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(71) Applicant: **Alfa Laval Corporate AB**
221 00 Lund (SE)

(72) Inventors:
- **Bergh, Jesper**
  SE-237 41 Bjärred (SE)
- **Nilsson, Maribel**
  SE-374 30 Karlshamn (SE)
- **Nilsson, Mats**
  SE-226 47 Lund (SE)

(74) Representative: **Alfa Laval Attorneys**
Alfa Laval Corporate AB
Patent Department
P.O. Box 73
221 00 Lund (SE)

(54) **Method for producing a plate heat exchanger**

(57) The invention relates to a method for producing a plate heat exchanger (1) comprising a plurality of heat exchanger plates (3), wherein the heat exchanger plates (3) are provided adjacent each other and form a plate package (2) with first plate interspaces (16) for a first medium and second plate interspaces (17) for a second medium, wherein each of the heat exchanger plates comprises portholes (15) which form ports (8, 9, 10, 11) extending through the plate package (2), a heat transfer area (12), an edge area (13) extending outside the heat transfer area (12) and the ports (8, 9, 10, 11), a gasket groove (19) extending in the edge area (13) outside the heat transfer area (12) and the ports (8, 9, 10, 11), and wherein a gasket (18) is provided in the gasket groove (19) for tight abutment against an adjacent plate (3) in the plate heat exchanger (1), the heat exchanger plates (3) being at least partly coated with a tantalum containing coating.

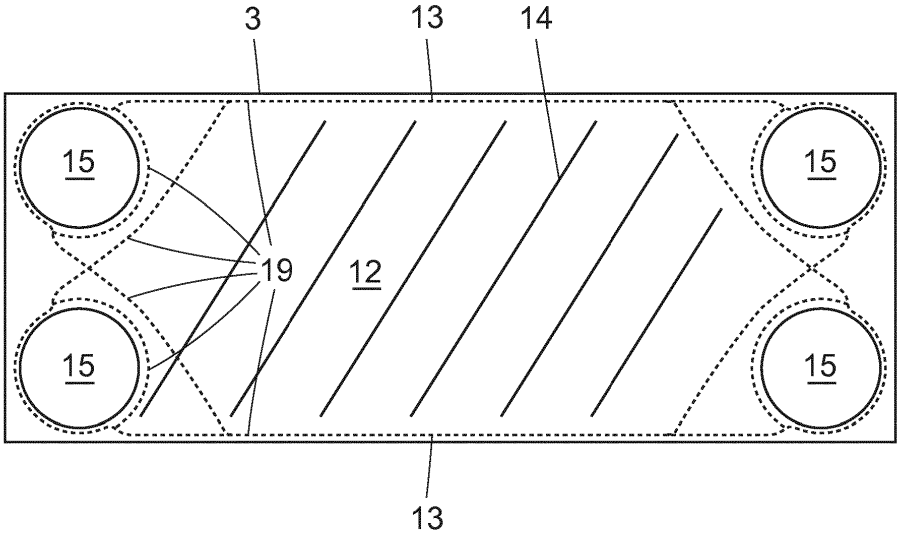

Fig.3

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Description

Technical Field

[0001] The invention relates to a method for producing a plate heat exchanger according to the preamble of claim 1.

[0002] The invention also relates to a plate for a plate heat exchanger and a plate heat exchanger produced according to the method.

Background

[0003] Plate heat exchangers provided with gaskets normally comprise a package of heat exchanger plates arranged adjacent to one another. Gaskets are disposed between the heat exchanger plates, or the plates may also be permanently joined together in pairs to form so-called cassettes, e.g. by welding, with gaskets placed between the respective cassettes. The gaskets are accommodated in gasket grooves formed during the form-pressing of the heat exchanger plates. Plate heat exchangers further comprise inlet and outlet ports, which extend through the plate package, for two or more media.

[0004] Heat exchanger plates are normally made by form-pressing of sheet metal and are disposed in the plate package in such a way as to form first plate intermediate spaces which communicate with the first inlet port and the first outlet port, and second plate intermediate spaces which communicate with the second inlet port and the second outlet port. The first and second plate intermediate spaces are disposed alternately in the plate package.

[0005] A heat exchanger plate for a plate heat exchanger normally includes a heat transfer area and a border area, which is located outside the heat transfer area and which extends along and delimits the heat transfer area. Such a heat exchanger plate further has a number of open portholes. The heat exchanger plates are kept together to a plate package by means of tie bolts.

[0006] The gaskets, which are used between the heat exchanger plates in the plate heat exchanger, are manufactured separately, for instance by compression moulding or injection moulding. The gaskets are usually manufactured in any relatively hard rubber material such as nitrile; EFDM or fluorine rubber. The gasket may be attached to the heat exchanger plate by gluing. The gasket may also include various guide members, for instance so called T-tabs, which extend outwardly from the gasket and which are pressed to attachment in corresponding grooves in the heat exchanger plate.

[0007] The plates of heat exchangers are predominantly made of metal sheets. Depending on the nature of the media that are to be used in the plate heat exchanger the quality of the metal may vary. If highly corrosive media are to be used the requirements on corrosion resistance are high. Today the choice is often between materials which may corrode giving a short life time of the plate heat exchanger with a risk of contaminating the fluid or a heat exchanger made of a more corrosion resistant material, the latter being very expensive in comparison.

[0008] Tantalum is a very corrosion resistant metal towards many fluids and it is known to make heat exchangers of this metal. However, tantalum is an expensive metal and is mechanically considerably weaker than other known materials for use in heat exchangers such as stainless steel. Thus, often thicker plates must be used to withstand the mechanical stress put on a heat exchanger made of tantalum which further adds to the costs.

[0009] One method of lowering the costs and still benefit from the high corrosion resistance properties of tantalum is to apply a layer of a tantalum containing coating on a cheaper base material, such as stainless steel and carbon steel.

[0010] In utility model No DE 8310039 (U1) a plate heat exchanger is described wherein the plates are made of a cheap base material and a covering layer of a corrosion resistant material is applied, such as titanium or tantalum.

[0011] However, a problem encountered with presently known tantalum anticorrosion coatings is the surface roughness which generates micro leakages in the gasket grooves of plate heat exchanger.

Summary

[0012] It is an object of the present invention to provide a plate heat exchanger which, at least partly, eliminate potential limitations of the prior art.

[0013] This object has been achieved by a method for producing a plate heat exchanger according to the preamble of claim 1 characterized in that the average surface roughness of the tantalum containing coating in the gasket groove (19) is decreased in a separate step after the coating of the plate (3) to an Ra- value of < 0.7 μm, preferably < 0.5 μm.

[0014] By this method a more corrosion resistant and leak proof plate heat exchanger is achieved which makes it possible to process highly corrosive media and increase the life time of the heat exchanger. Furthermore, the method may provide corrosion resistant heat exchangers made from cheaper base materials that have good mechanical properties. Due to the method all parts of the heat exchanger, e.g. both plates and joints, which are in contact with a highly corrosive fluid are equally highly corrosion resistant. Further, more fatigue and corrosion resistant internal parts of heat exchangers in contact with highly corrosive fluids are achieved.

[0015] According to one embodiment of the invention the average surface roughness of the tantalum containing coating in the gasket groove is decreased by polishing the gasket groove.

[0016] According to another embodiment of the invention the average surface roughness of the tantalum containing coating in the gasket groove (19) is decreased by

tumbling the plates in a space filled with steel balls.

[0017] According to yet another embodiment of the invention the tantalum containing compound is metal tantalum, tantalum oxide and/or tantalum nitride, preferably metal tantalum and/or tantalum oxide, more preferably metal tantalum.

[0018] The invention also relates to a plate for plate heat exchanger produced according to the method above and to a plate heat exchanger produced according to the method.

[0019] With the present invention simple rigid base materials for heat exchangers, such as stainless steel and carbon steel, may be used and with a tantalum containing coating be made corrosion resistant to highly corrosive fluids and still avoid the previous problems of leakage.

Brief Description of the Drawings

[0020] The invention will now be described in more detail with reference to the appended schematic drawings, in which

Fig. 1 discloses schematically a side view of a plate heat exchanger.

Fig. 2 discloses schematically a plan view of the plate heat exchanger in Fig 1.

Fig. 3 discloses schematically a heat exchanger plate of the plate heat exchanger in Fig 1.

Fig. 4 discloses the heat exchanger plate in Fig 3 with gaskets provided.

Detailed description of Embofiments of the invention

[0021] Figs 1 and 2 disclose a plate heat exchanger 1 comprising a plate package 2 having heat exchanger plates 3 which are provided beside each other. The plate package 2 is provided between two end plates 4 and 5 which may form a frame plate and a pressure plate, respectively. The end plates 4 and 5 are pressed against the plate package 2 and against each other by means of tie bolts 6 which extend through the end plates 4 and 5. The tie bolts 6 comprise threads and the plate package 2 may thus be compressed by screwing nuts 7 on the tie bolts 6 in a manner known per se. In the embodiment disclosed, four tie bolts 6 are indicated. It is to be noted that the number of tie bolts 6 may vary and be different in different applications.

[0022] The plate heat exchanger 1 comprises according to the embodiments described also a first inlet port 8 and a first outlet port 9 for a first medium, and a second inlet port 10 and a second outlet port 1 1 for a second medium. The inlet and outlet ports 8-1 1 extend in the embodiments disclosed through one of the end plates 4 and the plate package 2. The ports 8-11 may be arranged in many different ways and also through the second end plate 5.

[0023] Each heat exchanger plate 3 may be manufactured in a compression- moulded metal sheet, carbon steel, stainless steel, or any other material which is suitable for the intended application.

[0024] Each heat exchanger plate 3 comprises a heat transfer area 12 and an edge area 13, which extends around and outside the heat transfer area 12. The heat transfer area 12 is in the embodiment disclosed substantially centrally located on the heat exchanger plate 3, and in a known manner provided with a corrugation 14 of ridges and valleys. The corrugation 14 is obtained through compression-moulding of the metal sheet. In the embodiment disclosed, the corrugation 14 has merely been indicated schematically as extending obliquely over the heat transfer area 12. It is to be noted that the corrugation 14 also may comprise significantly more complicated extensions of the ridges and valleys, for instance along the fishbone pattern known per se. Also heat exchanger plates 3 having a substantially plane heat transfer area may be used within the scope of this invention.

[0025] Each heat exchanger plate 3 also comprises a number of portholes 15, in the embodiment disclosed four portholes 15, which extend through the heat exchanger plate 3 and are located inside and in the proximity of the edge area 13. The portholes 15 are located in the proximity a respective corner of the heat exchanger plate 3 and are substantially concentric with the above mentioned inlet and outlet ports 8-11 of the plate heat exchanger 1.

[0026] The heat exchanger plates 3 are provided in such a manner in the plate package 2 that first plate interspaces 16, which communicate with the first inlet port 8 and the first outlet port 9, and second plate interspaces 17, which communicate with the second inlet port 10 and the second outlet port 11, are formed, see figs. 1 and 6. The first and second plate interspaces 16 and 17 are provided in an alternating order in the plate package 2.

[0027] Such a separation of the plate interspaces 16, 17 may be achieved by means of one or several gaskets 18, which extend in the gasket grooves 19 which are formed during the compression-moulding of the heat exchanger plates 3. The gasket groove 19 of each heat exchanger plate 3 extends, as can be seen in fig. 3, around the heat transfer area 15 and around each of the portholes 18. At each heat exchanger plate 3 a gasket 18 is, in the embodiments disclosed, provided before the mounting of the plate heat exchanger 1. The gasket 18 extends in a part of the gasket groove 19 in such a way that the gasket 18 encloses the heat transfer area 12 and two of the portholes 15 and also each of the two remaining portholes 15. The gasket 18 thus forms three separate areas which are delimited from each other by means of the gasket 18. It is to be noted that the gasket 18 does not necessarily need to be shaped as one single gasket but may also consist of several different gaskets.

[0028] During the mounting, every second heat exchanger plate 3 may be rotated 180°, for instance around a central normal axis or round a central longitudinal axis. Thereafter the heat exchanger plates 3 are compressed so that the desired first and second plate interspaces are

obtained. In the plate package 2, the first medium may be introduced through the first inlet port 8, through the first plate interspaces 16 and out through the first outlet port 9. The second medium may be introduced through the second inlet port 10, through the second plate interspaces 17 and out through the second outlet port 11. The two media may for instance be conveyed in a counter current flow, as indicated in figs. 2 and 3, or in parallel flow in relation to each other.

[0029] In the embodiments described, the portholes 15 have a cylindrical or substantially circular shape. The portholes 15 may however also have any other suitable regular or irregular shape, for instance an oval shape or a polygonal shape, for instance a triangular, a square, a pentagonal etc. shape suitably with somewhat rounded corners.

[0030] Furthermore, the heat exchanger plate 3 may be used in various plate heat exchanger applications and include fewer or more than the portholes disclosed. Furthermore, the invention is applicable to plate heat exchangers without portholes, wherein the inlet members and the outlet members may connect to different sides of the plate package.

[0031] According to the invention a plate for a plate heat exchanger as described above is coated with a tantalum containing compound preferably metal tantalum, tantalum oxide and/or tantalum nitride, which is applied on the surfaces of the heat exchangers to be in contact with highly corrosive fluid. In a preferred embodiment the tantalum containing compound is metal tantalum and/or tantalum oxide, preferably metal tantalum. If the tantalum coating is made of metal tantalum the uppermost part of the coating is oxidized and thus is tantalum oxide.

[0032] The coating may according to the invention preferably be applied by means of Chemical Vapor Deposition (CVD). A basic CVD process may consist of the following steps: 1) a predefined mix of reactant gases and diluent inert gases are introduced at a specified flow rate into the reaction chamber; 2) the gas species move to the substrate; 3) the reactants get adsorbed on the surface of the substrate; 4) the reactants undergo chemical reactions with the substrate to form the film; and 5) the gaseous by-products of the reactions are desorbed and evacuated from the reaction chamber.

[0033] According to the present invention the tantalum containing coating applied onto the surfaces in at least one of the flow sides designated for being used for highly corrosive fluids has preferably a film thickness of about 1-125 μm, preferably 1-50 μm, more preferably 10-40 μm and even more preferably 15-25 μm.

[0034] Surface finish, also known as surface texture, is the characteristics of a surface. In this context the feature "surface roughness" is used which is a measure of the finely spaced surface irregularities of the tantalum containing coating. Normally, the surface roughness is determined as an average roughness value, Ra, measured in micrometers. A higher Ra-value relates to a high surface roughness which has the disadvantage of creating micro-leakage between the plate and the gasket. Especially when the plates have been coated by means of CVD the surface roughness Ra-value is higher than the surface roughness Ra-value for the clean metal surface before the CVD coating has been applied. As an example, a clean metal surface has an average surface roughness Ra-value of 0.2-0.3 μm. After CVD of a tantalum containing coating the Ra-value may be > 1 μm, and may sometimes even as high as 3μm.

[0035] According to the invention this problem has been solved by polishing, tumbling, or rolling at least the gasket groove (19) of the plates. By such treatment of both the back and front side of the plates (3) and especially the surface of the gasket groove, tighter abutment of the gasket to the surface of the gasket groove is achieved and the problem of micro leakage is decreased.

[0036] The process of tumbling may be achieved by means of steel balls e g in a large box which is shaken or rotated such that the surfaces of the plates are made more even. Polishing may be accomplished by a mild grinding material such as a Scotch Brite® pad.

[0037] The invention is not limited to the described embodiments but may be varied and modified within the scope of the following claims.

Claims

1. Method for producing a plate heat exchanger (1) comprising a plurality of heat exchanger plates (3), wherein the heat exchanger plates (3) are provided adjacent each other and form a plate package (2) with first plate interspaces (16) for a first medium and second plate interspaces (17) for a second medium, wherein each of the heat exchanger plates comprises
   portholes (15) which form ports (8, 9, 10, 11) extending through the plate package (2),
   a heat transfer area (12),
   an edge area (13) extending outside the heat transfer area (12) and the ports (8, 9, 10, 11),
   a gasket groove (19) extending in the edge area (13) outside the heat transfer area (12) and the ports (8, 9, 10, 11),
   and wherein a gasket (18) is provided in the gasket groove (19) for tight abutment against an adjacent plate (3) in the plate heat exchanger (1), the heat exchanger plates (3) being at least partly coated with a tantalum containing coating,
   characterized in that
   the average surface roughness of the tantalum containing coating in the gasket groove (19) is decreased in a separate step after the coating of the plate (3) to an Ra-value of < 0.7 μm, preferably < 0.5 μm.

2. Method for producing a plate heat exchanger (1) according to claim 1,

c h a r a c t e r i z e d in that the average surface roughness of the tantalum containing coating in the gasket groove (19) is decreased by polishing the gasket groove.

3. Method for producing a plate heat exchanger according to claim 1,
characterized in that the average surface roughness of the tantalum containing coating in the gasket groove (19) is decreased by tumbling the plates in a space filled with steel balls.

4. Method for producing a plate heat exchanger according to any one of claims 1-3, **characterized in that** the tantalum containing compound is metal tantalum, tantalum oxide and/or tantalum nitride, preferably metal tantalum and/or tantalum oxide, more preferably metal tantalum.

5. A plate for a plate heat exchanger produced according to the method of any one of claims 1-4.

6. A plate for a plate heat exchanger according to claim 5,
characterized in that the average surface roughness of the tantalum containing coating in the gasket groove has an Ra- value of < 0.7 μm, preferably < 0.5 μm.

7. A plate heat exchanger produced according to the method of any one of claims 1-4.

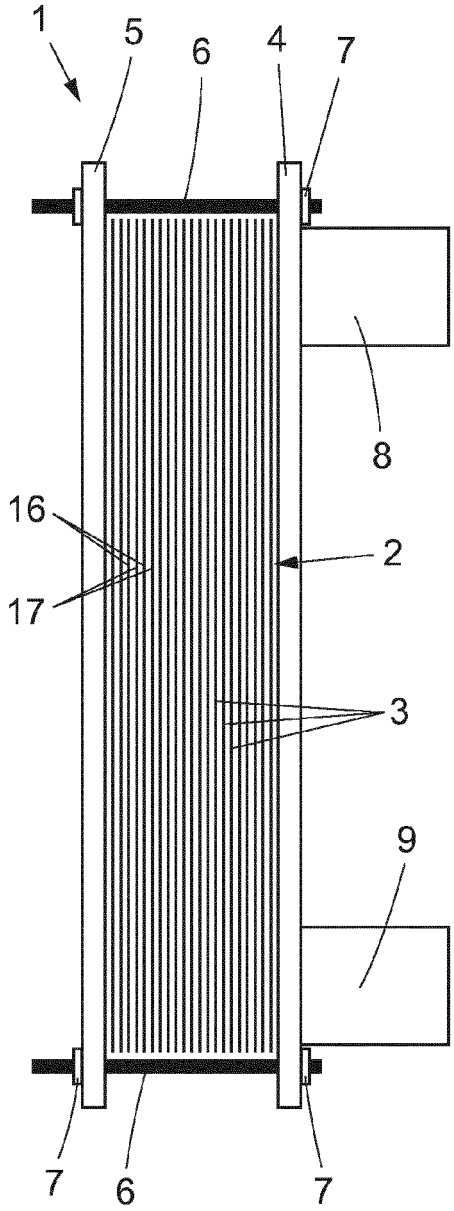

Fig.1

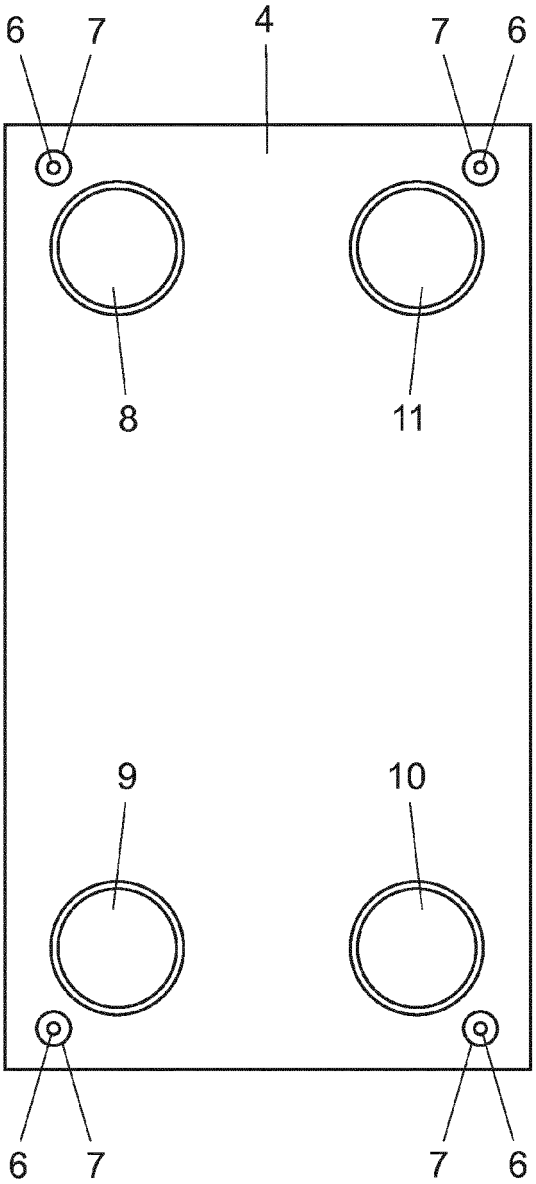

Fig.2

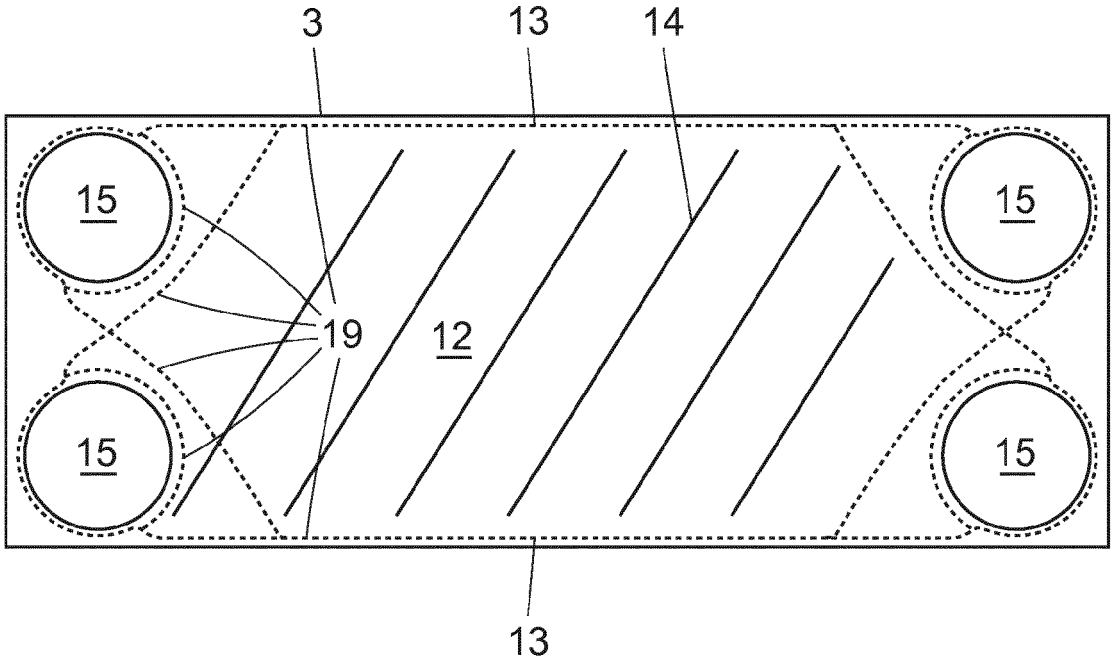

Fig.3

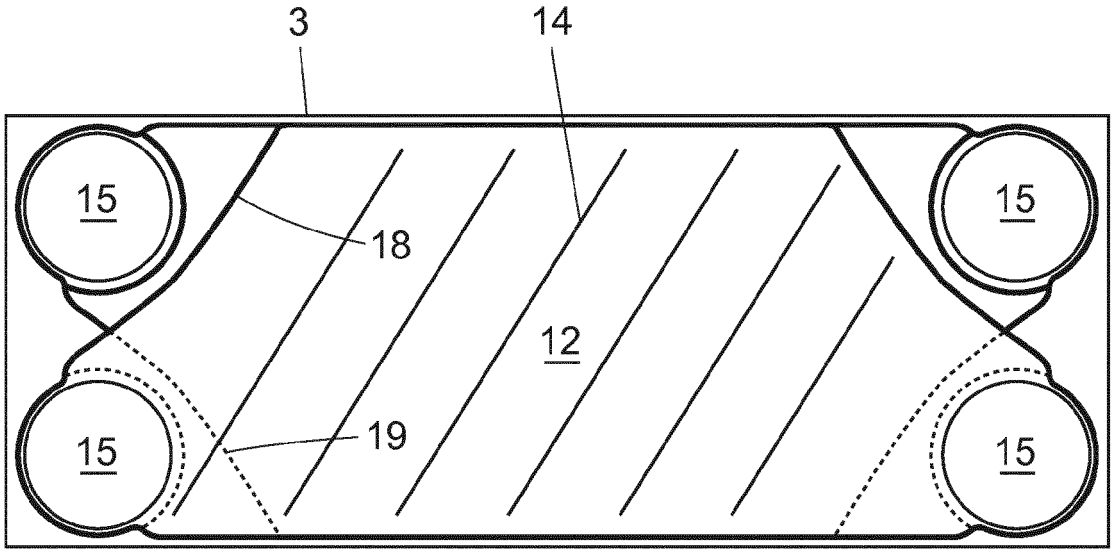

Fig.4

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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 7173

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	WO 2011/159238 A2 (ALFA LAVAL CORP AB [SE]; NILSSON MATS [SE]; NILSSON MARIBEL [SE]; BERG) 22 December 2011 (2011-12-22) * page 4, line 20 - page 5, line 20 * * page 6, line 6 - line 19 *	1-7	INV. F28F3/10 F28F19/02
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A	EP 2 042 789 A1 (KOMATSU MFG CO LTD [JP]) 1 April 2009 (2009-04-01) * paragraph [0046] - paragraph [0047]; figures 5,6 *	1	
			TECHNICAL FIELDS SEARCHED (IPC) F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 June 2014	Mendão, João

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 19 7173

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

REFERENCES CITED IN THE DESCRIPTION

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