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(54) **ENTHALPY-EXCHANGING UNIT FOR REDUCING THE INFLUENCE OF SURFACE TENSION, ENTHALPY EXCHANGER AND METHOD FOR PRODUCING AN ENTHALPY-EXCHANGING UNIT**

ENTHALPIE-AUSTAUSCHER EINHEIT ZUR REDUZIERUNG DES EINFLUSSES DER OBERFLÄCHENSPANNUNG, ENTHALPIEAUSTAUSCHER UND SEIN HERSTELLUNGSVERFAHREN

UNITÉ D'ÉCHANGE D'ENTHALPIE AYANT UNE INFLUENCE REDUITE SUR LA TENSION SUPERFICIELLE. ÉCHANGEUR ENTHALPIQUE ET PROCÉDÉ DE FABRICATION ASSOCIÉ

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(73) Proprietor: **FOXUS B.V.**
1017 JW Amsterdam (NL)

(72) Inventor: **UGES, Peter, Gerard, Hans**
1017 JW Amsterdam (NL)

(74) Representative: **Patentwerk B.V.**
P.O. Box 1514
5200 BN 's-Hertogenbosch (NL)

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Description

[0001] The invention relates to an enthalpy-exchanging unit comprising at least one plate along whose at least one contact side a first flowable medium and a second medium can travel while exchanging enthalpy, and which enthalpy-exchanging unit comprises at least one hygroscopic material layer, which connects to at least one contact side, in contact with the first flowable medium, of the plate, wherein the mutual orientation of the plate and the material layer is such that a liquid film of the first medium can form between the plate and the material layer, wherein the liquid film is in enthalpy-exchanging contact with both the plate and the material layer.

[0002] The working of such enthalpy-exchanging units is based on the fact that air to be cooled is conducted directly along a moist surface. The heat required to evaporate the water which is present is here extracted from the air stream, whereby the latter drops in temperature.

[0003] A similar enthalpy exchanger is already known. Dutch patent NL 2 000 079 discloses an enthalpy exchanger having a partition wall and a hygroscopic material layer, wherein the material layer is fastened to the partition wall at a plurality of mutually spaced point locations. The mutual orientation of the partition wall and the material layer is herein such that a liquid film of the first medium can form between the partition wall and the material layer, wherein the liquid film is in enthalpy-exchanging contact with both the partition wall and the material layer. Through the maintenance of a liquid film between the partition wall and the material layer, an optimal, virtually unobstructed heat transfer can take place between both media.

[0004] However, when the hygroscopic material layer is moistened, the force of attraction (cohesion) between the liquid molecules under the influence of the Van der Waals forces leads to a tension prevailing on the surface of the flowable medium, better known as the surface tension. As a result, the flowable medium is not fully or not evenly distributed over the space between the material layer and the partition wall, but rather one or more local accumulations of the flowable medium arise, which leads to an appreciable reduction of the enthalpy-exchanging capability of the enthalpy-exchanging unit and thus directly results in a reduction of the maximum capacity of the enthalpy exchanger.

[0005] The object of the invention is to provide an enthalpy exchanger which eliminates the abovementioned drawbacks and/or to provide a usable alternative to the prior art.

[0006] To this end, the invention provides an enthalpy-exchanging unit according to the type stated in the introduction, characterized in that the material layer is fastened to the plate with a plurality of seams, which extend substantially parallel to one another, are continuous, and are arranged at a centre-to-centre distance apart, such that a plurality of channels separated from one another by the seams are formed over the contact side of the plate. The often narrow, separated channels enclosed by the material layer and plate increase the degree of spread of the flowable medium over the contact side of the plate and thus reduce the influence of cohesion between the liquid molecules and the accompanying surface tension. On the other hand, the influence of the adhesion between the flowable medium and the plate is increased by means of this measure. This enables the flowable medium to extend along the seams and to form a liquid film over the full surface of the plate, helped in this by the hygroscopic effect of the material layer. This ensures a maximum enthalpy-exchanging capability of the enthalpy-exchanging unit.

[0007] It is generally advantageous that the plate comprises a peripheral margin whereto the seams extend in the longitudinal direction at at least one end. When the flowable medium is supplied to this same end of the seams, it is herewith achieved that the flowable medium is supplied separately to each channel, which is beneficial to the even distribution of the flowable medium over the channels. This ensures a broader even and complete spread of the liquid film over the full surface of the plate, which further increases the enthalpy-exchanging capability of the enthalpy-exchanging unit in accordance with the invention.

[0008] Moreover, it is generally advantageous that the seams extend in the longitudinal direction at one end up to a certain distance from the peripheral margin of the plate. When the flowable medium is evacuated at this same end of the seams, it is herewith achieved that the surplus of supplied flowable medium can jointly be evacuated. In this context, the distance preferably conforms to the centre-to-centre distance between the seams, so that, apart from being able to jointly evacuate the excess of supplied flowable medium, also effective control of the flowable medium also continues to take place.

[0009] In a preferred embodiment, the seams bind merely the surface of the plate-facing side of the material layer to the plate, wherein the seams only partially penetrate the material layer. As a result hereof, the flowable medium, during displacement through the hygroscopic material layer, is not obstructed by the seams. The flowable medium can thereby move freely through the hygroscopic material layer, whereby a homogeneous spread of the flowable medium over the material layer is promoted, which is beneficial to the enthalpy-exchanging capability of the enthalpy-exchanging unit.

[0010] In a further preferred embodiment, the plate of the enthalpy-exchanging unit is made of a plastic, which is preferably a thermoplastic polymer. The enthalpy-exchanging unit operates in a very humid environment, with relative air humidity values which are often higher than 95%. Such an environment has a corrosive effect on materials such as metal, which is detrimental to the strength and durability of components made from these materials. By producing the plate from a plastic, oxidation of the plate is prevented. The specific use of a thermoplastic polymer enables seams to be made in the plate by heating.

[0011] The invention also relates to an enthalpy exchanger comprising at least one enthalpy-exchanging unit according to one of Claims 1-9. The use of such an enthalpy-exchanging unit in an enthalpy exchanger, as a consequence of the high enthalpy-exchanging capability of the enthalpy-exchanging unit, results in an increased capacity of the enthalpy exchanger.

[0012] In a preferred embodiment, the enthalpy exchanger comprises a liquid supply unit, arranged in particular horizontally above a side, defined in intended usage as the top side, of the at least one enthalpy-exchanging unit, for supplying the first flowable medium evenly between the plate and the material layer under the effect of gravity. The placement of the liquid supply unit makes it possible for the supplied first flowable medium, helped by gravity, to be more easily distributed over the full surface of the plate.

[0013] In this context, it is generally advantageous that the liquid supply unit comprises a porous, absorbent bed made of a plastic, for supplying the first flowable medium such that it is spread over the at least one enthalpy-exchanging unit. The use of in particular a horizontally arranged spongy layer of this type results in an even supply of the flowable medium over the one or more enthalpy-exchanging units, which further facilitates the distribution of the flowable medium over the respective plates. This way, a more even liquid supply without the use of nozzles is secured, by on the top side a supply unit provided with a porous, absorbent bed. However, it is also conceivable that the liquid supply unit, whether or not in combination with the porous, absorbent bed, comprises one or more nozzles for supplying the first flowable medium, in a broadly spread manner, to the one or more enthalpy-exchanging units.

[0014] In a further preferred embodiment, the seams extend in the longitudinal direction at one end to a part, facing the liquid supply unit, of the peripheral margin of the material layer, whereby the first flowable medium can be supplied by the liquid supply unit separately to each channel, which is beneficial to the even distribution of the flowable medium over the channels.

[0015] In this context, it is generally advantageous that seams connecting the plate to the hygroscopic material layer extend substantially in the gravitational direction, with the result that the formed mutually separated channels extend in one and the same substantial gravitational direction. This has the advantage that, in the spreading of the flowable medium along the full length of the channels, use can be made of the gravitational effect, whereby only a small supply of the flowable medium is necessary to create a liquid film between the plate and the material layer of each of the enthalpy-exchanging units.

[0016] Generally, it is herein also advantageous that the centre-to-centre distance between the seams is between 30 and 80 mm and preferably between 40 and 60 mm, wherein the chosen centre-to-centre distance is dependent on the quantity of liquid to be supplied. With this distance range, a width of the mutually separated channels, with which, on the one hand, sufficient space is left for the liquid film to travel unobstructedly between the plate and the material layer and, on the other hand, sufficient control of the flowable medium takes place in the direction of extent of the seams, can be selected on the basis of the quantity of liquid to be supplied.

[0017] In another preferred embodiment, the seams extend, in correct usage of the enthalpy exchanger, in a substantially horizontal direction. The seams hereby run substantially parallel to that part of the peripheral margin of the plate which is facing towards the liquid supply unit. Such an orientation of seams connecting the material layer to the plate requires, in comparison with more vertical orientations of the seams, a greater supply of the flowable medium in order to create a liquid film between the plate and the material layer. A greater supply of the flowable medium to the enthalpy-exchanging unit is often desired in enthalpy exchangers in which the first flowable medium comprises brackish water or salt water. In this case, a surplus of the first flowable medium ensures that salt is evacuated before it can crystallize. The abovementioned preferred embodiment is also desired where the working principle of the enthalpy exchanger is based on wet-bulb cooling or adiabatic cooling, wherein, for optimal working of the enthalpy exchanger, it can be necessary that the second medium is guided as process air in different directions along the liquid film formed by the first flowable medium. As a result of the horizontal orientation of the seams, it becomes possible to have the liquid supply unit connected to only a part of that side of the at least one enthalpy-exchanging unit which is defined in correct usage as the top side, in order thus to provide water to the topmost channel formed by the seams. Under the effect of gravity, the water will be distributed over the underlying channels. The other part of the top side of the enthalpy-exchanging unit can hereby be used as the supply of process air, which can thereby also be conducted from the top side along the liquid film formed by the first flowable medium.

[0018] In this context, it is generally advantageous that the seams extend in the longitudinal direction at a first end, in turns, to a first side of the peripheral margin of the plate and a second side opposite the first side of the peripheral margin of the plate, wherein the seams extend in the longitudinal direction at a second end opposite the first end up to a certain distance from the peripheral margin of the plate. By interconnecting the plate and the material layer of the enthalpy-exchanging unit in this way, an unbroken zigzag-shaped channel formed from the different channels separated by the seams is formed, whereby the supplied first flowable medium is conducted along the entire surface of the plate. This results in a broad homogeneous spreading of the flowable medium over the plate, which is beneficial to the enthalpy-exchanging capability of the enthalpy-exchanging unit and thus leads to an increased capacity of the enthalpy exchanger.

[0019] Generally, it is herein also advantageous that the seams in the longitudinal direction, and preferably in the middle between their respective ends, comprise at least one interruption, wherein the interruption is appreciably smaller than the total length of the seam. With such an interruption of the seam, a recess is formed in the channels separated by the seams, whereby any air (or some other gaseous medium) which is present in the channels can be evacuated. As a result, possible accumulation of air (or some other gaseous medium) in the channels formed by the seams can be prevented, which is beneficial to the flow of the flowable medium over the channels, and thus the even distribution of the flowable medium over the channels.

[0020] In addition thereto, it is generally advantageous that the centre-to-centre distance between the seams is in this case between 30 and 80 mm and preferably between 30 and 50 mm, wherein the centre-to-centre distance between the seams for seam pairs which succeed one another in the gravitational direction decreases. Since the chosen centre-to-centre distance is dependent on the quantity of liquid to be supplied, with this distance range, a width of the mutually separated channels, with which, on the one hand, sufficient space is left for the liquid film to travel unobstructedly between the plate and the material layer and, on the other hand, sufficient control of the flowable medium takes place in the direction of extent of the seams, can be selected on the basis of the quantity of liquid to be supplied. By decreasing the centre-to-centre distance between the seams for seam pairs which succeed one another in the gravitational direction, and thus arranging the seams closer together on the, defined in correct usage, bottom side of the enthalpy-exchanging unit, account is taken of the reduced inflow of liquid as the distance to the liquid supply unit increases.

[0021] A further conceivable variant relates to a combination of seams extending at right angles to one another, wherein the advantages of both variants are combined.

[0022] In a further preferred embodiment, the at least one enthalpy-exchanging unit of the enthalpy exchanger at least partially delimits at least one passage for the feed-through of the second medium. This passage enables the second medium to be guided along the enthalpy-exchanging unit, so that direct or indirect enthalpy exchange takes place between the first flowable medium and the second medium. The second medium will generally be gaseous, so that the enthalpy exchanger can be used as air treatment in the commercial or private domain. In addition, during the enthalpy exchange, heat is generally extracted from the second medium, which heat is substantially transferred to the first medium. Thus the second medium, often an air stream, can be cooled before this air stream is brought into a room or the atmosphere. In addition, the enthalpy exchanger can be used as an industrial device for cooling industrial process gases or cooling a condenser cooling water stream in indirectly working cooling towers. The enthalpy exchanger as described above is not however limited to use in cooling applications. For instance, the enthalpy exchanger can also be employed as a humidifier in industrial processes which require a high relative humidity combined with minimum possible energy consumption.

[0023] In another preferred embodiment of the enthalpy exchanger, the at least one passage is at least partially delimited by that side of the enthalpy-exchanging unit which lies opposite the contact side in contact with the flowable medium, in order to allow the enthalpy exchange between the first medium and the second medium to take place via the plate and the liquid film. Since the second medium is in this way not in direct contact with the first flowable medium, the first flowable medium is prevented from being at least partly absorbed by the second medium. In other words: by preventing direct contact of the second medium with the first flowable medium, the absolute moisture content (g moisture/kg air) of the second medium will remain the same during passage through the enthalpy exchanger. This is favourable, for example, in the aforesaid application of the enthalpy exchanger for the purpose of air treatment in the commercial or private domain, where it is undesirable that the conditioned air acquires a higher absolute moisture content (g/Kg), resulting in the hence possible rise in the relative air humidity (%) and is herein dependent on the temperature (°C) prevailing in this room. A high relative humidity (%) increases the risk of mildew on goods which are susceptible thereto and on the walls. A high relative humidity (%) can also mean that less moisture is delivered to the environment. The combination of relative moisture content (%) and temperature (°C) is known as the "sensible heat factor", wherein a high relative humidity (%) can be perceived by the person as "clammy".

[0024] In yet another preferred embodiment, a fraction of the second medium, having passed through the at least one passage, is conducted along the hygroscopic material layer. Thus a part of the conditioned second medium is used to evaporate the first flowable medium. Because it is possible to make this process run diabatically, a minimum temperature of the conditioned second medium of only a few degrees above the dew point temperature can be reached. The minimum temperature of the conditioned second medium is hence lower than the wet-bulb temperature. The latter temperature is the minimum temperature of the conditioned second medium which can be achieved in an adiabatic cooling process. This embodiment therefore ensures that the temperature of the conditioned second medium is not limited to the theoretical wet-bulb temperature, but rather to the theoretical dew point temperature, which is also beneficial to the capacity of the enthalpy exchanger.

[0025] In addition, the invention relates to a method for producing an above-described enthalpy-exchanging unit, comprising the steps: A) the positioning of at least one hygroscopic material layer relative to at least one plate, B) the connection of the at least one hygroscopic material layer and the at least one plate through the simultaneous arrangement of continuous seams, extending substantially parallel to one another, between the at least one hygroscopic material layer and the at least one plate. This method enables the seams, on the one hand, to be able to be arranged simultaneously and, on the other hand, to be able to be arranged continuously. In comparison with a method in which the material layer is connected to the plate at a plurality of mutually spaced point locations, this method leads to an appreciable time gain in the production of the abovementioned enthalpy-exchanging units.

[0026] During the execution of the abovementioned method, the seams are preferably formed by a connection technique chosen from the group comprising welding, gluing or stitching. Each of these connection techniques is suitable for the cost-effective and rapid manner continuous arrangement of continuous seams, extending substantially parallel to one another, between the at least one hygroscopic material layer and the at least one plate.

[0027] It is also advantageous that, during step B) of the abovementioned method, the seams are merely connected to the surface of the plate-facing side of the material layer, wherein the seams only partially penetrate the material layer. As already set out in the above, the flowable medium can hereby move freely through the hygroscopic material layer, whereby a homogeneous spreading of the flowable medium over the material layer is promoted, which is beneficial to the enthalpy-exchanging capability of the enthalpy-exchanging unit.

[0028] The invention will be illustrated on the basis of non-limiting illustrative embodiments represented in the following figures, in which:

- Figure 1 shows a perspective view of an enthalpy-exchanging unit in accordance with the invention,
- Figure 2 shows an exploded perspective view of an enthalpy exchanger in accordance with the invention,
- Figure 3 shows a schematic view of an embodiment of an enthalpy-exchanging unit in accordance with the invention,
- Figure 4 shows a cross-sectional view along the line A - A in Figure 3,
- Figure 5 shows a schematic view of another embodiment of an enthalpy-exchanging unit in accordance with the invention,
- Figure 6 shows a cross-sectional view along the line B - B in Figure 5,
- Figure 7 shows a schematic cross-sectional view of an embodiment of the enthalpy exchanger in accordance with the invention,
- Figure 8 shows a schematic cross-sectional view of another embodiment of the enthalpy exchanger in accordance with the invention,
- Figure 9 shows a schematic cross-sectional view of yet another embodiment of the enthalpy exchanger in accordance with the invention,
- Figure 10 shows a schematic cross-sectional view of still another embodiment of the enthalpy exchanger in accordance with the invention,
- Figure 11 shows a schematic representation of a wet-bulb cooling or adiabatic cooling process which is used in an enthalpy exchanger in accordance with the invention,
- Figure 12 shows a schematic representation of yet another wet-bulb cooling or adiabatic cooling process which is used in an enthalpy exchanger in accordance with the invention.

[0029] Figure 1 shows a perspective view of an enthalpy-exchanging unit 1 in accordance with the invention. The enthalpy-exchanging unit comprises a plurality of plates 2, which are held at a distance apart by spacers. A first flowable medium, often salt water, brackish water or salt (sea) water, and a second medium, often air, can travel along contact sides 3 of plates 2 while exchanging enthalpy. Should the enthalpy-exchanging unit 1 be used in a dew point cooling process, the second medium will travel in the direction of the arrows q_v along the plates 2. The plates 2 are wrapped with a hygroscopic material layer 4, such that the material layer connects to the contact sides 3. Between each of the plates 2 and the material layer 4 is left a space, within which the first flowable medium can form a liquid film which is in enthalpy-exchanging contact with both the plate and the material layer. The material layer 4 is fastened to the plate with a plurality of continuous seams 5 extending substantially parallel to one another, such that a plurality of channels 6 separated from one another by the seams are formed over the contact side of the plate. The width of each of the channels is herein defined by the centre-to-centre distance 7 between the seams 5. Where the seams 5 extend at a first end to the peripheral margin 9 of the plate 2, the seams 5 extend at a second end up to a certain distance 8 from the peripheral margin 9 of the plate 2. This distance 8 preferably the surface

[0030] Figure 2 shows an exploded perspective view of an enthalpy exchanger 10 in accordance with the invention. The enthalpy exchanger 10 comprises a plurality of side-by-side enthalpy-exchanging units 1 of the type discussed above. On the top side of the enthalpy exchanger is placed a liquid supply unit 11, provided with a porous, absorbent bed 12, made of plastic, which makes evenly distributed water supply possible without the use of nozzles, thereby preventing cleaning, malfunction and maintenance of the nozzles. The liquid supply unit is designed to supply the first flowable medium to the channels 6 formed between the plates 2 and the material layers 4 by the continuous seams 5. Since the seams 5 extend in the gravitational direction over the plates 2, the first flowable medium, under the influence of gravity and with the aid of the hygroscopic material layer 4, will flow downwards via the channels 6, whereby a liquid film is formed between the plates 2 and the material layers 4 of the enthalpy-exchanging units. That embodiment of the enthalpy exchanger which is shown in

Figure 2 uses a dew point cooling process to cool the second medium (in this case air). The air stream 13 to be cooled enters in the direction of the arrows q_v and is subsequently guided by passages 14 along those sides of the enthalpy-exchanging unit 1 which lie opposite the side in contact with the flowable medium (in this case water). During this process, heat transfer of the air to be cooled takes place at the plates 2, whereby the air of the conditioned air stream 15, upon leaving the passages 14, has been reduced in temperature, whilst the absolute moisture content remains constant. A fraction (in this case one-third) of the conditioned air stream 15 is returned as the process air stream 16 along passages 17, along that side of the enthalpy-exchanging unit 1 which is in contact with the water. During this return travel, the process air stream 16 absorbs the moisture evaporating from the hygroscopic material layer 4 which has been kept moist. The heat required for the evaporation is hereupon at least partly extracted from the air stream 13 to be cooled, which is guided along the side lying opposite that side of the enthalpy-exchanging unit 1 which is in contact with the water. During return travel, the process air stream 16 also absorbs heat, whereby this is a case of a diabatic process. Following the absorption of both heat and moisture from that side of the enthalpy-exchanging unit 1 which is in contact with the water, the process air stream is evacuated to the atmosphere.

[0031] Figure 3 shows a schematic view of the contact side 3 of an embodiment of an enthalpy-exchanging unit in accordance with the invention. In this embodiment, the seams 5 are arranged in a substantially horizontal direction on the enthalpy-exchanging unit. In addition, an interruption 18 is arranged in the seams for the evacuation of any air which might accumulate in the channels 6.

[0032] Figure 4 shows a cross-sectional view along the line A - A in Figure 3. The shown enthalpy-exchanging unit comprises a plurality of plates 2, which are held at a distance apart by spacers and are wrapped with a hygroscopic material layer 4. The plate 2 and the material layer 4 are connected to each other by means of seams 5, which are arranged at a centre-to-centre distance 7 from one another.

[0033] Figure 5 shows a schematic view of the contact side 3 of another embodiment of an enthalpy-exchanging unit in accordance with the invention. In this embodiment, the seams 5 extend substantially in the gravitational direction. It can also be seen that the seams 5 extend at a first end to the peripheral margin 9 of the plate 2 and extend at a second end up to a certain distance 8 from the peripheral margin 9 of the plate 2.

[0034] Figure 6 shows a cross-sectional view along the line B - B in Figure 5. The shown cross-sectional view likewise reveals that the enthalpy-exchanging unit comprises a plurality of plates 2, wrapped with a hygroscopic material layer 4.

[0035] Figure 7 shows a schematic cross-sectional view of an embodiment of the enthalpy exchanger in accordance with the invention. The enthalpy exchanger 10 comprises an enthalpy-exchanging unit 1, above which a liquid supply unit 11 is arranged. On the bottom of the liquid supply unit 11 is arranged a porous, absorbent layer or bed 12, made of a plastic, for supplying the first flowable medium 19 in a spread manner over the channels 6 of the enthalpy-exchanging unit. Via the seams arranged in the gravitational direction, here helped by the hygroscopic layer and gravity, the first flowable medium flows downwards along the plate, whereafter the excess of supplied flowable medium is evacuated via a drain 20.

[0036] Figure 8 shows a schematic cross-sectional view of another embodiment of the enthalpy exchanger 10 in accordance with the invention. Similar to the enthalpy exchanger shown in Figure 7, multiple parallel seams 5 are arranged in a substantially vertical direction, to allow the first flowable medium 19 to flow in the gravitational direction downwards along the plate, upon which the excess of supplied flowable medium 19 is evacuated via a drain 20. Different from the enthalpy exchanger shown in Figure 7, two separate liquid supply units 11 are arranged above the enthalpy-exchanging unit 1 that together connect to only a part of the upper side of the enthalpy-exchanging unit 1 instead of covering said upper side substantially entirely. The remaining free part of the upper side of the enthalpy-exchanging unit 1 can then be used as a passage for process air 16. In the shown configuration, the process air steam 16 is guided over the enthalpy-exchanging unit 1 in a substantially perpendicular direction with respect to the conditioned air stream 15. To guarantee an even distribution of the first flowable medium 19 over the multiple parallel, vertically extending channels 6, the material layer is fastened to the plate 2 with an addition horizontally extending seam 5, provided above said vertically extending channels 6. The first flowable medium 19 is fed to the horizontal channel 6 that is formed above the horizontally extending seam 5 in an even and controlled fashion by the use of a porous, absorbent layer or bed 12 provided in the liquid supply units 11. The horizontally extending seam 5 hereby prevents the first flowable medium 19 from flowing down immediately. By contrast, the first flowable medium 19 is evenly spread over the multiple vertically extending channels 6 through an outflow in vertical direction via interruptions 18 in the horizontally extending seam 5.

[0037] Figure 9 shows a schematic cross-sectional view of yet another embodiment of the enthalpy exchanger in accordance with the invention. In contrast to the embodiment shown in Figure 7, the seams 5 are now arranged in a substantially horizontal direction on the enthalpy-exchanging unit 1. In addition, the seams 5 extend in the longitudinal direction at one end to the peripheral margin 9 of the plate 2, whilst the same seams 5 extend at their other end up to a certain distance from the peripheral margin 9 of the plate 2. As a result hereof, the separate channels 6 delimited by the seams form an unbroken zigzag-shaped channel. The liquid supply 11 at one edge connects to only a part of that side of the at least one enthalpy-exchanging unit 1 which is defined in correct usage as the top side, in order thus to provide liquid to the topmost channel 6 formed by the seams 5. Under the effect of gravity, the liquid will be conducted along the underlying channels, whereby the supplied first flowable medium 19 is distributed over the entire surface of the plate 2. The other part of the top side of the enthalpy-exchanging unit 1 can hereby be used as a supply of process air 16, which can thereby be conducted also from the top side along the liquid film formed by the first flowable medium 19. Interruptions 18 are arranged in the seams for the evacuation of any air which might accumulate in the channels 6.

[0038] Finally, Figures 10-12 show a schematic representation of a wet-bulb cooling process or adiabatic cooling process which is used in an enthalpy exchanger 10 in accordance with the invention. Figure 10 shows an enthalpy exchanger in which the air stream to be cooled flows from left to right along the one or more enthalpy-exchanging units, whereby the air stream 13 to be cooled enters the enthalpy exchanger 10 on the left and leaves the enthalpy exchanger 10 as a conditioned (cooled) air stream 15. The process air stream 16 flows in an opposite direction substantially from right to left along the one or more enthalpy-exchanging units. Figure 11 shows a wet-bulb cooling process or adiabatic cooling process which is identical to the process shown in Figure 10, except that the process air stream 16 is guided over the one or more enthalpy-exchanging units in a substantially perpendicular direction with respect to the air stream 15 to be cooled 13 and conditioned. Figure 12 shows a wet-bulb cooling process or adiabatic cooling process identical to the process shown in Figure 11, with the exception that the first flowable medium 19 is supplied via two separate liquid supply units 11 on either side of the top side of the enthalpy-exchanger 10.

Claims

1. Enthalpy-exchanging unit (10), comprising:

- at least one plate (2) along whose at least one contact side (3) a first flowable medium (19) and a second medium (13) can travel while exchanging enthalpy, and
- at least one hygroscopic material layer (4), which connects to at least one contact side (3), in contact with the first flowable medium, of the plate,

wherein the mutual orientation of the plate (2) and the material layer (4) is such that a liquid film of the first medium can form between the plate (2) and the material layer (4), wherein the liquid film is in enthalpy-exchanging contact with both the plate (2) and the material layer (4),
characterized in that the material layer (4) is fastened to the plate (2) with a plurality of seams (5), which extend substantially parallel to one another, are continuous, and are arranged at a centre-to-centre distance (7) apart, such that a plurality of channels (6) separated from one another by the seams (5) are formed over the contact side (3) of the plate (2).

2. Enthalpy-exchanging unit (1) according to Claim 1, **characterized in that** the plate comprises a peripheral margin (9) whereto the seams (5) extend in the longitudinal direction at at least one end.

3. Enthalpy-exchanging unit (1) according to one of the preceding claims, **characterized in that** the plate (2) is made of a plastic, preferably a thermoplastic polymer.

4. Enthalpy-exchanging unit (1) according to one of the preceding claims, **characterized in that** the seams (5) in the longitudinal direction, and preferably in the middle between their respective ends, comprise at least one interruption (18), wherein the total interruption is appreciably smaller than the total length of the seam (5).

5. Enthalpy-exchanging unit (1) according to one of the preceding claims, **characterized in that** this comprises seams (5) extending at right angles to one another.

6. Enthalpy exchanger (10) comprising at least one enthalpy-exchanging unit (1) according to one of the preceding claims.

7. Enthalpy exchanger (10) according to Claim 6, **characterized in that** above a side, defined in correct usage as the top side, of the at least one enthalpy-exchanging unit (1) is arranged a liquid supply unit (11) for supplying the first flowable medium (19) between the plate (2) and the material layer (4) under the effect of gravity.

8. Enthalpy exchanger (10) according to Claim 7, **characterized in that** the liquid supply unit (11) comprises a porous, absorbent bed (12) made of a plastic.

9. Enthalpy exchanger (10) according to Claim 7, **characterized in that** the seams (5) extend substantially in the gravitational direction, such that the first flowable medium, under the effect of gravity, can travel downwards through the plurality of channels (6) separated from one another by the seams.

10. Enthalpy exchanger (10) according to one of Claims 7-9, **characterized in that** the seams (5) extend in the longitudinal direction at a first end, in turns, to a first side of the peripheral margin (9) of the plate (2), or a second side opposite the first side of the peripheral margin (9) of the plate (2), wherein the seams

(5) extend in the longitudinal direction at a second end opposite the first end up to a certain distance from the peripheral margin (9) of the plate (2).

11. Enthalpy exchanger (10) according to claim 10, **characterized in that** the at least one enthalpy-exchanging unit (1) at least partially delimits at least one passage (14) for the feed-through of the second medium (13).

12. Enthalpy exchanger (10) according to Claim 11, **characterized in that** the at least one passage (14) is at least partially delimited by that side of the enthalpy-exchanging unit (1) which lies opposite the contact side (3) in contact with the flowable medium (19).

13. Method for producing an enthalpy-exchanging unit (1) according to Claim 1, comprising:

A) the positioning of at least one hygroscopic material layer (4) relative to at least one plate (2),
B) the connection of the at least one hygroscopic material layer (4) and the at least one plate (2) through the simultaneous arrangement of continuous seams (5), extending substantially parallel to one another, between the at least one hygroscopic material layer (4) and the at least one plate (2).

14. Method according to Claim 13, **characterized in that** the seams (5) are formed by a connection technique chosen from the group comprising welding, gluing or stitching.

15. Method according to Claim 13 or 14, **characterized in that,** during step B), the seams (5) are merely connected to the surface of the plate-facing side of the material layer (4), wherein the seams (5) only partially penetrate the material layer (4).

Patentansprüche

1. Enthalpieaustauschereinheit (1), umfassend:

- mindestens eine Platte (2), an deren mindestens einer Kontaktseite (3) entlang ein erstes fließfähiges Medium (19) und ein zweites Medium (13) sich bewegen können, während sie Enthalpie austauschen, und
- mindestens eine hygroskopische Materialschicht (4), die mit mindestens einer Kontaktseite (3) in Kontakt mit dem ersten fließfähigen Medium der Platte in Verbindung steht,

wobei die wechselseitige Orientierung der Platte (2) und der Materialschicht (4) so ist, dass sich ein Flüssigkeitsfilm des ersten Mediums zwischen der Platte (2) und der Materialschicht (4) bilden kann, wobei der Flüssigkeitsfilm in enthalpieaustauschendem Kontakt mit sowohl der Platte (2) als auch der Materialschicht (4) ist,
dadurch gekennzeichnet, dass die Materialschicht (4) mit einer Vielzahl von Nähten (5), die sich im Wesentlichen parallel zueinander erstrecken, kontinuierlich sind und in einem Mittenabstand (7) beabstandet angeordnet sind, an der Platte (2) befestigt ist, so dass eine Vielzahl von Kanälen (6), die mittels der Nähte (5) voneinander getrennt sind, über der Kontaktseite (3) der Platte (2) gebildet sind.

2. Enthalpieaustauschereinheit (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** die Platte einen Außenrand (9) umfasst, zu dem sich die Nähte (5) an mindestens einem Ende in der Längsrichtung erstrecken.

3. Enthalpieaustauschereinheit (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Platte (2) aus einem Kunststoff gefertigt ist, vorzugsweise einem thermoplastischen Polymer.

4. Enthalpieaustauschereinheit (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Nähte (5) in der Längsrichtung und vorzugsweise in der Mitte zwischen ihren jeweiligen Enden mindestens eine Unterbrechung (18) umfassen, wobei die gesamte Unterbrechung erkennbar kleiner als die Gesamtlänge der Naht (5) ist.

5. Enthalpieaustauschereinheit (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** sie Nähte (5) umfasst, die sich rechtwinklig zueinander erstrecken.

6. Enthalpieaustauscher (10), umfassend mindestens eine Enthalpieaustauschereinheit (1) gemäß einem der vorhergehenden Ansprüche.

7. Enthalpieaustauscher (10) nach Anspruch 6, **dadurch gekennzeichnet, dass** oberhalb einer Seite, die bei korrektem Gebrauch als die Deckseite definiert ist, von der mindestens einen Enthalpieaustauschereinheit (1) eine Flüssigzufuhreinheit (11) zum Zuführen des ersten fließfähigen Mediums (19) zwischen der Platte (2) und der Materialschicht (4) unter dem Einfluss der Schwerkraft angeordnet ist.

8. Enthalpieaustauscher (10) nach Anspruch 7, **dadurch gekennzeichnet, dass** die Flüssigkeitszufuhreinheit (11) ein poröses Absorbensbett (12) umfasst, das aus einem Kunststoff gefertigt ist.

9. Enthalpieaustauscher (10) nach Anspruch 7, **da-**

durch gekennzeichnet, dass sich die Nähte (5) im Wesentlichen in die Schwerkraftrichtung erstrecken, so dass das erste fließfähige Medium unter der Wirkung der Schwerkraft sich durch die Vielzahl der Kanäle (6), die durch die Nähte voneinander getrennt sind, abwärts bewegen kann.

10. Enthalpieaustauscher (10) nach einem der Ansprüche 7 bis 9, **dadurch gekennzeichnet, dass** sich die Nähte (5) an einem ersten Ende in der Längsrichtung in Windungen zu einer ersten Seite des Außenrands (9) der Platte (2) oder zu einer zweiten Seite gegenüber der ersten Seite des Außenrands (9) der Platte (2) erstrecken, wobei die Nähte (2) sich in der Längsrichtung an einem zweiten Ende gegenüber von dem ersten Ende bis zu einem bestimmten Abstand von dem Außenrand (9) der Platte erstrecken.

11. Enthalpieaustauscher (10) nach Anspruch 10, **dadurch gekennzeichnet, dass** die mindestens eine Enthalpieaustauschereinheit (1) den mindestens einen Durchgang (14) zum Durchführen des zweiten Mediums (13) mindestens teilweise begrenzt.

12. Enthalpieaustauscher (10) nach Anspruch 11, **dadurch gekennzeichnet, dass** der mindestens eine Durchgang (14) mindestens teilweise durch jene Seite der Enthalpieaustauschereinheit (1) begrenzt ist, die gegenüber der Kontaktseite (3) in Kontakt mit dem fließfähigen Medium (19) liegt.

13. Verfahren zum Produzieren einer Enthalpieaustauschereinheit (1) nach Anspruch 1, umfassend:

A) das Positionieren der mindestens einen hygroskopischen Materialschicht (4) relativ zu mindestens einer Platte (2),
B) das Verbinden der mindestens einen hygroskopischen Materialschicht (4) und der mindestens einen Platte (2) durch die simultane Anordnung von kontinuierlichen Nähten (5), die sich im Wesentlichen parallel zueinander erstrecken, zwischen der mindestens einen hygroskopischen Materialschicht (4) und der mindestens einen Platte (2).

14. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** die Nähte (5) durch eine Verbindungstechnik ausgewählt aus der Gruppe gebildet sind, die Schweißen, Kleben oder Nähen umfasst.

15. Verfahren nach Anspruch 13 oder 14, **dadurch gekennzeichnet, dass** während des Schrittes B) die Nähte (5) lediglich mit der Oberfläche der zu der Platte weisenden Seite der Materialschicht (4) verbunden sind, während die Nähte (5) nur teilweise die Materialschicht (4) durchdringen.

Revendications

1. Unité d'échange d'enthalpie (1) comprenant:

- au moins une plaque (2) le long de laquelle au moins un côté de contact (3) au moins un premier milieu fluide (19) et un second milieu (13) peuvent se déplacer en échangeant l'enthalpie, et
- au moins une couche de matériau hygroscopique (4), qui est reliée à au moins un côté de contact (3), en contact avec le premier milieu fluide de la plaque, l'orientation mutuelle de la plaque (2) et de la couche de matériau (4) étant telle qu'un film liquide du premier milieu peut se former entre la plaque (2) et la couche de matériau (4), le film liquide étant en contact d'échange d'enthalpie avec à la fois la plaque (2) et la couche de matériau (4),

caractérisée en ce que la couche de matériau (4) est fixée à la plaque (2) avec une pluralité de coutures (5), qui s'étendent sensiblement parallèlement les unes aux autres, sont continues et sont agencées à une distance centre à centre (7) les unes des autres, de telle sorte qu'une pluralité de canaux (6) séparés les uns des autres par les coutures (5) sont formés sur le côté de contact (3) de la plaque (2).

2. Unité d'échange d'enthalpie (1) selon la revendication 1, **caractérisée en ce que** la plaque comprend un bord périphérique (9) sur lequel les coutures (5) s'étendent dans la direction longitudinale au niveau d'au moins une extrémité.

3. Unité d'échange d'enthalpie (1) selon l'une des revendications précédentes, **caractérisée en ce que** la plaque (2) est en une matière plastique, de préférence un polymère thermoplastique.

4. Unité d'échange d'enthalpie (1) selon l'une des revendications précédentes, **caractérisée en ce que** les coutures (5) dans la direction longitudinale, et de préférence au milieu entre leurs extrémités respectives, comprennent au moins une interruption (18), l'interruption totale étant sensiblement inférieure à la longueur totale de la couture (5).

5. Unité d'échange d'enthalpie (1) selon l'une des revendications précédentes, **caractérisée en ce que** celle-ci comprend des coutures (5) s'étendant perpendiculairement les unes aux autres.

6. Échangeur enthalpique (10) comprenant au moins une unité d'échange d'enthalpie (1) selon l'une des revendications précédentes.

7. Échangeur enthalpique (10) selon la revendication

6, **caractérisé en ce qu'**au-dessus d'un côté, défini en utilisation correcte en tant que côté supérieur, de l'au moins une unité d'échange d'enthalpie (1) une unité d'alimentation en liquide (11) est agencée pour alimenter le premier milieu fluide (19) entre la plaque (2) et la couche de matériau (4) sous l'effet de la gravité.

8. Échangeur enthalpique (10) selon la revendication 7, **caractérisé en ce que** l'unité d'alimentation en liquide (11) comprend un lit poreux absorbant (12) en plastique.

9. Échangeur enthalpique (10) selon la revendication 7, **caractérisé en ce que** les coutures (5) s'étendent sensiblement dans la direction gravitationnelle, de sorte que le premier milieu fluide, sous l'effet de la gravité, peut descendre à travers la pluralité de canaux (6) séparés les uns des autres par les coutures.

10. Échangeur enthalpique (10) selon l'une des revendications 7 à 9, **caractérisé en ce que** les coutures (5) s'étendent dans la direction longitudinale au niveau d'une première extrémité, tour à tour, vers un premier côté du bord périphérique (9) de la plaque (2), ou un second côté opposé au premier côté du bord périphérique (9) de la plaque (2), les coutures (2) s'étendant dans la direction longitudinale au niveau d'une seconde extrémité opposée à la première extrémité jusqu'à une certaine distance du bord périphérique (9) de la plaque.

11. Échangeur enthalpique (10) selon la revendication 10, **caractérisé en ce que** l'au moins une unité d'échange d'enthalpie (1) délimite au moins partiellement au moins un passage (14) pour l'alimentation à travers le second milieu (13).

12. Échangeur enthalpique (10) selon la revendication 11, **caractérisé en ce que** l'au moins un passage (14) est délimité au moins partiellement par le côté de l'unité d'échange d'enthalpie (1) qui est opposé au côté de contact (3) en contact avec le milieu fluide (19).

13. Procédé de fabrication d'une unité d'échange d'enthalpie (1) selon la revendication 1, comprenant:

A) le positionnement d'au moins une couche de matériau hygroscopique (4) par rapport à au moins une plaque (2),
B) la liaison de l'au moins une couche de matériau hygroscopique (4) et de l'au moins une plaque (2) par l'agencement simultané de coutures continues (5) s'étendant sensiblement parallèlement les unes aux autres entre l'au moins une couche de matériau hygroscopique (4) et l'au moins une plaque (2).

14. Procédé selon la revendication 13, **caractérisé en ce que** les coutures (5) sont formées par une technique de connexion choisie dans le groupe comprenant le soudage, le collage ou la couture.

15. Procédé selon la revendication 13 ou 14, **caractérisé en ce que**, pendant l'étape B), les coutures (5) sont simplement reliées à la surface du côté de la couche de matériau (4) faisant face à la plaque,
les coutures (5) ne pénétrant que partiellement la couche de matériau (4).

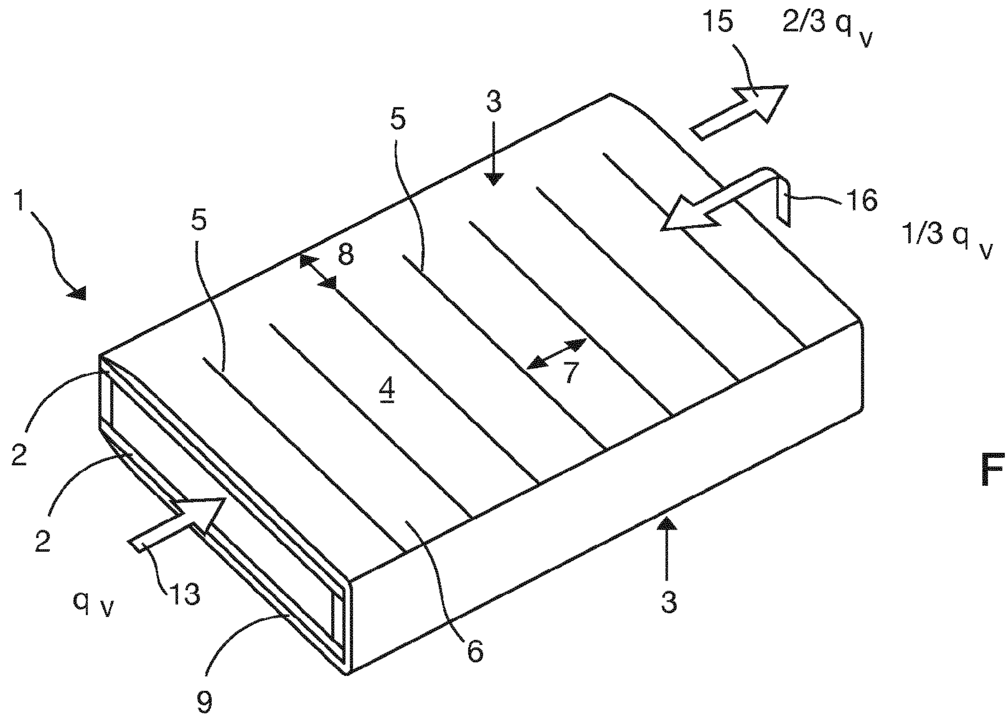
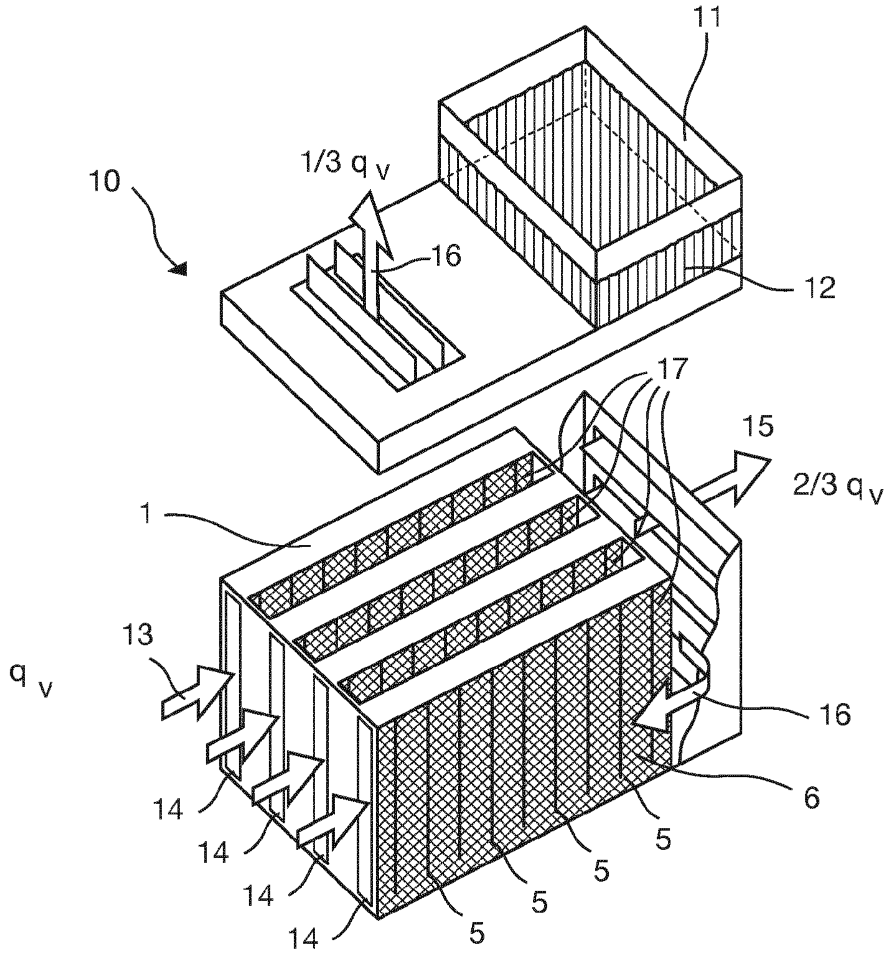

15
2/3 q v
3
5
16
1/3 q v
1
5
8
7
4
2
2
q v
13
3
6
9

FIG.1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10
1/3 q v
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q v
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14
14
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5
5
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5

FIG.2

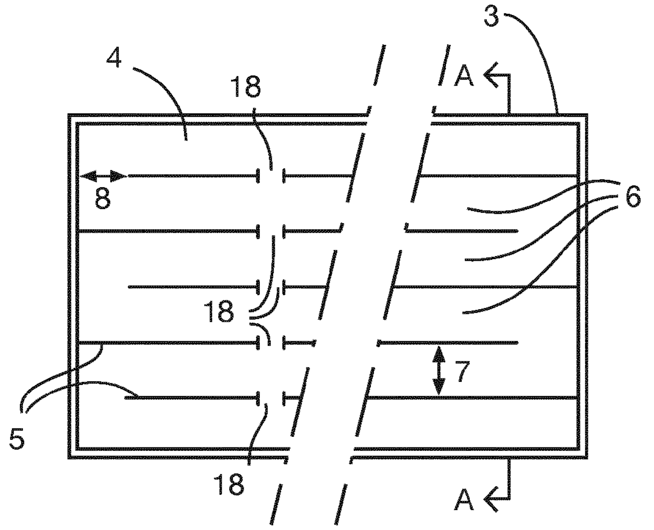


FIG.3

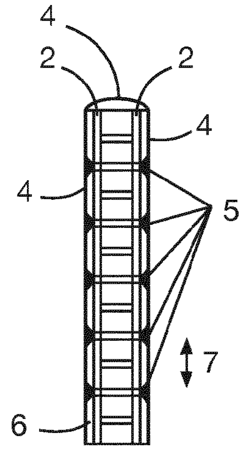


FIG.4

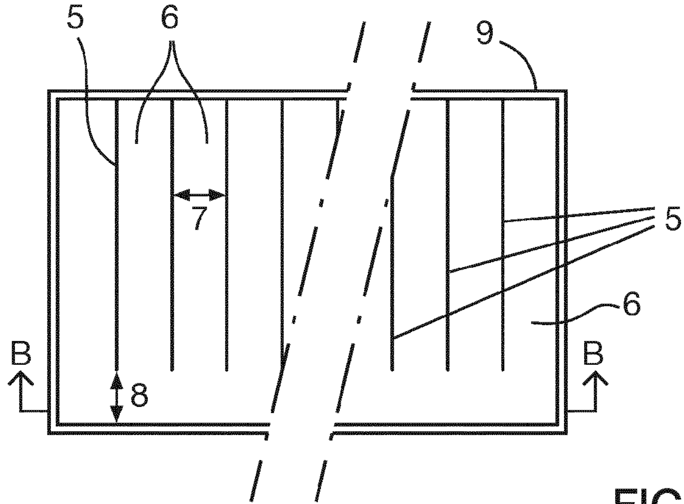
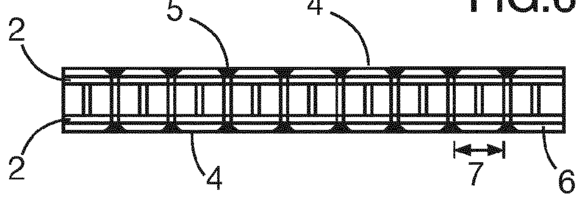
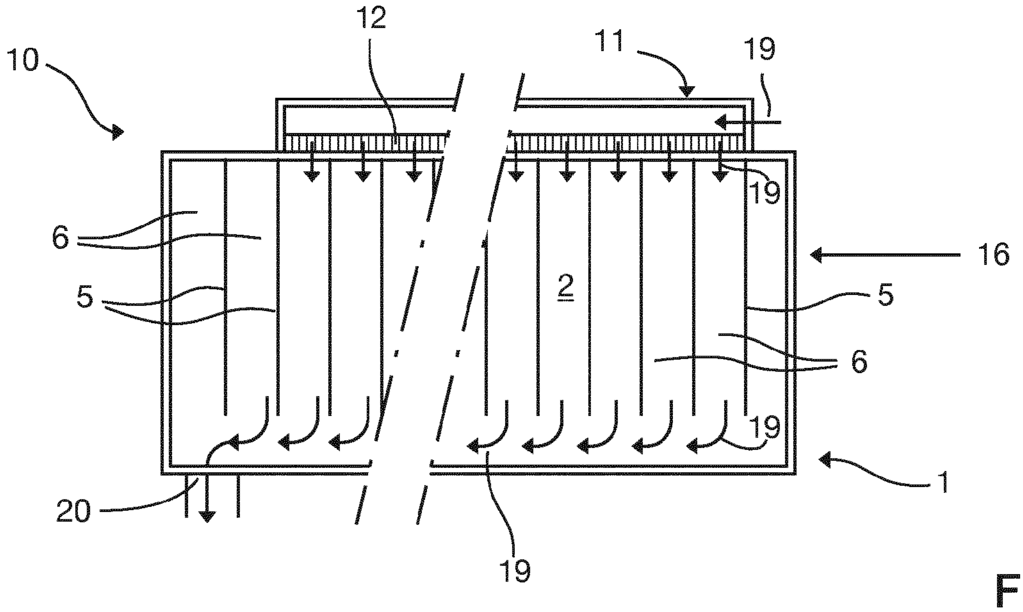


FIG.5

FIG.6





12
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FIG.7

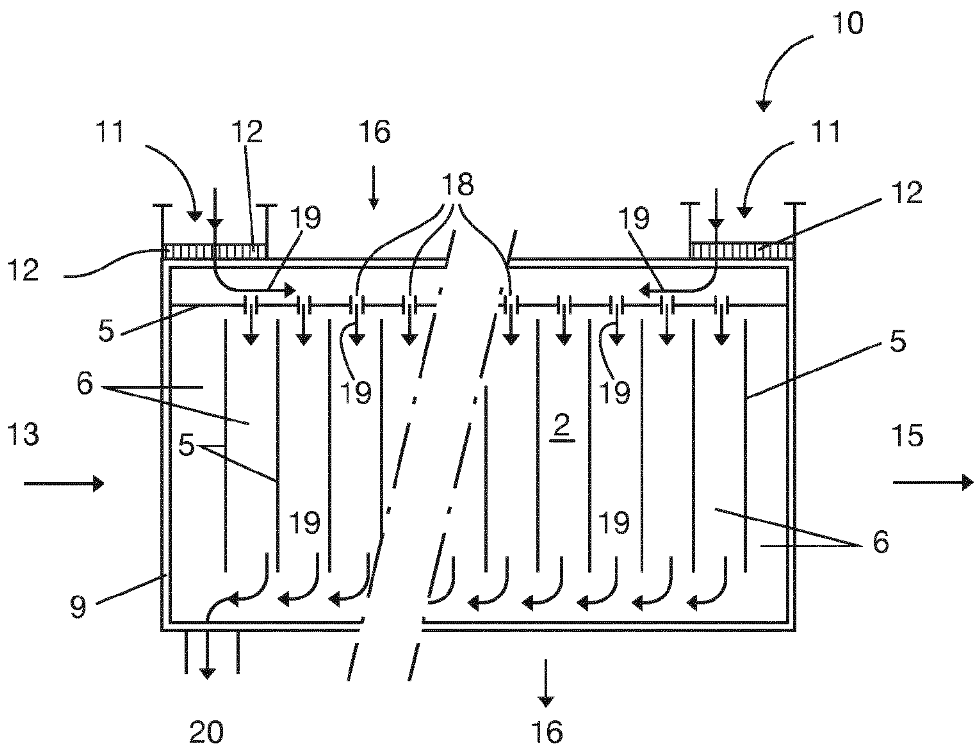

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FIG.8

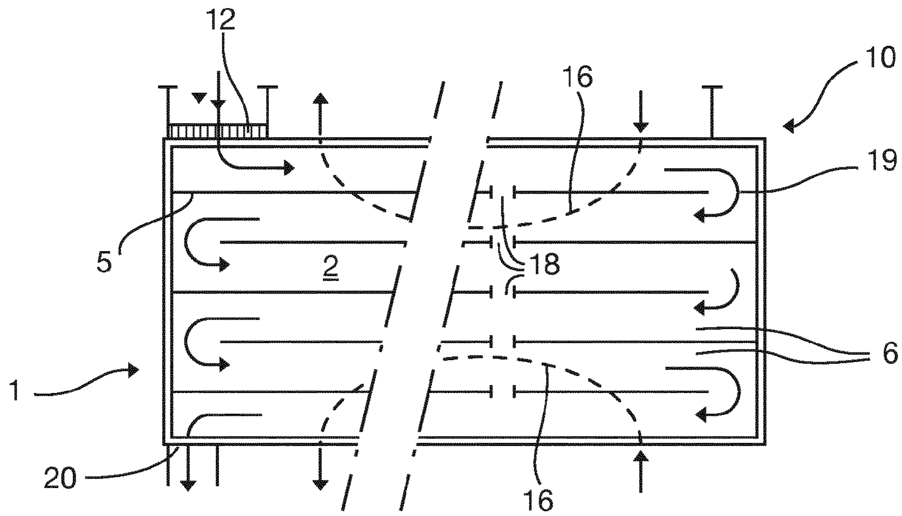

FIG.9

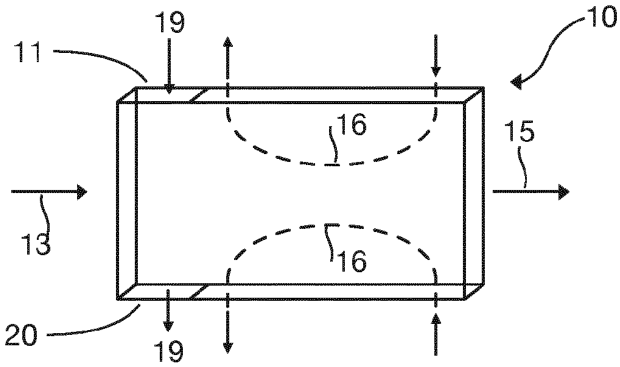

FIG.10

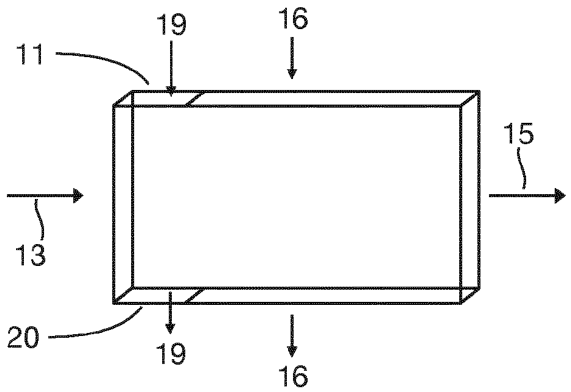

FIG.11

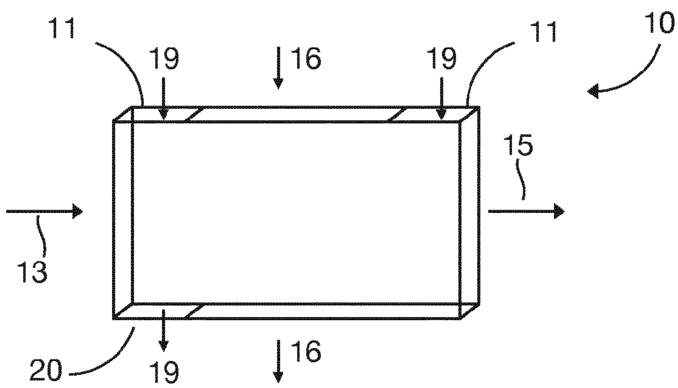

FIG.12

REFERENCES CITED IN THE DESCRIPTION

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