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(54) Apparatus for coating moving webs, in particular paper webs and carton webs

(57) Apparatus for coating a moving web (16), in particular of paper or carton, on one or both sides with a liquid or pastous coating material (28) comprising a coating station (12) for applying the coating material (28) onto the web (16), as well as a non-contact turning apparatus (14) following the coating station (12) in the moving direction of the web (16). According to the invention, the web moves in one plane only from the point at which it is leaving (36) the coating station (12) to the point at which entering (52) the non-contact turning apparatus (14) without changing direction.

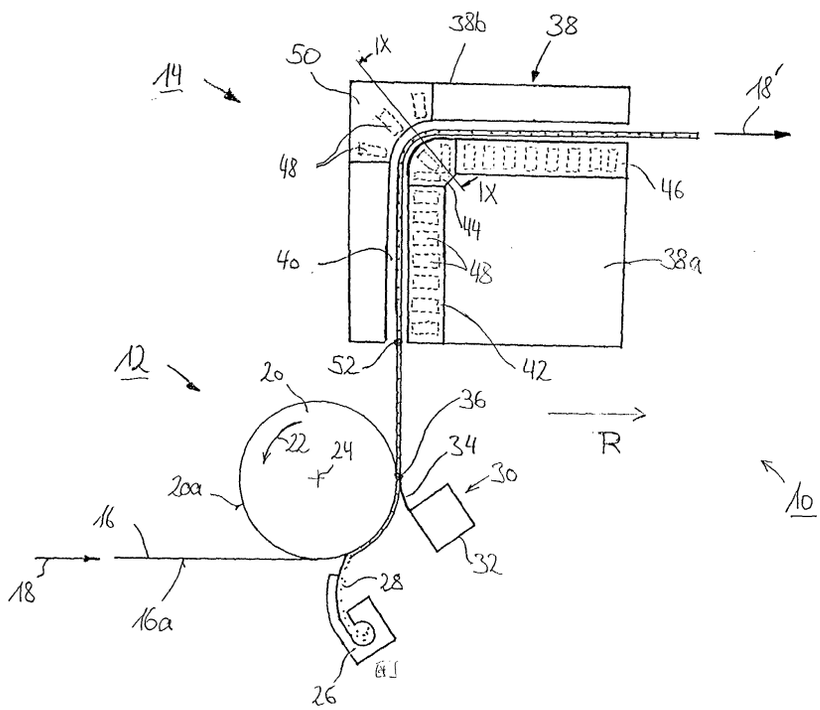

Fig. 1

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Description

[0001] The present invention concerns an apparatus for coating one or both sides of a moving web, in particular a paper web or a carton web, with a liquid or pastous coating material, comprising a coating station for applying a coating onto the web and a non-contact turning apparatus following-viewed in the web's moving direction - the coating unit.

[0002] From WO 98/32921 an apparatus for coating a paper web on one side comprising a coating station and a non-contact turning station is known. After the coating station in which a coating material is applied onto the moving paper web which is supported by a backing roll, the paper web moves on to a turning roll. From there it travels to a non-contact turning and drying apparatus, moves through this apparatus and after leaving the non-contact turning and drying apparatus. It is then led to calender-like cylinders in contact with the paper web to dry the paper web completely and then moved on to further processing. In WO 98/32921, for example, an arrangement of four such coating apparatuses in successive sequence is shown, wherein onto each side of the paper web a coating material is applied twice. One disadvantage of this prior art coating apparatus is on the one hand that the coating is negatively influenced by turning the humid paper web before it has at least partially dried. This is even more the case since due to the construction space available turning rolls with small roll diameters are usually used which leads to a sharp bending of the paper web at the turning point.

[0003] In addition, the use of such a turning roll makes it impossible to convert a coating apparatus to an apparatus with which double-coating can be realized since in this case the turning roll would be in direct contact with the humid coating which would influence the coating's quality intolerably.

[0004] The combination of a non-contact turning apparatus and a non-contact air dryer shown in WO 98/32921 in connection with the non-contact turning and drying apparatus is, for example, already known from DE 295 11 089 U1. From EP 0 777 731 A1 it is further known to locate a turning apparatus and a drying apparatus under one common housing in order to prevent humid exhaust gas and/or humid exhaust air from escaping into the machine hall.

[0005] It is therefore the object of the invention to provide a coating apparatus which at least reduces if not even eliminates the risk of quality losses of the coated web.

[0006] This problem is solved according to the invention by an apparatus of the aforementioned kind in which the web moves between its leaving the coating station and its entering the non-contact turning apparatus without changing direction in one plane only. This means that the web moves in free motion without applying an external force from the point of leaving the coating station and entering the non-contact turning apparatus which guarantees that the coating layer applied onto the web in-the coating station can be fixed in the turning apparatus while maintaining the quality obtained in the coating station.

[0007] Here, "leaving the coating station" refers to the point at which the web separates from the web guiding element serving the purpose of directly applying a coating onto the web. Such a guiding element can be, for example, an applicator roll, a support roll or a band endlessly running around a shoe or similar devices. Decisive is that the web's coating condition is changed at the guiding element concerned and, with the exception of some desired drying effects, remains unchanged from the point of separation from it.

[0008] When referring to the web entering the non-contact turning apparatus, the point at which the turning apparatus influences the web noticeably, i.e. the point at which gas jets from the turning apparatus or infra-red rays hit the web in such a way that the web's temperature is changed is referred to.

[0009] In the present invention the length of the web's free motion, i.e. the length of the path of the web between two guiding elements which are in contact with the web, is extended compared with the coating apparatuses known from prior art. This is even more extraordinary since many experts are of the opinion that with an increasing length of the free motion the instability of the web's path also increases and that therefore the expert should be urged to reduce the length of free motions. Surprisingly, the advantageous effects of the present invention can be achieved without taking additional measures or installing further components for increasing the stability of the web's path when moving through the coating apparatus.

[0010] In addition to the fact that quality impairing effects on the web during turning are avoided, a further advantage can be achieved by the coating apparatus of the present invention: in contrast to the coating apparatus known from prior art it is now possible to apply at a coating station a coating material onto both sides of the web because of the planar and externally unaffected path of the web after leaving the coating station. Thus, the space, especially the longitudinal dimension required by the coating apparatuses in which a web is to be double-coated one or several times can be considerably reduced. This means that valuable construction space can be saved.

[0011] The coated web's quality can be further improved by having the web leave the coating station in an upward direction, preferably in an essentially vertical direction. It is often the case that when the web separates, for example, from the applicator roll or a similar coating element used for indirectly applying a coating material onto the web, an effect called "misting" occurs, i.e. a vapour of small coating beads or droplets is formed in the wedge between the web and the surface of the coating element. If the web is, however, leaving the coating station in an upward direction, preferably in an es-

sentially vertical direction, the probability that the small beads fall on the coated web decreases with the increasing pitch angle. The beads are rather more likely to fall back on the coating element instead.

[0012] It is, however, also conceivable that the web leaves the coating station in a downward direction. This can be especially helpful in cases where already existing coating apparatuses and/or devices with non-contact turning apparatuses are to be converted in such a way that the web is traveling in one plane only without changing direction between leaving the coating station and entering the non-contact turning apparatus.

[0013] As has already been mentioned, the free motion of the web after the coating station serves the purpose of extracting humidity from the web. If the web is leaving the coating station in an upward or downward direction there is sufficient path for the web to dry without having to -increase the length of the coating apparatus and with it its need of space since in this case the turning apparatus can be located either essentially above or underneath the coating station.

[0014] The non-contact turning apparatus can turn the web by approximately 90°. This is advantageous if web processing units of greath length, e.g. a calender, follow the turning apparatus. The web can, for example, leave the coating station in an vertically upward direction, is turned by the turning apparatus by 90° to machine running direction, and then led back to the height level of the coating station by a vertically arranged calender.

[0015] In doing so, the available construction space can be used optimally by arranging the web processing units in a compact way. The machine running direction is the direction the web travels, starting with unwinding the web supply to be coated to reeling in the coated web.

[0016] In case no further web processing units are to follow the non-contact turning apparatuses, a sufficient drying length can also be obtained by having the web turned by approximately 180° by means of non-contact turning apparatuses. This means that about twice the distance between coating station and non-contact turning apparatus is available as drying length.

[0017] If only a limited construction height and/or depth (depending on whether the web is leaving the coating station in an upward or downward direction) is available, the required height of the coating station can be reduced if the first turn carried out in the turning apparatus is directed to machine running direction. If the first turn was in a direction opposite to the machine running direction, the web would inevitably have to be turned again to travel in machine running direction which can only be carried out above or underneath the first turn of the web.

[0018] The above-described turn of the web can be carried out in the turning apparatus in an easy way if the turning apparatus comprises a turning unit which is located at the concave side of an turning section of the web. The turning unit can be for example a so-called "airturn".

[0019] A particularly stable travel of the web which, for example, is desired in cases where the web travels in free motion, can be achieved if the turning apparatus comprises a stabilizing unit which is located at the opposite side of the turning unit, on the convex side of the turning section. Such a stabilising unit can be comprised of a non-contact drying unit in the form of a forced convection hood for example which will provide the same or differential drying from both sides of the web simultaneously, when considered together with the drying effect of the air turn unit.

[0020] A decisive factor of the profitability of, for example, paper or carton processing machines is the speed at which the web to be processed is moving. This moving speed can be increased without impairing the coated web's quality if at least one non-contact drying unit is - viewed in the web's moving direction - located before and/or after the turning unit. In doing so, the drying apparatus' drying performance in relation to the web's path can be increased, thus enabling a reduction of the time the web is in the drying apparatus.

[0021] In case the web is double-coated, the length of free motion can be reduced or the moving speed can be increased of at least two non-contact drying units are located opposite each other on different sides of the web. The at least one drying unit can be an air dryer or an infra-red dryer or an infra-red pre-heater. It is also possible to use both infra-red dryers and air dryers in the turning apparatus. It can be advantageous to first pre-dry the humid web by means of infra-red rays, thus making the web insensitive to the subsequently impacting air jets or air flows.

[0022] Thereafter, the web can be dried by air drying which -due to the turbulances of the air jets near the web's surface is very homogeneous. It can also be advantageous to firstly pre-heat the humid web by means of infra-red rays prior to drying with the impinging air jets, for purposes of increasing the rate of drying under the jets and thereby promoting improved final coat quality.

[0023] In connection with drying the web to a certain degree and at a certain point of the web's path, it can be desirable to extend the free motion, depending on the degree of the coated web's humidity in order to obtain more time for the web to dry while traveling at constant speed. This can be achieved in a space-saving manner by means of providing - viewed in the web's moving direction - at least one further non-contact turning unit after one non-contact turning unit. In addition, at least one of the non-contact turning units can also have a drying function in addition to turning the web. For example by means of heating it with gas which is warmer than the impingement air's ambient temperature and/or increasing the impingement jet velocity of the air turn unit, thereby increasing the Reynolds number of the impingement flow at the product surface. With this turning apparatus the forced convective drying effect is increased.

[0024] As the functions drying and turning can be combined in one apparatus, it is also conceivable to construct a combined drying and turning apparatus by means of constructionally combining a drying unit and a turning unit in one element.

[0025] During the drying process of the coated web, the coating which at first had been applied in a humid or pastous form emits humidity and/or solvents into the atmosphere which, if they mix with the ambient air in the machine hall, may have a harmful effect on the health and well-being of the personnel working in the machine hall as well as on the building itself. These harmful effects can be avoided if the non-contact turning unit and/or the at least one further turning unit and/or the at least one-non-contact drying unit are located in one common housing which, if desired, can consist of several housing parts. The common housing can for example have a suction hood sucking off the humid or/and solvent-containing exhaust gas directly from the area around the web such that it cannot get into the ambient atmosphere of the machine hall.

[0026] The coating station used for applying the coating can exhibit at least one coating unit for directly applying the coating material onto the web or/and at least one coating unit for indirectly applying the coating material onto the web. This guarantees a desired coating result taking into consideration the available construction space. If only little space for the coating station is available and if coating on both sides is desired, one side of the web can, for example, be coated indirectly by means of an applicator roll and the other side can directly be coated by means of a coating unit, wherein the applicator roll serves as a support roll for the coating unit. In addition, the use of any kind of coating device desired is conceivable, such as coating devices known by experts as JetFlow F, SDTA (Short Dwell Time Applicator), LDTA (Long Dwell Time Applicator), Curtain Coater etc.

[0027] If the web is to be coated in several layers, two or more coating units according to the invention can be arranged in succession in one coating apparatus, wherein each individual coating unit can apply a coating layer on one or both sides of the moving web.

[0028] The gas-nozzle arrangements used in turning and drying apparatuses play an important role for the operatability of such coating apparatuses. It is, for example, important that there is a stable air cushion at the turning point of non-contact turning apparatuses, such as airturns. The requirements to be met by such an air cushion and its stability increase with an increasing length of the web's free motion. If an inhomogenity, for example by a varying degree of the web's humidity in latitudinal direction is to be avoided, a uniform gas distribution over the length of a gas-nozzle arrangement or a gas distributor is also very important. Also of importance in this respect is the distrbution, velocity and direction of the air exiting from the air cushion region.

[0029] From the prior art WO 98/56985 certain gas distributors used for drying paper webs are known which are essentially made of an elongated hollow body extending in its longitudinal direction perpendicularly to the web's moving direction. This hollow body comprises a gas intake and a gas exhaust, wherein the gas exhaust is located at the wall section of the hollow body (gas exhaust section) which is essentially parallel to the web's surface and facing the moving web. The gas distributor of the prior art is characterized in that the introduction of gas takes place at the side wall. The height of the gas-flow relevant cross-section inside the gas distributor decreases linearly from the gas intake side to the side opposite this gas intake side. A disadvantage of this gas distributor is that a homogeneous gas flow over the entire gas distributor's length is not always guaranteed. This circumstance was tried to be compensated by linearly decreasing the gas-flow relevant cross-section, which, however, again due to the asymmectric gas intake from one side wall leads to an unnecessary large construction volume, in particular to an unnecessary high construction, of the gas distributor.

[0030] In order to save construction space as well as to guarantee a uniform gas discharge over the entire length of the gas distributor it is suggested to use an above-described gas distributor of the generic type whose gas intake is located at the longitudinal center of the hollow body in non-contact turning or/and drying apparatuses for moving webs.

[0031] The gas distributor does not necessarily have to extend in its longitudinal direction transversely to the web's moving direction. It can also be arranged parallel to the web's moving direction in its longitudinal direction in order to affect certain zones, such as the web's margin and, for example, to dry them. In addition, it can have any intermediate position desired.

[0032] The above-described gas distributor is - taken without the coating apparatus described so far - a technical novelty with a value of its own such that independent protection is sought.

[0033] Locating the gas intake at the longitudinal center of the elongated hollow body means that the distance from the gas intake point to the most remote gas outlet point is halved, making it more likely that the gas exhaust flow is homogeneous over the entire distributor's length.

[0034] A smaller width of the gas distributor which may be desirable if several gas distributors are to be arranged next to each other in a small space can be achieved by locating the gas intake at the hollow body's wall section opposite the gas exhaust section.

[0035] The elongated hollow body can have various forms. Constructing the hollow body as a hollow parallelepiped body can be a particularly simple and cost-efficient version. However, if the vertical clearance of the gas flow cross-section inside the hollow body starting from a longitudinal center section comprising the gas intake to the two longitudinal ends of the hollow body decreases, preferably decreases continuously, the ho-

mogenity of the gas exhaust flow can be increased even further. Especially preferably the vertical clearance of the gas flow cross-section of the hollow body at a certain longitudinal position changes proportional to the amount of gas which is to be emitted at that longitudinal position of the hollow body.

[0036] As a further measure to increase the homogenity of the discharged gas flow, the hollow body can be symmetric with respect to its- longitudinal center plane.

[0037] From WO 98/56985 an apparatus for drying a paper web with gas distributors arranged parallel to each other and perpendicular to the web's moving direction under one common gas suction hood is known. However, in the disclosed drying apparatus those gas distributors which are supplied with gas from a side wall and which are also described in WO 98/56985 are used, leading to an unnecessarily high construction of the drying apparatus.

[0038] As already mentioned, the gas distributor of the present invention is particularly suitable to be used in drying or turning apparatuses for drying or/and turning a moving web, in particular in the above-described coating apparatuses. According to the invention, in the turning units at least one gas distributor extends transversely to the web's moving direction. In contrast to the prior art, the above-described drying and/or turning unit of the present invention needs less construction height. A further advantage is that in case the web is turned, as large a latitudinal area of the web as possible is supported by an air cushion. Also, if a gas distributor used in a drying unit is arranged in such a way, as large a latitudinal area of the web as possible can be affected by drying gas. Independent protection is also sought for such a turning apparatus.

[0039] It was already mentioned that the humid or even solvent-containing exhaust gas is to be sucked off the drying and/or turning area in order to avoid impairing effects on the personnel and construction substance of the machine hall near the apparatus. This can, for example, be solved if the turning apparatus, in particular a drying or/and turning unit contained in it, comprises a gas suction hood which surrounds the at least one gas distributor, which is open in direction towards the web, and which is connected to at least one gas exhaust line. The at least one gas distributor is then supplied by a gas supply line.

[0040] An especially safe turning and a homogeneous drying of the web can be achieved if the at least one gas distributor essentially extends over the entire width of the moving web.

[0041] If the web's moving speed is to be increased without impairing drying performance and without losing any stability at the turning point, a plurality of gas distributors may be arranged under the gas suction hood parallel to each other and spaced apart in in the web's moving direction. Arranging the plurality of gas distributors spaced apart guarantees that the unit is provided with slots or openings through which humid or/and solvent-containing exhaust gas can be sucked off by the gas exhaust line.

[0042] In order to keep the effort for processing the gas suction hood as low as possible if several gas distributors are used under one gas suction hood, a central gas supply line can be introduced into the interior of the gas suction hood, wherein advantageously distribution lines inside the gas suction hood lead from the at least one gas supply line to the individual gas distributors. From experience it is known that one single gas supply line is not able to supply an arbitrary number of gas distributors. Depending on the number of distributors, it can therefore be practical to divide the plurality of gas distributors into groups, wherein advantageously one gas supply line and one gas exhaust line are allocated to each group which supply the gas distributors of the corresponding groups with gas and suck humid and/or solvent-containing exhaust gas of the web's surface respectively.

[0043] In case there is only one gas suction point through which gas from a-compared to the cross-section of the gas exhaust line - large area is sucked off, a non-uniform gas exhaust over the area may occurr. It may be that sections near the gas exhaust line experience a stronger gas exhaust than sections further away from this opening. Normally this is undesirable and can be avoided by providing the gas suction hood with a flow equalizing means for the gas flowing from the moving web into the gas suction hood. The flow equalizing means can, for example, exhibit openings which in part have differently sized cross-sections in order to provide sectionwise adapted flow resistances. A flow equalizing effect can, however, already be achieved if the flow equalizing means provide a constant flow resistance over their entire surface. These flow equalizing means can be realized in a material-saving manner by arranging them between the gas distributors parallel to the web's surface. The flow means can be made of various materials, such as a perforated plate, flow-permeable bonded fiber fabrics, honeycomb structures, grates or similar materials.

[0044] A further possible reason for an inhomogenity in the gas suction flow can be that the gas exhaust lines used for the individual groups perform differently. This effect can be avoided or at least reduced if flow throttle means are arranged in the gas suction space between the gas distributor groups in essentially vertical direction and parallel to the gas distributors. These flow throttle means extend at least over a part of, preferably over the entire cross-section of the gas suction hood. These flow throttle means can be conceived as flow-permeable but flow-resistive partitions between the individual gas distributor groups. These can also be made of the above-mentioned materials such as perforated plates, honeycomb structures, grates, flow-permeable bonded fiber fabrics, or similar materials.

[0045] Drying a double-coated moving web is a special technical challenge since from nearly the same ma-

terial volume twice as much humidity has to be removed per time unit. This can, for example, be solved by arranging at least two drying apparatuses or at least one turning and at least one stabilizing unit opposite to each other on different sides of the moving web. This applies not only to drying but also to turning the web, namely in cases where a particular stability of the web is required, such as in case of long free motions of the web. The at least two drying units or the at least one turning and the at least on stabilizing unit can be arranged in such a way that at least some of the gas distributors are located on both sides of the web at essentially the same longitudinal positions viewed in the web's moving direction in pairs opposite to each other. This has the advantage of being able to dry the web particularly gently since the forces applied on the web by the gas flows compensate each other mutually. A flexing of the web can thus be avoided.

[0046] It is, however, also possible to arrange at least some of the gas distributors on one side of the web and at least some of the gas distributors on the other side of the web alternatingly with respect to their longitudinal positions viewed in the web's moving direction. In other words: One gas distributor is located on one side of the web and - viewed in the web's moving direction - spaced apart from this gas distributor another gas distributor is located on the other side of the web etc. With this arrangement the web may under certain circumstances experience flexing, however, this arrangement has the advantage that the web's surface in the drying section is extended by this flexing such that a greater drying performance can be achieved without having to change the construction or running parameters of the drying and/or turning apparatus. It is also possible to arrange some of the gas distributors in one way and some of the other distributors in the other way, i.e. they can be arranged at the same longitudinal positions opposite to each other in some areas and alternatingly in others. This can, for example, be applied at a humid web which had just been coated. This web can initially be guided through an arrangement of alternating gas distributors resulting in the forming of waves on the web, thus increasing its surface. This increases the drying performance in the drying apparatus and then, with an already pre-dryed coating, the web is smoothly moved through the drying apparatus' gas distributors opposite to each other.

[0047] Summarizing, the air turn has been specifically designed to ensure that stable support of the moving web occurs by the generation of a pressure support cushion of dynamic air which comes into equilibrium with the operating web tension at the desired flotation height above the air turn surface. The resulting supporting cushion pressure generated has been made to be substantially independent of the impingement velocity at the nozzle exit to ensure high heat and mass transfer rates are achievable. This is brought about by varying the pressure of the gas inside the air turn elements in order to attain the requisite impingement gas velocity at the web surface . The desired web flotation height meanwhile is maintained by regulating the velocity of air exiting the pressure cushion region by ensuring that it flows through a variable gas distributor positioned between the impingement elements located parallel to the web surface. By this means the distribution of the air exiting from the cushion pressure region is also distrbuted evenly across the width of the unit whilst being maintained at the desired cushion pressure level.

[0048] Advantageously, nozzle systems as described in EP-B1-0 728 285 may be used, the disclosure of which document hereby is incorporated into the present application by reference. By using such nozzle systems it is possible to substantially shorten the drying lengths required and hence space taken up in the machine running direction by the overall apparatus.

[0049] In the following, the present invention will be described, referring to the enclosed drawings in which

Fig. 1 is a rough schematic cross-section of a coating apparatus in accordance with the present invention, wherein the web is coated on one side and is turned in the turning apparatus by 90°,

Fig. 2 is a rough schematic cross-section of a coating apparatus in accordance with the present invention, wherein the web is double-coated and is turned in the turning apparatus by 180°,

Fig. 3 is a further embodiment of the coating apparatus of the present invention,

Fig. 4 is a coating apparatus of the invention with a following calender,

Fig. 5 is a further embodiment of the coating apparatus of the present invention, wherein the web is coated on one side and turned in the turning apparatus by 90°,

Fig. 6 is a further embodiment of the coating apparatus of the present invention, wherein the web is double-coated and turned in the turning apparatus by 180°,

Fig. 7 is a further embodiment of the coating apparatus of the present invention, wherein the web is coated on one side and leaves the coating station in a vertically downward direction,

Fig. 8 is a further embodiment of the coating apparatus of the present invention, wherein the web is double-coated and leaves the coating station in a vertically downward direction,

Fig. 9 is a rough schematic cross-section of a gas distributor of the prior art,

Fig. 10 is a rough schematic cross-section of a gas distributor in accordance with the present invention,

Fig. 11 is a further embodiment of the gas distributor of the invention,

Fig. 12 is a rough schematic longitudinal section of two constructionally equivalent drying and turning apparatuses of the invention,

Fig. 13 is a rough schematic cross-section of the drying and turning apparatus of Fig. 12, wherein the cross-section is along the line XIII-XIII of Fig. 12,

Fig. 14 is a further embodiment of two drying and turning apparatuses according to the invention with an alternating arrangement of the gas distributors,

Fig. 15 is a rough schematic cross-section of a further embodiment of two drying and turning apparatuses, wherein the gas distributors of each apparatus are divided into groups.

[0050] In Fig. 1 a coating apparatus of the invention is in general marked with 10. The coating apparatus 10 comprises a coating station 12 as well as a non-contact turning apparatus 14. A web 16 moves into the coating station 12 in direction of the arrow 18.

[0051] The coating station 12 comprises a support element in form of a support roll 20 which rotates in the direction of the arrow 22 around its axis 24 which is perpendicular to the drawing plane of Fig. 1 in such a way that the web 16 is supported slip-free by the circumference 20a of the support roll 20.

[0052] The coating station 12 further comprises a coating unit 26 from which a liquid coating material 28 is directly applied onto the side 16a of the web 16 not facing the support roll 20. In the moving direction of the web 16 after the coating unit 26 an egalizing apparatus 30 is provided. This egalizing apparatus 30 comprises a stiff beam 32 on which a doctor blade 34 is mounted metering and egalizing the liquid coating 28 applied onto the web 16. In the moving direction of the web 16, the web 16 now layered with the coating 28 separates from the support roll 20 at a point 36 after having passed the tip of the doctor blade 34. This point 36 refers to the point at which the web 16 leaves the coating station 12. At this point the process of applying a coating is quantitatively and qualitatively terminated, with the exception of unavoidably beginning drying processes due to convection. In addition, there is no possibility for any element or component designed to directly apply a coating 28 onto the web 16 to have an effect on the web 16 after the web 16 has passed the leaving point 36. Further, from the point 36 the free motion of the web 16 begins and continues until the web 16 is again in contact with a guiding and/or directing element not shown in Fig. 1.

[0053] The non-contact turning apparatus 14 comprises a housing 38 which consists of a first housing part 38a and a second housing part 38b. Between the two housing parts 38a and 38b a gap 40 is provided in which the web 16 is traveling. In the first housing part 38a which is on the concave side of the web in the moving direction of the web 16 there is a drying unit 42 on the entering side, a turning unit 44, as well as a drying unit 46 on the exit side are located. Both drying units 42 and 46 as well as the turning unit 44 comprise gas distributors 48 arranged transversely to the moving direction of the web 16, i.e. perpendicular to the drawing plane of Fig. 1, whose cross-section outline is shown in broken lines in Fig. 1. Warm air is conducted by means of gas distributors against the humid side 16a of the web 16 onto which a coating 28 was applied in order to extract humidity from the web 16 or/and to turn the web. The first housing part 38a further comprises an exhaust apparatus not shown in Fig. 1 for conducting the humid exhaust air away from the area near the side 16a of the web.

[0054] In the second housing part 38b which is located at the convex side of the web and in radial direction opposite to the turning unit a stabilizing unit 50 is provided. The stabilizing unit 50 also comprises gas distributors 48 arranged transversely to the moving direction of the web 16 which blow air towards the web. The stabilizing unit 50 serves the purpose of providing a stable guidance for the web 16 in its turning section and of pressing the web 16 against an air cushion formed by the turning unit 44, thus facilitation the realization of long free motions of the web. A turn by 90° in the machine running direction R takes place in the non-contact turning apparatus 14. As a result, the non-contact turning apparatus 14 can be realized with a comparatively low construction height.

[0055] The coated web 16 enters the non-contact turning apparatus 14 at the point 52. The entering point 52 is the beginning of the gap 40, since here begins - viewed in the moving direction of the web 16 - the area in which the drying apparatus 42 at the entering side can significantly affect the web.

[0056] Between the points 36 and 52 the web 16 moves essentially in one plane which contains the points 36 and 52 and which in the example shown in Fig. 1 is perpendicular to the drawing plane. The web 16 is not affected mechanically between leaving the coating station 12 and entering the non-contact turning apparatus 14, whereby the risk of impairing the web coating is reduced or even avoided. The coating's quality can thus be guaranteed or even increased.

[0057] In Fig. 2 the same components as in Fig. 1 are marked with the same reference numbers, however, increased by 100. It is herewith explicitly referred to the description of Fig. 1.

[0058] In Fig. 2 a web 116 enters a coating station 112

in the direction of the arrow 118. The coating station 112 serves the purpose of double-coating the web 116. The combined support and applicator roll 120 rotates in direction of the arrow 122 around its turning axis 124 which is perpendicular to the drawing plane in such a way that no relative movement occurs between the circumference 120a and web 116.

[0059] On the side 116a of the web 116 facing away from the circumference 120a a coating 128 is applied by means of a directly-applying coating unit 126 as shown in Fig. 1. In the moving direction of the web 116 following after the first coating unit 126 an egalizing apparatus 130, as shown in Fig. 1, is provided. In addition, the coating station 112 comprises a further coating unit 154. This second coating unit 154 applies a coating 156 first onto the circumference 120a of the combined support and applicator roll from which it is then applied onto the side 116b of the web 116 facing the circumference 120a. Depending on the target to be met by the coating, the liquid coating 126 and the coating 156 can be the same or different coatings.

[0060] At the leaving point 136 at which the humid web 116 coated on both sides with the coatings 128 and 156 separates from the combined support and applicator roll 120, the web 116 leaves the coating station according to the definition in a vertical direction. Having the web 116 leave the combined support and applicator roll 120 in a vertical direction is of advantage since the beads 158 of coating 156 which can form in the wedge 160 between applicator roll 120 and web 116 are very likely to fall onto the roll 120 rather than on the web 116. This is remarkably increasing the coating results.

[0061] At the point 152 the web 116 enters the non-contact turning apparatus 114. The web 116 moves in one plane without changing direction between the points 136 and 152.

[0062] The non-contact turning apparatus 114 turns the web 116 by 180° in total, ie. at two points by 90° each. The web 116 leaves the non-contact turning apparatus 114 in the direction of the arrow 118'. The turning apparatus 114 exhibits a housing 138 with a first housing part 138a located on the concave side of the turned web 116 (= side 116a in Fig. 2) and a second housing part 138b on the convex side of the turned web 116 (= side 116b of the web 116). In the first housing part 138a in the web's moving direction there is a first drying unit 142 at the entering side, a first turning unit 144, a further drying unit 162 on the concave side as well as a second turning unit 164. In contrast, the second housing part 138b - also viewed in the moving direction of the web 116 - exhibits a second drying unit 166 on the entering side, a first stabilizing unit 150, a further drying unit 168 on the convex side as well as a second stabilizing unit 170. By means of arranging the drying units and the turning and/or stabilizing units - which can be run with warm or hot gas and thus also be used for drying the web 116 - on both sides of the web, a long free motion of the web 116 and an accordingly good drying effect can be realized due to the U-shaped path of the web 116 without having to occupy unnecessary space in the machine hall. This decreases, for example, the calculatory expenses for the space of the drying apparatus 110.

[0063] The schematically-shown drying units 142, 162, 166, 168 shown in Fig. 2 are infra-red drying units. They can, however, also be gas and/or air drying units as in Fig. 1.

[0064] In Fig. 3 the same components as in Fig. 2 are marked with the same reference numbers, however, increased by 100. In the following Fig. 3 is only described insofar as it differs from the Fig. 1 and 2. For the other components it is herewith referred to the descriptions of Fig. 1 and 2.

[0065] In Fig. 3 a web 216 is coated by means of indirectly applying a coating 228 on the side 216a of the web by means of an applicator roll 270 and the coating 256 on the side 216b of the web by means of an applicator roll 220. The turning axis 274 of the applicator roll 270 is parallel to the turning axis 224 of the applicator roll 220. The applicator rolls 270 and 220 rotate around their axes in the direction of the arrows 216 and 272 in such a way that no relative motion between the web 216 and the circumferences 220a and 270a of the two applicator rolls takes place at the pressing nip 276 which is provided for applying the coating from the applicator rolls onto the web.

[0066] As shown in Fig. 3, the point 236 at which the web leaves the coating station 212 is - viewed in the web's moving direction - a little behind the pressing nip 276 which lies in the plane connecting both turning axes 224 and 274. This is because of the delayed detachment of the web 216 from one of the two applicator rolls 220 and 270 due to adhesion effects of the humid web 216.

[0067] Due to the indirect double-coating with coatings 228 and 256 onto the web 216 on both sides 216a and 216b of the web a misting occurs after the web 216 separates from the two applicator rolls 220 and 270. Again, the quality of the application and the coating of the web 216 can be guaranteed by stripping the web off in a vertical upward direction such that the coating particles 158 are less likely to fall back on the coated web 216.

[0068] At the point 252 the coated web 216 enters the non-contact turning apparatus 214. The housing of the non-contact turning apparatus 214 is the gas suction hood allocated to the individual turning and drying units. The web 216 is turned in the non-contact turning apparatus 214 by 180° in total. In the turning apparatus 214 on the concave side of the U-shaped path of the web are - viewed in the web's moving direction - a turning unit 244 at the entering side, a drying unit 262 on the concave side, and a turning unit 264 on the exit side. On the convex side of the U-shaped path of the web there is a stabilizing unit 250 on the entering side, a drying unit 268 on the convex side, and a stabilizing unit 270 on the exit side (also viewed in the web's moving direction). All components are run with gas, to be more

precise with air. However, it is also conceivable to use gases other than air such as nitrogen or carbon dioxide. In contrast to the example shown in Fig. 2 the drying units 262 and 268 opposite to each other on different sides of the web have the same length.

[0069] The web 216 travels in one plane between the points 236 and 252.

[0070] In Fig. 4 the same components as in Fig. 3 are marked with the same reference numbers, however, increased by 100. Fig. 4 is only described insofar as it differs from the Fig. 1 - 3. For the other components, it is herewith referred to the descriptions of Fig. 1 - 3.

[0071] A coating 356 is indirectly applied onto the side 316b of the web 316 facing the applicator roll 320 by a coating unit 354. The web 316 enters the coating station 312 in the direction of the arrow 318 from diagonally below and leaves it at the point 336. The angle of contact α at which the web 316 is in contact with the circumference 320a of the applicator roll 320 can be reduced by having the web 316 enter from diagonally below. The optimal angle of contact can have different values depending on the running and material parameters such as moving speed of the web and coating and material used.

[0072] At the point 352 the web 316 enters the non-contact turning apparatus 314 after having traveled in one plane from point 336 at which the web 316 leaves the coating station 312 to this point 352. The web 316 is turned by 90° in this turning apparatus 314. The first housing part 338a facing the side 316a of the concave side of the web 316 - in the web's moving direction - comprises a combined drying and turning unit 378 followed by a further drying unit 346 on the concave side. Both the combined drying and turning unit 378 and the further drying unit 346 on the concave side are provided with gas distributors 348 (which are shown in broken lines) and are run with gas having a higher temperature than the ambient air in order to achieve a drying effect.

[0073] Combining a drying unit with a turning unit in one single component facilitates the assembly of the non-contact turning apparatus considerably since the number of components to be assembled is reduced.

[0074] In the second housing part 338b associated to the side 316b of the web 316 there are provided a drying unit 366 on the convex entering side and a drying unit 380 on the convex exit side. The two drying units 366 and 380 serve the purpose of directly drying the coating 356 on the web 316. The structural components 346 and 378 in the first housing part 338a serve to change the web's direction in its turning section and to stabilize the web's path and to indirectly dry the web 316 in its straight sections.

[0075] After leaving the non-contact turning apparatus 314, the web 316 enters a vertically arranged calender 380 in which the web 316 embraces the halves of six rolls 382 alternatingly which are arranged parallel to and one below the other. The web 316 is then guided back to the height level at which it entered the coating station 312. The web 316 leaves the calender in the direction of the arrow 318'.

[0076] In Fig. 5 the same components as in Fig. 4 are marked with the same reference numbers, however, increased by 100. Fig. 5 is only described insofar as it differs from the description of Fig. 1 - 4. For the other components, it is explicitly referred to the descriptions of Fig. 1 - 4.

[0077] The web 416 enters the coating station 412 in the direction of the arrow 418. The coating station 412 comprises an applicator roll 470 and a support roll 420. The applicator roll 470 and the support roll 420 rotate in opposite directions in such a way that the speeds of the circumferences 420a and 470a of the support roll 420 and the applicator roll 470 respectively, as well as of the web 416 are equal. Onto the side 416a of the web 416 a liquid coating 428 is indirectly applied by means of a coating unit 426 via the circumference 470a of the applicator roll 470. The coating takes place at the pressing nip 476 which lies in the plane comprising the two parallel turning axes 424 and 474 of the applicator and support roll respectively. The web 416 leaves the coating station 412-viewed in the web's moving direction - after the pressing nip 476 as has already been explained with respect to Fig. 3. After having passed the point 436, the web 416 travels in one plane to at least to the point 452 at which the web 416 enters the non-contact turning apparatus 414. In contrast to the last-described turning apparatus the turning apparatus 414 does not comprise a combined drying and turning unit at the concave side facing the web 416a but an individual drying unit 442 on the entering side as well as a turning unit 444 followed by a drying unit 446 on the exit side (viewed in the web's moving direction). In addition, the second drying unit 466 on the entering side as well as the drying unit 480 on the web's convex entering side located in the second housing part 438b facing the convex side of the web 416 are shorter than those described in Fig. 4. This is due to the fact that the side 416b of the web 416 - to which the drying units on the web's convex side are allocated - is not coated with the result that the web does not have to be directly dried. The drying units 466 and 480 on the web's convex side rather serve the purpose of stabilizing the web and, in addition, of indirectly drying the coating applied onto the side 416a of the web. The web 416 leaves the non-contact drying apparatus 414 in the direction of the arrow 418'.

[0078] In Fig. 6 the same components as in Fig. 5 are marked with the same reference numbers, however, increased by 100. Fig. 6 is only described insofar as it differs from the description of Fig. 1 - 5. For the other components, it is explicitly referred to the descriptions of Fig. 1 - 5.

[0079] In Fig. 6 the web 516 enters the coating station 512 from diagonally below in the direction of the arrow 518. A coating 556 and 528 is indirectly applied onto the web 516 via two applicator rolls 520 and 570 by coating stations 554 and 526 respectively. The rotations of the

applicator roll 520 in the direction of the arrow 522, of the applicator roll 570 in the direction of the arrow 572 as well as the path of the web 516 are coordinated in such a way that there is no relative movement between the circumferences 520a and 570a and between the circumferences and the web 516. The coatings 528 and 556 are applied onto the web 516, to be more precise onto both sides 516a and 516b of the web 516 at the pressing nip 556. At the point 536 the web leaves the coating station 512 and travels in one plane until it enters the non-contact turning apparatus 514 at the point 552. The turning apparatus 514 essentially corresponds to the turning apparatus 214 of Fig. 3, however, the non-contact turning apparatus 514 comprises at least on the convex side of the turn a housing 538 in which a drying unit 568 is arranged. In contrast to the turning apparatus 214 of Fig. 3 the turning apparatus 514 of Fig. 6 does not comprise stabilizing units. Neither the turning units 544 and 564 arranged at the web's concave side nor the drying unit 562 are located in a further housing. They comprise a gas suction hood each. All the turning units 544 and 564 as well as all the drying units 562 and 568 of the turning apparatus 514 are run with air. This is examplarily shown by two gas distributors 548 in broken lines.

[0080] The web 516 leaves the non-contact turning apparatus 514 in the direction of the arrow 518', i.e. vertically downwards.

[0081] In Fig. 7 the same components as in Fig. 6 are marked with the same reference numbers, however, increased by 100. Fig. 7 is only described insofar as it differs from the description of Fig. 1 - 6. For the other components, it is explicitly referred to the descriptions of Fig. 1 - 6.

[0082] In Fig. 7 a web 616 enters the coating station 612 in the direction of the arrow 618. The web 616 travels around a support roll 620 rotating around its turning axis 624 in the direction of the arrow 622 without any slip. A coating 628 is thereby applied onto the side 616a of the web 616 facing away from the support roll 620 by means of a coating unit 626. At the point 636 the web 616 separates from the outer circumference 620a of the support roll 620 and leaves the coating station 612 in a vertically downward direction. The web 616 moves in one plane from point 636 to a point 652 at which it enters the non-contact turning apparatus 614.

[0083] The turning apparatus 614 which turns the web 616 by 180° in total - this is done in two steps of 90° each - comprises on the web's concave side and in the web's moving direction a turning unit 644 on the entering side, a drying unit 662 on the web's concave side and a turning unit 664 on the exit side. The convex side is merely covered by one housing 638 serving the purpose of preventing humid or solvent-containing gases or vapours from escaping into the machine hall. The turning units 644 and 664 as well as the drying unit 662 are run with air which is warmer than the ambient air of the machine hall.

[0084] The embodiment of a coating apparatus 610 as shown in Fig. 7 is chosen if, for example, an already existing paper processing machine is to be equipped with a coating apparatus of the present invention and if there is no construction space available above the coating station.

[0085] In Fig. 8 the same components as in Fig. 7 are marked with the same reference numbers, however, increased by 100. Fig. 8 is only described insofar as it differs from the description of Fig. 1 - 7. For the other components, it is explicitly referred to the descriptions of Fig. 1 - 7.

[0086] Fig. 8 also shows a coating apparatus 710 where the web 716 leaves the coating station 712 at point 736 in a vertically downward direction. A coating 728 is applied onto the side 716a of the web 716 facing away from the combined applicator and support roll 720 by means of a coating unit 726 via the applicator roll 770. A coating 756 is indirectly applied onto the other side 716b by means of a coating unit 754 via the applicator roll 720. In the web's moving direction a misting in the form of coating particles 758 occurs in the wedge behind the point 736 and between the two rolls and the web. These coating particles 758 endanger the desired coating quality since they fall down due to gravity and may land on the web 716. If desired, a suction hood can be mounted on both sides of the web 716 near the point 736 removing coating particles 758 before they land on the web.

[0087] The web 716 travels in one plane from the point 736 to the point 752 at which the web 716 enters the non-contact turning apparatus 714. In the non-contact turning apparatus the web 716 is turned by 90° in the machine running direction R. For this purpose a turning unit 744 run with air is arranged on the concave side of the web 716 followed by an infra-red drying unit 746. Opposite the turning unit 744, i.e. on the convex side of the web 716, there is a stabilizing unit 750 also run with air and an infra-red drying unit 780 on the web's convex exit side following thereafter. The turning unit 744, the stabilizing unit 750 as well as the infra-red drying units 746 and 780 are not covered by further housings or protective covers. The gas suction hoods allocated to the respective components are sufficient to suck off humid or/and solvent-containing exhaust gas or exhaust air. The web 716 leaves the non-contact turning apparatus 714 in the direction of the arrow 718'.

[0088] Fig. 9 is a schematic cross-sectional view along a section IX-IX in Fig. 1, wherein the depiction of the gas suction hoods of the turning unit 44 and the stabilizing unit 50 is omitted. Fig. 9 shows an arrangement of gas distributors of the prior art through which gas flows towards a double-coated web. Since the arrangement of the gas distributors is axially symmetric only the upper gas distributor 48 will be described in the following.

[0089] The web 16 in Fig. 9 is seen in cross-sectional view, wherein the moving direction of the web is indicat-

ed by the arrow L. which extends perpendicularly to the drawing plane towards the viewer. The elongated gas distributor 48 extends parallel to and essentially over the entire width of the web 16. The gas distributor 48 exhibits a gas intake 84 on one side. From this gas intake gas, e.g. air, flows into the inside of the gas distributor and is discharged by a gas exhaust 86 which is located at a gas exhaust section 48a of the gas distributor 48. The gas exhaust section 48a is a wall section of the gas distributor 48 parallel to and facing the moving web 16. The gas intake section 48b of the gas distributor 48 of the prior art is formed by a wall section of a side wall. The gas distributor's height decreases from the gas intake section 48b to the end section 48c of the gas distributor 48 opposing the gas intake section 48b in longitudinal direction of the gas distributor in order to try to keep the amount of gas flowing out of the gas exhaust section 48a constant along the gas distributor. The gas flowing towards the web 16 is indicated by arrows 88. The gas flow occurring inside the gas distributor towards the gas exhaust 86 is indicated by arrows 90 in great simplification.

[0090] Fig. 10 is a schematic cross-sectional view of a section along the line X-X in Fig. 3. Fig. 10 shows an arrangement with improved gas distributors 248.

[0091] In Fig. 10 the same components as in Fig. 9 are marked with the same reference numbers, however, increased by 100. In the following only the upper gas distributor of the gas distributors 248 shown in Fig. 9 will be described. Its description also applies to the lower gas distributor 248.

[0092] The gas distributor 248 is essentially formed of an elongated, hollow parallelepiped body 292 which extends in its longitudinal direction over the entire width of the web 216. The hollow body 292 exhibits a gas exhaust 286 on its bottom side facing the web 216. The bottom side is thus the gas exhaust section 248a. In the upper side 248d opposite the gas exhaust section of the gas distributor 248 in the area of its longitudinal center there is a gas intake 284. Inside the gas distributor 248 there is a breaker plate 294 parallel to the gas exhaust section 248a spaced apart below the gas intake in the longitudinal center of the gas distributor. This breaker plate 294 avoids a short circuit of the gas exhaust nozzles arranged in direct prolongation to the gas intake 284 with the gas intake 284. The gas inside the gas distributor 284 has to flow around the breaker plate 294 as indicated by the arrows 290 on the left side of the gas distributor 284. Thus, a harmonized gas exhaust flow 288 along the gas distributor's length is achieved. The breaker plate can also have the form of an arrow as indicated by the breaker plate 294' of the lower gas distributor 248. The breaker plate inside the gas distributor could as well be omitted.

[0093] The advantage of this gas distributor compared with the gas distributor of the prior art shown in Fig. 9 is its reduced construction height. Assuming that the height of the end section 248c is determined by the amount of gas flowing out of this end section 248c, the height of the gas distributor of the prior art would increase linearly in the gas distributor's longitudinal direction starting from the end section 248c to the opposite end section 248b. An outline of a conventional gas distributor of the same length is indicated in Fig. 10 by a broken line.

[0094] Fig. 11 shows an arrangement of gas distributors 448 which are used in the drying units 442 and 466 of Fig. 5. The same components as in Fig. 10 are marked with the same reference numbers, however, increased by 200. As in Fig. 9 and 10, in Fig. 11 only the upper gas distributor 448 is described and only insofar as it differs from the gas distributor 248 shown in Fig. 10.

[0095] The gas distributor 448 is designed in such a way that its height or rather the height of the inner flow-relevant cross-section of its gas intake 484 near the longitudinal center of the gas distributor 448 decreases towards its end sections 448b and 448c. The decrease of the height of the flow-relevant cross-section at any given longitudinal position corresponds to the amount of gas discharged from the gas distributor 448 at this longitudinal position. This means that per path increment from this longitudinal position towards the next longitudinal end 448b or 448c, the height of the gas distributor 448 decreases proportionally to the amount of gas exhausted along the path increment. Assuming, as in Fig. 10, that the cross-section area of the end section 448c of the gas distributor 448 is proportional to the amount of gas flowing out of the end section 448c and thus has accordingly a fixed height, an equally working gas distributor of the prior art would result whose outline is shown in broken lines in Fig. 11. One can see that the gas distributor 448 shown in Fig. 11 has an essentially lower construction height than an equally working gas distributor of the prior art, thus saving construction space.

[0096] The gas flow inside the gas distributor 448 is indicated by arrows 490. In addition, the gas distributor 448 can be provided with a breaker plate 494 as shown in the lower gas distributor in Fig. 11.

[0097] Fig. 12 - 15 show embodiments of drying units or turning units as can be used in coating apparatuses of the present invention.

[0098] Fig. 12 shows a schematic cross-sectional view through the drying units 262 and 268 along the line XII-XII of Fig. 3. In the following only the upper drying unit 268 will be described since the construction of the lower drying unit 262 is a mirror image of and hence corresponds to the upper drying unit 268. The mirror image referrs to a reflection at the wet 216's plane.

[0099] The drying unit 268 exhibits a gas suction hood 294 in which a plurality of gas distributors 248 are arranged parallel to each other in longitudinal direction. The end sections 248b and 248c of the gas distributors are in contact with the inside of the gas suction hood 294. Via this contact the gas distributors 248 are attached via this contact to the gas suction hood 294 by

means of, e.g. welding, screwing, riveting or glueing. A gas supply line 296 is introduced to the inside of the drying unit 268 through an opening 295 in the gas suction hood 294. A plurality of distribution lines lead from the gas supply line to the gas distributors 248, supplying the gas distributors with gas. Gas flows along the solid-line arrows via the gas supply line 296 through the gas distribution lines 298 to the gas distributors 248. From there the gas flows from the gas exhaust section 248a and hits the web surface as indicated by arrows 288. There it absorbs humidity in form of water and/or solvent and is sucked off by means of a gas exhaust opening 299 (not shown in Fig. 12) along the dotted-line arrows. The gas exhaust opening 299 is on the level of the gas supply line 296, however, behind Fig. 12's drawing plane. In Fig. 12 - 15 the solid-line arrows generally indicate drying air blown onto the web 216 and the dotted-line arrows indicate the humid and/or solvent-containing exhaust air sucked off the web's surface.

[0100] In Fig. 13 the gas exhaust opening 299 can be seen more clearly. Fig. 13 is a section through the drying units 262 and 268a along the line XIII-XIII of Fig. 12. In Fig. 13 the gas exhaust opening 299 which is attached to a gas exhaust line (not shown) is shown on the right side next to the cross-section of the gas supply line. In Fig. 13 it can also be seen that the gas distributors 248 which are parallel to each other with respect to their longitudinal directions are spaced apart in the moving direction L of the web 216 such that humid and/or solvent-containing exhaust gas or exhaust air can be sucked off from the spaces 202 formed by this arrangement. Further, the first and last gas distributors 248 with respect to the web's moving direction L are spaced apart from the wall of the gas suction hood 294 in order to create more spaces through which the exhaust gas or exhaust air can be sucked off the web's surface.

[0101] In Fig. 13 it can further be seen that the gas distributors of the drying unit 268 and the gas distributors of the drying unit 262 are arranged in pairs opposite to each other at the same respective longitudinal positions in the moving direction L of the web 216. A stable air cushion is thereby formed above and underneath the web 216 which hardly affects the web 216 mechanically since the forces of the air flow compensate each other mutually.

[0102] Fig. 14 shows an alternative arrangement of gas distributors in the upper and lower drying unit. The only difference to the gas distributors of Fig. 13 is that the gas distributors 248' of the drying unit 268' of Fig. 14 are arranged opposite to each other on different sides of the web 216', however, alternatingly in the moving direction L' of the web 216'. That means that a fix point of the web 216' traveling through the drying units 262' and 268' is affected by drying air on both sides by the gas distributors 248' of the drying unit 268' and of the drying unit 262' alternatingly.

[0103] In this arrangement of gas distributors the flow forces from the gas distributors 248' of the different sides of the web 216' do no longer compensate each other such that the web 216' forms waves which enlarge the surface of the web 216' to be dried by the drying units 262' and 268'. The drying performance of the drying units is thus increased.

[0104] Fig. 15 is a longitudinal section of the drying units 562 and 568 shown in Fig. 6 corresponding to the Fig. 13 and 14. Fig. 15 shows an alternative embodiment of a drying unit. In Fig. 15 the same components as in Fig. 13 are marked with the same reference numbers, however, increased by 100. Since the drying units are symmetric, only the upper drying unit 568 will be described. Its description also applies to the lower drying unit 562. In the following Fig. 15 is only described insofar as it differs from Fig. 13. It is herewith explicitly referred to its description.

[0105] Two groups 591 and 593 of gas distributors 548 are contained in the gas suction hood 594. A gas supply line 596 with corresponding distribution lines as well as a gas exhaust opening 599 are each allocated to a group 591, 593 of gas distributors 548 each. This way also long drying and/or turning units with long radii can be realized and it can be guaranteed that all the gas distributors are supplied with sufficient drying gas. Between the groups 591, 593 there is a vertical perforated plate 504 running across the entire cross-sectional area of the gas suction hood 594 allocating one gas room for sucking off exhaust gas to each gas exhaust opening 599 by means of providing an increased flow resistance between the two groups 591, 593. Providing a perforated plate instead of a solid partition has the result that - in case of a total breakdown of one of the two gas exhaust lines connected to the gas exhaust openings 599 - the negative pressure present in the gas room of the still working gas exhaust opening can expand to the gas room of the broken-down gas exhaust opening, thus guaranteeing that the apparatus works even in cases of the aforementioned malfunctions. In addition, a flow equalizing means in the form of a perforated plate 506 is provided between the spaces 502 between the gas distributors 548 and between the spaces between one wall of the gas suction hood 594 and a gas distributor 548 in order to homogenize the sucking off of humid or/and solvent-containing exhaust gas from the surface of the web 516 over the length of the drying unit 568.

Claims

1. Apparatus for coating a moving web (16), in particular of paper or carton, on one or both sides with a liquid or pastous coating material (28) comprising:

   - a coating station (12) for applying the coating material (28) onto said web (16), as well as
   - a non-contact turning apparatus (14) following said coating station (12) in the moving direction of said web (16),

characterized in that
said web moves in one plane only between the point at which it is leaving (36) said coating station (12) and the point at which it is entering (52) said non-contact turning apparatus (14) without changing direction. (Fig. 1-8)

2. Coating apparatus according to claim 1,
characterized in that
said web (16) leaves said coating station (12) in an upward direction, in particular in an essentially vertical direction. (Fig. 1-6)

3. Coating apparatus according to claim 1,
characterized in that
said web (616) leaves said coating station (612) in a downward direction. (Fig. 7 and 8)

4. Coating apparatus according to one of the claims 1 - 3,
characterized in that
said non-contact turning apparatus (14) turns said web (16) by approximately 90°. (Fig. 1, 4, 5, 8)

5. Coating apparatus according to one of the claims 1 - 3,
characterized in that
said non-contact turning apparatus (114) turns said web (116) by approximately 180°. (Fig. 2, 3, 6, 7)

6. Coating apparatus according to one of the claims 1 - 5,
characterized in that
the first turning of said web effected in said non-contact turning apparatus (14) takes place in the machine running direction (R). (Fig. 1-8)

7. Coating apparatus according to one of the claims 1 - 6,
characterized in that
said turning apparatus (14) comprises a turning unit (44) arranged at the concave side of a turning section of said web (16). (Fig. 1-8)

8. Coating apparatus according to claim 7,
characterized in that
said turning apparatus (14) comprises a stabilizing unit (50) arranged opposite said turning unit (44) on the convex side of the turning section. (Fig. 1, 2, 3, 8)

9. Coating apparatus according to one of the claims 1 - 8,
characterized in that
at least one non-contact drying unit (42 or/and 46 and 62) is arranged in front of or/and behind said turning unit (44) in the moving direction of said web (16). (Fig. 1-8)

10. Coating apparatus according to claim 9,
characterized in that
at least two non-contact drying unit (142/166, 162/168, 346/380) are arranged opposite to each other on different sides of said web (116). (Fig. 2-6, 8, 12-15)

11. Coating apparatus according to one of the claims 1 - 10,
characterized in that
at least one drying unit (42, 46) is an air-dryer. (Fig. 1, 3-7, 12-15)

12. Coating apparatus according to one of the claims 1 - 10,
characterized in that
at least one drying unit (142, 162, 166, 168) is an infra-red-dryer. (Fig. 2 and 7)

13. Coating apparatus according to one of the claims 1 - 12,
characterized in that
at least one further non-contact turning unit (164) is provided following said one non-contact turning unit (144) in the moving direction of said web (116). (Fig. 2, 3, 6, 7)

14. Coating apparatus according to one of the claims 1 - 13,
characterized in that
the at least one of said non-contact turning units (44) is run with gas which is warmer than the ambient atmosphere surrounding said web (16). (Fig. 1, 3-8, 12-15)

15. Coating apparatus according to one of the claims 1 - 14,
characterized in that
said non-contact turning unit (44) or/and said at least one further non-contact turning unit or/and said at least one non-contact drying unit (42/46) are located under one common housing (38), said housing (38) - if desired - comprising several housing parts (38a, 38b). (Fig. 1, 2, 4-7)

16. Coating apparatus according to one of the claims 1 - 15,
characterized in that
said coating station (12) comprises at least one coating unit (26) for directly applying said coating material (28) onto said web (16) or/and at least one coating unit (154) for indirectly applying the coating (156) onto said web (116). (Fig. 1-8)

17. Coating facility for coating a moving web, in particular of paper or carton, on one or both sides using at least two coating apparatuses according to the claims 1 - 16 arranged in successive sequence.

18. Gas distributor (248) for use in a non-contact turning or drying apparatus (214) for moving webs (216) comprising an elongated hollow body (292) extending in its longitudinal direction parallel to the surface of said web (216), wherein said hollow body (292) comprises a gas intake (284) and a gas exhaust (286), wherein said gas exhaust (286) is located at a wall section (248a) of said hollow body (gas exhaust section) essentially parallel to said web surface and facing said moving web (216),
characterized in that
said gas intake (284) is located at the longitudinal center of said hollow body (292). (Fig. 10-15)

19. Gas distributor according to claim 18,
characterized in that
said gas intake (284) is located at said wall section (248d) of said hollow body (292) opposite said gas exhaust section (248a). (Fig. 10-15)

20. Gas distributor according to claim 18 or 19,
characterized in that
said hollow body (292) is essentially a hollow parallelepiped body (292). (Fig. 10-15)

21. Gas distributor according to one of the claims 18 - 20,
characterized in that
said hollow body (492) is designed in such a way that the vertical clearance of the gas-flow cross-section inside said hollow body (492) decreases, preferably continuously, from a longitudinal center section comprising said gas intake (484) towards two longitudinal ends (448b, 448c). (Fig. 11)

22. Gas distributor according to one of the claims 18 - 21,
characterized in that
said hollow body (292) is symmetric with respect to its longitudinal center plane (M). (Fig. 10-15)

23. Drying and turning apparatus (262, 268) for a moving web (216), preferably for use in a coating apparatus according to one of the claims 1 - 16, comprising at least one gas distributor (248) according to one of the claims 18 - 22 essentially extending transversely to the moving direction (L) of said web (216). (Fig. 12-15)

24. Apparatus according to claim 23,
characterized in that
it (262, 268) comprises at least one gas supply line (296) supplying the at least one gas distributor (248) and at least one gas suction hood (294) which is open towards said web (216), and which is connected to at least one gas exhaust line (299) and surrounding the at least one gas distributor (248). (Fig. 12-15)

25. Apparatus according to claim 23 or 24,
characterized in that
said at least one gas distributor (248) essentially extends over the entire width of said moving web (216). (Fig. 10-15)

26. Apparatus according to claim 24 or 25,
characterized in that
below the gas suction hood (294) a plurality of gas distributors (248) are located parallel to each other and spaced apart in the moving direction (L) of said web (216). (Fig. 12-15)

27. Apparatus according to claim 26,
characterized in that
inside said gas suction hood (294) distribution lines (298) lead from said at least one gas supply line (296) to said individual gas distributors (248). (Fig. 12-15)

28. Apparatus according to claim 27,
characterized in that
said plurality of gas distributors (548) are divided into groups (591, 593), wherein each group (591, 593) is allocated a gas supply line (596) supplying said gas distributors (548) of the corresponding group (591, 593) with gas. (Fig. 15)

29. Apparatus according to claim 28,
characterized in that
a gas exhaust line (599) is allocated to each group (591, 593) which removes gas near the surface of said web in the area around each group (591, 593). (Fig. 15)

30. Apparatus according to one of the claims 18 - 24,
characterized in that
said gas suction hood (594) comprises flow equalizing means (506) for said gas flowing from said moving web (516) into said gas suction hood (594). (Fig. 15)

31. Apparatus according to claim 30,
characterized in that
said flow equalizing means (506) are located between said gas distributors (548) parallel to said web's surface. (Fig. 15)

32. Apparatus according to claim 30 or 31,
characterized in that
said flow equalizing means (506) are at least in part made of perforated plate (506). (Fig. 15)

33. Apparatus according to one of the claims 28 - 32,
characterized in that
in said gas suction room between said gas distributor groups (591, 593) flow throttle means (504) are arranged in essentially vertical direction and paral-

lel to the gas distributors (548), said flow throttle means (504) extending over at least a part, preferably over the entire cross-section of the gas suction hood (594). (Fig. 15)

34. Apparatus according to claim 33,
characterized in that
said flow throttle means (504) are made of perforated plate (504). (Fig. 15)

35. Arrangement of at least two drying and/or turning units according to one of the claims 26 - 34,
characterized in that
said at least two drying and/or turning units (262, 268) are located opposite to each other on different sides of said moving web (216), wherein at least some of said gas distributors (248) are located in pairs on both sides of said web (216) at essentially the same longitudinal positions in moving direction (L) of said web (216) opposite to each other. (Fig. 13 and 15)

36. Arrangement of at least two drying and/or turning units according to one of the claims 26 - 35,
characterized in that
said at least two drying and/or turning units (262', 268') are located opposite to each other on different sides of said moving web (216'), wherein at least some of said gas distributors (248') of one side of said web are arranged alternatingly with at least some of said gas distributors (248') of the respective other side of said web with respect to their longitudinal positions in the moving direction (L') of said web (216'). (Fig. 14)

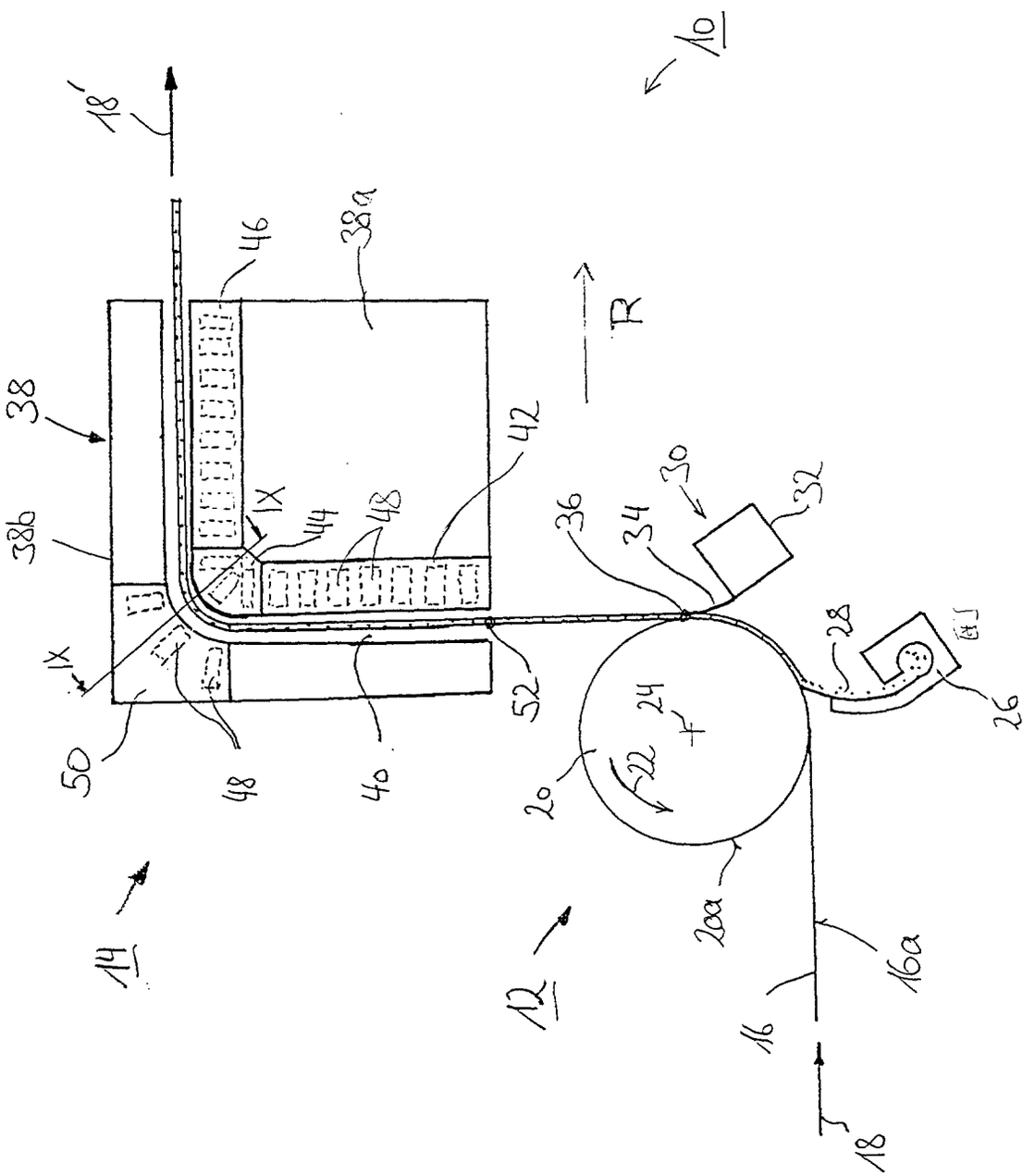
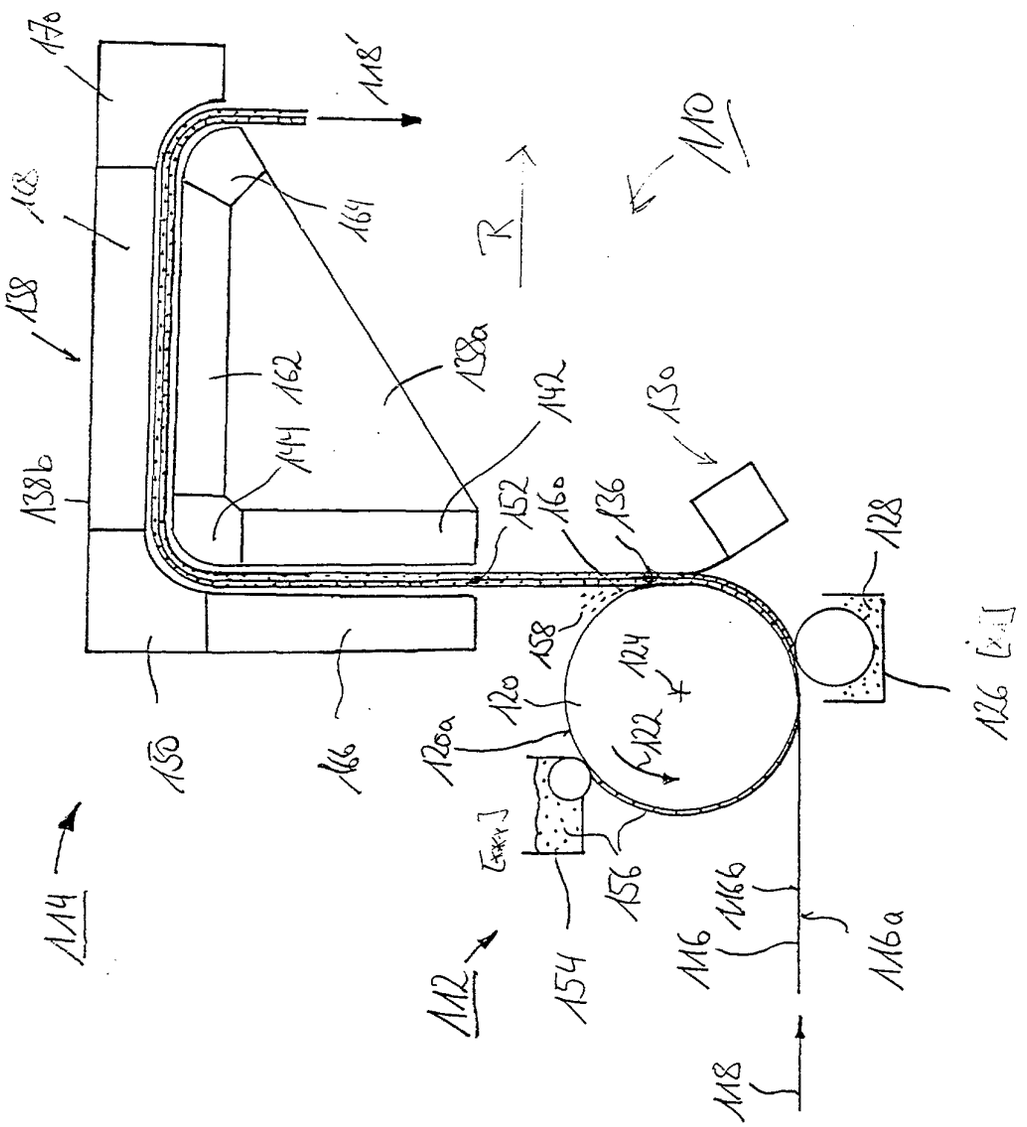

10
18'
46
38a
38
R
42
38b
IX
44
48
36
34
30
32
28
IX
52
24
26
50
48
40
22
20
20a
16a
14
12
16
18

Fig. 1


176
118'
168
138
164
R
110
162
138a
142
144
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138b
152
160
136
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122
120a
126
156
154
116
116b
116a
112
114
150
146
118

Fig. 2

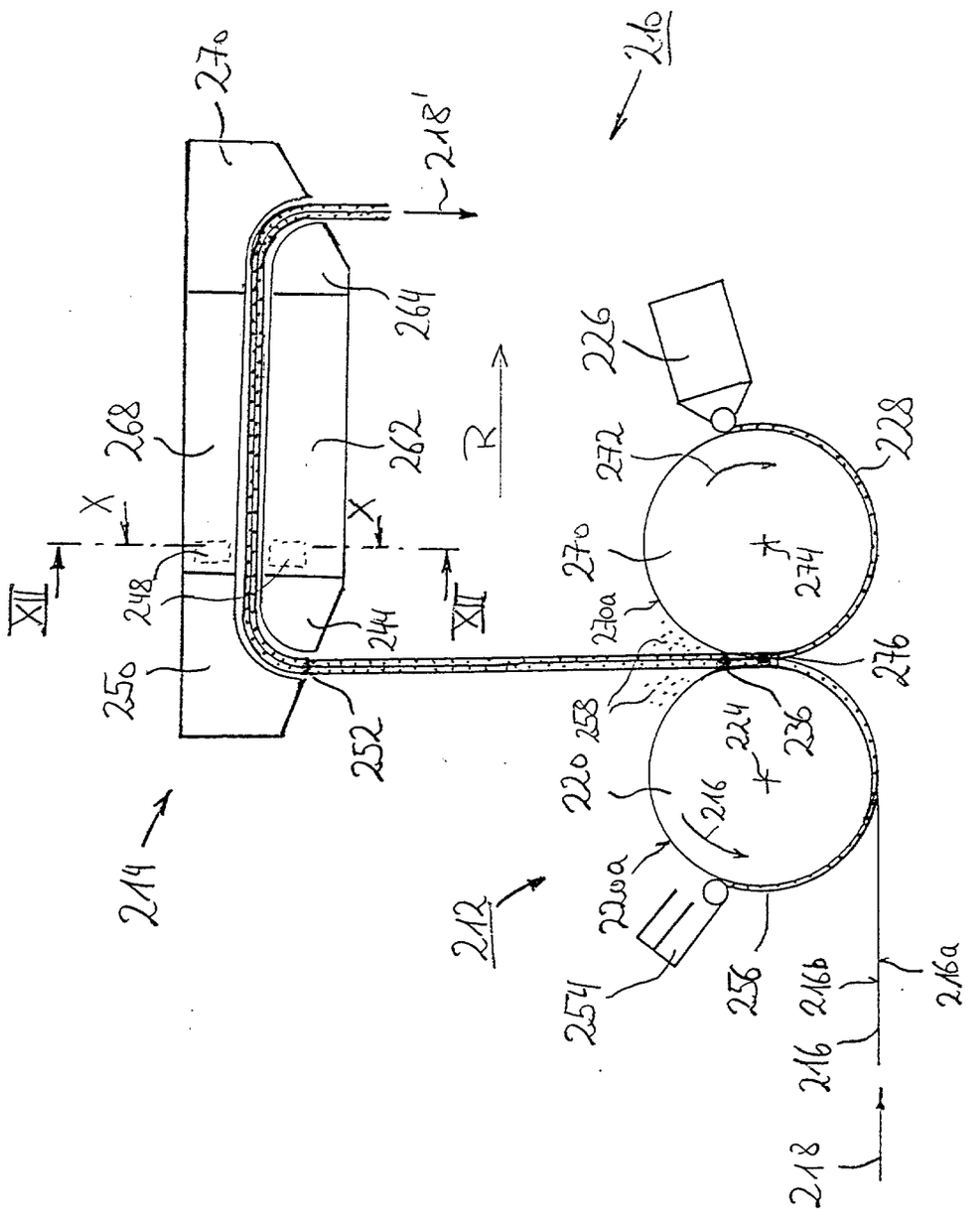
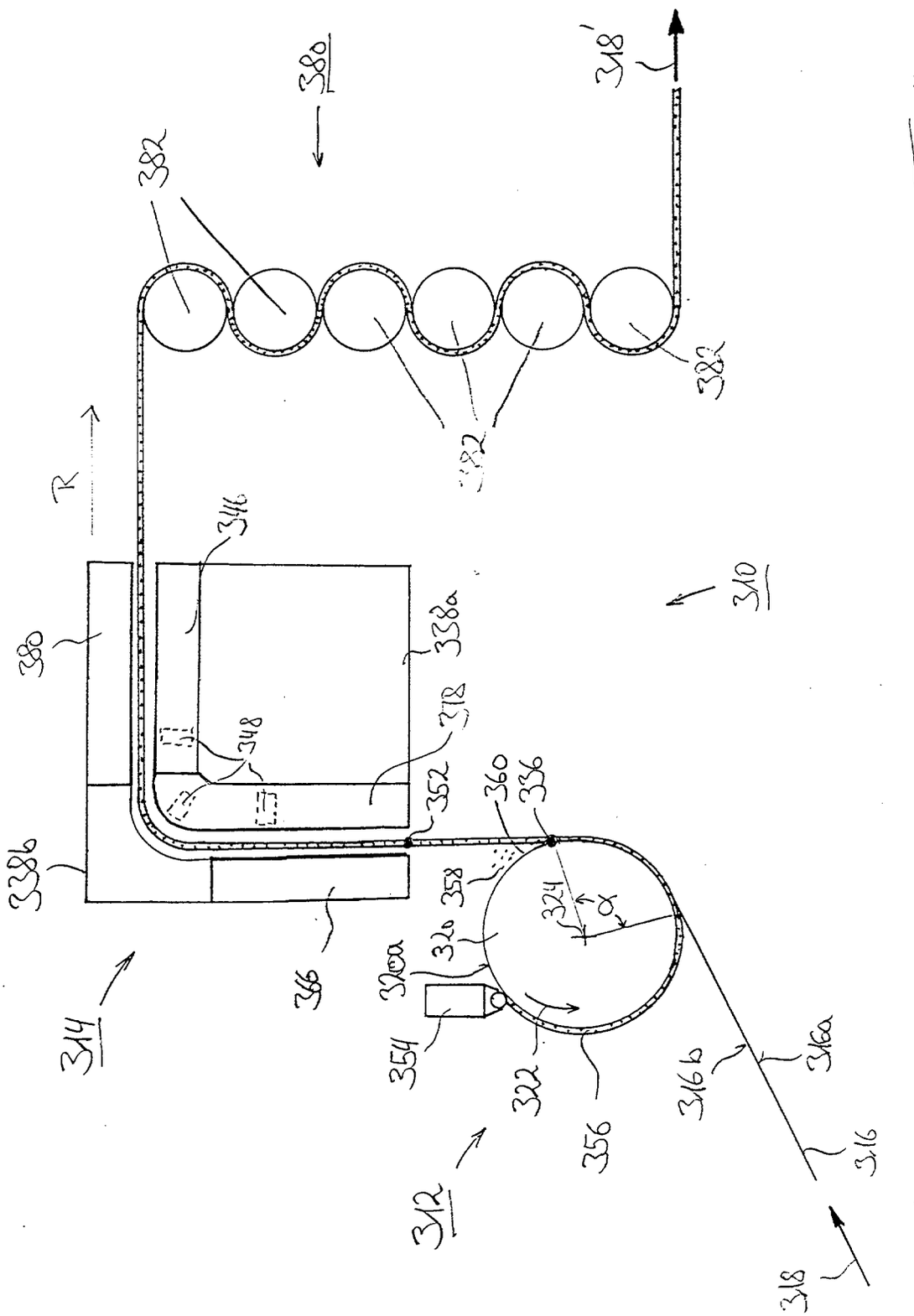

270
218'
216
264
226
268
262
R
272
228
X
X
248
270
274
XII
XII
244
230a
276
250
252
258
224
236
220
216
214
212
220a
254
256
216b
216a
216
218

Fig. 3


380
382
318'
R
346
338a
380
348
378
352
360
336
338b
358
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α
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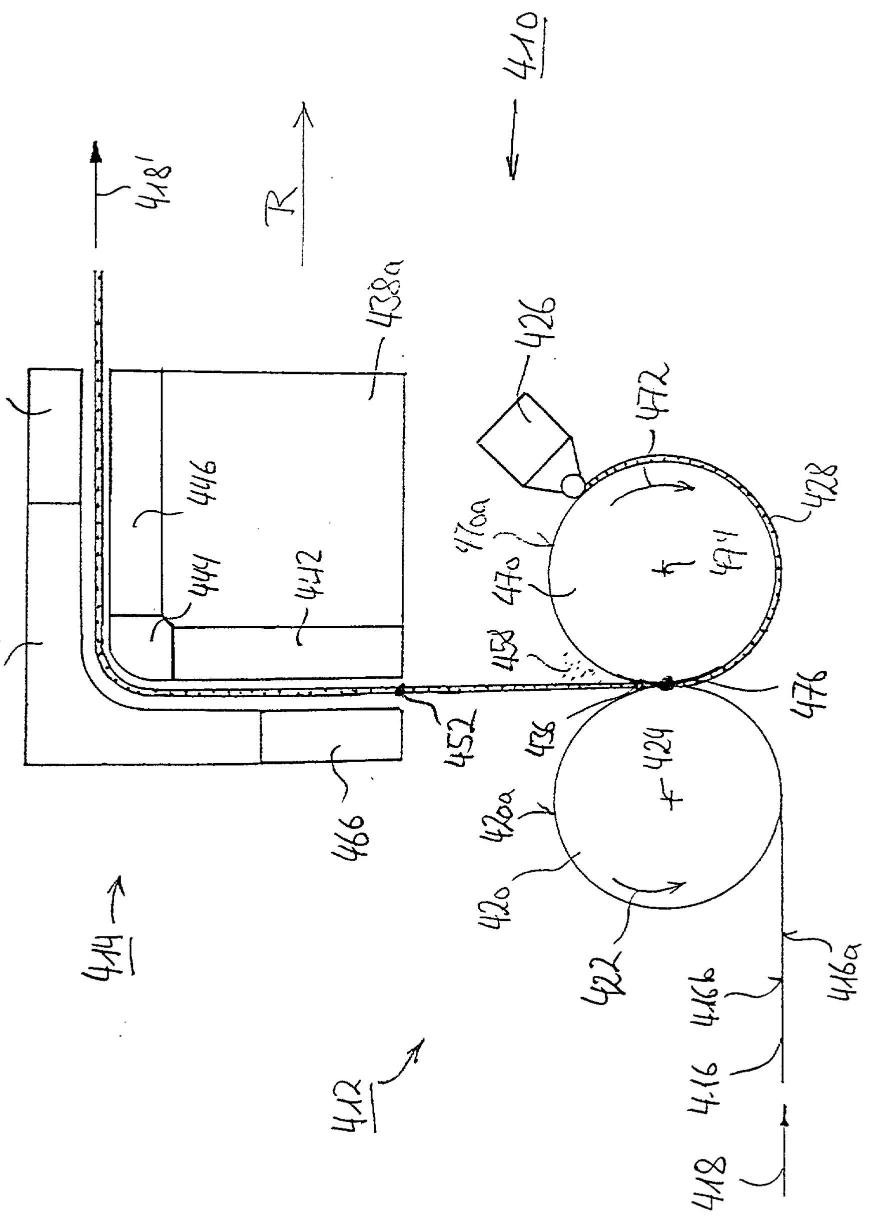
320a
354
322
356
316b
316a
316
318
310
312
314
386

Fig. 4


410
412
414
416
416a
416b
418
418'
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420a
422
424
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438b
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446
452
458
466
470
470a
472
474
476
480
R

Fig. 5

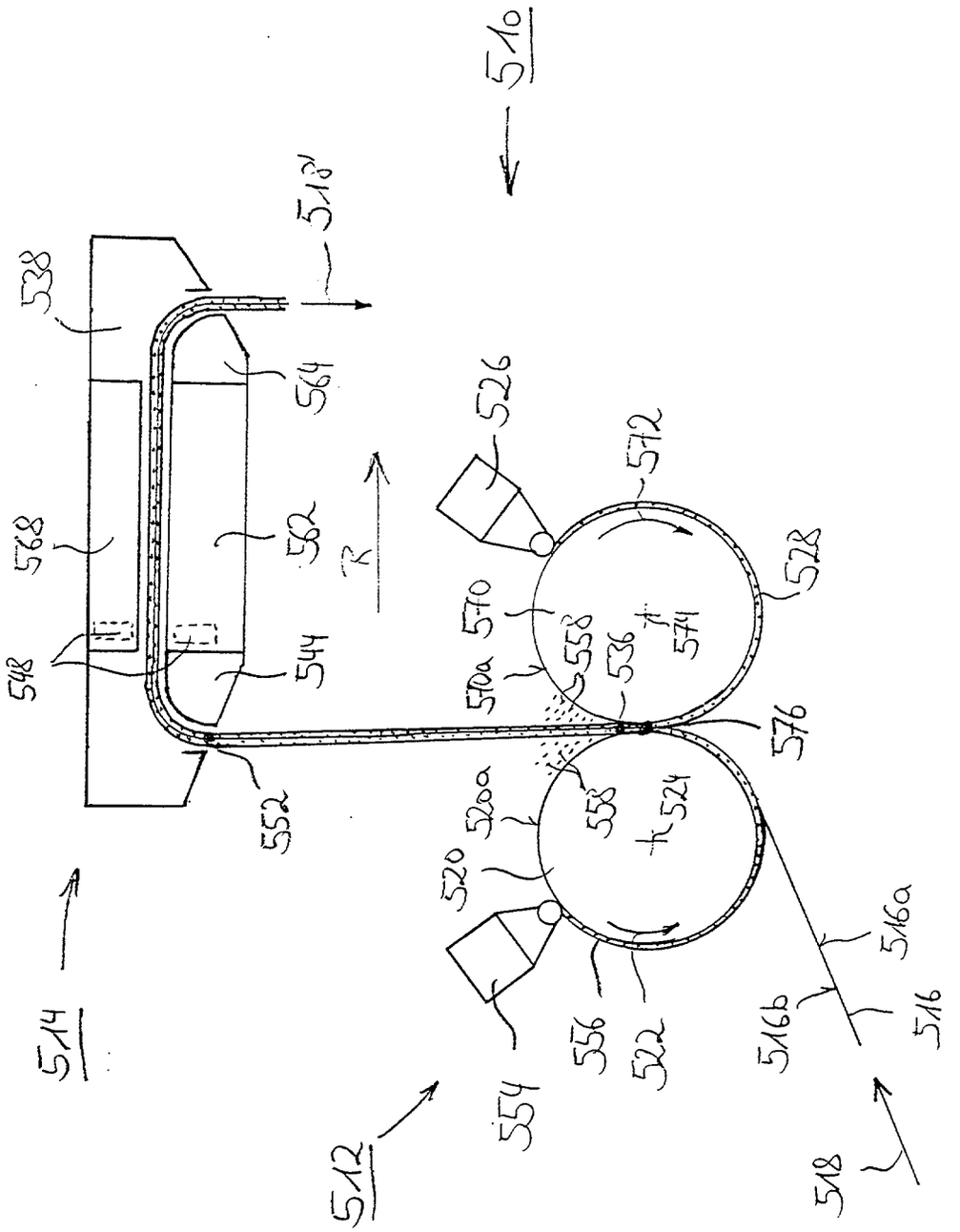

510
518'
538
564
526
572
568
562
548
544
570
570a
558
536
574
528
576
552
520a
558
524
520
556
522
554
516a
516b
516
514
512
518

Fig. 6

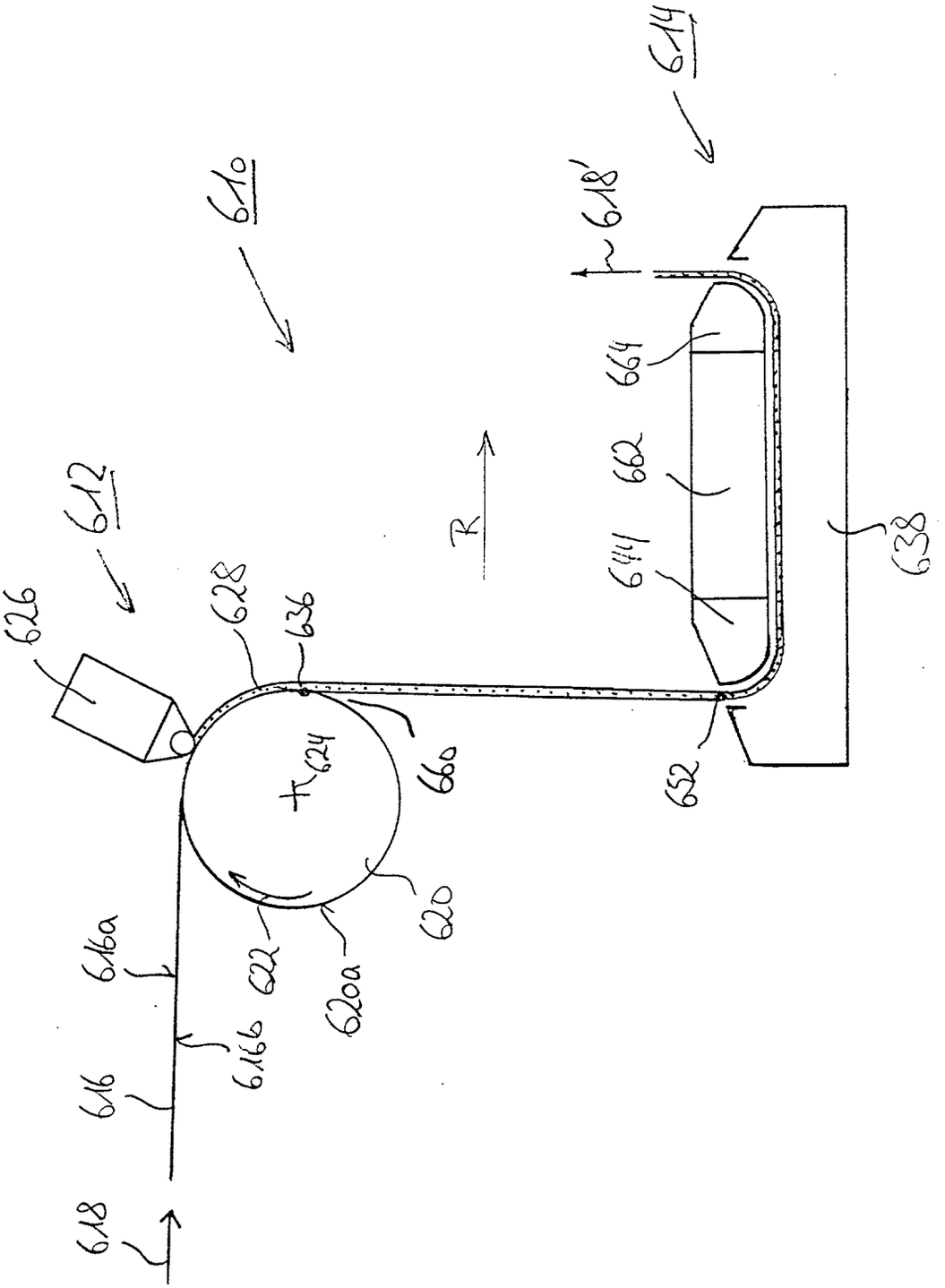
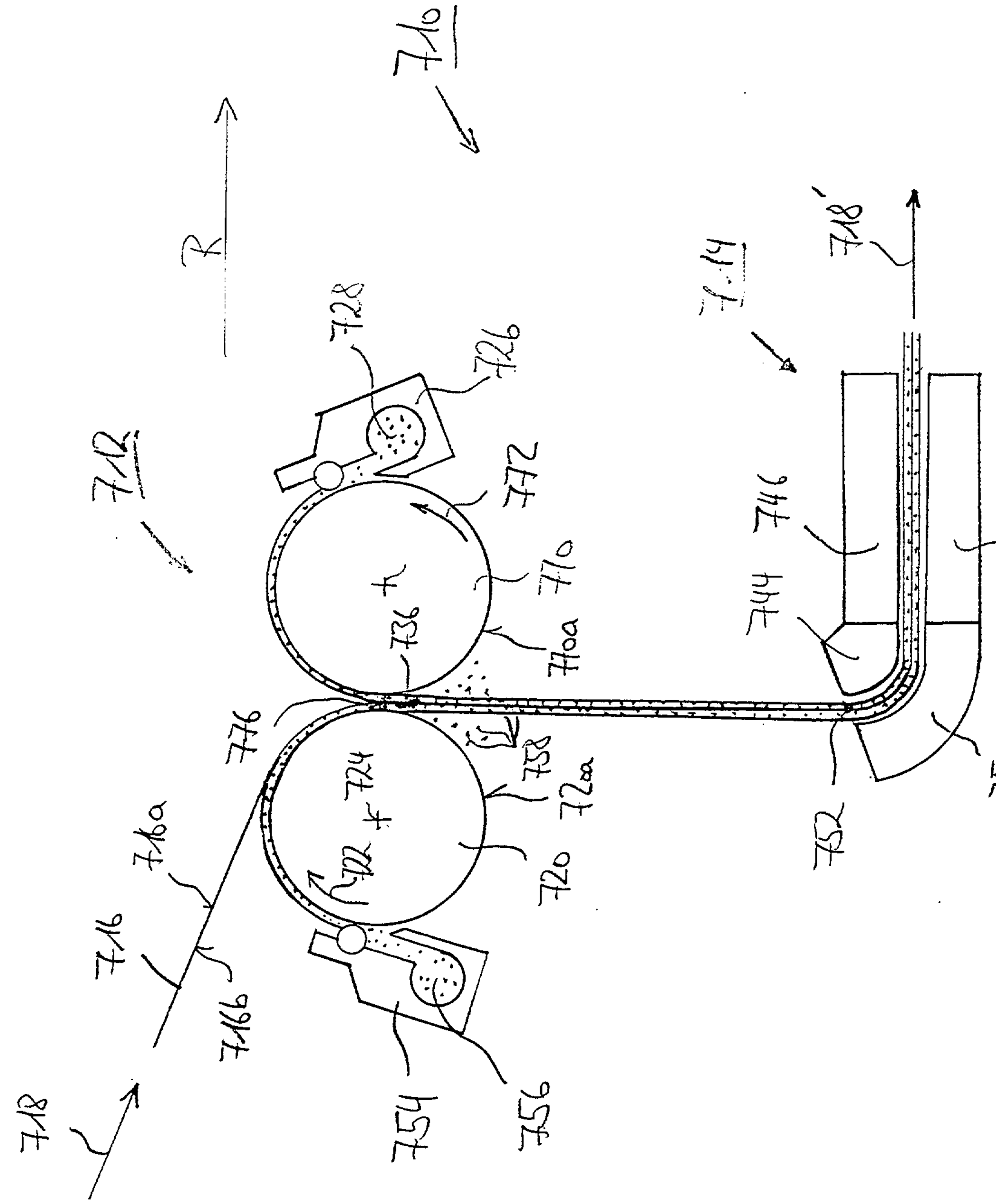
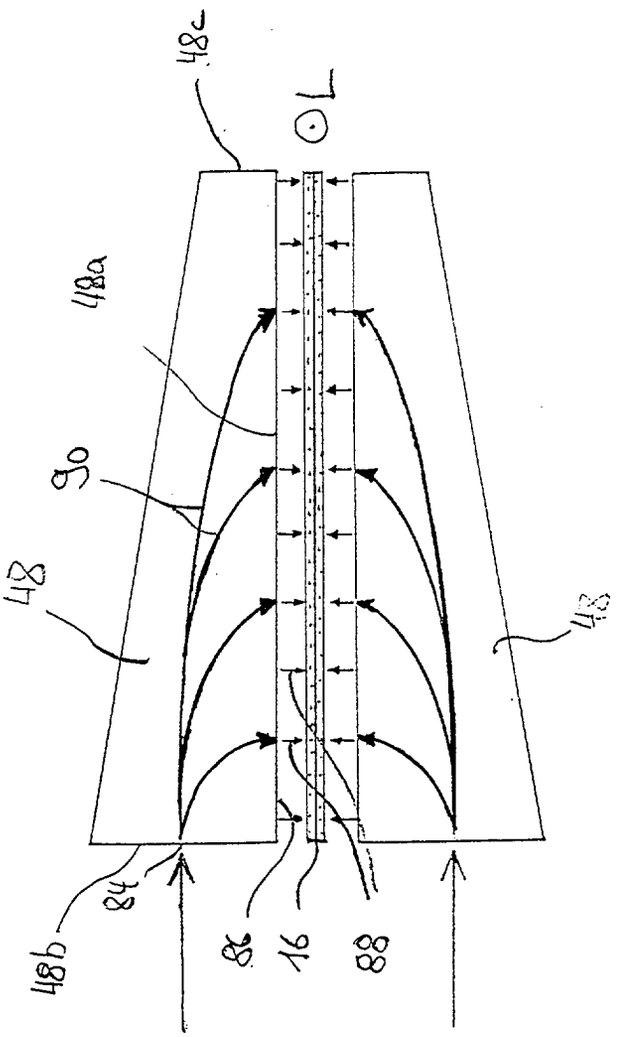

610
612
614
618'
664
662
641
638
652
660
624
620
622
620a
616a
616b
616
618
626
628
636
R

Fig. 7

Fig. 8


710
712
714
716
716a
716b
718
718'
720
722
724
726
728
736
738
744
746
750
752
754
756
770
770a
772
776
780
R



Stand der Technik

Fig. 9

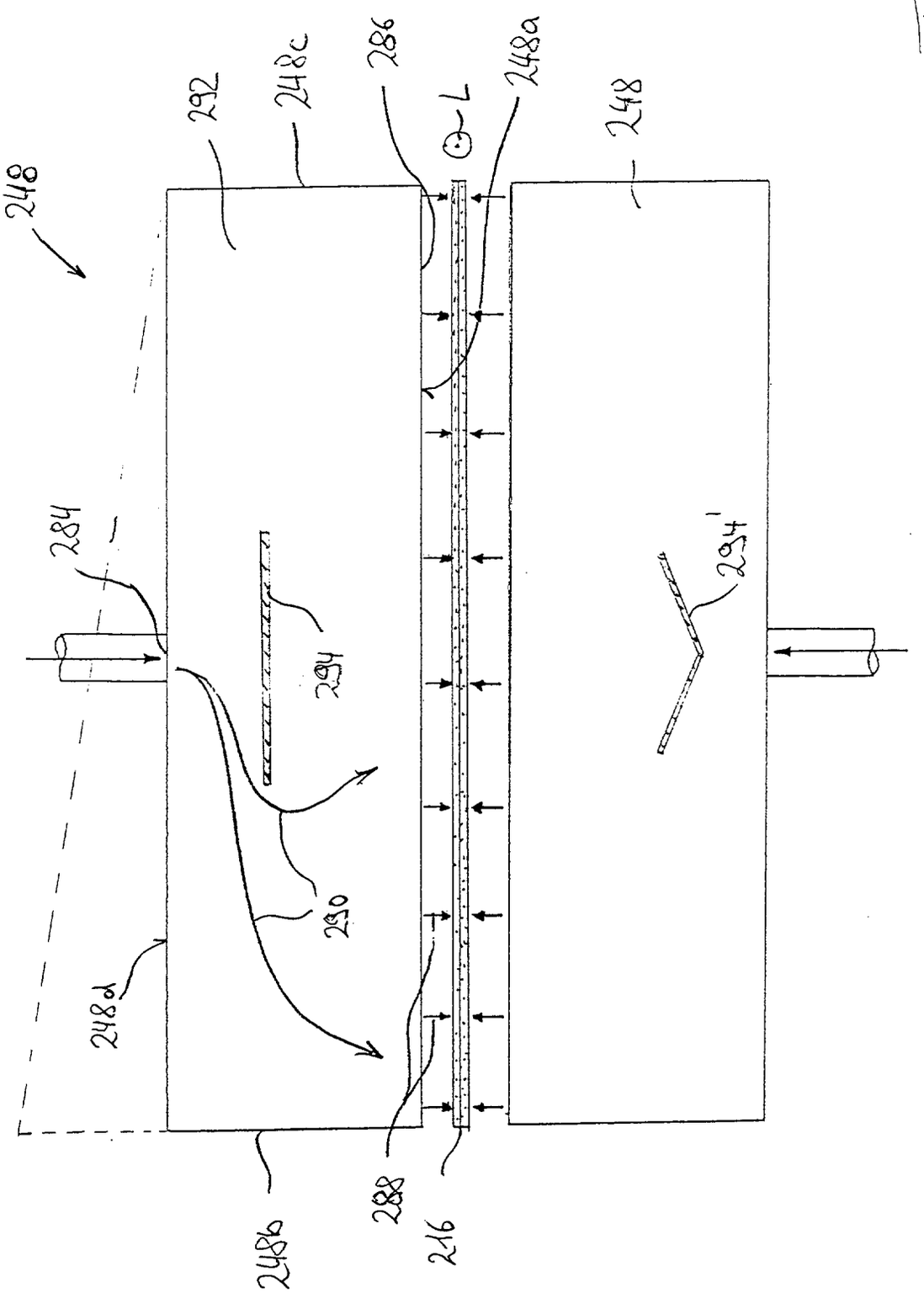


Fig. 10

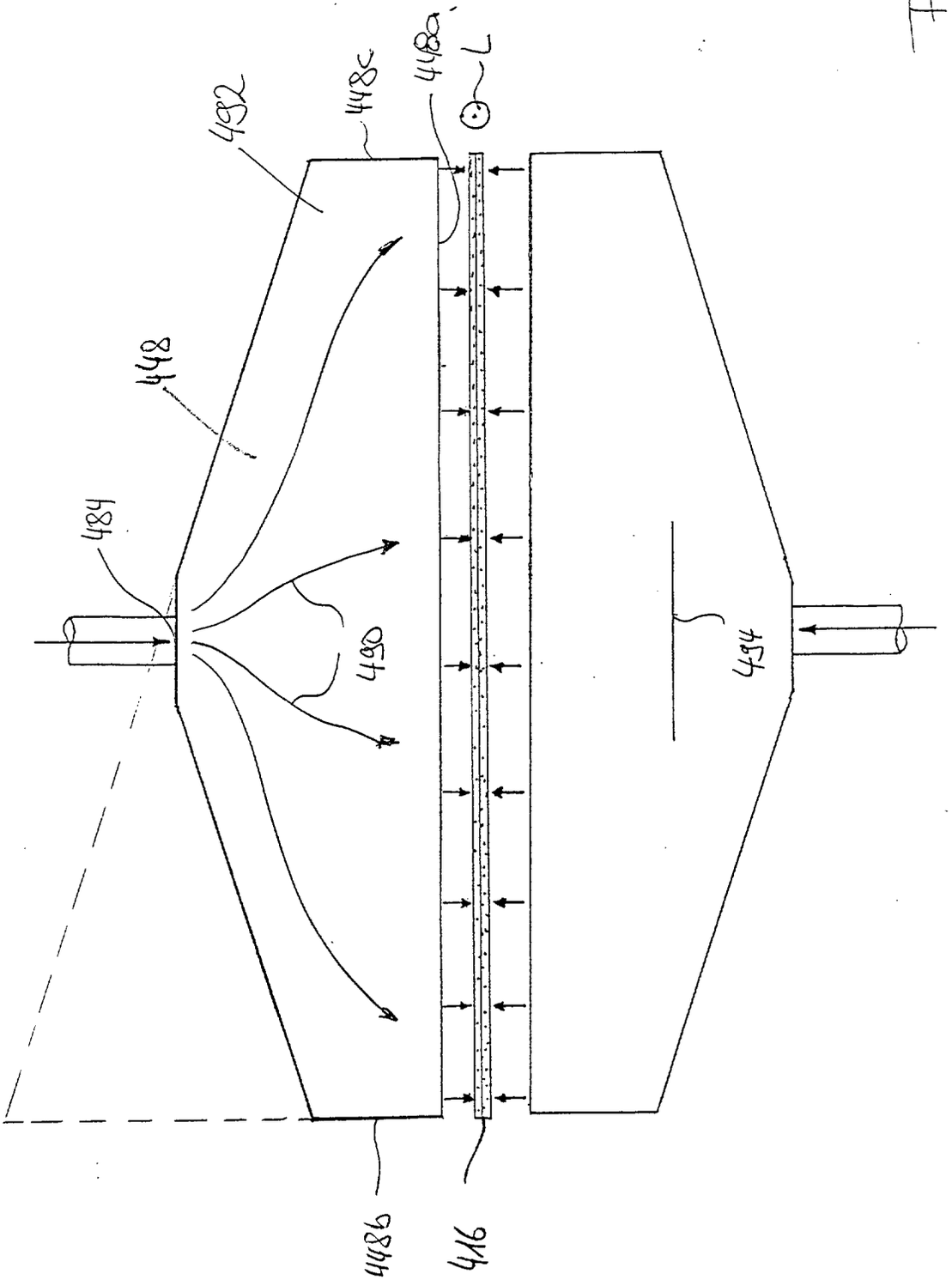


Fig. 11

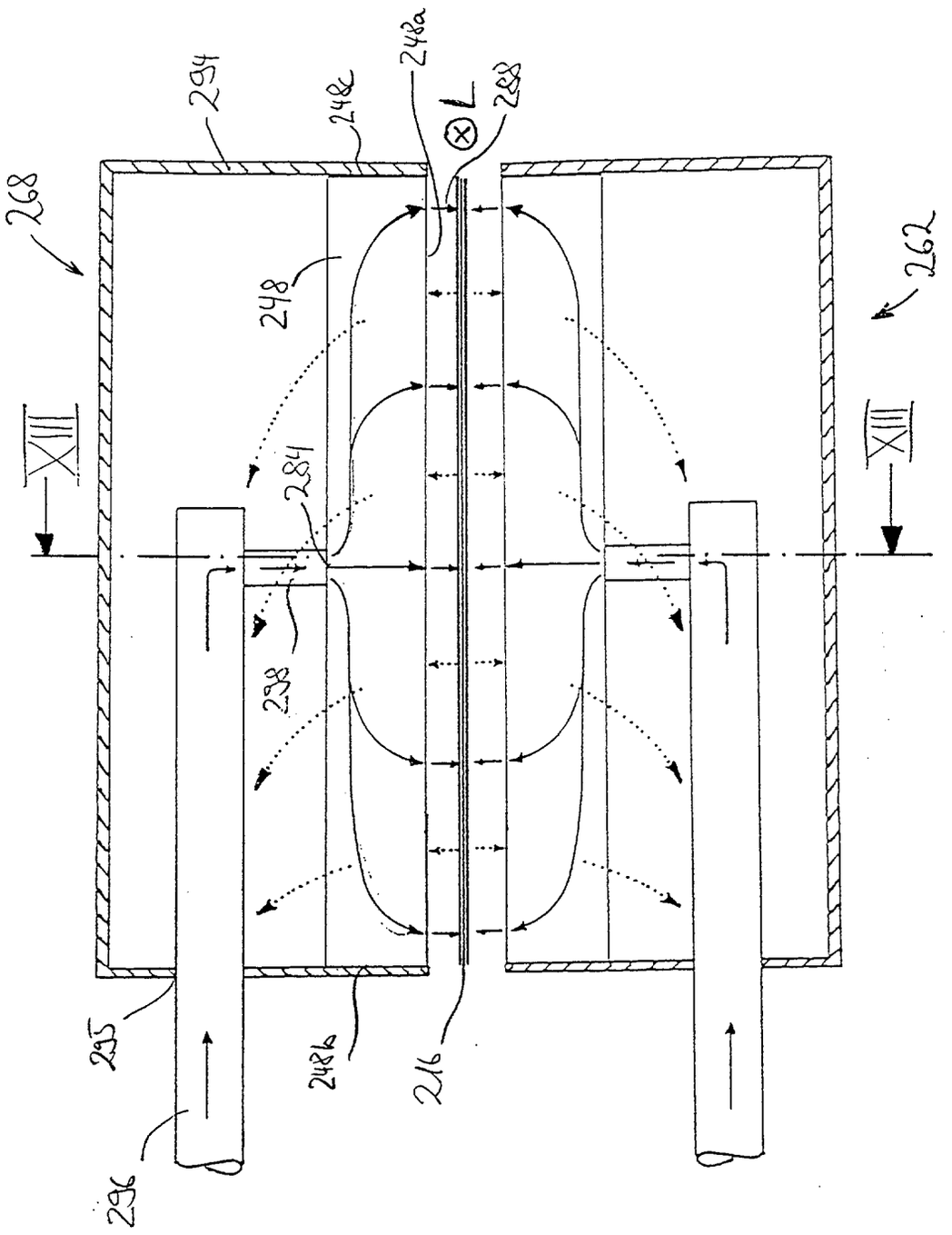

268
294
248c
248a
288
L
248
262
XIII
XIII
284
238
235
248b
216
296

Fig. 12

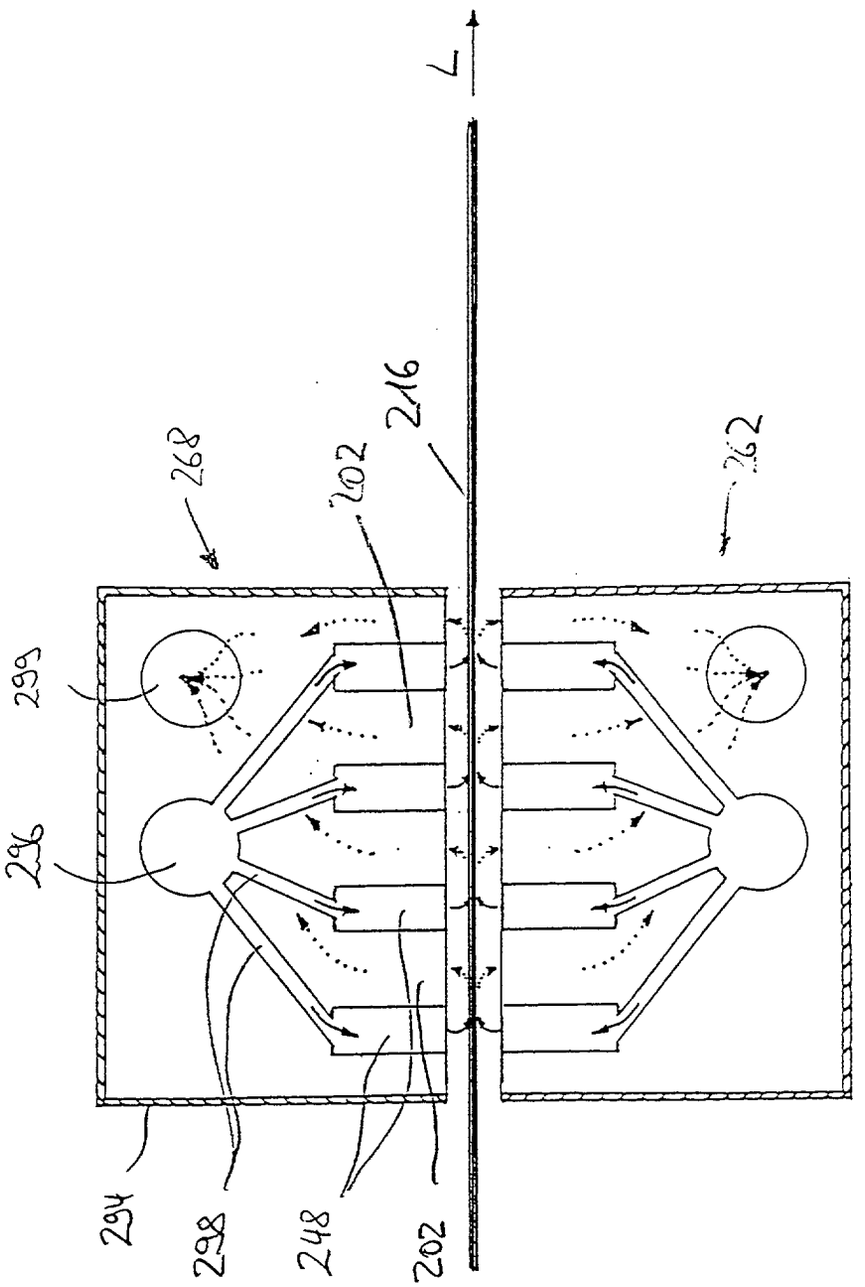


Fig. 13

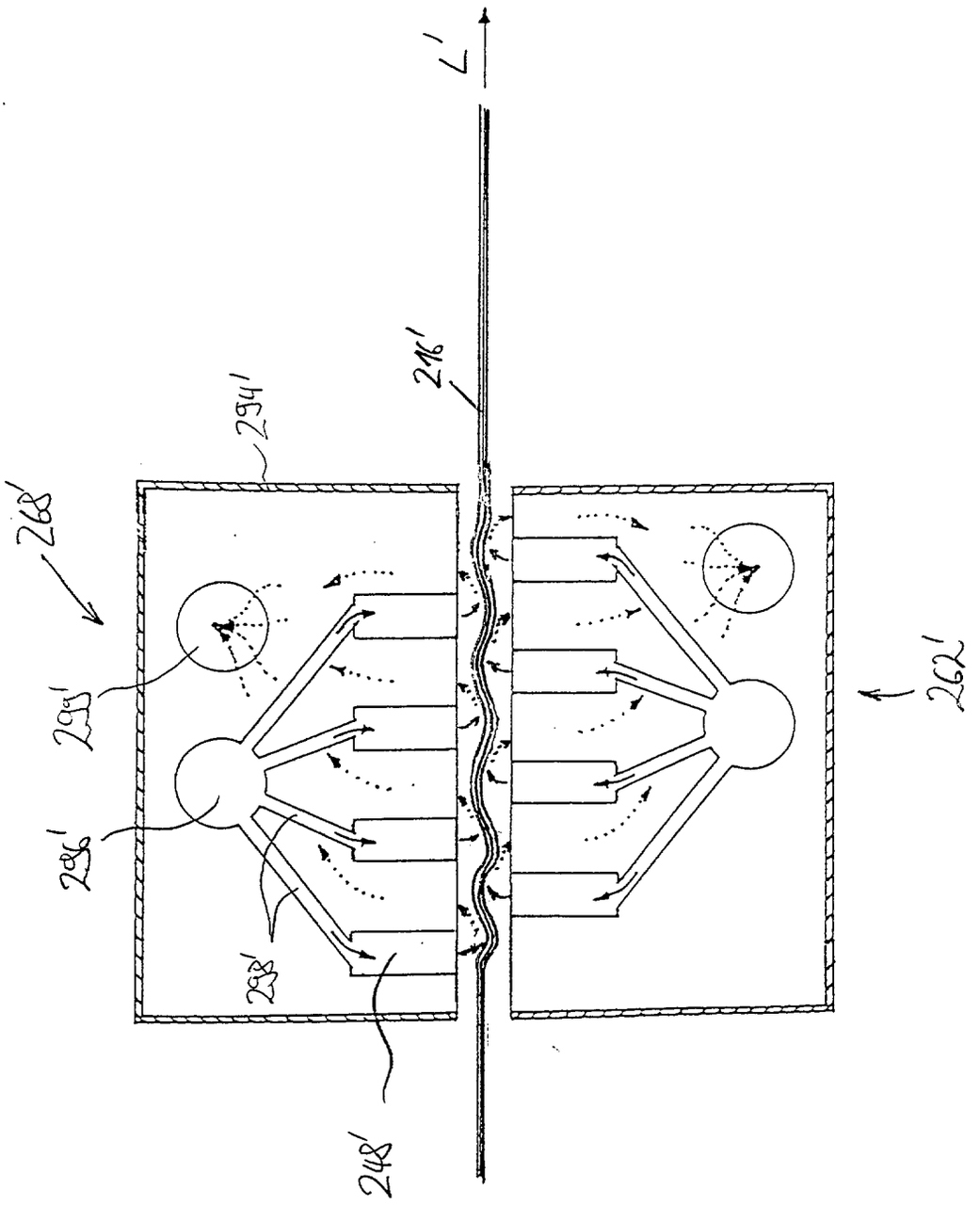


Fig. 14

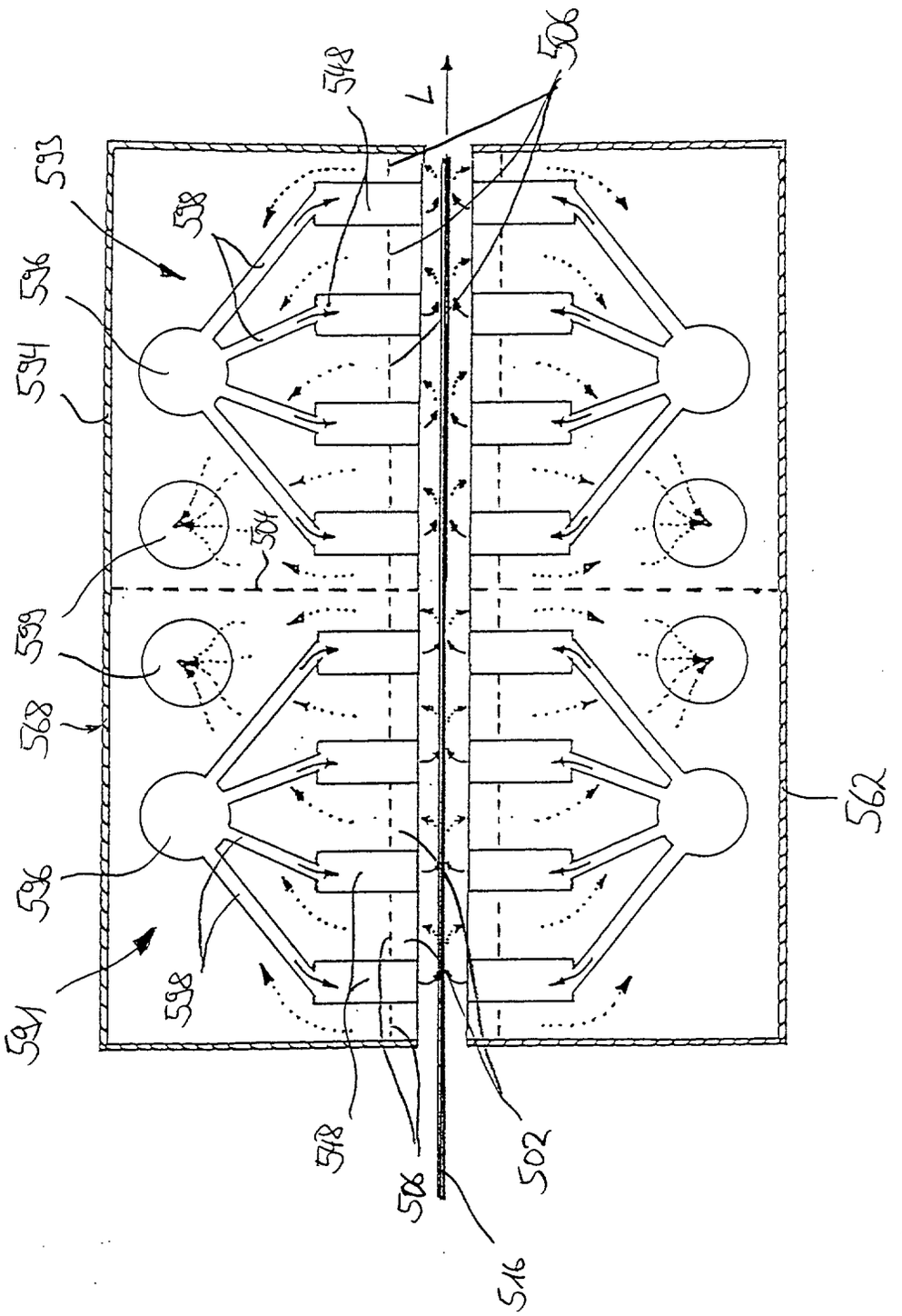

548
L
506
593
538
596
594
504
599
568
596
591
598
562
548
508
502
516

Fig. 15

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 10 7510

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X	DE 40 29 487 A (VALMET PAPER MACHINERY INC) 4 April 1991 (1991-04-04) * figure 5 * * column 4, line 53 - line 58 *	18,19, 21,23,25	D21H25/06 D21H23/22 D21F5/18
Y	* figures 1,3 *	1-17, 20-22, 24,26-36	
X	WO 99 02773 A (SOLIN RICHARD ;VALMET CORP (FI); RINGBOM KNUT (FI)) 21 January 1999 (1999-01-21) * page 10, line 29 - page 11, line 26; figure 1 *	18,19, 23,25, 26,35	
Y		1-17, 20-22, 24,26-36	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	2 May 2001	Naeslund, P

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EUROPEAN SEARCH REPORT

Application Number
EP 01 10 7510

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 3 549 070 A (FORST JOHN W ET AL) 22 December 1970 (1970-12-22)		

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	2 May 2001	Naeslund, P

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