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(54) Title: A HEAT EXCHANGER AND A VENTILATION ASSEMBLY COMPRISING IT

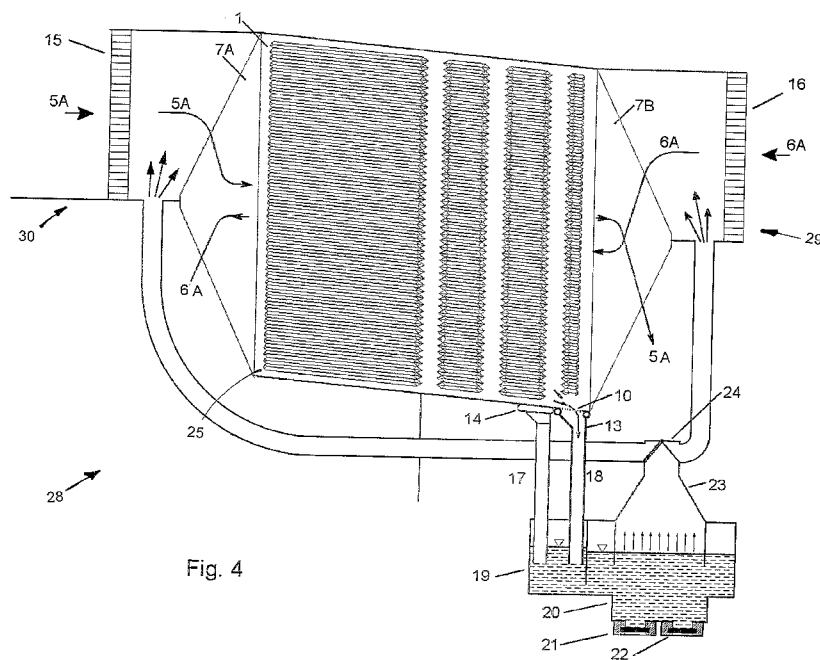


Fig. 4

(57) Abstract: A heat exchanger comprising two sets of channels (5, 6) arranged adjacent to each other, for heat exchange between a first and a second air stream. Each of the sets of channels (5, 6) comprises at least one transversal drainage channel (4) for drainage of condensate, and a ventilation assembly comprising such a heat exchanger.

A heat exchanger and a ventilation assembly comprising it

TECHNICAL FIELD

- 5 The present invention relates 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 to a ventilation assembly.

PRIOR ART

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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-

15 house air (exhaust air) and incoming air from the outside (intake air) in counter-flow. 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.

20

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

25 heating in the heat exchanger.

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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.

5 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 more cost demanding
10 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.

15 THE PROBLEM

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.

20 SOLUTION OF THE PROBLEM

The object of the invention is achieved for the exchanger discussed in the preamble of the application being characterized in that each of the sets of channels comprise at least one cross-directional drainage channel for draining off condensate.
25

Further advantages will be achieved if the heat exchanger is further characterized by one or several of the features according to claims 2 – 6.

Regarding the ventilation assembly the object is achieved when it comprises a heat
30 exchanger according to the above, and further advantages are achieved when it is further characterized by one or several of the features according to claims 8 – 10.

SHORT DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings, on which:

- 5
- Fig. 1A shows a partly cut up view in perspective of a heat exchanger according to one embodiment of the invention;
- 10 Fig. 1B shows a view corresponding to the view in Fig. 1A of a second embodiment of the heat exchanger according to the invention;
- Fig. 2 shows a cross-sectional view along a horizontal plane through a part of the heat exchanger;
- 15 Fig. 3A shows a partly cut up view of the heat exchanger according to the invention;
- Fig. 3B shows a view corresponding to the view in Fig. 3A of one detail of the heat exchanger; and
- 20 Fig. 4 shows a principal outline of a ventilation assembly according to the invention.

PREFERRED EMBODIMENT

- 25 Fig. 1A 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
- 30 air (intake air).

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.

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.

Fig. 1B 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. 1B.

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) 5A, and the incoming outside air (intake air) 6A 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 5A, 6A 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 5A, 6A 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.

- 5 However, a transfer of heat can take place from one of the air streams 5A to the other 6A, 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.

Fig. 3A 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 4A, 4B and 4C. 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.

20

Fig. 3B 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 5A, 6A do not get mixed with each other.

- 25 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.

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

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water to vaporize anew is reduced, which in turn leads to a more efficient dehumidification of the air streams 5A, 6A, 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 heat exchanger can be avoided completely or partly and the total efficiency of the heat exchanger will be higher.

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.

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) 5A is filtered in the filter 15 and the incoming outside air (intake air) in the filter 16.

Condensed water from the exhaust air 5A is collected in the channel 13 and any condensate from the outside air 6A (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.

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 6A 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 5A.

In the ventilation assembly 28 according to the invention is optionally also used an
5 evaporative cooling of the exhaust air 5A by supplying a water aerosol to the exhaust air 5A between the heat exchanger 25 and a filter 15. The object of this is to accomplish drainage of heat from too hot intake air 6A, for example during the summer months. In addition to the reduction of the intake air 6A 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
10 the heat exchanger 25 and down into the collecting vessel 19 in the above described way

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 5A flowing into the heat exchanger 25.

15 With a ventilation assembly 28 according to 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 6A, in the construction with the technology described in the Swedish patent No. SE 534 398 C2.

20 The novel features of the ventilation assembly 28 according to the invention are that the ultrasound generators 21, 22 here are also used for evaporative cooling of the exhaust air 5A 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
25 channels because of water droplets, or freezing of the condensate in the channels 5, 6 is prevented thereby.

In one connection part 7A the room air (exhaust air) 5A coming to the heat exchanger 25 is distributed over all the channels of the heat exchanger plate 1 on its front side to be
30 conducted through these to the opposite connection part 7B. Incoming outside air (intake air) 6A is distributed to the channels on the backside of the plate and is conducted out in the connection part 7A. The connection parts 7A, 7B are so designed that room air 5A

flowing in to and outside air 6A flowing out from the heat exchanger 25 exchange heat in cross flow like the room air 5A flowing out and the outside air 6A flowing in.

5 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 7B, this condensed water can be drained in several drainage channels 4B and 4C, 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
10 the corresponding way.

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 5A, moisture in the incoming outside air 6A
15 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.

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
20 the aid of nanotechnology, as has been discussed above. Quicker and more complete drainage of condensed water from 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 if the plates 1 can be vibrated with aerodynamic or mechanical appliances.
25

CLAIMS

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, **characterized in that** each of the
5 sets of channels (5, 6) comprise at least one transversal drainage channel (4) for drainage of condensate.
2. The heat exchanger according to claim 1, **characterized in that** the drainage
10 channels (4) are substantially vertical.
3. The heat exchanger according to claim 1 or 2, **characterized in that** the channels (4,
5, 6) have inside surfaces with a hydrophobic surface layer.
4. The heat exchanger according to claim 3, **characterized in that** the surface layer has
15 a nanostructure.
5. The heat exchanger according to any of claims 1-4, **characterized in that** each set of
channels (5, 6) for the air streams form an angle with the horizontal plane of 0 to 30°.
- 20 6. The heat exchanger according to any of claims 1-4, **characterized in that** the
drainage channels (4) are connected to a collecting vessel (19).
7. A ventilation assembly comprising a heat exchanger according to any of claims 1 –
6.
25
8. The ventilation assembly according to claim 7, **characterized in that** 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 (5A) before it is led into the channels
(5) of the heat exchanger.
30

9. The ventilation assembly according to claim 7 or 8, **characterized in that** means are arranged for shifting between evaporative cooling of the intake air (6A) and the exhaust air (5A), respectively.
- 5 10. The ventilation assembly according to claim 7 or 8, **characterized in that** a mist generator (21, 22) is arranged in order to obtain the evaporative cooling.

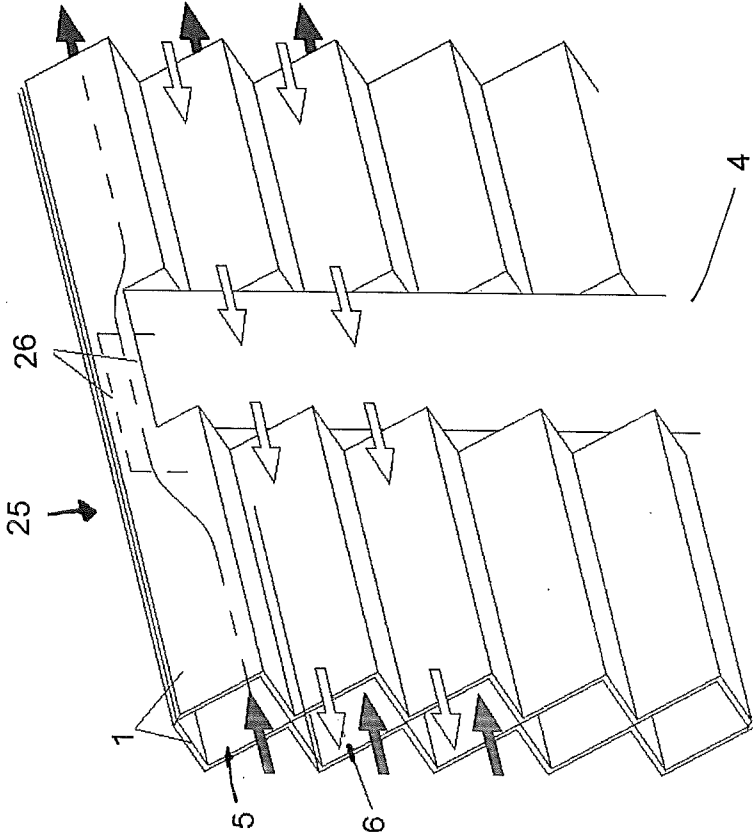


Fig. 1B

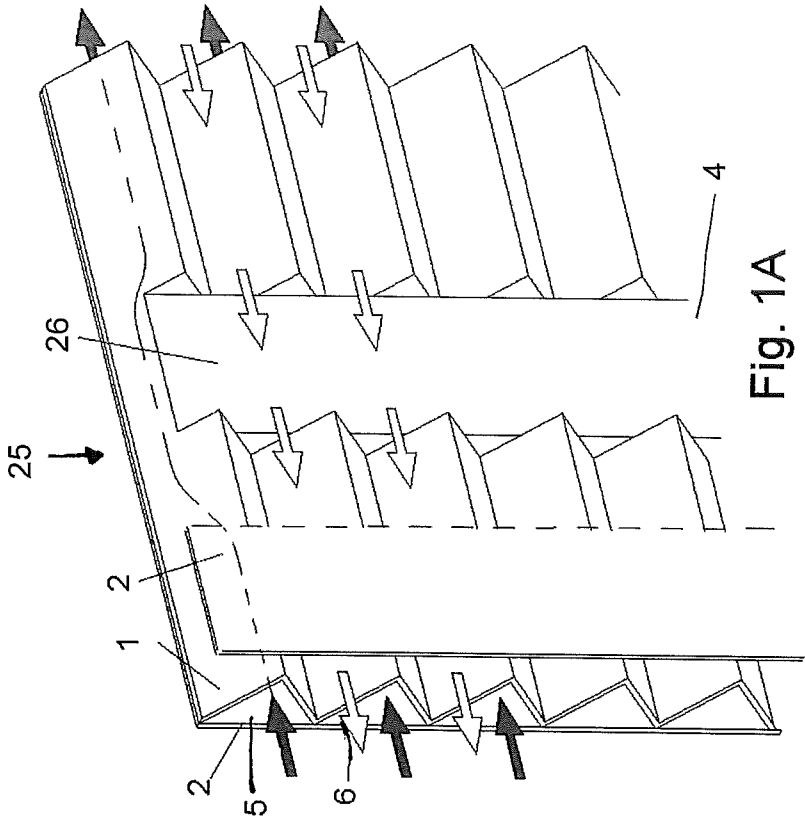


Fig. 1A

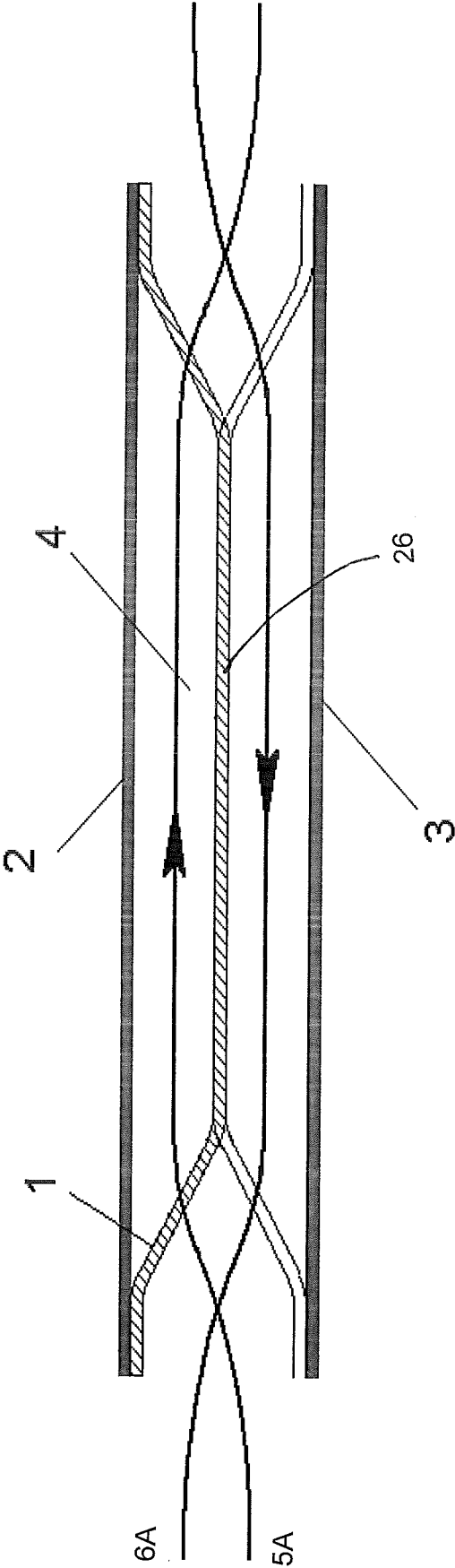
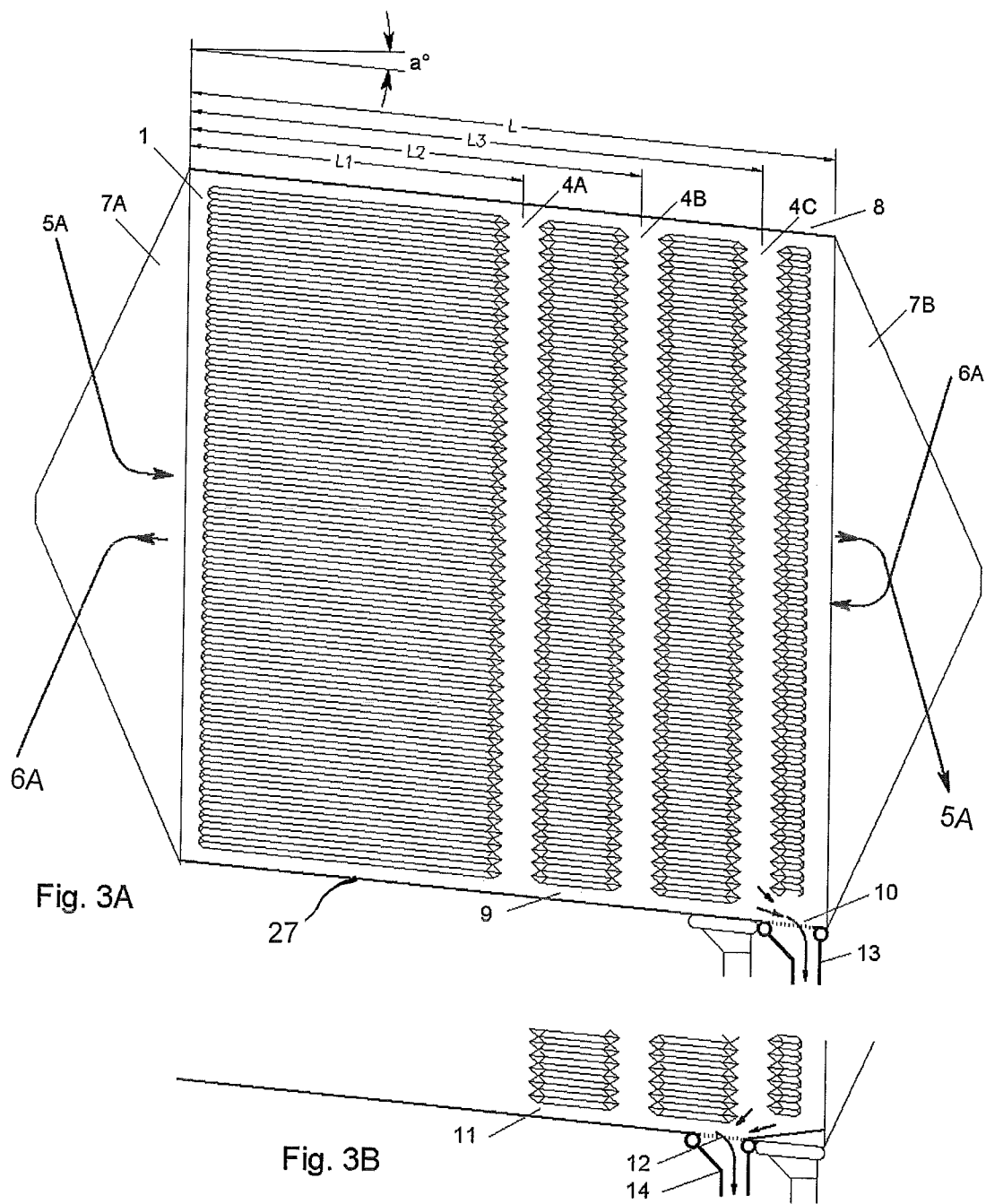


Fig. 2



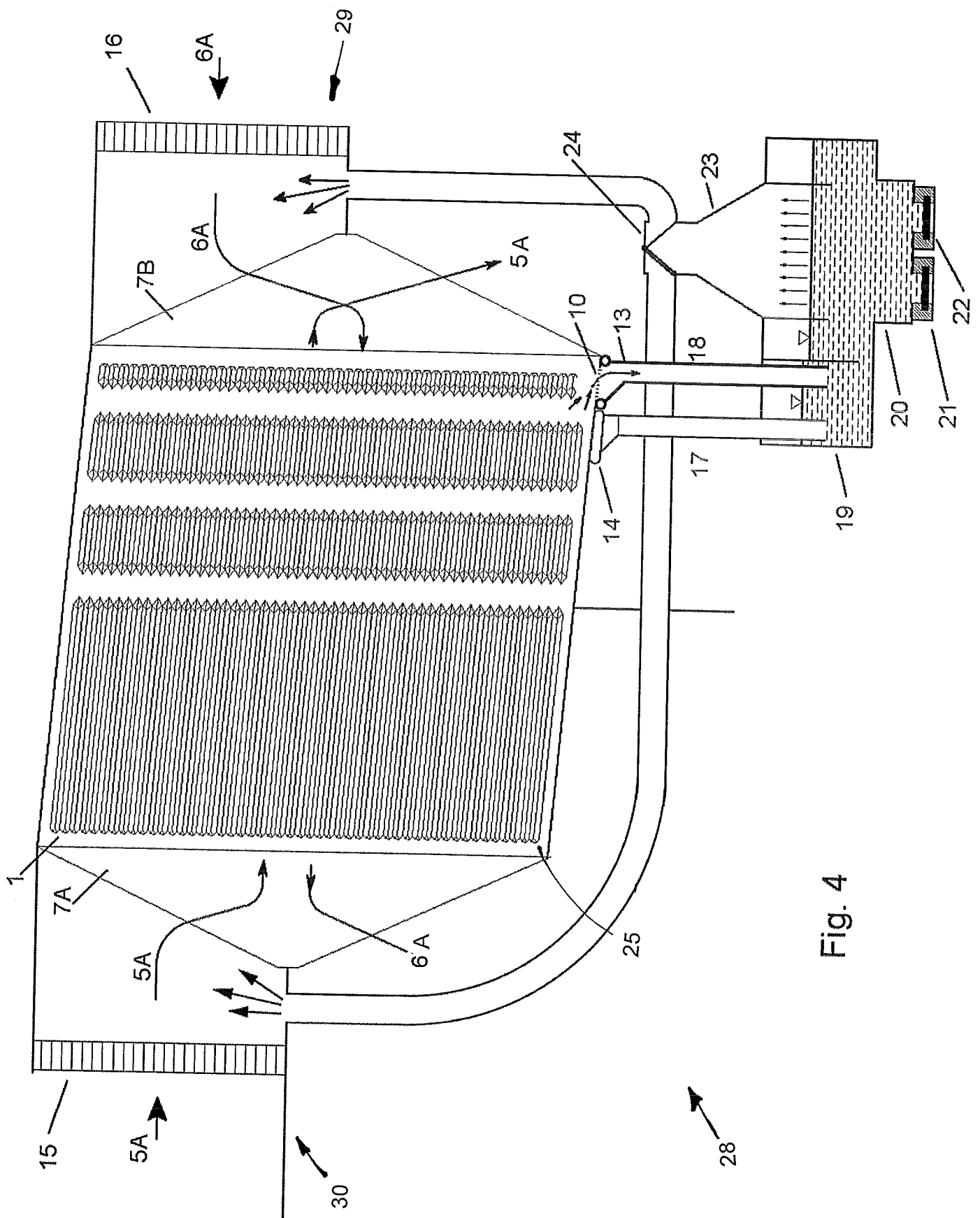


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2013/051315

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F24F, F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20010032714 A1 (HAGLID KLAS C), 25 October 2001 (2001-10-25); abstract; paragraphs [0002], [0004], [0013], [0044], [0050], [0086], [0092]-[0095]; figures 1,3-4,12 --	1-10
A	EP 2423628 A2 (UNIV MONS HAINAUT), 29 February 2012 (2012-02-29); claim 1 --	3-4
A	FI 91916 B (NOKIKANAKUJA HEINIÖ T), 23 April 1994 (1994-04-23); claims 1-2 --	9

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 8301998 A1 (ALFA LAVAL AB), 9 June 1983 (1983-06-09); abstract; figure 2 -- -----	1-6

Continuation of: second sheet**International Patent Classification (IPC)*****F28F 17/00*** (2006.01)***F24F 12/00*** (2006.01)***F24F 13/22*** (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

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