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(54) HEAT EXCHANGE PLATE AND METHOD FOR MANUFACTURING A HEAT EXCHANGE PLATE

(57) The invention relates to a heat exchange plate (1), plate block (20), heat exchanger (2) and method for manufacturing a heat exchange plate. The invention relates specifically to a novel way of arranging air flows in an air-to-air heat exchanger (2).

The heat exchange plate (1) is primarily planar and comprises first and second shapes (10, 11) on the first and second surface of the heat exchange plate. The first and second shapes comprise recesses (10) and protrusions (11) that are formed on the corresponding locations on the opposite surfaces of the heat exchange plate.

The plate block (20) comprises several heat exchange plates (1) arranged on top of one another, and the heat exchanger (2) comprises the plate block (20).

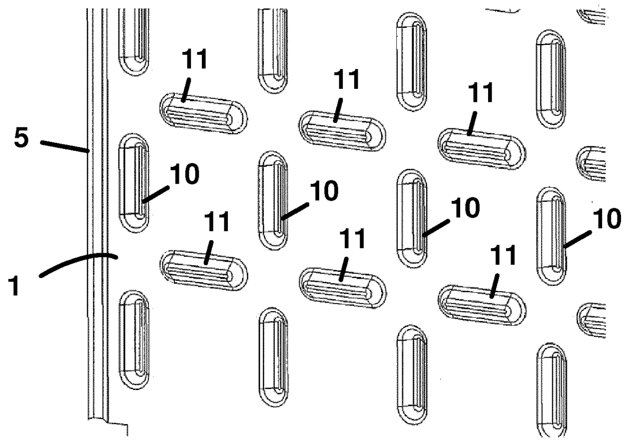

Fig. 4

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Description

TECHNICAL FIELD OF INVENTION

[0001] The present invention relates to a heat exchange plate, plate block, heat exchanger and method for manufacturing a heat exchange plate, as presented below in the introductions of the independent claims. The invention relates specifically to a novel way of arranging air flows in an air-to-air heat exchanger.

PRIOR ART

[0002] Air-to-air heat exchangers are used for example in industrial plants to recover heat from the air removed from a machine room. The air flow to be cooled and the air flow to be heated are led into a heat exchanger, where the air flows flow on different sides of a heat exchange plate on its heat exchange surfaces, without mixing with each other. The heat is transferred to the air flow to be heated via the heat exchange plate. Several heat exchange plates are typically stacked on top of one another to form a plate block. Plate gaps, in other words airflow channels, are left between the plates for the air flows. The air flow to be cooled and the air flow to be heated alternate in every second plate gap.

[0003] The heat exchange and air flows can be controlled for example by determining the size of the plate gaps to a desired dimension. Various kinds of pieces and flow shapes can be arranged in the air flow channels to guide the air flow and to cause turbulence in the air flow. Some of the plate gaps are closed and sealed for example at the edges of the heat exchange plates in order to guide the air flows in a desired manner. Support pieces of suitable sizes can be placed in the plate gaps to keep a suitable plate gap dimension. The support pieces can also serve as flow shapes.

[0004] For example patent publications US5816315A and US8784529B2 present air-to-air heat exchangers.

[0005] The supporting of the heat exchange plates to each other, in other words keeping the plate block together so that the desired plate gaps are kept, requires support structures. One way is to penetrate the plate block by means of draw rods. The openings made in the heat exchange plates require sealing. The draw rods, the openings made for them, the seals, support pieces and corresponding parts make the structure of the heat exchanger more complex. They also increase the risk of leaks, corrosion and structural breakdowns.

[0006] Pieces, support pieces, support structures and corresponding parts fastened to the heat exchange plates, placed for example in the plate gaps, cover some of the heat exchange surfaces, thus impairing the efficiency of heat exchange.

OBJECT OF INVENTION

[0007] The object of the present invention is to reduce or even to eliminate the above-mentioned problems appearing in the prior art.

[0008] One object of the present invention is to accomplish a simple and durable air-to-air heat exchanger specifically for industrial use.

[0009] One object of the present invention is to accomplish an air-to-air heat exchanger that operates more efficiently than earlier.

SHORT DESCRIPTION OF INVENTION

[0010] In order to realise the above-mentioned objects, among others, the heat exchange plate, plate block, air-to-air heat exchanger, method and other targets of the invention are characterised by what is presented in the characterising parts of the enclosed independent claims.

[0011] In this text, said application examples and advantages concern, as applicable, the heat exchange plate, plate block, air-to-air heat exchanger and method according to the invention, even though this is not specifically mentioned every time.

[0012] In a typical air-to-air heat exchanger, the first air flow releases heat to the heat exchange plate and the second air flow receives heat from the heat exchange plate. Several heat exchange plates are typically stacked on top of one another to form a plate block, which is placed inside the heat exchanger. The air flows are arranged to flow through the plate block. Heat exchange plates located on top of one another refer to plates that are stacked in a plate block and are typically in contact with each other.

[0013] A typical heat exchange plate according to the invention is primarily planar and comprises:

- an outer edge,
- a first surface on the first side of the heat exchange plate,
- a second surface on the second side of the heat exchange plate, in other words on the side opposite to the first surface,
- first and second shapes on the first and second surface of the heat exchange plate.

The first and second shapes comprise local recesses and protrusions that are formed on the heat exchange plate itself and on corresponding locations on the opposite surfaces of the heat exchange plate and that deviate from the general plane of the heat exchange plate. The first and second shapes guide the air flows that travel along the surfaces, and cause desired turbulence in the air flow.

[0014] In a typical method according to the invention, for the manufacture of a primarily planar heat exchange plate, several shapes that guide the air flow are arranged on a primarily planar metal plate, which shapes are intended to cause turbulence in the air flow that travels along the heat exchange plate. The method also comprises at least the following stages:

- several recesses are pressed to a primarily planar metal plate,
- protrusions are formed at the same time at the location of the recesses on the opposite side of the metal plate,

in which case said recesses and protrusions form said shapes.

[0015] It has been noticed now that the shapes that are needed in the air-to-air heat exchanger and that guide the air flow can be manufactured by pressing recesses in the heat exchange plate or its preform, in other words in the metal plate, in which case a corresponding protrusion is created on the other side of the plate. The pressing can be carried out for example by using the so-called stretch forming technique. When the shapes that guide the air flow are an integral part of the heat exchange plate itself, there is not necessarily a need to have separate parts or pieces or other shapes in the heat exchanger to guide the air flow. The shapes also serve as stiffeners of the heat exchange plate. The surface area of a plate stretched for the recesses is larger than that of a straight plate, so the effective heat exchange area of the heat exchange plate is larger than in a straight plate.

[0016] The shapes according to the invention can also be referred to with terms flow shape, flow guide shape or shape that guides the flow.

[0017] A typical plate block according to the invention comprises several heat exchange plates according to the invention, arranged on top of one another. The plate pack further comprises:

- sides formed by the outer edges of the heat exchange plates located on top of one another,
- plate gaps arranged in the gaps between the heat exchange plates located on top of one another. Some plate gaps, such as every second plate gap, are arranged as the air flow channel of the first air flow. Some plate gaps, such as every second plate gap, are arranged as the air flow channel of the second air flow.

Such a plate block is simple and easy to manufacture.

[0018] A typical air-to-air heat exchanger according to the invention comprises:

- a body structure, which comprises the inlet connections and outlet connections of the first and second air flow,
- a plate block according to the invention, which plate block is arranged inside the body structure so that:
    - the air flow channels of the first air flow of the plate block are connected to the inlet connections and outlet connections of the first air flow of the support structure, and
    - the air flow channels of the second air flow of the plate block are connected to the inlet connections and outlet connections of the second air flow of the support structure,
- support devices, which fasten the plate block to the body structure so that the plate block can be removed.

The support devices can be openable and closable for example by means of screw fastening. Such a heat exchanger is very simple and easy to manufacture and service.

[0019] In one application, the protrusions, in other words the flow shapes, located on the same side of a single heat exchange plate, or at least some of them, are in contact with the next heat exchange plate. In this case, the height of the protrusions from the general plane of the heat exchange plate determines the size of the plate gap between said heat exchange plates. In this way, no separate support pieces are needed in the plate gaps to keep a suitable plate gap dimension. In this way, the shapes according to the invention, in other words the configurations of the surfaces of the heat exchange plate, simultaneously arrange suitable plate gaps, and guide and create turbulence in the air flows. The height of the protrusions, in other words the size of the plate gap, can be set to a dimension suited to each situation. It can be for example 20 - 100 mm, 3 - 50 mm, 5 - 30 mm or 10 - 20 mm.

[0020] In one application, the heat exchange plate can also include shapes or configurations other than those according to the invention. The other shapes can have a height and/or depth of for example $\pm$ 5 mm from the general plane of the heat exchange plate. The height of the other shapes can be for example less than one half or less than one third of the height of the shapes according to the invention. For example, stiffeners or shapes needed for the assembling or fastening of the plate block can be formed in the heat exchange plate.

[0021] In one application, the first and second shapes are formed to be elongated in the direction of the plane of the plate. An elongated shape typically has two long edges and end edges that connect the long edges. In one application, all flow shapes of a single heat exchange plate are primarily parallel. By means of elongated and/or parallel flow shapes, the air flow travelling in a plate gap can be guided in a desired manner. In one application, the protrusions in each air flow channel are elongated in the primary flow direction of the air flow that flows in the air flow channel. In other words, the elongated protrusions guide the air flow along their long side. It is easy to make mutually similar and parallel recesses in a metal plate.

[0022] The length of the heat exchange plate in the flow direction can be for example more than 1 m, 1 - 3 m, 2 - 3 m or more than 2 m.

[0023] In one application, the elongated flow shape extends over the entire distance of the heat exchange plate, at least almost from edge to edge of the plate. As an example, the length of the shape can be more than 50% or more than 80% or more than 90% of the length of the heat exchange plate in the flow direction. In one application, all the shapes of the heat exchange plate are long. In this way, the airflow can be kept as several separate partial flows even in the same plate gap.

[0024] In one application, the elongated flow shape is considerably shorter than the length of the plate in the flow direction. As an example, the length of the shape can be less than 50%, less than 20%, less than 10% or less than 5% of the length of the heat exchange plate in the flow direction. In one application, all the heat exchange plate shapes according to the invention are short. From the gaps of the short flow shapes, the air flow can mix inside the same plate gap. This can be advantageous, at least if the air flow coming to different locations of the plate gap is uneven for example in terms of its temperature or humidity. Short shapes allow a flow even if there was a blockage in some location of the plate gap. Said short shapes can be local, discontinuous and intermittent ridges and recesses arranged in a line, which ridges and recesses deflect the flow at several locations along the distance of the heat exchange plate.

[0025] The shape can be for example a circle or oval in the direction of the plane of the heat exchange plate. The flow shape can have primarily straight longer edges and rounded end edges for example in the shape of a semi-circle. The size of the flow shape in the direction of the plane of the heat exchange plate, in its longitudinal direction, can be for example 40 - 300 mm, 60 - 160 mm or 90 - 120 mm. Correspondingly, the size of the flow shape in its width direction can be for example 10 - 150 mm, 25 - 75 mm or 40 - 60 mm.

[0026] In one application, the elongated shape has a bottom/peak, which can be primarily flat. The surface area of the bottom/peak is essentially smaller than the surface area remaining between the edges of the root of the flow shape. The sides of the flow shape are formed between the bottom/peak and edges of the flow shape.

[0027] In one application, less than 30%, for example 5 - 30% or 15 - 25%, of the surface of the heat exchange plate is formed into flow shapes. In this case, there is efficient through-flow and sufficient turbulence.

[0028] The heat exchange plate is typically of metal, for example rustproof steel or stainless steel.

[0029] The plate thickness used in the heat exchange plate is always selected to suit the situation. Potential plate thicknesses include for example 0.2 - 0.5 mm, 0.3 - 0.4 mm or 0.3 - 0.5 mm. The mouldability and heat transfer of thin plate are better than those of thick plate.

[0030] The width of the heat exchange plate in one flow direction can be for example 500 - 1500 mm or 800 - 1200 mm or 950 - 1000 mm. The length of the heat exchange plate in the other flow direction can be for example 1500 - 4000 mm or 2500 - 3500 mm.

[0031] There can be for example 50 - 200 or 80 - 120 heat exchange plates, for example 100 heat exchange plates, in a single plate block. The thickness of the plate block can be for example 600 - 2700 mm or 1200 - 1800 mm or approximately 1500 mm.

[0032] In a typical application, the plate block is assembled and installed in the heat exchanger so that the heat exchange plates are vertical. The plate block is typically installed so that the shorter longitudinal direction of the heat exchange plates is vertical in the heat exchanger.

[0033] In one application, the flow shapes of the heat exchange plates are elongated in the direction of the plane of the plate, and the flow shapes of the heat exchange plates located on top of one another have intersecting directions. In this way, the air flows travelling on different sides of the same plate can be made to travel as a cross flow. The angle between the flow shapes of the heat exchange plates located on top of one another can be set to suit each situation. The angle can be for example 45 - 135 degrees or 80 - 100 degrees or approximately 90 degrees between every second heat exchange plate.

[0034] In one application, at least some and even all protrusions of the heat exchange plates are in contact with the edges of the recesses of the next heat exchange plate, at least to some extent. In other words, the flow shapes of the heat exchange plates located on top of one another are at least approximately at corresponding locations. Even though the protrusions primarily guide the air flow along their long side fluently through the heat exchanger, the protrusions also guide air into the recesses that are at the location of the protrusions and that are transversal or intersecting in relation to the direction of travel of air. This intensifies turbulence and heat exchange. At the same time, the air flow channels remain open also at the location of the flow shapes. Flow in a plate gap is totally prevented only at those typically small locations where the plates located on top of one another are in contact.

[0035] In one application, the flow shapes in the heat exchange plates located on top of one another, in other words the recesses and protrusions, are elongated and intersecting so that a protrusion in one heat exchange plate is in contact with both long edges of a recess in the next heat exchange plate. This intensifies turbulence and heat exchange further. At the same time, the airflow channels remain open also at the location of the flow shapes. Flow in a plate gap is totally prevented only at those typically even smaller locations where the plates located on top of one another are in contact.

[0036] The flow shapes that intersect each other and/or are at corresponding locations support the heat exchange plates located on top of one another to each other at a few rare points of contact, for example at a few point-like or short line-like or elongated points of contact or otherwise at points of contact with a small surface area. If such points of contact are always at the same location in the entire plate block, the support point can be placed at the same location over the distance of the entire plate block.

[0037] In one application, the peak of the flow shape is arranged into contact with the next heat exchange plate at the location of the point of contact. In one application, primarily all points of contact between the heat exchange plates are located at the location of the peaks of the flow shape.

[0038] The invention makes it possible that there are only few points of contact between the heat exchange plates located on top of one another. The surface area of the points of contact on the inside of the outer edges of the heat exchange plates can be for example less than 1%, less than 0.5%, less than 0.2%, 0.05 - 1% or 0.1 - 0.5% of the surface area of the plate.

[0039] In one application, all recesses are on the same side of the heat exchange plate, and all protrusions are on the opposite side of the heat exchange plate. The manufacture of such a heat exchange plate is easy, because the modification of the recess can be performed from the same direction. It is even possible to form all flow shapes at the same time. The setting of such heat exchange plates to form a plate block can be made easy, because it is easy to arrange the protrusions in the previous plate to coincide with the recesses in the next plate.

[0040] In one application, the heat exchange plate has no openings over its entire surface between the outer edges. In one application, the plate block only contains such heat exchange plates, in which case the entire plate block is without openings over its surface between the outer edges. The plates without openings are durable, the likelihood of leaks is small, and in practice the entire surface area of the plate is in heat exchange use.

[0041] In one application, the support devices of the air-to-air heat exchanger comprise members that support only the plate block from the outside. The heat exchange plates can be supported for example only from their outer edges, for example by pressing only the first and last heat exchange plate of the plate block towards each other. The support devices can be for example beams that support the plate block, between which beams the plate block is installed. When heat exchange plates without openings are used in such a heat exchanger, a very efficient, easy-care and durable solution is accomplished.

[0042] In one application, the heat exchange plate is primarily a rectangle, in which case its outer edge is composed of four primarily straight edges. It is easy to stack rectangular plates to form a straight block. A plate block assembled from such heat exchange plates is primarily a rectangular prism. All sides of the plate block can be primarily planar.

[0043] In one application, every second plate gap on each side of the plate block is closed tightly and every second plate gap is open. The plate gaps can be closed for example by welding or press seaming the edges of the plates tightly to each other. In this way, the air flow channels of the first air flow can be arranged to open to the first side and to the third side opposite to it. Correspondingly, in this case the air flow channels of the second air flow can be arranged to open to the second side and to the fourth side opposite to it. Such a plate block hence operates under the so-called cross-flow principle. It is easy to install a plate block operating under the cross-flow principle in the heat exchanger, where the inlet and outlet connections of the first air flow are in conjunction with the first side and in conjunction with the third side opposite to it. Correspondingly, the inlet and outlet connections of the second air flow are in conjunction with the second side and in conjunction with the fourth side opposite to it.

[0044] In one application, a corner of the rectangular heat exchange plate or a piece of its edge has been cut off. In this way, a notch is formed on the corner or edge of the plate block. The beam that supports the plate block or a corresponding support member can be arranged in this notch. The notch and support member keep the plate block firmly in place in the heat exchanger. A seal can be installed between the notch and support member to prevent leaks from the plate block.

[0045] In one application, the entire plate block is of the one and the same material such as steel. In this way, thermal expansion is even throughout the plate block. The simplicity of the structures according to the invention also increases the heat resistance of the equipment.

[0046] An air-to-air heat exchanger refers to all gas-to-gas heat exchangers suited to the purpose. The invention can be used in various industrial applications such as in paper mills, in the metal engineering industry, in power plants and in the recovery of ventilation or flue gas heat.

[0047] The invention can be used in a heat recovery tower, which contains several plate blocks or heat exchangers according to the invention side by side and/or on top of one another. In one application, the air to be cooled is brought into the lowest plate block and led higher and higher. The cooled air can be led out for example on the roof of the mill.

[0048] It can be said that the heat exchange plates according to the invention themselves serve as the internal support structures of their plate block. The shapes according to the invention make the heat exchange plates stiff and support the plate block even at almost every location of the plate block. In this way, the plate material can be thinner than earlier, and fewer external support structures than earlier are needed. By means of the invention, the structure of the plate block is simplified, and the heat exchange surface is not wasted for external or separate support structures or flow guides. The guidance of the air flow is intensified by means of the invention. Air can flow in the plate gap even at the location of a flow shape. The invention enables more efficient, durable and lighter and hence more ecological heat exchangers than earlier.

BRIEF DESCRIPTION OF THE DRAWINGS

[0049] The invention is described in more detail below by making reference to the enclosed schematic drawing, in which:

Fig. 1 shows the heat exchange plate,
Fig. 2 shows the heat exchanger,
Fig. 3 shows the plate block with its support structure,
Fig. 4 shows a detail of the heat exchange plate,
Fig. 5 shows a detail of the plate block,
Fig. 6 shows two heat exchange plates according to the invention,
Fig. 7 shows the heat exchange plates of Fig. 6 against each other,
Fig. 8 shows the plate block from the side,
Fig. 9 shows two flow shapes according to the invention.

DETAILED DESCRIPTION OF THE EXAMPLES OF THE FIGURES

[0050] For reasons of clarity, the same reference numbers are used in the different figures and embodiments of some parts that correspond to each other.

[0051] Fig. 1 shows heat exchange plate 1 according to the invention, which heat exchange plate 1 is primarily planar and primarily rectangular. The heat exchange plate has an outer edge 5, which is composed of four primarily straight edges 12, 13, 14, 15. Fig. 1 shows the first side 6 and first surface 7 of the heat exchange plate. On the opposite side, in other words on the second side 8 of the heat exchange plate, is the second surface 9. First flow shapes or recesses 10 are pressed onto the first surface. A corresponding second flow shape or protrusion 11 is formed at the location of each recess 10 on the second surface 9.

[0052] In the heat exchange plate of Fig. 1, all recesses and protrusions are elongated in the direction of the plane of the plate and mutually parallel. All recesses 10 are on the same side of the heat exchange plate, and all protrusions 11 are on the opposite side of the heat exchange plate. The heat exchange plate 1 has no openings over its entire surface. Pieces are cut off from the corners of the heat exchange plate 1, in which case a notch 16 is formed in each corner. Beams 40, 41 or corresponding support members, which support the heat exchange plate and the plate block 20 formed from them, can be arranged in the notches 16 (see Fig. 3). The notch and support member keep the plate block 20 firmly in place. A seal can be installed between the notch and support member to prevent leaks from the plate block.

[0053] Fig. 3 shows a plate block 20, which comprises several heat exchange plates 1 arranged on top of one another. Fig. 8 shows another plate block 20 in a highly schematic manner. Fig. 5 shows a detail of a third plate block, where the heat exchange plates 1, 1b and 1c are slightly detached from each other. The primarily planar sides 22, 23, 24 and 25 of the plate block are composed of the outer edges 5 of the heat exchange plates located on top of one another. Plate gaps are formed in the gaps between the heat exchange plates 1, 1b, 1c located on top of one another. Every second plate gap 26 serves as the air flow channel of the first air flow 3, and every second plate gap 27 serves as the air flow channel of the second air flow 4. In Fig. 8, the second air flow 4 travels in plate gaps 27 perpendicularly in the direction of view of the figure, so it cannot be seen in Fig. 8.

[0054] Fig. 2 shows an air-to-air heat exchanger 2 according to the invention. In it, the first air flow 3 releases heat to the heat exchange plates 1 of the plate block 20, and the second air flow 4 receives heat from the heat exchange plates. The heat exchanger has a body structure 30, which comprises the inlet connections 31 of the first air flow, the inlet connections 32 of the second air flow, the outlet connections 33 of the first air flow and the outlet connections 34 of the second air flow. The plate block 20 is arranged inside the body structure and supported to the body structure by means of beams 40 and 41 so that the plate block 20 can be removed. The air flow channels 26 of the first air flow 3 travel in the plate block primarily in a vertical direction from the inlet connections 31 of the first air flow to the outlet connections 33. The air flow channels 27 of the second air flow 4 travel in the plate block primarily in a horizontal direction from the inlet connections 32 of the second air flow to the outlet connections 34. The inlet connections 31 of the first air flow also include a blower 35, by means of which the first air flow 3 is led in from the lower side 22 of the plate block.

[0055] The support devices shown in Figs. 2 and 3 comprise beams 40, 41, which only support the plate block 20 from the outside, in other words from the outer edges of the heat exchange plates, and which support the first and last heat exchange plate of the plate block.

[0056] Fig. 4 shows a detail of the heat exchange plate 1, where the recesses 10 and protrusions 11 are on the same side of the plate. The elongated recesses 10 are in vertical lines one after the other, and the elongated protrusions 11 are in horizontal lines one after the other.

[0057] Fig. 6 shows schematically heat exchange plates 1 and 1b, where each has only one flow shape according to the invention, which flow shape is a recess 10b on its one surface and a protrusion 11, 11b on its other surface. The flow shape of the plate 1 is vertical, and the flow shape of the plate 1b is horizontal. The plates 1 and 1b have outer edges 5, of which the lower edges 12 and upper edges 14 can be seen in the figure.

[0058] In Fig. 7, the plates 1 and 1b are set on top of one another into contact with each other. Now the peak 29b of the protrusion 11b of the plate 1b is in contact with the plate 1. The height of the peak 29b from the second surface 9 of the plate 1b determines the size H of the plate gap 27 that remains between the plates. The lower edges 12 and upper edges 14 of the plates 1 and 1b are bent towards each other so that when they are placed against each other, the lower edges 12 and upper edges 14 can be seamed tightly to each other. In this way, a horizontal second air flow channel 27 is formed between the plates 1 and 1b for the second air flow 4. A flow shape is formed of the protrusion 11b in the second air flow channel 27, against which flow shape some of the second air flow 4 collides and goes as a flow into the recess of the plate 1.

[0059] The point of contact of two heat exchange plates located on top of one another is described in more detail in the highly schematic Fig. 9. The situation of Fig. 9 corresponds to the situation of Fig. 7 when viewed from the left. The vertical elongated flow shape 11 has straight longer edges 28, end edges 37 in the shape of a semicircle and an even bottom/peak 29. The sides 36 of the flow shape are formed between the bottom/peak and edges of the flow shape 11. The horizontal elongated flow shape 11b has straight longer edges 28b, end edges 37b in the shape of a semi-circle and an even bottom/peak 29b. The sides 36b of the flow shape are formed between the bottom/peak and edges of the flow shape 11b. Fig. 9 shows how the surface area of the bottom/peak 29, 29b of the flow shape is essentially smaller than the surface area of the entire flow shape 11, 11b. The horizontal peak 29b is in contact with the plate 1 and with the vertical edges 28 only at the location of the two points of contact 17 with small surface areas. For reasons of clarity, Fig. 9 does not show the heat exchange plates 1 and 1b outside the edges of the flow shapes.

[0060] The invention is not intended to be limited by the examples presented, but the scope of protection is determined by the independent claims. The dependent claims present some advantageous applications of the invention.

[0061] The invention relates to a heat exchange plate (1), plate block (20), heat exchanger (2) and method for manufacturing a heat exchange plate. The invention relates specifically to a novel way of arranging air flows in an air-to-air heat exchanger (2).

[0062] The heat exchange plate (1) is primarily planar and comprises first and second shapes (10, 11) on the first and second surface of the heat exchange plate. The first and second shapes comprise recesses (10) and protrusions (11) that are formed on the corresponding locations on the opposite surfaces of the heat exchange plate.

[0063] The plate block (20) comprises several heat exchange plates (1) arranged on top of one another, and the heat exchanger (2) comprises the plate block (20).

Claims

1. A heat exchange plate (1) to be used in an air-to-air heat exchanger (2), which heat exchange plate is primarily planar and comprises:

    - an outer edge (5),
    - a first surface (7) on the first side (6) of the heat exchange plate,
    - a second surface (9) on the second side (8) of the heat exchange plate, in other words on the side opposite to the first surface,
    - first and second shapes (10, 11) on the first and second surface of the heat exchange plate,

    characterised in that

    - the first and second shapes comprise local recesses (10) and protrusions (11) that are formed on the heat exchange plate itself and on corresponding locations on the opposite surfaces of the heat exchange plate and that deviate from the general plane of the heat exchange plate.

2. A heat exchange plate according to claim 1, **characterised in that** the first and second shapes are elongated in the direction of the plane of the heat exchange plate, in which case the shape has two long edges (28) and end edges (37) that connect the long edges.

3. A heat exchange plate according to claim 2, **characterised in that** all shapes of the heat exchange plate are primarily parallel.

4. A heat exchange plate according to any one of the preceding claims, **characterised in that** all recesses (10) are on the same side of the heat exchange plate, and all protrusions (11) are on the opposite side of the heat exchange plate.

5. A heat exchange plate according to any one of the preceding claims, **characterised in that** the heat exchange plate is without openings over its entire surface between the outer edges.

6. A plate block (20), which comprises several heat exchange plates (1) arranged on top of one another, which plate block is suited for use in an air-to-air heat exchanger (2), where the first airflow (3) releases heat to the heat exchange plates and the second airflow (4) receives heat from the heat exchange plates, which plate block comprises:

    - sides (22, 23, 24, 25) formed by the outer edges (5) of the heat exchange plates located on top of one another,
    - plate gaps arranged in the gaps between the heat exchange plates (1, 1b, 1c) located on top of one another, where every second plate gap (26) is arranged as the air flow channel of the first air flow (3), and every second plate gap (27) is arranged as the air flow channel of the second air flow (4),

    characterised in that the heat exchange plates (1) arranged on top of one another are according to any one of the claims 1 - 5.

7. A plate block according to claim 6, **characterised in that** the plate block (20) is primarily a rectangular prism, where every second plate gap on each side (22, 23, 24, 25) is closed tightly and every second

plate gap is open so that the air flow channels (26) of the first air flow (3) open to the first side (22) and to the third side (24) opposite to it, and the air flow channels (27) of the second air flow (4) open to the second side (23) and to the fourth side (25) opposite to it.

8. A plate block according to any one of the preceding claims 6 - 7, **characterised in that** each heat exchange plate is without openings over its entire surface between the outer edges (5).

9. A plate block according to any one of the preceding claims 6 - 8, **characterised in that** the shapes (10, 11) of the heat exchange plates are elongated in the direction of the plane of the plate and that the shapes of the heat exchange plates located on top of one another have intersecting directions.

10. A plate block according to any one of the preceding claims 6 - 9, **characterised in that** the protrusions (11) in each air flow channel (26, 27) are elongated in the primary flow direction of the air flow that flows in the air flow channel.

11. A plate block according to any one of the preceding claims 6 - 10, **characterised in that** the protrusions (11) on the same side of a single heat exchange plate (1) are in contact with the next heat exchange plate (1b), in which case the height of the protrusions from the general plane of the heat exchange plate determines the size (H) of the plate gap between said heat exchange plates.

12. A plate block according to claim 11, **characterised in that** the protrusion (11) of the heat exchange plate is in contact at a point of contact (17) with the two long edges (28) of the recess (10) in the next heat exchange plate.

13. An air-to-air heat exchanger (2), where the first air flow (3) releases heat to the heat exchange plates (1) and the second air flow (4) receives heat from the heat exchange plates, which heat exchanger comprises:

- a body structure (30), which comprises the inlet connections (31, 32) and outlet connections (33, 34) of the first and second air flow,
- a plate block (20), which is arranged inside the body structure so that:

    ◦ the air flow channels (26) of the first air flow (3) of the plate block are connected to the inlet connections (31) and outlet connections (33) of the first air flow of the support structure, and
    ◦ the air flow channels (27) of the second air flow (4) of the plate block are connected to the inlet connections (32) and outlet connections (34) of the second air flow of the support structure,

- support devices (40, 41), which fasten the plate block to the body structure so that the plate block can be removed,

characterised in that the plate block (20) is according to any one of the preceding claims 6 - 12.

14. A heat exchanger according to claim 13, **characterised in that** the support devices (40, 41) comprise members (40, 41), which only support the plate block from the outside, in other words from the outer edges of the heat exchange plates, and/or which support the first and/or last heat exchange plate of the plate block.

15. A method for manufacturing a primarily planar heat exchange plate (1) from metal plate, to be used in an air-to-air heat exchanger (2), where the first air flow (3) releases heat to the heat exchange plate and the second air flow (4) receives heat from the heat exchange plate, which method comprises at least the following stages:

- several shapes (10, 11), which are intended to cause turbulence in the air flow (3, 4) that travels along the heat exchange plate, are arranged on the primarily planar metal plate,

characterised in that the method further comprises at least the following stages:

- several recesses (10) are pressed to the primarily planar metal plate,
- protrusions (11) are formed at the same time at the location of the recesses on the opposite side of the metal plate,

in which case said recesses and protrusions form said shapes (10, 11).

16. A method according to claim 15, **characterised in that**:

- the recesses and protrusions formed are elongated in the direction of the plane of the plate and primarily parallel.

17. A method according to any one of the preceding claims 15 - 16, **characterised in that**:

- all recesses (10) are formed on the same side of the heat exchange plate whose surface is without openings.

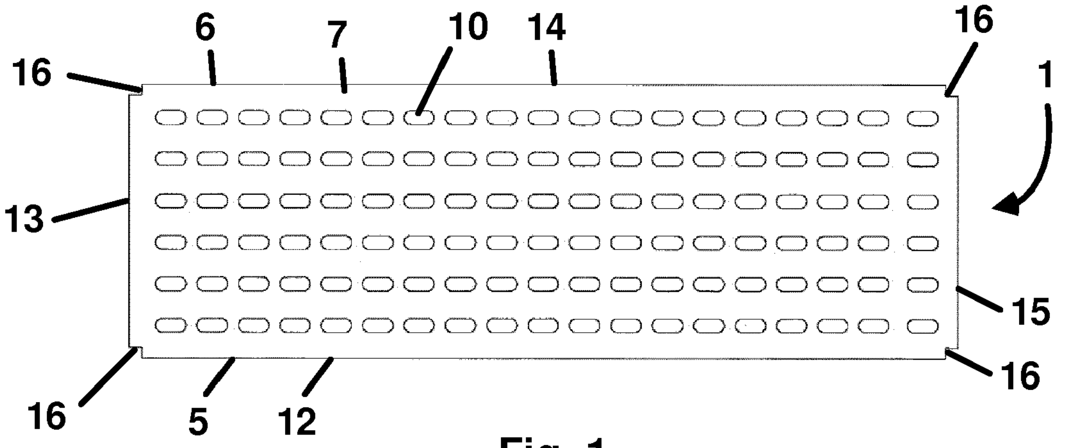


Fig. 1

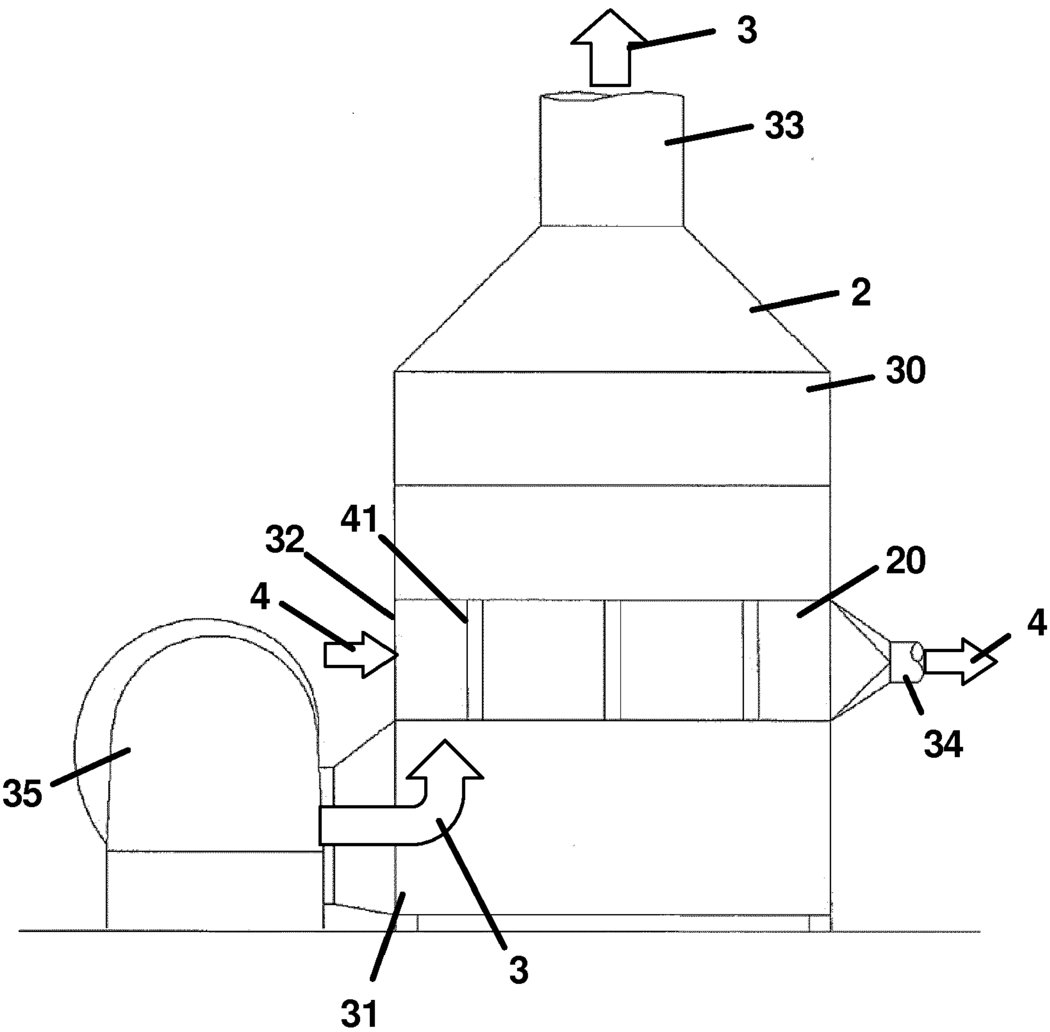


Fig. 2

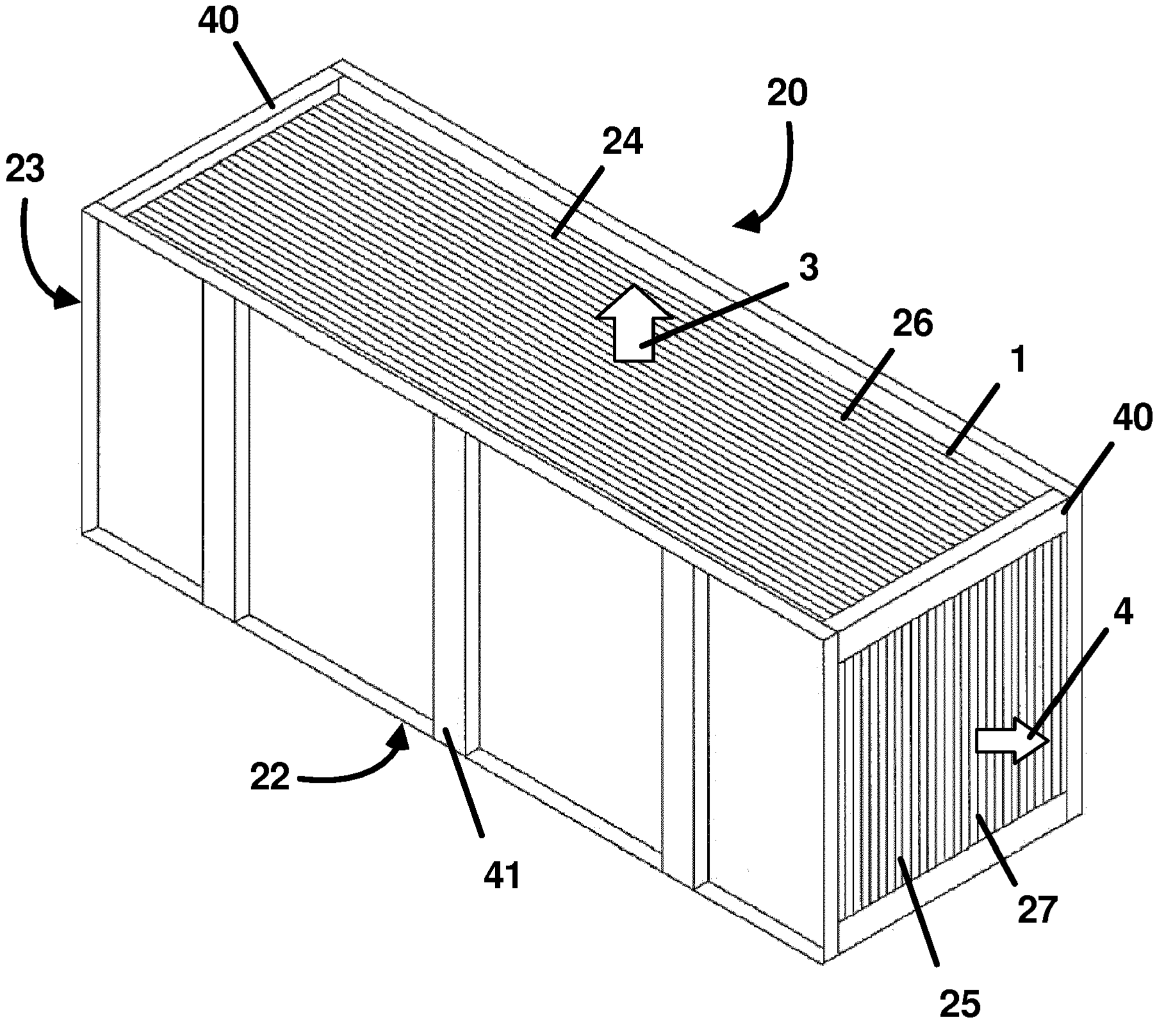


Fig. 3

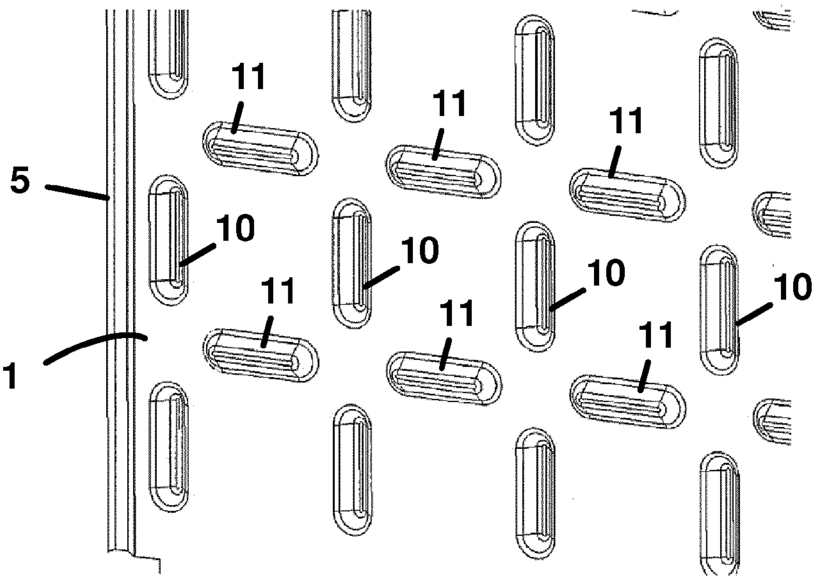


Fig. 4

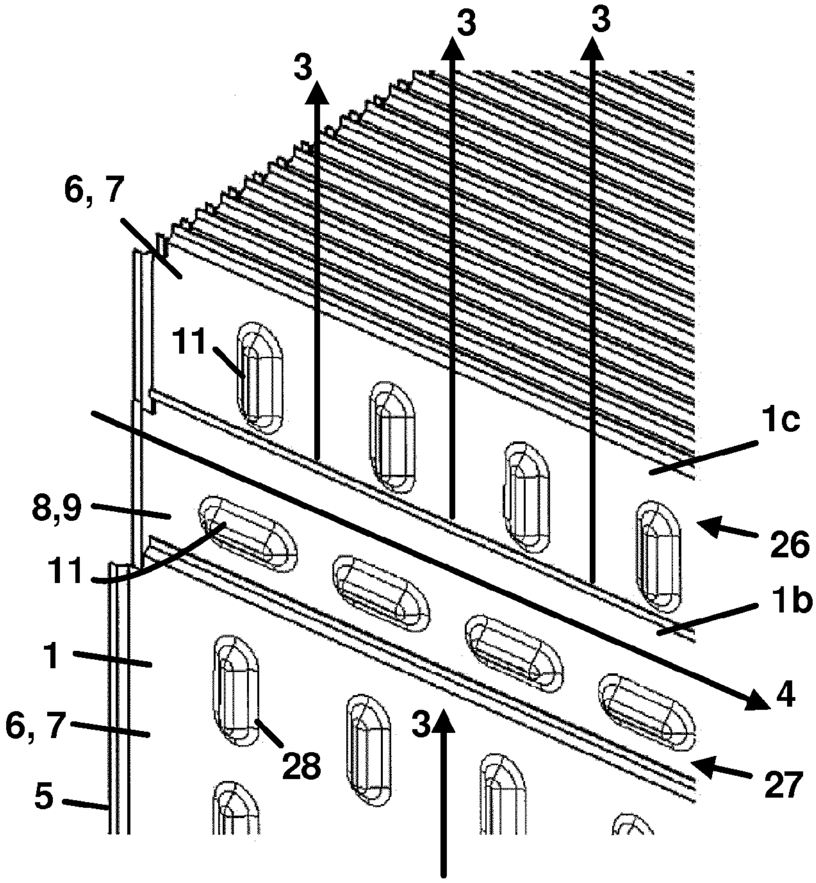
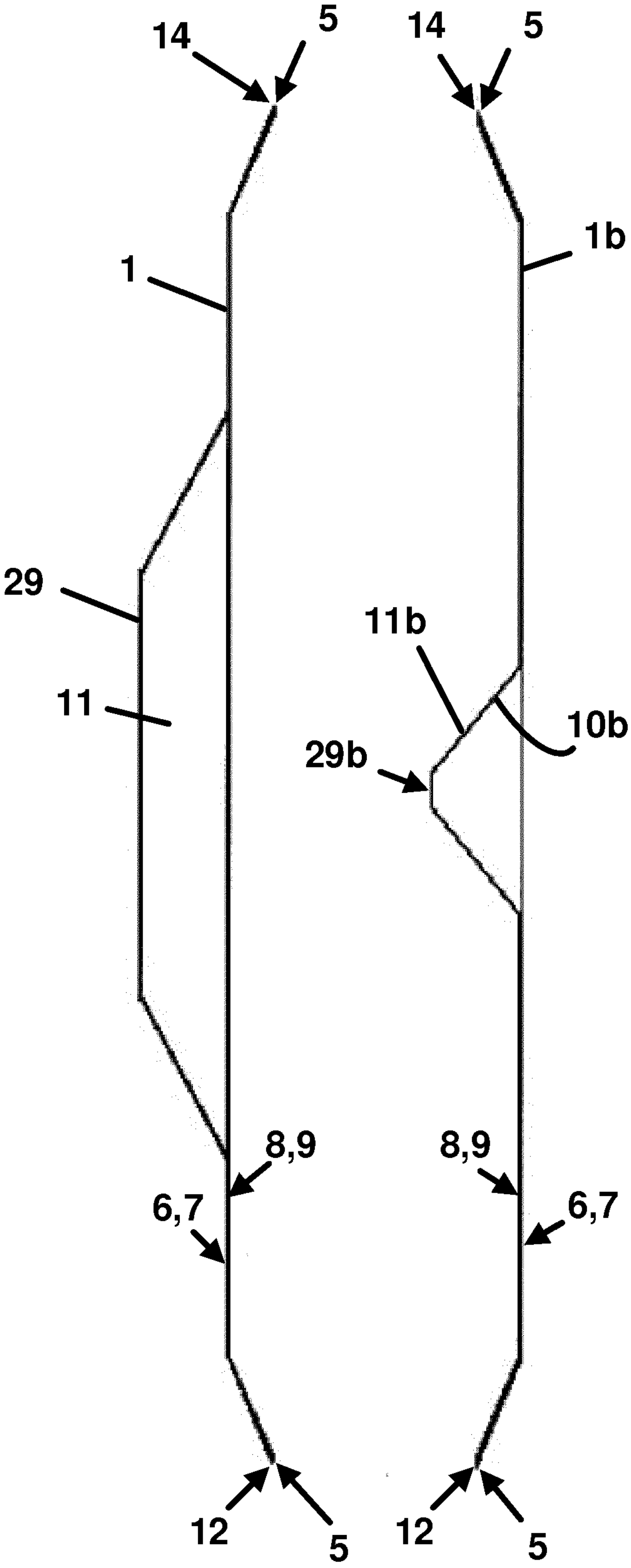


Fig. 5



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8,9
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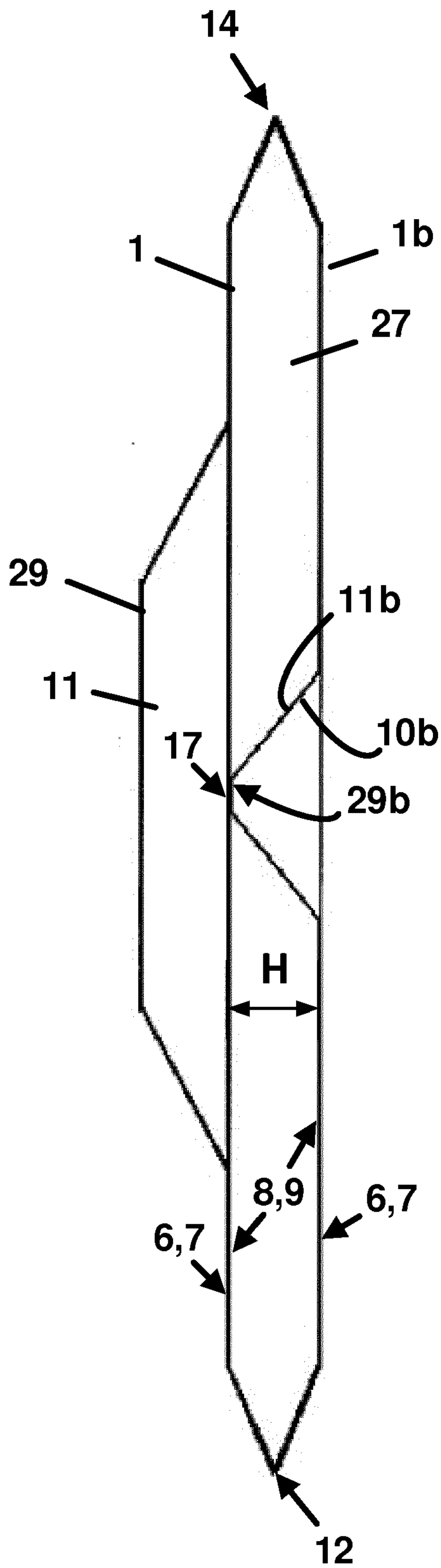
12
5

Fig. 6



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12

Fig. 7

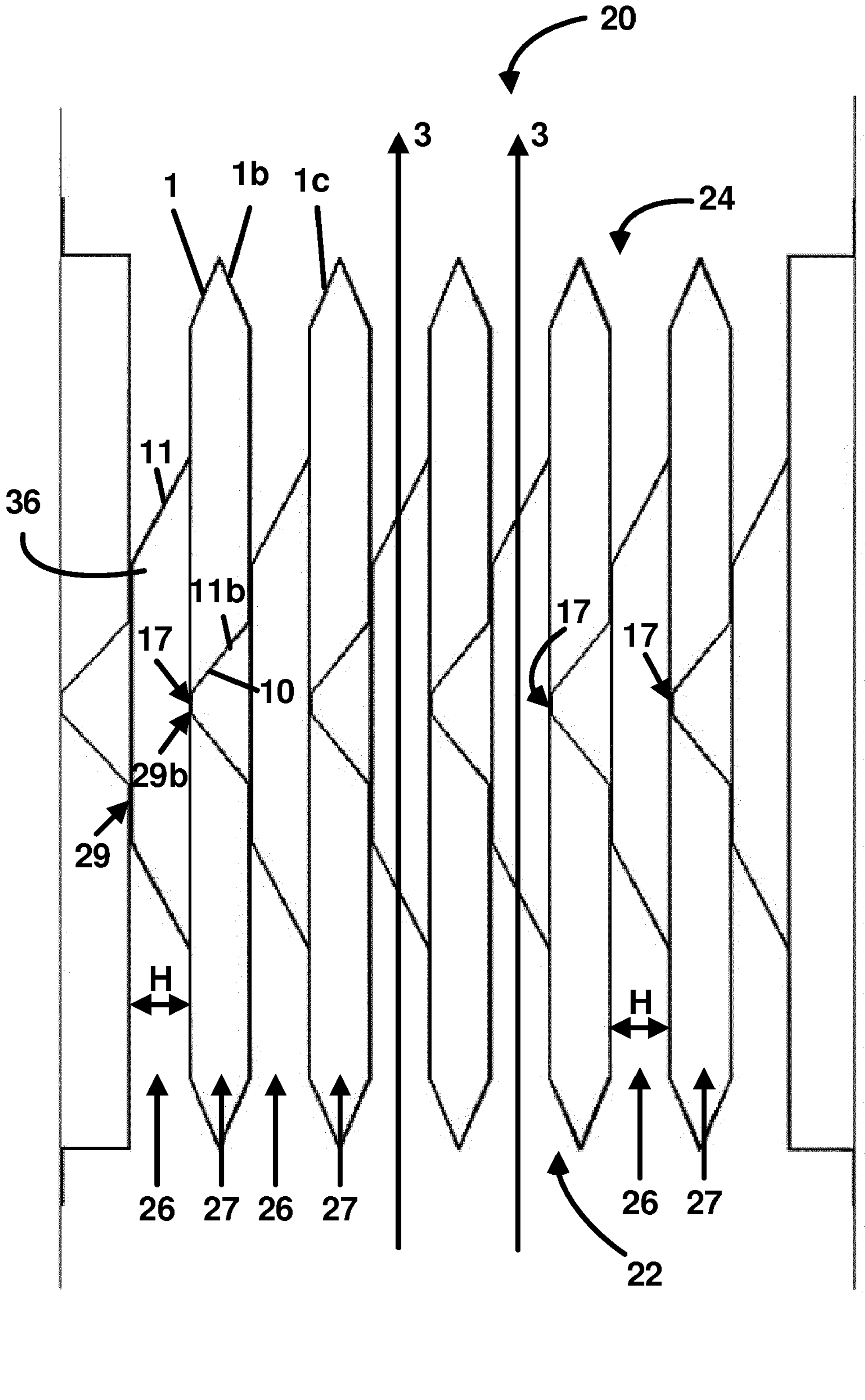

Fig. 8

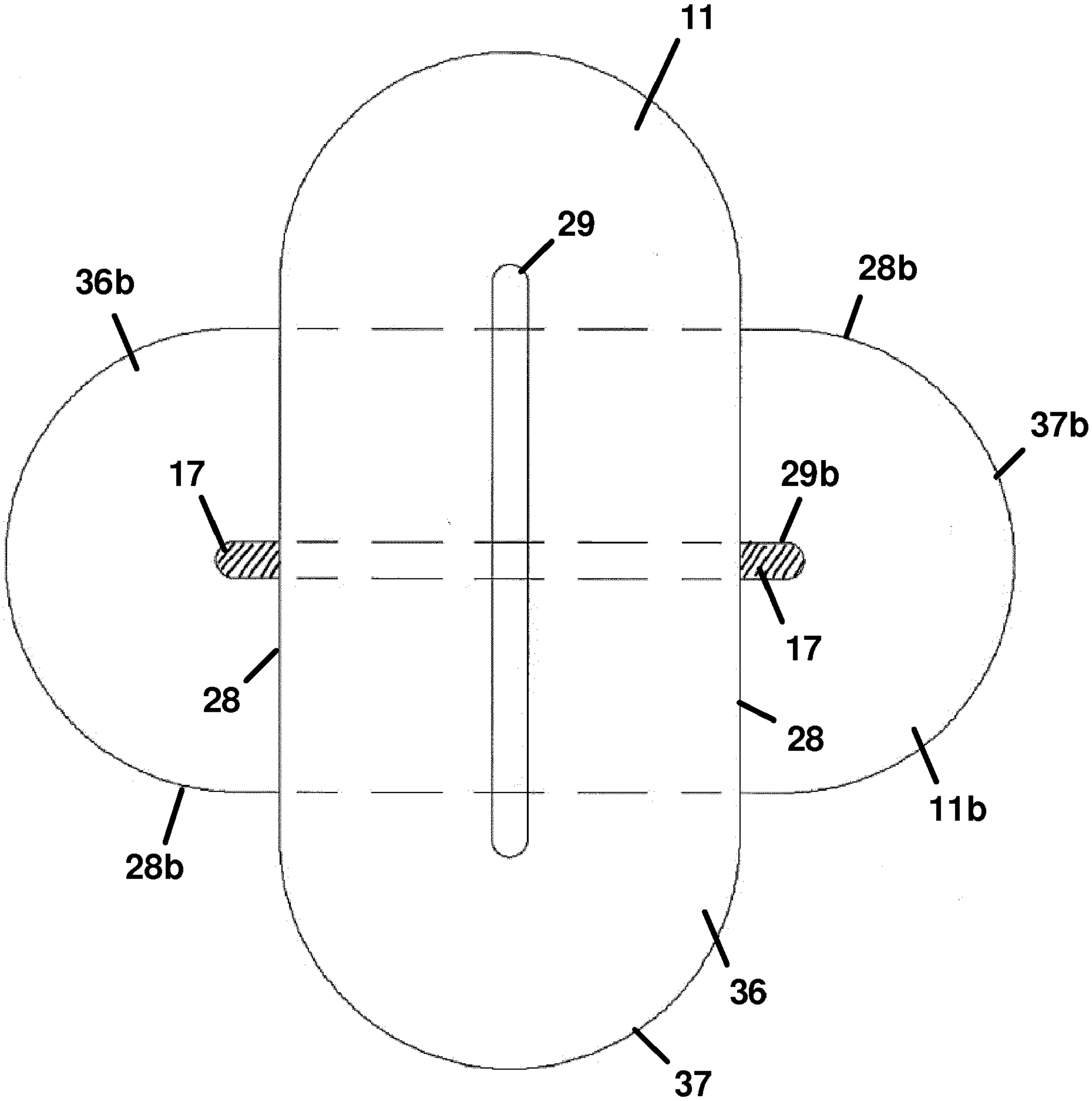

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 6603

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 645 039 A1 (HEATEX AB [SE]) 2 October 2013 (2013-10-02) * the whole document * -----	1-17	INV. F28D9/00 F28F3/04
X	US 2005/077637 A1 (MOCKRY ELDON F [US] ET AL) 14 April 2005 (2005-04-14) * paragraph [0001] - paragraph [0074]; figures 1-2,9-16 * -----	1-17	

TECHNICAL FIELDS SEARCHED (IPC)
F28D
F28F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	14 May 2018	Bloch, Gregor

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14-05-2018

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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