aspect of the invention;

Figs. 26 to 28 show a floor flush system according to one aspect of the invention;

Fig. 29 shows a pulper enclosure according to one aspect of the invention;

Figs. 30 and 31 show a pulper module according to another aspect of the invention;

Fig. 32 shows a pulper door according to one aspect of the invention;

Figs. 33 to 35 show a roll dust collector according to one aspect of the invention.

MODES FOR CARRYING OUT THE INVENTION

[0082] In the web transport system according to the present invention, air is used for conveying dust. The web transport system introduces supply air and evacuates dust-laden air at strategic locations. The sheet run is enclosed and the air flows are balanced such that flows into and out of the control volume are accounted for. If deemed beneficial, some of the exhaust air is re-used as supply air; It is re-circulated. This reduces the amount of exhaust air out of the machine room thereby decreasing machine room make-up air requirements.

[0083] Fig. 1 shows an example of a dry end of a tissue paper machine comprising a web transport system according to one embodiment of the invention for leading a web (not shown in Fig. 1) from a drying section in the form of a Yankee dryer 1 to a reeling section or station 2. The dry end also comprises a plurality of web-processing or web-monitoring apparatus being positioned between the Yankee cylinder 1 and the reeling station 2 along the run of the a calender 3, a scanner 4, a slitter 5 and a sheet spreader 6. However, it is understood that the web transport system according to the invention may be used in dry ends having other configurations.

[0084] This embodiment of the web transport system comprises a plurality of foils or plates 7, 68 being arranged to support the web during the travel from the Yankee cylinder 1 to the reeling station 2. Also, the web transport system comprises air supply modules 9, air exhaust modules 10, a dry end enclosure 61 (see Fig. 13), air curtain nozzles 12, a creper lead-out foil 13, airfoil nozzles 14 (optionally), a cut-off doctor 15, a calender air exhaust module 16, a calender air deflector 17, a reel drum air exhaust module 18, a reel drum air deflector 19, a pulper module 20 and a creping doctor 21.

[0085] The following sub-sections will describe each of the main components of the web transport system according to the invention in more detail.

[0086] The web transport system is comprised of:

- In-machine components (building blocks)
- Supporting air systems

[0087] The flexibility in the sizing and configuration of the various in-machine components allow for the use of this system on almost any tissue machine dry end regardless of it's size, speed or configuration.

[0088] The supporting air systems are customized to suit the application.

[0089] The sizing and selection of the components is well defined. It is repeatable. Regardless of who applies the

system, for a given application, the same solution is devised.

[0090] Air supply modules in the form of nip flooding air jets allow for the control of air flow patterns at a closing nip, whereby the entrance of unwanted materials into a closing nip such as that of a calender or reel can be hindered.

[0091] The top of the web does not need to release dust as it does in a conventional tissue machine dry end. Exposure of the top of the web needlessly results is dust escaping from above the web and forces the building of a big box around the dry end. All conventional efforts at containing the dust above the web are merely inefficient solutions that are costly to implement, operate and maintain while failing to get to the root of the problem.

[0092] The web transport system according to the invention comprises a multitude of sub-systems that can work in unison to efficiently enclose the sheet run from the creping doctor to the reel. Using the web transport system according to the invention, the following objectives are met:

1. The sheet run from the creping doctor 21 to the reeling station 2 is enclosed physically or with the use of controlled airflow patterns.

2. The sheet run is designed to maintain sheet tension within an acceptable range which results in improved product quality.

3. The airflow nozzles and air exhaust modules can be of a self-cleaning design if required.

4. The need for a large enclosure hood (dust cap) and associated dust collectors is greatly reduced. Most of the conventional dust control methods will become obsolete.

5. Dust release to the machine room is greatly reduced.

6. The need to control air flow patterns outside of the dry end is greatly reduced as the sheet run is enclosed. The tertiary dust control system will become obsolete.

7. The required dust control exhaust volumetric atmospheric discharge flowrate can be greatly reduced. The required machine room air change rate requirement is then reduced thus reducing capital and operating costs for building ventilation.

8. The machine frame and periphery equipment at the dry end remains relatively free of dust.

9. Tails, broke, dust and debris are substantially prevented from entering the roll. This results in improved product quality and greater efficiencies in the converting process.

[0093] The following items have been the same for many years and essentially remain the same in this new concept:

- Yankee and Yankee Hood
- Scanner
- Calender rolls
- Reel drum and spool handling

[0094] These items stay the same because when the web transport system is adopted, it is desirable to have the ability to retrofit it to existing machines.

[0095] Airfoil nozzles 14 are optional in the web transport system according to the invention. They are used when the maximum allowable sheet tension is low.

[0096] In some cases, active foils are not required. This reduces the complexity of cost of a system. Active type foils usually can be omitted in applications where:

- the length of the dry end is sufficiently short; and/or;
- the acceptable range of sheet tension is sufficiently large.

[0097] There are two main purposes for the airfoil nozzle.

- The airfoil nozzle pushes the sheet thus reducing sheet tension requirements.

- The high-velocity airstream cleans the surface of the web. This has always been the case but has not been identified as a benefit. In fact, up until now, it has been identified as a drawback because it generates dust in the dry end.

[0098] Air supply modules or nozzles 32 having a self cleaning mechanism according to one aspect of the invention will now be described with reference to Figs. 2 to 6.

[0099] For applications that require uninterrupted air flow from an air supply nozzle 32, a cleaning plate or blade 33 is oscillated longitudinally in the slot, opening or outlet 34 of the nozzle 32 (see Figs. 2 and 3). The plate 33 penetrates the slot 34 with a toothed edge 35. A small portion of the flow is interrupted by each of the teeth, but this is a small sacrifice for maintaining nozzle slot cleanliness. The cleaning blade 33 is housed in the plenum area 36 of the nozzle 32. The cleaning blade 33 is actuated in a cross-machine direction and it's actuated movement is mechanically constrained to a linear path by stationary pins 37 arranged in linear guide slots 38 in the cleaning blade 33, the pins 37 serving as guides for the cleaning blade 33.

[0100] Figs. 4 to 6 disclose a second embodiment of an air supply module or nozzle 39 having a self cleaning mechanism.

[0101] In this case the nozzle 39 comprises a cleaning plate or blade 40 having a linear edge 41. Also, the nozzle displays a V-shaped guide slot 42 in which a stationary pin 43 is arranged. An actuator 44 is arranged to bring the cleaning blade 40 to travel back and forth such that the cleaning blade 40 travels a V-shaped path and such that the edge 41 moves in and out of the air supply slot, opening or outlet 45 of the nozzle 39 when the blade 40 is oscillated longitudinally in the air supply slot 45. When the blade 40 is in its outermost position, i.e. the position disclosed in Fig. 5, the opening 45 is blocked by the blade 40. Consequently, the type of nozzle disclosed in Fig. 4 to 6 is preferably used only in situations where temporary flow interruptions can be tolerated, e.g. in air curtain nozzles.

[0102] In the web transport system according to the invention, dust is contained by exhausting and supplying air between adjacent foils 7a and 7b, as is shown in Figs. 7 and 8.

[0103] Air is supplied to the zone between the foils 7a and 7b via an air supply module 9 having a downstream facing cross-machine air supply nozzle 46 ejecting fresh air onto the trailing edge of the first, upstream foil 7a. This airflow is a uniform laminar flow that has a velocity field with a maximum magnitude that is much lower than the velocity of the web 47. The air supply nozzle 46 is adjustable such that the velocity and the volumetric flow of the ejected air can be changed. Also, on the leading edge of the second, downstream foil 7b there is an air exhaust module 10 being arranged to evacuate dust-laden air from the zone between the foils 7a and 7b. The air exhaust module 10 comprises an upstream facing cross-machine air exhaust slot 49.

[0104] The air supply module 9 and the air exhaust module 10 are connected to an air duct system (not shown) being arranged for leading fresh air to the air supply module 9 and for leading dust-laden air away from the air exhaust module 10.

[0105] The exhaust flow is slightly greater than the supply flow. This creates a very low under-pressure in the zone between the foils 7a and 7b. The air from the supply nozzle 46 combines with bleed-air relieved from the end of the first foil 7a and the induced machine room air from above the foils, as is shown in Fig. 11. All of this air is drawn into the exhaust slot 48. The air is not exhausted through the web 47. Final balance is automatically achieved by bleeding in air from above the web. If there was only the evacuation of the low flow of dust-laden air that bleeds from the trailing edge of the upstream foil 7a, the exhaust slot 47 would have to be very small and, consequently, would be prone to blockage. It would also be very difficult to balance the airflow.

[0106] Preferably, the gap g (see Fig. 9) of the exhaust slot 48 is in excess of ½" (13mm) in order to obtain a low probability of plugging. For example, an exhaust slot gap g of 5/8" (16mm) can be used. Such an exhaust slot is capable of evacuating 17.4 cfm/inch (19.4 (m3/min)/m) at a web velocity of 4,000 ft/min (20.3 m/s).

[0107] Preferably, the supply air is primarily re-circulated exhaust air that has been mixed with some fresh air. The required flowrate of the supply air is approximately 75% of the exhaust flowrate. This equates to approximately 13 cfm/inch (14.5 (m3/min)/m).

[0108] As with conventional foil applications, there is preferably a wrap on the trailing edge of the upstream foil 7a and on the leading edge of the downstream foil 7b.

[0109] This configuration allows for great flexibility during design, construction and start-up as it allows for adjustments to the foil geometry and airflows.

[0110] The distance between the foils 7a and 7b can vary depending on the application. A distance between the foils 7a and 7b of approximately 3 to 4 inches (76 to 102mm) has proven to be suitable.

[0111] There are no hidden passages or inaccessible locations in the air supply and air exhaust modules 9, 10. The tending side and drive side ends of the air exhaust module 10 have a round inspection port with a quick release latch. This allows for easy inspection of the interior of the air exhaust module 10.

[0112] The air exhaust module 10 can have a constant profile regardless of the width of the machine. There are semi-tangential outlets 49 located along the width of the module 10 approximately every 2500 mm. Also, the air supply module

9 can have a constant profile regardless of the width of the machine. There are rectangular inlet connections 50 located along the width of the module 9 approximately every 2500 mm.

[0113] The air supply and exhaust modules 9, 10 can be retrofitted to existing foils as required in a rebuild situation.

[0114] Preferably at least one, more preferably a majority and most preferably all of the air exhaust modules 10 of the web transfer system comprises a self-cleaning air exhaust slot 48.

[0115] A preferred embodiment of an air exhaust module having such a self-cleaning air exhaust slot 48 will be described in the following with reference to Fig. 9. An air exhaust module comprising this type of self-cleaning exhaust slot is suitable for evacuating dust-laden air having a relatively low moisture content.

[0116] The air exhaust module 10 comprises a rotatable section 51 being formed by a cylindrically shaped body 52 and a tangentially extending lip 53, which is fixed to the envelope surface of the body 52. The body 52 may be comprised of pipe sections. The section 51 is rotatably mounted in a support structure 54 such that when the section 51 is rotated, the lip 53 traverses the exhaust slot 48 of the module 10 and clears the exhaust slot 48. A scraper blade 55 removes any material that may be attached to the body 52. When clearing the exhaust slot 48, the lip 53 pushes any material blocking the slot 48 into the module 10 where the loosened material is carried away by the flow of the exhaust air.

[0117] The rotatable section 51 can be rotated more than 180 degrees between a first, idle position and a second position, which is illustrated using broken lines in Fig. 9. When operated, the rotatable section 51 is rotated very quickly from the first position to the second position and then back to the first position. A rotary actuator or a pneumatic cylinder with a special linkage assembly, preferably arranged on the drive side of the module 10, is used to rotate the rotatable section 51.

[0118] The support structure 54 comprises equally spaced support struts 56 being arranged along the cross-direction of the module 10. The lip 53 and the scraper blade 55 extends continuously along the cross-direction of the module 10 while the body 52 preferably is comprised of several pipe sections, each terminating at a support bearing carried by a support strut 56. The pipe sections are linked with a short piece of round bar that passes through each bearing and is fastened to the ends of the pipe sections with pins.

[0119] When traversing the exhaust slot 48, the lip 53 temporarily halts the flow of air and consequently the self-cleaning function cannot be used in applications where the sheet stability would be upset during it's use. In applications where the self-cleaning function would affect the sheet stability, it's use could be restricted to sheet-off conditions such as during crepe blade changes.

[0120] Alternatively, the rotatable section 51 can be divided into two part-sections that are actuated independently. This would allow for half of the slot 48 to be functioning while the other half is being cleaned. However, this would require the use of two actuator assemblies instead of one, in which case there would preferably be one actuator on the tending side and one actuator on the drive side of the module 10.

[0121] The design of the air exhaust module 10 disclosed in Fig. 9 allows for materials that may have bridged the exhaust slot 48 to be pushed into the slot 48. An optional configuration would allow for bridged materials to be pushed out of the slot 48, in which case the idle position of the lip 53 preferably is inside the air exhaust module 10. Also, the actuator or actuators would have to have a reversed configuration in such a configuration.

[0122] Another type of known air exhaust modules are long semi-cylindrical devices that have a longitudinal exhaust slot where dust-laden air is drawn into the module. Often, the exhaust slot of these modules becomes blocked by relatively large pieces of broken web material. In many cases, the exhaust slot is not easily accessible and a simple means of maintaining cleanliness of the slot is required.

[0123] The normal exhaust slot of such a dust collector is a long, narrow and semi-rectangular opening running in the cross-machine direction of the module. The opening may be slightly tapered in the direction of the flow of the exhaust air. The cross-machine length of the exhaust slot is usually within the range of 10 to 30 feet (3.0 to 9.1 m) and the normal slot gap range is approximately ½" to 2" (1.3 to 5.1 cm). If a wad of broken web material is lodged in the exhaust slot, it is sometime difficult for it to break free. In this type of dust collector applications, water may 'undermine' the back of the wad to help it become dislodged, but this is not always successful. With time, the performance of the collector is compromised as the effective exhaust slot area is reduced due to the blockage or blockages.

[0124] Up until now, only the following methods have been used for removing blockages from dust collector intake slots:

- Manual cleaning
- Compressed air knock-off shower

[0125] Manual cleaning is not always practical as the collectors are often located in areas that are difficult to access. The compressed air showers are also not effective since there is a high vacuum level at the intake slot which causes difficulties for the wads to become dislodged. If the air showers do dislodge any wads, the wads become airborne in the dry end of the machine and this is not desirable. Large wads that are allowed to fall outside of the collector may cause sheet breaks. Consequently, there is a need for a wet dust collector that allows for the wads to be drawn into the collector

so that disturbances outside of the collector are avoided.

[0126] Another embodiment of a dust collector having a self-cleaning air exhaust slot will be described in the following with reference to Figs. 10 to 12.

[0127] Figs. 10 to 12 schematically disclose a machine-directional view of such an air exhaust module in the form of a dust collector 57. The collector 57 comprises an upper slot plate 58 and a lower slot plate 59, each displaying a zig-zag pattern having a pitch P. The slot plates 58, 59 define an air exhaust slot 60.

[0128] The lower slot plate 59 is adjustably fixed in the collector 57 as in a conventional dust collector. The upper slot plate 58, however, is movably arranged in the collector 57 such that it can move back and forth in the longitudinal direction of the slot 60 with a length of stroke equal to or larger than P.

[0129] Consider a wad of broken web material at an arbitrary location along the slot 60. The effective slot gap varies as the upper slot plate 58 moves back and forth. The wad is exposed to this variation in the slot gap. As the slot gap increases at this location, the wad gets drawn into the slot 60 by the air sucked into the dust collector 57. As the effective slot gap decreases, the wad becomes compressed or sheared. With repeated cycles, the wad is completely drawn into the slot 60.

[0130] The open area of the intake slot 60 remains constant and the airflow remains approximately constant as the upper slot plate 58 moves back and forth. Thus, the airflow balance of the entire dust control system remains unchanged.

[0131] The oscillation of the upper slot plate 58 can be constant or cycled on and off depending on the rate at which material accumulates on the slot 60. The rest position of the upper slot plate 58 is preferably at the mid-point of it's travel, as is shown in Fig. 11. A simple pneumatic cylinder with a timer could be used for operating the upper plate 58. A limit switch could be used to provide feedback to identify the rest position of the upper slot plate 58. In an alternative embodiment, both slot plates may be movably arranged in the collector 57 such that they can move back and forth in the longitudinal direction of the slot 60.

[0132] A dry end enclosure according to one aspect of the invention will now be described with reference to Fig. 13.

[0133] The dry end enclosure of the web transport system is an assembly of physical barriers, air curtains and controlled air flow patterns that effectively envelope the dry end of the machine to prevent the escape of dust.

[0134] The boundaries of this dry end enclosure are shown in Fig. 13 and are described as follows:

- The top of the web
- From the drive side edge and tending side edge of the foils, vertically down to the tloor.
- The operating floor and pulper.
- Air Curtains and panels at the Reel Area

[0135] With several features as described in this document, the sheet run is enclosed. The dry end enclosure 61 is a control volume in which massflows and energy must be balanced.

[0136] Air curtains according to one aspect of the invention will now be described with reference to Figs. 14 and 15.

[0137] Part of the dry end enclosure may be accomplished by means of air curtains, as is shown in Figs. 14 and 15, in which case the dry end enclosure comprises air curtain nozzles 62 being positioned along the foils 7 such that vertically downward linear air curtains are created extending from the foils 7 to the floor 63 of the dry end.

[0138] In conventional dust control systems, air moves inwards to the machine near the edge of the web in an attempt to contain the dust. In the web transfer system according to the invention, the air moves outwards from the machine near the edge of the web.

[0139] An air curtain is a non-intrusive dynamic barrier between adjoining zones. A physical barrier such as a wall or strip curtain is perhaps lower cost but they inhibit the physical and visual access of the operators.

[0140] Air is introduced along the sides of the web or sheet run to stabilize the edges of the web or sheet 47 and contain the dust laden air to the dry end enclosure. Favourable air flow patterns are generated.

[0141] With the application of vertically downward linear air curtains that are oriented in the machine direction along the edges of the sheet run, two important results are achieved:

- The dry end is essentially enclosed as the space below the web is sealed to the floor on both the tending and drive sides, and,
- Induced Air flows close to the web are moving outwards from the center of the machine thus improving edge stability.

[0142] At first glance, one would think that the web 47 would get pushed away from the foil 7. This is not the case. The airflow patterns induced by the nozzles 62 in the area of the web 47 are as shown in Fig. 15.

[0143] In areas that air curtains are not practical, enclosure panels are preferably used. Where air curtains and panels are both impractical, the system shall rely upon containment velocities of 100 to 150 fpm (0.5 to 0.75 m/s) to contain the dust laden air.

[0144] A creper lead-out foil 13 according to one aspect of the invention will now be described with reference to Fig. 16.

[0145] The creper lead-out foil 13 is used to transfer the web from the creping doctor.

[0146] A cross-machine seal nozzle 64 in the up-stream end of the lead-out nozzle 13 is used to blow air onto the surface of the Yankee cylinder 1 such that the boundary layer air is removed from the Yankee cylinder 1 before the web 47 reaches the creping blade 65 of the creping doctor 21. This seal nozzle 64 is preferably of the self cleaning type described above in relation to Figs. 2 and 3. The foil 13 is a plenum for the nozzle air.

[0147] In the majority of cases, the dry end toe of the Yankee cylinder 1 will leak air. This leaked air is hot, humid and contaminated with dust and products of combustion from the direct fired heating system of the Yankee Hood. It is important that this air be contained and removed. In addition to the normal boundary layer air that exits due to the moving surface, the hood may be pressurized. Every machine has different leakage rates as it depends on the design and balance of the Yankee Hood. This moisture laden air is normally carried with the top surface of the web. It usually results in condensation on the downwards-facing surfaces of the foils. This leads to accumulations of sheet additives or 'stickies' on the foil surfaces.

[0148] A common problem encountered in this area is edge instability. This is mostly caused by an inflow of air on the sides of the machine as the web 47 pumps air towards the dry end. This symptom is usually worsened by a pulper exhaust system. The lead-out foil 13 is preferably equipped with side air-curtain nozzles of the type described above in relation to Figs. 14 and 15.

[0149] An exhaust module 10 acting as a dust collector having a cross-machine intake slot is located on the upstream end of the foil 68 that follows the creper lead-out foil 13 (see Fig. 1). The zone is balanced. The flowrate Q1 of the air that is exhausted by this dust collector is a summation of the following flows:

- The Yankee boundary layer and leakage air
- The seal nozzle air S1
- Ambient air bleed-in
- Low flow of dust-laden air from between the lead-out foil 13 and the web 47.

[0150] Air is drawn in to the area 66 below the web 47 at the creping doctor 21. This is a result of the movement of the web 47 as it 'pumps out' air with it's boundary layer. In high speed machines, it may be an advantage to introduce low-velocity air below the web 47 at the creping doctor 21.

[0151] This first foil 13 should not be an active foil because the sheet tension must be relatively low at the creping doctor 21.

[0152] The lead-out foil 13 is equipped with a knock-down air shower 67. If the web 47 needs to be directed to a pulper 125 (see Figs. 27 to 29) from the creping doctor 21, compressed air is released through the series of holes in the underside of the foil 13.

[0153] The cross-machine seal nozzle 64 stops the boundary layer air that is carried with the Yankee cylinder 1. This allows the required wrap angle on this foil 13 to be less than that used on conventional creper lead-out foils. This results in decreased sheet tension downstream of the foil 13.

[0154] Pressurized air is used to induce an airflow from the edges of the Yankee cylinder and direct it into the pulper opening. The misting showers are used to ensure that the trim or Yankee fuzz is knocked down into the pulper.

[0155] As with conventional designs, a web or sheet support is required directly after the creping doctor lead-out foil. In the following, this foil will be referred to as the 'second foil' of the web transport system. A second foil 68 according to one aspect of the invention will now be described with reference to Figs. 17 and 18.

[0156] This foil 68 is an important variable to be used in the design of a dry end. The geometry of this foil 68 is adjusted to suit the specific requirements of the machine. The leading edge of this foil is equipped with an exhaust module 10 that has a self-cleaning exhaust slot similar to the type described above in relation to Figs. 7 to 9. The air that enters this exhaust slot is a mixture of air from above and below the creper lead-out foil 13, as has been discussed above.

[0157] When there is a cut-off doctor 15, the second foil assembly must be retractable, as is shown in Fig. 18. This allows for the cut-off doctor 15 to engage and the web 47 to pass down into the pulper 125 (see Figs. 27 to 29).

[0158] A cross-machine knockdown air shower pipe 69 is located on the strong-back of the cut-off doctor 15. Favourable air currents are generated to draw the web 47 downwards when needed.

[0159] Fixed curtain panels 70 hang from the dry end toe of the Yankee Hood are close to the top end of the second foil 68 when the foil is retracted. This seals the area 70 next to the Yankee cylinder 1 to help contain dust while the web

47 is directed down to the pulper 125 (see Figs. 27 to 29) from the cut-off doctor 15.

[0160] A calender lead-in according to one aspect of the invention will now be described with reference to Fig. 19.

[0161] The majority of machines do not use a calender. For machines that do use a calender, special transition zones are incorporated in the foils to allow for transfer of the web into and out of the calender rolls while enclosing the web from above.

[0162] A calender lead-in foil 71 leads the web 47 into the gap formed between the counter-rotating calender rolls 72, 76 of the calender 3. At the entrance to the calender, there is a wrap on the lower calender roll 72. An air supply module in the form of an air curtain nozzle 12 producing a nip-flooding air jet is used to accomplish two main tasks.

- It prevents dust laden air from entering the closing nip.
- It pressurizes the area above the web to prevent 'ballooning' of the web on the lower calender roll.

[0163] An optional sheet spreading airfoil on the calender lead-in foil 71 may be used.

[0164] A dust collector 10 with a self-cleaning intake slot is strategically located at the downstream end of the web supporting foil 71 and removes dust laden air from the trailing edge of the foil 71.

[0165] A calender roll dust collector 16 and a calender roll air deflector 17 according to one aspect of the invention will now be described with reference to Fig. 20.

[0166] The deflector 17 and the dust collector 16 are used on the wet end side of the lower calender roll 72. This is similar in design to the unit used at the reel drum (to be described below).

[0167] Boundary layer dust-laden air is normally pumped into the zone 73 between the moving calender roll 72 and the underside of the web 47.

[0168] The minimum required flowrate of air from this collector 16 for relief of the over-pressure in this zone 73, can be predicted with the following equation.

$$Q1=B1+B2$$

where:

B1=the volumetric flowrate rate of the boundary layer on the underside of the web 47.

B2=the volumetric flowrate rate of the boundary layer on the rotating lower calender roll 72.

[0169] The boundary layer airflows can be approximated using CFD analysis tools.

[0170] A scanner passage according to one aspect of the invention will now be described with reference to Fig. 21.

[0171] The dust laden air is effectively contained above the web while it passes through the scanner 4.

[0172] The concept employed here is similar to the foil to foil transfer as described above in relation to Figs. 7 and 8.

[0173] The web 47 is supported by a scanner lead-in foil 77 at the entrance of the scanner 4. The trailing edge of this foil 77 is close to a scanner head 80 as shown in Fig. 21. An air supply module 9 having a low pressure supply nozzle 46 is located above this trailing edge and it releases air in the direction of the sheet travel and towards an air exhaust module 10 acting as a dust collector having an air intake or exhaust slot 48. The velocity of the air is of relatively lower magnitude than that of the web 47.

[0174] A scanner lead-out foil 78 is positioned downstream of the scanner 4. The foil 78 is sloped such that approximately 2 degrees of wrap is achieved to ensure good transfer. The leading edge of this foil 78 has a smooth leading edge. The exhaust slot 48 is located directly above this edge. The exhaust slot 48 is self-cleaning. The volumetric flow rate of the exhaust air is slightly higher than the volumetric flow rate of the air supply module 9. The web is not drawn in as the zone is balanced.

[0175] An enclosure panel 79 is oriented cross-machine and extends from the top of the dust collector 10 to the upper dry end face of the scanner frame. Adequate clearance to the moving scanner head is provided.

[0176] As the scanner head passes in the cross-machine direction, a portion of the supply nozzle 46 and a corresponding portion of the exhaust slot 48 are covered simultaneously. The exhaust slot self-cleaning mechanism is prevented from operating (with controls logic) while the scanner head is in the sheet run.

[0177] A reeling station 2 comprising a reel drum 87 according to one aspect of the invention will now be described with reference to Fig. 22.

[0178] The area on the wet end side of the reel drum is a zone that is naturally pressurized due to the incoming boundary layer air that moves with the underside of the web 47 and the outer surface of the reel drum 87. The boundary

layer air on the underside of the web 47 has a relatively high concentration of dust.

[0179] A deflector 19 is oriented cross-machine and is located on the wet end side of the reel drum 87. It is equipped with a wiper blade 88. The wiper blade 88 cuts off the boundary layer air that moves with the reel drum 87 and helps prevent the web 47 from 'ballooning' above the reel drum. The air is deflected downwards with the curved cross-machine deflector 19.

[0180] A reel drum air exhaust module 18 in the form of a dust collector is used to evacuate air from the area. If this air is not evacuated directly from this zone, the zone would be pressurized and it would squeeze the dust laden air out the sides of the machine. It would also cause the web 47 to 'balloon' as it is transferred to the reel drum 87.

[0181] The dust collector 18 is sized to suit the flowrate of boundary layer air that comes with the web 47 and the rotation of the reel drum 87.

[0182] The intake of the collector 18 may be the self-cleaning type described above in relation to Fig. 9.

[0183] The minimum required flowrate of air from this collector 18 for relief of the over-pressure in this zone, can be predicted with the following equation.

$$Q1=B1+B2$$

where:

B1=the volumetric flowrate rate of the boundary layer on the underside of the web 47.
B2=the volumetric flowrate rate of the boundary layer on the rotating reel drum 87.

[0184] The boundary layer airflows can be approximated using CFD analysis tools.

[0185] Web or sheet pressurization at the reel drum according to one aspect of the invention will now be described with reference to Fig. 23.

[0186] A sheet spreader 6 is located directly before the reel drum area. Air is introduced above the web 47 directly after the sheet spreader 6 and before a reel shield 101. This zone is covered by an enclosure 102 and is pressurized to help keep the web 47 tight to the surface of the reel drum 87.

[0187] To transfer the web from the sheet spreader 6 to the reel drum 87 while preventing 'ballooning' of the web, air is released at the trailing edge of the spreader 6. The geometry of the enclosure 102 helps create a pressurized zone or volume 103 above the web 47. Initially, the air has a low velocity and a positive static pressure. The air travels with the web 47 and passes through the restriction between the shield 101 and the reel drum 87. The air is released to the area above the reel drum 87. The static gauge pressure is zero where it is released and the dynamic pressure is positive.

[0188] Creating an over-pressure on top of the web 47 is the same as creating an under-pressure below the web 47. Importantly, there is a pressure differential that pushes the web 47 downwards. The pressure differential is easily adjustable by changing the air flowrate into the zone 103 or adjusting the gap between the shield 101 and the reel drum 87. The air is introduced at low velocity thus avoiding web stability issues.

[0189] Bernoulli's theorem (the conservation of energy) shows that the static pressure in the low velocity zone is converted to velocity pressure at the flow restriction where the air ultimately exits the zone. The static pressure is essentially zero at this location. 'Static pressure' is a term that actually means static gauge pressure. Ambient air has a 'static pressure' of zero because this is the datum or reference pressure.

[0190] A reel shield with a dust collector and a nip flooding air curtain according to one aspect of the invention will now be described with reference to Fig. 24.

[0191] Favourable airflow patterns are generated in the reel drum area with the use of air curtains 104, a dust collector 105 and enclosure panels. The special combination will achieve a stable web that is wrapped cleanly while dust is contained. The equipment is not intrusive on the normal mechanical motions that occur at the reel.

[0192] The reel shield 101 extends across the machine and is oriented vertically above the reel drum 87. An air exhaust module in the form of an area dust collector 105 is attached to the top of the reel shield 101. Preferably, the dust collector 105 comprises a self-cleaning slot as described in connection with Fig. 9.

[0193] The nip flooding air jet concept is employed in a similar fashion as used with the entrance to the calender. An air supply module in the form of a nip flooding or air curtain nozzle 12 is located above the reel drum 87. This linear free jet is oriented cross-machine and is directed at the roll 107.

[0194] The nip flooding air nozzle 12 is preferably fitted with a self cleaning mechanism as described above in relation to Figs. 4 to 6. The supply air duct 109 has a diver damper (not shown) to temporarily halt the nozzle air flow during threading.

[0195] The air curtain nozzle 12 air floods the nip 110 across the full width of the web. The majority of the air that enters the nip originates from the nozzle 12 and the boundary layer air of the jumbo roll 107. When this air enters the

converging nip 110, it is rejected opposite the direction of the web as it passes over the reel drum 87. Particulate and small pieces of broke that may be carried with the top of the web over the reel drum 87 are rejected by the strong air currents that exit the closing nip 110.

[0196] An intense rotational flow field is generated in the zone bounded by the air curtain 104, the top of the reel drum 87, and the reel shield 101.

[0197] The air flows in this zone are balanced to achieve containment of dust and debris.

Q1= Minimum required exhaust flow rate from the reel shield collector 105

S1= Supply flow from reel above-sheet pressurization

S2=Supply flow from the nip flooding air nozzle 12

B1=Boundary layer flow rate on full jumbo roll 107

C1=Air flow required at tending side and drive side for containment = Area x Containment Velocity

$$Q1=S1+S2+B1+C1$$

[0198] The boundary layer airflows can be approximated using CFD analysis tools.

[0199] The reel collector 105 has a relatively large exhaust volumetric flowrate and it has a large intake slot gap of 3 inches (76mm). It is capable of drawing in large amounts of broke. A broke trap is used downstream of this collector to separate the large pieces of broke and deliver them to the pulper.

[0200] A lower reel drum air curtain according to one aspect of the invention will now be described with reference to Fig. 25.

[0201] A lower reel drum air curtain nozzle 117 is used to contain dust that would otherwise get carried out with the boundary layer air of the roll 107. This nozzle 117 can also clean the web immediately after it has been rolled up. It blows air against the roll 107 immediately after it touches the reel drum 87. The nozzle 117 is a fixed cross-machine nozzle and preferably comprises a self cleaning mechanism as described above in relation to Figs. 4 to 6.

[0202] A soft curtain 118 extends down from the nozzle plenum to the floor. This curtain is made of former fabric or similar material. It allows for the passage of broke which is normally pushed into the pulper opening. If there is no pulper opening below the reel, then rigid panels are used for the curtain below the nozzle 117.

[0203] As an option, this nozzle 117 can be actuated if deemed necessary. It could be actuated such that it follows the varying jumbo roll 107 diameter as it is wound. With the nozzle 117 close to the surface of the roll 107 at all times, the web is cleaned. This is the best time to clean the sheet.

[0204] A floor flush system according to one aspect of the invention will now be described with reference to Figs. 26 to 28.

[0205] After knocking the sheet into the pulper 125 at the cut-off doctor 15 or creping doctor 21, and prior to re-establishing the sheet to the reel, a clean-up is required.

[0206] The web transport system according to the invention is designed such that there are very few locations where broke can hang-up or accumulate below the sheet run.

[0207] In the event of a sheet break, the majority of the broke falls on the floor below the web.

[0208] Compressed-air blow-pipes (not shown) can be installed to help ensure that all broke goes to the floor.

[0209] The floor 119 is sloped towards the pulper opening(s) 120. The floor area is curbed along the sides of the machine near the sole plates.

[0210] A cross-machine spray header pipe 121 is located on the floor 119 and oriented cross-machine. Water is released from this pipe 121 with a low velocity and hits a curved plate 122. The water 'fans-out' and produces a uniform flow of water on the floor 119 in the machine direction. This shower can wash across the entire machine width of the floor. The water flowrate is sufficient to wash the broke down into the pulper 125 (see Figs. 27 to 29). The spray pipe 121 is designed such that it does not cause atomization of the water which could cause humidity problems within the enclosure zone. This header 121 requires low pressure and high flow for a short duration (perhaps 30 seconds).

[0211] The entire process of broke disposal and dry end clean-up may be automated.

[0212] The floor 119 can be sloped to one or more other broke chute openings 120. It is a function of existing machine geometries. Fig. 27 shows how it is applied to a machine that has three openings 120.

[0213] Fig. 28 shows how it is applied to a machine that has only one broke chute opening 120.

[0214] A pulper enclosure 127 according to one aspect of the invention will now be described with reference to Fig. 29.

[0215] The escape of mist and hot humid air from the pulper 125 into the enclosed zone below the web, i.e. into the

dry end enclosure 61 (see Fig. 13), is prevented. This is achieved with physical barriers and air curtains while evacuating air from the pulper enclosure at an optimum low flow rate.

[0216] This aspect of the innovation allows for the containment of the 'bubble' of hot humid air and mist in the pulper 125. The exhaust, to be directed outside of the building, is much less than that of a conventional system.

[0217] Normally, the pulper 125 has up to three broke chute openings 120. One is located below the creping doctor 21 and optional openings 120 are under the calender 3 and under the reeling station 2. Sometimes, an additional opening (not shown) is included beside the machine for manual disposal of broke.

[0218] A pulper module 20 is positioned at the floor opening below the creping doctor 21.

[0219] Preferably, pulper doors 124 are arranged on all broke chute openings 120 with the exception of the opening below the Yankee cylinder 1, where an air-curtain 128 (see Fig. 30) is used to prevent the escape of mist and vapour into the enclosed zone below the web.

[0220] This system allows for complete control of the pulper's mist and vapour.

[0221] A pulper module 20 according to another aspect of the invention will now be described with reference to Figs. 30 and 31.

[0222] The pulper module 20 seals the pulper 125 at the operating floor below the creping doctor 21 while allowing for the occasional passage of broke.

[0223] A cross-machine air curtain 128 is used at the pulper floor opening. The air curtain nozzle 129 is directed slightly downward from horizontal. During production, the air curtain nozzle 129 is in operation. It accomplishes two tasks:

- Adverse airflows such as those due to trim discharge into the pulper are controlled while needing only a minimal exhaust flowrate.
- The nozzle 129 is a good destination for the supply air. Air that is supplied back into the machine from a recirculation system is air that does not need to be discharged to the atmosphere.

[0224] Fig. 30 shows a pulper module 20 that would be used on a machine that has a single pulper opening below the creping doctor.

[0225] A cross-machine opening 130 on the dry end side of the pulper module 20 allows for the passage of broke from the floor flush system as described above in relation to Fig. 28. This opening 130 on the dry end side of the pulper module 20 is only needed in applications where there is only one broke-chute floor opening below the creping doctor. In applications where there are more than one broke-chute openings, the floor flush system would direct the water and broke to the other openings 120 (see Figs. 27).

[0226] When the web is directed into the pulper at full machine speed, it carries a boundary layer flow of air with it. In this situation, the supply air to the nozzle 129 would be temporarily halted using a divert damper (not shown).

[0227] The air curtain nozzle 129 could have water mist introduced internally to ensure that it remains clean in situations where the supply air is not very clean. A mechanical self-cleaning nozzle design, e.g. of the type shown above in relation to Figs. 4 to 6, is another acceptable option.

[0228] An air exhaust module in the form of a cross-machine pulper exhaust header or collector 131 is located above the operating floor. An array of vertically oriented intake or pick-up tubes 132 extend from the header 131 and into the top of the pulper 125 adjacent the floor opening 130.

[0229] Each of the intake tubes 132 have a concentric tapered section at it's intake 134 located at the bottom end of the tube 132 (see Fig. 31). The intake diameter is smaller than the diameter of the main section of the tube 132. The intake 134 serves as a venturi throat. Water is introduced to each of the pick-up tubes 132 via a semi-tangential water pipe 133.

[0230] During normal operating conditions, water is prohibited from spilling from the intake 134 (and into the pulper) due to the high magnitude of the vertically upwards velocity of the air at the intake 134.

[0231] In the event of the occurrence of a blockage at the intake 134 due to the attempted entrance of broke or other materials, the water is no longer prevented from spilling into the pulper 125. The water accumulates above the blockage until there is sufficient weight to dislodge the materials and cause them to drop into the pulper 125. The blockage either gets drawn into the collector 131 or it must drop into the pulper.

[0232] If fibre accumulates on the rim (edge) of the intakes 134, water will accumulate along the edge and wet the materials causing them to drop.

[0233] Inspection ports (not shown) are included in the main cross-machine header 131. They are located on top of the header concentrically above each tube 132.

[0234] A pulper door according to one aspect of the invention will now be described with reference to Fig. 32.

[0235] In applications where there is more than one pulper opening, and where these openings are used primarily for manual broke disposal and clean-ups, a gravity operated pulper door 135 is preferably used.

[0236] The hinged door 135 is made of light-weight stainless steel sheet metal. It is held closed by gravity but it easily opens to allow for the passage of wetted broke 136. It functions like a check-valve. A flushing shower 137 preferably

having a manual valve is needed to wet the broke and ensure that it moves through the door. A manual button and a controls system timer can be used to give a few minutes of flushing with a control valve. Alternatively, water from a floor flush system would suffice.

[0237] In large cross-machine openings such as those below the reel or below the calender, the axis of rotation for the door is preferably oriented cross-machine.

[0238] A sloped panel 138 may be added as shown in Fig. 32 or an existing portion of a sloped broke chute wall may serve the same purpose.

[0239] Various types of actuated doors have been used in the past, however gravity has proven to be more reliable than actuators.

[0240] An air exhaust module in the form of a roll dust collector according to one aspect of the invention will now be described with reference to Figs. 33 to 36.

[0241] A moving web carries air with it. When a web is wrapped around a roll (such as a turning roll or a spreading roll), some of the boundary layer air gets trapped between the web and the roll. This phenomena reduces traction.

[0242] Fig. 33 shows a roll 196 in the dry end of a tissue machine. Dust-laden air travels over the roll 196. A high-pressure zone 197 is formed at the web run-in position 208 and a low-pressure zone 198 is formed at the web run-out positing 209. The high-pressure zone 197 pushes the web 47 away from the roll 196 and the low-pressure zone 198 makes the web adhere to the roll 196.

[0243] The roll dust collector according to the invention has been devised to capture dust at it's source.

[0244] The roll dust collector improves traction while removing the dust laden boundary layer air.

[0245] The roll dust collector 199 (see Fig. 34) can be integrated to a new or existing roll. The dust collector 199 comprises a plenum chamber 206 which is open towards the rotating roll 196 such that the roll 196 forms part of the dust collector housing. On the upstream side of the interface, the roll is sealed to the roll dust collector. At the downstream side of the interface, adjacent to the web run-in position, the roll dust collector comprises an air intake or exhaust slot 200 running in the cross-machine direction of the dust collector 199.

[0246] The intake slot 200 has an out-going nip. Broke which may land on the intake slot, is dislodged due to the movement of the roll 196. If the exhaust flow is temporarily halted with a divert damper, the air will flow out of the slot due to the pumping action of the rotating roll.

[0247] The roll dust collector housing 201 is sealed to the roll with a sealing device in the form of a doctor blade 202. The doctor blade is a light-weight cleaning doctor comprised of plastic or composite material. It is lightly loaded against the roll. As an alternative, the sealing device can be made with an airknife.

[0248] Inside the roll dust collector 199, an internal vortex airflow pattern is generated because of the internal moving surface of the roll 196. As with conventional dry type dust collectors, the internal vortex serves to help maintain internal cleanliness.

[0249] Bridging of the intake slot 200 by accumulated dust particulate is impossible due to the movement of one side of the intake slot, i.e. the roll surface. Thus, small intake gaps are feasible.

[0250] It is known by experience that in tissue/towel grade dust control applications, slot intake gaps smaller than 1/2" (12.6 mm) are normally very susceptible to pluggage and bridging due to particulate accumulations. It is also known that a minimum required intake velocity of 4,000 ft/min (20.3 m/s) is necessary to minimize the likelihood of plugging. In many cases, exhaust flowrates are dictated by the minimum required intake velocity and the minimum required slot gap. In these cases, the capacity required is in excess of actual capacity required to control dust. With the roll dust collector 199, slot gaps as small as 1/4" (6.3 mm) can be achieved. Thus the exhaust flowrate capacity can be as much as 50% lower than that of a conventional dust collector.

[0251] The volumetric flowrate is determined by predicting the volumetric flowrate of air carried with the boundary layer of the moving web plus any supplemental airflows introduced to the zone upstream of the roll.

[0252] The roll dust collector according to the invention can be applied to almost any in-going nip where a web wraps a roll. It improves traction and contains dust.

[0253] As an example of a roll dust collector application, Fig. 35 shows a tissue machine spreader roll 203 equipped with a roll dust collector 199. The spreader roll 203 is positioned immediately downstream a slitter 204 comprising saw blades 205 which are adjustable in the cross-machine direction. Thus, the roll dust collector 199 forms a slitter dust collector in this case.

[0254] Upstream of the spreader 203 and roll dust collector 199, an air supply module 9 of the type previously described is used to introduce supplemental air to the zone.

[0255] Dust from the saw blade slitters is contained and the web traction is improved thus improving the spreading capacity of the roll.

[0256] There are many turning rolls and spreading rolls used in unwinders/re-winders and also in grade re-winders. It is understood that the roll dust collector according to the invention can be applied to many of the rolls in such apparatus.

Claims

1. An air exhaust module (10) for use in a system for transporting a fiber web (47) through a dry end of a fibre web processing machine from a drying section (1) to a reeling section (2) of the machine, the module comprising a self-cleaning air exhaust slot (48), **characterized in that** the module comprises a rotatable section (51) having an extending lip (53), which rotatable section (51) is arranged to be rotated such that the lip (53) traverses and clears the exhaust slot (48).

2. An air exhaust module (57) for use in a system for transporting a fiber web (47) through a dry end of a fibre web processing machine from a drying section (1) to a reeling section (2) of the machine, the module comprising a self-cleaning air exhaust slot (60), **characterized in that** the module comprises two slot plates (58, 59) forming the air exhaust slot (60) therebetween, each slot plate (58, 59) displaying a zig-zag pattern having a pitch (P), wherein at least one of the slot plates (58) is movably arranged in the air exhaust module (57) such that it can move back and forth in the longitudinal direction of the slot (60) with a length of stroke equal to or larger than said pitch (P).

3. An air supply module (32) for use in a system for transporting a fiber web (47) through a dry end of a fibre web processing machine from a drying section (1) to a reeling section (2) of the machine, the module comprising a self-cleaning air supply slot (34), **characterized in that** the module comprises a cleaning blade (33) having a toothed edge (35), the blade (33) being movably arranged in the air supply slot (34) in the longitudinal direction of the slot (34) such that it can be oscillated longitudinally in the air supply slot (34).

4. An air supply module (39) for use in a system for transporting a fiber web (47) through a dry end of a fibre web processing machine from a drying section (1) to a reeling section (2) of the machine, the module comprising a self-cleaning air supply slot (45), **characterized in that** the module (39) comprises a cleaning blade (40) having a linear edge (41), the blade (40) being movably arranged in the air supply slot (45) to follow a V-shaped path such that it can be oscillated longitudinally in the air supply slot (45) and such that the cleaning blade (40) is moved in and out of the slot (45) during the longitudinal oscillation.

5. A system for transporting a fiber web (47) through a dry end of a fibre web processing machine from a drying section (1) to a reeling section (2) of the machine, wherein the system comprises one or a plurality of groups of air modules, wherein each group of air modules is arranged for supplying and evacuating air from a predetermined, localized zone along the web run of the dry end, and wherein each group of air modules comprises:

   - at least one air supply module (9) being arranged for supplying air to the localized zone; and
   - at least one air exhaust module (10) being arranged for evacuating air from the localized zone,

   wherein the air flow-rate of said at least one air supply module (9) is balanced by the air flow-rate of said at least one air exhaust module (10) such that dust-laden air is prevented from escaping the localized zone by other means than through said at least one air exhaust module (10); and
   wherein said at least one air exhaust module (10) is an air exhaust module according to claim 1 or 2 and/or said at least one air supply module (9) is an air supply module according to claim 3 or 4.

6. The system according to claim 5, wherein the air flow-rate of said at least one air exhaust module (10) is at least equal to the air flow-rate of said at least one air supply module (9).

7. The system according to any one of claims 5 and 6, which comprises an upstream web-supporting foil (7a) and a downstream web supporting foil (7b) being arranged one after the other such that a free draw gap is defined between the foils (7a, 7b), wherein said at least one air supply module (9) is positioned at the downstream end of the upstream foil (7a), and wherein said at least one air exhaust module (10) is positioned at the upstream end of the downstream foil (7a).

8. The system according to any one of claims 5 to 7, which comprises:

   - at least one rotating roll (196, 203, 206) over which the web (47) is wrapped between a web run-in position (208) and a web run-out position (209); and
   - an air exhaust module (199) having a plenum chamber (207) which is open towards the rotating roll (196, 203, 206) between an upstream sealing device (202) and a downstream air exhaust slot (200), the air exhaust slot (200) being positioned adjacent to the web run-in position (208).

9. A dry end of a fiber web processing machine comprising a drying section (1), a reeling section (2), and a system according to any one of claims 5 to 8 for transporting the fibre web from the drying section (1) to the reeling section (2).

10. A method of preventing dust laden air from escaping a localized zone in a dry end of a fiber web processing machine, comprising the steps of:

- placing within the localized zone at least one air supply module (9) having an air supply slot (34; 45);
- placing within the localized zone at least one air exhaust module (10); and
- balancing the air flow-rates of said at least one air supply module (9) and said at least one air exhaust module (10) such that the air flow-rate of said at least one air exhaust module (10) is at least equal to the air flow-rate of said at least one air supply module (9);

wherein said at least one air exhaust module (10) is an air exhaust module according to claim 1 or 2 and/or said at least one air supply module (9) is an air supply module according to claim 3 or 4.

Patentansprüche

1. Luftabführungsmodul (10) zur Verwendung in einem System zum Transport einer Faserstoffbahn (47) durch ein Trockenende einer Faserstoffbahnherstellungsmaschine von einem Trocknungsabschnitt (1) zu einem Spulabschnitt (2) der Maschine, wobei das Modul einen selbstreinigenden Luftabführungsschlitz (48) umfasst, **dadurch gekennzeichnet, dass** das Modul einen drehbaren Abschnitt (51) mit einer sich erstreckenden Lippe (53) umfasst, wobei der drehbare Abschnitt (51) dazu angeordnet ist, so gedreht zu werden, dass die Lippe (53) den Abführungsschlitz (48) quert und reinigt.

2. Luftabführungsmodul (57) zur Verwendung in einem System zum Transport einer Faserstoffbahn (47) durch ein Trockenende einer Faserstoffbahnherstellungsmaschine von einem Trocknungsabschnitt (1) zu einem Spulabschnitt (2) der Maschine, wobei das Modul einen selbstreinigenden Luftabführungsschlitz (60) umfasst, **dadurch gekennzeichnet, dass** das Modul zwei Schlitzplatten (58, 59) umfasst, die den Luftabführungsschlitz (60) dazwischen bilden, wobei jede Schlitzplatte (58, 59) ein Zickzackmuster aufweist, das einen Abstand (P) aufweist, wobei wenigstens eine der Schlitzplatten (58) bewegbar in dem Luftabführungsmodul (57) angeordnet ist, so dass sie sich in Längsrichtung des Schlitzes (60) mit einer Weglänge, die gleich oder größer als der Abstand (P) ist, hin und her bewegen kann.

3. Luftzuführungsmodul (32) zur Verwendung in einem System zum Transport einer Faserstoffbahn (47) durch ein Trockenende einer Faserstoffbahnherstellungsmaschine von einem Trocknungsabschnitt (1) zu einem Spulabschnitt (2) der Maschine, wobei das Modul einen selbstreinigenden Luftzuführungsschlitz (34) umfasst, **dadurch gekennzeichnet, dass** das Modul eine Reinigungsklinge (33) mit einer Zahnkante (35) umfasst, wobei die Klinge (33) bewegbar in dem Luftzuführungsschlitz (34) in Längsrichtung des Schlitzes (34) angeordnet ist, so dass sie in Längsrichtung in dem Luftzuführungsschlitz (34) oszillieren kann.

4. Luftzuführungsmodul (39) zur Verwendung in einem System zum Transport einer Faserstoffbahn (47) durch ein Trockenende einer Faserstoffbahnherstellungsmaschine von einem Trocknungsabschnitt (1) zu einem Spulabschnitt (2) der Maschine, wobei das Modul einen selbstreinigenden Luftzuführungsschlitz (45) umfasst, **dadurch gekennzeichnet, dass** das Modul (39) eine Reinigungsklinge (40) mit einer linearen Kante (41) umfasst, wobei die Klinge (40) bewegbar in dem Luftzuführungsschlitz (45) angeordnet ist, so dass sie einem V-förmigen Weg folgt, so dass sie in Längsrichtung in dem Luftzuführungsschlitz (45) oszillieren kann, und so dass die Reinigungsklinge (40) während der Oszillation in Längsrichtung in den Schlitz (45) und aus diesem heraus bewegt wird.

5. System zum Transport einer Faserstoffbahn (47) durch ein Trockenende einer Faserstoffbahnherstellungsmaschine von einem Trocknungsabschnitt (1) zu einem Spulabschnitt (2) der Maschine, wobei das System eine oder eine Vielzahl von Gruppen von Luftmodulen umfasst, wobei jede Gruppe von Luftmodulen dafür vorgesehen ist, Luft in eine vorbestimmte örtlich begrenzte Zone entlang der Stoffbahnführung des Trockenendes zu- und aus diesem abzuführen, und wobei jede Gruppe von Luftmodulen umfasst:

- wenigstens ein Luftzuführungsmodul (9), das dafür vorgesehen ist, Luft in die örtlich begrenzte Zone zuzuführen; und
- wenigstens ein Luftabführungsmodul (10), das dafür vorgesehen ist, Luft aus der örtlich begrenzten Zone

abzuführen,

wobei die Luftströmungsgeschwindigkeit des wenigstens einen Luftzuführungsmoduls (9) durch die Luftströmungsgeschwindigkeit des wenigstens einen Luftabführungsmoduls (10) ausgeglichen wird, so dass ein Entweichen staubhaltiger Luft aus der örtlich begrenzten Zone durch andere Mittel als durch das wenigstens eine Luftabführungsmodul (10) verhindert wird; und wobei das wenigstens eine Luftabführungsmodul (10) ein Luftabführungsmodul nach Anspruch 1 oder 2 ist und/oder das wenigstens eine Luftzuführungsmodul (9) ein Luftzuführungsmodul nach Anspruch 3 oder 4 ist.

6. System nach Anspruch 5, wobei die Luftströmungsgeschwindigkeit des wenigstens einen Luftabführungsmoduls (10) wenigstens gleich der Luftströmungsgeschwindigkeit des wenigstens einen Luftzuführungsmoduls (9) ist.

7. System nach einem der Ansprüche 5 und 6, das eine stromaufwärtige Stoffbahnhaltefolie (7a) und eine stromabwärtige Stoffbahnhaltefolie (7b) umfasst, die nacheinander so angeordnet sind, dass eine freie Zuglücke zwischen den Folien (7a, 7b) gebildet wird, wobei das wenigstens eine Luftzuführungsmodul (9) an dem stromabwärtigen Ende der stromaufwärtigen Folie (7a) angeordnet ist und wobei das wenigstens eine Luftabführungsmodul (10) an dem stromaufwärtigen Ende der stromabwärtigen Folie (7b) angeordnet ist.

8. System nach einem der Ansprüche 5 bis 7, umfassend:

- wenigstens eine drehende Rolle (196, 203, 206), über die die Stoffbahn (47) zwischen einer Stoffbahneinlaufposition (208) und einer Stoffbahnauslaufposition (209) gewickelt ist; und
- ein Luftabführungsmodul (199) mit einer Sammelkammer (207), die zu der drehenden Rolle (196, 203, 206) zwischen einer stromaufwärtigen Dichtungseinrichtung (202) und einem stromabwärtigen Luftabführungsschlitz (200) geöffnet ist, wobei der Luftabführungsschlitz (200) angrenzend an die Stoffbahneinlaufposition (208) angeordnet ist.

9. Trockenende einer Faserstoffbahnherstellungsmaschine, die einen Trocknungsabschnitt (1), einen Spulabschnitt (2) und ein System nach einem der Ansprüche 5 bis 8 zum Transport der Faserstoffbahn von dem Trocknungsabschnitt (1) zu dem Spulabschnitt (2) umfasst.

10. Verfahren, um das Entweichen von staubbelasteter Luft aus einer örtlich begrenzten Zone in einem Trockenende einer Faserstoffbahnherstellungsmaschine zu verhindern, umfassend die Schritte:

- Anordnen wenigstens eines Luftzuführungsmoduls (9), das einen Luftzuführungsschlitz (34, 45) aufweist, in der örtlich begrenzten Zone;
- Anordnen wenigstens eines Luftabführungsmoduls (10) in der örtlich begrenzten Zone; und
- Ausgleichen der Luftströmungsgeschwindigkeiten des wenigstens einen Luftzuführungsmoduls (9) und des wenigstens einen Luftabführungsmoduls (10), so dass die Luftströmungsgeschwindigkeit des wenigstens einen Luftabführungsmoduls (10) wenigstens gleich der Luftströmungsgeschwindigkeit des wenigstens einen Luftzuführungsmoduls (9) ist;

wobei das wenigstens eine Luftabführungsmodul (10) ein Luftabführungsmodul nach Anspruch 1 oder 2 ist und/oder das wenigstens eine Luftzuführungsmodul (9) ein Luftzuführungsmodul nach Anspruch 3 oder 4 ist.

Revendications

1. Module d'évacuation d'air (10) destiné à être utilisé dans un système de transport d'une bande fibreuse (47) dans une extrémité sèche d'une machine de traitement de bande fibreuse entre une section de séchage (1) et une section d'enroulement (2) de la machine, le module comprenant une fente d'évacuation d'air autonettoyante (48), **caractérisé en ce que** le module comprend une section rotative (51) qui possède une lèvre en extension (53), ladite section rotative (51) étant prévue pour être tournée de sorte que la lèvre (53) traverse et s'éloigne de la fente d'évacuation (48).

2. Module d'évacuation d'air (57) destiné à être utilisé dans un système de transport d'une bande fibreuse (47) dans une extrémité sèche d'une machine de traitement de bande fibreuse entre une section de séchage (1) et une section d'enroulement (2) de la machine, le module comprenant une fente d'évacuation d'air autonettoyante (60), **caractérisé en ce que** le module comprend deux plaques fendues (58, 59) qui forment la fente d'évacuation d'air (60) entre

elles, chaque plaque fendue (58, 59) présentant un motif en zigzag qui possède un pas ($_{P}$), dans lequel au moins l'une des plaques fendues (58) est disposée de manière mobile dans le module d'évacuation (57) de sorte qu'elle puisse se déplacer vers l'avant et vers l'arrière dans la direction longitudinale de la fente (60) avec une longueur de course égale ou supérieure audit pas ($_{P}$).

3. Module d'alimentation en air (32) destiné à être utilisé dans un système de transport d'une bande fibreuse (47) dans une extrémité sèche d'une machine de traitement de bande fibreuse entre une section de séchage (1) et une section d'enroulement (2) de la machine, le module comprenant une fente d'alimentation en air autonettoyante (34), **caractérisé en ce que** le module comprend une lame de nettoyage (33) qui possède un bord denté (35), la lame (33) étant disposée de manière mobile dans la fente d'alimentation en air (34) dans la direction longitudinale de la fente (34) de sorte qu'elle puisse être oscillée longitudinalement dans la fente d'alimentation en air (34).

4. Module d'alimentation en air (39) destiné à être utilisé dans un système de transport d'une bande fibreuse (47) dans une extrémité sèche d'une machine de traitement de bande fibreuse entre une section de séchage (1) et une section d'enroulement (2) de la machine, le module comprenant une fente d'alimentation en air autonettoyante (45), **caractérisé en ce que** le module (39) comprend une lame de nettoyage (40) qui possède un bord linéaire (41), la lame (40) étant disposée de manière mobile dans la fente d'alimentation en air (45) afin de suivre un trajet en forme de V de façon à être oscillée longitudinalement dans la fente d'alimentation en air (45) et de sorte que la lame de nettoyage (40) soit déplacée à l'intérieur et à l'extérieur de la fente (45) pendant l'oscillation longitudinale.

5. Système de transport d'une bande fibreuse (47) dans une extrémité sèche d'une machine de traitement de bande fibreuse entre une section de séchage (1) et une section d'enroulement (2) de la machine, dans lequel le système comprend un ou plusieurs groupes de modules d'air, dans lequel chaque groupe de modules d'air est prévu pour fournir et évacuer l'air d'une zone localisée prédéterminée le long du passage de bande de l'extrémité sèche, et dans lequel chaque groupe de modules d'air comprend :

- au moins un module d'alimentation en air (9) prévu pour fournir de l'air à la zone localisée ; et
- au moins un module d'évacuation (10) prévu pour évacuer l'air de la zone localisée,

dans lequel le débit d'air dudit au moins un module d'alimentation en air (9) est équilibré par le débit d'air dudit au moins un module d'évacuation (10) de sorte que l'air chargé en poussière ne puisse pas s'échapper de la zone localisée par un autre moyen que par ledit au moins un module d'évacuation d'air (10) ; et
dans lequel ledit au moins un module d'évacuation d'air (10) est un module d'évacuation d'air selon la revendication 1 ou 2 et/ou ledit au moins un module d'alimentation en air (9) est un module d'alimentation en air selon la revendication 3 ou 4.

6. Système selon la revendication 5, dans lequel le débit d'air dudit au moins un module d'évacuation d'air (10) est au moins égal au débit d'air dudit au moins un module d'alimentation en air (9).

7. Système selon l'une quelconque des revendications 5 et 6, qui comprend une feuille de support de bande amont (7a) et une feuille de support de bande aval (7b) prévues l'une après l'autre de sorte qu'un espace de tirage libre soit défini entre les feuilles (7a, 7b), dans lequel ledit au moins un module d'alimentation en air (9) est positionné au niveau de l'extrémité aval de la feuille amont (7a), et dans lequel ledit au moins un module d'évacuation d'air (10) est positionné au niveau de l'extrémité amont de la feuille aval (7a).

8. Système selon l'une quelconque des revendications 5 à 7, qui comprend :

- au moins un rouleau rotatif (196, 203, 206) sur lequel la bande (47) est enroulée entre une position d'entrée de bande (208) et une position de sortie de bande (209) ; et
- un module d'évacuation d'air (199) qui possède une chambre de répartition (207) qui est ouverte vers le rouleau rotatif (196, 203, 206) entre un dispositif de fermeture amont (202) et une fente d'évacuation d'air aval (200), la fente d'évacuation d'air (200) étant positionnée de manière adjacente à la position d'entrée de bande (208).

9. Extrémité sèche d'une machine de traitement de bande fibreuse comprenant une section de séchage (1), une section d'enroulement (2), et un système selon l'une quelconque des revendications 5 à 8 pour transporter la bande fibreuse entre la section de séchage (1) et la section d'enroulement (2).

10. Procédé destiné à empêcher l'air chargé de poussière de s'échapper d'une zone localisée dans une extrémité sèche d'une machine de traitement de bande fibreuse, comprenant les étapes de :

- placement, dans la zone localisée, d'au moins un module d'alimentation en air (9) qui possède une fente d'alimentation en air (34 ; 45) ;
- placement, dans la zone localisée, d'au moins un module d'évacuation d'air (10) ; et
- d'équilibrage des débits d'air dudit au moins un module d'alimentation en air (9) et dudit au moins un module d'évacuation d'air (10) de sorte que le débit d'air dudit au moins un module d'évacuation d'air (10) soit au moins égal au débit d'air dudit au moins un module d'alimentation en air (9) ;

dans lequel ledit au moins un module d'évacuation d'air (10) est un module d'évacuation d'air selon la revendication 1 ou 2 et/ou ledit au moins un module d'alimentation en air (9) est un module d'alimentation en air selon la revendication 3 ou 4.

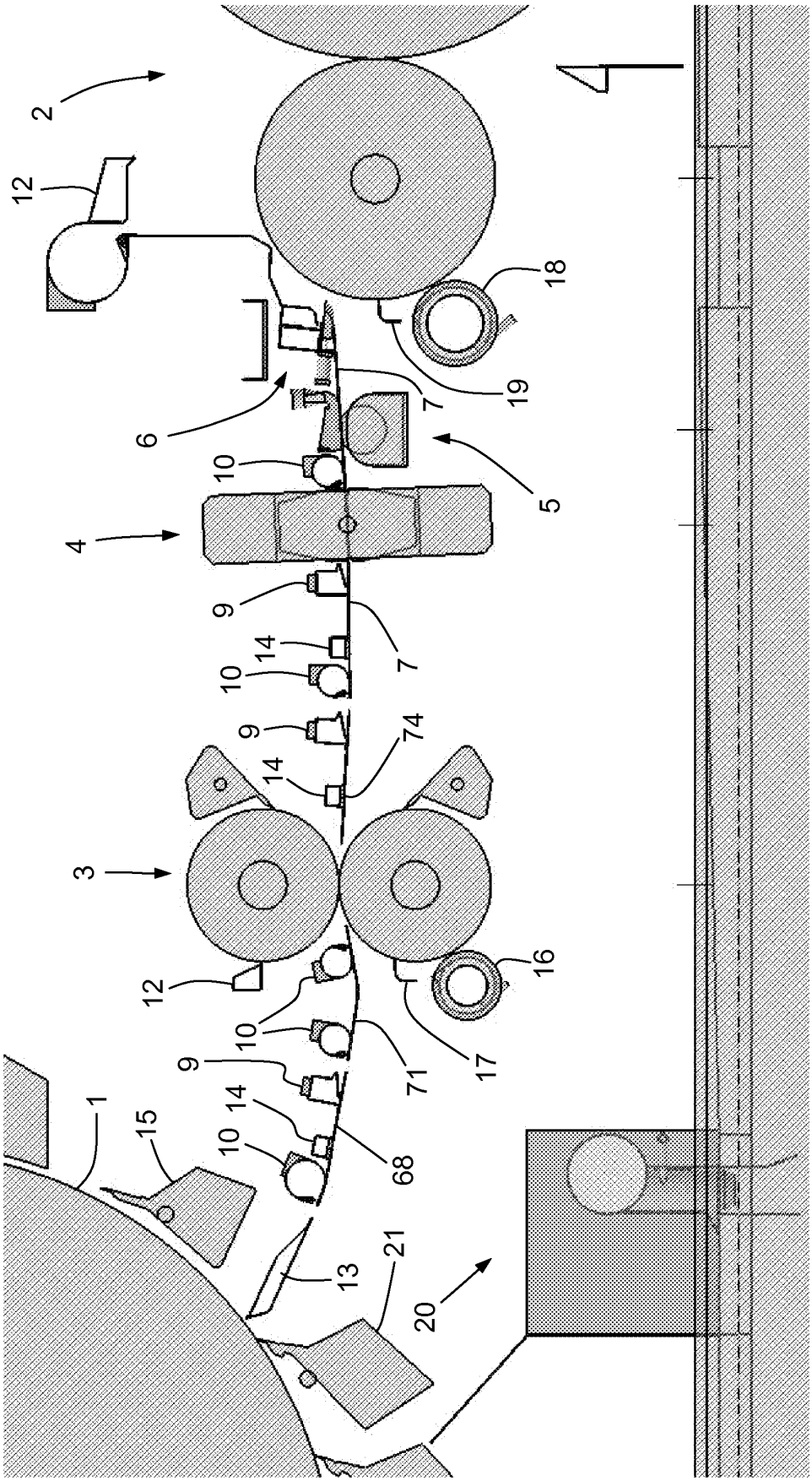

2
12
18
19
7
6
10
5
4
9
14
10
7
9
74
14
3
12
16
10
9
71
17
14
10
68
1
15
13
21
20

Fig. 1

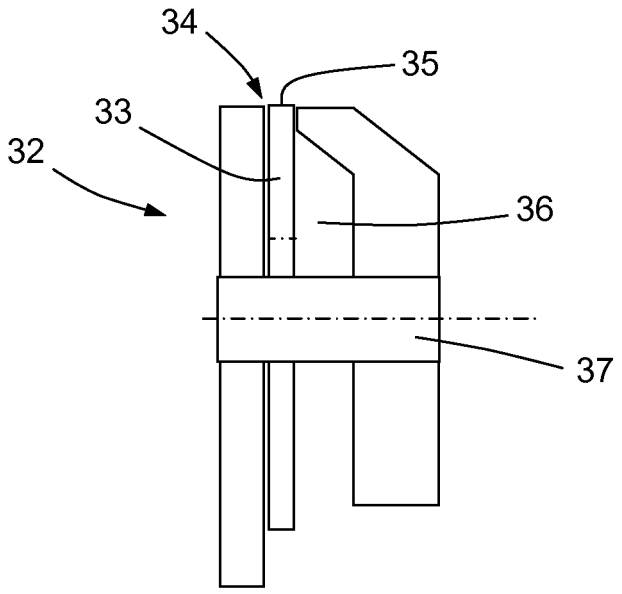


Fig. 2

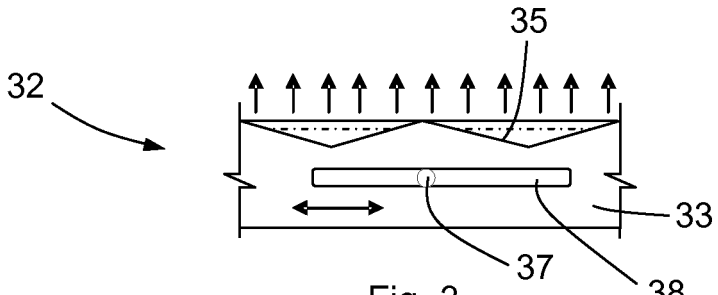


Fig. 3

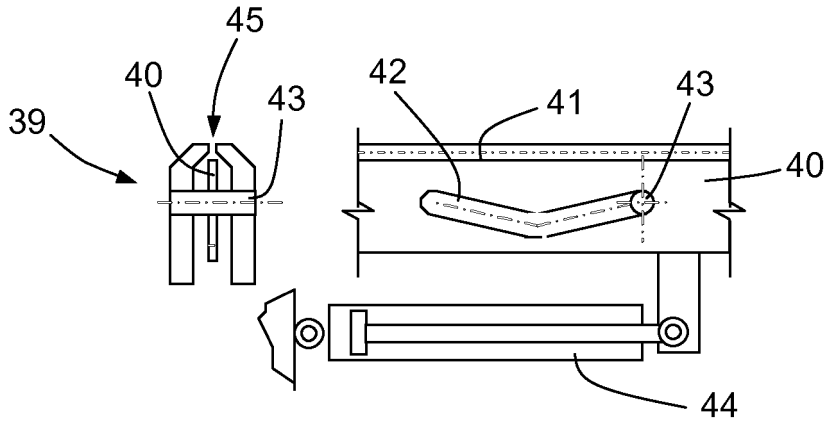


Fig. 4

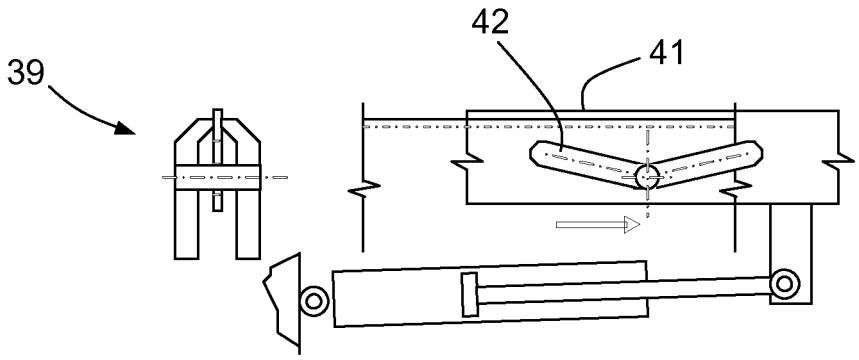


Fig. 5

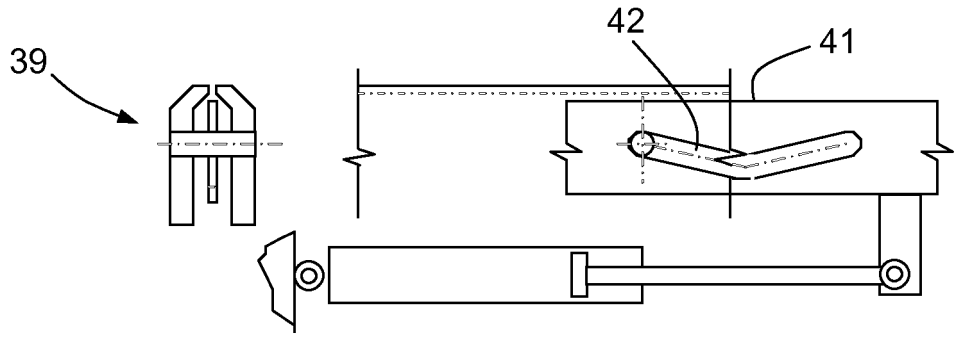


Fig. 6

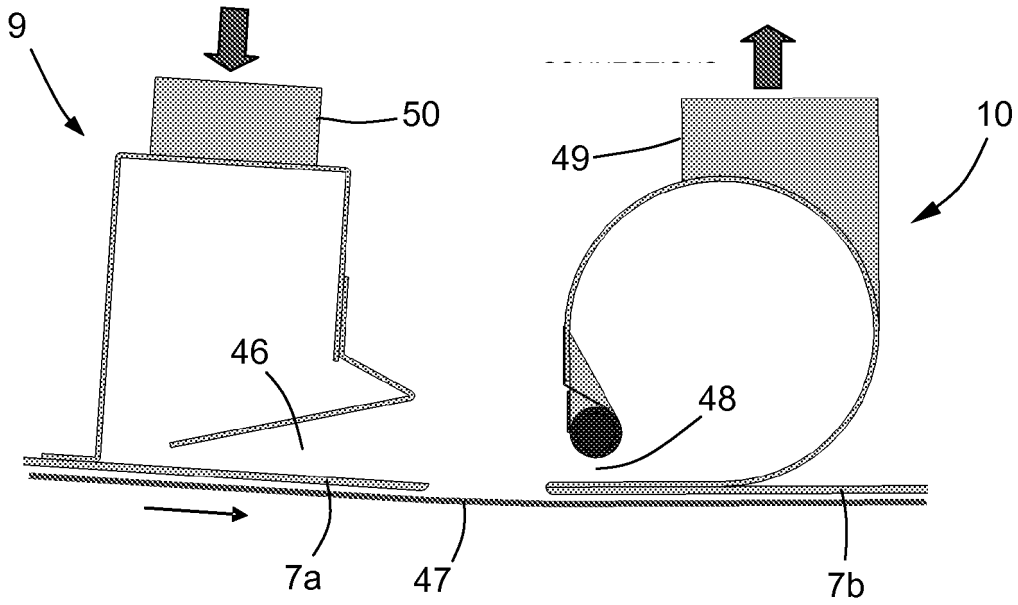


Fig. 7

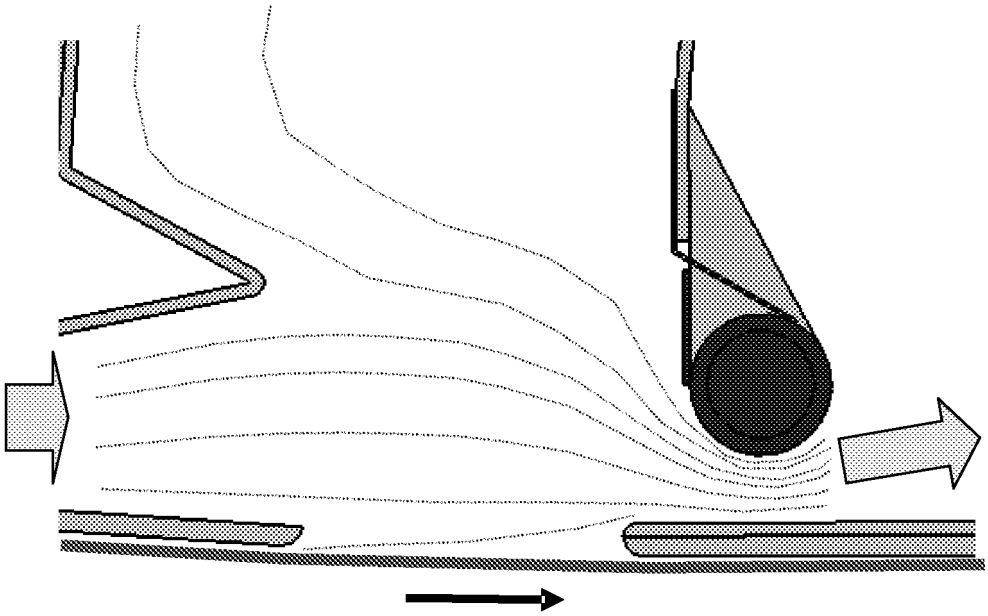


Fig. 8

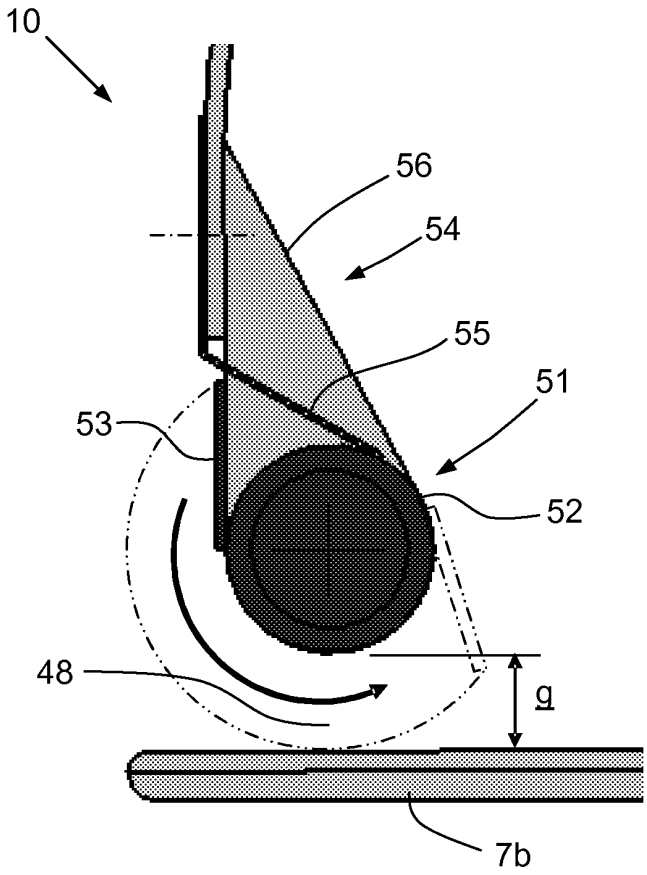


Fig. 9

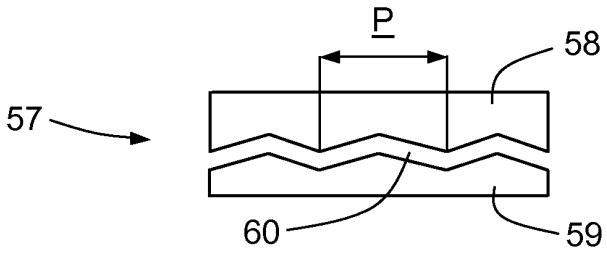


Fig. 10

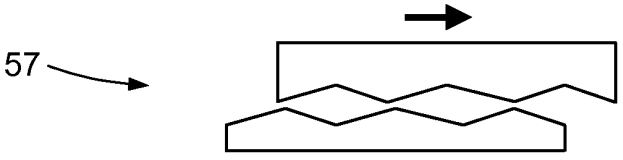


Fig. 11

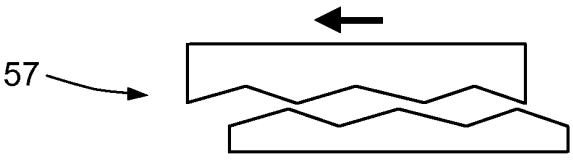


Fig. 12

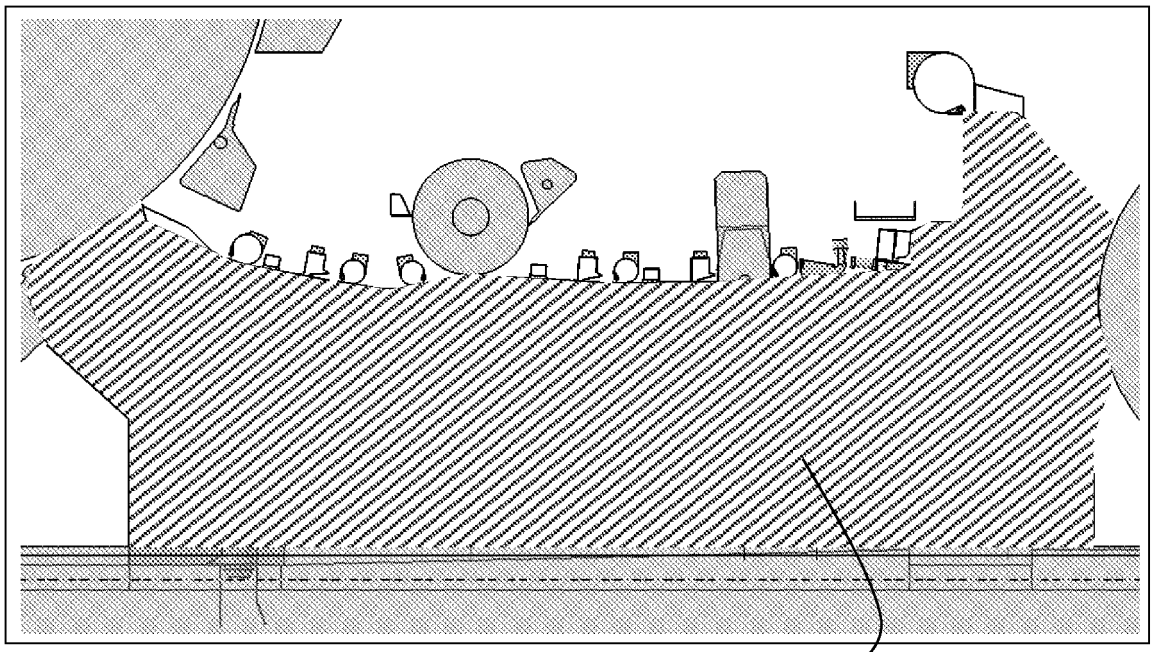


Fig. 13

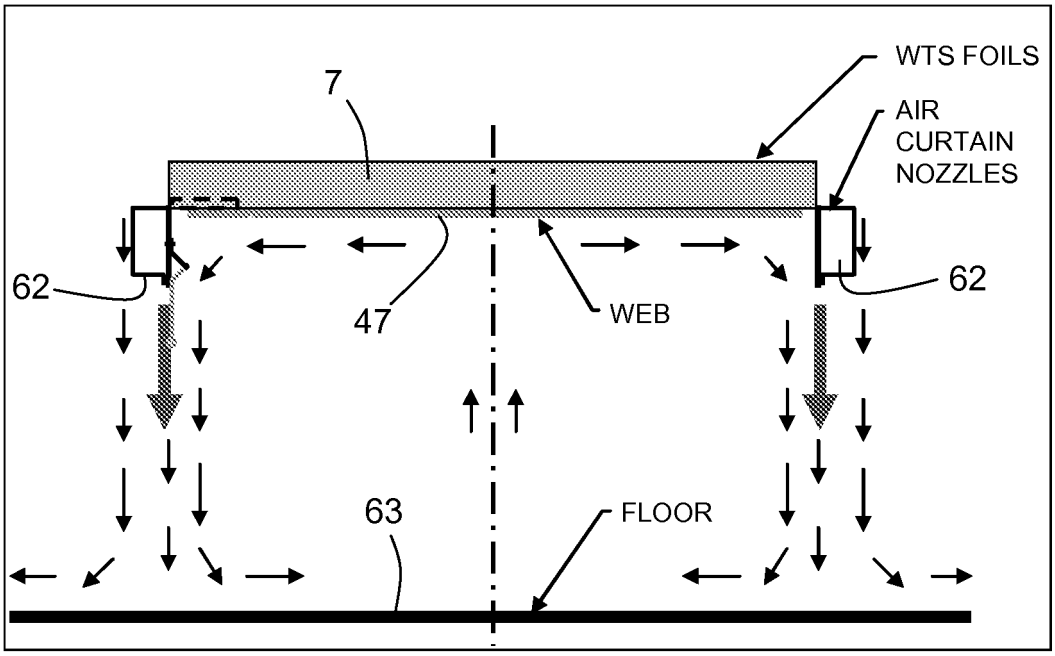

WTS FOILS
7
AIR
CURTAIN
NOZZLES
62
47
WEB
62
63
FLOOR

Fig. 14

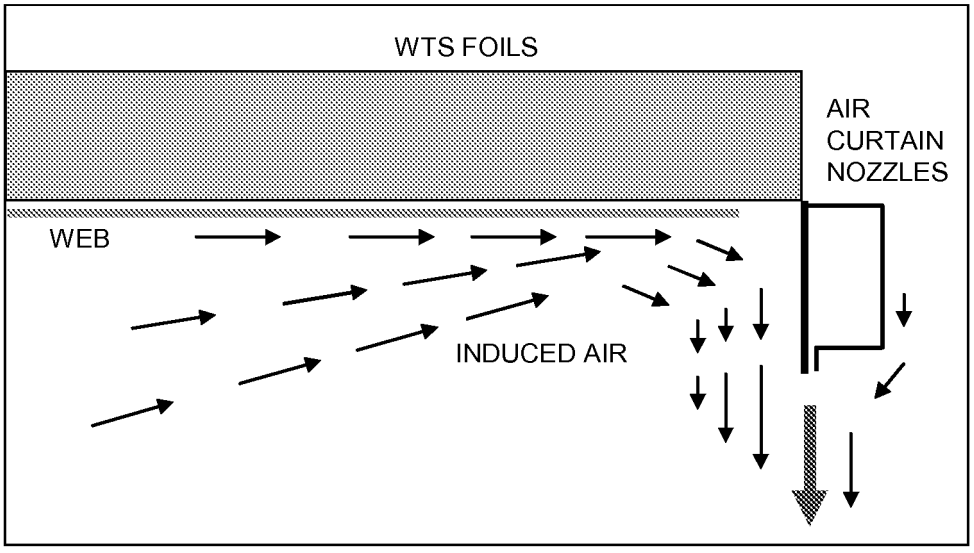

WTS FOILS
AIR
CURTAIN
NOZZLES
WEB
INDUCED AIR

Fig. 15

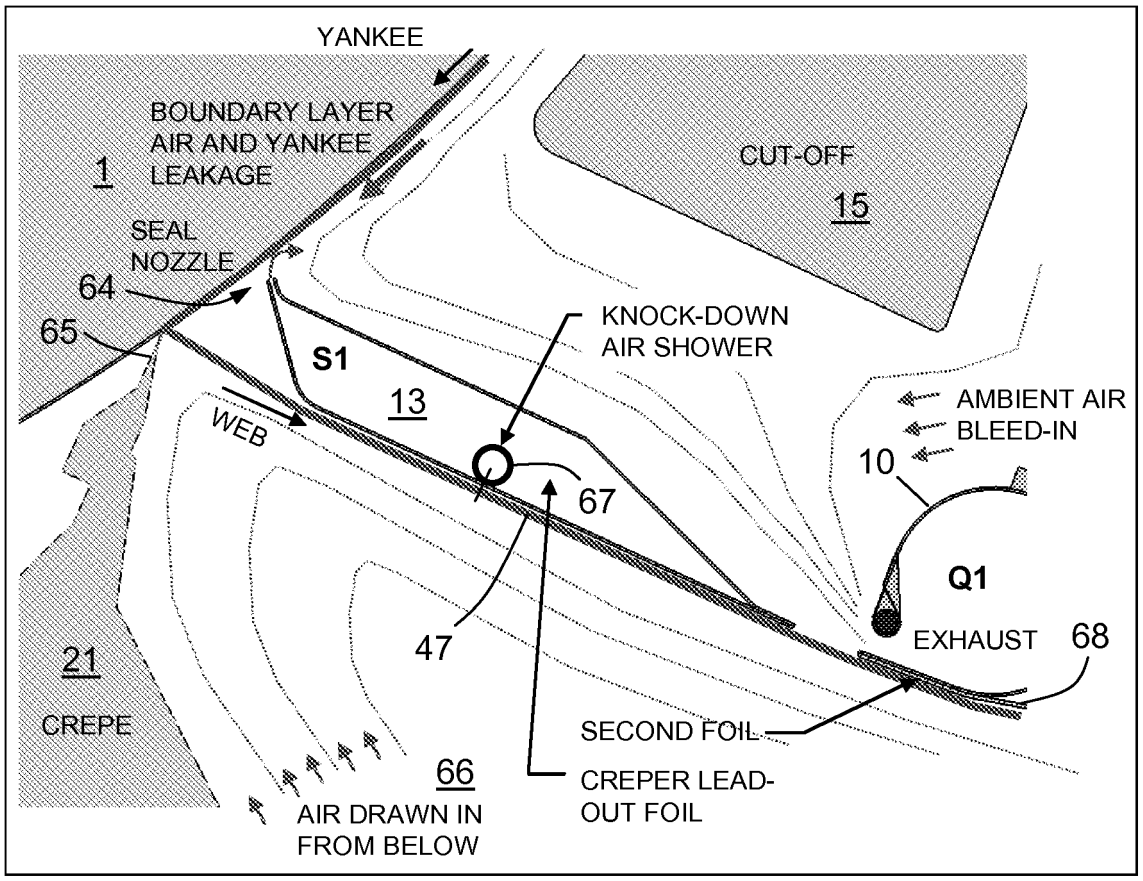

YANKEE
BOUNDARY LAYER
AIR AND YANKEE
LEAKAGE
1
SEAL
NOZZLE
64
65
CUT-OFF
15
KNOCK-DOWN
AIR SHOWER
S1
13
WEB
AMBIENT AIR
BLEED-IN
10
67
Q1
EXHAUST
68
47
21
CREPE
SECOND FOIL
66
CREPER LEAD-
OUT FOIL
AIR DRAWN IN
FROM BELOW

Fig. 16

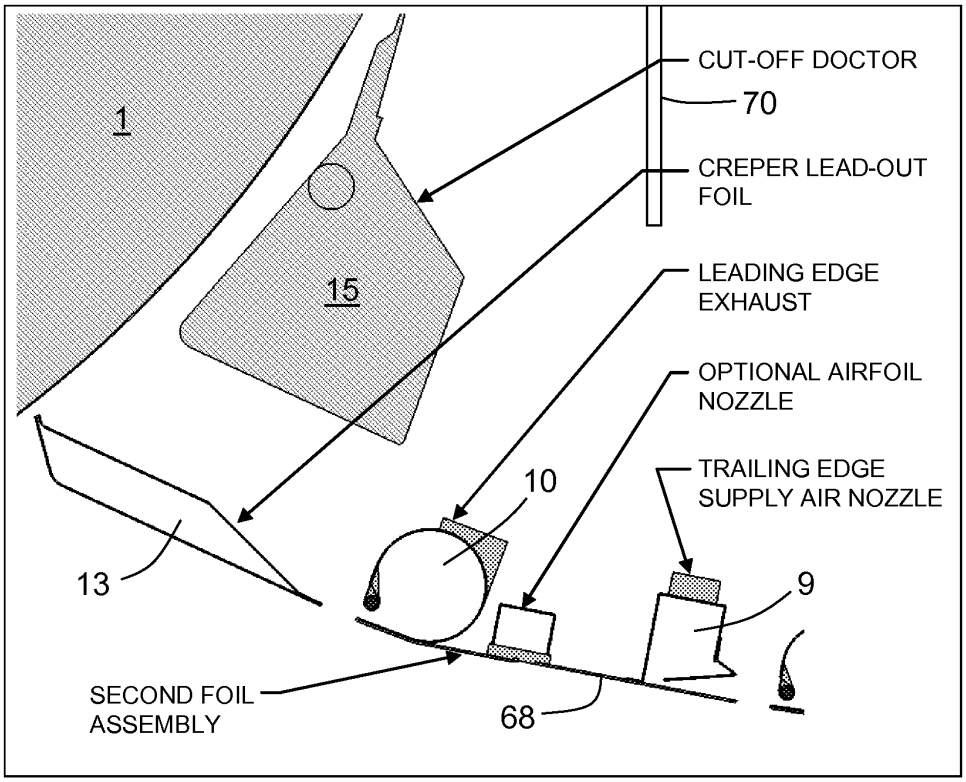

1
15
CUT-OFF DOCTOR
70
CREPER LEAD-OUT FOIL
LEADING EDGE EXHAUST
OPTIONAL AIRFOIL NOZZLE
TRAILING EDGE SUPPLY AIR NOZZLE
10
13
9
SECOND FOIL ASSEMBLY
68

Fig. 17

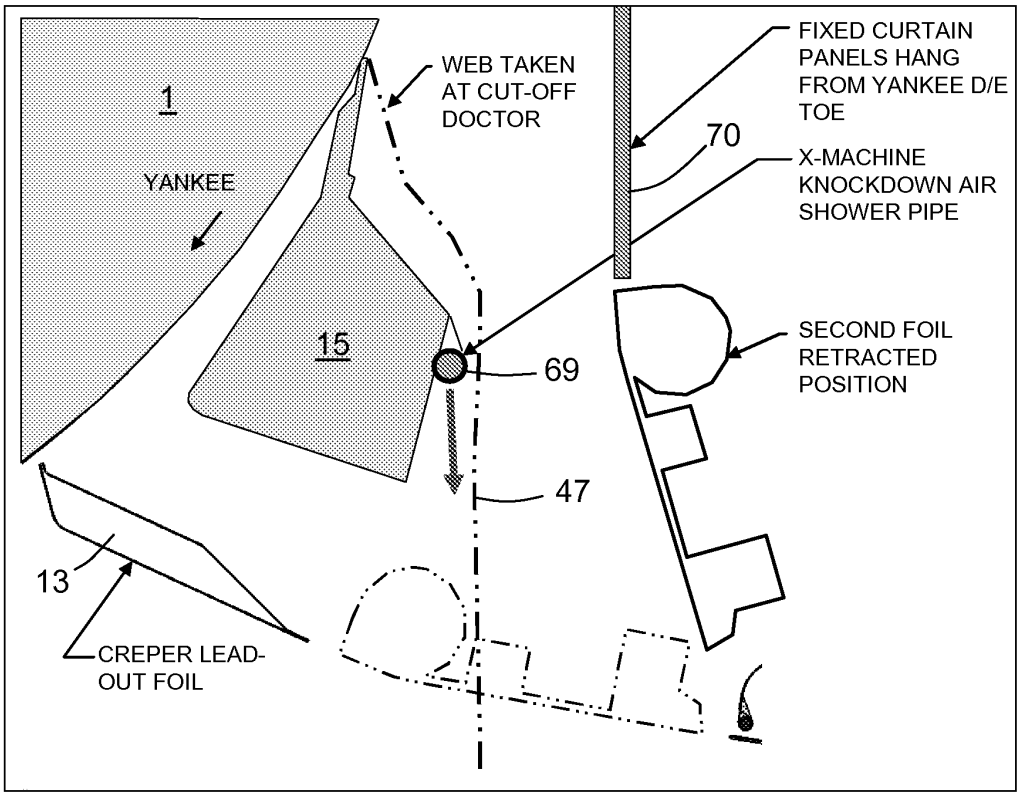

1
YANKEE
15
WEB TAKEN AT CUT-OFF DOCTOR
FIXED CURTAIN PANELS HANG FROM YANKEE D/E TOE
70
X-MACHINE KNOCKDOWN AIR SHOWER PIPE
SECOND FOIL RETRACTED POSITION
69
47
13
CREPER LEAD-OUT FOIL

Fig. 18

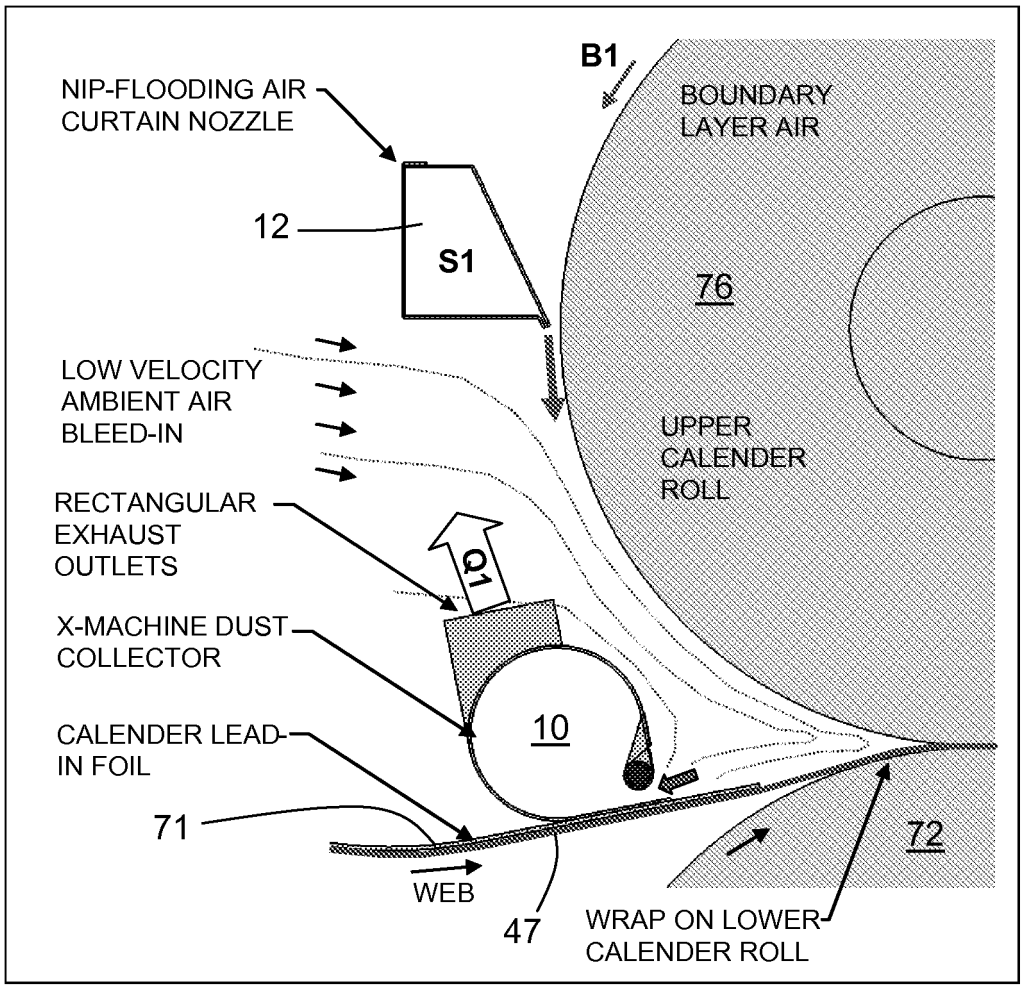

B1
NIP-FLOODING AIR CURTAIN NOZZLE
BOUNDARY LAYER AIR
12
S1
76
LOW VELOCITY AMBIENT AIR BLEED-IN
UPPER CALENDER ROLL
RECTANGULAR EXHAUST OUTLETS
Q1
X-MACHINE DUST COLLECTOR
10
CALENDER LEAD-IN FOIL
71
72
WEB
47
WRAP ON LOWER CALENDER ROLL

Fig. 19

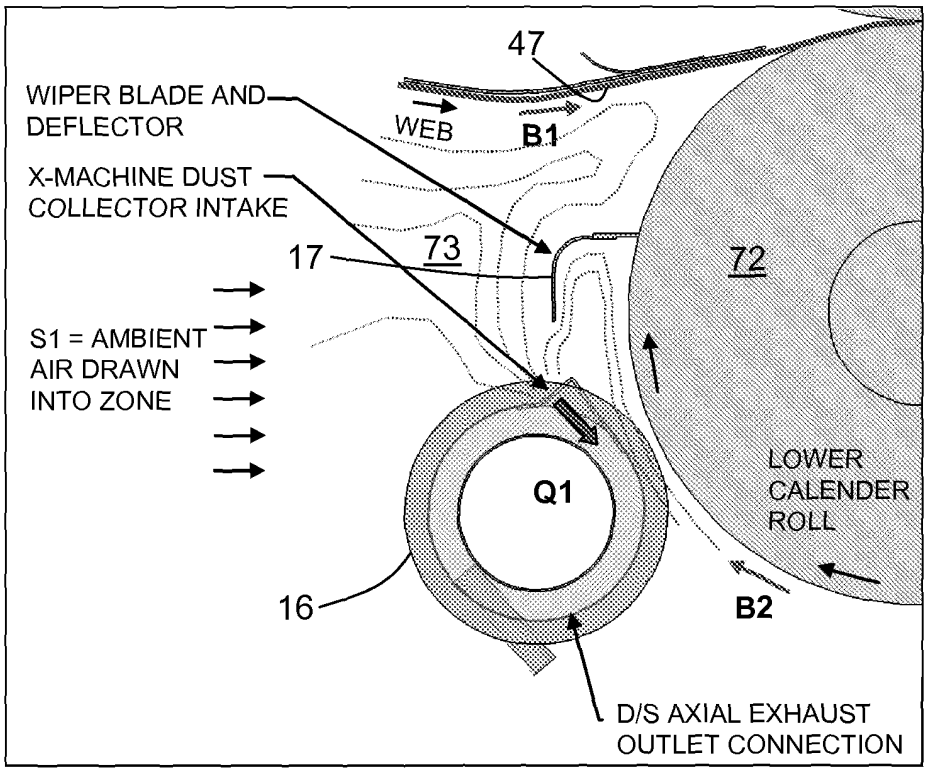

47
WIPER BLADE AND DEFLECTOR
WEB
B1
X-MACHINE DUST COLLECTOR INTAKE
17
73
72
S1 = AMBIENT AIR DRAWN INTO ZONE
Q1
LOWER CALENDER ROLL
16
B2
D/S AXIAL EXHAUST OUTLET CONNECTION

Fig. 20

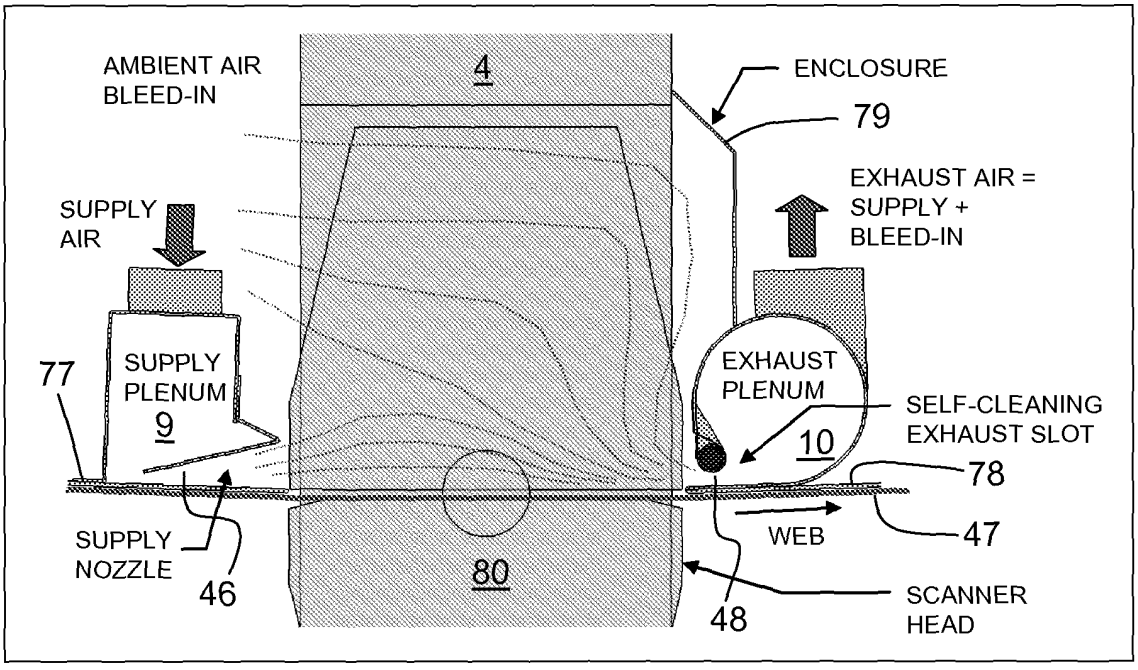

AMBIENT AIR BLEED-IN
4
ENCLOSURE
79
EXHAUST AIR = SUPPLY + BLEED-IN
SUPPLY AIR
77
SUPPLY PLENUM 9
EXHAUST PLENUM
10
SELF-CLEANING EXHAUST SLOT
78
47
WEB
SUPPLY NOZZLE
46
80
48
SCANNER HEAD

Fig. 21

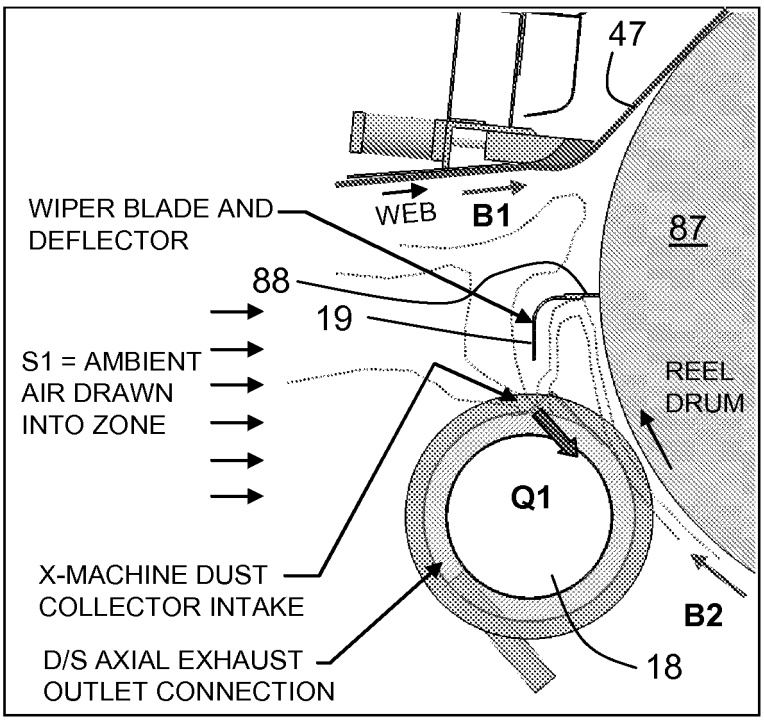

47
WIPER BLADE AND
DEFLECTOR
WEB
B1
87
88
19
S1 = AMBIENT
AIR DRAWN
INTO ZONE
REEL
DRUM
Q1
X-MACHINE DUST
COLLECTOR INTAKE
B2
D/S AXIAL EXHAUST
OUTLET CONNECTION
18

Fig. 22

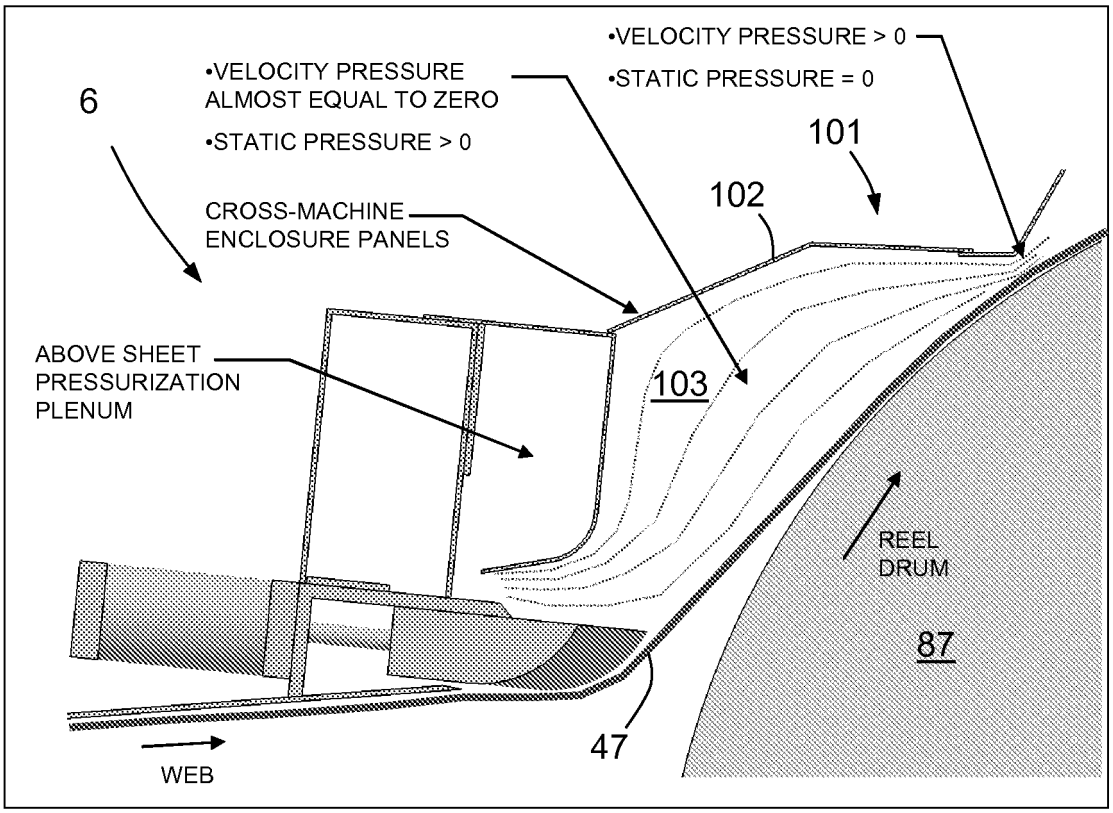

•VELOCITY PRESSURE > 0
•VELOCITY PRESSURE
ALMOST EQUAL TO ZERO
•STATIC PRESSURE = 0
6
•STATIC PRESSURE > 0
101
102
CROSS-MACHINE
ENCLOSURE PANELS
ABOVE SHEET
PRESSURIZATION
PLENUM
103
REEL
DRUM
87
47
WEB

Fig. 23

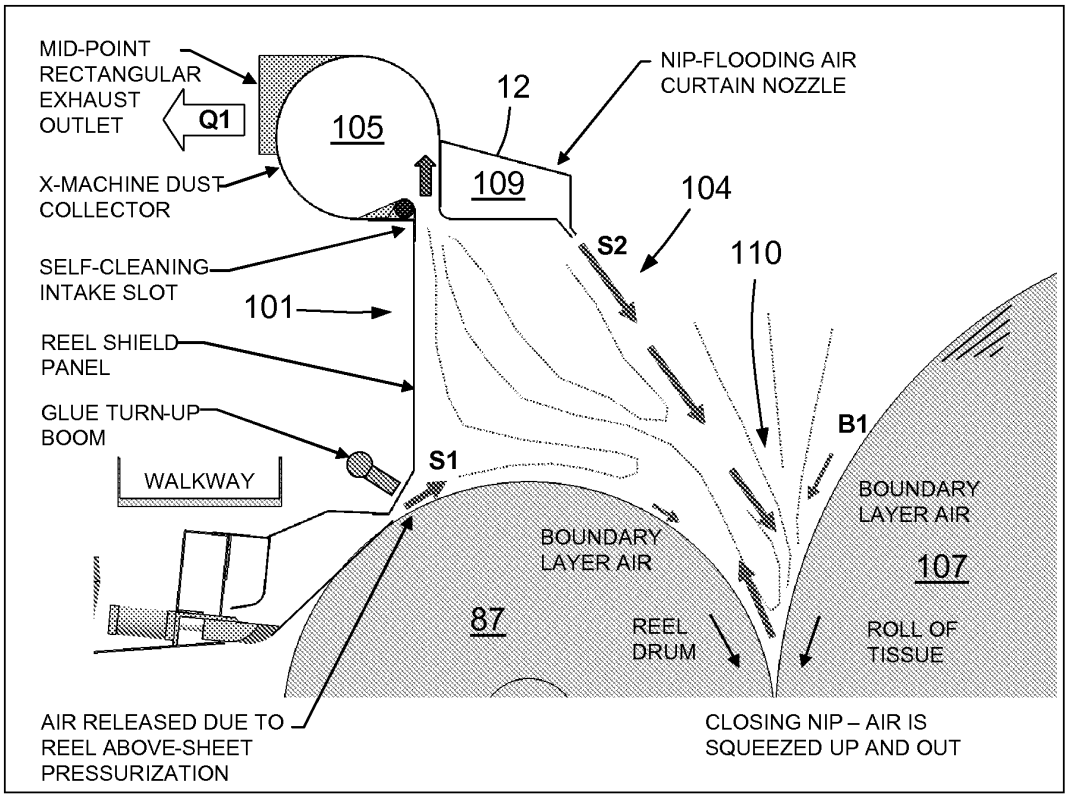

MID-POINT RECTANGULAR EXHAUST OUTLET
Q1
X-MACHINE DUST COLLECTOR
SELF-CLEANING INTAKE SLOT
101
REEL SHIELD PANEL
GLUE TURN-UP BOOM
WALKWAY
105
12
NIP-FLOODING AIR CURTAIN NOZZLE
109
104
S2
110
B1
S1
BOUNDARY LAYER AIR
107
87
REEL DRUM
ROLL OF TISSUE
AIR RELEASED DUE TO REEL ABOVE-SHEET PRESSURIZATION
CLOSING NIP – AIR IS SQUEEZED UP AND OUT

Fig. 24

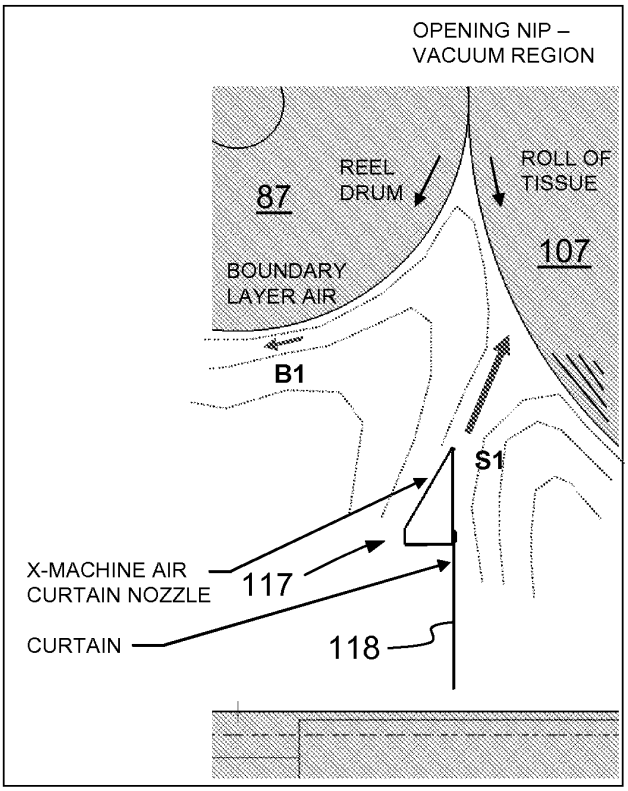

OPENING NIP – VACUUM REGION
87
REEL DRUM
ROLL OF TISSUE
107
BOUNDARY LAYER AIR
B1
S1
X-MACHINE AIR CURTAIN NOZZLE
117
CURTAIN
118

Fig. 25

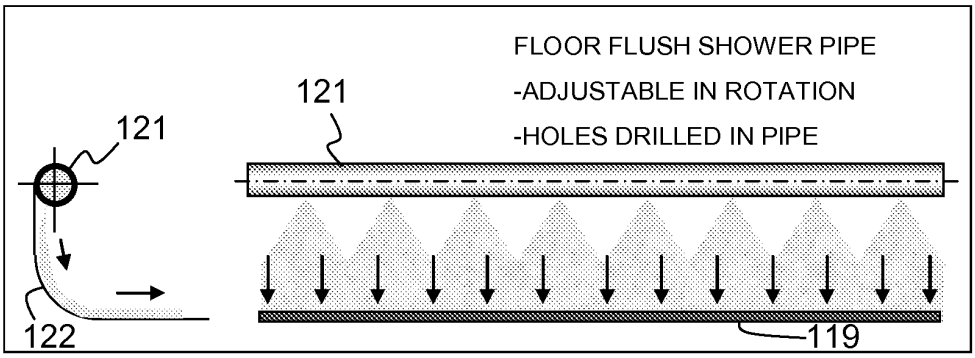


Fig. 26

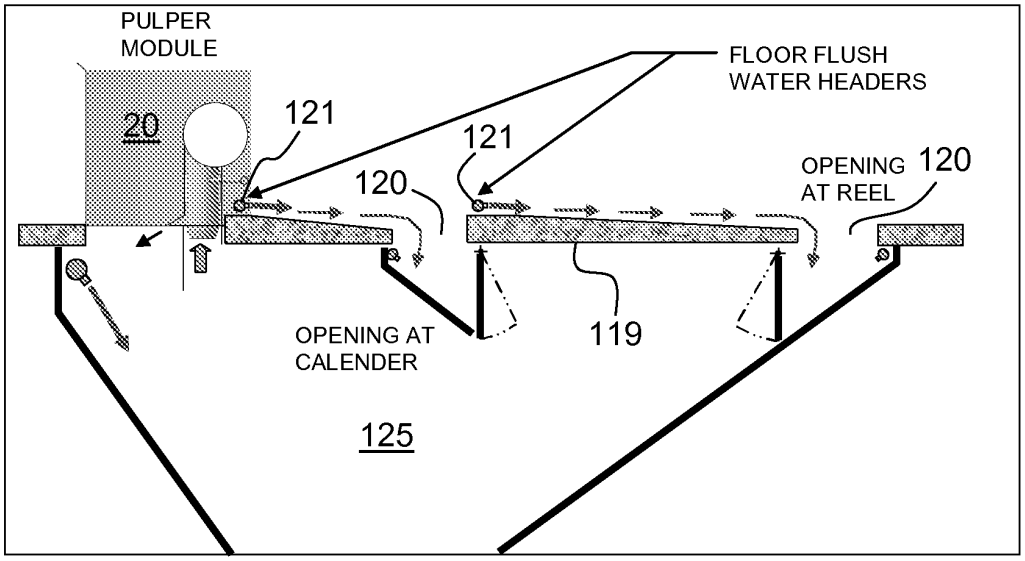


Fig. 27

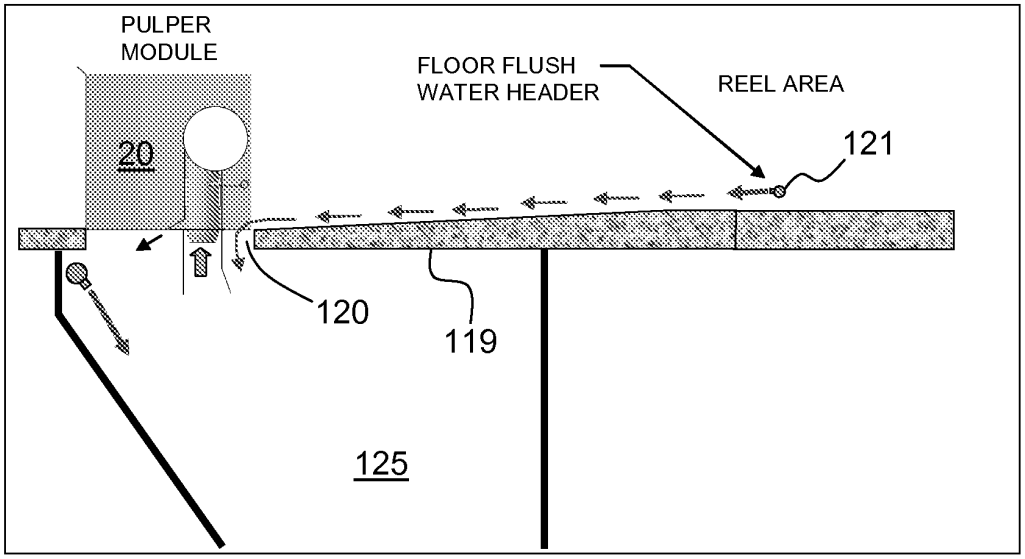


Fig. 28

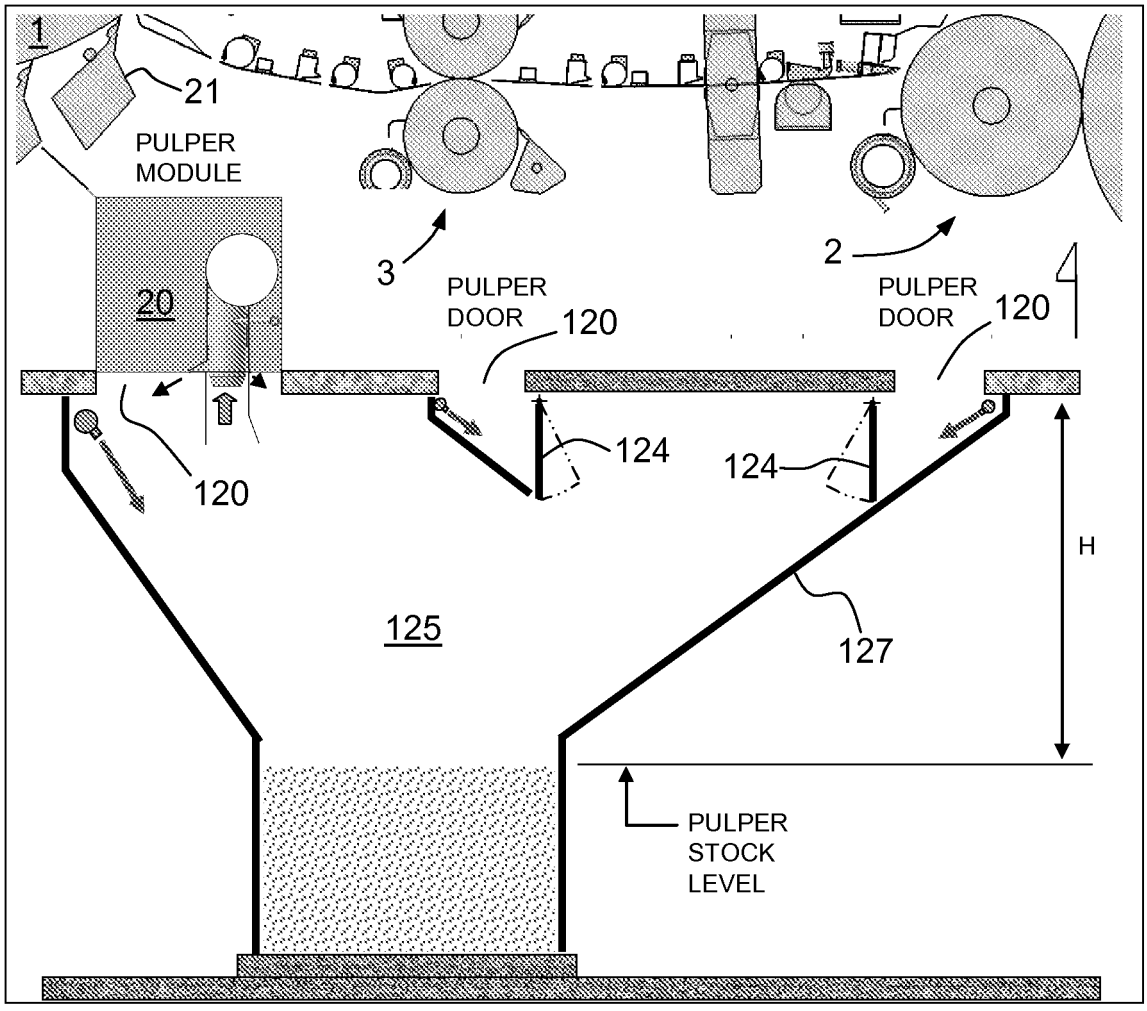

1
21
PULPER
MODULE
3
2
20
PULPER
DOOR
120
PULPER
DOOR
120
120
124
124
H
125
127
PULPER
STOCK
LEVEL

Fig. 29

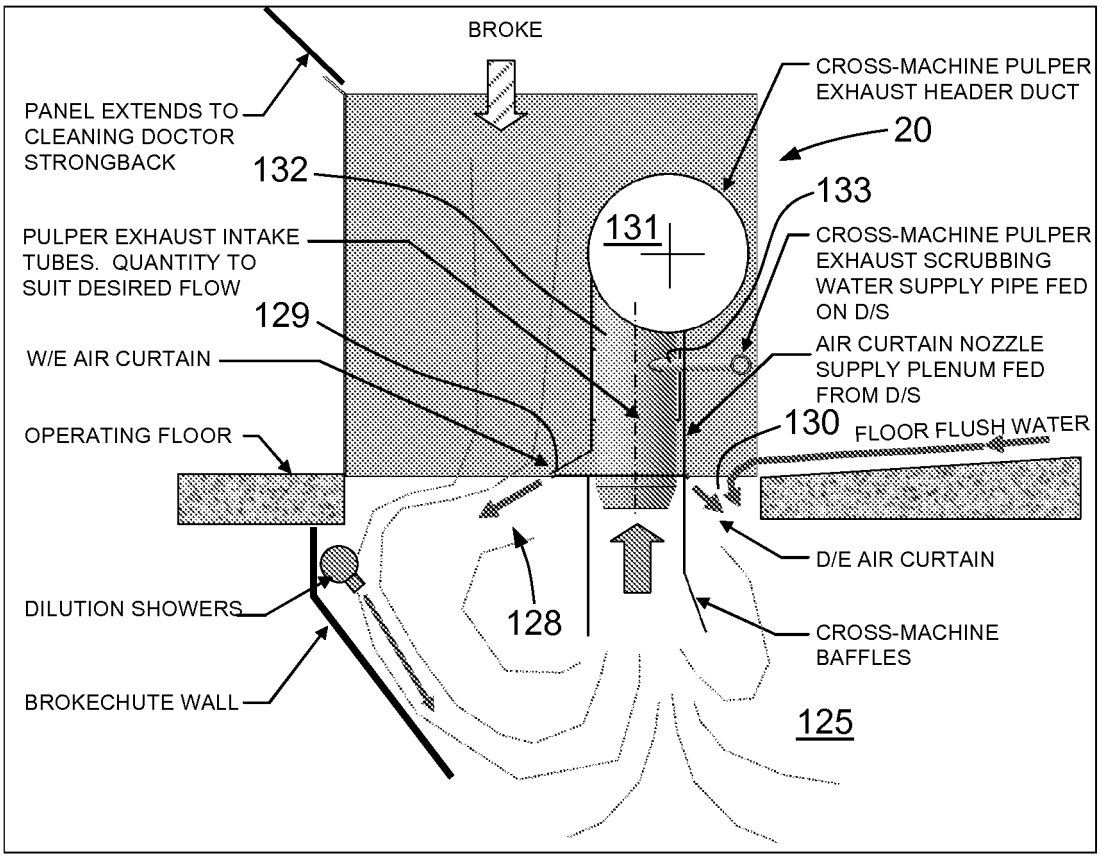

BROKE
CROSS-MACHINE PULPER EXHAUST HEADER DUCT
20
PANEL EXTENDS TO CLEANING DOCTOR STRONGBACK
132
133
131
PULPER EXHAUST INTAKE TUBES. QUANTITY TO SUIT DESIRED FLOW
CROSS-MACHINE PULPER EXHAUST SCRUBBING WATER SUPPLY PIPE FED ON D/S
129
W/E AIR CURTAIN
AIR CURTAIN NOZZLE SUPPLY PLENUM FED FROM D/S
OPERATING FLOOR
130
FLOOR FLUSH WATER
D/E AIR CURTAIN
DILUTION SHOWERS
128
CROSS-MACHINE BAFFLES
BROKECHUTE WALL
125

Fig. 30

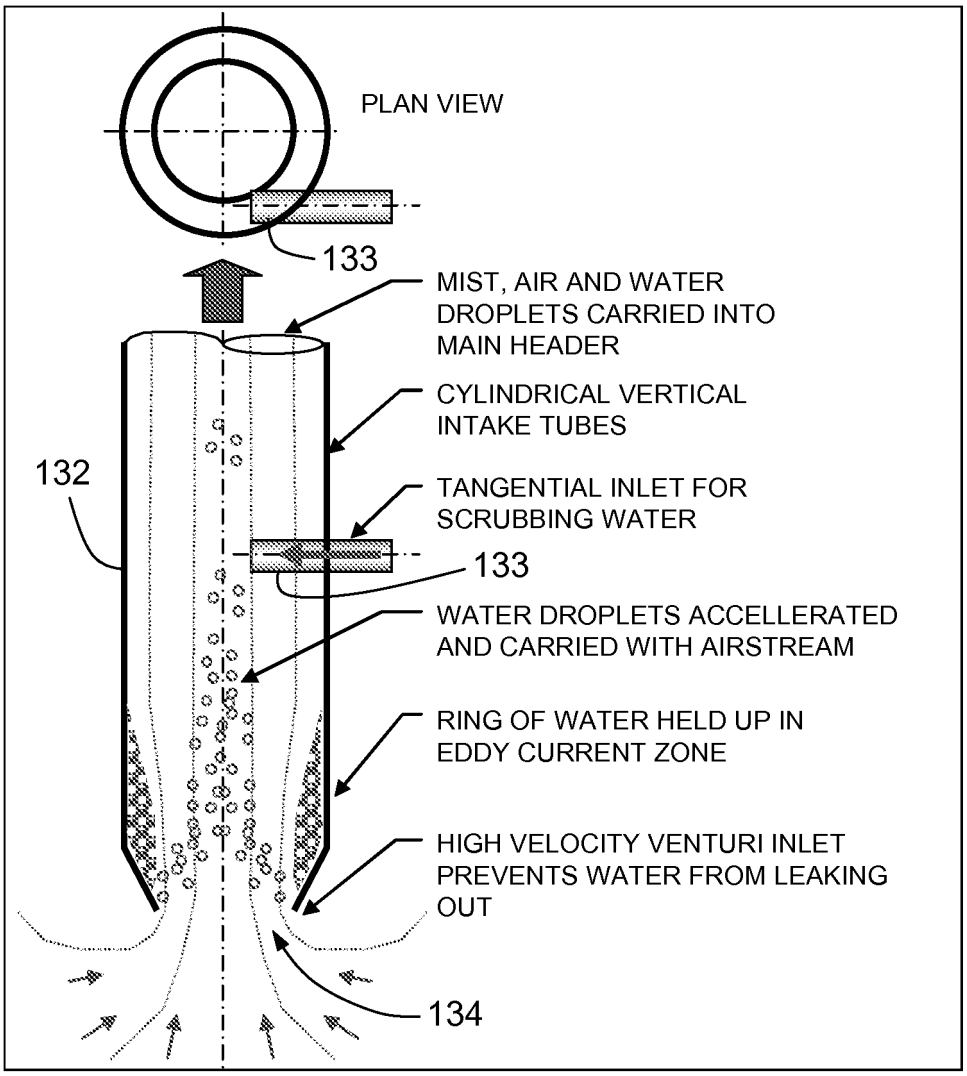

PLAN VIEW
133
MIST, AIR AND WATER DROPLETS CARRIED INTO MAIN HEADER
CYLINDRICAL VERTICAL INTAKE TUBES
132
TANGENTIAL INLET FOR SCRUBBING WATER
133
WATER DROPLETS ACCELLERATED AND CARRIED WITH AIRSTREAM
RING OF WATER HELD UP IN EDDY CURRENT ZONE
HIGH VELOCITY VENTURI INLET PREVENTS WATER FROM LEAKING OUT
134

Fig. 31

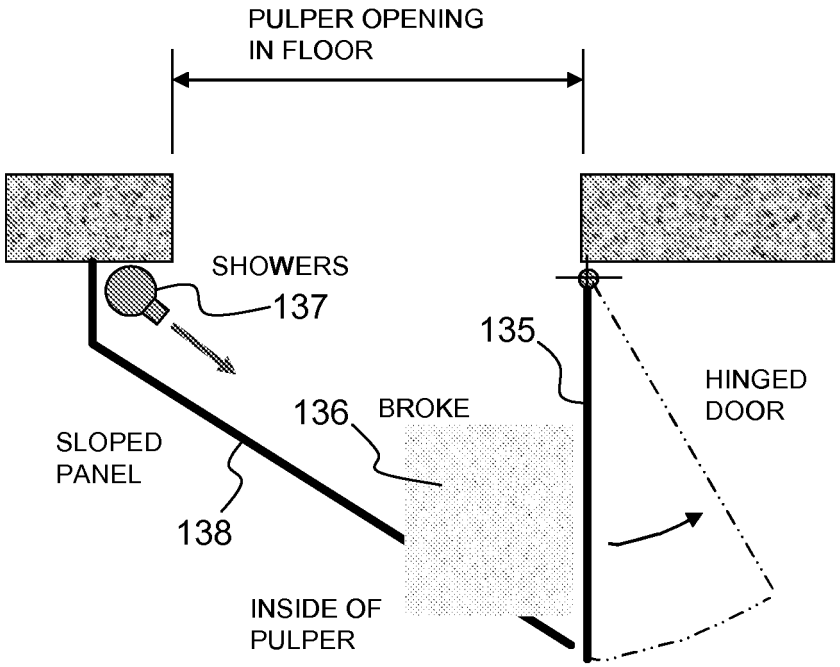

PULPER OPENING
IN FLOOR
SHOWERS
137
135
HINGED
DOOR
136
BROKE
SLOPED
PANEL
138
INSIDE OF
PULPER

Fig. 32

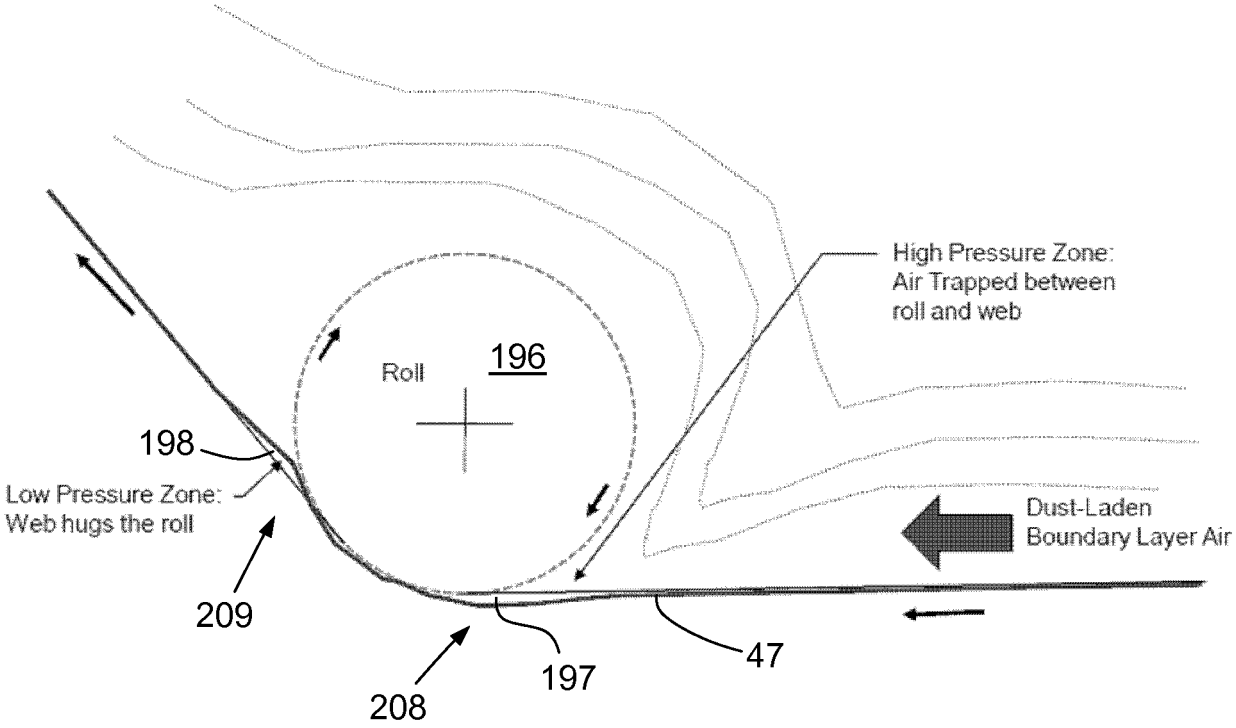

High Pressure Zone:
Air Trapped between
roll and web
Roll
196
198
Low Pressure Zone:
Web hugs the roll
Dust-Laden
Boundary Layer Air
209
208
197
47

Fig. 33

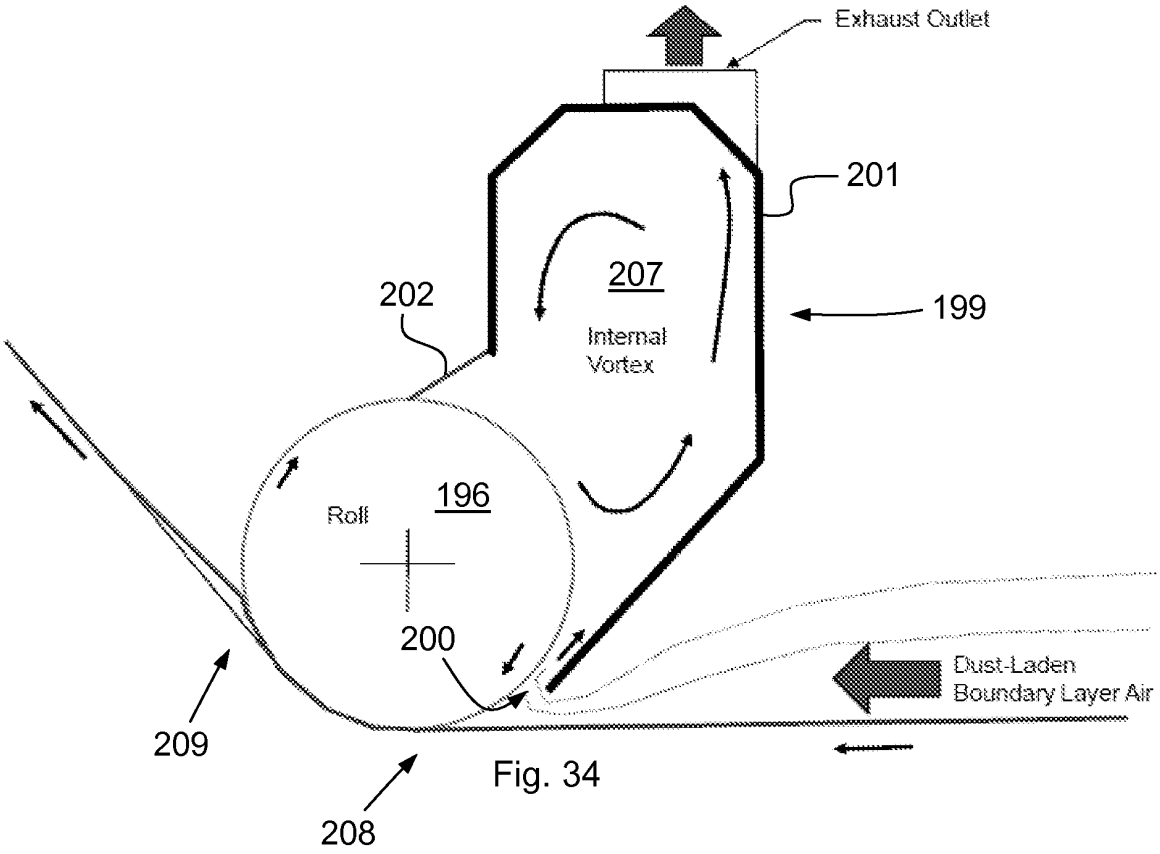

Exhaust Outlet
201
207
202
199
Internal
Vortex
Roll
196
200
Dust-Laden
Boundary Layer Air
209
208

Fig. 34

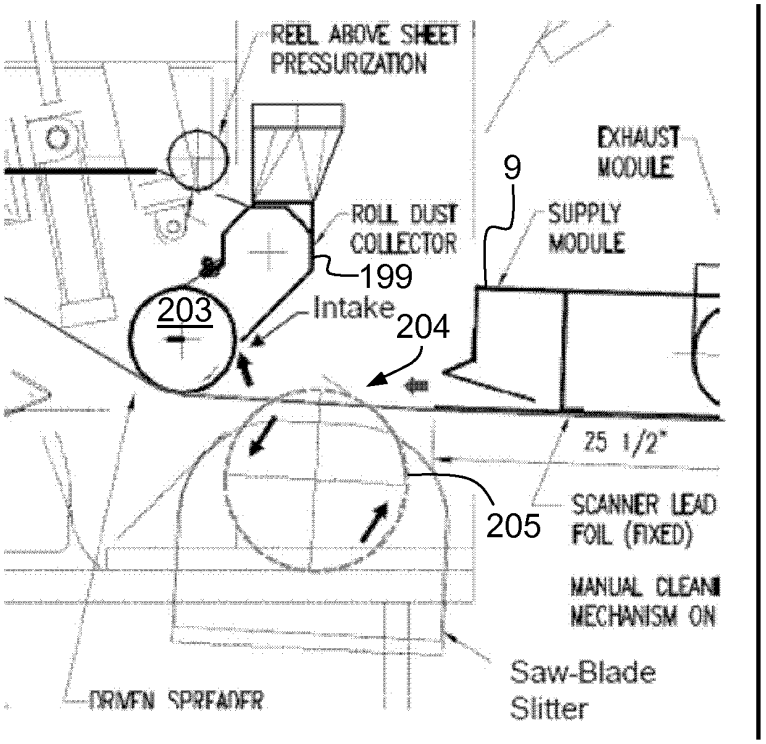

REEL ABOVE SHEET
PRESSURIZATION
EXHAUST
MODULE
9
SUPPLY
MODULE
ROLL DUST
COLLECTOR
199
203
Intake
204
25 1/2"
205
SCANNER LEAD
FOIL (FIXED)
MANUAL CLEANI
MECHANISM ON
Saw-Blade
Slitter

Fig. 35

REFERENCES CITED IN THE DESCRIPTION

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