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(54) **A HEAT EXCHANGER**

(57) The disclosure relates to a heat exchanger (100) comprising a stack of heat exchanger plates (105), a first set of channels (401), and a second set of channels (402), in each of the channels in the respective set of channels (401, 402) fin structures (210) are positioned between the heat exchanger plates (107), each heat exchanger plate (107) comprises a first inlet port (201), a first outlet port (211), a second inlet port (202) and a second outlet port (212) formed at a respective corner portion of the respective heat exchanger plate (107) and extending through the stack (105), the heat exchanger (100) further comprises a distribution structure (220) at the respective inlet port (201, 202) and a collection structure (230) at the respective outlet port (211, 212), the distribution structure (220), respectively the collection structure (230) is positioned between the port (201, 202, 211, 212) and the respective fin structure (210), a port interface between the inlet port (201, 202) and the distribution structure (220), respectively a port interface between the outlet port (211, 212) and the collection structure (230) is inclined relative to the fin direction (FD).

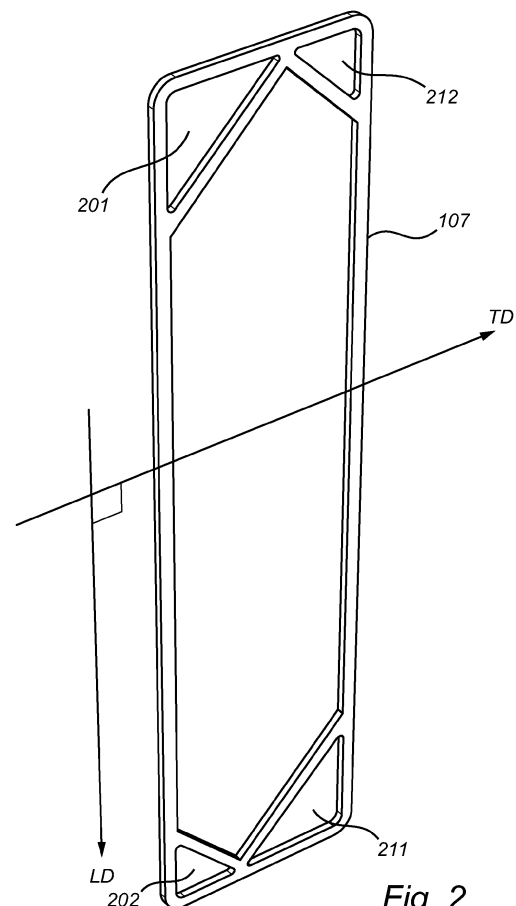


Fig. 2

Description

Field of invention

[0001] The invention relates to a heat exchanger comprising a stack of heat exchanger plates stacked one on top of the other along a stacking direction.

Technical Background

[0002] Plate heat exchangers for transferring heat between different mediums, e.g., different fluids or gases, are well known in the art. The plate heat exchanger may comprise a stack of a plurality of heat exchanger plates stacked one on top of the other between two end plates. A first set of channels may be formed in every second interspace between the heat exchanger plates and a second set of channels may be formed in the other interspaces between the heat exchanger plates. The components of the plate heat exchangers and especially the heat exchanger plates are typically made of metal but could be made of any other material as long as it is sufficiently strong and has sufficient heat conduction properties. The components of the plate heat exchange may be assembled by being clamped between the end plates, or by using brazing, bonding, or welding by way of example. Since the mediums are in contact with a large surface area on a respective side of each heat exchanger plate a plate heat exchanger provides an efficient heat transfer. Plate heat exchangers may be of a kind often referred to as plate-fin heat exchanger. A plate-fin heat exchanger typically comprises a stack of heat exchanger plates with wave-shaped structures sandwiched between the heat exchanger plates.

[0003] In order to make efficient use of the available surface area of the heat exchanger plates, it is typically desirable to design the heat exchanger such that it displays an efficient distribution, and typically also an efficient collection, of the flow of medium across the whole width of the heat exchanger plates. Further, it is typically desirable to design the heat exchanger such that it is mechanically stable in relation to material consumption, manufacturing costs and/or final weight.

[0004] In an attempt to address this, document CN 207963578 U discloses a plate and fin heat exchanger with guiding distribution fins and exchanging fins.

[0005] However, as will be explained below, the prior art document does not disclose a heat exchanger which adequately addresses the set of design criteria of providing an efficient distribution, and preferably also an efficient collection, of the flow of medium across the whole width of the heat exchanger plates, while preferably also considering that the heat exchanger should be mechanically stable in relation to material consumption, manufacturing costs and/or final weight.

Summary of invention

[0006] It is an object of the invention to provide a heat exchanger which adequately addresses the set of design criteria of providing an efficient distribution, and preferably also an efficient collection, of the flow of medium across the whole width of the heat exchanger plates, while preferably also considering that the heat exchanger should be mechanically stable in relation to material consumption, manufacturing costs and/or final weight.

[0007] This object has been achieved by a heat exchanger comprising a stack of heat exchanger plates stacked one on top of the other along a stacking direction,

a first set of channels formed in every first second interspace between the heat exchanger plates, a second set of channels formed in every second interspace between the heat exchanger plates,

wherein, in each of the channels in the first and second set of channels fin structures formed of sheets being folded back and forth are positioned between the heat exchanger plates such that the respective fin structure abuts the heat exchanger plates along a plurality of contact lines having a main extension extending in parallel with a longitudinally extending fin direction thereby defining plurality of fluid channels forming said first and second set of channels, wherein each heat exchanger plate comprises four through-going openings formed at a respective corner portion of the respective heat exchanger plate and configured to form a first inlet port extending through the stack along the stacking direction, a first outlet port extending through the stack along the stacking direction, a second inlet port extending through the stack along the stacking direction, and a second outlet port extending through the stack along the stacking direction, the first inlet port and first outlet port being in fluid connection with each other via the first set of channels and the second inlet port and second outlet port being in fluid connection with each other via the second set of channels,

wherein the heat exchanger further comprises, in each interspace between the heat exchanger plates, a distribution structure at the respective inlet port and a collection structure at the respective outlet port, wherein the respective distribution structure, respectively the respective collection structure is positioned between the respective port and the respective fin structure in the respective first and second set of channels,

wherein a port interface between the respective inlet port and the respective distribution structure, respectively a port interface between the respective outlet port and the collection structure is inclined relative to the fin direction such that a distance between the port interface and the fin structure, as measured

along the fin direction, increases with increasing distance, as seen along a line extending across the fin direction, from an edge of the respective heat exchanger plate which is closest to the respective port and which extends along the longitudinally extending fin direction.

[0008] The first and second set of channels are alternately arranged such that there in every interspace between the heat exchanger plates is either a channel of the first set of channels or a channel of the second set of channels. This may also be expressed as that the first and second set of channels are alternately arranged such that there is a channel of the first set of channels in every second interspace and that there is a channel of the second set of channels in the other interspaces between the heat exchanger plates, i.e., in the interspaces not forming part of the first set of channels. In the phrase "every first second interspace", the word "first" is mainly a label within the phrase "every second interspace". In the phrase "every second second interspace", the first instance of the word "second" is mainly a label within the phrase "every second interspace". It may be noted that it is conceivable that the repeating pattern of either a channel of the first set of channels or a channel of the second set of channels in every interspace between the heat exchanger plates may after a plurality of repetitions be interrupted. Similarly, the ports extending through the stack may extend through all the plates of the heat exchanger or may extend through only a sub-set of neighbouring plates forming one stack. This latter configuration may e.g., be the case where there is a plurality of stacks brought together to form a combined heat exchanger. One example where such different configurations may be used is e.g., in a so-called multi-pass heat exchanger.

[0009] It may be noted that in a preferred embodiment, the fin structure/-s is/are folded such that every fold has an extension sufficient to bridge the distance between neighbouring heat exchanger plates such that the respective fin structure abuts the neighbouring heat exchanger plates between which it is positioned. In a preferred embodiment, the respective fin structure abuts the respective heat exchanger plate along a plurality of contact lines having a main extension extending along the longitudinally extending fin direction, with the actual abutment forming continuous or semi-continuous line contacts. It may in this context be noted that the fin structure may be folded along straight lines such that the contact lines may be straight lines extending along the longitudinally extending fin direction. The fin structure may however be folded along lines having other shapes, such as e.g., wavy, or curved lines such that the contact lines become wavy or curved lines undulating back and forth along a main extension. Irrespective of the shape of the fold lines, it is preferred that the main extension extends in parallel with a longitudinally extending fin direction.

[0010] In a preferred embodiment, the channels in the first set of channels, preferably each of the channels in

the first set of channels, comprises a respective first fin structure positioned between the heat exchanger plates, and the channels in the second set of channels, preferably each of the channels in the second set of channels, comprises a respective second fin structure positioned between the heat exchanger plates. However, it should be noted that it is also conceivable that the heat exchanger may be designed such that only the channels in the first set of channels comprises fin structures. Alternatively, it is also conceivable that the heat exchanger may be designed such that only the channels in the first set of channels comprises fin structures.

[0011] The stacking direction is preferably orthogonal to the longitudinally extending fin direction.

[0012] The fin structure may be said to form part of a heat transfer area at which heat is transferred to or from the respective medium from or to the respective heat exchanger plate. Since the respective fin structure is formed such that it presents a plurality of folds, or interspaced walls, bridging the height of the respective channel, the medium in the respective channel is in contact with not only the respective heat exchanger plate but also all the folds or interspaced walls in said channel. Since the respective fin structure also abuts the heat exchanger plates, the heat may be transferred from the medium directly to the respective heat exchanger plate and also indirectly by being transferred to the fin structure which in turn transfers it to the respective heat exchanger plate.

[0013] The fin structure may be in the form of a thin sheet being folded back and forth. The fin structure is preferably formed of a thin metal sheet being folded back and forth. This may be referred as that the fin structure is folded back and forth in an accordion-like design. The folds back and forth may have different designs. The folds may e.g., be shaped as a repeating triangular wave, a repeating square wave, a repeating sinus wave, or combinations thereof. The folds may e.g., be a repeating square wave with a fully rounded top/bottom or rounded corners on each side of the top/bottom at of each period. The rounding may e.g., be in the shape of a sinus wave or a radius. The folds may be in the form of an undulating pattern, which also may be referred to as a repeating pattern of interconnected U:s and inverted U:s.

[0014] An advantage with folds based on a square wave, sinus wave or undulating pattern is that the area of the fin structure that abuts the heat exchanger plates is increased compared to e.g., a folding pattern formed of repeating triangular waves. When this abutment area is increased, an increased heat transfer may be achieved. In any case, the fact that the fin structure abuts the heat exchanger plates, provides for an improved stability between the fin structure and the heat exchanger plates. This is further advantageous as it allows for a mechanically stable heat exchanger with improved structural support.

[0015] The respective fin structure is positioned, as seen along the flow direction of the respective medium, between the respective distribution structure and the re-

spective collection structure. As mentioned above, the respective distribution structure is positioned between the respective inlet port and the respective fin structure in the respective first and second set of channels. The respective distribution structure is configured to distribute a flow from the respective inlet port to the respective fin structure such that the flow of medium is distributed over the whole width of the respective channel. The respective collection structure is configured to collect the flow from the respective fin structure and to direct the flow to the respective outlet port. It may in this context be noted that

[0016] The disclosed design is advantageous as it allows for an improved distribution of the medium in the first set of channels. The disclosed design is further advantageous as it allows for an improved distribution of the medium in the second set of channels. The disclosed design is advantageous as it allows for an improved collection of the medium in the first set of channels. The disclosed design is further advantageous as it allows for an improved collection of the medium in the second set of channels.

[0017] By the port interface between the respective inlet port and the respective distribution structure being inclined relative to the fin direction it is facilitated to provide an optimized flow such that the distribution of the medium in the first and/or second set of channels is improved. The inclined port interface allows for a large interface between the respective inlet port and the respective distribution structure. The inclined port interface allows for the inlet port to be designed in a skewed or basically triangular, or at least partly triangular, shape such that the interface is comparably large in relation to the ports total surface area. The inclined port interface also allows for the provision of a large interface of the distribution structure in a simple and cost-efficient manner. It is e.g., possible to manufacture the distribution structure from a basically triangular or truncated triangular sheet being folded back and forth in a manner similar to the fin structure discussed above. Thus, the inclined port interface facilitates the provision of the flow being distributed over the whole width of the distribution structure thereby in turn facilitating the provision an optimized the flow over the width of the heat exchanger.

[0018] By the interface between the respective outlet port and the respective collection structure being inclined relative to the fins structure it is facilitated to accomplish an efficient collection of the medium in the first or second set of channels and thereby in turn it is facilitated to accomplish an optimisation of the flow over the width of the heat exchanger. The advantages discussed above in relation to the inclined port interface between the inlet port and the distribution structure is correspondingly applicable for the inclined port interface between the respective outlet port and the respective collection structure.

[0019] The respective port interface may form an angle α with the fin direction. As mentioned above, the interface is inclined relative to the fin direction, i.e., the angle α is greater than 90° , but smaller than 180° , such that the

respective interface is inclined. Greater than and smaller than may in this context refer to at least 5° from 90° respectively 180° . The angle α is measured between on the one hand a line being centrally positioned as seen in the transverse direction and extending along the fin direction and on the other hand the side of the interface facing the distribution or collection structure. Preferably the angle α is between 110° and 160° , more preferably between 120° and 150° . This is advantageous as it allows for optimizing the flow such that the distribution of medium and/or the collection of medium as discussed above is improved. It may be noted that the port interface of the distribution structure may, but need not, be inclined the same angle as the port interface of the collection structure.

[0020] The respective port interface may extend along a substantially straight line. This is advantageous as it allows for a good distribution of the medium from the respective inlet port to the fin structure. This is advantageous as it allows for a good collection of the medium from the fin structure. This is further advantageous as it allows for fatigue optimizing in the heat exchanger. It is preferred that the straight line is straight in the sense that along at least a central portion forming 75% of its length, any deviation transverse to its extension is less than $\pm 10\%$ of its length.

[0021] The respective distribution structure, and/or the respective collection structure, extends from a first, transversally central, corner of the respective port towards a second, transversally outer, corner of the respective port and leaves a transversally extending gap at the longitudinally extending edge being closest to the respective port.

[0022] The term "transversally central" in the phrase "a first, transversally central, corner" refers to that the first corner is positioned centrally as seen along the transverse direction. Correspondingly, "the second, transversally outer, corner" refers to a corner which is positioned closer to an outer portion as seen along the transverse direction compared to the position of the first corner.

[0023] It may be noted that in a preferred embodiment, the first corner is positioned at a distance from the second corner both in the fin direction and in the transversal direction such that the port interface between the respective inlet port and the respective distribution structure is inclined. It may be noted that in a preferred embodiment, the first corner is positioned at a distance from the second corner both in the fin direction and in the transversal direction such that the port interface between the respective outlet port and the respective collection structure is inclined.

[0024] The gap may with reference to the preferred embodiments with the inclined port interface also be expressed as that there is a corner piece of the respective distribution structure, and/or the respective collection structure missing.

[0025] Providing a gap is e.g., advantages when it comes to manufacture of the respective distribution struc-

ture, and/or the respective collection structure. By allowing a gap to be formed it is e.g., possible to allow a respective distribution structure, and/or a respective collection structure being inclined and still ending as seen along the transversal direction in an end portion being formed of a piece of material having an extension along the fin direction also at the transversal outer perimeter which makes such an end portion significantly stronger compared to if the respective distribution structure, and/or the respective collection structure would end in a sharp corner.

[0026] An open gap may also aid in distributing the flow over a couple of the transversally outermost channels thereby reducing the risk that turbulence or other corner effects in the flow from the ports to the channels in the fin structure results in any undesired imbalances in the flow in the channels closest to the longitudinal edge.

[0027] The gap preferably has a transversal extension being at least equal to three channels formed of the folds of the fin shaped structure of the respective distribution structure, and/or the respective collection structure.

[0028] A major portion of a flow from the respective inlet port is preferably distributed via the distribution structure to the fin structure, respectively a major portion of a flow from the fin structure is preferably collected via the collection structure to the respective outlet port; and wherein a minor portion of the flow from the respective inlet port may be transferred to the fin structure via said gap, respectively a minor portion of the flow from the fin structure may be transferred to the respective outlet port via said gap.

[0029] This is advantageous as it allows to distribute the flow along the entire width of each heat exchanger plate seen along the transversal direction, wherein the major portion of the flow is distributed via the distribution structure and the minor portion of the flow is distributed to the fin structure via the gap. This is further advantageous as it allows to collect the flow from the entire width of each heat exchanger plate seen along the transversal direction, wherein the major portion of the flow is collected via the collection structure and the minor portion of the flow is collected from the fin structure via the gap. The disclosed design, in which the gap is introduced, is advantageous as it allows for an improved and efficient flow distribution and flow collection along the entire width of the heat exchanger plate. Preferably at least 80%, more preferably at least 90%, of the flow is distributed and/or collected via the respective distribution structure, and/or the respective collection structure.

[0030] A cut in the respective plate forming the respective port may be arc-shaped along at least a major portion of a transversal extension of said gap. The arc-shaped design of the respective port in the gap may facilitate provision of smoothly directing the minor portion of the flow into the fin structure without the need of being distributed via the distribution structure. This helps to improve the flow distribution throughout the fin structure hence the flow distribution is optimized. The design of

the respective port and the distribution structure may cooperate in order to direct and distribute the medium to the fin structure in an efficient way. The arc-shaped design of the respective port in the gap may further facilitate provision of smoothly collecting the minor portion of the flow from the fin structure without the need of being collected via the collection structure. The design of the respective port and the collection structure may cooperate in order to direct and collect the medium from the fin structure in an efficient way. Moreover, an arc-shaped portion of this kind will result in reduced local mechanical stress which is especially beneficial when it comes to the plates possibility to withstand fatigue.

[0031] The distribution structure may be formed by a basically triangular or truncated triangular fin structure. The shape is basically triangular or truncated triangular with the normal of the triangle surface extending in the stacking direction. It may be noted that in a preferred embodiment, the fin structure of the distribution structure, i.e., the folds back and forth, may have a similar structure as the fin structure discussed above. In that case, the distribution structure typically has diagonally extending fins; diagonally relative to the fin direction. This is advantageous as it allows to distribute the flow from a port positioned in a corner of the plate over the whole transversal width and still allowing the respective distribution structure, and/or the respective collection structure to be manufactured by folding a sheet of material back and forth. The fin structure of the respective distribution structure, and/or the respective collection structure aids in keeping the heat exchanger plates at their intended mutual distances as seen along the stacking direction. The multiple contact lines formed by the fin structure at the respective distribution structure, and/or the respective collection structure also takes part in the provision of a heat transfer. It may be noted that in a preferred embodiment, the fin structure of the respective distribution structure, and/or the respective collection structure has vertical fins or folds as seen along the fin direction.

[0032] The collection structure may be formed by a basically triangular or truncated triangular fin structure. The shape is basically triangular or truncated triangular with the normal of the triangle surface extending in the stacking direction. It may be noted that in a preferred embodiment, the fin structure of the collection structure, i.e., the folds back and forth may have a similar structure as the fin structure discussed above. In that case, the collection structure typically has diagonally extending fins as seen relative to the fin direction. The advantages have been discussed above with reference to the corresponding structure of the respective distribution structure.

[0033] The respective ports may be formed as substantially triangular ports. The respective triangular inlet port helps to match the respective triangular distribution area in an easy and efficient way. The respective triangular outlet port helps to match the respective triangular collection area in an easy and efficient way.

[0034] The dimensions of the first inlet and outlet ports

may be different from the dimensions of the second inlet and outlet ports.

[0035] In this context, the term "dimensions" should be interpreted as a total area of the first ports being different from a total area of the second ports. The first ports and the second ports are in one preferred embodiment asymmetric in relation to each other. This allows for a difference in total flow of the first medium in relation to total flow of the second medium.

[0036] However, it may also be noted that in other preferred embodiments, the first ports and the second ports have the same size and shape. This is typically the case if the total flow of the first medium is intended to be about the same as the total flow of the second medium.

[0037] It may be noted that it is also conceivable to have asymmetry in dimension in the inlet ports for one medium in relation to the outlet ports for the same medium. This allows for an efficient flow of said medium even in cases the medium undergoes significant changes in properties as it flows through the heat exchanger. Such a change could for instance involve a phase change of all or parts of the medium between a liquid and a gaseous phase.

[0038] An internal interface between the respective distribution structure and the fin structure and/or an internal interface between the respective collection structure and the fin structure in the respective channel of the first set of channels and/or in the respective channel of the second set of channels may be inclined relative to the longitudinally extending fin direction and also relative to a transversal direction.

[0039] By designing the internal interface between the respective distribution structure and the fin structure and/or an internal interface between the respective collection structure and the fin structure in the respective channel of the first set of channels and/or in the respective channel of the second set of channels such that it is inclined relative to the longitudinally extending fin direction and inclined also relative to a transversal direction, it is facilitated to design the heat exchanger with different shapes and sizes of the ports and still make use of distribution and/or collection structures formed of fin structures formed of a material being folded back and forth. Such a distribution or collection fin structure has a plurality of channels extending along its own or local fin direction and it has to have one edge extending along that local fin direction and one side forming the interface to the port, and one side forming the interface with the main fin structure. By allowing the interface between the distribution or collection structure and the main fin structure to be inclined, it opens up for a greater variation of the shape of the interface with the port and still allowing the distribution or collection structure to be basically triangular or truncated triangular shaped which in turn facilitates manufacture and assembly.

[0040] The respective internal interface may form an angle β with the fin direction, wherein the angle β is between 95 and 130°, preferably between 95 and 120°, or

between 50 and 85°, preferably between 60 and 85°.

[0041] It may in this context be noted that the angle β may be angled such that there are two options available for the designer to use depending upon e.g., the desired relative shapes and sizes of the ports at the same transversally extending side, i.e., of the ports at the same longitudinal position, the desired thickness of the pressed panel portions closing of the ports, the desired size and shape of the ports in relation to the transversal width of the heat exchanger.

[0042] It may also be noted that the internal interface may in some cases, see e.g., figure 6, be inclined in the same direction on both major surfaces at the same ports. For instance, if there is a significant difference in the sizes of the ports with one large port and one small port arranged side by side, the internal interface is typically inclined such that it is closer to a transversally extending midline of the heat exchanger at the longitudinal side closest to the large port on both major surfaces of the heat exchanger plate and further away from said transversally extending midline of the heat exchanger at the longitudinal side closest to the small port on both major surfaces of the heat exchanger plate. The angle β on one of the major surface may however be slightly different from the angle β on the other major surface since the area available is basically determined by the port size and the pressed portion selectively closing of one or the other port. In figure 6, the large port to the left is open to the channel in front of the plate whereas the small port to the right is closed off from the channel in front of the plate. On the other side, the general direction of inclination is the same but since there is a pressed portion along the underside of the large port to the left, right if viewed from the opposite side, closing it off from the channel on the other side of the plate whereby the left hand side, right hand side if viewed from the opposite side, of the interface need to be slightly lower than in figure 6 whereas to the right hand side, left hand side if viewed from the opposite side, the interface may extend all the way up to the lower corner of the smaller port since that port is open to the channel on the other side of the plate. Thus, the inclination is slightly larger on the other side of the plate where the larger port is closed off from the channel on that side of the plate.

[0043] It may also be noted that the internal interface may in some cases, see e.g., figure 7, be inclined in opposite directions on the two major surfaces at the same ports. For instance, if there is no significant difference in the sizes of the ports, the internal interface is typically inclined such that it on a first major side is closer to a transversally extending midline of the heat exchanger at the longitudinal side closest to the port being closed off from the channel on that major surface and further away from said transversally extending midline at the longitudinal side closest to the port being open to the channel on that major surface. Since the ports are of the same or about the same size, the available area is varied mostly by the presence or absence of the pressed portion closing

off said port from the channel at the respective major surface. The angle β on one of the major surface may be the same or be slightly different from the angle β on the other major surface since the area available is basically determined by the port size and the pressed portion selectively closing of one or the other port. In figure 7, the port to the left is open to the channel in front of the plate whereas the port to the right is closed off from the channel in front of the plate. On the other side of the plate, the general direction of inclination of the internal interface is opposite since there is a pressed portion along the underside of the port to the left, to the right if viewed from the other side, whereas to the right hand side, left hand side if viewed from the other side, the interface may extend all the way up to the lower corner of the right hand port, left hand port if viewed from the opposite side, since that port is open to the channel on the other side of the plate. Thus, the inclination is basically opposite on the other side of the plate. It may also be noted that one of the interfaces may be angled an angle β between 95 and 130°, preferably between 95 and 120°, or between 50 and 85°, preferably between 60 and 85°, whereas the interface directly opposite on the other major side of the plate may be angled 90° to the fin direction. It may also be noted that it is conceivable that both interfaces on both major sides of a plate are angled 90° to the fin direction. Similarly, it may also be noted that one of the interfaces, such as the interface at the distribution structure or the collection structure may be angled an angle β between 95 and 130°, preferably between 95 and 120°, or between 50 and 85°, preferably between 60 and 85°, whereas the interface at the other one of the distribution structure or the collection structure may be angled 90° to the fin direction. It may also be noted that it is conceivable that both interfaces at both the distribution structure and the collection structure are angled 90° to the fin direction. Thus, there are for each plate four internal interfaces that may be selected to be angled differently. The respective internal interface may extend along a substantially straight line. This is advantageous since it facilitates production of the distribution and/or collection structure and of the fin structure while still allowing for different designs of the ports and while still allowing for a smooth distribution of the flow of medium across the width of the heat exchanger. It is preferred that the straight line is straight in the sense that along at least a central portion forming 75% of its length, any deviation transverse to its extension is less than $\pm 10\%$ of its length.

[0044] The internal interface at the respective inlet port and the internal interface at the respective outlet port are preferably inclined in the same general direction relative to the transverse direction.

[0045] Thus, the internal interface at the first inlet port and the internal interface at the first outlet port is preferably inclined in the same general direction, a first direction, relative to the transverse direction. Furthermore, the internal interface at the second inlet port and the internal interface at the second outlet port are preferably inclined

in the same general direction, a second direction, relative to the transverse direction. However, as mentioned above, the general direction of inclination on the opposite major surfaces may be the same or may be opposite.

Thus, the first general direction may be the same as or be opposite to the second direction. Being inclined in the same general direction may be said as that both directions are within an angular range being less 90° or that both directions are within an angular range being greater than 90° relative to the fin direction. Being inclined in opposite general directions may be said as that one of the directions is within an angular range being less 90° and that the other direction is within an angular range being greater than 90°. Thus, the phrase the internal interface at the respective inlet port and the internal interface at the respective outlet port are preferably inclined in the same general direction relative to the transverse direction is intended to refer to the fact that the respective internal interface of the first set of channels has the same general direction at the first inlet ports as the internal interface of the first set of channels has at the first outlet ports. Similarly, the respective internal interface of the second set of channels has the same general direction at the second inlet ports as the internal interface of the second set of channels has at the second outlet ports. It may in this context also be noted that the interfaces are only said to be inclined in the same general direction relative to the transverse direction, i.e., they are not necessarily at the same angle β , but only that both have an angle being greater than 90° or both have an angle being less than 90° relative to the fin direction. However, preferably the internal interface close to the first inlet port is inclined an angle β being the same as the angle β of the inclination of the internal interface close to the first outlet port. Similarly, the internal interface close to the second inlet port is inclined an angle β being the same as the angle β of the inclination of the internal interface close to the second outlet port. However, as discussed in detail above, the angle β on the first major side may or may not be the same as the angle β on the other major side, e.g., depending upon if the ports are of significantly different size or if they are of the same or about the same size.

[0046] The first inlet port may be arranged on a first longitudinally extending side of the stack of heat exchanger plates and the first outlet port may be arranged on a second longitudinally extending side of the stack of heat exchanger plates, the second longitudinally extending side being opposite the first longitudinally extending side.

[0047] The second inlet port may be arranged on the first longitudinally extending side of the stack of heat exchanger plates and the second outlet port may be arranged on the second longitudinally extending side of the stack of heat exchanger plates, the first longitudinally extending side being opposite the second longitudinally extending side.

[0048] Opposite refers in this context to opposite the transversal direction. With this arrangement, a diagonally

extending flow path between the first inlet and outlet and preferably also between the second inlet and outlet is formed. With the disclosed design, it is facilitated to provide an improved distribution and collection of the medium in the heat exchanger. The provision of a diagonally extending flow may provide a good heat transfer.

[0049] In an alternative embodiment, the inlet ports and the outlet ports of the first medium are both arranged on the first longitudinally extending side of the stack of heat exchanger plates and the inlet ports and the outlet ports of the second medium are both arranged on the second longitudinally extending side of the stack of heat exchanger plates, the second longitudinally extending side being opposite the first longitudinally extending side.

[0050] In accordance with one embodiment, the inlet port of the first medium is positioned at the same transversally extending side as the outlet port of the second medium and outlet port of the first medium is positioned at the same transversally extending side as the inlet port of the second medium. Thereby the two mediums flow in opposite directions as seen along the longitudinally extending fin direction. This may be referred to as a counter-flow. Alternatively, the inlet ports of both mediums are positioned at the same transversally extending side and the outlet ports of the mediums are positioned at the other transversally extending. This may be referred to as a parallel flow. Both the counter-flow and the parallel flow may be combined with both the diagonal flow or with the flow with both the inlet ports and the outlet ports of the first medium are both arranged on the first longitudinally extending side of the stack. It may in this context also be noted that it is conceivable that the heat exchanger is designed such that it allows the flow direction to be changed for one or both of the mediums between different operational states. It is e.g., conceivable that the first medium flows in a first flow direction in a first operational state in the opposite direction in a second operational state. In such a case the port referred to the inlet port will become the outlet port and vice versa. Similarly, the structure referred to as the distribution structure will become a collection structure and vice versa.

[0051] Each fin structure of each of the channels of the first and second set of channels may comprise at least a first and a second part arranged one after the other along the fin direction. Normally, there are manufacturability constraints on the maximum length of the fin structure along the flow direction. Such manufacturability constraints are e.g., introduced by the fact that there are difficulties to in a cost-efficient manner manufacture and transport sheet metal on sheet metal rolls over a certain width. It is also often difficult to in a cost-efficient manner fold the sheets back and forth if they are larger than a certain width. A common maximum fin length is 500 mm. In order to manufacture heat exchangers of dimensions having channels longer than this, several fin structures need to be arranged in series on after the other along the flow direction. Therefore, an advantage with this design is that the heat exchanger may be provided with

longer channels without being restricted by the manufacturability constraints.

[0052] The interface between the first and second part of each of the fin structures will be defined by a transversally extending edge of the first part being opposite to and facing a transversally extending edge of the second part. In some embodiments the transversally extending sides of the first and second part being opposite to each other may abut each other. In some embodiments the transversally extending sides of the first and second part being opposite to each other may be separated from each other by a gap. The interface between the first and second part of the first fin structure is positioned at a first position along the fin direction. If there is a gap present, the position is defined as the mid-point of the gap. The interface between the first and second part of the second fin structure is positioned at a second position along the fin direction. The first position respectively the second position is determined by choosing the dimensions of the first and second part in each of the fin structures. In order to facilitate assembly, the dimensions, or at least the tolerances, of the first and second part are typically chosen such that the actual total length is slightly shorter than the nominal space available. This often results in that a small longitudinal gap is formed between the first and second parts. It may in this context be noted that such a gap may also be deliberately provided. Independently of if the gap is unwanted but an unavoidable or deliberately provided for, it is advantageous to choose the dimensions of the first and second parts of the first fin structure in relation to the dimensions of the first and second parts of the second fin structure such that the interface between the first and second parts of the first fin structure becomes separated a longitudinal distance from the interface between the first and second parts of the second fin structure. With such a design it is secured that the any gap between the first and second parts of the first fin structure does not fully align with any interface between the first and second parts of the second fin structure. That is, it is secured that any gap on a first side of a heat exchanger plate does not fully align with any gap on a second side of the same heat exchanger plate.

[0053] It has been found that if there are gaps on both sides of a heat exchanger plate, there is a risk that the heat exchanger plate becomes deformed. Such deformation may occur during the manufacture or during use.

[0054] By the interfaces of the first and second fin structure being positioned at a first position and a second position, respectively, and which are being separated a longitudinal distance from each other, the heat exchanger plates will be subject to minimal amount of deformation. Deformation of the heat exchanger plates affects the flow of the medium through the channel in that there is a risk that the flow in each of the channels will be inconsistent and not optimized. In worst case, deformation might be so acute that the flow may risk being completely disrupted in some channels. Deformation of the plates may also give rise to turbulence in the flow past or after the defor-

mation. Thus, deformation of the channels may result in the heat exchanger not functioning efficiently. The disclosed design is advantageous in that it facilitates the provision of channels that are mechanically strong and resistant to deformation, hence allowing for an optimized flow such that the intended efficiency of the heat exchanger is achieved. The disclosed design is also advantageous in that allows for large heat exchangers being manufactured in a cost-efficient manner. It may in this context also be noted that the gap may be formed of parallel edges of the first and the second part, or that the gap may be formed of the edges of the first and second part being angled relative to each other and thereby forming a triangular shape, or a trapezoid shape with the parallel sides formed of the longitudinal sides of the plates. It may also be noted that the gap may be formed as a void or lack of material through-out the complete width of the plates or alternatively that the gap may be formed by one or both of the parts having a plurality of protrusions forming intermittent abutments and a non-continuous gap between the parts of the fin structure. The protrusions may be formed as rods, small rectangular pieces, or the like. Alternatively, the protrusions may be formed by cutting the edge/edges of the part/parts in a non-straight manner, such as e.g., in a saw tooth pattern, a wave-shaped pattern, such as a sinus wave or square wave pattern, such that the ridges of the teeth or waves of one part abuts the edge of the other part. Intermittent abutments may be used to provide a controlled size of any gap.

[0055] The dimensions of the first and second parts of the first and second fin structure is preferably chosen such that the distance between the first and second positions is such that any longitudinal gap at the central interface between the first and second part in the first channel of the first set of channels at least does not overlap a midline of any longitudinal gap at the central interface between the first and second part in the first channel of the second set of channels, and vice versa. This may shortly also be referred to as that any gap between the first and second part in the first channel of the first set of channels does not exceed a midline of any gap between the first and second part in the first channel of the second set of channels, or vice versa.

[0056] This is advantageous as it provides channels which are mechanically strong and resistant to deformation which allows for optimizing the flow in the channels such that the efficiency of the heat exchanger is improved.

[0057] It has been found that there is an improvement in the strength of the heat exchanger in case any overlap of the gaps is limited such that a gap does not exceed a midline of any gap on the opposing side of the same heat exchanger plate. Midline refers to an imaginary line or position positioned at equal distance to the respective edges of the first and second part facing each other as measured along the fin direction. Exceed refers to the extension of the gap along the fin direction.

[0058] The dimensions of the first and second parts of the first and second fin structure is preferably chosen such that the distance between the first and second positions is such that any longitudinal gap at the central interface between the first and second part in the first channel of the first set of channels does not overlap with any longitudinal gap at the central interface between the first and second part in the first channel of the second set of channels, and vice versa.

[0059] It has been found that there is an improvement in the strength of the heat exchanger by securing that there is no overlap at all of the gaps on the opposing side of the same heat exchanger plate.

[0060] The interface between the first and second parts of the first fin structure may be defined by an edge of the first part of the first fin structure and an edge of the second part, wherein the edge of the first part may have an extension with a transversal component and face the edge of the second part and the second edge may have an extension with a transversal component and faces said edge of the first part, and wherein the edge of the first part may be arranged in parallel with the edge of the second part.

[0061] As mentioned above, the edges may abut each other or may be positioned with a gap therebetween. It is preferred that the abutment or gap at the interface as measured along fin direction is constant between any given point on the transversally extending edge of the first part to any directly opposing point on the transversally extending edge of the second part. Directly opposing points refers to points being aligned along the fin direction. This is advantageous as it facilitates manufacturing. It is also advantageous since it facilitates provision of a balanced flow across the transversal width of the heat exchanger plates since the parallel edges typically provides uniform flow properties across the transversal width of the interface as the medium transitioning from a respective fluid channel in the first part to a respective fluid channel in the second part.

[0062] The edges of the first and second parts, respectively, of the first fin structure may extend at an angle γ relative to the fin direction, the angle γ preferably being between 95 and 130°, more preferably between 95 and 120°, or being 90°. Thus, the interface is either oriented such that the angle γ is preferably 90° or inclined an angle such that the angle γ is preferably between 95 and 130°, more preferably between 95 and 120°.

[0063] It may in this context be noted that the angle γ may be chosen independently from other angles or that the angle γ may be related to an angle β formed by an interface between a respective part of the fin structure and a distribution structure or collection structure provided at the vicinity of the inlet respectively outlet port.

[0064] The angle β may be angled 90° relative to the fin direction. In such a case, the edges of the first and second parts may extend at an angle γ being 90° relative to the fin direction thereby allowing each first and second part be formed of a rectangular piece of material being

folded back and forth perpendicular to the side edges thereof. It is however conceivable that even in case the angle β is angled 90° relative to the fin direction, the edges of the edges of the first and second parts, respectively, of the first fin structure may extend at an angle γ relative to the fin direction being different from 90° . The angle γ is in such a case preferably between 95 and 130° , more preferably between 95 and 120° . The central interface of the first fin structure on a first side of the heat exchanger plate and the central interface of the second fin structure on the second side of the same heat exchanger plate may be angled such that they extend in parallel with each other. In such a case it is advantageous to take into consideration the various discussions concerning separation of the positions along the fin direction and the impact on any overlap of any gaps thus formed. In such a case the various discussions are applicable and are related to a line which is slightly inclined relative to the transversal direction; namely said angle γ minus 90° . However, it is also conceivable that the central interface the first fin structure on a first side of the heat exchanger plate and the central interface of the second fin structure on the second side of the same heat exchanger plate are be angled such that they extend in crossing directions. It may be noted that the two angles are preferably, but need not be, chosen to be the same but in opposite directions. It may in this context be noted it may be advantageous, especially if any or both of the gaps have a significant length along the fin direction, to take into consideration the various discussions concerning separation of the positions along the fin direction and the impact on any overlap of any gaps thus formed. Significant length along the fin direction may e.g., be that the along the fin direction gap is greater a complete repeat of the folds as measured across the fin direction. However, the central interfaces extending in crossing directions may alternatively, especially if at least one or both of the gaps does not have a significant length along the fin direction, be used to allow the gaps to actually cross each other since the overlap in such a case will have a limited transversal extension compared to if the central interfaces would extend in parallel with each other. It may in this context be noted that a design with the angle γ being between 95 and 130° , more preferably between 95 and 120° , with the central interfaces crossing each other may alternatively be expressed as that the angle γ is between 95 and 130° , more preferably between 95 and 120° , on one side of the heat exchanger plate and between 50 and 85° , preferably between 60 and 85° , on the other side of the heat exchanger plate.

[0065] The angle β may be between 95 and 130° , more preferably between 95 and 120° , or between 50 and 85° , preferably between 60 and 85° . In one embodiment it is preferred that the angle γ is the same as angle β . In such a case it is possible to manufacture the fin structure from a rectangular piece of material extending substantially transversally at a slight inclination relative to the transversal direction at an angle being the angle β minus 90° .

The leading and trailing edge of the sheet; the edges that will extend along the longitudinal edges of the heat exchanger are in such a case trimmed at said angle being angle β minus 90° in respective direction. If the angles β at the distribution structure and the collection structure are different the angle γ may be selected to be the same as one of the angles β or in case there are more than two parts of the fin structure, the respective angle γ may be chosen to be the same as the respective angle β and then the one or more central interfaces formed of parts not sharing an interface with the distribution structure of collection structure having an angle γ being chosen e.g., as one of the angles β or e.g., being 90° relative to the fin direction. It may in this context be noted that the discussion concerning the angle γ being chosen to be the same on both sides such that the interfaces on the different sides are parallel or being chosen to be different on the different sides such that the interfaces on the different sides cross each other is equally applicable the cases where the angle β is between 95 and 130° , more preferably between 95 and 120° , or between 50 and 85° , preferably between 60 and 85° .

[0066] This design is advantageous since it allows for a smooth transition of the flow of medium at the interface since it facilitates manufacture of the fin structure even for different specific design choices when it comes to other parts of the heat exchanger and since it results in a mechanically strong heat exchanger.

[0067] The interface between the first and second parts of the second fin structure may be defined by an edge of the first part of the second fin structure and an edge of the second part, wherein the edge of the first part may have an extension with a transversal component and face the edge of the second part and the second edge may have an extension with a transversal component and face said edge of the first part, and wherein the edge of the first part may be arranged in parallel with the edge of the second part. Advantages and variations of this has been discussed in relation to the corresponding feature in respect of the first fin structure and that discussion is equally applicable to the second fin structure.

[0068] The edges of the first and second parts, respectively, of the second fin structure may extend at an angle γ relative to the fin direction, the angle γ preferably being between 95 and 130° , more preferably between 95 and 120° , or being 90° . Thus, the interface is either oriented such that the angle γ is preferably 90° or inclined an angle such that the angle γ is preferably between 95 and 130° , more preferably between 95 and 120° . Advantages and variations of this has been discussed in relation to the corresponding feature in respect of the first fin structure and that discussion is equally applicable to the second fin structure.

[0069] In some embodiments, the geometries, such as the height, width, shape and/or thickness, of the folds of the fin structures of the channels of the respective first and second set of channels may be different from each other. Thereby it is possible to exchange heat between

two different mediums having different properties, such as different phases, different densities, different flows, etc.

[0070] However, it may also be noted that the first and second set of channels may be designed equal to each other.

[0071] It may be noted that the use of first, second, third, fourth, fifth, etc. are mainly to be seen as labels facilitating reading and that it does not necessarily mean that there need to be all the intervening numbers of portions present. It may e.g., be noted that it is contemplated to have a design where there is a first portion, a second portion, a third portion and a fifth portion, with the fourth portion being omitted. However, to facilitate reading, we have consistently used the numbering first, second, third, fourth, etc., as labels, and in a sense based on an embodiment including all conceivable portions.

[0072] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the [element, device, component, means, step, etc]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

[0073] The invention may also in short be said to relate to a heat exchanger comprising a stack of heat exchanger plates, a first set of channels, and a second set of channels, in each of the channels in the respective set of channels fin structures are positioned between the heat exchanger plates, each heat exchanger plate comprises a first inlet port, a first outlet port, a second inlet port and a second outlet port formed at a respective corner portion of the respective heat exchanger plate and extending through the stack, the heat exchanger further comprises a distribution structure at the respective inlet port and a collection structure at the respective outlet port, the distribution structure, respectively the collection structure is positioned between the port and the respective fin structure, a port interface between the inlet port and the distribution structure, respectively a port interface between the outlet port and the collection structure is inclined relative to the fin direction.

Brief description of the drawings

[0074] The above, as well as additional objects, features, and advantages of the present disclosure, will be better understood through the following illustrative and non-limiting detailed description of preferred embodiments of the present invention, with reference to the appended drawings, where the same reference numerals will be used for similar elements, wherein:

Figure 1 discloses a heat exchanger.

Figure 2 discloses a heat exchanger plate of the heat

exchanger in figure 1.

Figure 3 discloses a heat exchanger plate of figure 2 with a fin structure arranged on the plate.

Figure 4 illustrates a first cross-sectional side view of a stack of heat exchanger plates of the heat exchanger in figure 1.

Figure 5 illustrates a second cross-sectional side view of a stack of heat exchanger plates of the heat exchanger in figure 1.

Figure 6 discloses a portion of the plate of figures 2 and 3.

Figure 7 discloses a portion corresponding to figure 6 of a plate according to another embodiment.

Figure 8 discloses a whole plate according to the embodiment of figure 7.

Detailed description of preferred embodiments

[0075] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness, and fully convey the scope of the invention to the skilled person.

[0076] Figure 1 illustrates a heat exchanger 100 by way of example. The heat exchanger 100 comprises a stack of heat exchanger plates 105. The stack of heat exchanger plates 105 is formed by stacking one heat exchanger plate 107 on top of another heat exchanger plate 107 along a stacking direction SD. The stack of heat exchanger plates 105 is arranged between two end plates 109 (only one of the two end plates is illustrated in the figure). It may be noted that the different embodiments disclosed herein are in general terms useful for different combinations of fluids, such as gas-liquid, liquid-gas, gas-gas, and liquid-liquid in the first respectively the second set of channels. However, a skilled person will realize that some of the embodiments are more suitable for some specific combinations of fluids than other combinations of fluids.

[0077] The heat exchanger 100 comprises a first inlet 101 along a first longitudinally extending side LES1 and a first outlet 111 along a second longitudinally extending side LES2. The heat exchanger 100 further comprises a second inlet 102 along the first longitudinally extending side LES1 and a second outlet 112 along the second longitudinally extending side LES2. It should however be noted that the first inlet 101 may be arranged along the second longitudinally extending side LES2 and the first outlet 111 may be arranged along the first longitudinally extending side LES1. It should further be noted that the second inlet 102 may be arranged along the second longitudinally extending side LES2 and the second outlet 112 may be arranged along the first longitudinally extending side LES1. It may however be noted that in a

preferred embodiment, the first and second inlets 101, 102 are arranged along the same longitudinally extending side and the first and second outlets 111, 112 are arranged along the same longitudinally extending side. The first and second longitudinally extending sides LES1, LES2 being arranged opposite to each other.

[0078] As best illustrated in figure 4, the heat exchanger 100 further comprises a first set of channels 401 and a second set of channels 402. The first set of channels 401 is formed in every second interspace between the heat exchanger plates 107 of the stack of heat exchanger plates 105. The second set of channels 402 is formed in every other interspace between the heat exchanger plates 107 of the stack of heat exchanger plates 105.

[0079] In each channel of the first and second set of channels 401, 402 fin structures 210 are positioned in between the heat exchanger plates 107. The respective fin structure 210 abuts the heat exchanger plates 107 along a plurality of contact lines 415. The fin structure 210 may be folded along straight lines such that the contact lines 415 extends in parallel with a longitudinally extending fin direction FD. However, as indicated in figure 6, the fin structure 210 may alternatively be folded along lines having other shapes. In the example of figure 6, there is shown wavy or curved lines resulting in that the contact lines becomes wavy or curved lines undulating back and forth along a main extension. Irrespective of the shape of the fold lines, it is preferred that the main extension extends in parallel with a longitudinally extending fin direction. Thereby, a plurality of fluid channels forming the first and second set of channels 401, 402 is defined. The fin structure 210 is preferably formed of sheets being folded back and forth. As is e.g., shown in figure 4, the folds of the respective fin structure 210 are essentially being shaped as a sinus wave with elongated legs or along the stacking direction SD. The type of structure of the respective fin structure 210 may differ. For instance, the folds of the respective fin structure 210 may be shaped as a square wave, a triangular wave, a sawtooth wave, or combinations thereof. The extension of the fin structure 210 of the first set of channels 401 along the stacking direction SD is longer than the extension of the fin structure 210 of the second set of channels 402 along the stacking direction SD. The folds of the fin structure 210 of the first set of channels 401 are wider, as measured along the transverse direction TD, than the folds of the fin structure 210 of the second set of channels 402. It should however be noted that the geometries of the each of the respective fin structure 210 of each of the channels may differ. For instance, in some embodiments, the folds of each of the fin structures 210 of each channel of the respective first set of channels 401 and second set of channels 402 may be identical. In some embodiments, the extension of the fin structure 210 of the first set of channels 401 along the stacking direction may be shorter than that of the fin structure 210 of the second set of channels 402. In some embodiments, the folds of the fin structure 210 of the first set of channels 401 may be nar-

rower than those of the fin structure 210 of the second set of channels 402. In some embodiments, the folds of the fin structures 210 of the first set of channels 401 may be shaped as a square wave while the folds of the fin structures 210 of the second set of channels 401 may be shaped as a sawtooth wave. It should be conceivable that each individual fin structure 210 of each channel of the first set of channels 401 may not be identical but may vary in geometry. It should be conceivable that each individual fin structure 210 of each channel of the second set of channels 402 may not be identical but may vary in geometry.

[0080] With reference to figure 2, a heat exchanger plate 107 of the stack of heat exchanger plates 105 is illustrated by way of example. The heat exchanger plate 107 comprises four through-going openings. The through-going openings are formed at a respective corner portion of the heat exchanger plate 107. The through-going openings are configured to form a first inlet port 201, a first outlet port 211, a second inlet port 202 and a second outlet port 212 extending through the stack along the stacking direction SD.

[0081] It should be noted that each heat exchanger plate 107 of the stack of heat exchanger plates 105 comprises the first inlet port 201, the first outlet port 211, the second inlet port 202 and the second outlet port 212. Each port 201, 202, 211, 212 extend through the stack 105 along the stacking direction SD. The first inlet port 201 is arranged on the first longitudinally extending side LES1 of the heat exchanger plate 107. The first outlet port 211 is arranged on the second longitudinally extending side LES2 of the heat exchanger plate 107. The second inlet port 202 is arranged on the first longitudinally extending side LES1 of the heat exchanger plate 107. The second outlet port 212 is arranged on the second longitudinally extending side LES2 of the heat exchanger plate 107. Hence, the first inlet port 201 coincides with the first inlet 101 and the first outlet port 211 coincides with the first outlet 111. The first inlet port 201 and first outlet port 211 being in fluid connection with each other via the first set of channels 401 formed in every second interspace. Thereby, the first set of channels 401 form diagonally extending flow paths by having the first inlet 101, the first outlet 111, the first inlet port 201 and the first outlet port 211 arranged as discussed above. The second inlet port 202 coincides with the second inlet 102 and the second outlet port 212 coincides with the second outlet 112. The second inlet port 202 and second outlet port 212 being in fluid connection with each other via the second set of channels 402 formed in the other every second interspace. The second set of channels 402 form diagonally extending flow path by having the second inlet 102, the second outlet 112, the second inlet port 202 and the second outlet port 212 arranged as discussed above.

[0082] The heat exchanger 100 further comprises, in each space between the heat exchanger plates 107, a distribution structure 220 at the respective inlet port 201, 202 and a collection structure 230 at the respective outlet

port 211, 212. The respective distribution structure 220 is positioned between the respective inlet port 201, 202, and the respective fin structure 210 in the respective first and second set of channels 401, 402. The respective collection structure 230 is positioned between the respective outlet port 211, 212, and the respective fin structure 210 in the respective first and second set of channels 401, 402.

[0083] An interface 227, also referred to as a port interface 227, between the respective inlet port 201, 202 and the respective distribution structure 220 is inclined relative to the fin direction FD. Thereby, a distance between the interface 227 and the fin structure 210, as measured along the fin direction FD, increases with increasing distance, as seen along an imaginary line extending across the fin direction FD. The distance along the fin direction FD increases as one follows the imaginary line from an edge 121 of the respective heat exchanger plate 107 which is closest to the respective inlet port 201, 202 and which extends along the fin direction FD. An interface 237, also referred to as a port interface 237, between the respective outlet port 211, 212 and the respective collection structure 230 is inclined relative to the fin direction FD. Thereby, a distance between the interface and the fin structure 210, as measured along the fin direction FD, increases with increasing distance, as seen along an imaginary line extending across the fin direction FD. The distance along the fin direction FD increases from as one follows the imaginary line from an edge 122 of the respective heat exchanger plate 107 which is closest to the respective outlet port 211, 212 and which extends along the fin direction FD.

[0084] Although figure 2 only illustrates the port interface 227 between the first inlet port 201 and the distribution structure 220, it should be clearly understood by the skilled person that in practice, the port interface between the second inlet port 202 and the distribution structure 220 is designed in a similar way as discussed above. Further, although figure 2 only illustrates the port interface 237 between the first outlet port 211 and the collection structure 230, it should be clearly understood by the skilled person that in practice, the port interface between the second outlet port 212 and the collection structure 230 is designed in a similar way as discussed above.

[0085] The respective port interface forms an angle α with the fin direction FD. It may be noted that in a preferred embodiment, the angle α is between 110 and 160°, preferably between 120 and 150°.

[0086] The distribution structure 220 is formed as a triangular or truncated triangular distribution structure. It should be noted that in the distribution structure, the fins or folds extends along an internal fin direction being diagonally arranged relative to the fin direction FD of the fin structure 210. Basically, the fins or folds of the distribution structure 220 extends between the respective inlet port and the fin structure 210 along said internal fin direction. The fins or folds as such may be vertically arranged as viewed along its diagonal extension. The fins

or folds of the distribution structure 220 may basically be of any kind discussed above in relation to the fin structure 210 with the fin direction referring to its diagonally extending internal fin direction.

[0087] The collection structure 230 is formed as a triangular or truncated triangular collection structure. Preferably, the collection structure 230 is formed by a triangular or truncated triangular fin structure such that the collection structure 230 has the similar design as the distribution structure 220. It should be noted that in the collection structure 230 the fins or folds extends along an internal fin direction being diagonally arranged relative to the fin direction FD of the fin structure 210. The fins or folds of the collection structure 230 may basically be of any kind discussed above in relation to the fin structure 210 with the fin direction referring to its diagonally extending internal fin direction. Depending upon the positioning of the different ports, the internal diagonally extending fin direction of the distribution structure 220 and the collection structure 230 may be basically in the same orientation or in crossing directions. The fins or folds as such may be vertically arranged as viewed along its diagonal extension. The fins or folds of the collection structure 230 may basically be of any kind discussed above in relation to the fin structure 210 with the fin direction referring to its diagonally extending internal fin direction. Depending upon the positioning of the different ports, the internal diagonally extending fin direction of the distribution structure 220 and the collection structure 230 may be basically in the same orientation or in crossing directions.

[0088] One edge of the distribution structure 220 extends from a first corner 223 of the first inlet port 201 towards a second corner 224 of the inlet port 201. The first corner 223 may be referred to as a transversally central corner and the second corner 224 may be referred to as a transversally outer corner. As illustrated e.g., in figures 3, 5 and 6, the distribution structure 220 extends towards the second corner 224 but not all the way to the second corner 223. This leaves a transversally extending gap 225 at a longitudinally extending edge 121 which is closest to the first inlet port 201. With such a design, a major portion of a flow from the first inlet port 201 is distributed via the distribution structure 220 to the fin structure 210. Further, with such a design, a minor portion of the flow from the first inlet port 201 is transferred to the fin structure 210 via the gap 225. However, it may be noted that the distribution structure 220 may extend all the way to the second corner 223.

[0089] One edge of the collection structure 230 extends from a first corner 233 of the first outlet port 211 towards a second corner 234 of the outlet port 211. The first corner 233 may be referred to as a transversally central corner of the first outlet port 211 and the second corner 234 may be referred to as a transversally outer corner of the first outlet port 211. As illustrated, the collection structure 230 extends towards the second corner 234 but not all the way to the second corner 234. This leaves

a transversally extending gap 235 at a longitudinally extending edge 122 which is closest to the first outlet port 211. With such a design, a major portion of a flow is collected via the collection structure 230 to the first outlet port 211. Further, with such a design, a minor portion of the flow from the fin structure 210 is transferred to the first outlet port 211 via the gap 235. However, it may be noted that the collection structure 230 may extend all the way to the second corner 234.

[0090] The second inlet port 202 is preferably designed in a similar way as the first inlet port 201 as discussed above and the second outlet port 212 is preferably designed in a similar way as the first outlet port 202 as discussed above.

[0091] As further depicted in figure 2, the respective inlet ports 201, 202 are designed as asymmetric inlet ports i.e., the dimensions of the first respective second inlet port 201, 202 is different. This is because the respective inlet port 201, 202 is designed to supply different flows of medium to its respective distribution structure 220 and to its respective fin structure 210. It may be noted that in a preferred embodiment, and as illustrated in the figure, the first inlet port 201 and the second inlet port 202 have a triangular shape. This is to match the inlet ports 201, 202 with the respective distribution structure in an easy and efficient way. The respective outlet ports 211, 212 are designed as asymmetric outlet ports i.e., the dimensions of the first respective second outlet port 211, 212 is different. This is because the respective outlet port 211, 212 is designed to receive different flows of medium from its respective collection structure 230. It may be noted that in a preferred embodiment, and as illustrated in the figure, the first outlet port 211 and the second outlet port 212 have a triangular shape. This is to match the outlet ports 211, 212 with the respective distribution structure in an easy and efficient way. It may be noted that in a preferred embodiment, and as illustrated, the respective port 201, 202, 211, 212 is arc-shaped along at least a major portion of a transversal extension of the gap.

[0092] As is shown in figure 3 and also in figures 6-8, an internal interface 228 between the respective distribution structure 220 and the fin structure 210 in the respective channel of the first set of channels 401 is inclined relative to the longitudinally extending fin direction FD and is inclined also relative to a transversal direction TD. The internal interface 228 forms an angle β with the fin direction FD. The angle β is between 95 and 130°, preferably between 95 and 120°, or between 50 and 85°, preferably between 60 and 85°. In figures 3 and 6, there is disclosed a design where the angle β is between 95 and 130°, preferably between 95 and 120°. In figures 7 and 8, there is disclosed a design where the angle β is between 50 and 85°, preferably between 60 and 85°.

[0093] As shown in figures 3 and 8, an internal interface 238 between the respective collection structure 230 and the fin structure 210 in the respective channel of the first set of channels 401 is inclined relative to the longitudinally

extending fin direction FD and is inclined also relative to a transversal direction TD. The internal interface 238 forms an angle β with the fin direction FD. The angle β is between 95 and 130°, preferably between 95 and 120°, or between 50 and 85°, preferably between 60 and 85°. In figures 3 and 6, there is disclosed a design where the angle β is between 95 and 130°, preferably between 95 and 120°. In figure 8, there is disclosed a design where the angle β is between 50 and 85°, preferably between 60 and 85°.

[0094] On the opposite side of the plate 107, an internal interface 228 between the respective distribution structure 220 and the fin structure 210 in the respective channel of the second set of channels 402 is inclined relative to the longitudinally extending fin direction FD and is inclined also relative to a transversal direction TD. The internal interface 228 forms an angle β with the fin direction FD. The angle β is between 95 and 130°, preferably between 95 and 120°, or between 50 and 85°, preferably between 60 and 85°.

[0095] In figures 3 and 6, there is disclosed a design where the angle β on said opposite side is also between 95 and 130°, preferably between 95 and 120°. That is, in the design of figures 3 and 6, the internal interface 228 on the side shown in the figures and the internal interface on the opposite side have a similar inclination. In figures 7 and 8, there is disclosed a design where the angle β is between 50 and 85°, preferably between 60 and 85° on the side visible in said figures and where the angle β is between 95 and 130°, preferably between 95 and 120°. That is, in the design of figures 7 and 8, the internal interface 228 on the side shown in the figures and the internal interface 228 on the opposite side have a opposite inclinations.

[0096] The above discussion concerning the directions of the internal interfaces 228 on the opposite sides is equally applicable in respect of the internal interfaces 238 on the opposite sides.

[0097] As is shown in figures 3, and 6-8, the respective internal interface 228, 238 preferably extends along a substantially straight line.

[0098] In the embodiments shown in figures 3, and 6-8, the internal interface 228 at the first inlet port 201 and the internal interface 238 at the first outlet port 211 are inclined in the same direction relative to the transverse direction TD. In the preferred embodiment, also the angle β is the same for the two internal interfaces 228, 238 of the first channel 401. In the preferred embodiment also the internal interface 228 at the second inlet port 202 and the internal interface 238 at the second outlet port 212 are inclined in the same direction relative to the transverse direction TD. As mentioned above, this "same direction" refers to the directions of the internal interfaces 228, 238 of the same channel and that the directions may be the same or be different on the opposite sides of the plate 107. In the preferred embodiment, also the angle β is the same of the two internal interfaces 228, 238 of the second channel 402.

[0099] As e.g., shown in figure 3 and 5, a first fin structure 210a in a first channel of the first set of channels 401 comprises a first part 210a1 and a second part 210a2. The first and second part 210a1-2 are arranged one after the other along the fin direction FD. Hence, an interface is formed between the first and second part 210a1-2 by a transversally extending side or edge of the first part 210a1 being directly opposite to a transversally extending side or edge of the second part 210a2. This interface may also be referred to as a central interface. It may in this context be noted that the word central is a label facilitating differentiation from other interfaces and that the word used as a label could also be e.g., a third interface. The transversally extending sides or edges are arranged in parallel with each other. The interface extends across the fin direction. The transversally extending sides of the respective first and second part 210a1-2 extend at an angle γ with respect to the fin direction. In preferred embodiments, the transversally extending sides or edges of the respective first and second part 210a1-2 extend at 90° with respect to the fin direction. The interface is positioned at a first position P1 along the fin direction. The interface is positioned by choosing the dimensions of the first and second parts 210a1-2. It may be noted that the edges of the first and second parts 210a1-2, respectively, of the first fin structure 210a may alternatively extend at an angle γ relative to the fin direction FD, where the angle γ is between 95 and 130°, preferably between 95 and 120°. It is conceivable that the interface is formed of the edges abutting each other and it is conceivable that the interface includes a gap.

[0100] As e.g., shown in figure 5, a second fin structure 210b in a first channel of the second set of channels 402 comprises a first and a second part 210b1-2. The first and second part 210b1-2 are arranged one after the other along the fin direction. Hence, an interface is formed between the first and second part 210b1-2 by a transversally extending side or edge of the first part 210b1 being directly opposite to a transversally extending side or edge of the second part 210b2. The transversally extending sides or edges are arranged in parallel with each other. The interface extends across the fin direction. The transversally extending sides or edges of the respective first and second part 210b1-2 extend at an angle γ with respect to the fin direction FD. In preferred embodiments, the transversally extending sides of the respective first and second part 210b1-2 extend at 90° with respect to the fin direction. The interface is positioned at a second position P2 along the fin direction. The interface is positioned by choosing the dimensions of the first and second parts 210b1-2. It may be noted that the edges of the first and second parts 210b1-2, respectively, of the second fin structure 210b may alternatively extend at an angle γ relative to the fin direction FD, where the angle γ is between 95 and 130°, preferably between 95 and 120°. It is conceivable that the interface is formed of the edges abutting each other and it is conceivable that the interface includes a gap.

[0101] Figure 5 illustrates a stack of heat exchanger plates 105 and a stack of a set of first channels 401 and a second set of channels 402. The first and second positions P1, P2 of the interfaces are separated a distance DP from each other along the fin direction. The distance DP between the first and second positions P1, P2 is such that any longitudinal gap G1 at the central interface 239a between the first and second part 210a1-2 in the first channel of the first set of channels 401 at least does not overlap a midline of any longitudinal gap G2 at the central interface 239b between the first and second part 210b1-2 in the first channel of the second set of channels 402, and vice versa.

[0102] It is preferred that any gap between the first and second part 210a1-2 in the first channel of the first set of channels 401 does not overlap with any gap between the first and second parts 210b1-2 in the first channel of the second set of channels 402. In figure 4, the dimensions of the first and second parts 210a1-2 in the first channel of the first set of channels 401 have been chosen such that the gap therebetween does not overlap with any gap between the first and second parts 210b1-2 in the first channel of the second set of channels 402. It may be noted that fin structures 210 not being neighbouring fin structures 210 may comprise parts 210a1-2, 210b1-2 with identical dimensions. That is, there may be gaps overlapping each other as long as the gaps are not formed on opposite sides of the same heat exchanger plate.

[0103] The person skilled in the art realizes that the present invention by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims. Additionally, variations to the disclosed embodiments may be understood and effected by the skilled person practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

Claims

1. A heat exchanger (100) comprising a stack of heat exchanger plates (105) stacked one on top of the other along a stacking direction (SD),

a first set of channels (401) formed in every first second interspace between the heat exchanger plates (107),

a second set of channels (402) formed in every second second interspace between the heat exchanger plates (107),

wherein, in each of the channels in the first and second set of channels (401, 402) fin structures (210) formed of sheets being folded back and forth are positioned between the heat exchanger plates (107) such that the respective fin structure (210) abuts the heat exchanger plates (107)

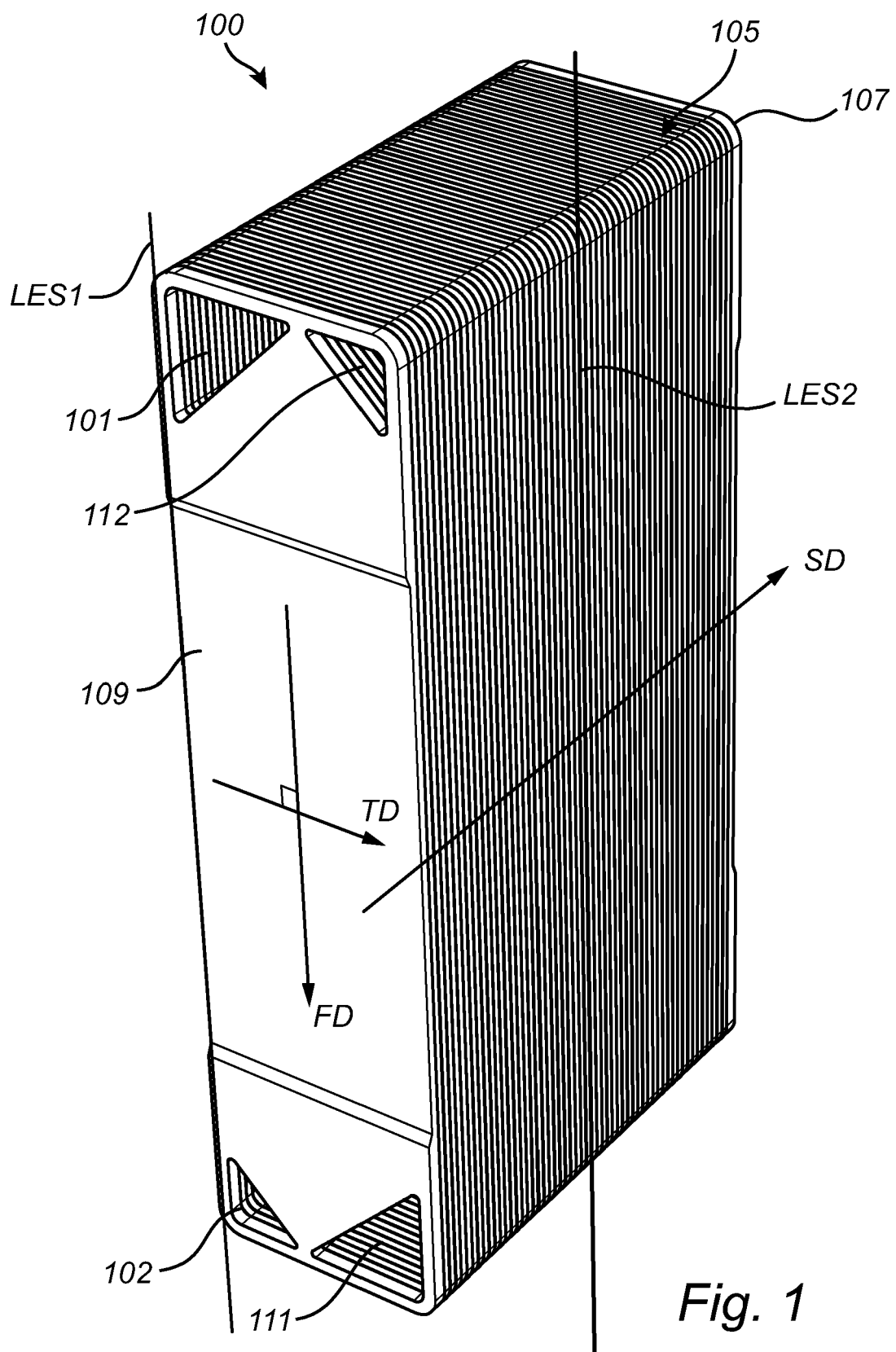
- along a plurality of contact lines (415) having a main extension extending in parallel with a longitudinally extending fin direction (FD) thereby defining plurality of fluid channels forming said first and second set of channels (401, 402), wherein each heat exchanger plate (107) comprises four through-going openings (201, 202, 211, 212) formed at a respective corner portion of the respective heat exchanger plate (107) and configured to form a first inlet port (201) extending through the stack (105) along the stacking direction (SD), a first outlet port (211) extending through the stack (105) along the stacking direction (SD), a second inlet port (202) extending through the stack (105) along the stacking direction (SD), and a second outlet port (212) extending through the stack (105) along the stacking direction (SD), the first inlet port (201) and first outlet port (211) being in fluid connection with each other via the first set of channels (401) and the second inlet port (202) and second outlet port (212) being in fluid connection with each other via the second set of channels (402), wherein the heat exchanger (100) further comprises, in each interspace between the heat exchanger plates (107), a distribution structure (220) at the respective inlet port (201, 202) and a collection structure (230) at the respective outlet port (211, 212), wherein the respective distribution structure (220), respectively the respective collection structure (230) is positioned between the respective port (201, 202, 211, 212) and the respective fin structure (210) in the respective first and second set of channels (401, 402), wherein a port interface (227) between the respective inlet port (201, 202) and the respective distribution structure (220), respectively a port interface (237) between the respective outlet port (211, 212) and the collection structure (230) is inclined relative to the fin direction (FD) such that a distance between the port interface (227, 235) and the fin structure (210), as measured along the fin direction (FD), increases with increasing distance, as seen along an imaginary line extending transversally across the fin direction (FD), from an edge (121, 122) of the respective heat exchanger plate (107) which is closest to the respective port (201, 202, 211, 212) and which extends along the longitudinally extending fin direction (FD).
2. The heat exchanger (100) according to claim 1, wherein the respective port interface forms an angle α with the fin direction (FD), wherein the angle α is between 110 and 160°, preferably between 120 and 150°.
 3. The heat exchanger (100) according to any one of the preceding claims, wherein the respective port interface extends along a substantially straight line.
 4. The heat exchanger (100) according to any one of the preceding claims, wherein the respective distribution structure (220), and/or the respective collection structure (230), extends from a first, transversally central, corner (223, 233) of the respective port (201, 202, 211, 212) towards a second, transversally outer, corner (224, 234) of the respective port (201, 202, 211, 212) and leaves a transversally extending gap (225, 235) at the longitudinally extending edge (224, 234) being closest to the respective port (201, 202, 211, 212).
 5. The heat exchanger (100) according to claim 4, wherein a major portion of a flow from the respective inlet port (201, 202) is distributed via the distribution structure (220) to the fin structure (210), respectively a major portion of a flow from the fin structure (210) is collected via the collection structure (230) to the respective outlet port (211, 212); and wherein a minor portion of the flow from the respective inlet port (201, 202) is transferred to the fin structure (210) via said gap (235), respectively a minor portion of the flow from the fin structure (210) is transferred to the respective outlet port (211, 212) via said gap (235).
 6. The heat exchanger (100) according to claim 5 or 6, wherein a cut in the respective heat exchanger plate (107) forming respective port (201, 202, 211, 212) is arc-shaped along at least a major portion of a transversal extension of said gap (225, 235).
 7. The heat exchanger (100) according to any one of the preceding claims, wherein the distribution structure (220) is formed by a basically triangular or truncated triangular fin structure.
 8. The heat exchanger (100) according to any one of the preceding claims, wherein the collection structure (230) is formed by a basically triangular or truncated triangular fin structure.
 9. The heat exchanger (100) according to any one of the preceding claims, wherein the respective ports (201, 202, 211, 212) are formed as substantially triangular ports.
 10. The heat exchanger (100) according to any one of the preceding claims, wherein dimensions of the first inlet and outlet ports (201, 211) are different from dimensions of the second inlet and outlet ports (202, 212).

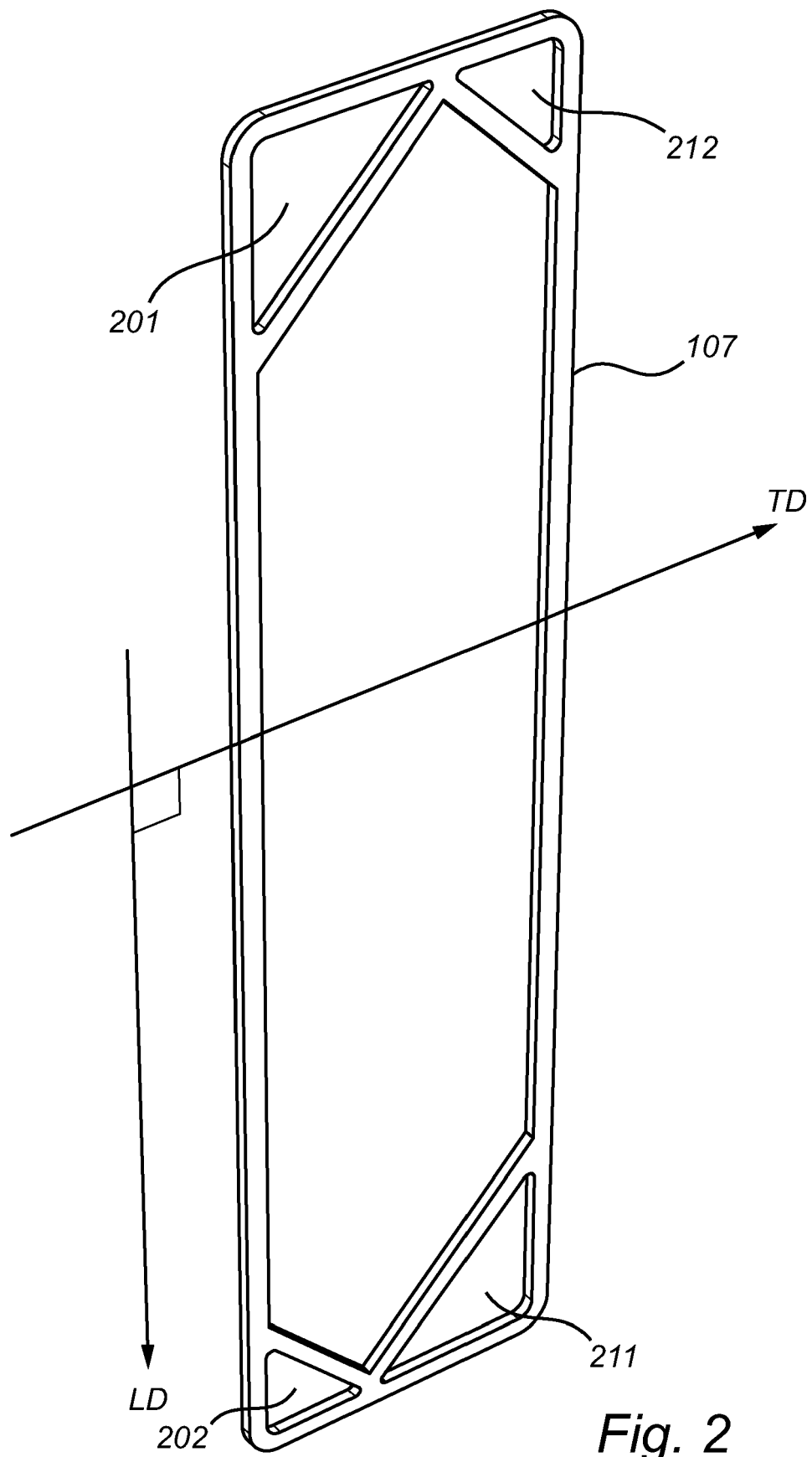
11. The heat exchanger (100) according to any one of the preceding claims, wherein an internal interface (228) between the respective distribution structure (220) and the fin structure (210) and/or an internal interface (238) between the respective collection structure (230) and the fin structure (210) in the respective channel of the first set of channels (401) and/or in the respective channel of the second set of channels (402) is inclined relative to the longitudinally extending fin direction (FD) and is inclined also relative to a transversal direction (TD). 5 10
12. The heat exchanger (100) according to claim 11, wherein the respective internal interface (228, 238) forms an angle β with the fin direction (FD), wherein the angle β is between 95 and 130°, preferably between 95 and 120°, or between 50 and 85°, preferably between 60 and 85°. 15
13. The heat exchanger (100) according to claim 11 or 12, wherein the respective internal interface (228, 238) extends along a substantially straight line. 20
14. The heat exchanger (100) according to any one of the preceding claims, wherein the first inlet port (201) is arranged on a first longitudinally extending side (LES1) of the stack of heat exchanger plates (105) and the first outlet port (211) is arranged on a second longitudinally extending side (LES2) of the stack of heat exchanger plates (105), the second longitudinally extending side (LES2) being opposite the first longitudinally extending side (LES1), and wherein the second inlet port (202) is arranged on the first longitudinally extending side (LES1) of the stack of heat exchanger plates (105) and the second outlet port (212) is arranged on the second longitudinally extending side (LES2) of the stack of heat exchanger plates (105), the first longitudinally extending side (LES1) being opposite the second longitudinally extending side (LES2). 25 30 35 40
15. The heat exchanger (100) according to any one of the preceding claims, wherein, in a first channel of the first set of channels (401), a first fin structure (210a) comprises at least a first and a second part (210a1-2) arranged one after the other along the fin direction (FD), 45

wherein, in a first channel of the second set of channels (402), the first channel of the second set of channels (402) being a neighbouring channel to the first channel of the first set of channels (401), a second fin structure (210b) comprises at least a first and a second part (210b1-2) arranged one after the other along the fin direction (FD), 50 55

wherein a central interface (239a) between the first and second parts (210a1-2) of the first fin

structure (210a) extends across the longitudinal fin direction (FD) and is positioned at a first position (P1) along the fin direction (FD), wherein a central interface (239b) between the first and second parts (210b1-2) of the second fin structure (210b) extends across the fin direction (FD) and is positioned at a second position (P2) along the fin direction (FD), and wherein the first and second positions (P1, P2) are separated a longitudinal distance (DP) from each other.





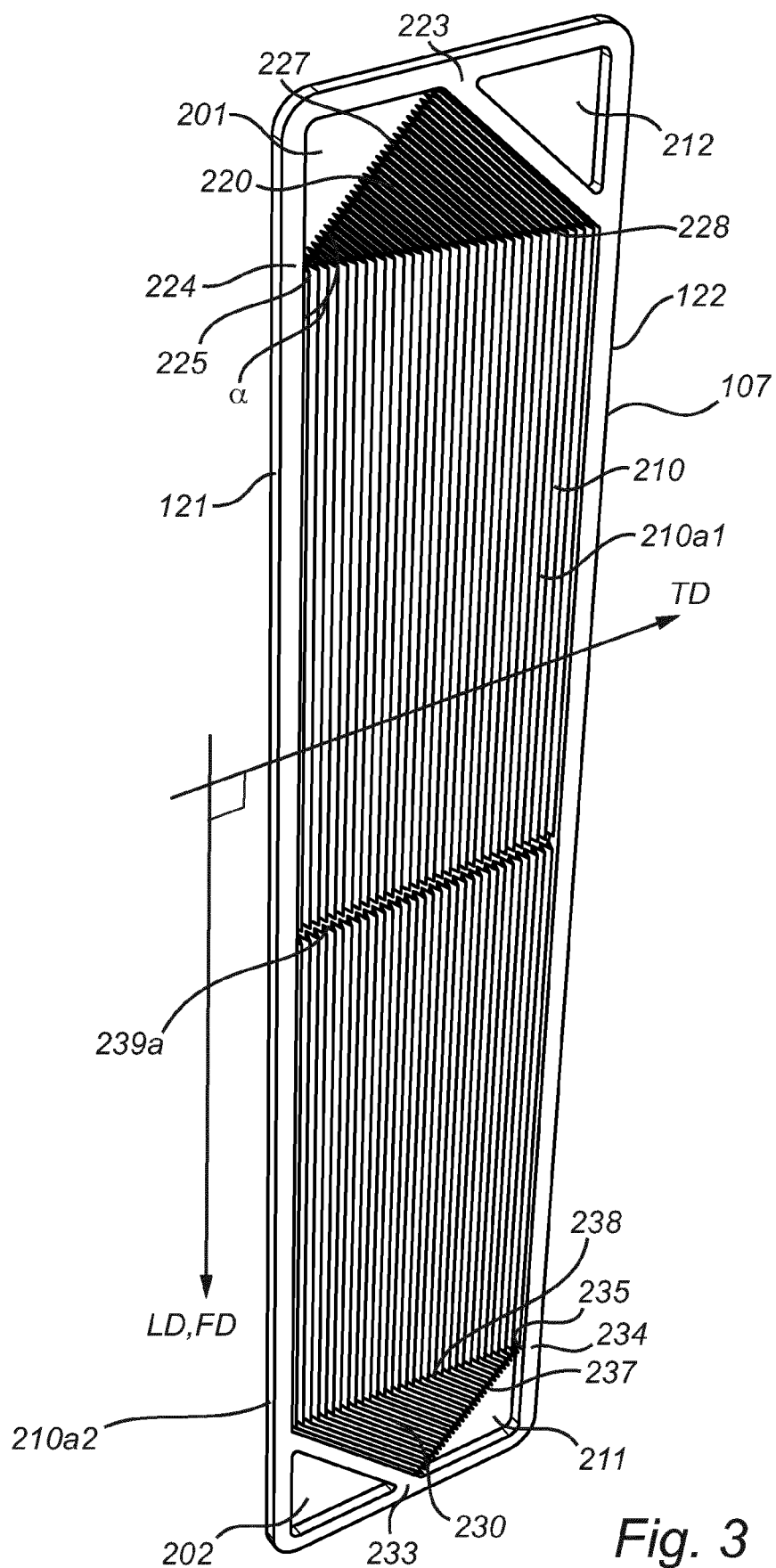


Fig. 3

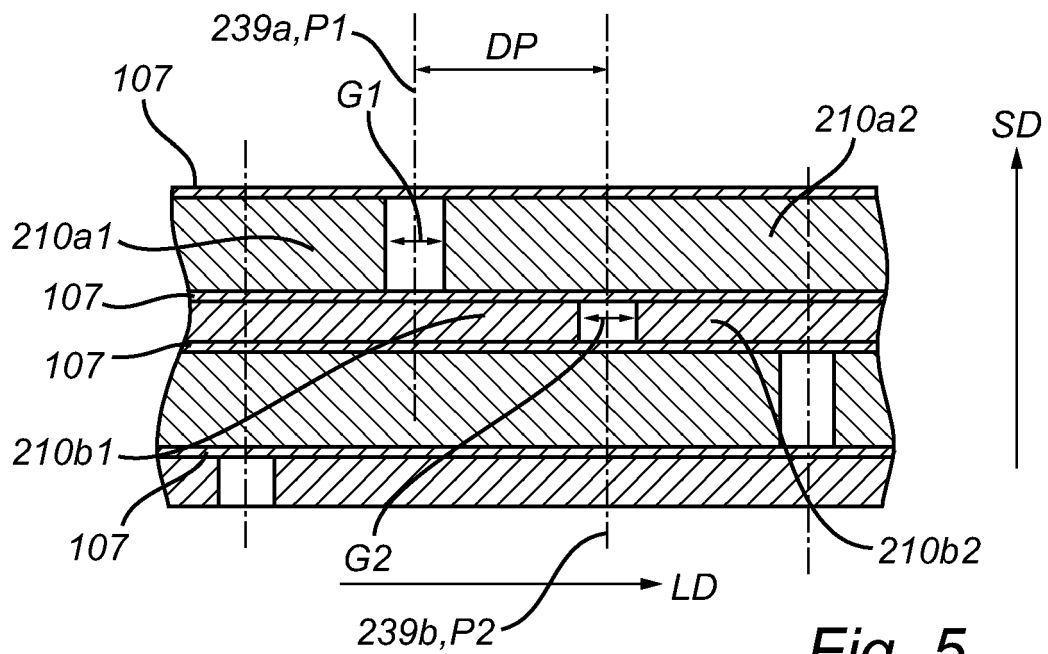
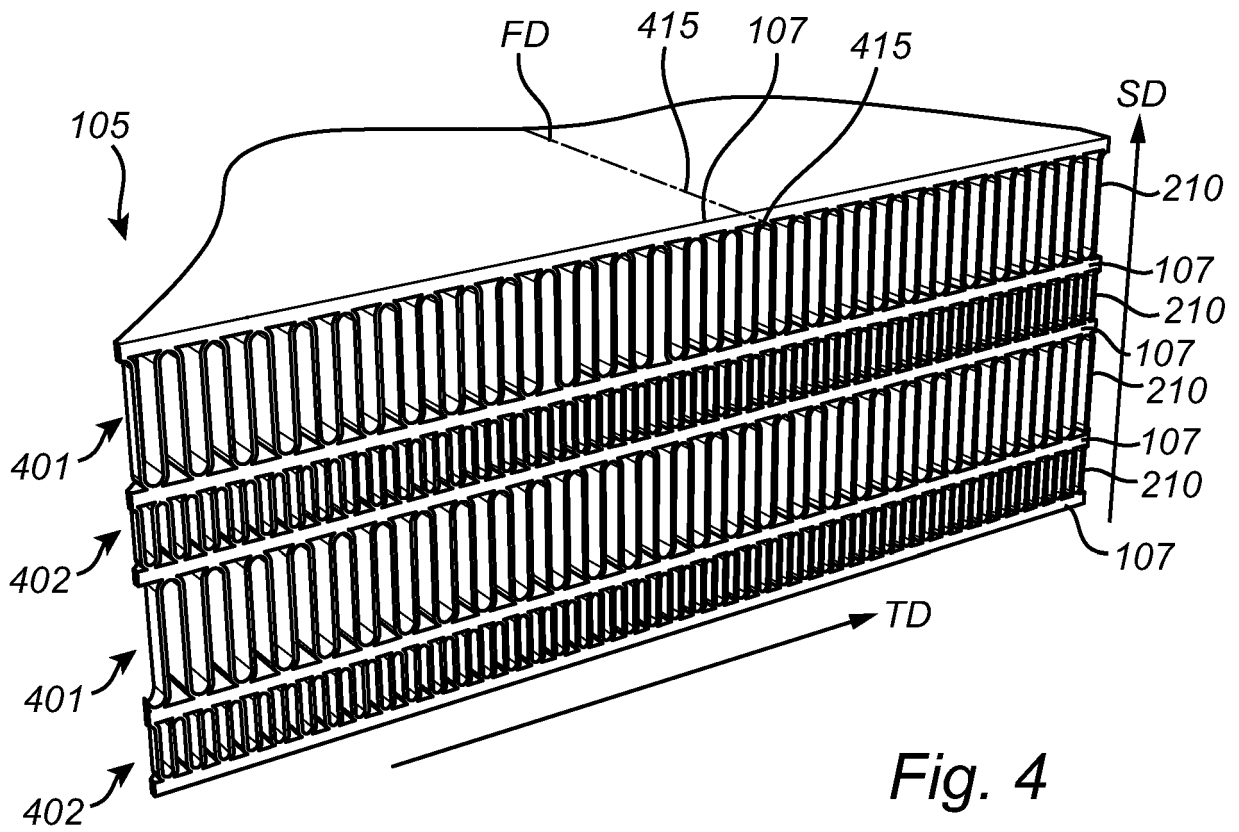


Fig. 5

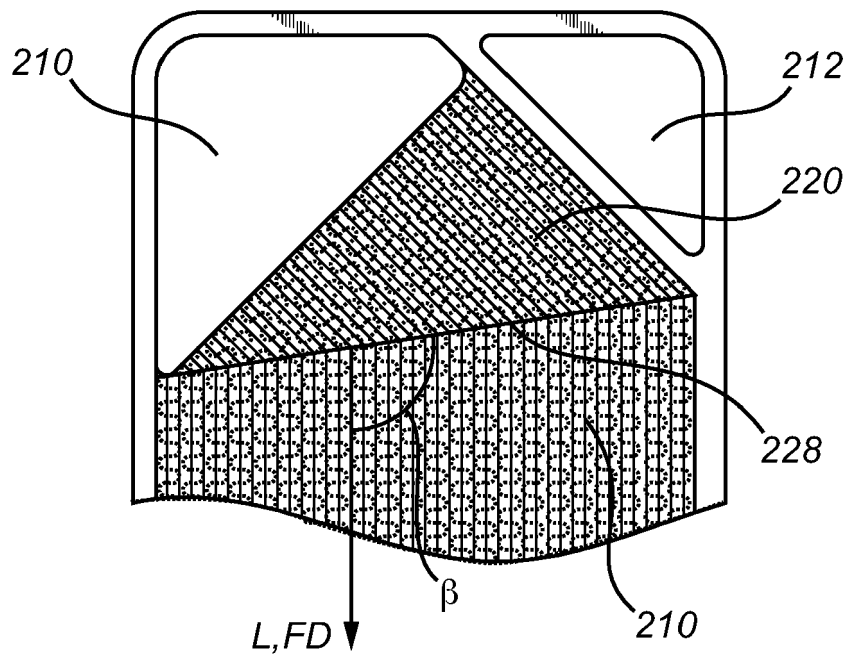


Fig. 6

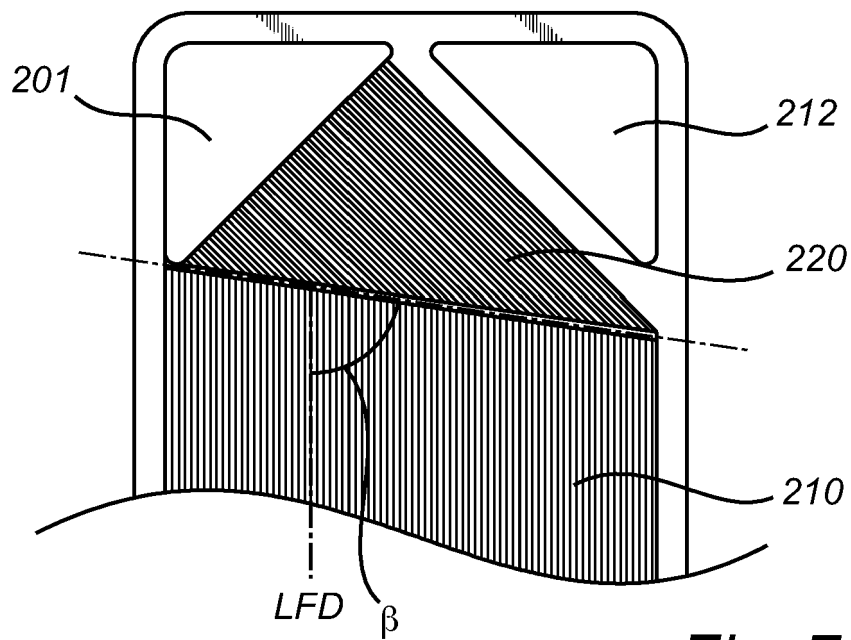


Fig. 7

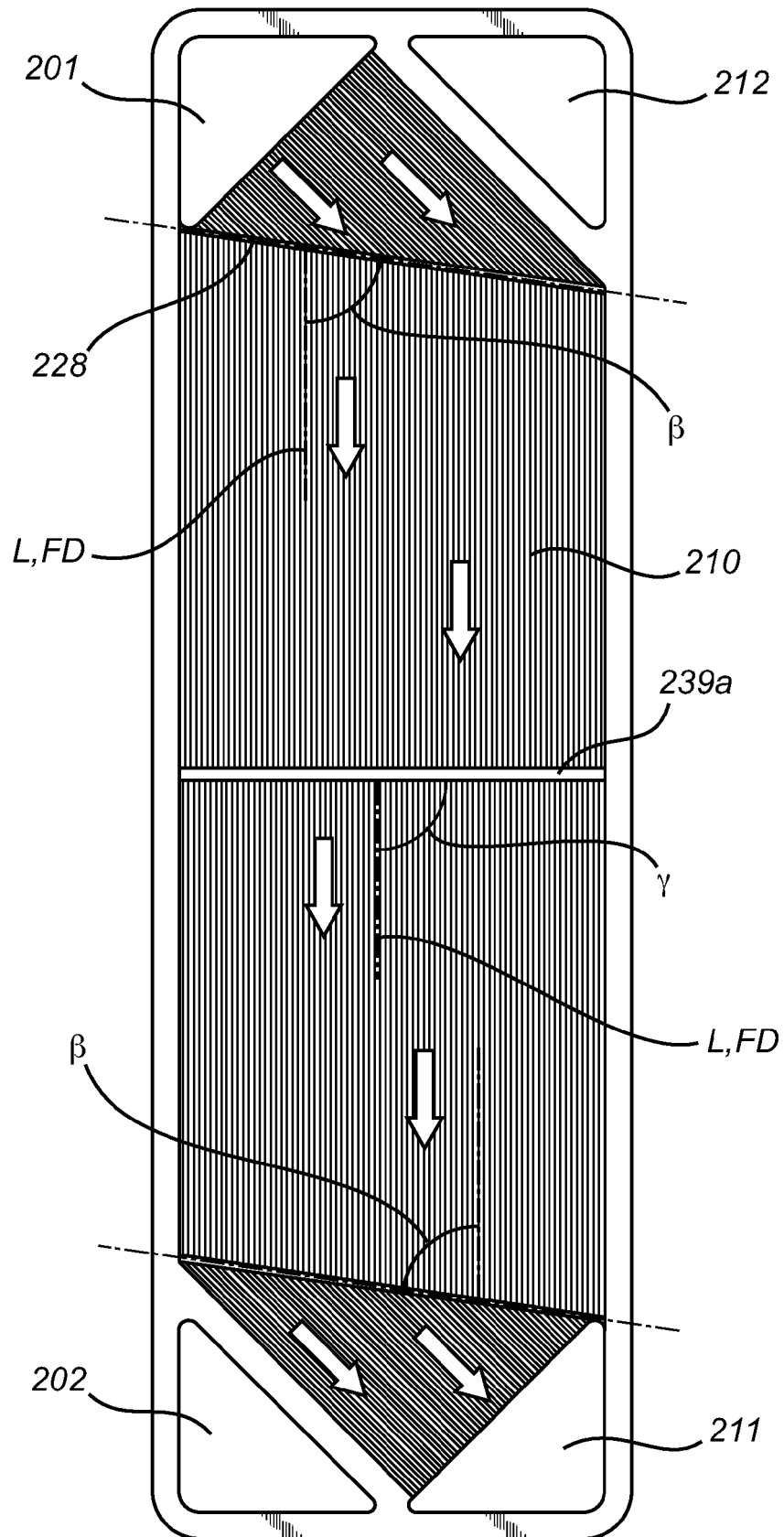


Fig. 8



EUROPEAN SEARCH REPORT

Application Number

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 7 March 2023	Examiner Vassoille, Bruno
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