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(54) **Method and apparatus for curtain coating**

(57) In a method and apparatus for curtain coating of a paper or board web a web substrate is moved below a hopper means providing a single or multilayer liquid coating in the form of a freefalling curtain impinging the substrate at a dynamic wetting line. An air shield is located upstream of the dynamic wetting line with respect to the moving direction of the web. The dynamic wetting line of the coating curtain on the web is oriented generally perpendicular to the moving direction of the web, providing substantially the same air pressure over an essential part of the coating curtain on its front and back side with respect to the moving direction of the web pro-

viding a first supply air flow upstream to the wetting line wherein the supply air flows over a substantial length along the freefalling curtain, and evacuating air from a location further upstream of a supply air flow outlet so that the air near the dynamic wetting line is moved against the moving direction of the web and the boundary air layer entrained to the web. A second supply air is provided in close proximity to the wetting line. The first and second supply air is evacuated by a first air suction and the boundary air is evacuated by a second air suction.

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Description

[0001] The present invention relates to a method and apparatus for coating of a paper or board web wherein a web substrate is moved below a hopper means providing a single or multiplayer liquid coating in the form of a freefalling curtain impinging the substrate at a dynamic wetting line and an air shield located upstream of the dynamic wetting line with respect to the moving direction of the web wherein the dynamic wetting line of the coating curtain on the web is oriented generally perpendicular to the moving direction of the web, providing substantially the same air pressure over an essential part of the coating curtain on its front and back side with respect to the moving direction of the web, providing a first supply air flow upstream to the wetting line wherein the supply air flows over a substantial length along the freefalling curtain, and evacuating air from a location further upstream at a supply air flow outlet so that the air near the dynamic wetting line is moved against the moving direction of the web and the boundary air layer entrained to the web.

[0002] Mainly in the field of manufacture of photographic papers or coated films, curtain coating methods and apparatus are widely known and used. Typically a continuous web or sheets are continuously moved below a coating hopper. One or more liquid compositions are provided from a hopper arrangement in the form of a liquid curtain.

[0003] For the manufacture of photographic papers, liquid compositions are used of relatively low viscosity, generally less than about 150 cP (centipoise), most in the range from about 5 to about 100 cP.

[0004] The manufacture of photographic papers is a tremendously difficult art requiring extremely accurate control. The practical use of curtain coating provides a number of difficulties coming with a need for an extremely uniform coating on the one hand and a need for coating of substrates in form of a continuous web at high speeds on the other hand.

[0005] A number of problems associated with curtain coating have been addressed in the prior art and many proposals have been made to overcome such problems.

[0006] Besides obtaining a free-falling curtain having uniform curtain characteristics over its width perpendicular to the moving direction of the substrate, one of the most often addressed problems for coating at speeds higher than approximately 150 m/min is the displacement or deformation of the curtain by the air, which is carried along the uncoated substrate due to friction. That air is carried along with the moving substrate to the coating point, which designates the location where the coating liquid first contacts the substrate. In the curtain coating process this location has the form of a line across the substrate and is referred to as the dynamic wetting line. The area near the substrate where the air is in motion due to friction is called the boundary layer.

[0007] In the prior art a number of problems are de-

scribed with respect to the air boundary layer.

[0008] One of these problems described for instance in US 6,162,502 A is that air is entrained between the substrate and the liquid film and no coherent coating will be obtained at increased coating speeds.

[0009] Two main effects have been observed in the past in view of the boundary layer hitting a curtain. One is that the air layer hits the contact line between the curtain and the web. As the air needs to reverse its flow direction, the displacement of the wetting line is not uniform over the length of the curtain, and the curtain assumes a wavelike or undulating deformation across the web substrate. As a consequence of the curtain deformation the coated layer gets areas of varying thickness of the coating, which means that the coated layer gets band like thickness deviations along the moving direction of the web.

[0010] Another effect is that the curtain is blown up in the direction of the motion of the substrate like a balloon.

This results not only in deformation of the wetting line but also results in an irregular coating behavior of the curtain transversely to the coating direction and the momentum of the air or the pressure difference over the curtain may temporarily slit the curtain, thus inducing streaks in the coating.

[0011] In a curtain coater arrangement involving an air shield located between a roller for supporting and forwarding the substrate a number of methods are known for mitigating the detrimental effect of boundary layer air.

One approach is reported in US 3,508,947 to Hughes where the minimization of entrained air on the moving web is proposed by use of an air shield that has been provided with a vacuum manifold which is positioned adjacent to the web to be coated and connected to a vacuum pump to withdraw air there from. In this manner Hughes proposes that the multi-layer, free-falling vertical curtain of coating material is shielded from ambient air currents and the air entrained by the moving web is drawn off before the curtain impinges on the moving web at the wetting line.

[0012] US 5,976,630 reports a more recent curtain coating practice employing the air shield mainly for the purpose of drawing off air entrained by the moving web as opposed to shielding the free-falling curtain from ambient air currents. This is because curtain-coating operations typically include an enclosure to shield the free-falling liquid curtain from ambient air currents. The enclosure is continuously supplied with a laminar low velocity air flow from the top, while at the same time air is exhausted from both the front and rear of the enclosure. It is known that air shield systems employing a single manifold and a single vacuum source have been operated to exhaust higher air volumes in an attempt to remove additional air from behind the free-falling curtain as well as air entrained on the web.

[0013] EP 0 489 978 B1 further describes additional arrangements to increase the air resistance by further means like protruding parts, strips or even one or more

laminae connected to the air shield and directed towards the web. The laminae are taught to extend over the total width of the air shield or a group of smaller randomly placed laminae. The aim, which should be reached by such an arrangement, is described to obtain a reduced pressure with a low flow rate of evacuated air. Higher flow rates are reported not to be desirable since they can cause non-uniformities inside the air shield. Such non-uniformities are reported to cause band-like disturbances in the coated material.

[0014] EP 0 489 978 B1, the disclosure of which is hereby incorporated by reference, further reports that the pressure difference between the ambient air and the inside of the air shield has to be high enough to evacuate the boundary layer of air adhering to the web, but needs to be limited to avoid an air flow in a direction from the coating curtain towards the air shield, that is against the moving direction of the web. It is reported that an air flow from the coating curtain towards the air shield may cause the entire liquid curtain or at least a part of it to become sucked up into the air shield, therefore destroying the coating procedure, which is to be avoided under any circumstances.

[0015] Further, it is described to arrange the outlet end of the air shield at a distance between 5 and 30 mm upstream of the wetting line, because smaller distances involve the risk for a swinging curtain to touch and to soil the air shield, thereby interrupting the coating process, whereas larger distances strongly reduce the effect of the air removal and allow rebuilding of a new boundary layer of entrained air.

[0016] US 5,976,630 to Korokeyi et al. proposes use two different intake slots in combination with an air shield which slots are connected to one common or two separate vacuum pumps, wherein one air intake slot is dedicated to removing the entrained boundary air layer of the moving substrate and one is dedicated to the removal of the entrained boundary air layer of the free-falling curtain. Further it is proposed to provide fresh, filtered, optionally heated, laminar, low velocity air flow having a speed of about 10 to about 20 ft/min (about 5 to about 10 cm/s) which is supplied to the enclosure surrounding the free-falling curtain through an upper perforated wall thereof. It is further mentioned that the free-falling curtain is to be supplied with fresh air as spent air as withdrawn from the enclosure surrounding the apparatus through exhaust ports in the enclosure. The exhaust ports are described essentially to remove the supplied air to minimize pressure differential across the free-falling curtain. The teaching of US 5,976,630 is intended to reduce or avoid circulation or vortex pattern of air currents along the curtain, which is named to cause disturbances in the curtain, which in turn can lead to streaks in the coated product.

[0017] US 6,416,690 to Kustermann describes an arrangement for curtain coating for instance of a paper web which should prevent forming of air bubbles by parts of a boundary air layer entrapped between the

substrate and the coating applied in an amount making the coated product economically unusable at coating conditions where the web has a width up to 4 m and coating speeds at up to 1,000 m/min. To achieve this goal, it is proposed to locate a dynamic air pressure sensor in close proximity to the wetting line where a coating medium contacts the material web surface, and where an increased dynamic pressure relative to the normal air pressure should be observable caused by the boundary air layer entrained to the substrate web. The dynamic pressure signal is compared to a predetermined dynamic pressure value and a suction device to remove air entrained to the substrate web and/or the coating curtain is controlled to maintain a predetermined dynamic pressure value near the wetting line on the substrate.

[0018] In a further embodiment of the invention described it is proposed to provide a scraper bar for removal of the air entrained with a moving surface of the substrate located upstream from the wetting line to reduce the mechanical power needed for the suction device, and, further, it is suggested to engage an additional suction device producing a partial vacuum on the side of the substrate web facing away from the coating curtain pulling the substrate web against a support element like a backing roll.

[0019] US 5,624,715 to Gueggi et al. proposes to extract any air entrained with a moving substrate via a slot at the edge of a blade oriented towards the curtain so that the size of the remaining boundary layer striking the curtain is minimized. Further, an air supply opening is proposed at the underside of a lip of the curtain hopper to provide air to this point at a low speed and downwardly deflected, which low speed air flow is also evacuated by the slot of the blade arranged at the edge of the blade facing towards the curtain. By these measures the formation of rotating air turbulences between the blade and the curtain should be avoided which otherwise may divide into individual unstable cells causing the curtain becoming disturbed and unsteady and, consequently, results in a reduced coating quality.

[0020] WO 01/16427 A1 assigned to Valmet Corp. proposes a curtain coater with a conventional doctor arrangement upstream in the travel direction of a web substrate in front of an impingement point of the coating mix curtain on the surface of the web. According to the teaching of this document, besides provision of an usual evacuating means within the doctoring means, it is proposed to increase the momentum of the coating mix curtain by making the height of the falling curtain larger and thereby increasing falling velocity so that the coated liquid becomes more energetic to penetrate through the boundary air layer traveling on the web surface. More particularly it is proposed to provide a gas-injection nozzle downstream from the curtain supplying a significant stream of gas, including air or steam, towards the coating curtain near the wetting line so that the combined momentum of the coating mix curtain and the gas jet becomes sufficiently energetic to force the coating mix

to penetrate through the boundary air layer traveling on the web surface and thus, the curtain can unobstructedly adhere to the surface of the web.

[0021] Although many approaches have been made in the prior art to overcome the drawbacks and problems coming with the use of a curtain coating process, in particular at high coating speeds, there are still remaining drawbacks effecting the quality and cost effectiveness of curtain coating methods, in particular with respect to curtain coating of paper substrates.

[0022] It is therefore an object of the invention to provide an improved curtain coating method and apparatus particularly for high-speed coating of a paper web substrate, more particularly for high-speed coating of a continuous paper web substrate, more particularly in connection with a coating liquid having a relatively high viscosity compared to the coating liquids used for the manufacture of photographic papers, that has a low shear viscosity of generally well above 1.5 Pa·s.

[0023] Briefly stated, these and other features, objects and advantages are obtained by providing a second supply air in close proximity to the wetting line and in that the first and second supply air is evacuated by a first air suction and the boundary air is evacuated by a second air suction.

[0024] By providing the first supply air along the backside of the free-falling curtain it is possible to hold an equal pressure between the front side and the backside of the falling curtain. By adding the second supply air to the wetting line it is possible to hold the dynamic wetting line in a straight line in the cross-direction of the moving web.

[0025] By evacuating the first and second supply air with a first air suction and a separate evacuation of the boundary air by a second air suction it is possible to improve the curtain coating method especially by avoiding wave-like movements due to the fact that the air flow and the pressure can be effectively controlled along the falling curtain and in the region of the wetting line. A further advantage of the separation of the first and second air suction is the possibility to remove the supplied air from the wetting line in a very short distance from the wetting line avoiding long gaps between the web and the air shield.

[0026] An apparatus according to the invention for curtain coating of a paper web includes a hopper means for providing a free-falling curtain of coating liquid, an air shield providing a small gap between the web and the air shield, a first air supply opening extending generally over the width of the web providing a first air flow in the region of the dynamic wetting line where the liquid coating curtain impinges on the web and a suction or vacuum providing means connected to the air shield arranged to remove air wherein the arrangement comprises a second air supply flow with an air supply outlet in proximity to the wetting line and wherein for the first and for the second air flow a first air suction means and for a boundary air layer entrained to the web a second air

suction means is provided.

[0027] In a preferred embodiment of the invention a first guide member directs the second air flow to the wetting line and a second guide member is located between the second air supply and a vacuum channel of the first suction means.

[0028] More preferably the second guide member has edge providing a slot between the supply air outlet of the second air supply, the first suction means and the moved web. Preferably the second guide member is displaceable to change the distance between the edge and the web.

[0029] By avoiding a long gap between the air shield and the web due to the second air supply and the second suction means the distance between the slot provided by the guiding means and the web can be made greater and therefore the air flow speed in this area can be reduced, which means the wetting line is more stable and vortices can be avoided.

[0030] In a preferred embodiment of the invention as the second air suction means the first and second guide member at least partly in the region of the wetting line are plates extending in cross direction over the width of the web to be coated.

[0031] As doctoring means an arrangement can be used as described in the WO 01/16427 A1. Such a doctoring means is complemented with a suction channel extending over the cross-machine width of the web and having its suction channel upstream of the direction of the web movement near the region of the wetting line.

[0032] In a very advantageous further embodiment of the invention the second guide member is displaceable to change the distance of the edge to the web.

[0033] In a further embodiment of the invention between the first air suction means and the second air suction means a web support blow means is provided.

[0034] In practice it has been found, that along the falling curtain and in the region of the wetting line there are lots of vortices, which means the curtain and the wetting line is unstable.

[0035] By using the second air suction means and by providing the additional web support blow the vortices become smaller and also pressure differences are smaller.

[0036] It has been found that the pressure of the vortex or vortices depends on the vortex speed. If the supply air blow amount increases too much the vortex's rotation speed and pressure begin to rise. This means there is some kind of optimum in the supply air blow amount, which depends on the speed of the web.

[0037] Due to the fact that in a preferred embodiment of the invention there are two separate supply air means and also two separate air suction means and additionally in a more preferred mode by adding a web support blow a lot of possibilities in controlling the air flow are given and by controlling these air flows best results in practice can be made.

[0038] A further advantage of a web support blow

means is, that this support blow disables the rubbing of the web and the air shield.

[0039] Preferably the web support blow means is therefore a non-contact blow with a blow channel extending over the cross-machine width of the web.

[0040] Preferably is between the blow channel and the suction channel an air connection provided, which means the support blow air is suctioned by the boundary air vacuum of the second air suction means.

[0041] In a further preferred embodiment of the invention a guiding shield plate for direction the first supply air along the free-falling curtain is provided.

[0042] In the arrangement the distance between the nozzle provided by the edge of the second guide means and the web is about 5 mm. By using a displaceable guiding means it is possible to provide greater distances when starting the paper machine. With the nozzle and the named distance it is possible by using a specific amount of air to reduce the air flow speed in the gap in the new arrangement; for example to only fifth of the air speed compared with a gap of 1 mm size.

[0043] The support blow air can be sucked by the boundary air vacuum.

[0044] The air amount coming with the curtain from the ambient air as first air supply can be at about 0,03 kg/s/m. The supply air amount depends on the web speed. Both supply air namely air coming with the curtain and by the second air supply is evacuated by a common first air suction means.

[0045] By using the second air supply it is possible to provide a specific profile of the air flow in cross-machine direction, which means the air flow can be influenced to get a stable curtain at the wetting line by using a lot of adjustable air supply nozzles which extend in cross-machine direction and which can be operated separately.

[0046] To receive a stable curtain an even cross direction profile is necessary for air pressure and velocity. With the second air supply it is possible to make a profiling system for different air flows, which is especially advantageous on wider slides.

[0047] Additionally or alternatively it is possible to locate a lot of adjustable suction nozzles in the first air suction means which extend in cross-machine direction and which can be operated independent of each other.

[0048] In the following a preferred method and an apparatus by means of the drawings is described.

[0049] It shows:

Figure 1 a schematic overview showing generally a curtain coater arrangement as known from the prior art;

Figure 2 a schematic cross sectional view of a curtain coater air shield arrangement providing for a vacuum source as well as an air supply near a coating curtain as known from the prior art;

Figure 3 a schematic review of an improved curtain coating apparatus according to a preferred embodiment of the invention in a cross sectional view; and

Figure 4 an curtain coating apparatus similar to the apparatus according to figure 3 in a simplified mode.

[0050] Figure 1 shows the main parts of a curtain coater as known from the prior art and generally involved with an improved method and apparatus according to this invention. A conventional curtain coater has means, preferably in form of a backing roller 1, for forwarding separate sheets or a continuous web 2 as a substrate to be coated. The web 2 which may comprise a paper is forwarded along the backing roller 1 through the curtain coater. A hopper means 3 located generally above the backing roller 1. Various forms of hopper means 3 are known, generally providing a curtain 4 of a coating liquid 5 free falling over a distance h forwarded over a lid 6 or any other suitable means. The coating curtain 4 is moved towards the web 2 on the backing roller 1 by gravity force and impinging on the web 2 along a wetting line 7 generally perpendicular to the moving direction of the web 2. The wetting line 7 is generally below the lid 6 but moving relatively to the web 2 when in motion and therefore called the dynamic wetting line 7.

[0051] For the purpose of this application, the area of the curtain coater orientated in a direction where the substrate web 2 is uncoated before reaching the dynamic wetting line 7 is called "upstream", whilst the area where the web 2 is located after being coated at the dynamic wetting line 7 is called downstream.

[0052] The hopper means 3 provides a multi-layer coating film provided from several sources 8 (see dotted lines) of coating liquid 5.

[0053] Figure 2 schematically shows an arrangement of an air shield means 9 near the dynamic wetting line 7 of a curtain coater as prior art known from US 5,624,715. A small gap 10 is provided between the air shield 9 and the web 2 on the backing roller 1. Near an edge 11 of the air shield 9 facing towards the coating curtain 4 is arranged an air inlet 12 connecting the wetting line 7 with a vacuum pump 13 for extracting air.

[0054] Additionally, an air flow is provided by an air supply means 14 through channel 13 into a chamber 16 formed on the upstream side of the curtain 4 approximately from the web 2 at the bottom to lid 6 of the hopper means 3 at the top. The supply air flow depicted by arrows 17 is dedicated to reduce disturbances of the coating curtain 4 by providing an air flow traveling along the falling direction of the curtain 4 to prevent forming of vortex or circular flow patterns within the chamber 16. The air flow 17 is also sucked off by the vacuum pump 13 through opening 12 and vacuum channel 19.

[0055] The curtain coating apparatus according to the invention is shown in a cross sectional view in figure 3.

Parts being the same or similar to those described above are depicted by the same reference number for the ease of understanding. However due to the invention a backing roller 1 is not absolutely necessary.

[0056] In close proximity to the wetting line 7 and the downstream edge 11 of the air shield 9 is arranged a supply air outlet 20 for providing an air stream towards the downstream edge 11 of the air-shield. The upstream side of the coating curtain 4 is partly shielded by a first guide member 21a to ensure that the second air supply flow 22 from a supply air source 23 does not hit or disturb the free-falling curtain 4 along most of its height. The vacuum pump 13 as first air suction is connected with the air outlet 20 arranged directly upstream of the edge 11 for evacuating air from the wetting line 7. The vacuum pump 13 is capable of removing not only the amount of air entrained with the free-falling curtain 4 from the chamber 16, but also the second air supply flow 22 provided through the air supply opening 20 of the air shield 9 by sucking this air in the air inlet 12.

[0057] A second guide member 21b is located between the second air supply flow 22 and the vacuum channel 19 as first suction means. As can be seen from figure 3 the second guide member 21b at the edge 11 at its end facing the web 2 provides a slot between the supply air outlet 20 at the second air supply 22, the first suction means with the air inlet 12 and vacuum channel 19 and the moved web 2. Therefore the second air supply flow 22 and the vacuum channel 19 of the first suction means are in close proximity avoiding a longer gap or distance in the direction opposite to the moving web for sucking the air from the area of the wetting line. The near location to each other, namely the second air supply and the vacuum channel and the first and second guide members 21a and 21b, which can be plates extending in cross direction over the width of the web 2, results not only in a better manufacturing and construction of the air shield 9, but also in a better air flow. Especially it is not necessary to use a very high air flow speed for removing the air from the wetting line 7. The slot, which is provided between the edge 11 of the second guide member 21b and the web 2, can have a distance of about 1 to 10 mm, preferably 3 to 5 mm, to the web 2. The second air supply flow 22 and the first air suction means with the vacuum channel 19 are located side-by-side only separated by the second guide member 21b.

[0058] Preferably the distance of the nozzle is displaceable by shifting the guide member 21 away from the web 2 for controlling the amount and speed of air flowing through the nozzle.

[0059] The air chamber 16 is provided upstream of the coating curtain 4 and located between the curtain 4, a guiding shield plate 24 of the air shield 9 and the hopper means 3. The chamber 16 has an opening 25 between the hopper means 3 and the shield plate 24 allowing free flow of air between the chamber 16 and the ambient air space. Generally, it is desirable to maintain ambient air

pressure within the chamber 16 being the same air pressure on the downstream side of the coating curtain 4, thus, preventing the curtain 4 from being blown up or pulled back.

[0060] Within the opening 25 an air flow sensor 26 is arranged for detecting any air flow from ambient air space to the chamber 16 or vice versa. A signal corresponding to an air flow detected is provided from the sensor 26 to a control means (not shown), controlling also the air supply means and thus the second supply air flow 22 towards the dynamic wetting line 7. The sensor 26 and - if necessary - any additional sensor in the air shield 9 can control the air flow within the chamber 16 to ambient air pressure without forming of remarkable air flow on the upstream side of the curtain 4, thus, avoiding any disturbances of the coating curtain 4. However there should be big enough first air supply (air flow) in order to prevent the air flow from the second air supply to flow upwards the curtain. The structure of the air shield 9 and the second supply air system is designed to obtain a air flow speed from the wetting line 7 against the moving direction of the web 2 towards the suction opening 20 of the air shield 9.

[0061] To essentially seal the chamber 16 to have the opening 25 as the only practical connection of the chamber 16 to the ambient air space, side plates (not shown) are provided on both sides of the curtain coater to cover chamber 16, air-shield 9, and at least part of the hopper means 3 in a direction perpendicular to the moving direction of the web 2, to enable proper operation as described above.

[0062] As can be seen from the figure 3 the hopper means 3 and the air shield 9 are manufactured in two parts with the guiding shield plate 24 in between which provides an opening 25 for the first supply air flow. The shield plate 24 also provides a back wall for the chamber 16.

[0063] In case the guiding shield plate 24 is displaceable the amount of air flowing through the opening 25 can be controlled.

[0064] As second air suction means a doctoring means 27 is used which is located upstream of the vacuum channel 19 in the air shield 9. A doctoring means 27 can be used as described in the WO 01/16427 A1.

The doctoring means 27 has a curved contour and extends over the cross-machine width of the web 2 so as to scatter boundary air layer traveling on the surface of the moving web 2 and which has not been deflected on the air shield 9, but flows in the direction of the arrow 28 along the web 2. For the removal of this boundary air layer the doctoring means is complemented with a suction channel 29 extending over the cross-machine width of the web 2 and having a connection with an inlet air opening 30 located at the rear part of the doctoring means and leading to a vacuum pump (not shown).

[0065] Generally, between the moving web 2 and the doctoring means 27 is formed a boundary air layer, the thickness of which is determined, among other factors,

by the speed of the web 2 and the radius of curvature on the curved contour of the doctoring means 27. Typically, the thickness of the air layer remaining between the web 2 and the curved contour of the doctoring means 27 is the range of 0 - 500 μ .

[0066] Between the doctoring means 27 as second suction means and the first air suction means with the vacuum channel 19 a web support blow means 31 is provided. The web support blow means 31 is a non-contact blow means with a blow channel 32 extending over the cross-machine with of the web 2. Instead of a web support blow means 31 a tube (or a profile) which is in contact with the web also can be used.

[0067] The blow channel 32 of the web support blow means 31 is directed in an angle against the direction of the moving of the web 2, which means air is blown in direction opposite to the moving web holding the web at a distance from the web support blow means 31. Additionally by this non-contact support blow rubbing of the web 2 at the air shield 9 is avoided.

[0068] As discussed for the second air supply flow 22 it is also possible to provide the web support blow means 31 with a specific profile of the air flow in cross-machine direction.

[0069] Between the blow channel 32 and the suction channel 29 of the second air suction means 27 an air connection is provided which means the support blow air can be sucked together with the boundary air layer by the second air suction means into the suction channel 29.

[0070] The air amount coming with the curtain 4 from the ambient air is substantially constant and about 0,03 kg/s/m. The supply air amount depends on the web speed. Both supply air from the supply air flow 22 and air coming with the curtain 4 is evacuated by the first supply air suction with the vacuum channel 19.

[0071] By using the doctoring means it is possible to reduce the thickness of the boundary layer entering the air shield 9. Due to the fact that there is only a small distance between the air outlet 20 for the second air supply flow 22 it is not absolutely necessary to have a very high air speed against the moving direction of the web 2. Additionally it is possible to create a strong under-pressure - if necessary - for a quick removing of air from the wetting line 7. However it is preferred to have no great air movement to avoid turbulence creating vortices.

[0072] Figure 4 shows a simplified apparatus according to figure 3. Therefore for identical parts the same reference numbers have been used.

[0073] The main difference to the apparatus according to figure 3 is that there is only one suction means namely the suction channel 29 for removing the supply air from the wetting line 7 and from the boundary air supply 28 penetrating through the gap 10. As can be seen compared with the apparatus according to figure 3 there is a distance with a gap 33 between the second air supply flow 22 and the suction channel 29 necessary.

[0074] As can be seen from figure 3 with the second suction means made by the vacuum channel 19 there is only a slot made by the downstream edge 11 of the air shield between the second air supply flow 22 and the vacuum channel 19.

[0075] In the following some paper grades which can be produced with curtain coater are named: Newsprint and SC-papers, LWC, ULWC, MWC, HWC, MFC (coated woodcontaining paper grades) and Coated fine papers.

[0076] Possible board grades are: FBB (Folding box-board), WLC (White lined chipboard), SBS (Solid bleached board), SUS (Solid unbleached board), LPB (Liquid packaging board).

[0077] Of course also any other paper/board qualities that need to be coated can be used.

[0078] Besides the excellent coating results at coating speeds well above those previously used for curtain coating the method and apparatus according to the invention provides excellent operating behavior without the necessity of complicated and sophisticated control means and is therefore much easier to use and not only assumed to be more reliable compared to the prior art but in any way much more cost effective.

[0079] Where this invention has been described in terms of a preferred embodiment, the present invention can be further modified within the spirit and the scope of this disclosure. This application is therefore intended to cover any variations, uses or adaptations of the invention using its general principles.

Claims

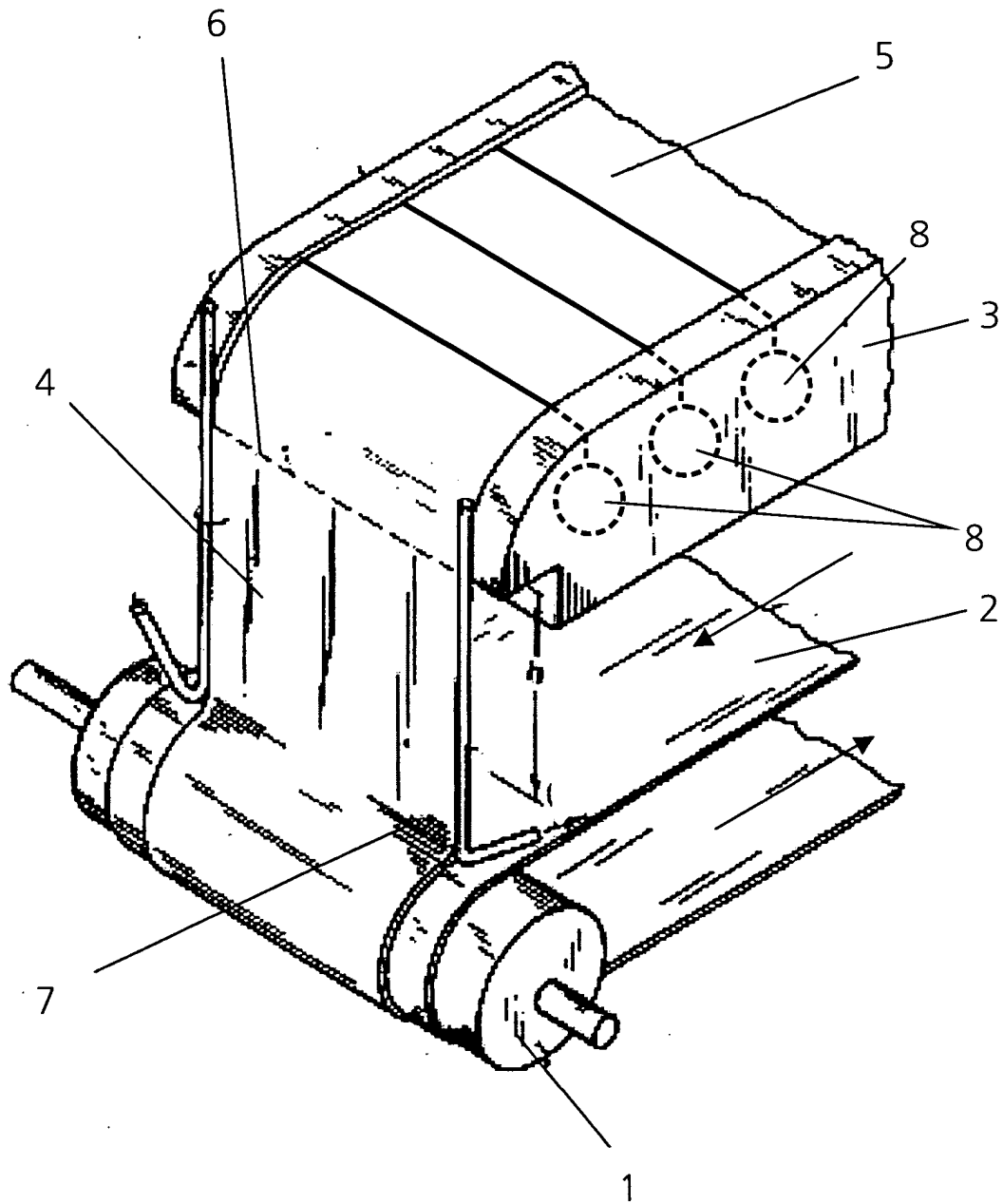
1. Method for curtain coating of a paper or board web (2) wherein a web substrate is moved below a hopper means (3) providing a single or multilayer liquid coating in the form of a freefalling curtain (4) impinging the substrate at a dynamic wetting line (7) and an air shield (9) located upstream of the dynamic wetting line (7) with respect to the moving direction of the web (2) wherein the dynamic wetting line (7) of the coating curtain (4) on the web (2) is oriented generally perpendicular to the moving direction of the web (2), providing substantially the same air pressure over an essential part of the coating curtain (4) on its front and back side with respect to the moving direction of the web (2), providing a first supply air flow upstream (17) to the wetting line (7) wherein the supply air flows over a substantial length along the freefalling curtain, and evacuating air from a location further upstream at a supply air flow outlet (20) so that the air near the dynamic wetting line (7) is moved against the moving direction of the web (2) and the boundary air layer entrained to the web (2), **characterized in that** a second supply air is provided in close proximity to the wetting line (7) and **in that** the first and second supply air

(17, 22) is evacuated by a first air suction (19, 13) and the boundary air is evacuated by a second air suction (29, 30).

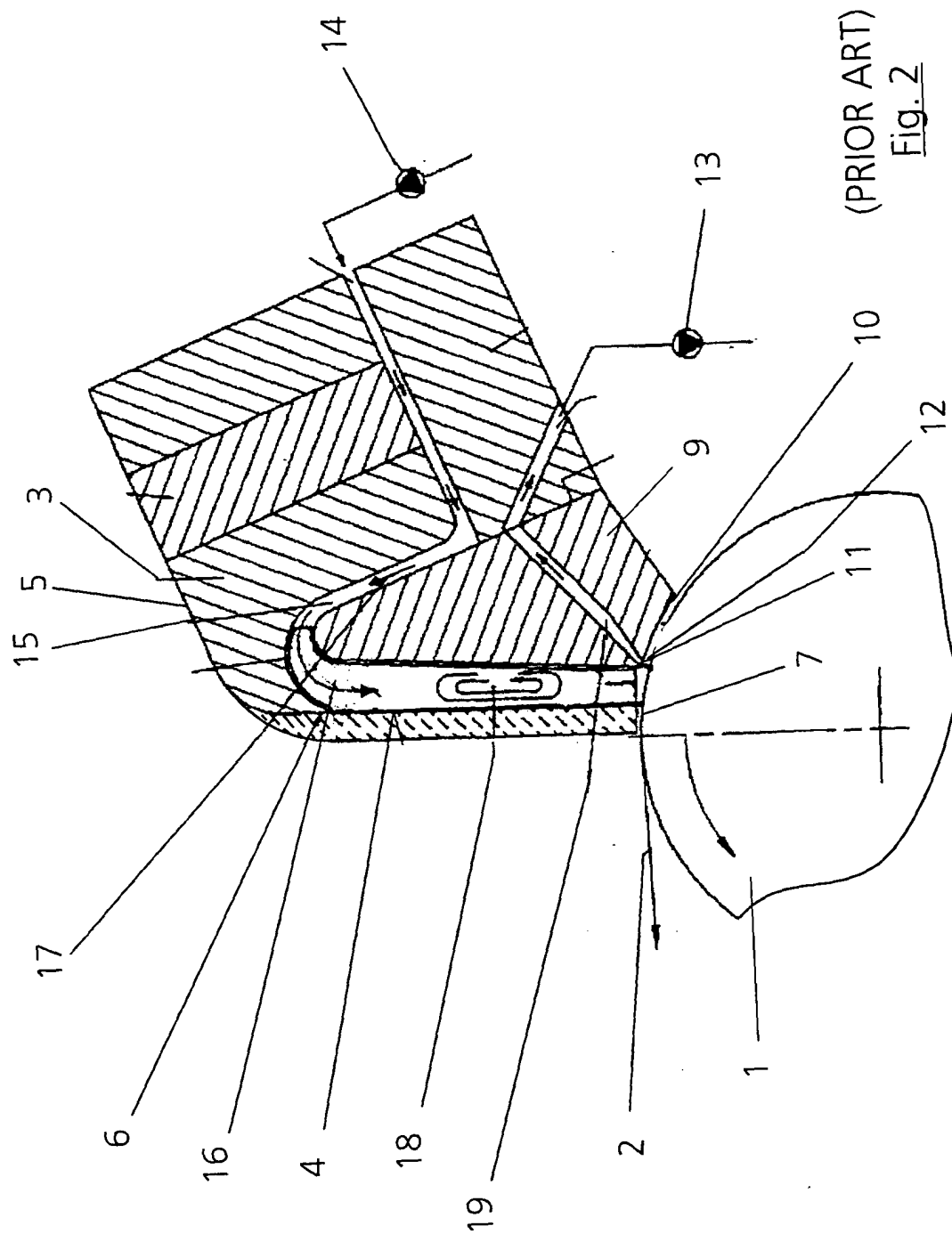
2. An apparatus for curtain coating of a paper or board web (2) including a hopper means (3) for providing a free-falling curtain (4) of coating liquid, an air shield (9) providing a small gap (10) between the web (2) and the air shield (9), a first air supply opening (25) extending generally over the width of the web (2) providing a first air flow (17) in the region of the dynamic wetting line (7) where the liquid coating curtain (4) impinges on the web (2), and a suction or vacuum providing means (19, 13) connected to the air shield (9) arranged to remove air **characterised in that** the arrangement comprises a second air supply flow (22) with an air supply outlet (20) in proximity to the wetting line (7) and **in that** for the first and for the second air flow (17, 22) a first suction means (19, 13) and for a boundary air layer entrained to the web (2) a second air suction means (27, 29, 30) is provided. 5 10 15 20
3. Apparatus according to claim 2, **characterised in that** a first guide member (21a) directs the second air flow (22) to the wetting line (7) and a second guide member (21b) is located between the second air supply (22) and a vacuum channel (19) of the first suction means. 25 30
4. Apparatus according to claim 3, **characterised in that** the second guide member (21b) with an edge (11) provides a nozzle between the supply air outlet (20) of the second air supply (22), the first suction means and the moved web (2). 35
5. Apparatus according to claim 3 or 4 **characterised in that** the first and second guide members (21a, 21b) at least partly in the region of the wetting line (7) are plates extending in cross direction over the width of the web (2) to be coated. 40
6. Apparatus according to claim 4 **characterised in that** the edge (11) providing the slot has a distance of about 1 to 10 mm, preferably 3 to 5 mm, to the web (2). 45
7. Apparatus according to claim 4 **characterised in that** the second guide member (21b) is displaceable to change the distance of the edge (11) to the web (2). 50
8. Apparatus according to claim 2, **characterised in that** as the second air suction means a doctoring means (27) is provided downstream of the first air suction means (19, 13). 55
9. Apparatus according to claim 8,

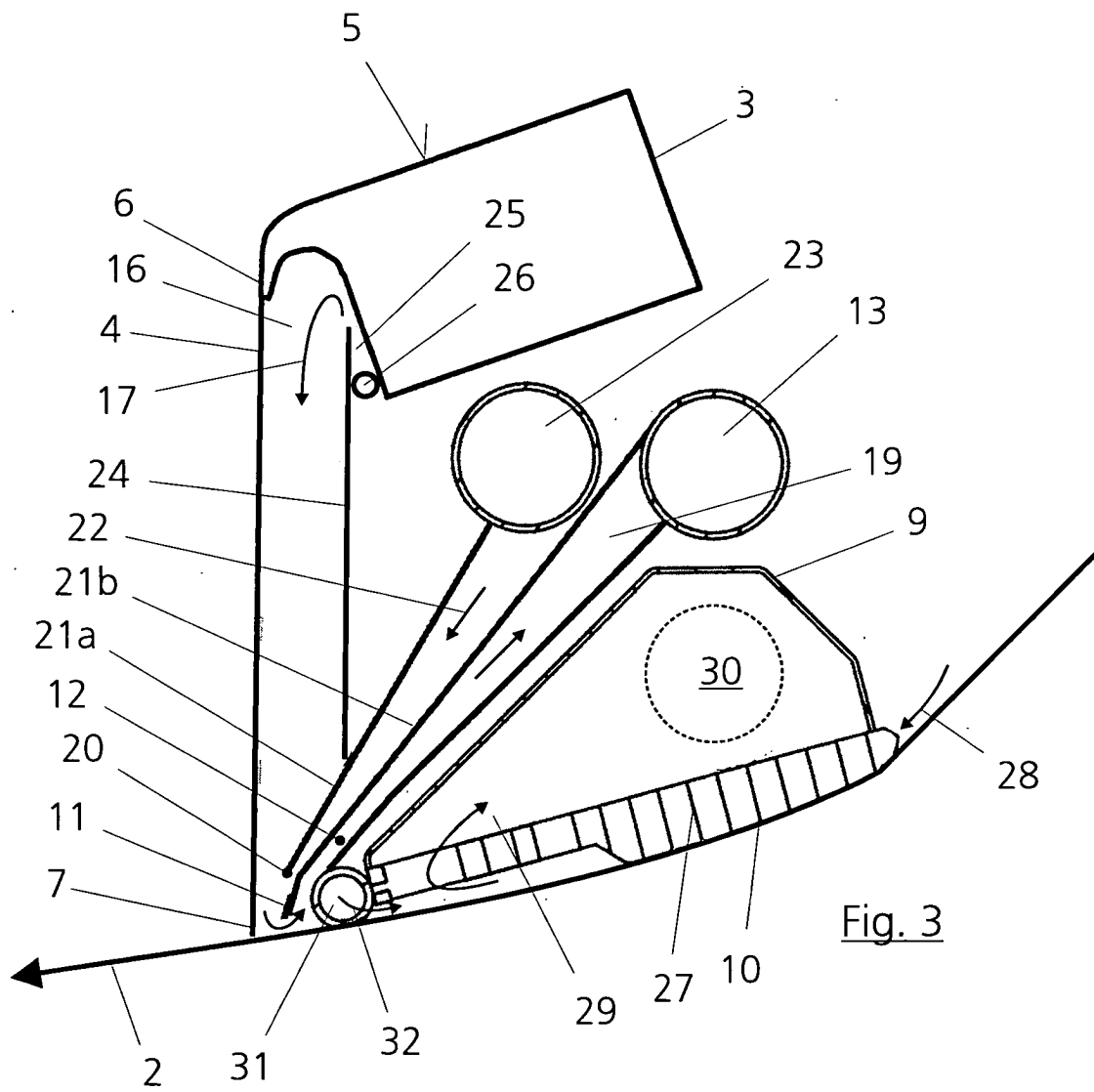
characterised in that the doctoring means is complemented with a suction channel (29) extending over the cross-machine width of the web.

10. Apparatus according to claim 2, **characterised in that** between the first air suction means (19, 13) and the second air suction means (27, 29, 30) a web support blow means (31) is provided.
11. Apparatus according to claim 10, **characterised in that** the web support blow means (31) is a non-contact blow with a blow channel (32) extending over the cross-machine width of the web (2).
12. Apparatus according to claim 11, **characterised in that** the blow channel (32) of the web support blow means (31) is directed in an angle against the direction of the moving of the web (2).
13. Apparatus according to claim 9 and 12, **characterised in that** between the blow channel (32) and the suction channel (29) an air connection is provided.
14. Apparatus according to claim 2, **characterised in that** the hopper means (3) and the air shield (9) are separate parts and that an opening (25) between the hopper means (3) and the air shield (9) is provided for the first supply air flow (17).
15. Apparatus according to claim 14, **characterised in that** a guiding shield plate (24) for direction the first supply air flow (17) along the free-falling curtain is provided.
16. Apparatus according to claim 14 and 15, **characterised in that** the guiding shield plate (24) is displaceable for changing the width of the opening (25) for the first supply air flow (17).



(PRIOR ART)
Fig. 1





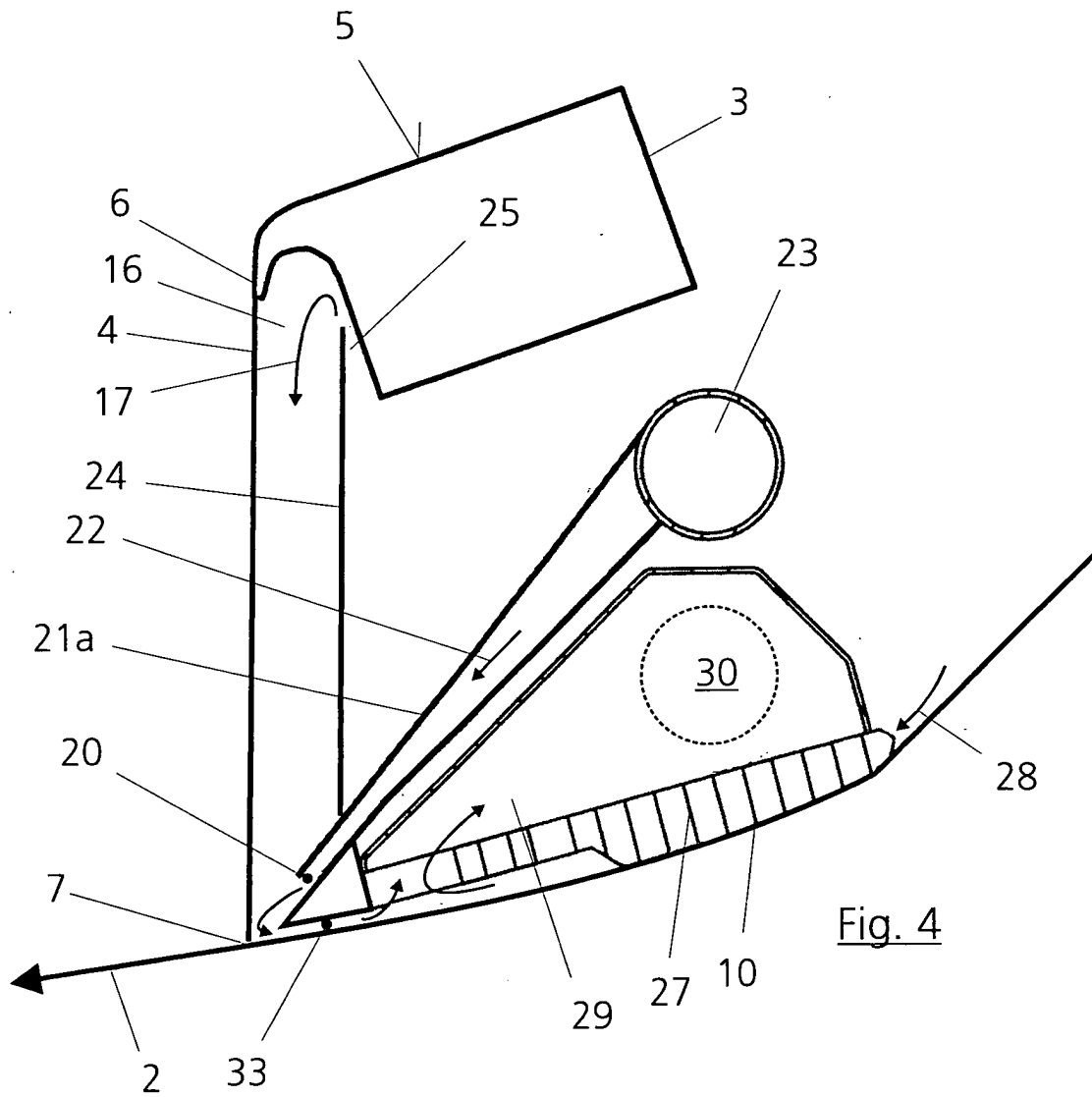


Fig. 4



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 02 02 7834

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Place of search THE HAGUE		Date of completion of the search 14 February 2003	Examiner Roldán, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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