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(54) **PORTHOLE GASKET FOR A PLATE HEAT EXCHANGER, A PLATE PACKAGE AND A PLATE HEAT EXCHANGER WITH SUCH A PORTHOLE GASKET**

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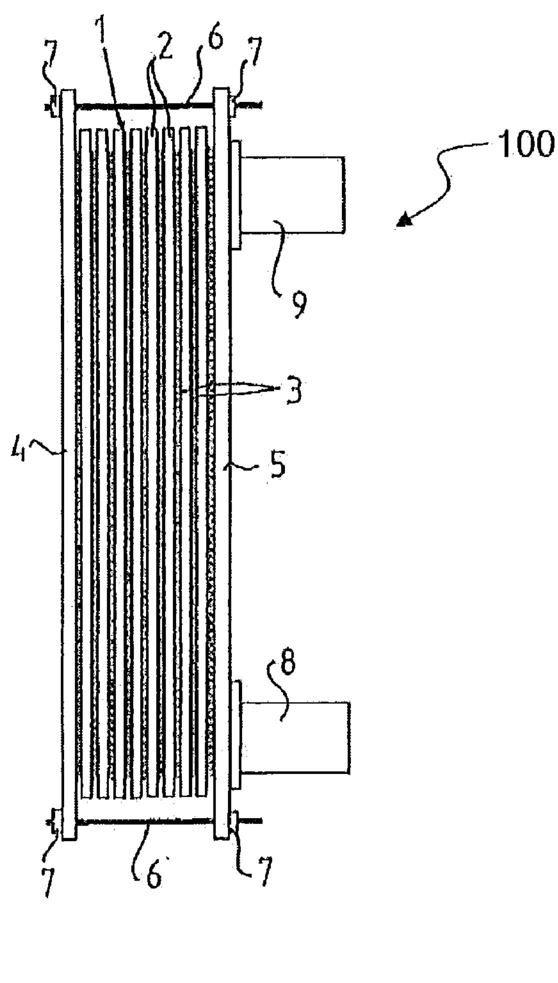
(57) **ABSTRACT**

A porthole gasket is configured to seal a circumferential region around two overlapping portholes in two adjacent heat exchanger plates of a plate heat exchanger, so as to define a passage for a fluid into or out of the plate heat exchanger. The porthole gasket has a ring-shaped portion to be compressed between the two adjacent heat exchanger plates while surrounding the overlapping portholes. The porthole gasket further comprises a plurality of projections that protrude from an outer perimeter of the ring-shaped portion and are configured to be compressed between the two adjacent heat exchanger plates so as to support the ring-shaped portion against pressure exerted by the fluid. A plate package for a plate heat exchanger is configured to include the two adjacent heat exchanger plates and the porthole gasket.



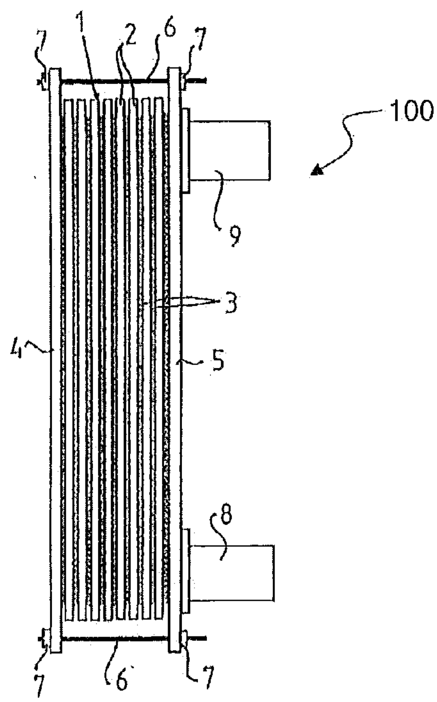


Fig. 1

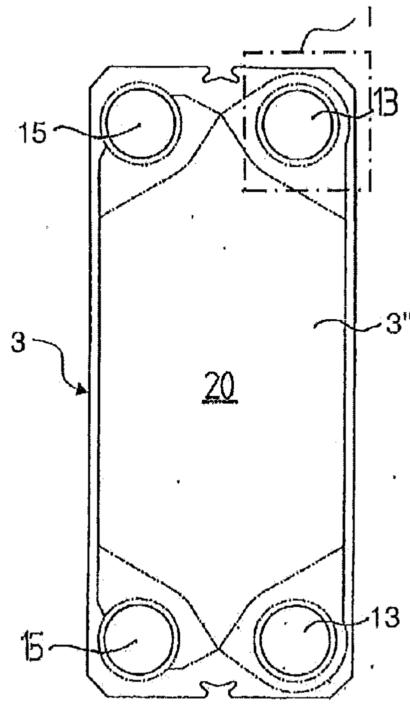


Fig. 2

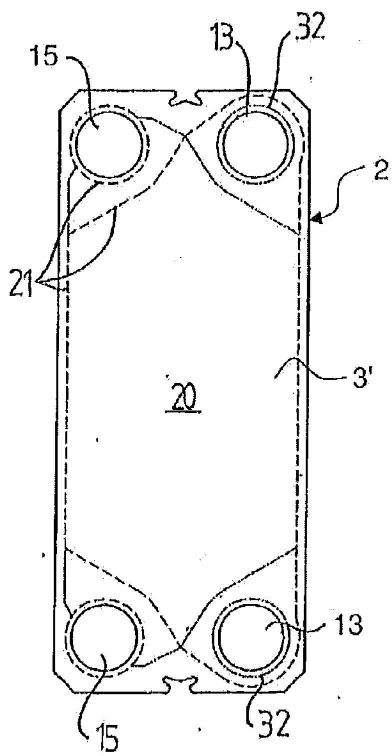


Fig. 3

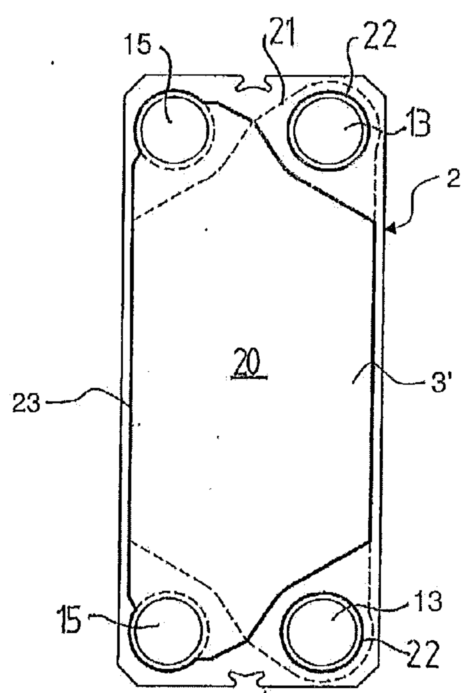


Fig. 4

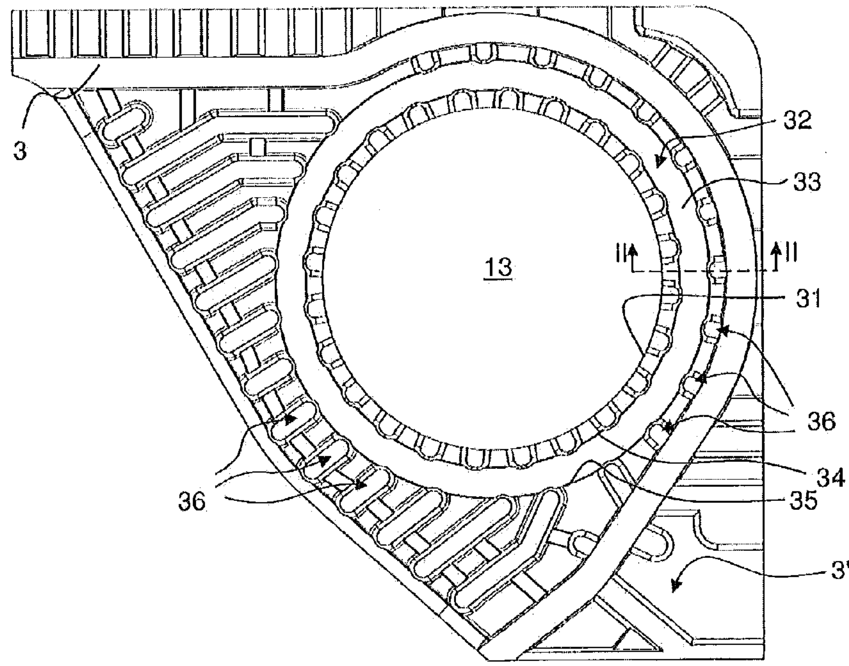


Fig. 5

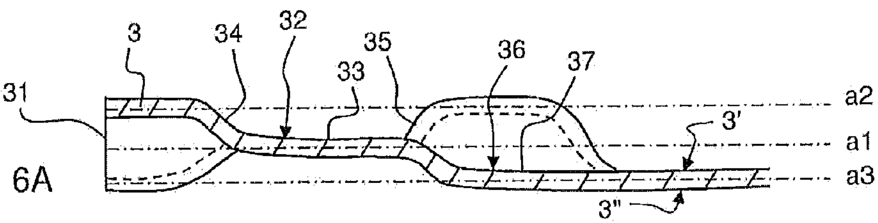


Fig. 6A

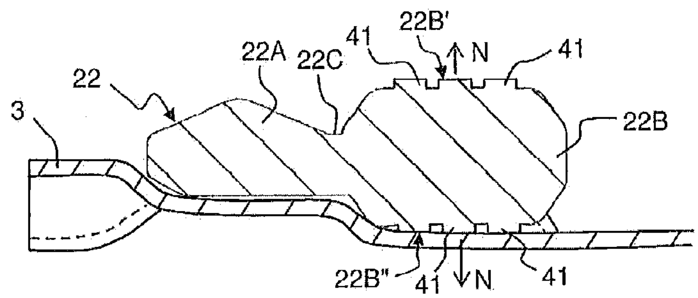


Fig. 6B

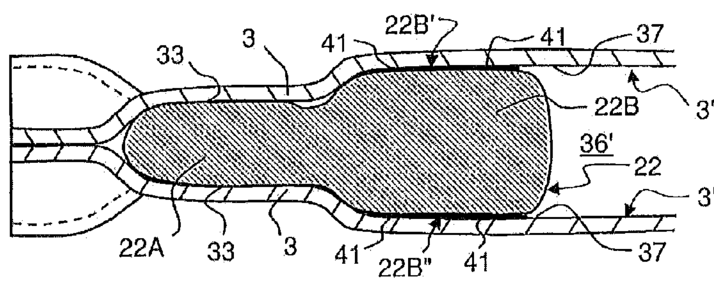


Fig. 6C

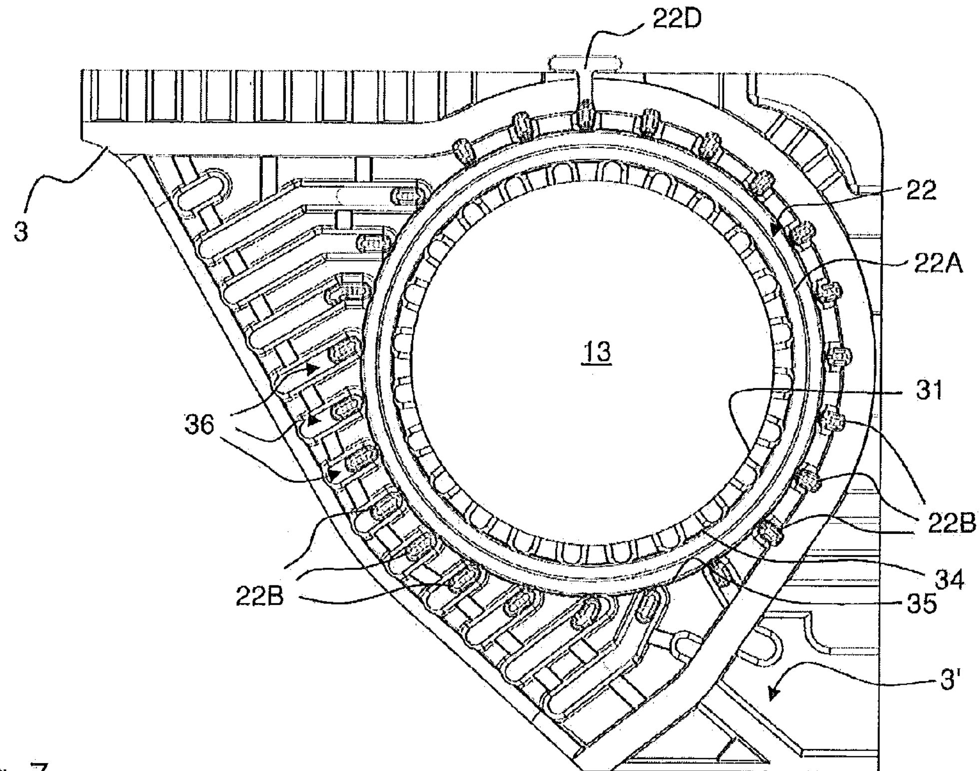


Fig. 7

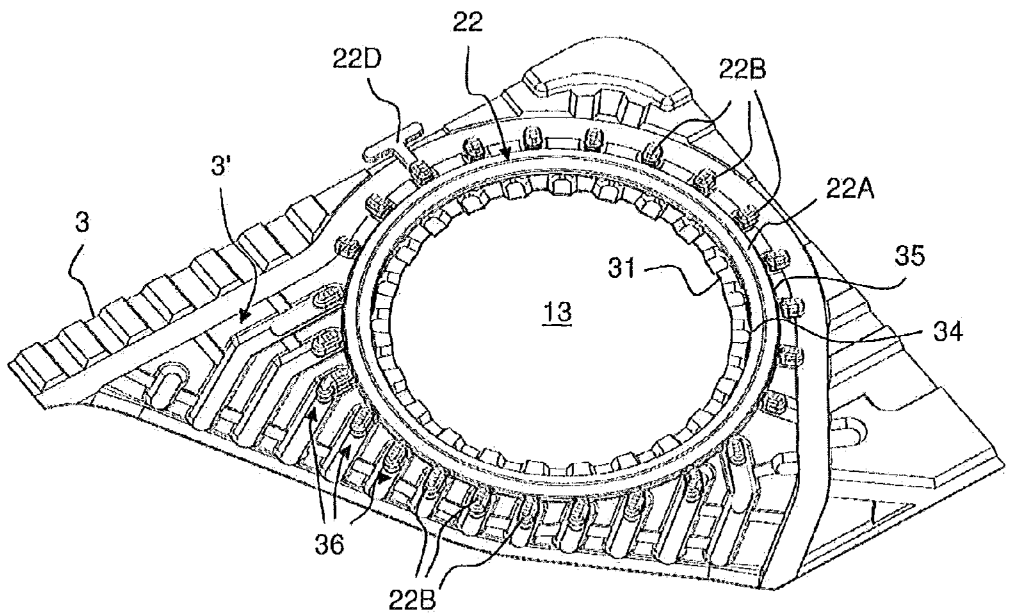
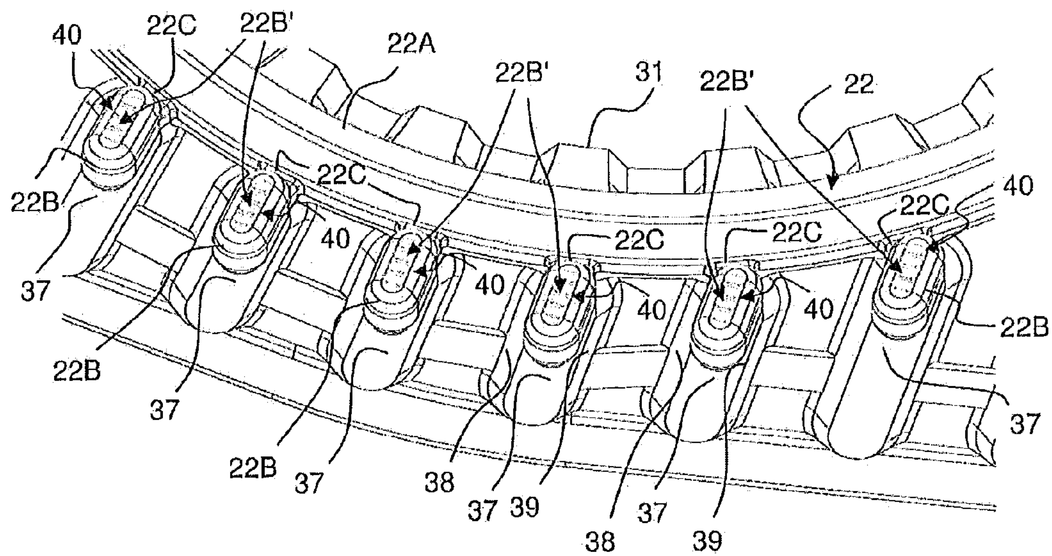


Fig. 8


40
22C
22B'
22A
22B'
31
22B'
22
22B
22C
40
22C
22C
22C
40
37
40
40
40
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22B
22B
37
37
22B
37
38
37
39
37
38
39
37

Fig. 9

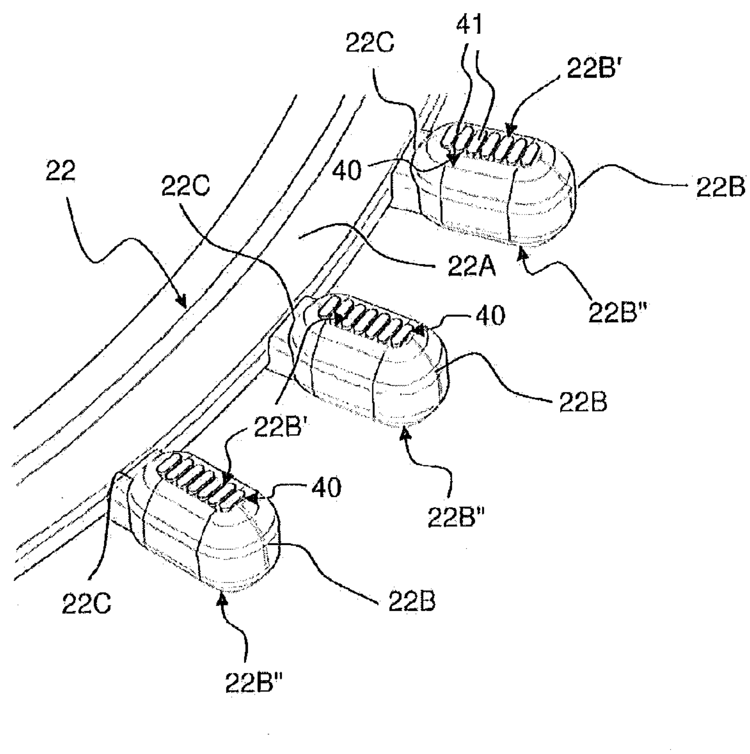
41
22C
22B'
22
40
22C
22B
22A
22B"
40
22B
22B'
22B"
40
22C
22B
22B"

Fig. 11

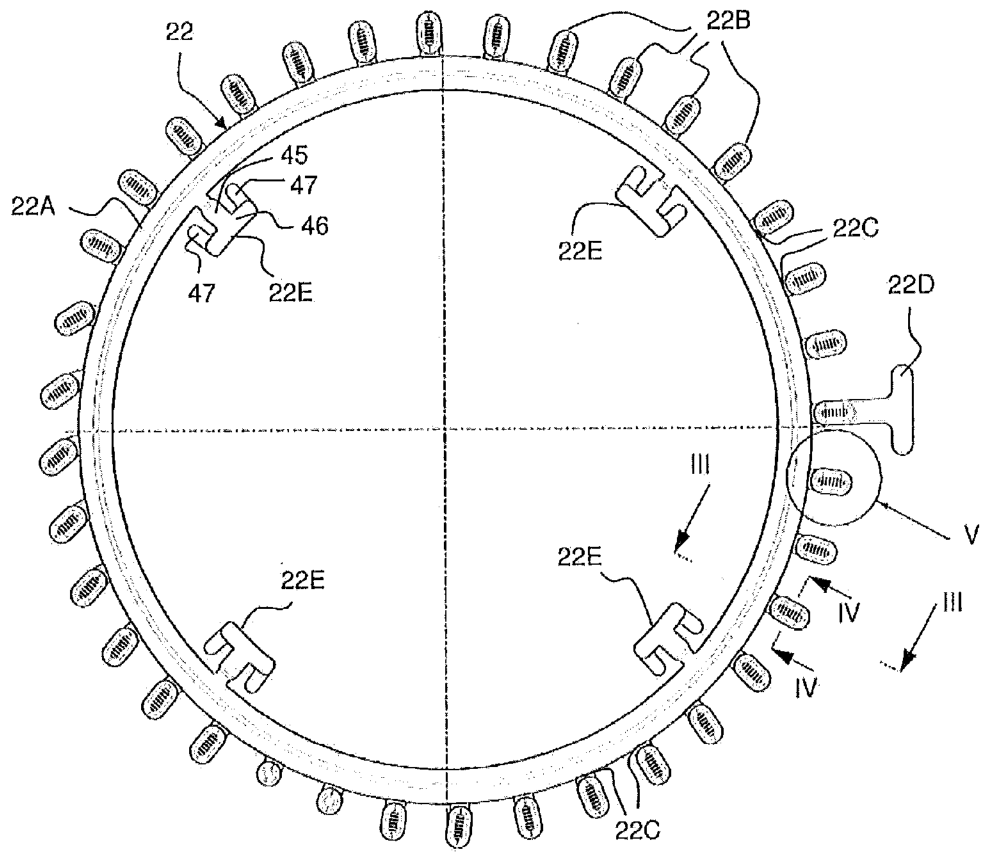

Fig. 10

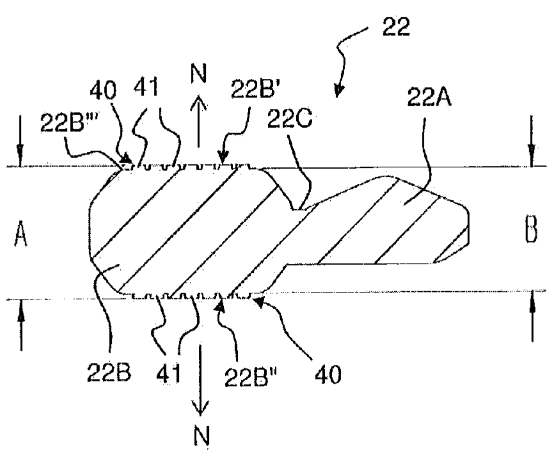

Fig. 12

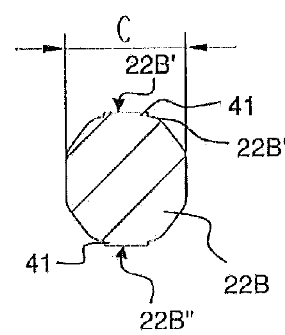

Fig. 13

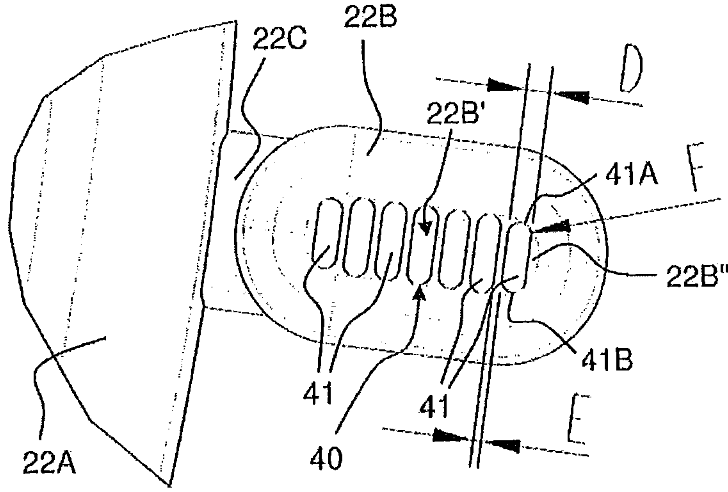
22C
22B
D
22B'
41A
F
22B'''
41B
41
41
40
E
22A

Fig. 14

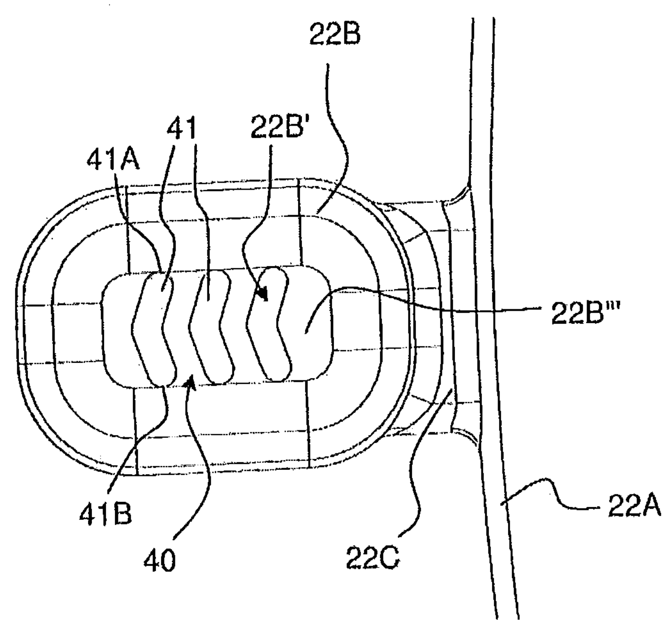
22B
41
22B'
41A
22B'''
41B
40
22C
22A

Fig. 15

PORTHOLE GASKET FOR A PLATE HEAT EXCHANGER, A PLATE PACKAGE AND A PLATE HEAT EXCHANGER WITH SUCH A PORTHOLE GASKET

TECHNICAL FIELD

[0001] The present invention generally relates to plate heat exchangers, and in particular to a porthole gasket for installation between two adjacent heat exchanger plates of a plate heat exchanger.

BACKGROUND

[0002] Plate heat exchangers, PHEs, typically consist of two end plates in between which a heat exchanger plate package is arranged. The plate package typically includes a plurality of heat exchanger plates stacked on each other to define first and second spaces for first and second fluids, where each heat exchanger plate includes portholes that permit fluid communication with the first and second spaces. In one type of well-known PHEs, the so called gasketed PHEs, field and porthole gaskets are arranged between the heat exchanger plates. The field gaskets are typically arranged in field gasket grooves which run along outer edges of the heat exchanger plates while the porthole gaskets typically are arranged in porthole gasket grooves which run along inner edges, more particularly around the portholes, of the heat exchanger plates. The end plates, and therefore the heat exchanger plates, are pressed towards each other whereby the gaskets seal between the heat exchanger plates. In another type of well-known PHEs, the so-called semi-welded plate heat exchangers, the plate package is formed by plate modules, which each comprises two heat exchanger plates welded to each other to define one of the first spaces, the field and porthole gaskets thus being replaced by welds, and the plate modules are stacked, with intermediate field and porthole gaskets arranged in field and ring gasket grooves, respectively, to define the second spaces between them. The semi-welded heat exchangers are frequently used in applications where the first fluid is aggressive or under a significantly elevated pressure, and the second fluid is relatively non-aggressive. The porthole gaskets will be subjected to the first fluid and may have to be manufactured of a high quality material. However, since the porthole gaskets contain a relatively small material volume, this should not have to involve any major increase in costs.

[0003] For a plate heat exchanger to be leak proof, it may be important that the gaskets are properly positioned in the gasket grooves. The gasket grooves are typically defined by an outer lateral wall, an inner lateral wall and a bottom wall extending there between. The outer and inner lateral walls typically result from pressing of the heat exchanger plates during which operation the plates are provided with a pattern of valleys and ridges. In conventional plate heat exchangers the outer lateral walls of the porthole gasket grooves are intermittent so as to provide, to the porthole gaskets, only periodical support, i.e. support in separated support areas. Thus, there is a risk of the porthole gaskets being displaced, between the support areas, from their proper positioning in the porthole gasket grooves, especially when a pressure prevailing within the porthole gaskets, i.e. inside the portholes, is considerably higher than a pressure prevailing outside the porthole gaskets.

[0004] As a solution to this problem, WO2004/072570 proposes to re-design the heat exchanger plates so as to make the outer lateral walls of the porthole gasket grooves continuous and thereby capable of providing uninterrupted porthole gasket support. However, there is a need for alternative solutions.

SUMMARY

[0005] It is an objective of the invention to at least partly overcome one or more limitations of the prior art. Another objective is to reduce the risk for fluid leakage in plate heat exchangers with overlapping portholes sealed by porthole gaskets. A still further objective is to reduce the risk for fluid leakage in plate heat exchangers sealed by porthole gaskets located in dedicated ring-shaped gasket grooves with intermittent openings along their outer lateral walls. One or more of these objectives, as well as further objectives that may appear from the description below, are at least partly achieved by means of a porthole gasket, a plate package for a plate heat exchanger and a plate heat exchanger according to the independent claims, embodiments thereof being defined by the dependent claims.

[0006] A first aspect of the invention is a porthole gasket for installation between two adjacent heat exchanger plates of a plate heat exchanger, the porthole gasket being configured to seal a circumferential region around two overlapping portholes, each of which being formed in a respective one of the two adjacent heat exchanger plates, so as to define a passage for a fluid into or out of the plate heat exchanger. The porthole gasket comprises a ring-shaped portion configured to be compressed between the two adjacent heat exchanger plates while surrounding the overlapping portholes. The porthole gasket further comprises a plurality of projections that protrude from an outer perimeter of the ring-shaped portion and are configured to be compressed between the two adjacent heat exchanger plates so as to support the ring-shaped portion against pressure exerted by the fluid.

[0007] Compared to a conventional porthole gasket, which has a smooth continuous outer perimeter, the projections will serve to increase the total contact area of the porthole gasket and thus the friction between the porthole gasket and the two adjacent heat exchanger plates when the porthole gasket is compressed between the heat exchanger plates. Thereby, the porthole gasket is more firmly held in place around the two overlapping portholes, reducing the risk for fluid leakage across the circumferential region that is sealed by the porthole gasket.

[0008] The increased contact area and friction allows the porthole gasket to be firmly held in place if installed, for example, in a ring-shaped gasket groove that has openings in its outer lateral wall. For installation in such a gasket groove, the porthole gasket is suitably configured such that its ring-shaped portion mates with the gasket groove, while its projections mate with and extend through at least a subset of the openings in the outer lateral wall of the gasket groove. These openings may have any distribution along the outer lateral wall.

[0009] However, the inventive porthole gasket may be installed between any types of adjacent heat exchanger plates, which may or may not be provided with gasket grooves for receiving the porthole gasket. In certain applications, and depending on the design of the porthole gasket and its projections, the porthole gasket may have a sufficient ability to seal the circumferential region around the overlapping portholes and withstand the pressure exerted by the fluid inside the portholes, even if installed and compressed between essentially flat surfaces on the two adjacent heat exchanger plates.

[0010] It is to be understood that "ring-shaped" does not imply a circular shape, but merely indicates that the ring-shaped portion is configured to surround the overlapping portholes in the circumferential region. Thus, the ring-shaped portion of the porthole gasket may be either circular or non-circular, including regular shapes, such as oval, rectangular, triangular or hexagonal shapes, and irregular shapes.

[0011] In one embodiment, at least one of the projections comprises a friction-enhancing surface pattern that defines a patterned first surface portion for engaging a first one of the two adjacent heat exchanger plates when the projections are compressed between the two adjacent heat exchanger plates. The provision of such a surface pattern has been found to significantly improve the ability of the porthole gasket to withstand pressure, by further increasing the friction between the porthole gasket and the two adjacent heat exchanger plates.

[0012] The sealing ability and stability of the porthole gasket may be further improved by optimizing the design of the surface pattern, for example according to one or more of the following embodiments.

[0013] In one embodiment, the surface pattern defines a patterned second surface portion for engaging a second one of the two adjacent heat exchanger plates when the projections are compressed between the two adjacent heat exchanger plates, the first and second surface portions being arranged on opposite sides of said at least one of the projections.

[0014] In one embodiment, the surface pattern comprises a plurality of spaced-apart pattern structures, as seen parallel to a normal direction of the patterned first surface portion. It may further be advantageous for the pattern structures to be separated by a gap distance, as seen parallel to the normal direction of the patterned first surface portion, the gap distance being at least half of a smallest dimension of the pattern structures, as seen parallel to the normal direction of the patterned first surface portion. Furthermore, at least a subset of the pattern structures may have rounded ends, as seen parallel to the normal direction of the patterned first surface portion, said rounded ends having a radius which is approximately equal to half of the smallest dimension of the respective pattern structure, as seen parallel to the normal direction of the patterned first surface portion.

[0015] In one embodiment, the pattern structures comprise protrusions protruding, parallel to the normal direction of the patterned first surface portion, from a bulk portion of said at least one of the projections, to define the patterned first surface portion. Each of the protrusions may have an extent, from the bulk portion and parallel to the normal direction, which is approximately 2.5-5%, or even 2-10%, of a thickness of the bulk portion parallel to the normal direction.

[0016] In one embodiment, the pattern structures comprise elongated ribs.

[0017] In one embodiment, said at least one of the projections is elongated and extend in a longitudinal direction away from the outer perimeter of the ring-shaped portion, and at least part of the pattern structures extend essentially transverse to the longitudinal direction.

[0018] Alternatively or additionally, the sealing ability and stability of the porthole gasket may be further improved by optimizing the design of the projections, for example according to one or more of the following embodiments.

[0019] One or more of the projections may be connected to the ring-shaped portion by a link portion, which has a smaller material thickness than said one or more of the projections.

[0020] In one embodiment, at least a subset of the projections are elongated and extend in a longitudinal direction away from the outer perimeter of the ring-shaped portion. It may further be advantageous for the longitudinal direction to be non-perpendicular to the outer perimeter of the ring-shaped portion, for at least one of the projections.

[0021] The projections may be uniformly distributed around at least a major part of the outer perimeter of the ring-shaped portion.

[0022] The ring-shaped portion may extend in a geometric plane, and the projections may extend from the ring-shaped portion parallel to the geometric plane. The ring-shaped portion and the projections may extend in the same geometric plane.

[0023] To facilitate installation of the porthole gasket between the two adjacent heat exchanger plates, the porthole gasket may further comprise an attachment member which protrudes from an inner perimeter of the ring-shaped portion and is arranged to engage with an edge portion of one of the overlapping portholes.

[0024] In a further embodiment, the porthole gasket comprises a label member which protrudes from the outer perimeter of the ring-shaped portion and is arranged to extend beyond the two adjacent heat exchanger plates so as to be visible externally of the plate heat exchanger.

[0025] A second aspect of the invention is a plate heat exchanger comprising a porthole gasket of the first aspect.

[0026] A third aspect of the invention is a plate package for a plate heat exchanger, comprising two adjacent heat exchanger plates and the porthole gasket of the first aspect compressed between the two adjacent heat exchanger plates, each of the two adjacent heat exchanger plates being formed with a porthole, the portholes of the two adjacent heat exchanger plates being overlapping, and the porthole gasket surrounding the portholes.

[0027] In one embodiment, each of the projections is compressed between a respective pair of opposite engagement surfaces on the two adjacent heat exchanger plates, and wherein each of the projections has a thickness, before compression, which exceeds a distance between the respective pair of opposite engagement surfaces after compression by approximately 10-20%, or even 5-20%.

[0028] In one embodiment, the ring-shaped portion is located in a ring groove formed in at least one of the two adjacent heat exchanger plates, and at least a subset of the projections are located in channels that are defined by the two adjacent heat exchanger plates to extend away from the ring groove. The respective channel may be formed by single channel groove in one of the heat exchanger plates, or by two mutually aligned channel grooves as defined further below. To further improve the stability of the porthole gasket, one or more of the projections may be fitted in a respective one of the channels that has a non-linear extent away from the ring groove, and each of said one or more of the projections may have an extent that conforms to the non-linear extent of the respective one of the channels. Alternatively or additionally, the ring-shaped portion may be compressed between bottom surfaces of a first ring groove formed in a first one of the two adjacent heat exchanger plates and a second ring groove formed in a second one of the two adjacent heat exchanger plates, the first and second ring grooves being arranged in mutual alignment, and said at least a subset of the projections may be compressed between bottom surfaces of channel grooves, which are formed in the two adjacent heat exchanger plates and arranged in mutual alignment to define said channels.

[0029] At least one of the two adjacent heat exchanger plates may be formed to extend in at least an intermediate plane, an upper plane and a lower plane, said planes being substantially parallel to each other, wherein the ring-shaped portion may engage said at least one of the two adjacent heat exchanger plates in the intermediate plane, and wherein the projections may engage said at least one of the two adjacent heat exchanger plates in the lower plane. The intermediate plane and the lower plane may coincide.

[0030] Any one of the embodiments of the first aspect can be combined with the second to third aspects to attain the corresponding technical effects or advantages.

[0031] Still other objectives, features, aspects and advantages of the present invention will appear from the following detailed description, from the attached claims as well as from the drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0032] Embodiments of the invention will now be described in more detail with reference to the accompanying schematic drawings.

[0033] FIG. **1** is a side view of a plate heat exchanger with a plate package.

[0034] FIG. **2** is a schematic plan view of a heat exchanger plate for the plate package in FIG. **1**.

[0035] FIG. **3** is a schematic plan view of the heat exchanger plate in FIG. **2** welded to another heat exchanger plate.

[0036] FIG. **4** is a schematic plan view of the heat exchanger plate in FIG. **2** welded to another heat exchanger plate and provided with gasket members.

[0037] FIG. **5** is an enlarged plan view of area I of the heat exchanger plate in FIG. **2**.

[0038] FIG. **6**A is a section view taken along line II-II in FIG. **5**, FIG. **6**B is a corresponding section view with a porthole gasket placed on the heat exchanger plate, and FIG. **6**C is a section view of two assembled heat exchanger plates with a porthole gasket between them.

[0039] FIG. **7** is a plan view corresponding to FIG. **5** in which a porthole gasket according to one embodiment is installed to surround a porthole in the heat exchanger plate.

[0040] FIG. **8** is a perspective view corresponding to FIG. **7**.

[0041] FIG. **9** is an enlargement of a portion of the heat exchanger plate and the porthole gasket in FIG. **8**.

[0042] FIG. **10** is a plan view of a porthole gasket according to another embodiment.

[0043] FIG. **11** is a perspective view of a portion of the porthole gasket in FIG. **10**.

[0044] FIG. **12** is a section view taken along line in FIG. **10**.

[0045] FIG. **13** is a section view taken along line IV-IV in FIG. **10**.

[0046] FIG. **14** is a plan view of area V in FIG. **10**.

[0047] FIG. **15** is a plan view of a portion of a ring gasket according to yet another embodiment.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0048] FIG. **1** illustrates a plate heat exchanger **100** including a plate package **1** with a number of plate modules **2**, which each includes a number of heat exchanger plates **3** arranged adjacent to each other. In the embodiments disclosed herein, each such plate module **2** includes two heat exchanger plates **3**, but the plate modules **2** may be formed by combining a group of more than two heat exchanger plates **3**.

[0049] The plate package **1** is arranged between two end plates **4**, **5**. The end plates **4**, **5** are pressed against the plate package **1** and each other by means of tightening bolts **6** extending through the end plates **4**, **5**. The tightening bolts **6** include threads and the stack of plate modules **2** may thus be compressed by threading nuts **7** onto the tightening bolts **6** in a manner known per se. In the embodiments disclosed herein, four tightening bolts **6** are implied (of which only two are visible in the figures). It is to be noted that the number of tightening bolts **6** may vary and be different in different applications. The plate heat exchanger **100** also includes two inlet members **8** (only one shown) and two outlet members **9** (only one shown). The inlet and outlet members **8**, **9** may be attached to one of the end plates **4**, **5** in alignment with respective inlet and outlet ports (not shown) in the end plates **4**, **5**. These inlet and outlet ports are in turn aligned with inlet and outlet channels that are formed by mutually aligned portholes of the heat exchanger plates **3**, as will be described in more detail below.

[0050] Each heat exchanger plate **3** has a primary side **3'** and a secondary side **3"** (FIG. **6**A) and is formed to extend in at least three planes, which are substantially parallel to each other: an intermediate plane al, an upper plane a**2** and a lower plane a**3**. The intermediate plane a**1** may, but need not, be located centrally between the upper plane a**2** and the lower plane a**3**.

[0051] In the embodiments disclosed herein, the heat exchanger plates **3** in each plate module **2** are so arranged that their secondary sides **3"** face each other and define an inner first space. Further, each pair of two adjacent ones of the plate modules **2** defines a second space. Thus, the second spaces are defined by the primary sides **3'** of two adjacent ones of the heat exchanger plates **3**, which adjacent heat exchanger plates are comprised in different, but adjacent, plate modules **2**. The heat exchanger plates **3** in each plate module **2** are preferably permanently connected to each other, e.g. by means of welding, brazing or gluing.

[0052] FIG. **2** shows an example of a heat exchanger plate **3** as seen towards its secondary side **3"**, and FIG. **3** shows a plate module **2** which is created by combining two of the heat exchanger plates **3** in FIG. **2**. When combining the two heat exchanger plates **3** into the plate module **2**, one of the heat exchanger plates **3** is turned upside down with respect to the other heat exchanger plate **3**. Therefore, in the plate package **1** of stacked plate modules **2**, every second one of the heat exchanger plates **3** will be turned upside down with respect to a reference orientation of the heat transfer plates.

[0053] As seen in FIG. **2**, each heat exchanger plate **3** includes first portholes **13** which are arranged to permit fluid communication with the first space. Each plate **3** also includes second portholes **15** which are arranged to permit fluid communication with the second space. When the plate modules **2** are assembled into the plate package **1**, the portholes **13** are aligned to define an inlet channel and an outlet channel in fluid communication with the first spaces, and the portholes **15** are aligned to define an inlet channel and an outlet channel in fluid communication with the second spaces. As noted above, when the plate package **1** is installed as part of a heat exchanger **100**, the inlet channels are in fluid communication with a respective inlet member **8**, and the outlet channels are in fluid communication with a respective outlet member **9**.

[0054] A first fluid may thus be introduced via one of the inlet members **8** and the inlet channel defined by the first portholes **13**, flow through the first spaces and leave through the outlet channel defined by the first portholes **13** and one of the outlet members **9**. A second fluid may be introduced via the other inlet member **8** and the inlet channel defined by the second portholes **15**, flow through the second spaces and leave through the outlet channel defined by the second portholes **15** and the other outlet member **9**.

[0055] Each heat exchanger plate **3** is preferably manufactured of a metal sheet, for instance stainless steel, aluminum or titanium, and includes a substantially central heat exchanging surface **20**, see FIGS. **2-4**. The heat exchanging surface **20**, just like other portions of the heat exchanger plates **3**, may in a manner known per se be provided with a corrugation of ridges and valleys (not disclosed) obtained through forming of the metal sheet. In a variant, one or more of the heat exchanging surfaces **20** may lack the corrugation and thus be completely planar.

[0056] FIGS. **3-4** disclose a plate module **2** in which the plates **3** are connected to each other by means of a weld joint **21** (illustrated by a dashed line) extending around the heat exchanging surface **20** and the first portholes **13**. Weld joints **21** (illustrated by a respective dashed line) also extend around each of the second portholes **15**.

[0057] Between the plate modules **2**, gasket members are installed and compressed to seal the second spaces. As shown in FIG. **4**, the gasket members include porthole gaskets **22** (also denoted "ring gaskets") which are installed in a circumferential region around each of the first portholes **13**, and a peripheral or field gasket **23** which is installed to extend around the heat exchanging surface **20** and the second portholes **15**.

[0058] Each of the portholes **13**, **15** is defined by a port edge **31**, as shown for the first porthole **13** in FIG. **5**. Each of the first portholes **13** is surrounded by a ring groove **32**, which is arranged to receive the respective porthole gasket **22**. The ring groove **32** is provided on the primary side **3'** at a determined distance from the port edge **31**. As shown in greater detail in FIGS. **5** and **6**A, the ring groove **32** is defined by a bottom surface **33**, an inner lateral wall **34** and an outer lateral wall **35**. As seen in the section view of FIG. **6**A, the bottom surface **33** is substantially formed at the level of the intermediate plane al. The inner lateral wall **34** extends upwardly from the bottom surface **33** in a direction towards the port edge **31** and around the bottom surface **33**. The outer lateral wall **35** extends upwardly from the bottom surface **33** away from the port edge **31** and around the bottom surface **33**. Both the inner lateral wall **34** and the outer lateral wall **35** include openings along their respective extension around the bottom surface **33** and are thus discontinuous. The openings along the inner lateral wall **34** on the primary side **3'** are defined by a wave-shaped portion of alternately arranged ridges and valleys which are located at the upper and lower planes a**2**, a**3**, respectively. When the plates **3** have been assembled into a plate package **1**, the wave-shaped portions of adjacent plates **3** provide support for the port edge **1**, by the valleys of one plate **3** abutting on the ridges of the other plate **3**, and vice versa, while allowing fluid to flow into or out of the first spaces via the first portholes **13**. The openings along the outer lateral wall **35** on the primary side **3'** are likewise defined by a wave-shaped portion of alternately arranged ridges and valleys which are located at the upper and lower planes a**2**, a**3**, respectively. These valleys define channel grooves **36** that extend from the openings in the outer lateral wall **35** away from the first porthole **13**. The channel grooves **36** are defined by a bottom surface **37**, which is located at the level of the lower plane a**3**, and lateral side walls **38**, **39** (FIG. **9**). As will be described in more detail below, at least a subset of the channel grooves **36** are configured to accommodate a respective projection **22**B of the porthole gasket **22** such that the bottom surface **37** engages with the projection **22**B. In this sense, the bottom surface **37** forms an "engagement surface". The placement of the channel grooves **36** along the outer lateral wall **35**, and their extent away from the outer lateral wall **35**, may be set to achieve a desired flow path for the first fluid from the first porthole **13** inside the first spaces (since the valleys that form the channel grooves **36** correspond to ridges on the opposite secondary side **3"**). It is also conceivable that at least a subset of the channel grooves **36** are provided for the sole purpose of accommodating a respective projection **22**B, e.g. the channel grooves **36** at the upper right portion of the ring groove **32** in FIG. **5**.

[0059] The following description will focus on the configuration of the porthole gasket **22**. As used herein, a peripheral direction of the porthole gasket **22** extends around its perimeter, a radial direction of the porthole gasket **22** extends radially with respect to its center point, and an axial direction of the porthole gasket **22** extends perpendicular to its peripheral and radial directions.

[0060] Generally, the porthole gasket **22** is an integral component made of a flexible material, such as rubber or a rubber composition.

[0061] FIGS. **7-8** illustrate a porthole gasket **22** as mounted on the primary side **3'** of the heat exchanger plate **3** in FIG. **5**, so as to surround the porthole **13**. The porthole gasket **22** is composed of a ring-shaped portion **22**A (denoted "ring portion" in the following) and a plurality of projections **22**B which are distributed with essentially equal spacing (uniformly) around the outer perimeter of the ring portion **22**A. In the illustrated example, the projections **22**B are formed as fingers that generally extend away from the ring portion **22**A in a respective longitudinal direction. The ring portion **22**A extends in a two-dimensional geometric plane which is parallel to a figure plane of FIG. **7**, and the projections **22**B generally extend away from the ring portion **22**A parallel to this geometric plane. The ring portion **22**A conforms to and is arranged in the ring groove **32**, and the projections **22**B conform to and are arranged in the channel grooves **36**. The projections **22**B are integrally formed with the ring portion **22**A.

[0062] It is understood that when the plate modules 2 have been assembled into the plate package 1 (FIG. 1), the porthole gaskets 22 are compressed between the primary sides 3' of adjacent plates 3. The ring portion 22A of each porthole gasket 22 is received within a pair of mutually aligned ring grooves 32 around the respective first porthole 13 of the adjacent plates 3, while a respective projection 22B of the porthole gasket 22 is received within a pair of mutually aligned channel grooves 36 of the adjacent plates 3. Each pair of mutually aligned channel grooves 36 thus forms a channel 36' for receiving one of the projections 22B (cf. FIG. 6C).

[0063] The projections 22B serve to increase the contact area of the porthole gasket 22 and thereby increase the friction between the porthole gasket 22 and the adjacent plates 3 when the plate modules 2 are pressed together to compress the porthole gasket 22. To achieve the increase in contact area, each projection 22B has a thickness, before compression, in the axial direction of the porthole gasket 22, which exceeds the total distance between the surfaces of the plates 3 that engage with the projection 22B when the plates 3 are assembled into the plate package 1. This ensures that the projections 22B are compressed between the plates 3 in the plate package 1. In the illustrated embodiment, as understood from FIG. 6A, this total distance is twice the distance between the upper and lower planes a2, a3. It is currently believed that optimum sealing and gasket stability is achieved when the ratio between the projection thickness and the total distance is in the range from about 1.05 to about 1.2.

[0064] In the illustrated example, all projections 22B are elongated to achieve high friction and ensure that the ring portion 22A is not dislocated in the ring groove 32 by the pressure exerted on the ring portion 22A by the first fluid via the first porthole 13.

[0065] As seen in the section view of FIG. 6B, which is taken in FIG. 7 at the location of line in FIG. 5, the ring portion 22A has an essentially flat bottom surface, which conforms to the shape of the bottom surface 33 of the ring groove 32, and a roof-shaped top surface. The roof-shaped top surface may be provided to achieve a desired deformation and sealing action when the gasket 22 is compressed. However, the ring portion 22A may have any other cross-section known in the art.

[0066] In the section view of FIG. 6C, another heat exchanger plate 3 has been arranged and pressed onto the heat exchanger plate 3 shown in FIG. 6B, such that the porthole gasket 22 is fitted between the two adjacent plates 3. The ring portion 22A is thereby compressed between the plates 3 to essentially fill the space between the two mutually facing ring grooves 32, and the projection 22B is likewise compressed to essentially fill the space between the two mutually facing channel grooves 36. Thus, the ring portion 22A is engaged with and compressed between the bottom surfaces 33 of the opposing ring grooves 32, and the projections 22B are engaged with and compressed between the bottom surfaces 37 of the opposing channel grooves 36, which thus define a channel 36' for accommodating the respective projection 22B. By their engagement with the porthole gasket 22, the bottom surfaces 33, 37 form "engagement surfaces". Although not shown in FIG. 6C, it is to be understood that the plates 3 belong to a respective plate module 2.

[0067] As seen in FIGS. 6B-6C, the respective projection 22B has first and second surface portions 22B', 22B" on its opposite sides that face and engage with the bottom surface 37 of the respective channel groove 36 when the porthole gasket 22 is compressed between the plates 3. These first and second surface portions 22B', 22B" are denoted "main contact surfaces" in the following. As indicated in FIG. 6B, each main contact surface 22B', 22B" is associated with a normal direction N, which is perpendicular to the respective main contact surface 22B', 22B". It is understood that the normal direction N typically is parallel to the above-mentioned axial direction of the porthole gasket 22.

[0068] Returning to FIGS. 7-8, it is seen that a portion of the projections 22B extend non-perpendicularly from the ring portion 22A, i.e. in a direction that deviates from the radial direction of the porthole gasket 22. Such a non-radial extension may be governed by the layout of the flow channels on the secondary side 3", as discussed above. However, it may also be advantageous to deliberately design the channel grooves 36 to provide for such non-radial extension of the projections 22B. The non-radial extension may provide for a more secure attachment of the porthole gasket 22 on the plate 3 during assembly of the plate package 1. It may also increase the resistance of the porthole gasket 22 to radial displacement caused by the pressure exerted by the first fluid via the first porthole 13. Furthermore, as also seen in FIGS. 7-8, one or more projections 22B may have a non-linear extension, in the above-mentioned two-dimensional geometric plane, to further improve the resistance to radial displacement. The non-linear extension may be implemented as a bend or knee along the extent of the projection 22B.

[0069] In the example of FIGS. 7-8, the porthole gasket 22 is also integrally formed with a label member 22D which is arranged to project from the plate package 1 when assembled. The label member 22D has a connecting portion that extends from the ring portion 22A, or one of the projections 22B, to a crossbar portion. It is understood that the plates 3 are provided with appropriate channel grooves for accommodating the connecting portion. The crossbar portion is labeled to designate the type of porthole gasket 22 that is installed in the plate package 1. For example, the heat exchanger may be provided with different types of porthole gaskets 22 depending on the type of fluids to be conveyed through the plate package/heat exchanger.

[0070] In the illustrated example, as best shown in FIG. 6B and FIG. 9, a link portion 22C connects the respective projection 22B to the ring portion 22A. The link portion 22C has a thinner (smaller) material thickness than the connected projection 22B, at least parallel to the normal direction N of the main contact surfaces 22B', 22B", so as to increase the flexibility between the respective projection 22B and the ring portion 22A, in particular in the axial direction of the porthole gasket 22. This flexibility may facilitate mounting of the porthole gasket 22 on the plate 3, to ensure that the projections 22 are properly received and compressed in the channel grooves 36 when the plate package 1 is assembled. Alternatively or additionally, the link portion 22C may have a material thickness in the peripheral direction of the porthole gasket 22 that is smaller than the material thickness of the projection 22B in the transverse direction of the projection 22B (see e.g. FIGS. 14 and 15), to increase flexibility in the peripheral direction of the porthole gasket 22. However, if more rigid link portions 22 are desired or required, the material thickness of the link portions 22B may be equal to or exceed the material thickness of the projection 22B.

[0071] As seen in FIG. **9** in conjunction with FIG. **6**B, the main contact surfaces 22B', 22B" of the projections 22B are defined by a surface pattern **40**. In the illustrated example, the surface pattern **40** is composed of three or four pattern structures in the form of ribs **41** that are spaced in the longitudinal direction of the projection 22B and have an elongated extent in the transverse direction of the projection 22B. The ribs **41** are three-dimensional structures that protrude from a bulk portion 22B'" of the projection 22B and thus have a predefined height in the normal direction N. The bulk portion 22B'" thus designates the remaining material of the projection 22B after a removal of the three-dimensional pattern structures, such as the ribs **41**. In the illustrated implementation, the ribs **41** have a height of about 0.2 mm, a width in the transverse direction of about 0.4 mm, a width in the longitudinal direction of about 0.2 mm, and are spaced in the longitudinal direction by a gap distance of about 0.2 mm. These dimensions are merely given as a non-limiting example.

[0072] The provision of a surface pattern **40** on the main contact surfaces 22B', 22B" has been generally found to increase the friction between the projections 22B and the plates **3** (viz. the bottom surfaces **37**) and thereby enhance the ability of the porthole gasket **22** to withstand fluid pressure. The surface pattern **40** may also reduce the impact of fluid being deposited on the bottom surfaces **37** of the channel grooves **36** before assembly, by allowing such fluid to be pressed out between the structures (e.g. ribs) of the pattern **40**, when the plate modules **2** are pressed together during assembly. Without the pattern **40**, a fluid film might be formed between the projections 22B and the plate **3**, resulting in an undesirably low friction there between.

[0073] FIGS. **10-14** illustrate a variant of the porthole gasket **22**, in which the projections 22B are provided with a different surface pattern **40**, which is composed of seven pattern structures in the form of elongated ribs **41**. Furthermore, as shown to the lower left of the porthole gasket **22** in FIG. **10**, two of the projections 22B are formed as non-elongated bulbs, which also lack surface pattern. This configuration of the projections **22** may be governed by the design of the heat exchanger plates **3** (not shown) between which the porthole gasket **22** is to be installed. As further seen in FIG. **10**, the porthole gasket **22** includes a number of attachment members 22E for attachment of the porthole gasket **22** in the ring groove **32**. The attachment members 22E are provided on the inner perimeter of the ring portion 22A to ensure that the porthole gasket **22** is immobilized during assembly of the plate package **1**, and in particular when the plate modules **2** are brought into engagement with each other. Each attachment member 22E has a T-like shape. A connecting portion **45** extends radially inwards from the ring portion 22A to a crossbar portion **46**. The crossbar portion **46** extends in the peripheral direction of the porthole gasket **22** and has two hooks **47** at its ends. The hooks **47** extend towards the ring portion 22A and have a cross-section that fits within the openings that are formed by the valleys and ridges along the port edge **31**. Thus, when the porthole gasket **22** is mounted on the heat exchanger plate **3**, the hooks **47** are inserted into these openings to immobilize the porthole gasket **22**. More particularly, the attachment members 22E are fastened to the port edge **31** by their respective connecting portion **45** engaging with the primary side **3'**, and their respective hooks **47** engaging with the secondary side **3"**, of the heat exchanger plate **3**.

[0074] FIG. **15** shows a further example of a protruding surface pattern **40**, which is composed of a series of arrow-shaped ribs **41** that are spaced apart in the longitudinal direction of the projection 22B.

[0075] Many further variants of the surface pattern **40** are conceivable within the scope of the invention. For example, the pattern **40** may include pattern structures that are essentially linear, oval, circular, zigzag-shaped or arrow-shaped, or any combination thereof. It is also conceivable that at least part of the pattern structures are formed as cuts, grooves or notches in the projection 22B. It is realized that the layout, type and implementation of the pattern structures may be optimized for a particular installation by simulation and testing.

[0076] In the embodiments shown herein, the ribs **41** protrude from the bulk portion 22B'" on opposite sides of the projection 22B so as to define the main contact surfaces 22B', 22B". It is currently believed that adequate performance, with respect to friction and ability to dispense with fluid deposits, may be achieved by applying a design rule that relates the height of the ribs **41** to the thickness of the bulk portion 22B". This design rule is further explained in relation to FIG. **12**, where variable A designates the total or maximum thickness of the projection 22B including the ribs **41** (parallel to the normal direction N), and variable B designates the thickness of the bulk portion 22B'", i.e. the thickness of the projection 22B excluding the ribs **41** (parallel to the normal direction N). According to the design rule, the ratio A/B is about 1.05-1.1 for a projection 22B that is provided with ribs **41** on both of its main contact surfaces 22B', 22B", and about 1.025-1.05 for a projection 22B that is provided with ribs **41** on only one of its main contact surfaces 22B', 22B". This means that each of the ribs **41** has a height (i.e. an extent from the bulk portion 22B'" parallel to the normal direction N), which is approximately 2.5-5% of the thickness of the bulk portion 22B'" parallel to the normal direction N. This design rule applies to any type of projection 22B that has protruding pattern structures ("protrusions") on at least one of its main contact surfaces 22B', 22B".

[0077] It is currently believed that the provision of pattern structures that extend essentially transverse to the longitudinal direction of the respective projection 22B, such as the ribs **41** in FIGS. **14-15**, serve to improve the friction between the porthole gasket **22** and the plates **3**.

[0078] With specific reference to patterns **40** composed of a plurality of parallel transversely extending ribs **41**, it is currently believed that the gap distance between the ribs **41** should be at least half the width of the ribs **41** in the longitudinal direction of the projection 22B, E≥D/2 (FIG. **14**). This configuration will facilitate manufacture of the patterned porthole gasket **22**, e.g. by molding. According to a more general design rule, which may be applied to any surface pattern composed of a plurality of separated pattern structures, the gap distance should be at least half of the smallest dimension of the pattern structures, as seen in plan view of the main contact surface 22B', 22B", i.e. parallel to the normal direction N of the respective main contact surface 22B', 22B" (cf. FIG. **6**B).

[0079] Manufacture is also facilitated by providing the respective rib **41** with a radius at its ends 41A, 41B, i.e. the ends 41A, 41B are rounded in plan view (FIGS. **14** and **15**).

In one preferred embodiment, the radius is approximately equal to half the width of the rib **41** in the longitudinal direction of the projection **22**B, F≈D/2 (FIG. **14**). As a general design rule, which may be applied to any surface pattern, each pattern structure that has a rounded end **41**A, **41**B should be designed with a radius of the rounded end **41**A, **41**B that is approximately equal to half of the smallest dimension of the pattern structure, as seen in plan view of the main contact surface **22**B', **22**B", i.e. parallel to the normal direction N of the respective main contact surface **22**B', **22**B" (cf. FIG. **6**B).

[0080] The surface pattern **40** need not be confined to the main contact surfaces **22**B', **22**B", but may also be circumferential to the projections **22**B, so as to also engage with the side walls **38**, **39** of the channel grooves **36**. This may further enhance the friction between the porthole gasket **22** and the plates **3**. For example, not shown, the projection **22**B may be provided with a plurality of circumferential flanges that are spaced from each other in the longitudinal direction of the projection **22**B. These flanges may e.g. correspond to the ribs **41** on opposite sides of the projection **22**B in FIG. **14** being extended to meet and thereby go around the entire perimeter of the projection **22**B.

[0081] The above described embodiments of the present invention should only be seen as examples. A person skilled in the art realizes that the embodiment discussed can be varied and combined in a number of ways without deviating from the inventive conception.

[0082] For example, the above described plate heat exchanger is of parallel counter flow type, i.e. the inlet and the outlet for each fluid are arranged on the same half of the plate heat exchanger and the fluids flow in opposite directions through the first and second spaces between the heat exchanger plates **3**. Naturally, the plate heat exchanger could instead be of diagonal flow type and/or a co-flow type.

[0083] Furthermore, the plate package **1** need not be formed by plate modules **2** that include a number of permanently connected heat exchanger plates **3**. Instead, the plate package **1** may be formed as a stack of individual heat exchanger plates **3** and the weld lines disclosed in the foregoing may be replaced by appropriate gasket members, including the porthole gasket **22**.

[0084] Still further, the porthole gasket **22** may be used between any type of heat exchanger plates **3** for sealing a circumferential region around overlapping portholes. Thus, the adjacent plates **3** need not be arranged with their primary sides **3**' facing each other, and the secondary sides **3**" facing each other, but could be arranged with the primary side **3**' of one plate **3** facing the secondary side **3**" of the other plate **3**, as in known in the art. It is also possible that the adjacent plates are of different types.

[0085] It is also possible that all or a subset of the projections **22**B are formed without a surface pattern **40**, or that the surface pattern **40** is provided on only one of the main contact surfaces **22**B', **22**B". Likewise, all or a subset of the projections **22**B may be formed as non-elongated bulbs on the outer perimeter of the ring portion **22**A (cf. FIG. **10**).

[0086] Still further, the projections **22**B need not be uniformly distributed around the ring-shaped portion **22**A. Depending on the design of the plate heat exchanger **100**, it may be advantageous to ensure that the projections **22**B are uniformly distributed around at least a major part of the outer perimeter of the ring-shaped portion **22**A.

[0087] The field and porthole gaskets need not be separated but could be connected to each other or even integrally formed.

[0088] 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. 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.

1. A porthole gasket for installation between two adjacent heat exchanger plates of a plate heat exchanger, the porthole gasket being configured to seal a circumferential region around two overlapping portholes, each of which being formed in a respective one of the two adjacent heat exchanger plates, so as to define a passage for a fluid into or out of the plate heat exchanger, wherein the porthole gasket comprises a ring-shaped portion configured to be compressed between the two adjacent heat exchanger plates while surrounding the overlapping portholes, the porthole gasket further comprising a plurality of projections that protrude from an outer perimeter of the ring-shaped portion and are configured to be compressed between the two adjacent heat exchanger plates so as to support the ring-shaped portion against pressure exerted by the fluid.

2. The porthole gasket of claim **1**, wherein at least one of the projections comprises a friction-enhancing surface pattern that defines a patterned first surface portion For engaging a first one of the two adjacent heat exchanger plates when the projections are compressed between the two adjacent heat exchanger plates.

3. The porthole gasket of claim **2**, wherein the surface pattern defines a patterned second surface portion for engaging a second one of the two adjacent heat exchanger plates when the projections are compressed between the two adjacent heat exchanger plates, the first and second surface portions being arranged on opposite sides of said at least one of the projections.

4. The porthole gasket of claim **2**, wherein the surface pattern comprises a plurality of spaced-apart pattern structures, as seen parallel to a normal direction (N) of the patterned first surface portion.

5. The porthole gasket of claim **4**, wherein the pattern structures comprise protrusions protruding, parallel to the normal direction of the patterned first surface portion, from a bulk portion of said at least one of the projections, to define the patterned first surface portion.

6. The porthole gasket of claim **4**, wherein the pattern structures comprise elongated ribs.

7. The porthole gasket of claim **4**, wherein said at least one of the projections is elongated and extend in a longitudinal direction away from the outer perimeter of the ring-shaped portion, and wherein at least part of the pattern structures extend essentially transverse to the longitudinal direction.

8. The porthole gasket of claim **1**, wherein at least a subset of the projections are elongated and extend in a longitudinal direction away from the outer perimeter of the ring-shaped portion.

9. The porthole gasket of claim **8**, wherein the longitudinal direction is non-perpendicular to the outer perimeter of the ring-shaped portion, for at least one of the projections.

10. The porthole gasket of claim **1**, which further comprises an attachment member which protrudes from an inner perimeter of the ring-shaped portion and is arranged to engage with an edge portion of one of the overlapping portholes.

11. A plate heat exchanger, comprising a porthole gasket according to claim **1**.

12. A plate package for a plate heat exchanger, comprising two adjacent heat exchanger plates and the porthole gasket according to claim **1** compressed between the two adjacent heat exchanger plates, each of the two adjacent heat exchanger plates being formed with a porthole, the portholes of the two adjacent heat exchanger plates being overlapping, and the porthole gasket surrounding the portholes.

13. The plate package of claim **12**, wherein each of the projections is compressed between a respective pair of opposite engagement surfaces on the two adjacent heat exchanger plates, and wherein each of the projections has a thickness, before compression, which exceeds a distance between the respective pair of opposite engagement surfaces by approximately 5-20%.

14. The plate package of claim **12**, wherein the ring-shaped portion is located in a ring groove formed in at least one of the two adjacent heat exchanger plates, and wherein at least a subset of the projections are located in channels that are defined by the two adjacent heat exchanger plates to extend away from the ring groove.

15. The plate package of claim **14**, wherein one or more of the projections is fitted in a respective one of the channels that has a non-linear extent away from the ring groove, wherein each of said one or more of the projections has an extent that conforms to the non-linear extent of the respective one of the channels.

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