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# (54) HEAT EXCHANGER PLATE, PERMEATION BARRIER GASKET ARRANGEMENT, PLATE ARRANGEMENT AND HEAT EXCHANGER CASSETTE

(57) The present invention relates to a heat exchanger plate (100), a permeation barrier gasket arrangement (300), a plate arrangement (400) and a heat exchanger cassette (200). The heat exchanger plate (100) comprises an evacuation hole (140) arranged outside of a permeation barrier seat (120) at least partially circumscribing a port hole gasket seat (118). A permeation space (130) is defined between the permeation barrier seat (120) and the port hole gasket seat (118). An evacuation space (150) is defined by a portion (102a) of a first plate pattern (102) being recessed relative to a first abutment surface (122) such that the first abutment surface (122) partially circumscribes the evacuation space (150). The evacuation space (150) circumscribes the evacuation hole (104) and extends to the permeation barrier seat (120). The first abutment surface (122) is adapted to abut a corresponding abutment surface of a first adjoining heat exchanger plate (100). A second abutment surface (124) is defined on an opposite side and circumscribes the evacuation hole (140). The second abutment surface (124) is adapted to abut a corresponding abutment surface of a second adjoining heat exchanger plate (100).

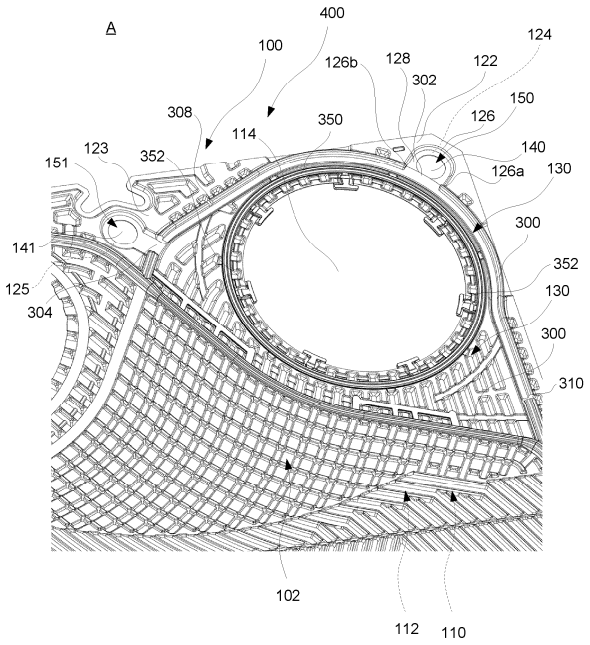



*Fig. 7*

EP 4 818 621 A1

## Description

### Technical Field

**[0001]** The invention relates to the field of plate heat exchangers. More particularly, it is related to heat exchanger plate for a plate heat exchanger, a permeation barrier gasket arrangement for a plate heat exchanger and a plate arrangement for a plate heat exchanger comprising such a heat exchanger plate and permeation barrier gasket arrangement. The invention also relates to a heat exchanger cassette for a plate heat exchanger comprising such heat exchanger plate.

### Background Art

**[0002]** Plate heat exchangers, PHEs, are used in numerous applications where heat is to be transferred from one fluid to another or vice versa. A typical plate heat exchanger includes two end plates between which plurality of heat exchanger plates or heat transfer plates are arranged in a stacked configuration so as to form a plate stack or plate pack. Generally, a number of heat exchanger plates and gaskets are stacked in an alternating fashion. In this way first plate interspaces and second plate interspaces are alternately formed between the heat exchanger plates. The first plate interspaces and the second plate interspaces are typically separated from each other and are designed to receive a respective fluid between which fluids heat is to be exchanged. Thus, the first plate interspaces and the second plate interspaces form channels for the respective fluids. Further, respective inlet and outlet ports are typically provided to the first plate interspaces and to the second plate interspaces. The inlet and outlet ports are typically formed by aligned portholes extending through the plate stack.

**[0003]** In a common type of PHE gaskets are used between each heat exchanger plate to seal the fluids from each other and to define fluid channels for the respective fluids. Such PHEs are generally referred to as gasketed PHEs.

**[0004]** In another type of common PHE two adjoining heat exchanger plates are welded to each other to form what is generally referred to as a heat exchanger cassette or simply a cassette. The cassettes are in turn stacked with gaskets in between. Such PHEs are generally referred to as semi-welded PHEs. Thus, in semi-welded PHEs, the plate interspaces formed between the heat exchanger plates making up a cassette are sealed off by a weld, whereas the plate interspaces formed between the cassettes are sealed off by gaskets. In other words, a semi-welded PHE includes a combination of welded plate interspaces (welded fluid channels) and gasketed plate interspaces (gasketed fluid channels). However, in semi-welded PHEs, the fluid attributable to the welded pate interspaces of the cassettes is typically sealed off by a ring gasket around the inlet port and a ring gasket around the outlet port in between the cassettes. Thus, even if a fluid is fed through welded plate interspaces it is still sealed off by two gaskets for each cassette.

**[0005]** Some fluids used in heat exchangers are capable of permeating gaskets meaning that although a generally speaking tight gasket is in place, the fluid will still permeate through the material of the gasket and escape e.g. to the ambient. Although a semi-welded PHE may significantly reduce the permeation through gaskets owing to the welded palate interspaces or channels, problems related to permeation through the ring gaskets can still be outspoken. For instance, in ammonia applications problems related to permeation through the ring gaskets of a semi-welded PHE can lead to work environment problems and health issues since ammonia e.g. has a pungent smell. Problems related to permeation through gaskets are for natural reasons more pronounced in gasketed PHEs. Given the problems associated with fluids permeating the gaskets of a PHEs, it desirable to handle permeated fluid in a safe way.

**[0006]** To this end, it has been suggested to surround relevant gaskets by another gasket to capture the permeated fluid between the gaskets. It has further been suggested to provide the heat exchanger plates or cassettes with an opening located between the gaskets to be able to lead away the permeated fluid in a safe way via the opening.

**[0007]** Although such solutions have proved efficient when it comes to handling permeated fluid, such as ammonia, the provision of an opening through the heat exchanger plates or cassettes can result in several drawbacks. For instance, the flow of the fluid may be disturbed e.g. with an increased pressure drop and lower efficiency as a result. Moreover, the provision of an opening through the heat exchanger plates or cassettes which affects the flow of one or more of the fluids results in that additional gaskets for surrounding the opening have to be used between the heat exchanger plates or cassettes. Another drawback resides in that the heat exchanger plates and correspondingly the cassettes may be become weaker and more prone to leakage owing form the presence of such an opening.

**[0008]** Hence, there is room for improvement when it comes to handling fluid having permeated through gaskets of a PHE.

### Summary

**[0009]** With the above in mind, it is an objective of the present invention to provide an improved heat exchanger plate for a plate heat exchanger, an improved permeation barrier gasket arrangement for a plate heat exchanger, an improved plate arrangement for a plate heat exchanger as well as an improved heat exchanger cassette for a plate heat exchanger.

**[0010]** Another objective is to provide such a heat exchanger plate which is capable of evacuating permeated fluid in a safe way.

**[0011]** Another objective is to provide such a heat exchanger plate which is capable of evacuating permeated fluid in a safe way while not negatively affecting the heat transfer performance.

**[0012]** Another objective is to provide such a heat exchanger plate which is capable of evacuating permeated fluid while not negatively affecting the flow of the fluids between which heat is to be exchanged.

**[0013]** Another objective is to provide such a heat exchanger plate which is less prone to cracking or breaking.

**[0014]** Another objective is to provide such a heat exchanger plate which is more cost-effective.

**[0015]** Another objective is to provide such a permeation barrier gasket arrangement which is capable of evacuating permeated fluid in a safe way.

**[0016]** Another objective is to provide such a permeation barrier gasket arrangement which is capable of evacuating permeated fluid in a safe way while not negatively affecting the heat transfer performance.

**[0017]** Another objective is to provide such a permeation barrier gasket arrangement which is capable of evacuating permeated fluid while not negatively affecting the flow of the fluids between which heat is to be exchanged.

**[0018]** Another objective is to provide such a permeation barrier gasket arrangement which is more cost-effective.

**[0019]** To achieve at least one of the above objects and also other objects that will be evident from the following description, heat exchanger plate for a plate heat exchanger, having the features defined in claim 1, is provided according to the present inventive concept. A permeation barrier gasket arrangement for a plate heat exchanger is provided according to claim 8. A plate arrangement for a plate heat exchanger comprising a heat exchanger plate and a permeation barrier gasket arrangement is provided according to claim 13. A heat exchanger cassette for a plate heat exchanger, comprising a heat exchanger plate is provided according to claim 14.

**[0020]** More specifically, according to a first aspect, there is provided a heat exchanger plate for a plate heat exchanger, comprising:

a first plate pattern on a first side of the heat exchanger plate and a second plate pattern on a second side of the heat exchanger plate opposite to the first side,

a port hole,

a port hole gasket seat defined on the first side by the first plate pattern, the port hole gasket seat circumscribing the port hole and being adapted to receive a port hole gasket,

a permeation barrier seat defined on the first side by the first plate pattern, the permeation barrier seat at least partially circumscribing the port hole gasket seat and being adapted to receive a permeation barrier gasket arrangement such that a permeation space is defined at the first side of the heat exchanger plate between the permeation barrier seat and the port hole gasket seat,

an evacuation hole arranged outside of the permeation barrier seat,

a first abutment surface defined on the first side by the first plate pattern, the first abutment surface being adapted to abut a corresponding abutment surface of a first adjoining heat exchanger plate,

an evacuation space defined on the first side of the heat exchanger plate by a portion of the first plate pattern being recessed relative to the first abutment surface such that the first abutment surface partially circumscribes the evacuation space, the evacuation space circumscribing the evacuation hole and extending to the permeation barrier seat, wherein the permeation space is fluidly connected to the evacuation hole via the evacuation space, and

a second abutment surface defined on the second side by the second plate pattern and circumscribing the evacuation hole, the second abutment surface being adapted to abut a corresponding abutment surface of a second adjoining heat exchanger plate.

**[0021]** Hereby an improved heat exchanger plate for a plate heat exchanger is provided.

**[0022]** The heat exchanger plate is designed for, and hence suitable to be used with, gasketed PHEs and semi-welded PHEs.

**[0023]** The present invention is based on the realization that by providing an evacuation space in the pattern of a heat exchanger plate at an evacuation hole in combination with abutment surfaces at the evacuation hole on both sides of the heat exchanger plate, where the evacuation hole, and hence the evacuation space, are located outside of a permeation space, allows for efficient evacuation of permeated fluid with no or minimal impact on the performance of the PHE at hand. In this regard, the evacuation hole and the evacuation space may in practice be located outside of any area forming part of any fluid channel of the heat exchanger plate. That is, the evacuation hole and the evacuation space may not align with any fluid channel of the heat exchanger plate as seen in a normal direction to a major side surface of the heat exchanger plate. Thus, in practice the evacuation hole and the evacuation space may be located in an edge region or a peripheral region, such as a corner region, of the heat exchanger plate. Moreover, the evacuation hole, and hence the evacuation space may be formed with no additional manufacturing steps as compared to a standard heat exchanger plate. In practice, the evacuation hole may be cut when cutting the plate and the evacuation space may be defined or formed when pressing the pattern on the first side of the heat exchanger plate. Further, by the first and second abutment surfaces being adapted to abut corresponding abutment surfaces of adjoining heat exchanger plates, the need for any addi-

tional gaskets at the evacuation hole may be eliminated. In this regard, the first and second abutment surfaces may to advantage be adapted to directly abut corresponding abutment surfaces of adjoining heat exchanger plates.

**[0024]** By the heat exchanger plate comprising a first plate pattern on a first side of the heat exchanger plate and a second plate pattern on a second side of the heat exchanger plate opposite to the first side properties of the heat exchanger plate may be tailored. In practice, the first plate pattern and the second plate pattern may be pressed at the same time using the same manufacturing step meaning that the first plate pattern and the second plate pattern may generally speaking be complementary patterns or patterns which "mirror" each other. Further, as is known in the art, by rotating, flipping or turning identical or similar heat exchanger plates, the heat exchanger plates may interact with each other to define fluid channels having desired properties.

**[0025]** By the heat exchanger plate comprising a port hole gasket seat defined on the first side by the first plate pattern, a port hole gasket, also known as a ring gasket, may be received and retained at the porthole seat.

**[0026]** By the heat exchanger plate comprising a permeation barrier seat defined on the first side by the first plate pattern, a permeation barrier gasket arrangement may be received and retained at the permeation barrier seat. In this way, a permeation space may be defined at the first side of the heat exchanger plate between the permeation barrier seat and the port hole gasket seat. In practice, the permeation space will be formed when a port hole gasket is received and retained at the porthole seat and a permeation barrier gasket arrangement is received in the permeation barrier seat.

**[0027]** The so formed permeation space will then become fluidly connected to the to the evacuation hole via the evacuation space. As a result, fluid having permeated through a porthole gasket may be evacuated through the evacuation hole, via the permeation space and the evacuation space. In this regard, it is to be understood that the so formed permeation space and the evacuation space will be open in a normal direction of the first side of the heat exchanger plate unless arranged in a stack of heat exchanger plates or a stack of cassettes. However, when the heat exchanger plate is arranged in a stack of heat exchanger plates with relevant gaskets in between a gasketed or sealed permeation space will in practice be formed along the first side of the heat exchanger plate between the port hole gasket seat and the permeation barrier seat. Correspondingly, a sealed evacuation space will be formed when the first abutment surface abuts a corresponding abutment surface of a first adjoining heat exchanger plate.

**[0028]** It should be noted that within the context of this application the term "port hole gasket seat" may here mean any area, groove, set of grooves or similar which is adapted to receive a port hole gasket.

**[0029]** It should be noted that within the context of this application the term "permeation barrier seat" may here mean any area, groove, set of grooves or similar which is adapted to receive a permeation barrier gasket arrangement, gasket, seal or similar so as to define a permeation space at the first side of the heat exchanger plate between the permeation barrier seat and the port hole gasket seat.

**[0030]** It should be noted that within the context of this application the term "evacuation hole" may here mean any hole or opening extending through the heat exchanger plate.

**[0031]** At least a portion of the evacuation space may be located directly opposite to the second abutment surface. By at least a portion of the evacuation space being located directly opposite to the second abutment surface, the second abutment surface may abut a corresponding abutment surface of a second adjoining heat exchanger plate in direct proximity of the evacuation hole. Thus, a seal may be provided between the second abutment surface and the corresponding abutment surface.

**[0032]** The first plate pattern may define a wall section defining a sidewall of the evacuation space, the wall section extending from a first position at the permeation barrier seat, about the evacuation hole, and to a second position of the permeation barrier seat, thereby encircling the evacuation space. In this way, the evacuation space may be defined by the material of the heat exchanger plate. Further, in this way, the evacuation space may be defined via a single manufacturing step. In practice, the evacuation space may be defined when pressing the first pattern in the heat exchanger plate.

**[0033]** The permeation barrier gasket seat may comprise a seat outlet connecting to the evacuation space, wherein the first and second positions are on opposite sides of the seat outlet. In this way, fluid may enter into the evacuation space via the seat outlet. Further, in this way, the seat outlet and the evacuation space may be defined via a single manufacturing step. In practice, the seat outlet and the evacuation space may be defined when pressing the first pattern in the heat exchanger plate.

**[0034]** The wall section may connect the first abutment surface and a bottom surface of the evacuation space. In this way, the evacuation space may be defined by the material of the heat exchanger plate. Further, in this way, the evacuation space may be defined via a single manufacturing step. In practice, the evacuation space may be defined when pressing the first pattern in the heat exchanger plate.

**[0035]** The first abutment surface may be a flat surface configured to seal against the corresponding abutment surface of the first adjoining heat exchanger plate, and/or the second abutment surface may be a flat surface configured to seal against the corresponding abutment surface of the second adjoining heat exchanger plate.

**[0036]** The first abutment surface may be a flat surface configured to seal against the corresponding abutment surface of the first adjoining heat exchanger plate. In this

way, a seal between the first abutment surface and the corresponding abutment surface of the first adjoining heat exchanger plate may be realized in a simple yet reliable manner.

**[0037]** The second abutment surface may be a flat surface configured to seal against the corresponding abutment surface of the second adjoining heat exchanger plate. In this way, a seal between the second abutment surface and the corresponding abutment surface of the second adjoining heat exchanger plate may be realized in a simple yet reliable manner.

**[0038]** The port hole gasket seat may comprise a groove configured to retain the port hole gasket, and/or the permeation barrier seat may comprise a groove configured to retain the permeation barrier gasket arrangement.

**[0039]** The port hole gasket seat may comprise a plurality of groove sections defined by the first plate pattern.

**[0040]** The port hole gasket seat may comprise a plurality of groove sections defined by protruding portions of the first plate pattern.

**[0041]** The permeation barrier seat may comprise a plurality of groove sections defined by the first plate pattern.

**[0042]** The permeation barrier seat may comprise a plurality of groove sections defined by protruding portions of the first plate pattern.

**[0043]** The first plate pattern and the second plate pattern may be complementary patterns.

**[0044]** The heat exchanger plate may be integrally formed by being cut and pressed from sheet metal, such as stainless steel sheet metal. Thus, the heat exchanger plate may be formed in a single piece.

**[0045]** The first abutment surface may be located in a top plane of the heat exchanger plate.

**[0046]** The first abutment surface may be located in an uppermost plane of the heat exchanger plate.

**[0047]** The first abutment surface may be located in an upper extreme plane of the heat exchanger plate.

**[0048]** The second abutment surface may be located in a base plane of the heat exchanger plate.

**[0049]** The second abutment surface may be located in a bottom plane of the heat exchanger plate.

**[0050]** The second abutment surface may be located in a lowermost plane of the heat exchanger plate.

**[0051]** The second abutment surface may be located in a lower extreme-plane of the heat exchanger plate.

**[0052]** The heat exchanger plate, may further comprise:

a further evacuation hole arranged outside of the permeation barrier seat,

a further first abutment surface defined on the first side by the first plate pattern, the further first abutment surface being adapted to abut a further corresponding abutment surface of the first adjoining heat exchanger plate,

a further evacuation space defined on the first side by a portion of the first plate pattern being recessed relative to the further first abutment surface such that the further first abutment surface partially circumscribes the further evacuation space, the further evacuation space circumscribing the further evacuation hole and extending to the permeation barrier seat, wherein the permeation space is fluidly connected to the further evacuation hole via the further evacuation space, and

a further second abutment surface defined on the second side by the second plate pattern and circumscribing the further evacuation hole, the further second abutment surface being adapted to abut a further corresponding abutment surface of the second adjoining heat exchanger plate.

**[0053]** According to a second aspect of the invention, there is provided a permeation barrier gasket arrangement for a plate heat exchanger, adapted to be arranged on a first side of a heat exchanger plate and to circumscribe a port hole gasket circumscribing a port hole of the heat exchanger plate such that a permeation space is defined at the first side of the heat exchanger plate between the permeation barrier gasket arrangement and the port hole gasket, wherein the permeation barrier gasket arrangement comprises an outlet opening extending therethrough, the outlet opening being adapted to fluidly connect the permeation space and an evacuation space fluidly connected to an evacuation hole of the heat exchanger plate.

**[0054]** Hereby an improved permeation barrier gasket arrangement for a plate heat exchanger is provided.

**[0055]** The permeation barrier gasket arrangement is designed for, and hence suitable to be used with, gasketed PHEs and semi-welded PHEs. In particular, the permeation barrier gasket arrangement is designed to be used with a heat exchanger plate according to first aspect. Thus, the permeation barrier gasket arrangement is designed to interrelate with a heat exchanger plate according to the first aspect.

**[0056]** In general, features of this aspect provide similar advantages as discussed above in relation to the first aspect. Consequently, said advantages will not be repeated in order to avoid undue repetition.

**[0057]** However, by the permeation barrier gasket arrangement comprising an outlet opening extending therethrough, where the outlet opening is adapted to fluidly connect the permeation space and an evacuation space fluidly connected to an evacuation hole of the heat exchanger plate, the barrier gasket arrangement may provide a fluid communication between the permeation space and an evacuation hole of a heat exchanger plate such that fluid having permeated through a port hole gasket may be evacuated through the evacuation hole via an evacuation space defined at a first side of the heat exchanger plate, i.e. as have been described above in relation to the first aspect.

**[0058]** The outlet opening may be formed by a notch in

the permeation barrier gasket arrangement. By the outlet opening being formed by a notch in the permeation barrier gasket arrangement, fluid may efficiently exit through the outlet opening while at the same time the integrity of the permeation barrier gasket arrangement may be not be affected or may be minimally affected. Further, it may become easier to arrange the permeation barrier gasket arrangement in the permeation barrier gasket seat of a heat exchanger plate, thereby reducing a time needed to e.g. assemble a PHE.

**[0059]** The outlet opening may be formed by an interruption of the permeation barrier gasket arrangement. By the outlet opening being formed by an interruption of the permeation barrier gasket arrangement, a cross-sectional area of the outlet opening may be optimized or maximized.

**[0060]** At least a portion of a length extension of the permeation barrier gasket arrangement may have a generally L-shaped, C-shaped, I-shaped or inverted T-shaped cross section so as to from a passageway along said at least a portion of the length extension of the permeation barrier gasket arrangement. In this way, a flow of permeated fluid may be promoted or facilitated along said at least a portion of the length extension of the permeation barrier gasket arrangement. Thus, a flow of permeated fluid may be more easily reach the outlet opening of the permeation barrier gasket arrangement. In practice, the permeation space may be a narrow space allowing only a limited fluid flow therethrough. In such a situation, the provision of a passageway along at least a portion of the length extension of the permeation barrier gasket arrangement may significantly improve how efficiently permeated fluid may be evacuated.

**[0061]** The permeation barrier gasket arrangement may further comprise an inlet opening extending therethrough, the inlet opening being adapted to fluidly connect the permeation space with the ambient. By the permeation barrier gasket arrangement comprising an inlet opening extending therethrough, a forced flow of fluid through the permeation space may be achieved. Such forced flow may significantly improve how efficiently permeated fluid may be evacuated.

**[0062]** The permeation barrier gasket arrangement may comprise a material selected from the group consisting of polymer materials, elastomer materials, hydrated nitrile materials, chloroprene materials, ethylene propylene diene monomer materials, nitrile butadiene rubber materials and fluoroelastomer materials.

**[0063]** The permeation barrier gasket arrangement may be integrally formed.

**[0064]** The permeation barrier gasket arrangement may comprise a first part and a separate second part.

**[0065]** A first portion of the permeation barrier gasket arrangement may be adapted to form a barrier between the permeation space and a heat exchange area at the first side of the heat exchanger plate. Thus, the permeation barrier gasket arrangement may in part be common to what is commonly referred to as a field gasket.

**[0066]** The permeation barrier gasket arrangement may integrally formed with a gasket member adapted to define a gasketed heat exchange area at the first side of the heat exchanger plate.

**[0067]** The permeation barrier gasket arrangement may integrally formed with a field gasket.

**[0068]** The inlet opening through the permeation barrier gasket arrangement may be formed of a hole in the permeation barrier gasket arrangement.

**[0069]** The inlet opening through the permeation barrier gasket arrangement may be formed by a notch in the permeation barrier gasket arrangement.

**[0070]** The inlet opening through the permeation barrier gasket arrangement may be formed by an interruption of the permeation barrier gasket arrangement.

**[0071]** According to a third aspect of the invention, there is provided a plate arrangement for a plate heat exchanger, comprising:

a heat exchanger plate according to the first aspect, and

a permeation barrier gasket arrangement according to the second aspect, wherein the permeation barrier gasket arrangement is received in the permeation barrier seat.

**[0072]** In general, features of this third aspect provide similar advantages as discussed above in relation to the first aspect and the second aspect. Consequently, said advantages will not be repeated in order to avoid undue repetition.

**[0073]** According to a fourth aspect of the invention, there is provided a heat exchanger cassette for a plate heat exchanger, comprising a heat exchanger plate according to the first aspect and the second adjoining heat exchanger plate, wherein the second adjoining heat exchanger plate is welded to the second side of the heat exchanger plate, and wherein the second abutment surface abuts the corresponding abutment surface of the second adjoining heat exchanger plate.

**[0074]** In general, features of this fourth aspect provide similar advantages as discussed above in relation to the first aspect, the second aspect and the third aspect. Consequently, said advantages will not be repeated in order to avoid undue repetition.

**[0075]** However, by the second abutment surface abutting the corresponding abutment surface of the second adjoining heat exchanger plate, the evacuation hole may fluidly connect to a corresponding evacuation hole of the second adjoining heat exchanger plate.

**[0076]** The second abutment surface may welded to the corresponding abutment surface of the of the second adjoining heat exchanger plate by a weld circumscribing the evacuation hole. In this way, leakage of fluid at the interface between the second abutment surface and the corresponding abutment surface of the of the second adjoining heat exchanger plate may be prevented or counteracted. Moreover, the second abutment surface

may be welded to the corresponding abutment surface of the of the second adjoining heat exchanger plate by a weld circumscribing the evacuation hole when providing other welds of the heat exchanger cassette. Thus, a leakage of fluid at the interface between the second abutment surface and the corresponding abutment surface of the of the second adjoining heat exchanger plate may be prevented or counteracted with no or only limited additional work when fabrication the heat exchanger cassette.

**[0077]** A gasketed plate heat exchanger comprising a plurality of heat exchanger plates according to the first aspect and a plurality of permeation barrier gasket arrangement according to the second aspect alternatingly stacked.

**[0078]** In general, features of such gasketed plate heat exchanger provide similar advantages as discussed above in relation to the first aspect, the second aspect and the third aspect. Consequently, said advantages will not be repeated in order to avoid undue repetition.

**[0079]** A semi-welded plate heat exchanger comprising a plurality heat exchanger cassettes according to the fourth aspect and a plurality permeation barrier gasket arrangements according to the second aspect alternatingly stacked.

**[0080]** In general, features of such semi-welded plate heat exchanger provide similar advantages as discussed above in relation to the first aspect, the second aspect and the fourth aspect. Consequently, said advantages will not be repeated in order to avoid undue repetition.

**[0081]** A further scope of applicability of the present invention will become apparent from the detailed description given below. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

**[0082]** Hence, it is to be understood that this invention is not limited to the particular component parts of the device described as such device may vary. It is also to be understood that the terminology used herein is for purpose of describing particular embodiments only and is not intended to be limiting. It must be noted that, as used in the specification and the appended claim, the articles "a," "an," "the," and "said" are intended to mean that there are one or more of the elements unless the context clearly dictates otherwise. Thus, for example, reference to "a unit" or "the unit" may include several devices, and the like. Furthermore, the words "comprising", "including", "containing" and similar wordings does not exclude other elements or steps.

## Brief Description of the Drawings

**[0083]** The above and other aspects of the present inventive concept will now be described in more detail, with reference to appended figures showing variants. The figures should not be considered limiting, instead, they are used for explaining and understanding.

**[0084]** As illustrated in the figures, the sizes of layers and regions may be exaggerated for illustrative purposes and, thus, are provided to illustrate the general structures of variants. Like reference numerals refer to like elements throughout.

Fig. 1 is a is a schematic front view of a plate heat exchanger in which the present invention may be employed.

Fig. 2 is a schematic side view of the plate heat exchanger in Fig. 1.

Fig. 3 is a schematic perspective view of a portion of a pack of heat exchanger plates and associated gaskets which may be used in the plate heat exchanger of Figs. 1 and 2.

Fig. 4 is a schematic perspective view of a portion of a pack of heat exchanger cassettes and associated gaskets which may be used in the plate heat exchanger of Figs. 1 and 2.

Fig. 5 is a plane view of a short end portion of a heat exchanger plate which may be used in the plate heat exchanger of Figs. 1 and 2.

Fig. 6 is a detailed plane view of a corner region of the heat exchanger plate of Fig. 5.

Fig. 7 is a partial perspective view of the heat exchanger plate of Figs. 5 and 6 employed with gaskets including a permeation barrier gasket arrangement.

Fig. 8 is a perspective view of a permeation barrier gasket arrangement.

## Detailed Description

**[0085]** The present inventive concept will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred variants or embodiments of the inventive concept are shown. This inventive concept may, however, be implemented in many different forms and should not be construed as limited to the variants set forth herein; rather, these variants are provided for thoroughness and completeness, and fully convey the scope of the present inventive concept to the skilled person.

**[0086]** Figs. 1 and 2 show a plate heat exchanger 2 or PHE, 2. The PHE 2 comprises a frame plate 4 and a pressure plate 6. A pack 8 of heat exchanger plates 100 is sandwiched between the frame plate 4 and the pressure plate 6. At least a majority of the heat exchanger plates 100 or plates 100 of the pack 8 are all similar, which is

common practice in PHEs. The frame plate 4 is provided with fluid inlets and fluid outlets 10. The fluid inlets and fluid outlets 10 are, as is known in the art, configured to receive and eject fluids between which heat is to be transferred. In the depicted PHE 2, one fluid inlet and one fluid outlet 10 are configured to receive and eject a first fluid, whereas another fluid inlet and another fluid outlet 10 are configured to receive and eject a second fluid. In this way, heat may be transferred between the first fluid and the second fluid. In the depicted PHE 2, the fluid inlet and the fluid outlet 10 to the left in Fig. 1 may be configured to receive and eject a first fluid. Similarly, in the depicted PHE 2, the fluid inlet and the fluid outlet 10 to the right in Fig. 1 may be configured to receive and eject a second fluid. Further, as is known in the art, porthole channels are formed through the pack 8 of heat transfer plates 100 for each one of the fluid inlets and the fluid outlets 10. Generally speaking, the porthole channels are formed by aligned portholes of the heat exchanger plates 100 of the pack 8. The depicted PHE further comprises tightening means 12, an upper bar 14 and a lower bar 16.

**[0087]** Fig. 3 schematically illustrates how the plates 100 of the pack 8 may be alternately stacked with gaskets 13a in between. Thus, in case the plates 100 of the pack 8 are stacked like in Fig. 3 with gaskets 13a in between each plate 100, the depicted PHE 2 of Figs. 1 and 2 is a so-called gasketed PHE. The plates 100 of Fig. 3 are schematically illustrated. It is, however, to be understood that the design of the plates 100 may vary greatly e.g. depending on application, fluid type, size etcetera. Fig. 3 illustrates how eleven plates 100 are alternately stacked with gaskets 13a in between. However, in practice, the number of plates 100 in the pack 8 may vary greatly.

**[0088]** Fig. 4 illustrates how the plates 100 of the pack 8 may be welded in pairs, back side to back side, to form fluid tight heat exchanger cassettes 200 or cassettes 200. In other words, each cassette 200 comprises a first heat exchanger plate 100 and a second adjoining heat exchanger plate 100 wherein the second adjoining heat exchanger plate 100 is welded to the first heat exchanger plate 100. In yet other words, each cassette 200 comprises two plates 100 which are welded to each other. The cassettes 200 of Fig. 4 are alternately stacked with gaskets 13b in between. Hence, gaskets 13b are provided between adjoining cassettes 200. Thus, in case the plates 100 are welded in pairs to form cassettes 200, where the cassettes are stacked like in Fig. 4, the depicted PHE 2 of Figs. 1 and 2 is a so-called semi-welded PHE. The cassettes 200 of Fig. 4 are schematically illustrated. It is, however, to be understood that the design of the cassettes 200 may vary greatly e.g. depending on application, fluid type, size etcetera. Fig. 4 illustrates how fourteen cassettes 200, each comprising two plates 100 welded to each other, are alternately stacked with gaskets 13b in between. However, in practice, the number of cassettes 200 in the pack 8 may vary greatly.

**[0089]** Since gasketed PHEs 2 and semi-welded PHEs 2 are similar in many ways, the following description is generally applicable to both gasketed PHEs 2 and semi-welded PHEs 2. However, whenever appropriate, e.g. reasons of clarity, refence may be made to a gasketed PHE 2 or a semi-welded PHE 2. Despite this, it is to be noted that the herein described inventive concept is generally applicable to both gasketed PHEs 2 and semi-welded PHEs 2.

**[0090]** Further, the frame plate 4 and pressure plate 6 may be moved or pressed towards each other by tightening the tightening means 12. As a result, the pack 8 may be pressed between the frame plate 4 and pressure plate 6 by tightening the tightening means 12.

**[0091]** Thus, in the case of a gasketed PHE 2, the plates 100 of the pack 8 may be pressed against each other, whereby the gaskets 13a seal between the plates 100.

**[0092]** Correspondingly, in case of semi-welded PHE 2, the cassettes 200 of the pack 8 may be pressed against each other, whereby the gaskets 13b seal between the cassettes 200.

**[0093]** In this way parallel fluid channels are formed between the heat exchanger plates 100 of the pack 8. More specifically, one fluid channel is formed between each pair of adjacent heat exchanger plates 100. As a result, a first fluid and a second fluid of initially different temperatures, may be fed to/from the PHE 2 through the fluid inlets and outlets 10, and flow alternately through every second fluid channel for transferring heat from the first fluid to the second fluid or vice versa.

**[0094]** Now referring to Fig. 5. Fig. 5 illustrates a portion of a heat exchanger plate 100. More specifically, a region at a short end of a heat exchanger plate 100 is illustrated. Thus, Fig. 5 illustrates a portion of a plate 100 corresponding to a top region of a plate 100 in Figs. 1-4. In practice, a bottom region at an opposite short end of the plate 100 may have a corresponding design. The depicted plate 100 of Fig. 5 may be used in a PHE 2 of the above described type. Thus, the plate 100 may be used in a gasketed PHE 2 or in a in a semi-welded PHE 2. In case the plate 100 of Fig. 5 is used in a semi-welded PHE 2 it will in practice be welded back side to back side with another plate 100, to form part of a fluid tight heat exchanger cassette 200 of the type generally illustrated in Fig. 4.

**[0095]** Further, as is known in the art, a pack 8 of a gasketed PHE 2 or a semi-welded PHE may be formed of plates 100 of corresponding design. However, in order to establish desired fluid channels for a first fluid and a second fluid, the plates 100 may be rotated, turned or flipped in relation to each other as is known in the art. In this way, a pack 8 may be realized with a single type of plate 100. However, plates of different designs may be used in the pack 8 of the PHE 2.

**[0096]** The depicted plate 100 of Fig. 5 may in practice be formed by being cut from sheet metal which is pressed to become generally speaking corrugated or patterned. The depicted plate of 100 may be formed of an essentially rectangular sheet of stainless steel. Other materials are,

however, conceivable as is known in the art.

**[0097]** By the plate 100 being pressed to become corrugated, the plate 100 comprises a first plate pattern 102. The first plate pattern 102 is pressed into the material of plate 100 on a first side 104 of plate 100, i.e. the side visible in Fig. 5. The first plate pattern 102 may, as illustrated in Fig. 5, comprise a patterned heat exchange area 106 and a patterned distribution area 108. In practice, a distribution area 108 is typically provided at each end of the heat exchange area 106. Heat exchange areas 106 and a distribution areas 108 are as such known in the art and will not be discussed in greater detail herein.

**[0098]** As a result of the first plate pattern 102 being pressed into the material of the plate 100, a second plate pattern 110 may typically be formed simultaneously on a second side 112 of the heat exchanger plate opposite to the first side 104. The second plate pattern 110 may thus generally speaking be complementary to the first plate pattern 104 since the material of the plate 100 has been pressed so as to form the first plate pattern 102 and the second plate pattern 110. In Fig. 5, the second plate pattern 110 and the second side 112 of the plate 100 are indicted by hatched arrows to show that these element are present on the backside of the plate 100 which per se is not visible in Fig. 5.

**[0099]** Further, the short end region of the plate 100 illustrated in Fig. 5 comprises a porthole 114 to the right and porthole 116 to the left. The porthole 114 is for receiving or ejecting a first fluid, whereas the porthole 116 is for receiving or ejecting a second fluid, between which fluids heat is to be transferred. The function of the portholes 114, 116 are as such known in the art and will not be discussed in further detail herein. In the following, the porthole 114 to the right will however be discussed to some extent.

**[0100]** The porthole 114 of the depicted plate 100 is, as illustrated in Fig. 5, circumscribed by a port hole gasket seat 118. The port hole gasket seat 118 is defined on the first side 104 by the first plate pattern 102. The port hole gasket seat 118 is adapted to receive a port hole gasket 350 as illustrated in Fig. 7. Further, the port hole gasket seat 118 may typically be adapted to retain the port hole gasket 350 so as to keep the port hole gasket 350 in its intended position in the port hole gasket seat 118. The port hole gasket seat 118 depicted in Fig. 5 is generally speaking a groove 118. The port hole gasket seat 118 depicted in Fig. 5 is generally speaking circular and is adapted to receive a port hole gasket 350 in form of a ring gasket 350. It is, however, to be understood the port hole gasket seat 118 may be formed in any suitable way and may have any suitable shape. The port hole gasket seat 118 may for instance comprise a surface or area at least partially surrounded by a set of protrusions for retaining the port hole gasket 350. When considering the porthole 116 to the left of Fig. 5, it is clear that the porthole 116 has a shape diverting form the circular shape of the porthole 114. As a result, the porthole 116 is in practice to be surrounded by a port hole gasket not being strictly speaking ring shaped.

**[0101]** The plate 100 of Fig. 5, further comprises a permeation barrier seat 120. The permeation barrier seat 120 is, like the port hole gasket seat 118, defined on the first side 104 by the first plate pattern 102. The permeation barrier seat 120 circumscribes the port hole gasket seat 118. The permeation barrier seat 120 is adapted to receive a permeation barrier gasket arrangement 300 as illustrated in Fig. 7. In order to more clearly conceive the extent of the permeation barrier seat 120, reference is also made to Fig. 7 and 8. A permeation space 130 will be defined at the first side 104 of the plate 100 between the permeation barrier seat 120 and the port hole gasket seat 118, when a port hole gasket 350 is received in the port hole gasket seat 118 and a permeation barrier gasket arrangement is received in the permeation barrier gasket seat 120, i.e. as illustrated in Fig. 7.

**[0102]** Further, the depicted permeation barrier seat 120 is adapted to retain the permeation barrier gasket arrangement 300 so as to keep the permeation barrier gasket arrangement 300 in its intended position in the permeation barrier seat 120. The permeation barrier seat 120 depicted in Fig. 5 is generally speaking a groove 120 surrounded by the first plate pattern 102. It is, however, to be understood the permeation barrier seat 120 may be formed in any suitable way. The permeation barrier seat 120 may for instance comprise a surface or area at least partially surrounded by a set of protrusions of the first plate pattern 102 for retaining permeation barrier gasket arrangement 300.

**[0103]** Further, as best illustrated in Fig. 5, a portion 120a of the permeation barrier seat 120 may extend essentially along a perimeter of the plate 100 outside of the porthole gasket seat 118 and serve the purpose of receiving a portion of permeation barrier gasket arrangement 300. However, another portion 120b of the barrier gasket seat 120 may be defined by a groove 120b adapted to receive a portion of permeation barrier gasket arrangement 300 which also serves the purpose of sealing against the patterned distribution area 108 and the patterned heat exchange area 106. Thus, such portion 120b may be adapted to receive a portion of permeation barrier gasket arrangement 300 which also forms part of what is generally referred to as a field gasket.

**[0104]** The function of permeation space 130 will be discussed in detail further below.

**[0105]** The plate 100 further comprises an evacuation hole 140. The evacuation hole 140 is as clearly illustrated in Fig. 5 arranged or located outside of the permeation barrier seat 120. That is, the evacuation hole 140 is located outside of the permeation barrier seat 120 as seen from the evacuation space 130 and the port hole 114. As illustrated in Fig. 5, the evacuation hole 140 is located in an edge region or a peripheral region of the plate 100. More specifically, the evacuation hole 140 is located in a corner region of the plate 100. Importantly, the evacuation hole 140 of the plate 100 is located outside of any area where a first fluid or a second fluid is

flowing when the plate 100 forms part of a pack 8 of a PHE 2. As a result, the evacuation hole 140 will not influence the flow of the first fluid and will also not influence the flow of the second fluid. Thus, the presence of the evacuation hole may not influence or hamper the performance of a PHE 2 in which the plate 100 is used.

**[0106]** A detailed view of the corner region of the plate 100 of Fig. 5 is illustrated in Fig. 6 to which reference is also made. In other words, Fig. 6 illustrates a region of the plate 100 of Fig. 5 around the evacuation hole 140.

**[0107]** As best illustrated in Fig. 6 and 7, a first abutment surface 122 is defined on the first side 104 of the plate 100 by the first plate pattern 102. The first abutment surface 122 is adapted to abut a corresponding abutment surface of a first adjoining heat exchanger plate 100. Thus, the first abutment surface 122 is adapted to abut a corresponding abutment surface of a first adjoining heat exchanger plate 100 when the plate 100 and the first adjoining plate 100 are arranged in a pack 8 or stack 8 of plates 100 as illustrated in Figs. 3 and 4. Put differently, the first abutment surface 122 is adapted to abut an abutment surface of an adjoining plate arranged on the first side 104 of the depicted plate 100. To advantage, the corresponding abutment surface of such adjoining plate 100 may be of a design corresponding to the design of the first abutment surface 122. In practice, the first abutment surface 122 may to advantage be adapted to directly abut a corresponding abutment surface of a first adjoining heat exchanger plate 100. In this way, the first abutment surface 122 may seal directly against a corresponding abutment surface of a first adjoining heat exchanger plate 100. However, a seal a caulking compound or similar may be arranged between the first abutment surface 122 and the corresponding abutment surface of a first adjoining heat exchanger plate 100. Moreover, as best illustrated in Figs. 6 and 7, the first abutment surface 122 may be a flat surface configured to seal against the corresponding abutment surface of the first adjoining heat exchanger plate 100.

**[0108]** It is to be noted that the corresponding abutment surface of the first adjoining heat exchanger plate 100 will for natural reasons face in a direction opposite to the direction in which the first abutment surface 122 faces.

**[0109]** In practice, the first abutment surface 122 may be located in a top plane or uppermost plane of the heat exchanger plate 100. I other words, the first abutment surface 122 may in practice be located in an upper extreme plane of plate 100. In this way abutment with the corresponding abutment surface of the first adjoining heat exchanger plate 100 may be facilitated.

**[0110]** Further, as best illustrated in Fig. 6 and 7, an evacuation space 150 is defined on the first side 104 of the heat exchanger plate 100 by a portion 102a of the first plate pattern 102 being recessed relative to the first abutment surface 122. More specifically, the portion 102a of the first plate pattern 102 is recessed relative to the first abutment surface 122 such that the first abutment surface 122 partially circumscribes the evacuation space 150. Further, as best illustrated in Fig. 6 and 7, the evacuation space 150 circumscribes the evacuation hole 140 and extends to the permeation barrier seat 120. In other words, the evacuation space 150 is located above and about the evacuation hole 140 and extends to the permeation barrier seat 120. In this way, the permeation space 130 is fluidly connected to the evacuation hole 140 via the evacuation space 150. In this regard, it is to be understood that the so formed evacuation space 150 will be open in a normal direction of the first side 102 of the plate 100 unless arranged in a stack of heat exchanger plates 100 or a stack of cassettes 200. However, when the heat exchanger plate 100 is arranged in a pack 8 of heat exchanger plates 100 the evacuation space 150 will in practice meet a corresponding evacuation space of the first adjoining plate 100 when the first abutment surface 122 abuts the corresponding abutment surface of the first adjoining heat exchanger plate 100. In this way, the evacuation hole 140 will in practice align with a corresponding evacuation hole of the first adjoining heat exchanger plate 100.

**[0111]** The overall function of the permeation space 130, the evacuation space 150 and the evacuation hole 140 will be described further below.

**[0112]** Further, as best illustrated in Figs. 6 and 7, a second abutment surface 124 is defined on the second side 112 by the second plate pattern 110. In Figs. 6 and 7, second abutment surface 124 as well as the second plate pattern 110 and the second side 112 are indicted by hatched arrows to show that these element are present on the backside of the plate 100 which per se is not visible in Figs. 6 and 7. The second abutment surface 124 circumscribes the evacuation hole 140. Thus, the second abutment surface 124 circumscribes the evacuation hole 140 in the sense that a surface area circumscribing the evacuation hole 140 is formed on the second side 112, i.e. the backside, of the plate 100. The second abutment surface 124 is adapted to abut a corresponding abutment surface of a second adjoining heat exchanger plate 100. Thus, the second abutment surface 124 is adapted to abut an abutment surface of an adjoining plate 100 arranged on the second side 112 of the depicted plate 100. Thus, when the heat exchanger plate 100 is arranged in a pack 8 of heat exchanger plates 100 the second abutment surface 124 will in practice meet a corresponding abutment surface of the second adjoining plate 100. In this way, the evacuation hole 140 will in practice align with a corresponding evacuation hole of the second adjoining heat exchanger plate 100.

**[0113]** Generally speaking, a heat exchanger cassette 200 will thus comprise a heat exchanger plate 100 and a second adjoining heat exchanger plate 100, wherein the second adjoining heat exchanger plate 100 is welded to the second side 112 of the heat exchanger plate in a way such that the second abutment surface 124 abuts a corresponding abutment surface of the second adjoining heat exchanger plate.

**[0114]** As a result, when a plurality of plates 100 or

cassettes 200 are stacked to form a pack 8, evacuation holes 140 of the plurality of plates 100 or cassettes 200 will align with each other such that the permeation spaces 130 and evacuation spaces 150 fluidly connect throughout the pack 8 via the aligned evacuation holes 140.

**[0115]** It is to be noted that the corresponding abutment surface of the second adjoining heat exchanger plate 100 will for natural reasons face in a direction opposite to the direction in which the second abutment surface 124 faces.

**[0116]** In practice, the second abutment surface 124 may be located in a bottom plane or lowermost plane of the heat exchanger plate 100. In other words, the second abutment surface 124 may in practice be located in a lower extreme plane of the plate 100. In this way abutment with the corresponding abutment surface of the second adjoining heat exchanger plate 100 may be facilitated.

**[0117]** Moreover, as best illustrated in Figs. 6 and 7, the second abutment surface 124 may be a flat surface configured to seal against the corresponding abutment surface of the second adjoining heat exchanger plate 100. To advantage, the corresponding abutment surface of such adjoining plate 100 may be of a design corresponding to the design of the second abutment surface 124. In practice, the second abutment surface 124 may to advantage be adapted to directly abut a corresponding abutment surface of a second adjoining heat exchanger plate 100. In this way, the second abutment surface 124 may seal directly against a corresponding abutment surface of a second adjoining heat exchanger plate 100. However, a seal, a caulking compound or similar may be arranged between the first abutment surface 122 and the corresponding abutment surface of a first adjoining heat exchanger plate 100 in case the plate 100 is used in a gasketed PHE.

**[0118]** On the other hand, when the plate 100 forms part of a cassette 200 for a semi-welded PHE, the second abutment surface 124 may to advantage be welded to the corresponding abutment surface of the second adjoining heat exchanger plate by a weld circumscribing the evacuation hole 140. In this way, a fluid tight connection between the plates 100 of the cassette 200 may be realized around the evacuation hole 140 and a corresponding evacuation hole of the second adjoining plate 100.

**[0119]** Further, as best illustrated in Figs. 6 and 7, the evacuation space 150 may be partially located directly opposite to the second abutment surface 124. Put differently, a portion of the evacuation space may be located directly opposite to the second abutment surface 124.

**[0120]** Further, as best illustrated in Figs. 6 and 7, the first plate pattern 102 may define a wall section 126 where the wall section 126 defines a sidewall of the evacuation space 150. Thus, the wall section 126 may be formed when pressing the plate 100. In this way, the wall section 126 may connect the first abutment surface 122 and a bottom surface 128 of the evacuation space 150. This means in practice, that the bottom surface 128 of the evacuation space 150 may be arranged at least partially directly opposite to the second abutment surface 124 of the second side 112 of the plate 100, i.e. as illustrated in Fig. 6.

**[0121]** Further, the wall section 126 may, as best illustrated in Figs. 6 and 7, extend from a first position 126a at the permeation barrier seat 120, about the evacuation hole 140, and to a second position 126b of the permeation barrier seat 120. In this way, the wall section 126 may encircle the evacuation space 150.

**[0122]** Further, as best illustrated in Fig. 6, the permeation barrier gasket seat 120 may comprise a seat outlet 120c. The seat outlet 120c may as illustrated connect seamlessly to the evacuation space 150. The seat outlet 120c may, however, connect to the evacuation space 150 in any suitable way. Thus, the seat outlet 120c may connect the barrier gasket seat 120 to the evacuation space 150. As illustrated in Fig. 6, the first and second positions 126a, 126b may typically be arranged on opposite sides of the seat outlet 120c. As a result, the evacuation space 150 will be open to the barrier gasket seat 120 via the seat outlet 120c between the first position 126a at the permeation barrier seat 120 and the second position 126b of the permeation barrier seat 120. Thus, a width extension or size of the seal outlet 120c may be altered by altering a distance D between the first position 126a and the second position 126b at the permeation barrier seat 120. In this way, a cross-sectional area of the seat outlet 120c may be altered by altering the distance D between the first position 126a and the second position 126b at the permeation barrier seat 120.

**[0123]** Further, as illustrated in Figs. 5 and 7, the plate 100 may be provided with a further evacuation hole 141. The further evacuation hole 141, may like the evacuation hole 140 be arranged outside of the permeation barrier seat 120. A further first abutment surface 123 may as illustrated be defined on the first side 104 by the first plate pattern 102. The further first abutment 123 surface being adapted to abut a further corresponding abutment surface of the first adjoining heat exchanger plate, i.e. correspondingly to what have been described above in relation to the first abutment surface 122. Correspondingly, a further evacuation space 151 may defined on the first side 104 by a portion of the first plate pattern being recessed relative to the further first abutment surface 151 such that the further first abutment surface 123 partially circumscribes the further evacuation space 151. The further evacuation space 151 may as illustrated circumscribe the further evacuation hole 151 and extend to the permeation barrier seat 120. In this way, the permeation space 130 may be fluidly connected to the further evacuation hole 141 via the further evacuation space 151. Moreover, a further second abutment surface 125 may be defined on the second side 112 by the second plate pattern 110 such that the further second abutment surface 125 circumscribes the further evacuation hole 141. Further, the further second abutment surface 125 may be

adapted to abut a further corresponding abutment surface of the second adjoining heat exchanger plate 100.

**[0124]** In general, features and functions of the further evacuation hole 141, the further evacuation space 151 and the associated further abutment surfaces 123, 125 are similar or corresponding to what has been described herein. Consequently, said features and functions will not be repeated to avoid undue repetition.

**[0125]** Now, referring in particular to Figs. 7 and 8. Fig. 7 illustrates, in perspective, a region around the port hole 114 of the plate 100 of Figs. 5 and 6. In Fig. 7 it is illustrated how the porthole 114 is circumscribed by the port hole gasket 350. The port hole gasket 350 is received in the port hole gasket seat 118 of the plate 100. The port hole gasket 350 is received and retained in the port hole gasket seat 118. Apart from the port hole gasket seat 118 retaining the port hole gasket 350 in its intended position, the port hole gasket 350 is employed with a plurality of fastening members 352 configured to engage the plate 100 at a perimeter of the port hole 114 so as to keep the port hole gasket 350 in its intended position in the port hole gasket seat 118 where it surrounds the port hole 114. The port hole gasket 350 is consequently configured to seal around the port hole 114 between adjacent plates 100 when the plate 100 is arranged in a stacked configuration in a pack 8 of heat exchanger plates 100, i.e. as illustrated in Figs. 3 and 4.

**[0126]** In case the plate forms part of a cassette 200, the port hole gasket 350 of Fig. 7 will seal between adjacent plates 100 of adjoining cassettes 200 when arranged in a stacked configuration, i.e. in a pack 8 of the type illustrated in Fig. 4. In other words, in case the plate forms part of a cassette 200, the port hole gasket 350 will seal between adjacent cassettes 200. Although a semi welded PHE utilizes generally speaking permeation tight welded cassettes 200, the fluid flowing through the welded plate interspaces or channels of the cassettes 200 will when flowing between cassettes 200 via portholes 114 flow past port hole gaskets 350 of the type depicted in Fig. 7. As a consequence, fluids prone to permeating gasket materials may, when flowing between cassettes 200 risk permeating the port hole gaskets 350 of a pack 8 of cassettes 200. Ammonia is a typical example of a fluid prone to permeating the material of gaskets, such as the port hole gasket 350. Correspondingly, fluids prone to permeating gasket materials may when flowing between plates 100 of a gasketed PHE risk permeating the port hole gaskets 350 of a pack 8 of plates 100. In the case of a gasketed PHE 2 the risk of a fluid permeating a gasket of some type is, for natural reasons, more outspoken. Despite this, the present inventive concept may significantly reduce the risk of fluid having permeated the port hole gasket 350 from escaping the PHE 2 at hand in an uncontrolled manner. As a result, the working environment at the PHE 2 at hand may be made safer or better.

**[0127]** In order to prevent or counteract fluid having permeated the port hole gasket 350 from escaping in an uncontrolled manner when the plate 100 is arranged in a pack 8 of a PHE 2, a permeation barrier gasket arrangement 300 may be received in the permeation barrier gasket seat 120 as illustrated in Fig. 7.

**[0128]** A plate 100 and a permeation barrier gasket arrangement 300 may jointly be said to form a plate arrangement 400. Put differently, a plate 100 having a permeation barrier gasket arrangement 300 received in the permeation barrier seat 120 may be said to form a plate arrangement 400.

**[0129]** The permeation barrier gasket arrangement 300 of Fig. 7 is illustrated in Fig. 8 in isolation. The permeation barrier gasket arrangement 300 of Figs. 7 and 8 may be may be integrally formed, i.e. formed in a single piece. However, the permeation barrier gasket arrangement 300 may according to an example be formed of a first part and a separate second part. It is, however, to be understood that that the permeation barrier gasket arrangement 300 may include any number or separate parts.

**[0130]** In this regard it is to be understood that the permeation barrier gasket arrangement 300 may be integrally formed with what is commonly referred to as a field gasket. Such field gasket is, as is known in the art, adapted to form a gasketed plate interspace or gasketed channel between adjacent plates 100. In this regard, a portion 300a of the barrier gasket arrangement 300 may only or mainly act as a barrier for preventing or counteracting fluid having permeated through the port hole gasket 350 from escaping. On the other hand, another portion 300b of the barrier gasket arrangement 300 may at the same time be adapted to form a barrier between the permeation space 130 and the heat exchange area 106 at the first side 104 of the heat exchanger plate 100. Thus, the permeation barrier gasket arrangement 300 may in part be common to a field gasket. In other words, a portion 300b of the barrier gasket arrangement 300 may constitute a portion of a field gasket.

**[0131]** The permeation barrier gasket arrangement 300 may typically be formed of polymer materials and/or elastomer materials. The permeation barrier gasket arrangement 300 may typically be molded into a desired shape. Suitable materials for the permeation barrier gasket arrangement 300 include but are not limited to hydrated nitrile materials, chloroprene materials, ethylene propylene diene monomer materials, nitrile butadiene rubber materials and fluoroelastomer materials.

**[0132]** The permeation barrier gasket arrangement 300 of Fig. 8 is adapted to be arranged on the first side 104 of the heat exchanger plate 100, i.e. as illustrated in Fig. 7. Thus, the permeation barrier gasket arrangement 300 is adapted to circumscribe the port hole gasket 350 when arranged in on the first side 104 of the heat exchanger plate 100. As illustrated in Fig. 7, the permeation barrier gasket arrangement 300 is adapted to be received in the permeation barrier seat 120 of the plate 100. In this way, the permeation barrier gasket arrangement 300 will, as illustrated in Fig 7, circumscribe the port hole 114 and

the port hole gasket 350, when received in the permeation barrier seat 120 of the plate 100. As a result, the permeation space 130 is defined at the first side 104 of the heat exchanger plate 100 between the permeation barrier gasket arrangement 300 and the port hole gasket 350. In this regard, it is to be understood that the so formed permeation space 130 will be open in a normal direction of the first side 102 of the plate 100 unless arranged in a stack of heat exchanger plates 100 or a stack of cassettes 200. However, when the heat exchanger plate 100 is arranged in a pack 8 of heat exchanger plates 100 a gasketed or sealed permeation space 130 will be formed along the first side 104 of the heat exchanger plate 100 between the port hole gasket 350 and the permeation barrier gasket arrangement 300.

**[0133]** Further, the depicted permeation barrier gasket arrangement 300 of Fig. 8 comprises an outlet opening 302. The outlet opening 302 extends through the permeation barrier gasket arrangement 300. The outlet opening 302 is, as best illustrated in Fig. 7, adapted to fluidly connect the permeation space 130 and the evacuation space 150. Thus, when the permeation barrier gasket arrangement 300 is received in the permeation barrier seat 120, i.e. as illustrated in Fig. 7, the permeation space 130 will be fluidly connected to the evacuation hole 140 of the heat exchanger plate 100 via the outlet opening 302 of the permeation barrier gasket arrangement 300.

**[0134]** As best illustrated in Figs. 7 and 8, the outlet opening 302 may formed by a notch 302 in the permeation barrier gasket arrangement 300. In this way, the outlet opening 302 may be formed with a relatively speaking large cross sectional area while not significantly affecting the integrity of the permeation barrier gasket arrangement 300.

**[0135]** Alternatively of additionally, the outlet opening may be formed by a hole or channel extending through the material of the permeation barrier gasket arrangement 300.

**[0136]** Alternatively of additionally, as best illustrated in Figs. 7 and 8, an outlet opening 304 may formed by an interruption 304 of the permeation barrier gasket arrangement 300. In this way, a cross sectional area of the outlet opening 304 may be maximized and thus made larger as compared to when the outlet opening is formed by e.g. a notch 302 or a hole extending through the permeation barrier gasket arrangement 300. The depicted outlet opening 304 is adapted to fluidly connect the permeation space 130 and the further evacuation space 151 which is fluidly connected to the further evacuation hole 141 of the heat exchanger plate 100.

**[0137]** As best illustrated in Fig. 8, the portion 300a of the barrier gasket arrangement 300 may have a generally L-shaped cross section so as to from a passageway 306 along the portion 300a. The generally L-shaped cross section of the portion 300a of the permeation barrier gasket arrangement 300 is clearly visible in Fig. 8 at the outlet opening 304. The so formed passageway 306 may consequently promote or facilitate a flow of fluid having permeated through the port hole gasket 350 along the portion 300a of the barrier gasket arrangement 300 such that the fluid may more easily reach the outlet opening 302 or the outlet opening 304.

**[0138]** It is, however, conceivable to use other cross sectional shapes to form a passageway 306 which extends along at least a portion of the length extension of the permeation barrier gasket arrangement 300. Such passageway 306 may extend along the entire length extension of the permeation barrier gasket arrangement 300. In order to form a passageway 306 which extends along at least a portion of the length extension of the permeation barrier gasket arrangement 300 at least a portion of a length extension of the permeation barrier gasket arrangement 300 may according to non-limiting examples have a generally C-shaped or I-shaped cross section.

**[0139]** As best illustrated in Figs. 7 and 8, the permeation barrier gasket arrangement 300 may be provided with one or more inlet openings 308, 310 extending therethrough. The depicted inlet openings 308, 310 are adapted to fluidly connect the permeation space 130 with the ambient A. It is, however, to be noted that any number of inlet openings 308, 310 are conceivable. As best illustrated in Fig. 8, the inlet opening 308 is formed by a notch 308 in the permeation barrier gasket arrangement 300, whereas the inlet opening 310 is formed by an interruption of the permeation barrier gasket arrangement 300.

**[0140]** In practice, an edge region of the plate 100 may be provided with an opening adapted to align or match with an inlet opening 308, 310 provided in the permeation barrier gasket arrangement 300. In this way, the permeation space 130 may be fluidly connected with the ambient A via the inlet opining 308, 310 and the opening in the edge region of the plate 100. Such opening in the edge region of the plate 100 may for instance be formed by a recessed portion of the first plate pattern 102 extending along the first side 104 between an edge of the plate 100 and the permeation barrier seat 120. Other types of openings are, however, conceivable.

**[0141]** In the following the main aspects of the interplay between the different elements and features of the plate 100 and the permeation barrier gasket arrangement 300 will be briefly discussed. As already explained, fluid may permeate the port hole gasket 350 meaning that fluid may escape through the material of the port hole gasket 350 although the port hole gasket as such is intact. By the permeation barrier gasket arrangement 300 being received in the permeation barrier seat 120 such that it circumscribes or at least partially circumscribes the port hole gasket 350, fluid having permeated through the port hole gasket 350 may be caught in the permeation space 130, i.e. between the port hole gasket 350 and the permeation barrier gasket arrangement 300. Such permeated fluid may then reach the evacuation hole 140 via the evacuation space 150. The fluid may then be evac-

uated from the pack 8 of the PHE 2 at hand via a plurality of aligned or substantially aligned evacuation holes 140 of the plates 100 of the pack 8. To this end, the frame plate 4 of the PHE 2 at hand may be provided with an evacuation outlet. Such an evacuation outlet may for instance be connected to a vacuum source, such as a vacuum pump, or may be connected to a funnel for ventilating the permeated fluid to a safe location, such as to the outside of a room where the PHE 2 is located. Moreover, if the permeation barrier gasket arrangement 300 is provided with one or more inlet openings 308, 310 a forced flow of air may be provided through the permeation space and out of the evacuation hole 140 via the evacuation space 150.

**[0142]** However, the elements and features of the plate 100 and the permeation barrier gasket arrangement 300 may be used in different ways. For instance, an inert gas, such as nitrogen, may be provided to the permeation space 130 via the evacuation hole 140 and the evacuation space 150. In this way, the port hole gasket 350 may be prevented or counteracted from being affected by substances present in the ambient A surrounding the PHE 2 at hand. In such a case, the permeation barrier gasket arrangement 300 may to advantage be void of any inlet openings 308, 310.

**[0143]** Another use for the elements and features of the plate 100 and the permeation barrier gasket arrangement 300 is to pressurize the permeation space 130 by forcing a gas into the permeation space 130 via the evacuation hole 140 and the evacuation space 150. By providing an overpressure to the permeation space 130 a significant reduction of fluid permeating through the port hole gasket may be achieved since the overpressure will act as counterpressure. In such a case, the permeation barrier gasket arrangement 300 may to advantage be void of any inlet openings 308, 310.

**[0144]** Further, it should be stressed that a description of details not relevant to the present invention has been omitted and that the figures are just schematic and not drawn according to scale. Some details in the figures may also be exaggerated for the sake of clarity. It should also be said that some of the figures have been more simplified than others. Therefore, some components may be illustrated in one figure but left out on another figure.

**[0145]** It will be appreciated that the present inventive concept is not limited to the variants and examples shown. Several modifications and variations are thus conceivable within the scope of the invention which thus is defined by the appended claims.

## Claims

**1.** A heat exchanger plate (100) for a plate heat exchanger (2), comprising:

a first plate pattern (102) on a first side (104) of the heat exchanger plate (100) and a second plate pattern (110) on a second side (112) of the heat exchanger plate (100) opposite to the first side (104),
a port hole (114),
a port hole gasket seat (118) defined on the first side (104) by the first plate pattern (102), the port hole gasket seat (118) circumscribing the port hole (114) and being adapted to receive a port hole gasket (350),
a permeation barrier seat (120) defined on the first side (104) by the first plate pattern (102), the permeation barrier seat (120) at least partially circumscribing the port hole gasket seat (118) and being adapted to receive a permeation barrier gasket arrangement (300) such that a permeation space (130) is defined at the first side (104) of the heat exchanger plate (100) between the permeation barrier seat (120) and the port hole gasket seat (118),
an evacuation hole (140) arranged outside of the permeation barrier seat (120),
a first abutment surface (122) defined on the first side (104) by the first plate pattern (102), the first abutment surface (122) being adapted to abut a corresponding abutment surface of a first adjoining heat exchanger plate (100),
an evacuation space (150) defined on the first side (104) of the heat exchanger plate (100) by a portion (102a) of the first plate pattern (102) being recessed relative to the first abutment surface (122) such that the first abutment surface (122) partially circumscribes the evacuation space (150), the evacuation space (150) circumscribing the evacuation hole (104) and extending to the permeation barrier seat (120), wherein the permeation space (130) is fluidly connected to the evacuation hole (140) via the evacuation space (150), and
a second abutment surface (124) defined on the second side (112) by the second plate pattern (110) and circumscribing the evacuation hole (140), the second abutment surface (124) being adapted to abut a corresponding abutment surface of a second adjoining heat exchanger plate (100).

**2.** The heat exchanger plate (100) according to claim 1, wherein at least a portion of the evacuation space (150) is located directly opposite to the second abutment surface (124).

**3.** The heat exchanger plate (100) according to claim 1 or 2, wherein the first plate pattern (102) defines a wall section (126) defining a sidewall of the evacuation space (150), the wall section (126) extending from a first position (126a) at the permeation barrier seat (120), about the evacuation hole (140), and to a second position (126b) of the permeation barrier seat (120), thereby encircling the evacuation space

(150).

4. The heat exchanger plate (100) according to claim 3, wherein the permeation barrier gasket seat (120) comprises a seat outlet (120c) connecting to the evacuation space (150), wherein the first and second positions (126a, 126b) are on opposite sides of the seat outlet (120c).

5. The heat exchanger plate (100) according to claim 3 or 4, wherein the wall section (126) connects the first abutment surface (122) and a bottom surface (128) of the evacuation space (150).

6. The heat exchanger plate (100) according to any one of the preceding claims, wherein the first abutment surface (122) is a flat surface configured to seal against the corresponding abutment surface of the first adjoining heat exchanger plate (100), and/or wherein the second abutment surface (124) is a flat surface configured to seal against the corresponding abutment surface of the second adjoining heat exchanger plate (100).

7. The heat exchanger plate according to any one of the preceding claims, wherein the port hole gasket seat comprises a groove configured to retain the port hole gasket, and/or wherein the permeation barrier seat comprises a groove configured to retain the permeation barrier gasket arrangement.

8. A permeation barrier gasket arrangement (300) for a plate heat exchanger (2), adapted to be arranged on a first side (104) of a heat exchanger plate (100) and to circumscribe a port hole gasket (350) circumscribing a port hole (114) of the heat exchanger plate (100) such that a permeation space (130) is defined at the first side (104) of the heat exchanger plate (100) between the permeation barrier gasket arrangement (300) and the port hole gasket (350), wherein the permeation barrier gasket arrangement (300) comprises an outlet opening (302) extending therethrough, the outlet opening being (302) adapted to fluidly connect the permeation space (130) and an evacuation space (150) fluidly connected to an evacuation hole (140) of the heat exchanger plate (100).

9. The permeation barrier gasket arrangement (300) according to claim 8, wherein the outlet opening (302) is formed by a notch (302) in the permeation barrier gasket arrangement (300).

10. The permeation barrier gasket arrangement according to claim 8, wherein the outlet opening (304) is formed by an interruption (304) of the permeation barrier gasket arrangement (300).

11. The permeation barrier gasket arrangement (300) according to any one of claims 8-10, wherein at least a portion (300a) of a length extension of the permeation barrier gasket arrangement (300) has a generally L-shaped, C-shaped, I-shaped or inverted T-shaped cross section so as to from a passageway along said at least a portion (300a) of the length extension of the permeation barrier gasket arrangement (300).

12. The permeation barrier gasket arrangement (300) according to any one of claims 8-11, wherein the permeation barrier gasket arrangement (300) further comprises an inlet opening (308, 310) extending therethrough, the inlet opening (308, 310) being adapted to fluidly connect the permeation space (130) with the ambient (A).

13. A plate arrangement (400) for a plate heat exchanger, comprising:

a heat exchanger plate (100) according to any one of claims 1-7, and
a permeation barrier gasket arrangement (300) according to any one of claims 8-12, wherein the permeation barrier gasket arrangement (300) is received in the permeation barrier seat (120).

14. A heat exchanger cassette (200) for a plate heat exchanger (2), comprising a heat exchanger plate (100) according to any one of claims 1-7 and the second adjoining heat exchanger plate (100), wherein the second adjoining heat exchanger plate (100) is welded to the second side (112) of the heat exchanger plate (100), and wherein the second abutment surface (124) abuts the corresponding abutment surface of the second adjoining heat exchanger plate (100).

15. The heat exchanger cassette (200) according to claim 14, wherein the second abutment surface (124) is welded to the corresponding abutment surface of the of the second adjoining heat exchanger plate (100) by a weld circumscribing the evacuation hole (140).

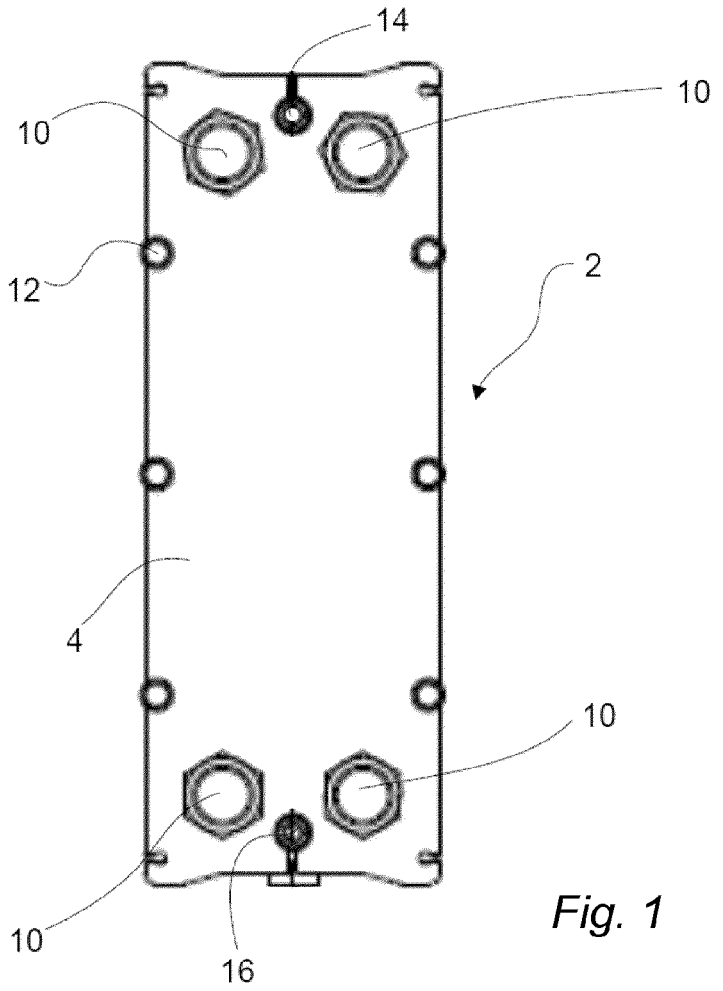



Fig. 1

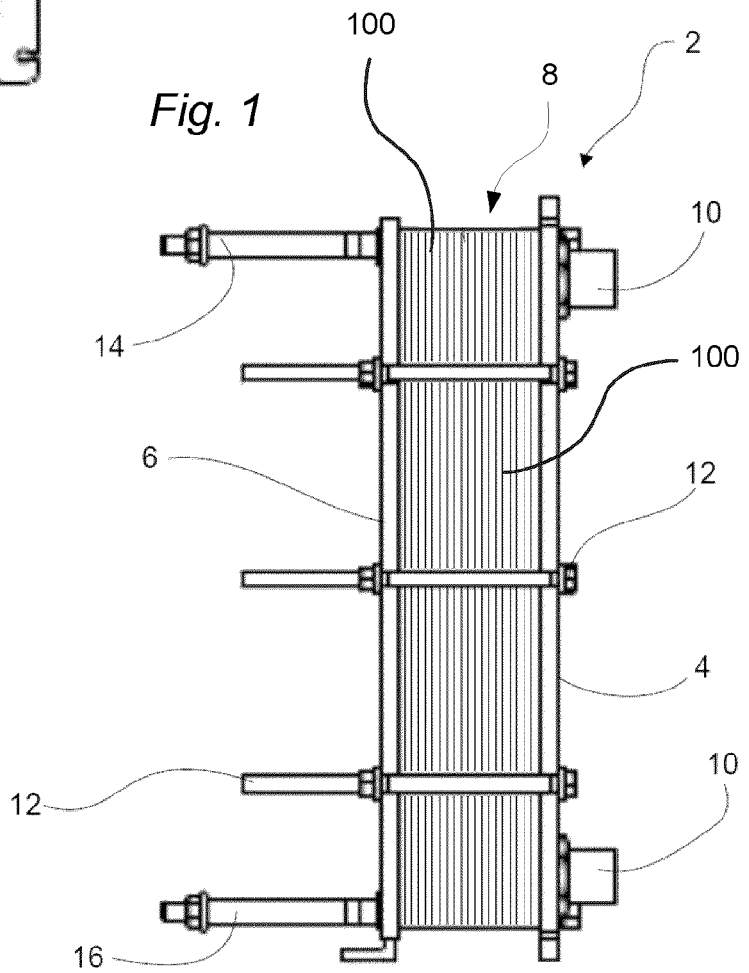



Fig. 2

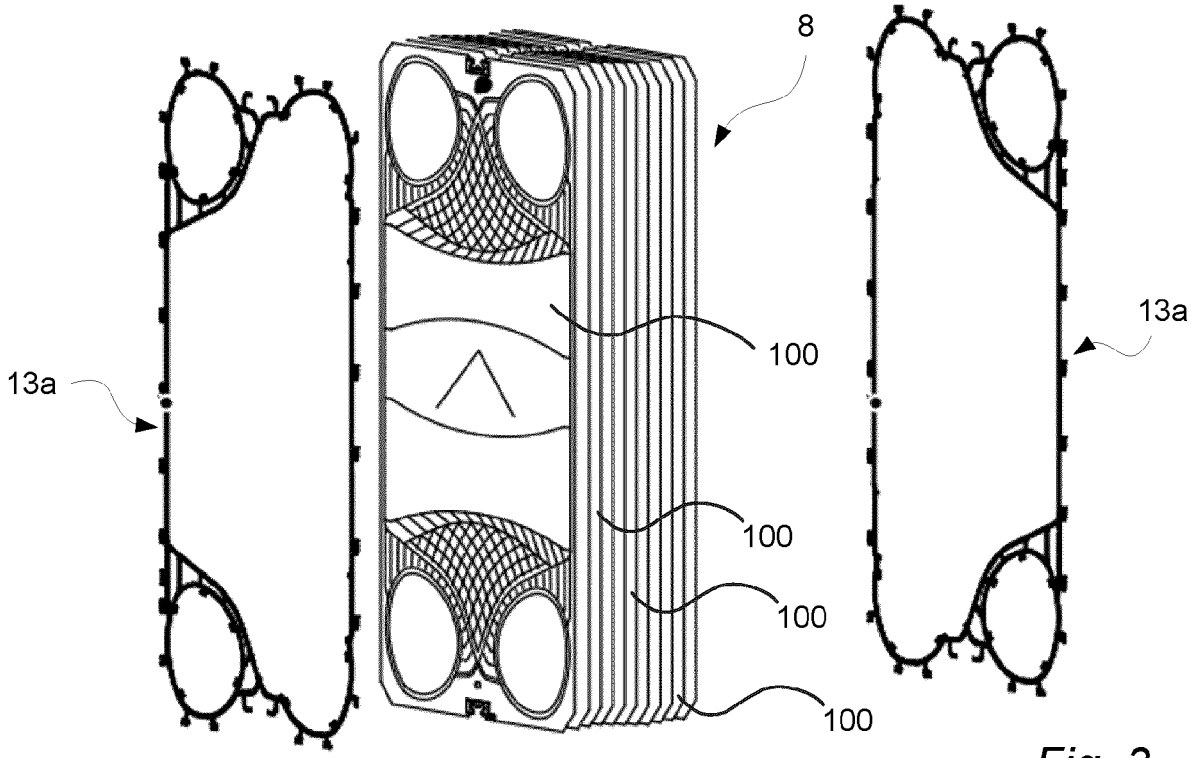



Fig. 3

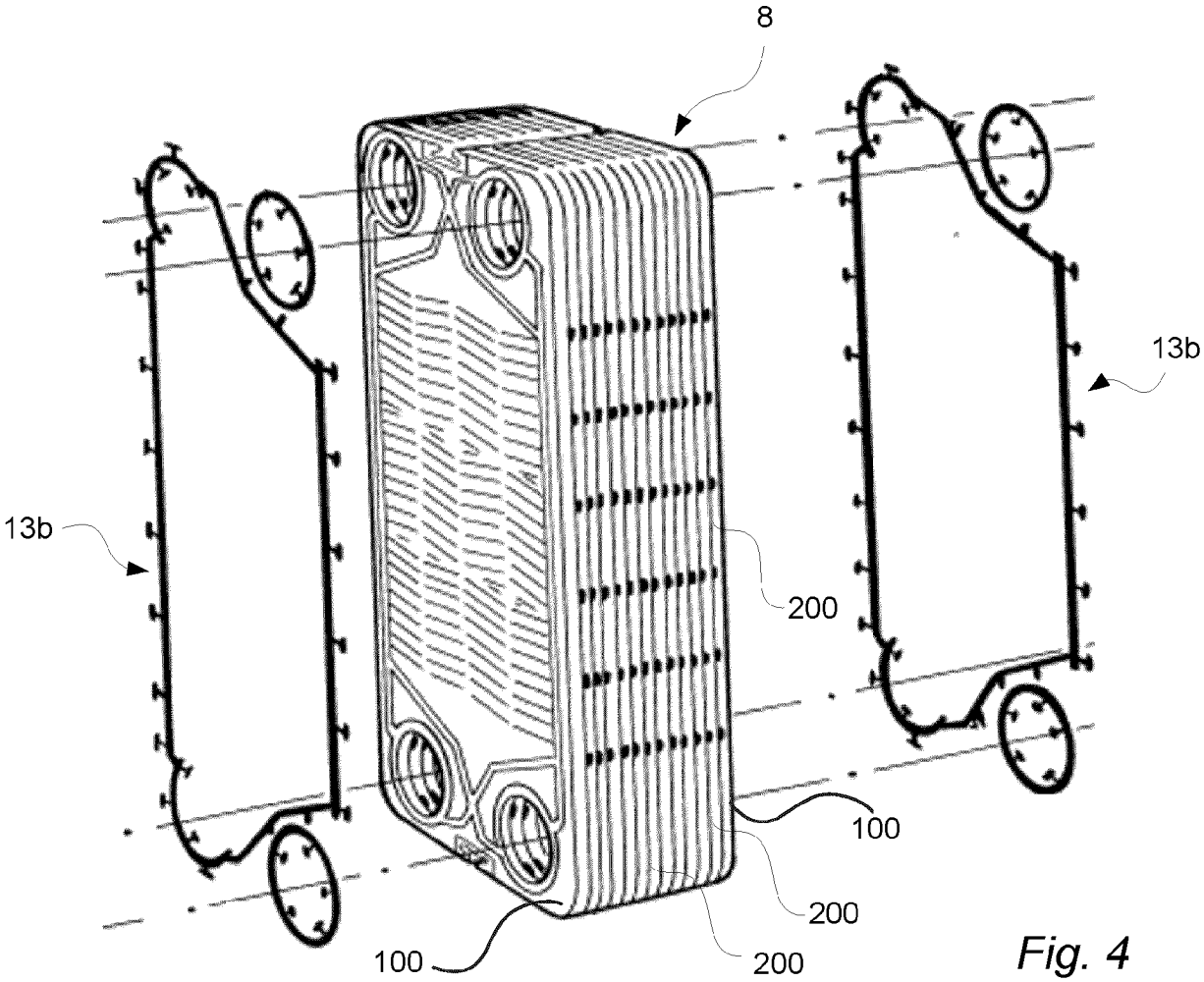



Fig. 4

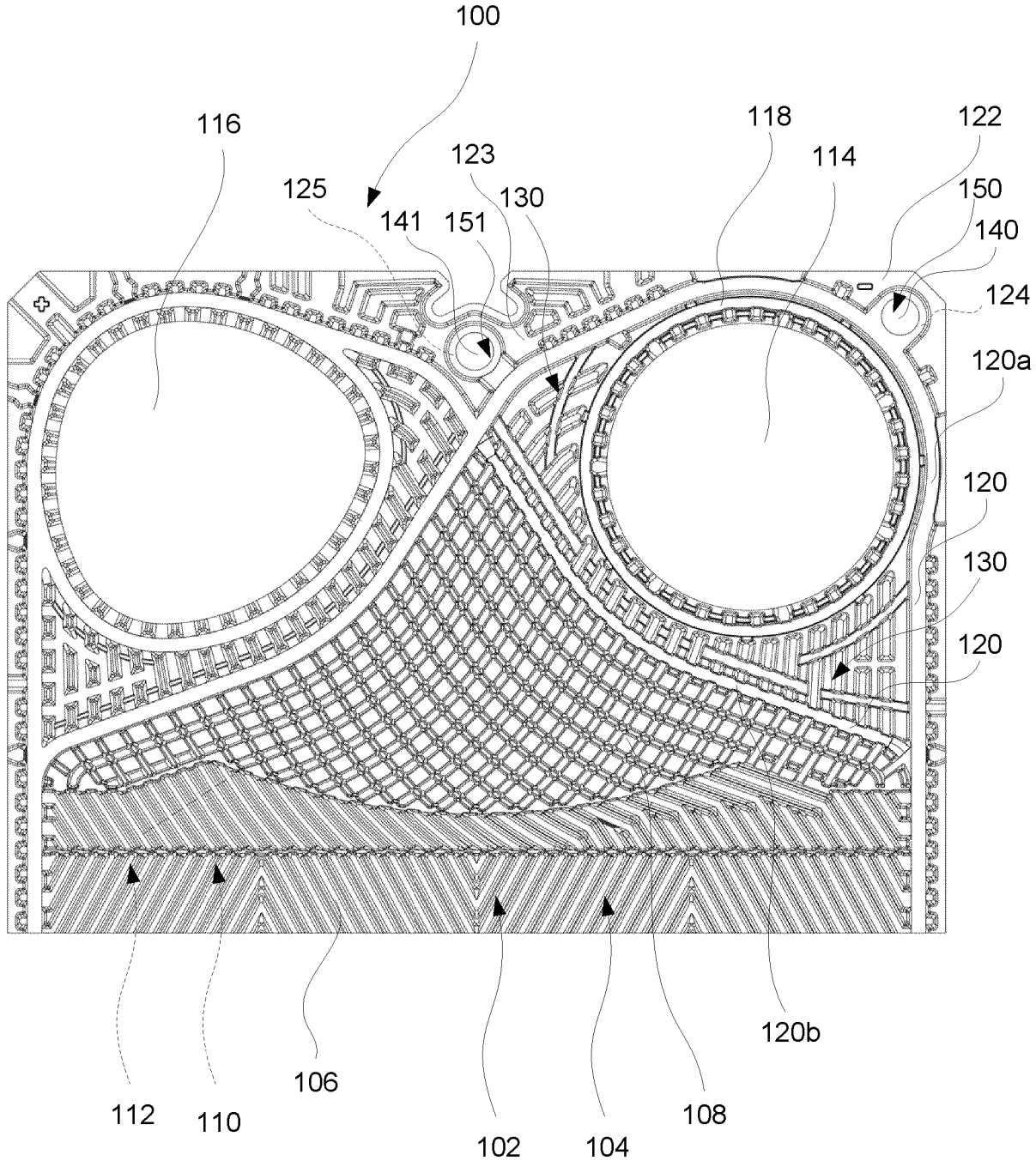

100
116
118
122
123
114
125
130
150
141
151
140
124
120a
120
130
120
120b
106
112
110
102
104
108

*Fig. 5*

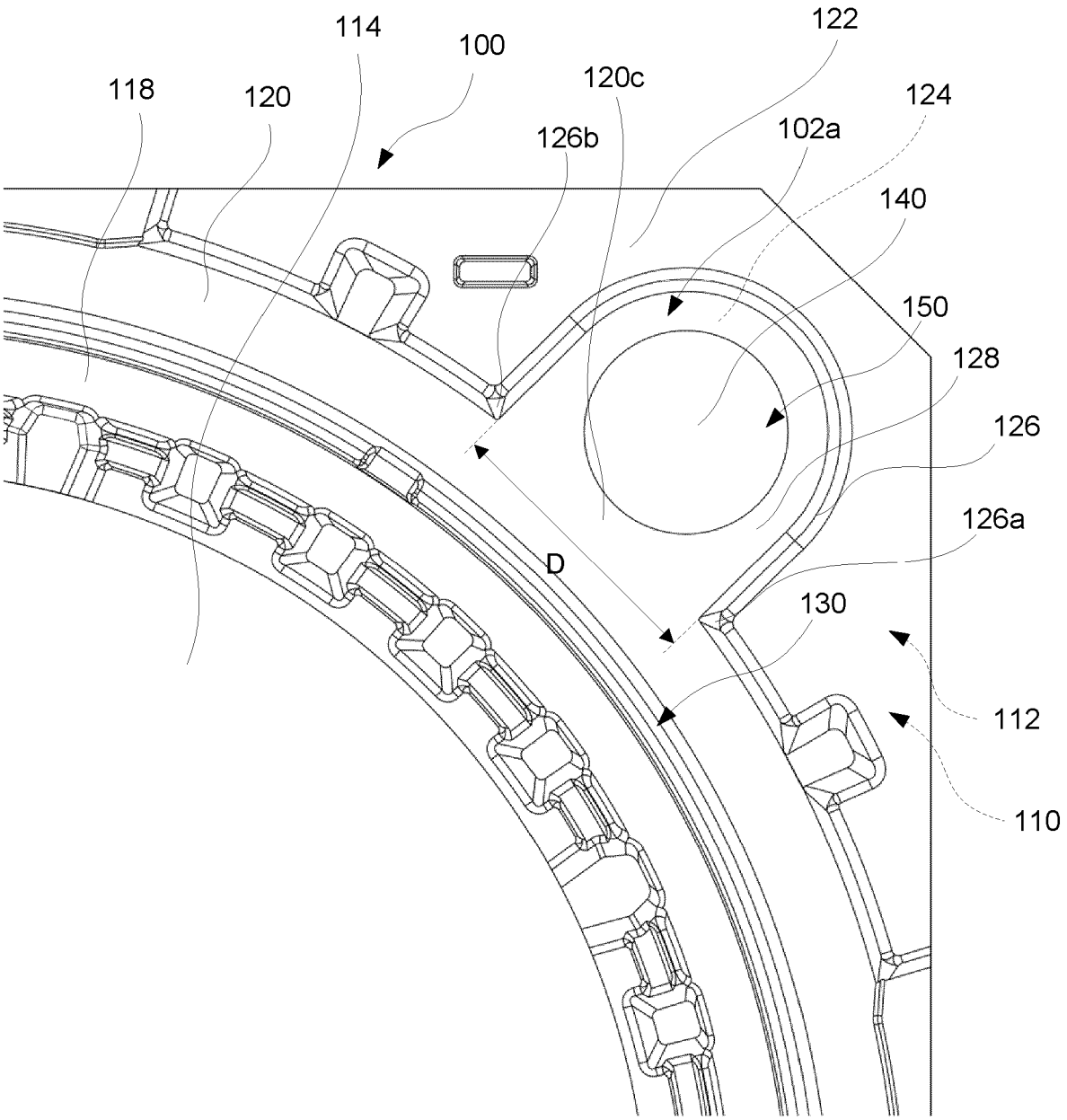

114
100
122
118
120
120c
124
126b
102a
140
150
128
126
126a
D
130
112
110

*Fig. 6*

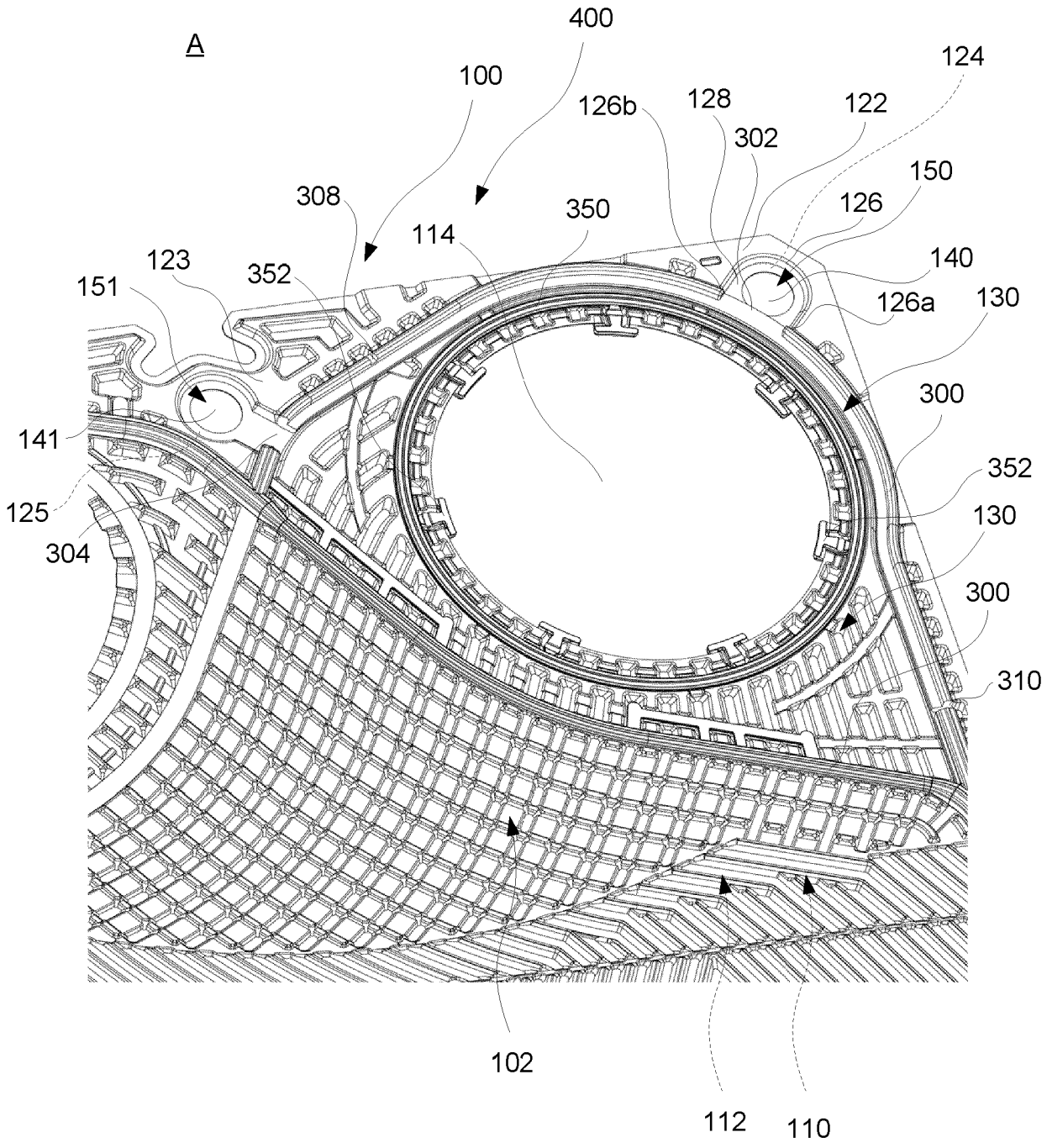

A
400
100
124
126b
128
122
302
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308
350
126
114
140
123
352
151
126a
130
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141
352
125
130
304
300
310
102
112
110

*Fig. 7*

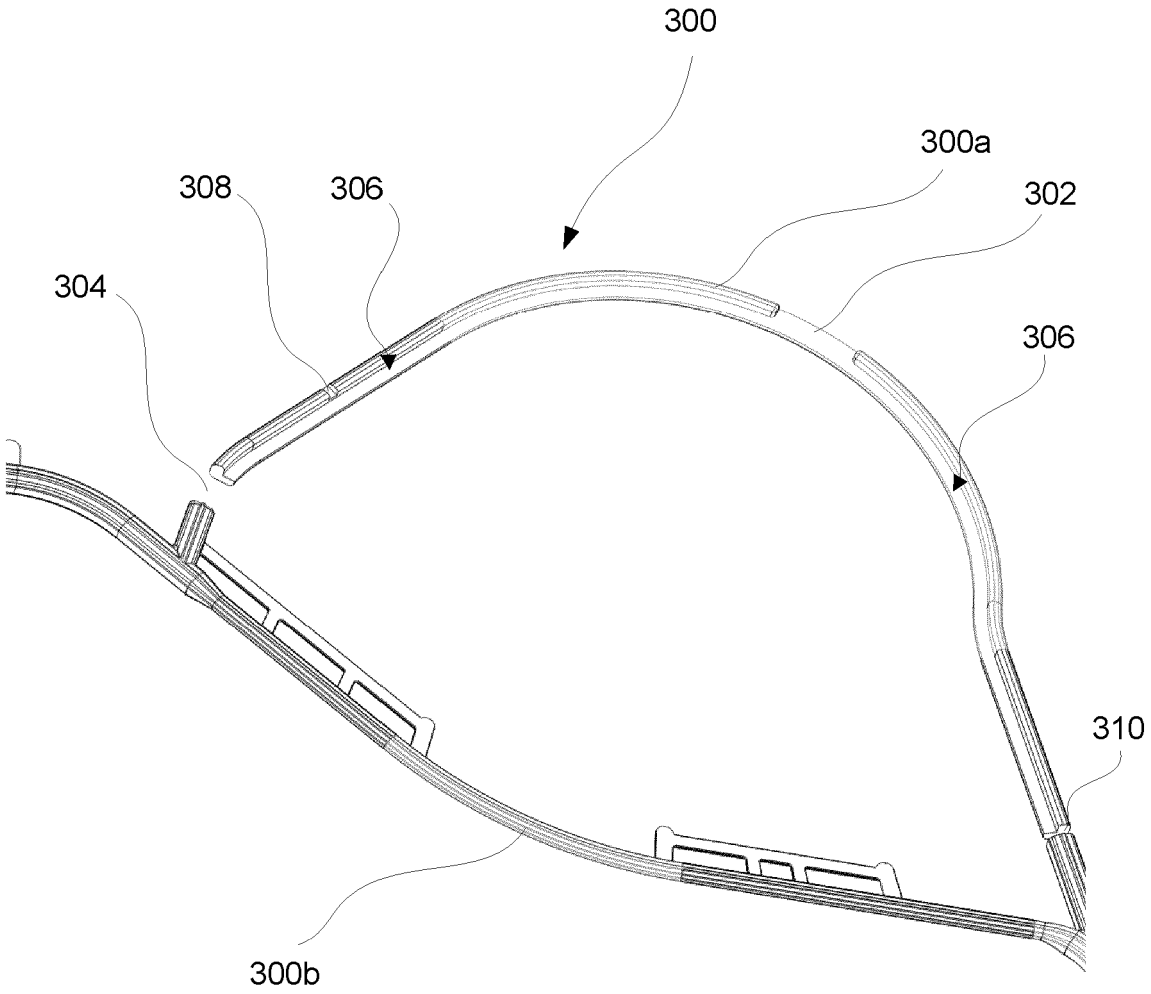



*Fig. 8*

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Application Number
EP 25 16 8282

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