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(54) **MULTI-PASS HEAT EXCHANGER**

(57) The present invention relates to a plate heat exchanger formed of a plate stack of patterned heat transfer plates arranged on top of each other and positioned within a shell and defining a first flow path and a second flow path between the plates. Outer distribution chambers are formed in the space between the other edges of the heat

transfer plates and the inside wall of the shell being in fluid communication to the first flow path and first flow connections. The present invention introduces a baffle adjustable positioned in an outer distribution chamber separating it into two outer sub-chambers forming a flow barrier.

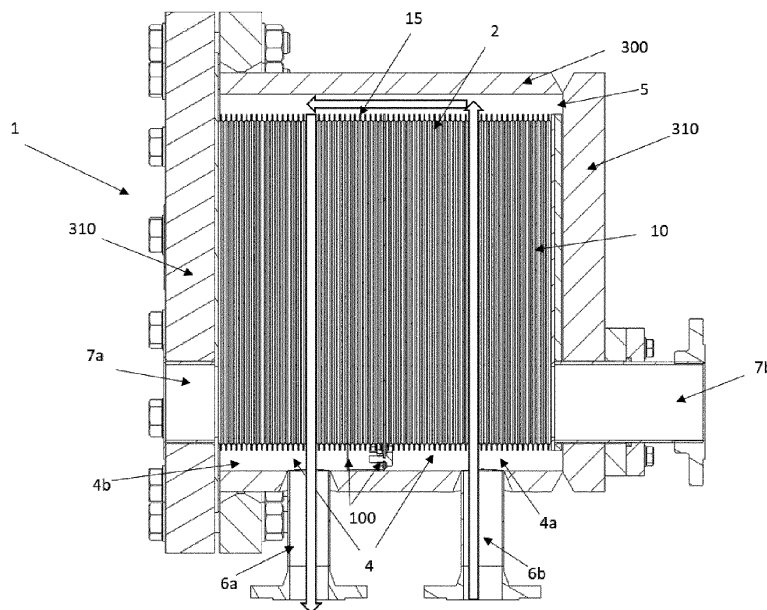


Fig. 1

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Description

BACKGROUND

[0001] The present invention relates to a plate heat exchanger and a method for constructing multiple passes in the plate heat exchanger. Such plate and shell type often are constructed by of a stack of patterned heat transfer plates positioned inside a shell. The heat transfer plates may have been welded or brazed tightly together at the circumference of openings formed therein and at their perimeters. This together with the patterns formed in the heat transfer plates defines a first flow path between connections of the shell surrounding the plate pack and a second flow path between the openings in the plates. This enables a heat exchange medium to flow in the first flow path formed at the one side of the heat transfer plates in fluid connection to the plate perimeter, and in second side of the heat transfer plates in fluid connection to the openings.

[0002] It has been found that the performance of the heat exchanger can be improved by forming a multi-pass heat exchanger where the heat exchange mediums pass each other several times. This can be implemented by including baffles, or stoppers, diverging the medium back and forth across the plate pack a plural of times.

[0003] If the baffles are welded into the heat exchanger, this disables later changes of the heat exchanger configuration, such as if the requirements change, or simply to adjust to optimize the heat exchanger.

[0004] Further, since the shells often not are fully circular, but may be slightly oval, it is essential forming an adjustable baffle able to be tightly fitted against an uneven or un-circular shell wall. For example, if the shell is oval, it would be an advantage if the baffle can be adjusted to fit at any position within the shell.

[0005] It is therefore an object of the present invention to introduce a heat exchange where the configuration is adjustable and even exchangeable.

SUMMARY OF THE INVENTION

[0006] The problems are solved as it is indicated in the claim section.

[0007] This includes to introduce a plate heat exchanger, which comprises - a plate stack of patterned heat transfer plates arranged on top of each other and positioned within a shell and defining a first flow path and a second flow path between the plates, where outer distribution chambers are formed in the space between the other edges of the heat transfer plates and the inside wall of the shell being in fluid communication to the first flow path and first port connections, where a baffle is positioned adjustable in an outer distribution chamber separating it into two outer sub-chambers forming a flow barrier.

[0008] In an embodiment the term 'adjustable' refers to the baffle being positioned in a manner where it is not

fixed unremovable in the position, but fixed in a detachable, or removable, manner, thus allowing it to be removed and possible positioned differently. This makes a more flexible heat exchanger, where one or more baffles may be inserted or removed at any time, either during production or on site.

[0009] In an alternative or additional embodiment, the term 'adjustable' refers to the baffle being flexible in such a manner that by pushing it against the inner surface of the external distribution chamber, then it adapts the curvature of said inner surface.

[0010] In one embodiment the baffle is adjustable in the manner it can be connected to any of a plural of either said heat transfer plates, or additionally or alternatively, to sealing plate(s) positioned between any of the heat transfer plates. In the following the term 'plate' refers in common to either a heat transfer plate or sealing plate.

[0011] The baffle may be connected to said plate by detachable fastening means, being a separate device being inserted. Alternatively, it is integrated in the baffle, or as part of the possible specialized plates.

[0012] The adjustable connection may imply that the baffle is detachably connected to a plate.

[0013] The baffle may be positioned with a first part in contact only to said heat transfer plate through the fastening means positioned between said first part and the rim of the plate.

[0014] The fastening means may comprise or act on biasing means pushing the baffle against the inner surface of the shell. In this manner the positioning is done possible by fixing the baffle to the plate(s) and at the same time stabilizing it by squeezing it between the plate(s) and inner surface of the shell.

[0015] The first part may be formed with a plural of flexible flaps forming biasing means, which when bend pushes the baffle against the inner surface of the shell when being bend slightly.

[0016] The baffle may comprise a second part connected to the first part, said second part being positioned against the inner surface of the shell and being flexible to allow it to adapt to the inner shell surface curvature.

[0017] The baffle may comprise a third part connected to the surface of the rim of said plate reaching into the space of said outer distribution chamber forming part of the flow barrier. The said third part may be connected to said first part.

[0018] A fourth part may be sandwiched between said first part and said third part.

[0019] The first port connections and baffle may be positioned in the same of a first or a second of said outer distribution chambers, where said baffle is positioned between a first and second of said first port connections.

[0020] In an embodiment at least one baffle is positioned in said first outer distribution chamber, and at least one baffle is positioned in said second of the outer distribution chamber.

[0021] The present invention further relates to a method to assemble a baffle in a plate heat exchanger com-

prising - a plate stack of patterned heat exchange plates arranged on top of each other and positioned within a shell and defining a first flow path and a second flow path between the plates, where outer distribution chambers are formed in the space between the other edges of the heat transfer plates and the inside wall of the shell being in fluid communication to the first flow path and first port connections, said method including to position said baffle in an outer distribution chamber separating it into two outer sub-chambers forming a flow barrier between said two outer sub-chambers, and fixing it detachable and adjustable by activating fastening means pushing the baffle against the inner surface of the shell.

[0022] The fastening means may comprise or act on biasing means pushing the baffle against the inner surface of the shell.

[0023] The method may be used on a heat exchanger according to any of the embodiment.

FIGURES

[0024]

- Fig. 1 Side view of multi-pass shell kind heat exchanger according to an embodiment of the present invention
- Fig. 2 Side view of the connected rims of a section of the stacked heat transfer plates.
- Fig. 3 Top view of a heat transfer plate in the shell and connected to a baffle according to an embodiment of the present invention.
- Fig. 4 Baffle to be connected to a heat transfer plate according to a first embodiment.
- Fig. 5 Baffle connected to a heat transfer plate according to a first embodiment.
- Fig. 6 Baffle to be connected to a heat transfer plate according to a second embodiment.
- Fig. 7 Baffle connected to a heat transfer plate according to a second embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0025] It should be understood, that the detailed description and specific examples, while indicating embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from the detailed description.

[0026] Fig 1 illustrate an embodiment of a shell type heat exchanger (1), where plural of patterned heat transfer plates (10) are arranged on top of each other to form a plate stack (2). The plate stack (2) is positioned within

a shell (300) which may be a tube e.g. with circular cross area section, the heat transfer plates (10) possible being circular accordingly, as illustrated in e.g. fig. 3.

[0027] End covers (310) then may be connected to the open ends of the shell (300) to fully enclose the plate stack (2) in a sealed manner within.

[0028] When connected, by the patterns of the heat transfer plates (10) respectively a first flow path is formed at between the one side and its connected neighbouring heat transfer plate (10), and a second flow path is formed at between the second side and its connected neighbouring heat transfer plate (10).

[0029] The heat transfer plates (10) comprises openings (11) and is at the one side connected to the rim of openings (11), e.g. by brazing or welding. The first fluid to flow in the first flow path then enters and leaves at the rim of the heat transfer plates (10).

[0030] At the second side the heat transfer plates (10) is connected at their rim (15) e.g. by brazing or welding.

The second fluid to flow in the second flow path then enters and leaves through the openings (11). Together the openings (11) of the connected heat transfer plates (10) defines inner inlet and outlet distribution chambers for the individual flow paths

[0031] First port connections (6a, 6b) may be formed in the shell (300) and/or the end covers (310) forming connection to e.g. external flow pipe systems and acting as fluid inlet and outlet for the outer distribution chambers (4, 5) and thus the first flow path

[0032] Second port connections (7a, 7b) may be formed in the shell (300) and/or the end covers (310) forming connection to e.g. external flow pipe systems and acting as fluid inlet and outlet for the inner distribution chambers and thus the second flow path

[0033] It has been found that the performance of the heat exchanger can be improved by forming a multi-pass heat exchanger where the heat exchange mediums pass each other several times. This can be implemented by including baffles, or stoppers, diverging the medium back and forth across the plate pack a plural of times. The number of passes depend on the number, and positioning, of baffles. For this it is an advantage if the baffle forms tight barriers, even when the basic shape of the baffle (100) does not match the inner wall shape of the shell (100).

[0034] The present invention introduces a baffle (100) being positioned in an outer distribution chamber (4, 5) separating it into two outer sub-chambers (4a, 4b) forming a flow barrier between said outer sub-chambers (4a, 4b). The illustration in fig. 1 shows the simplest embodiment with one baffle (100) positioned in a first outer distribution chamber (4), and that both first port connections (6a, 6b) are positioned in fluid communication with the same first outer distribution chamber (4). Fluid entering in inlet (6a) is distributed in the first outer sub-chamber (4a) to all the connected first flow paths formed between the heat transfer plates (10). By the first flow paths the fluid is flows to second outer distribution chamber (5)

where it is distributed to the remaining of the first flow paths being connected to the second outer sub-chambers (4b). Finally, the flow reaches the second outer sub-chamber (4b) before leaving by outlet (6b). This is illustrated by the white arrows.

[0035] This one baffle (100) thus enables two passes of the fluid flow. In this embodiment the first port connections (6a, 6b) and baffle (100) are positioned in the same of a first (4) or a second (5) of said outer distribution chambers, where said baffle (100) is positioned between a first (6a) and second (6b) of said first port connections.

[0036] A third path could be introduced by adding a baffle (100) in the second outer distribution chamber (5) to the one illustrated in fig. 1, thus splitting this to two outer sub-chambers too, and move the outlet port connection (6b) to connect to the second outer distribution chamber (5).

[0037] Any such number of passes in principle can be introduced by adding baffles (100) and to position the inlet and outlet port connections (6a, 6b) accordingly.

[0038] If a baffle (100) however e.g. is welded or brazed into the heat exchanger (1), it would be difficult to be adjusted or changed.

[0039] The present invention therefore introduces the baffle (100) being adjustable and detachable in the manner it e.g. can be connected to any of a plural of said heat exchanger plates (10), or at any position between these, are easy to remove, but by adjustable is also meant that they can be made to fit tightly against the inner shell (300) wall.

[0040] This offers a wide range of advantages. Firstly, it eases the production of heat exchanger as standard components can be used, just adding the number of baffles (100) according to the requirements. Secondly, it would be easy later to update the heat exchanger (1) by adding or removing baffles (100). In one embodiment the first port connections (6a, 6b) are positioned in one or both of the end covers (310) otherwise being symmetric, and the external distribution chambers (4, 5) are positioned symmetric in the shell (300). Then the connection of e.g. the outlet first port connection (6b) simply can be changed between the first (4) and second (5) outer distribution chambers by rotating the respective end cover (310).

[0041] Fig. 2 is an enlarged view of the rim (15) section area of the connected heat transfer plates (10), the shell (300) and baffle (100) in the illustrated embodiment being connected to a sealing plate (20), such as to its rim (25). Alternatively, the baffle (100) could be connected to the rim(s) (15) of heat transfer plate(s) (10). The sealing plate (20) in the embodiment reaches further into the respective external distribution chamber (4, 5) than the heat transfer plates (10). Alternatively, the sealing plate (20) rim (25) is aligned with the heat transfer plate (10) rims (15) or may even reach lesser into the external distribution chamber (4, 5) than these. The sealing plate (20) may be substantially thicker than the heat transfer plates (10), as illustrated, and may e.g. be without patterns. Al-

ternatively, the sealing plate (20) is simply a heat transfer plate (20), or even a pair of heat transfer plates (10, 20) connected at their rims (15, 25) reaching further out than the other heat transfer plates (10). The sealing plate (20) then as such forms part of the barrier.

[0042] In this embodiment the sealing plate (20) may be inserted in a removable manner between any of the heat transfer plates (10).

[0043] Fig. 3 is a top view showing a heat transfer plate (10), or alternatively a sealing plate (20), inside the shell (300). Side sealings (350) is positioned to separate the space between the edges of the heat transfer plates (10) and the inner surface of the shell (300) separating the space into the first (4) and second (5) outer distribution chambers.

[0044] A baffle (100) is seen to be positioned in the first outer distribution chamber (4) fixed in position by fastening means (150).

[0045] Fig. 4 illustrates one such embodiment of an attachable and detachable baffle (100) to be positioned in connection to a heat transfer plate (10). In the illustrated embodiment the baffle (100) is seen to be positioned with a first part (105) in contact to said plate (10, 20), either directly such as on its rim (15, 25), or as illustrated contacting the rim (15, 25) only through the fastening means (150). In this latter embodiment the fastening means (150) is positioned between said first part (105) and the rim (15, 25) of the plate (10, 20). In the following 'plate' refers to be any of a heat transfer plate (10) or sealing plate (20).

[0046] In either embodiment it may be an advantage when the baffle (100) is pushed against the inner surface of the shell (300) to stabilize its positioning in the distribution chambers (4, 5) under the influence of the forces of the fluid flow. The one side of the baffle (100) being connected directly to the rim (15, 25) of the plate (10, 20) or indirectly through the fastening means (150), the other side being held in position by a pushing force and friction.

[0047] To enable such a pushing force the biasing means (130) may be introduced pushing the baffle (100) against the inner surface of the shell (300) when the fastening means (150) are activated. The biasing means (130) could be part of the fastening means (150), or as illustrated integrated in the baffle (150), or being separately inserted. In the illustrated embodiment the biasing means (130) are formed as a plural of flexible flaps (130) in the first part (105), such as formed by cuts. The flaps (130) comprise some elasticity such that when bend by a force, the flaps (130) push back with the same force. In the illustrated embodiment this effect is utilized by introducing fastening means (150) formed as a shaped bolt between one or more flaps (130) and the plate (10, 20) rim (15, 25). At the one side the fastening means (150) comprises a first feature (155) positioned on a first rim (15, 25) surface, such as a nut connected at the one end of a specially formed bolt (160) of the fastening means (150). The bolt (160) is shaped such that in one position of rotation seen it forms a first diameter seen in the distance

between the plate (10, 20) end and the inner surface of the shell (300), whereas in a second rotation it forms a second diameter larger than the first diameter. The first position of rotation thus enables the insertion, and removal, of the baffle (100) and fastening means (150), and when rotation to the second position the larger diameter pushes to the flaps (130) to push the baffle (100) against the inner surface of the shell (300).

[0048] The fastening means (150) may at the opposite side relative to the first feature (155) comprise a second feature (165) contacting a second rim (15, 25) surface. The first and second rim (15, 25) surfaces may be the respective outer rim surfaces (15, 25) of plates (10, 20) connected at their rim (15, 25). The first feature (155) and second feature (165) in addition contacts and end of the first part (105) from both sides (e.g. the end of the contacted flap(s) (30)), thus fixing the baffle (100) and fastening means (150) to the rim (15, 25) of the plate(s) (10, 20).

[0049] In one embodiment a winding connection of e.g. the bolt (160) to the first feature (155), e.g. a nut, ensures that the rotation reduces the distance between first feature (155) and second feature (165) to tighten the fixation.

[0050] The baffle (100), such as the first part (105), may also comprise flexible openings for the introduction of the fastening means (150). These may be normally closed, but to be opened for the insertion of the fastening means (150). These flexible openings may simply be the biasing means (130), such as the illustrated flaps (130) allowing to bend.

[0051] In one different embodiment the fastening means (150), such as a bolt, does not show a first and second diameter, but simply activates by being inserted through the flexible openings. In the illustrated embodiment the flaps (130) may operate as flexible openings allowing the insertion of the fastening means (150) which bends the flaps (130).

[0052] In one embodiment the first part (105) is not positioned at a distance to the plates (10, 20) but is positioned and fixed to a rim (15, 25) surface according to any embodiment.

[0053] In any of the embodiments the width of the baffle (100), or at least the first part (105), is such that the baffle (100) and fastening means (150) fits relatively loosely in the distribution chambers (4, 5) easing its insertion, or removal. The fixation then is done by activating the fastening means (150), such as in the disclosed embodiments.

[0054] The baffle (100) in the embodiment as illustrated in fig. 4 further includes a second part (110) connected to the first part (105) being positioned against the inner surface of the shell (300). This adds to the stability of the baffle (100) as well as increases the connection and thus the friction of the baffle (100) against the inner surface of the shell (300).

[0055] The second part (110) may be formed to match some average curvature of the inner surface of the shell

(300). It further may be flexible such that its curvature can change. In this situation, when the fastening means (150) acts on the first part (105), this and the second part (110) is pushed against the inner surface of the shell (300), where the flexibility ensures at least the second part (110) adapting to the shape of the shell (300) inner surface. The second part (110) then by the flexibility forms a first part of the flow barrier sealing the baffle (100) towards the shell (300).

[0056] In the illustrated embodiment with cuts in the first part (105) forming the flaps (130) ensures enough flexibility of the first part (105), allowing this to follow the adaptation of the second part (110). Alternatively, the first part (105) could be made of a flexible material, e.g. a material being elastic.

[0057] In the illustrated embodiment the baffle (100) further includes to a third part (115) reaching into the space of said outer distribution chamber (4, 5) forming a second part of the flow barrier. The third part (115) is in a sealing manner attached a plate (10, 20) rim (15, 25) preventing fluid flow from passing the baffle (100) in this section. In the illustrated embodiment two third parts (115) is introduced sandwiching the rim (15, 25), first part (105) and a fourth part (120) of the baffle (100).

[0058] The fourth part (120) is a sealing positioned between the first part (105) and a second part (115) preventing fluid passing through this connection.

[0059] In an embodiment the third part (115) and second part (120) may comprise recesses or openings allowing the insertion of the fastening means (150). In this embodiment the fastening means (150) themselves then form part of the barrier forming sealings of the openings or recesses when inserted.

[0060] Fig. 5 shows a top view of the first part (105) connected to the heat transfer plate (10) by fastening means (150) bending one or more of the biasing means (130), or flaps.

[0061] The present invention also relates to a method to assemble a baffle (100) in a shell heat exchanger (1), said method including to position said baffle (100) in an outer distribution chamber (4, 5) separating it into two outer sub-chambers (4a, 4b) forming a flow barrier between said two outer sub-chambers (4a, 4b), and fixing it detachable by activating fastening means (150) pushing the baffle (100) against the inner surface of the shell (300) when activated.

[0062] Fig. 6 illustrates another embodiment of an attachable and detachable baffle (100') operating as the embodiment of e.g. figs. 2 and 4, but where the second part (110') is adapted push the baffle (100') against the inner surface of the shell (300'), instead of the fastening means (150). The second part (110') in an embodiment operates as a spring element biased in an outward direction. At least sections of the second part (110') may be biased to reach further out than the extension of the inner of the shell (300'). In this case, the sections are biased such that they are being bend inwards by the inner surface of the shell (300') when inserted. In the embod-

iment of fig. 6 the whole circumference of the second part (110') extends with a larger diameter than the diameter of the inner surface of the shell (300'), and is formed as flaps bend relative to the first part (105') with an angle higher than 90 degree, such when inserted the flaps are deformed inwards pushing against the inner surface of the shell (300').

[0063] In this embodiment the first part (105') may or may not be formed with flaps (130').

[0064] Two such elements comprising a first part (105') and second part (110') may be inserted at each side of the fourth part (120'), each possible sandwiched between the fourth part (120'), the sealing part, and third parts (115').

[0065] As seen in fig. 7, where the inserted baffle (100') is seen from the side, the two second parts (110') touch at least when inserted cooperating to fix the baffle (100') within the shell.

[0066] are not adapted to push the baffle (100) against the inner surface of the shell (300) when the fastening means (150) are activated. In this embodiment the second part (110) is formed flaps (130), but the second part (110) is

Claims

1. A plate heat exchanger (1), which comprises

- a plate stack (2) of patterned heat transfer plates (10) arranged on top of each other and positioned within a shell (300) and defining a first flow path and a second flow path between the plates, where outer distribution chambers (4, 5) are formed in the space between the other edges (15) of the heat transfer plates (10) and the inside wall of the shell (3) being in fluid communication to the first flow path and first port connections (6a, 6b), **characterized in that** a baffle (100) is positioned adjustable in an outer distribution chamber (4, 5) separating it into two outer sub-chambers (4a, 4b, 5a, 5b) forming a flow barrier.

2. A plate heat exchanger (1) according to claim 1, wherein the baffle (100) is adjustable in the manner it can be connected to plates (10, 20) inserted between any of the heat transfer plates (10).

3. A plate heat exchanger (1) according to claim 1 or 2, wherein the baffle (100) is adjustable in the manner it can be connected a sealing plate (20) positioned between two heat transfer plates (10) and reaching further into the respective external distribution chamber (4, 5) than the heat transfer plates (10)

4. A plate heat exchanger (1) according to claim 2 or 3, wherein the baffle (100) is connected to said plate

(10, 20) by detachable fastening means (150).

5. A plate heat exchanger (1) according to claim 2, 3 or 4, wherein the baffle (100) is detachably connected to said plate (10, 20).

6. A plate heat exchanger (1) according to according to any of claims 1-5, wherein the baffle (100) is positioned with a first part (105) in contact only to said plate (10, 20) through the fastening means (150) positioned between said first part (105) and the rim (15, 25) of the plate (10, 20).

7. A plate heat exchanger (1) according to claim 5, wherein the fastening means (150) comprises or acts on biasing means (130) pushing the baffle (100) against the inner surface of the shell (300).

8. A plate heat exchanger (1) according any of claims 6-8, wherein the first part (105) is formed with a plural of flexible flaps (130) forming biasing means when bend pushing the baffle (100) against the inner surface of the shell (300).

9. A plate heat exchanger (1) according any of claims 6-9 wherein the baffle (100) comprises a second part (110) connected to the first part (105), said second part (110) being positioned against the inner surface of the shell (300) and being flexible to allow it to adapt to the inner shell (300) surface curvature.

10. A plate heat exchanger (1) according to any of the previous claims, wherein the baffle (100) comprises a third part (115) connected to the surface of the rim (15, 25) of said plate (10, 20) reaching into the space of said outer distribution chamber (4, 5) forming part of the flow barrier.

11. A plate heat exchanger (1) according claim 10, wherein said third part (115) further is connected to said first part (105).

12. A plate heat exchanger (1) according to claim 11, wherein a fourth part (120) is sandwiched between said first part (105) and said third part (115).

13. A plate heat exchanger (1) according to claim 5, wherein the second part (110') operates as a spring element biased in an outward direction.

14. A plate heat exchanger (1) according any of the previous claims, wherein the first port connections (6a, 6b) and baffle (100) are positioned in the same of a first (4) or a second (5) of said outer distribution chambers, where said baffle (100) is positioned between a first (6a) and second (6b) of said first port connections.

15. A plate heat exchanger (1) according to claim 13, wherein at least one baffle (100) is positioned in said first outer distribution chamber, and at least one baffle (100) is positioned in said second (5) of the outer distribution chamber (5). 5
16. Method to assemble a baffle (100) in a plate heat exchanger (1) comprising
- a plate stack (2) of patterned heat exchange plates (10) arranged on top of each other and positioned within a shell (300) and defining a first flow path and a second flow path between the plates, where outer distribution chambers (4, 5) are formed in the space between the other edges (15) of the heat transfer plates (10) and the inside wall of the shell (300) being in fluid communication to the first flow path and first port connections (6a, 6b), said method including to position said baffle (100) in an outer distribution chamber (4, 5) separating it into two outer sub-chambers (4a, 4b, 5a, 5b) forming a flow barrier between said two outer sub-chambers, and fixing it detachable and adjustable by activating fastening means (150) pushing the baffle (100) against the inner surface of the shell (300). 10
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17. Method according to claim 15, wherein the fastening means (150) comprises or acts on biasing means (130) pushing the baffle (100) against the inner surface of the shell (300). 30
18. Method according to claim 15 or 16 used on a heat exchanger according to any of the claims 2-14. 35

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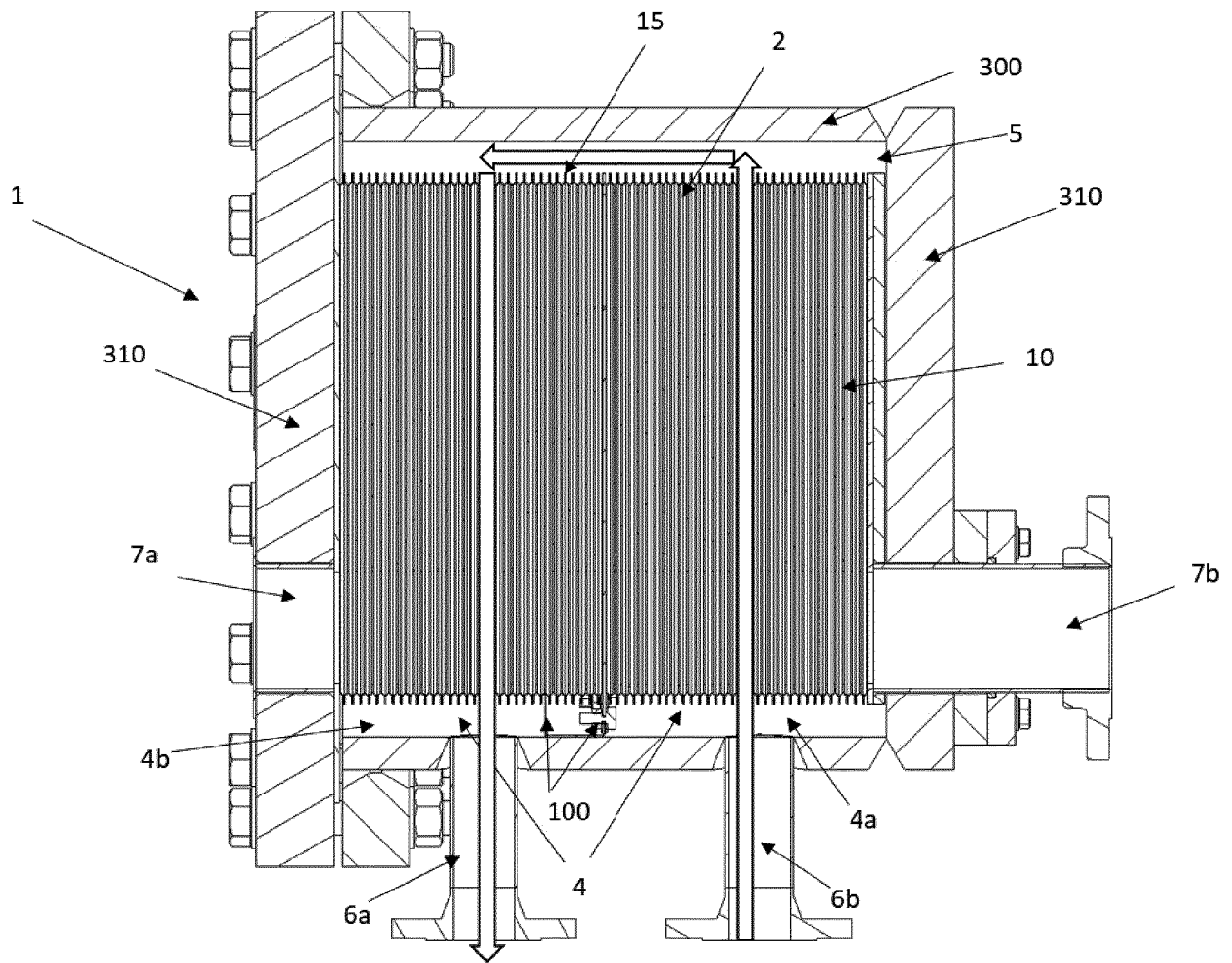


Fig. 1

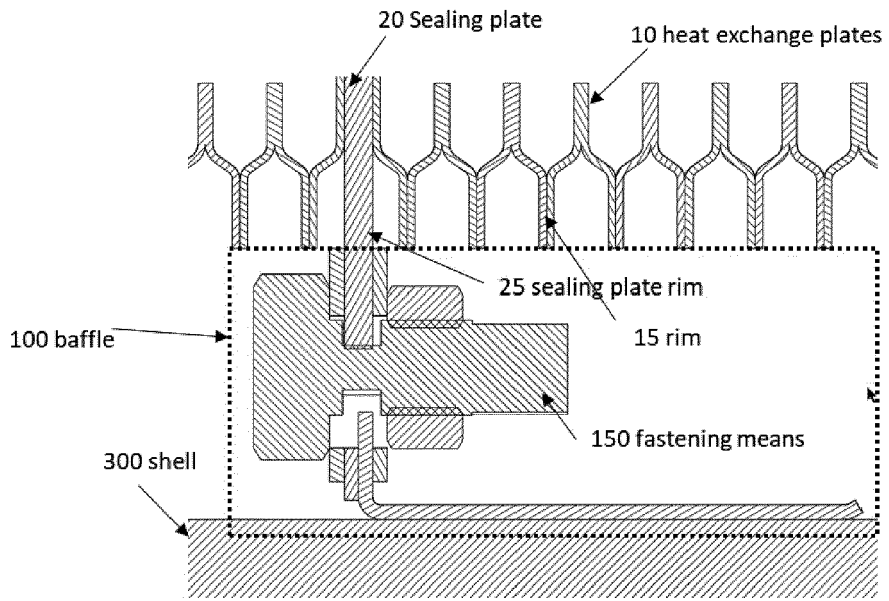


Fig. 2

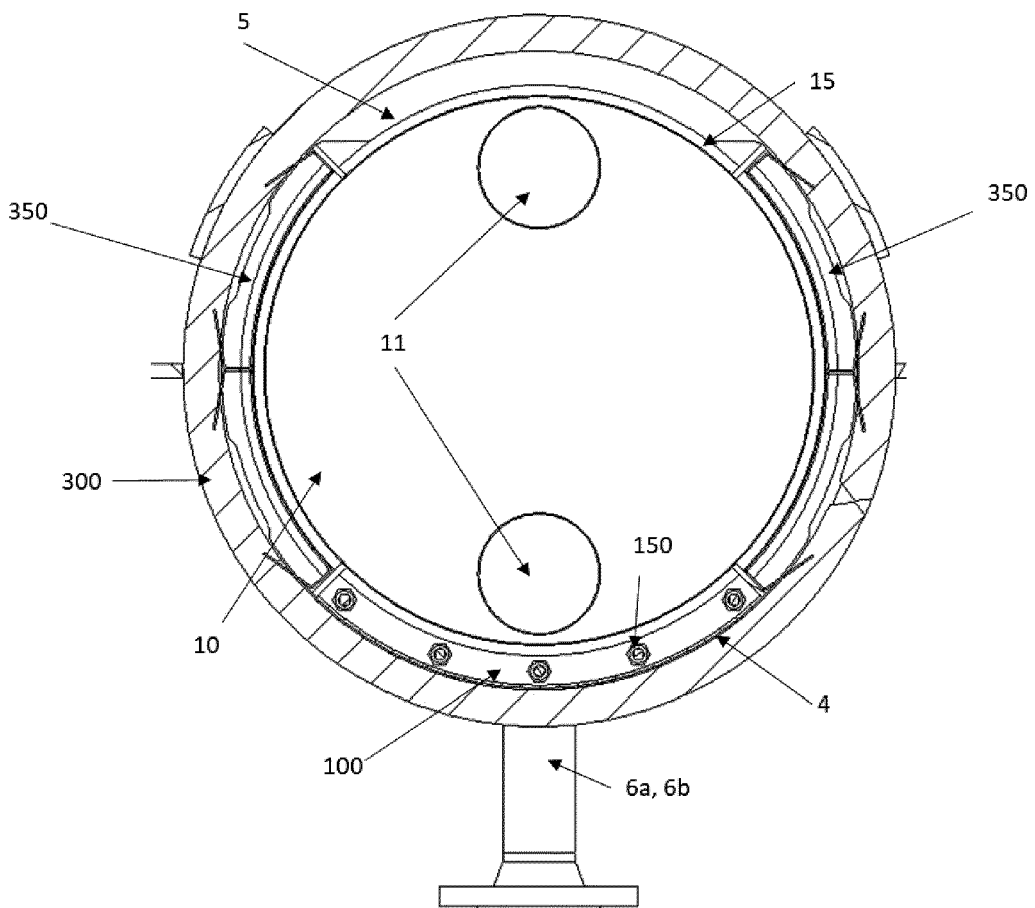


Fig. 3

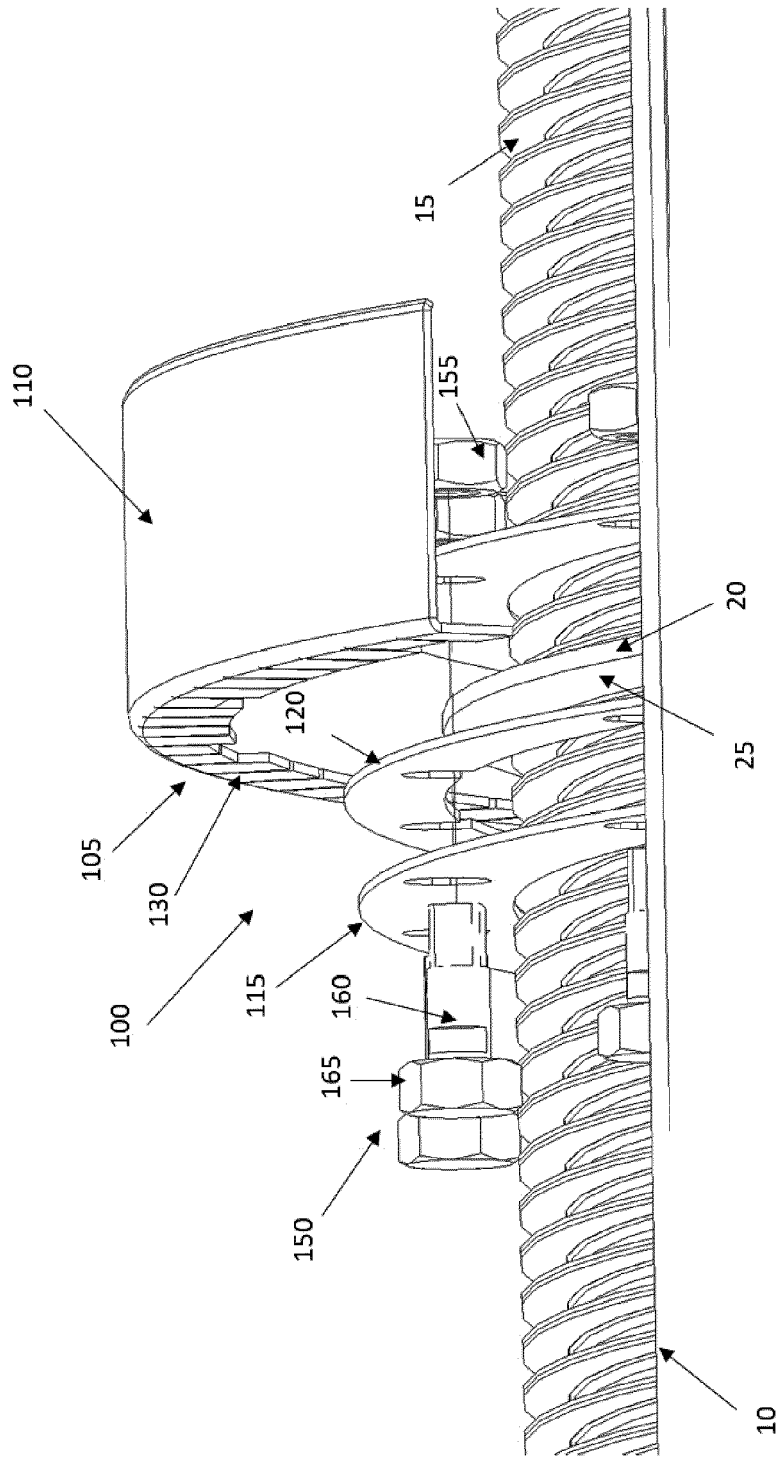


Fig. 4

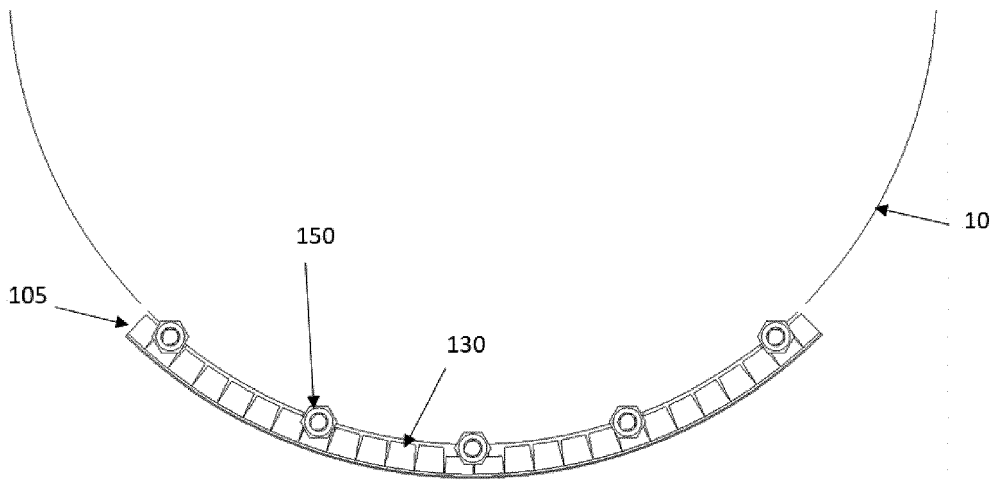


Fig. 5

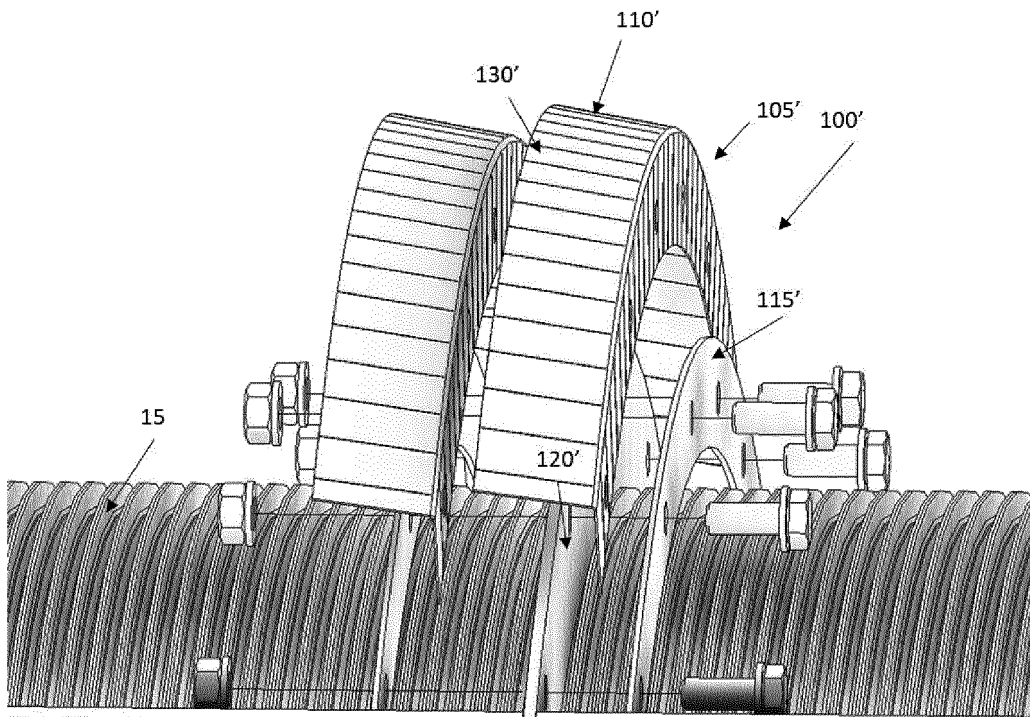


Fig. 6

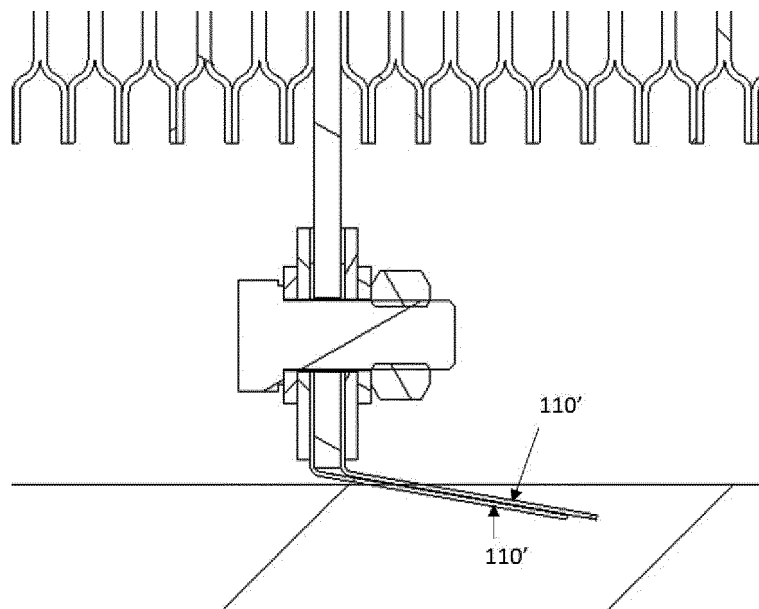


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 January 2021	Examiner Bain, David
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