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(54) **A HEAT EXCHANGER AND A VENTILATION ASSEMBLY COMPRISING IT**

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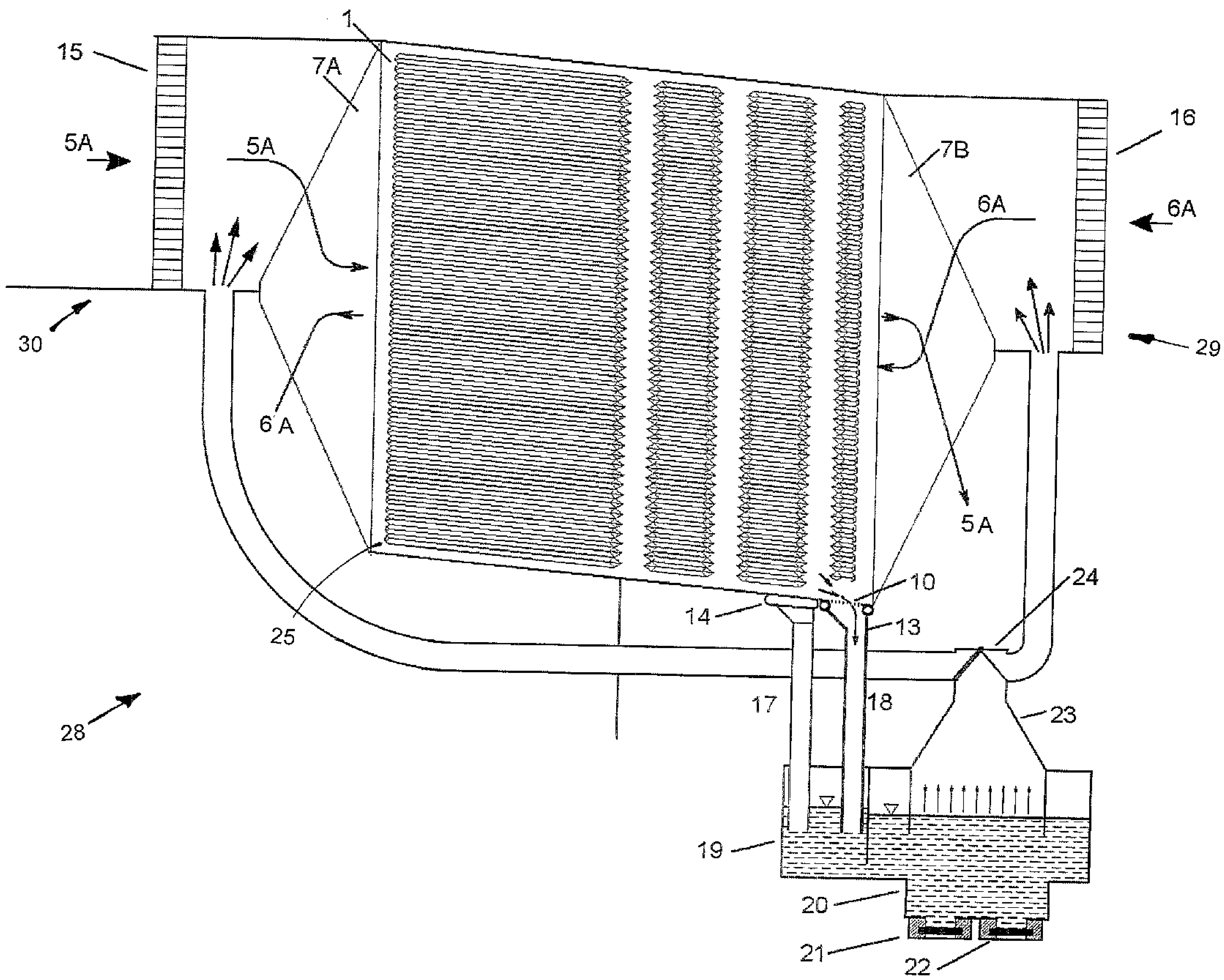
(57) **ABSTRACT**

A heat exchanger includes two sets of channels arranged adjacent to each other, for beat exchange between a first and a second air stream. Each of the sets of channels includes at least one transversal drainage channel for drainage of condensate, and a ventilation assembly including such a heat exchanger.



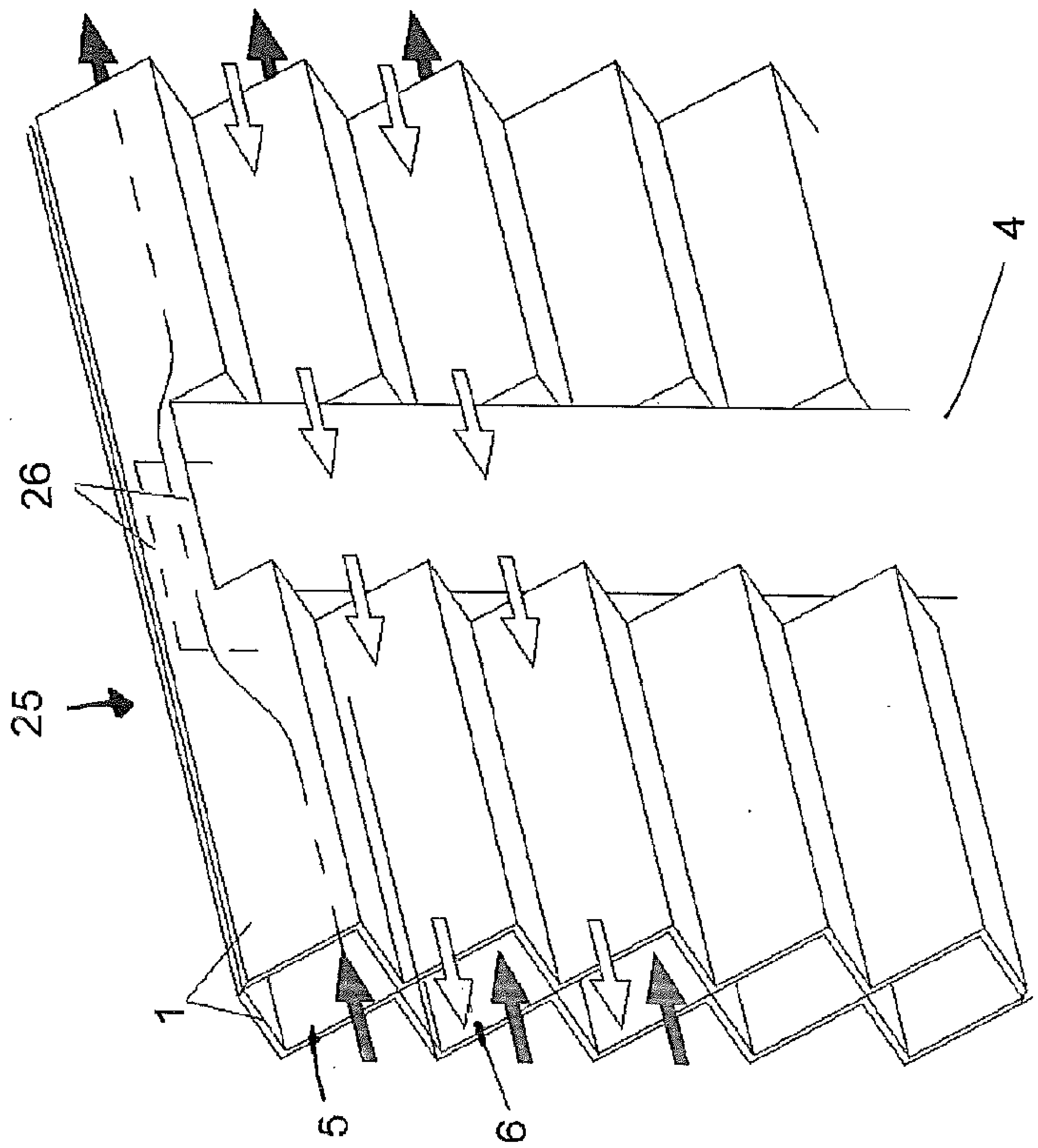


Fig. 1B

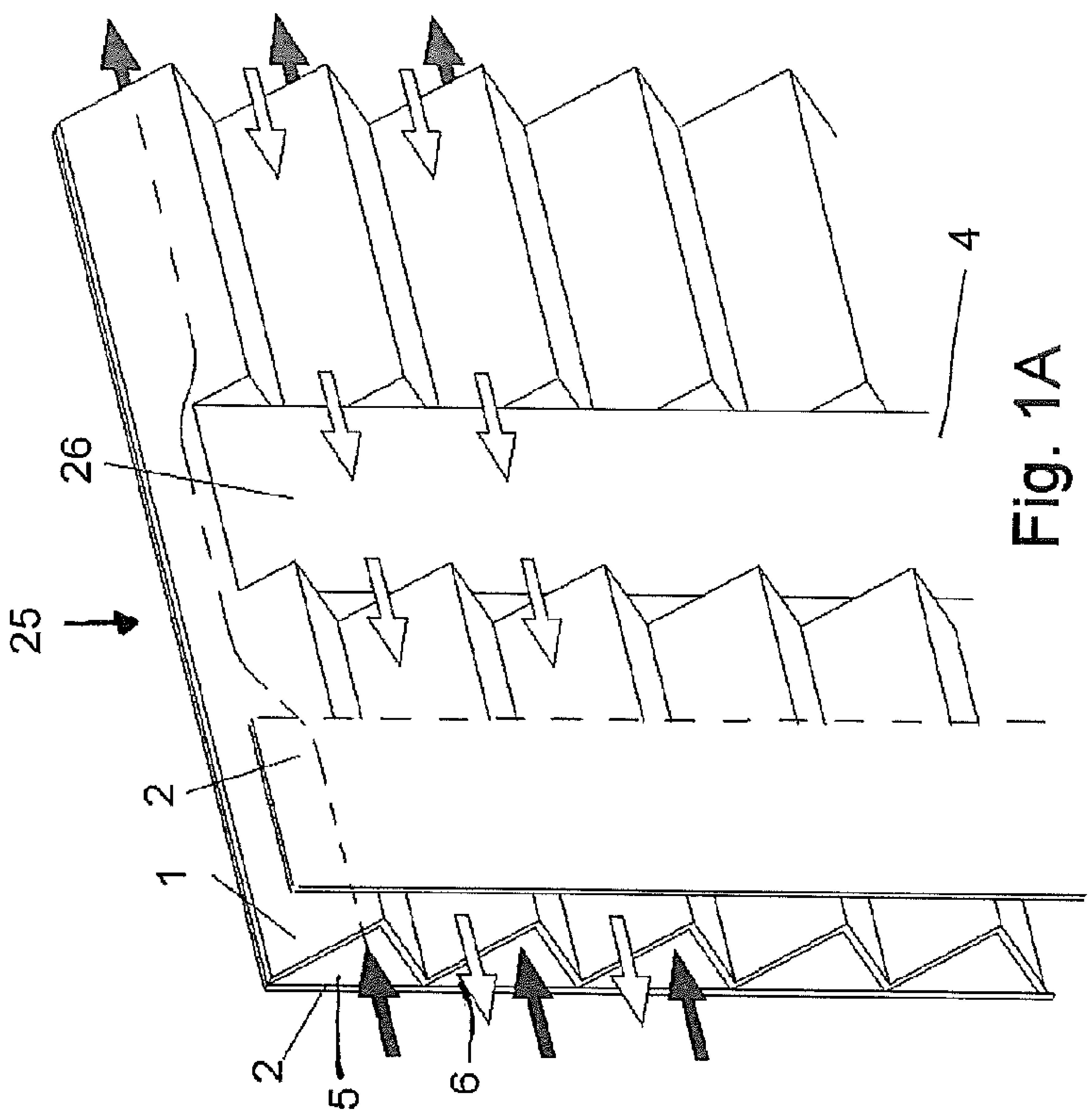


Fig. 1A

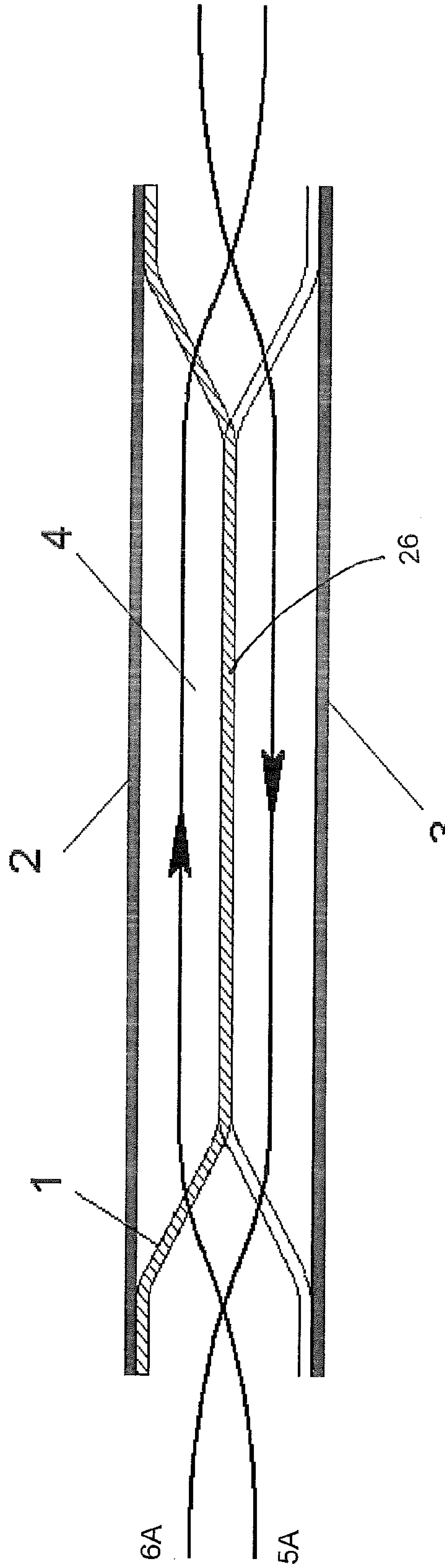


Fig. 2

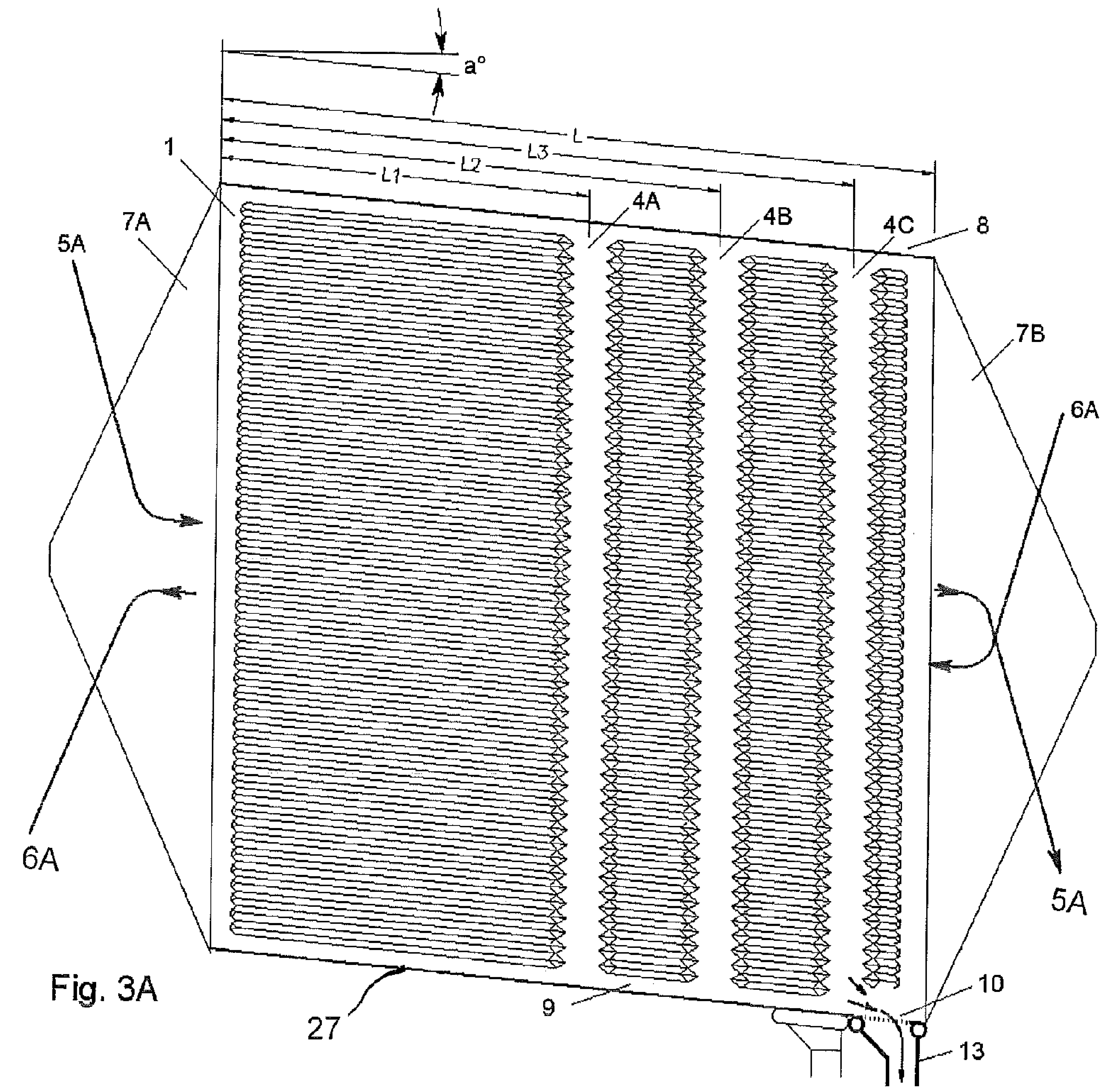


Fig. 3A

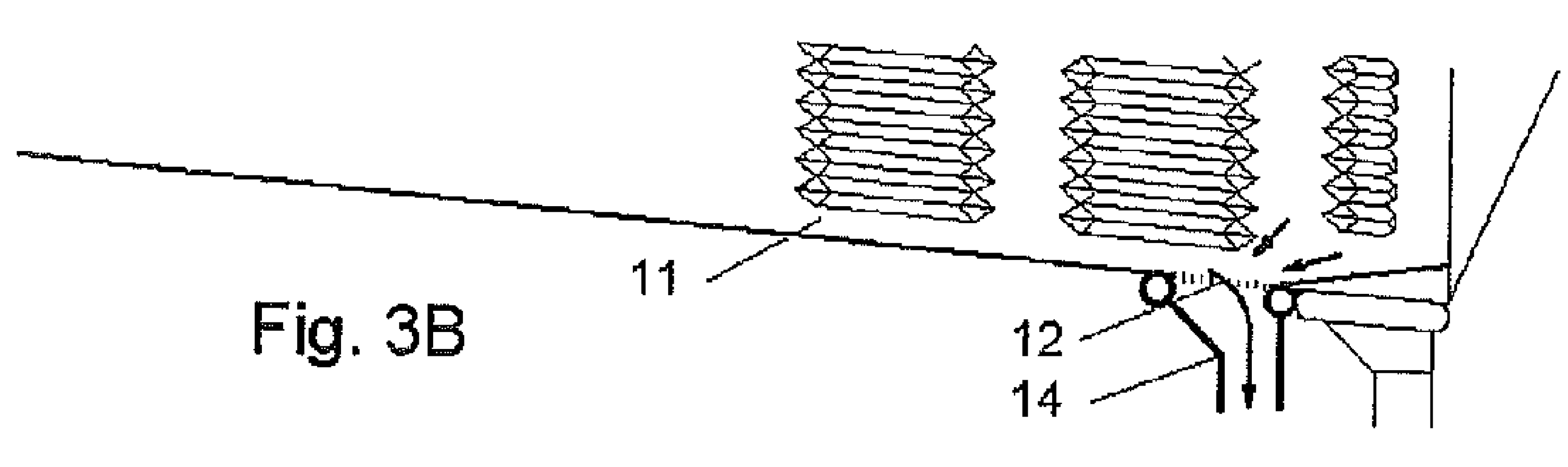


Fig. 3B

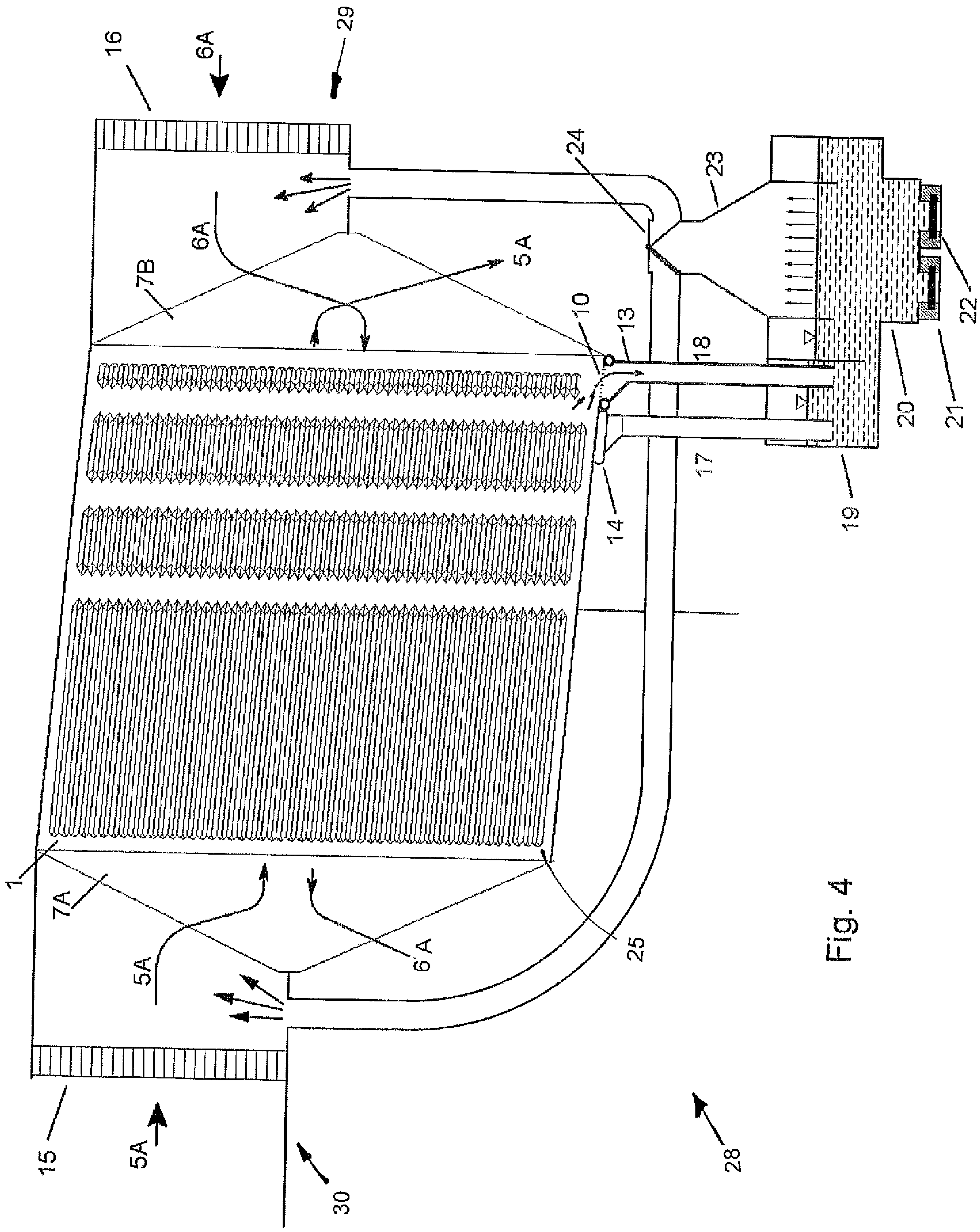

16
6A
29
24
23
6A
5A
7B
10
13
18
20
21
22
19
17
14
1
7A
5A
6A
25
15
5A
30
28

Fig. 4

A HEAT EXCHANGER AND A VENTILATION ASSEMBLY COMPRISING IT

BACKGROUND AND SUMMARY

[0001] The present invention relates according to an aspect thereof to a heat exchanger comprising two sets of channels arranged adjacent, to each other for heat exchange between a first and a second air stream. The invention also relates according to an aspect thereof to a ventilation assembly.

[0002] In order to obtain maximum heat recovery from outgoing in-house air when having a balanced housing ventilation most often heat exchangers are used having parallel, vertically arranged plates, e.g. made from thin plastic or aluminum, and wherein the heat exchanging surface is maximized by designing the plates with channels with outgoing in-house air (exhaust air) and incoming air from the outside (intake air) in counter-now. A usual geometry is a plate thickness of 0.1-0.5 mm, a distance between the plates 1.5-5 mm and a channel width (channel height) of 2-5 mm.

[0003] When the outside temperature is substantially lower than the room temperature the moisture of the room air will condense in the exhaust air channels of the heat exchanger and will sometimes cause clogging of water droplets resulting in an increase of the air resistance at the exhaust air side of the heat exchanger. At outside temperatures below −2° to −4° C. the condensate will freeze in the room air channels of the heat exchanger so that efficiency deteriorating measures have to be taken, such as introducing additional electric heating in the heat exchanger.

[0004] During winter time the outside air contain in absolute numbers (grams water/kilogram, air) very little moisture, which results in that the indoor climate will be dry. Moistening of the heated air will lower its temperature, which means either a too low blowing-in temperature with supply of heat of vaporization from the room air, or in that the supply air has to be post-heated before blowing it into the room. The problem with too dry air during the winter time is advantageously solved by integrating an aerosol generator in order to increase the moisture content of the supply air in the construction with the technique that is described in the Swedish patent No. SE 534 398 C2.

[0005] In the summer time, when sometimes there is a need of cooling, the heat exchanger may give an undesired heating of the intake air through heat transfer from warm exhaust air, which has been heated by people and equipment indoors. A frequent solution to this problem is to arrange a thermostatically or manually operated by-pass channel for the exhaust air, internally in the ventilation assembly or as an addition to the assembly. This will, however, result in a more complicated and thus more bulky and mote cost demanding construction, while at the same time the need for occasional cooling of the intake air, if the temperature outside is high, remains. Further, during certain temperature and moisture conditions a clogging of water droplets might occur on the intake air side of the heat exchanger with accompanying increase of the air resistance.

[0006] Thus, there is a desire to provide a heat exchanger and a ventilation assembly lacking the above drawbacks, not least regarding the undesired increase of the air resistance.

[0007] According to an aspect of the invention, an exchanger is characterized, in that each of the sets of channels comprise at least one cross-directional drainage channel for draining off condensate.

[0008] A ventilation assembly can comprise a heat exchanger according to the above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The invention will now be described with reference to the accompany in g drawings, on which;

[0010] FIG. **1**A shows a partly cut up view in perspective of a heat exchanger according to one embodiment of the invention;

[0011] FIG. **1**B shows a view corresponding to the view in FIG. **1**A of a second embodiment of the heat exchanger according to the invention;

[0012] FIG. **2** shows a cross-sectional view along a horizontal plane through a pan of the heat exchanger;

[0013] FIG. **3**A shows a partly cut up view of the heat exchanger according to the invention;

[0014] FIG. **3**B shows a view corresponding to the view in FIG. **3**A of one detail of the heat exchanger; and

[0015] FIG. **4** shows a principal outline of a ventilation assembly according to the invention.

DETAILED DESCRIPTION

[0016] FIG. **1**A shows a first embodiment of a heat exchanger **25**, which comprises a number of pleated plates **1**, which are mounted between smooth plates **2**. The pleated plates **1** can in principal also be comprised of a larger number of thin ribs, being arranged to form an angle in relation to each other, in order to build up the pleated structure. Hereby are formed two sets of adjacent channels **5**, **6** for outgoing room air (exhaust air) and incoming outside air (intake air).

[0017] The pleated plate **1** has according to a preferred, embodiment of the invention at least one flattening **26** forming drainage channels **4** for condensation water, one on each side of the flattening **26**, for the two sets of channels **5**,**6**. The drainage channels **4** might have varying designs, having in common that the two sets of channels **5**, **6** remain closed in relation to each other, so that the two air streams with exhaust air and intake air, respectively, are not mixed.

[0018] The object of the drainage channels **4** is that condensed moisture from the respective air stream shall be led from the channels **5**, **6** to the respective drainage channel **4**, and flow to a collecting vessel **19**. The drainage channels **4** are therefore advantageously upright, preferably substantially vertical, while the channels **5**, **6** preferably form an angle with a horizontal plane, so that droplets of condensed moisture in the channels **5**,**6** are made to flow in a direction towards one or the drainage channels **4**. When the condensate droplets arrive at some of the drainage channels **4** they will flow downwards along the flattening **26** or some of the other walls in the drainage channel **4**, and finally be guided down into a collecting vessel **19** (see FIG. **4**), Condensate will fall out both in contact with the walls of the channels **5**, **6** and in contact with the walls of the drainage channels **4**, but irrespective of where the condensation takes place, the condensate shall be guided to the collecting vessel **19**.

[0019] FIG. **1**B shows a second embodiment of the invention with plates **1** with pleats or cavities, mounted in such a way that channels **5** for outgoing room air and **6** for incoming outside air lying adjacent to each other are formed between the plates. The plates **1** according to the invention shown here also have a flattening **4** forming vertical drainage channels for condensed water. The pleated plate or plates **1** are surrounded by external, smooth plates **2**, which are not shown in FIG. **1**B.

[0020] FIG. **2** shows a cross section in a horizontal plane through, the area around the flattening **4** and shows how the room air (exhaust air) **5**A, and the incoming outside air (intake air) **6**A in counter flow are fed on either side of the flattened part **26** of the heat exchanger plate **1**. For the sake of clarity it should be noted that the two air streams **5**A, **6**A are somewhat displaced in view of each other in a direction perpendicular to the plane of the drawing, and they are separated so that the air streams **5**A, **6**A are not mixed with each other. In that way an efficient transport of two air volumes take place, so that an exchange of the air in the ventilated space takes place.

[0021] However, a transfer of heat can take place from one of the air streams **5**A to the other **6**A, through the thin walls of the pleated plate **1**, which are manufactured in such a material and with such a thickness that heat transfer is favored.

[0022] FIG. **3** A shows a planar view of the room air side (exhaust air side) of a heat exchanger plate **1**. The upper and lower edges **8**, **27** and the channels **5**, **6** of the plate **1** form an angle in relation to a horizontal plane, so that condensate in the channels **5**, **6** under the gravitational effect is brought to flow in a direction towards the flattened parts **26**, being parts of the drainage channels **4**A, **4**B and **4**C. In their upper edge **9** all heat exchanger plates **1** are sealed against the surroundings, in the lower edge **27** on the room air side there is a water collecting channel **9** with an outlet opening **10** between the plates, and on the intake side there is a corresponding water collecting channel **11** with an outlet opening **12** between the plates **1**. The outlet openings **10** and **12** are connected to transversal collecting channels **13**, **14**. The condensate flows down into a water collecting channel **9** at the lower edge **27** of the plate **1** and finally out through, a channel **13**.

[0023] FIG. **3**B shows a corresponding detail of the intake side with a channel **11** for water collecting and a channel **14**, which are separate from corresponding details of the exhaust side in order to guarantee that the air streams **5**A, **6**A do not get mixed with each other.

[0024] With this suggested design of the heat exchanger plates the condense water of the room air will be removed from the air channels before the water reaches zones where there is a risk that the water freezes.

[0025] The heat exchanger plates **1** have completely or partly been given a hydrophobic surface structure, which facilitates the drainage, since the adherence of the condensed water to the surfaces decreases, and in that droplets are more easily formed. The surface of the condensed water towards the surrounding air is also reduced and the risk for the condensed water to vaporize anew is reduced, which in turn leads to a more efficient dehumidification of the air streams **5**A, **6**A, which move through the heat exchanger. Further, the heat exchanger has been designed with one or several vertical drainage channels **4** for leading away of the condensed water, in that way the need of additional heating in the beat exchanger can be avoided completely or partly and the total efficiency of the heat exchanger will be higher.

[0026] The hydrophobic surface structure can be achieved in a number of different ways. One way is to give the surface a nanostructure by coating the surfaces with a suitable agent. For plastic surfaces it could be an agent containing silicon compounds so that silicon crystals are formed, which clog microscopic pores which could exist in the surface of a plastic material. Another way to achieve a nanostructure is to emboss it in the surface during the manufacture of the walls of the channels **4**, **5**, **6**.

[0027] FIG. **4** shows a cross-section (principal view) of a ventilation assembly **28** according to the invention, wherein heat exchanger plates **1** according to the above are comprised. The room air (exhaust air) **5**A is filtered in the filter **15** and the incoming outside air (intake air) in the filter **16**.

[0028] Condensed water from the exhaust air **5**A is collected in the channel **13** and any condensate from the outside air **6**A (in a warm, moist climate) is collected in the channel **14**. From the channels **13** and **14** condensed water is fed through pipes or hoses **17**, **18** down so far under the surface in a water vessel **19** that air passage between the pipes **17** and **18** is prevented.

[0029] The vessel **19** is assembled with a water vessel **20** in which are arranged piezoelectric ultrasound generators **21** and **22**, which in the preferred embodiment are two in number. The ultrasound generators **21** and **22** can be operated separately each on their own (50 % capacity) or both together (100 % capacity). The water aerosol which is formed in the collector **23** can, according to the Swedish patent No. SE 534 398 C2, be conducted to the intake air inlet **29** or the heat, exchanger **25** between the heat exchanger **25** and a filter **16**, wherein the aerosol with the aid of the cold air stream **6**A is transported into the heat exchanger **25** in order to be able to be evaporated therein with the aid of heat from the exhaust air **5**A.

[0030] In the ventilation assembly **28** according to an aspect of the invention is optionally also used an evaporative cooling of the exhaust air **5**A by supplying a water aerosol to the exhaust air **5**A between the heat exchanger **25** and a filter **15**. The object of this is to accomplish drainage of heat from too hot intake air **6**A, for example during the summer months. In addition to the reduction of the intake air **6**A temperature, also its humidity can be lowered by the deposit of condensate on the inner surfaces of the channels **6** and which is led from the heat exchanger **25** and down into the collecting vessel **19** in the above described way

[0031] The aerosol from the ultrasound generators **21** and **22** are fed to the exhaust air inlet **30** by change-over of a control valve **24**, wherein it is evaporated and accordingly cools down, the exhaust air **5**A flowing into the heat exchanger **25**.

[0032] With a ventilation assembly **28** according to an aspect of the invention the problem with too dry air is avoided during wintertime by the integration of the ultrasound, generators **21**, **22**, which establish an aerosol for humidifying the intake air **6**A, in the construction with the technology described in the Swedish patent No. SE 534 398 C2.

[0033] Novel features of the ventilation assembly **28** according to an aspect of the invention, include that the ultrasound generators **21**,**22** here are also used for evaporative cooling of the exhaust air **5**A with the evaporation heat taken from the condensation heat of the exhaust air. Condensate in the channels **5**,**6** is led out to the drainage channels **4**, and clogging of the channels because of water droplets, or freezing of the condensate in the channels **5**, **6** is prevented thereby.

[0034] In one connection part **7**A the room air (exhaust air) **5**A corning to the heat exchanger **25** is distributed over all the channels of the heat exchanger plate **1** on its front side to be conducted through these to the opposite connection part **7**B. Incoming outside air (intake air) **6**A is distributed to the channels on the backside of the plate and is conducted out in the connection part **7**A. The connection parts **7**A, **7**B are so designed that room air **5**A flowing in to and outside air **6**A flowing out from the heat exchanger **25** exchange heat in cross flow like the room air **5**A flowing out and the outside air **6**A flowing in.

[0035] If condensate has formed in the room air channels **5** it will flow down onto the flattened part **26** or the heat exchanger plate **1** and will thus not be transported further to colder parts of the heat exchanger plate. If continued condensation occurs at the further transport of room air towards the connection part **7**B, this condensed water can be drained in several drainage channels **4**B and **4**C, closer to the outlet of the room air. If condensation occurs on the intake air side of the heat exchanger plates **1**, this condensed water can be drained in the corresponding way.

[0036] The condensed water in the channels **4** can on the room air side freely flow out through the opening **10** down into the transversal collecting channel **13**. During summertime, at evaporative cooling of the exhaust air **5**A, moisture in the incoming outside air **6**A condenses on the intake air side of the heat exchanger plates **1** and there it flows out through the opening **12**, and down into the transversal collecting channel **14**.

[0037] Discharge of condensed water down, into the channels **4** is facilitated if the surface of the heat exchanger plate **1**, especially at the channels **4** have hydrophobic properties, e.g. with the aid of nanotechnology, as has been discussed above. Quicker and more complete drainage of condensed water front all air channels **5**, **6** of the heat exchanger plate **1** is facilitated if the whole heat exchanger plate **1** has corresponding hydrophobic properties. Tests have proven that the drainage from the heat exchanger plates **1** can be further improved it the plates **1** can be vibrated with aerodynamic or mechanical appliances.

1. A heat exchanger comprising two sets of channels arranged adjacent to each other for heat exchange between a first and a second air stream, wherein each of the sets of channels comprise at least one transversal drainage channel for drainage of condensate.

2. The heat exchanger according to claim **1**, wherein the drainage channels are substantially vertical.

3. The heat exchanger according to claim **1**, wherein the channels have inside surfaces with a hydrophobic surface layer.

4. The heat exchanger according to claim **3**, wherein the surface layer has a nanostructure.

5. The heat exchanger according to claim **1**, wherein each set of channels for the air streams form an angle with the horizontal plane of 0 to 30°.

6. The heat exchanger according to claim **1** , wherein the drainage channels are connected to a collecting vessel.

7. A ventilation assembly comprising a heat exchanger according to claim **1**.

8. The ventilation assembly according to claim **7**, wherein the first and the second air streams are intake air and exhaust air, respectively, and in that means are arranged for evaporative cooling of the exhaust air before it is led into the channels of the heat exchanger.

9. The ventilation assembly according to claim **7**, wherein means are arranged for shifting between evaporative cooling of the intake air and the exhaust air, respectively.

10. The ventilation assembly according to claim **7**, wherein a mist generator is arranged in order to obtain the evaporative cooling.

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