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(54) **PLATE HEAT EXCHANGER**

(57) A plate heat exchanger comprising a casing (2) that has a shell (3), a top cover (4) and a bottom cover (5) that are joined to form an enclosure (14), a stack (20) of heat transfer plates is arranged within the enclosure (14), the heat transfer plates having openings in form of through holes in the heat transfer plates, the openings forming a space (24) in the plate stack (20) in which a first fluid (F1) flows, wherein a reinforcement element (50) extends through the openings in the heat transfer plates and is connected to each of the top cover (4) and the bottom cover (5) for supporting the covers (4, 5) when the plate heat exchanger is subjected to a pressure from any of the first fluid (F1) and a second fluid (F2) that flows through the plate heat exchanger.

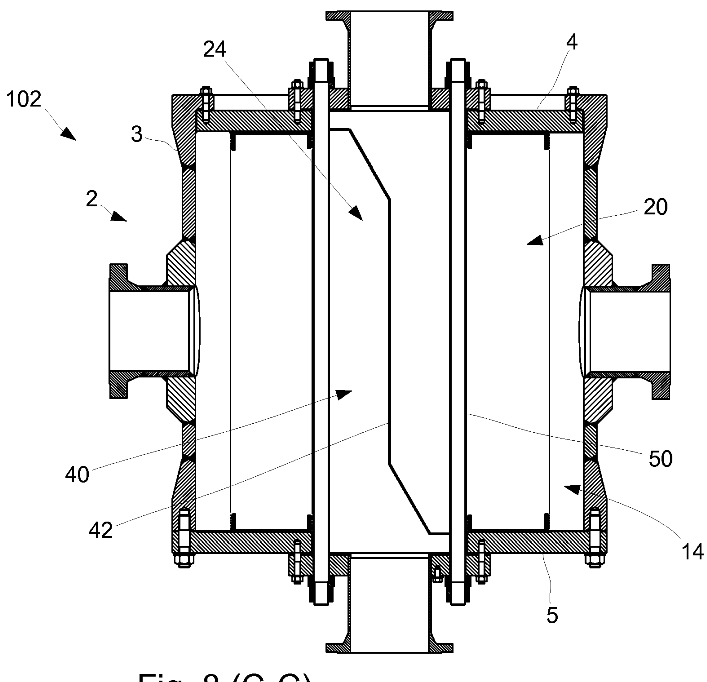

Fig. 8 (C-C)

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Description

Technical Field

[0001] The invention relates to a plate heat exchanger that has a casing in form of a shell, a top cover and a bottom cover that are joined to form an enclosure in which a stack of heat transfer plates is arranged. The heat transfer plates have openings in form of through holes in the heat transfer plates, and the openings form a space in the plate stack in which a first fluid flows. The plates have first sections that act as fluid entries for the second fluid, and second sections that are opposite the first sections and act as fluid exits for the second fluid.

Background Art

[0002] Today many different types of plate heat exchangers exist and are employed in various applications depending on their type. Some types of plate heat exchangers are assembled from a casing that forms a sealed enclosure in which heat transfer plates that are joined are arranged. The heat transfer plates form a stack of heat transfer plates where alternating first and second flow paths for a first and a second fluid are formed in between the heat transfer plates.

[0003] One type of plate heat exchangers has one or more openings (ports) in form of through holes in the heat transfer plates. Fluid flows into the openings, either directly or via e.g. a pipe structure that extends through the openings. The fluid typically enters an individual heat transfer plate at an inlet section of the opening in the heat transfer plate, flows across the plate and leaves the plate at an outlet section of the same opening or of another opening. The outlet section is, on the heat transfer plate, arranged opposite the inlet section.

[0004] The second fluid often enters the heat transfer plate at an inlet section of a periphery of the plate, flows across the plate and leaves the plate at an outlet section of a periphery of the plate, which outlet section is opposite the inlet section. For some plate heat exchangers the second fluid enters and leaves the heat transfer plates via additional openings in the heat transfer plates.

[0005] Obviously, the inlet and outlet for the first fluid are located between every second pair of plates while the inlet and outlet for the second fluid are located between every other, second pair of plates. Thus, the first and second fluid flows over a respective side of a heat transfer plate, in between every second pair of heat transfer plates. The plates of a plate pair that have an inlet and an outlet for the first fluid are typically sealed to each other along all edges but where the openings for the first fluid is located, while the plates of a plate pair that have an inlet and outlet for the second fluid are sealed to each other at all edges but where the openings for the second fluid is located.

[0006] The sealed heat transfer plates are this joined to each other and the heat transfer plates are sometimes referred to as a plate pack or a stack of heat transfer plates. The stack of heat transfer plates has a substantially cylindrical shape with one or more internal through holes. The stack of heat transfer plates may be all-welded such that rubber gaskets may be omitted between heat transfer plates. This makes the heat exchanger suitable for operation with a wide range of aggressive fluids, at high temperatures and at high pressures.

[0007] When the heat transfer plates are surrounded by a casing, the plate heat exchanger may withstand high pressure levels in comparison with many other types of plate heat exchangers. Still, the plate heat exchanger with a casing is compact, it has good heat transfer properties and may withstand hard operation conditions without breaking.

[0008] During maintenance of the heat exchanger, the stack of heat transfer plates may be accessed and cleaned by removing e.g. a top or bottom cover of the shell and by flushing the stack of heat transfer plates with a detergent. It is also possible to replace the stack of heat transfer plates with a new stack that may be identical to or different from the previous stack as long as it is capable of being properly arranged within the shell.

[0009] Generally, the plate heat exchanger is suitable not only for use as a conventional heat exchanger but also as a condenser or reboiler. In the two latter cases the shell may comprise additional inlets/outlets for a condensate, which may eliminate the need for a special separator unit.

[0010] A plate heat exchanger with a casing and a plate stack arranged therein provides, as indicated, a combination of advantages and properties that are quite specific for the type. A number of embodiments of such heat exchangers have been disclosed, such as those found in patent document EP2002193A1. In comparison to several other types of plate heat exchangers, the plate heat exchanger with a casing has a compact design and may withstand high pressure levels. However, it is estimated that such heat exchangers may be improved in respect of its capability to handle internal stresses due to e.g. temperature changes and fluid pressure variations that occur during operation of the heat exchanger.

Summary

[0011] It is an object of the invention to provide improved durability of a plate heat exchanger with a casing. In particular, it is an object to improve the capability of such as plate heat exchanger to withstand temperature variations and fluid pressure fluctuation better.

[0012] To solve these objects a plate heat exchanger is provided. The heat plate heat exchanger comprises a casing that has a shell, a top cover and a bottom cover that are joined to form an enclosure. A number of heat transfer plates are permanently joined to each other to form a plate stack that is arranged within the enclosure and has alternating first and second flow paths for a first fluid and a second fluid in between the heat transfer plates. The heat transfer plates have openings in form of through holes in the heat transfer plates, the openings forming a space in the plate stack in which the first fluid flows, and first sections that act as a fluid entries for the second fluid, and second sections that are opposite the first sections and act as fluid exits for the second fluid. A reinforcement element extends through the openings in the heat transfer plates, from the top cover to the bottom cover, the reinforcement element being connected to each of the top cover and the bottom cover for supporting the covers when the plate heat exchanger is subjected to a pressure from any of the first fluid and the second fluid.

[0013] The provided plate heat exchanger is advantageous in that it has a very high capability to withstand temperature variations and fluid pressure fluctuations. Additionally, relatively less material is required for the shell in order to obtain a desired durability and mechanical strength for the plate heat exchanger. The plate heat exchanger may include a number of additional features as described below. These additional further contribute, either alone or in combination, to the capability of the plate heat exchanger to effectively withstand temperature variations and fluid pressure fluctuations, while still being able to use a shell with relatively little material.

[0014] Still other objectives, features, aspects and advantages of the invention will appear from the following detailed description as well as from the drawings.

Brief Description of the Drawings

[0015] Embodiments of the invention will now be described, by way of example, with reference to the accompanying schematic drawings, in which

Fig. 1 is a cross-sectional top view of a reinforced plate heat exchanger, as seen along line B-B in Fig. 2,
Fig. 2 is a cross-sectional side view of the heat exchanger of Fig. 1, as seen along line A-A in Fig. 1,
Fig. 3 is a cross-sectional side view of a flow divider that is arranged in the heat exchanger of Fig. 1,
Fig. 4 is a side view of the flow divider of Fig. 3,
Fig. 5 is a principal top view of a heat transfer plate that together with similar heat transfer plates may form a plate stack for the heat exchanger of Fig. 1,
Fig. 6 is a principal cross-sectional side view of four heat transfer plate of the kind shown in Fig. 5,
Fig. 7 is a cross sectional top view of a second embodiment of a reinforced plate heat exchanger,
Fig. 8 is a cross-sectional side view of the heat exchanger of Fig. 7, as seen along line C-C in Fig. 7,
Fig. 9 is a cross sectional side view of a third embodiment of a reinforced plate heat exchanger,
Fig. 10 is a cross sectional side view of a fourth embodiment of a reinforced plate heat exchanger,
Fig. 11 is a cross-sectional side view of the heat exchanger of Fig. 10,
Fig. 12 is a principal top view of a heat transfer plate that may be used in the heat exchanger of Fig. 11,
Fig. 13 is a cross sectional side view of a fifth embodiment of a reinforced plate heat exchanger, and
Fig. 14 is a principal top view of a heat transfer plate that may be used in the heat exchanger of Fig. 13.

Detailed description

[0016] With reference to Figs 1 and 2 a plate heat exchanger 101 is illustrated. The plate heat exchanger 101 has a casing 2 that comprises a cylindrical shell 3, a top cover 4 and a bottom cover 5. The top cover 4 has the shape of a circular disc and a periphery of the top cover 4 is attached to an upper edge of the cylindrical shell 3. The bottom cover 5 has the shape a circular disc and a periphery of the bottom cover 5 is attached to a lower edge of the cylindrical shell 3. The covers 4, 5 are in the illustrated embodiment welded to the cylindrical shell 3. In another embodiment the covers 4, 5 are attached to the cylindrical shell 3 via bolts that engage flanges (not shown) of the cylindrical shell 3 and the covers 4, 5. A number of heat transfer plates 21, 22, 23 that are permanently joined to each other form a plate stack 20 that is arranged within an enclosure 14 within the casing 2. The stack 20 has, in between the heat transfer plates 21, 22, 23, alternating first and second flow paths 11, 12 for a first fluid F1 and for a second fluid F2, i.e. the first fluid F1 flow in between every second pair of heat transfer plates.

[0017] The top cover 4 has a fluid inlet 6 for the first fluid F1 which passes through the heat exchanger 101 via the first flow path 11. This fluid inlet 6 is referred to as a first fluid inlet 6. The bottom cover 5 has a fluid outlet 7 for the first fluid F1 that passes through the heat exchanger 101 via the first flow path 11. This fluid outlet 7 is referred to as a first fluid outlet 7. The first fluid inlet 6 is located at a center of the top cover 4 and the first fluid outlet 7 is located at a center of the bottom cover 5. The first fluid inlet 6 and the first fluid outlet 7 are located opposite each other in the casing 2.

[0018] The cylindrical shell 3 has a fluid inlet 8 for the second fluid F2 which passes through the heat exchanger 101 via the second flow path 12. This fluid inlet 8 is referred to as a second fluid inlet 8. The cylindrical shell 3 also has a fluid outlet 9 for the second fluid F2 that passes through the heat exchanger 101 via the second flow path 12. The outlet 9 is referred to as a second fluid outlet 9. The second fluid inlet 8 is located on a side of the cylindrical shell 3, midway between the upper edge of the cylindrical shell 3 and the lower edge of the cylindrical shell 3. The second fluid outlet 9 is located on a side of the cylindrical shell 3 that is opposite the second fluid inlet 8, midway between the upper edge of the cylindrical shell 3 and the lower edge of the cylindrical shell 3.

[0019] The casing 2, i.e. in the illustrated embodiment the cylindrical shell 3, the top cover 4 and the bottom cover 5, forms the enclosure 14 or an interior space 14 in which the stack 20 of heat transfer plates is arranged. The heat transfer plates in the stack 20, such as heat transfer plates 21, 22 and 23, are permanently joined and arranged in the sealed enclosure such that the first and second flow paths 11, 12 flow in respective, alternating flow paths in between the heat transfer plates. Each of the heat transfer plates in the stack 20 has a central opening 31. The central openings of several heat transfer plates in the stack 20 together form a central space 24 in the stack 20.

[0020] With further reference to Figs 3 and 4, a fluid separation device 40 is inserted into the central space 24 in the stack 20. The separation device 40 has the form of a cylinder 41 that fits close to central openings 31 of the heat transfer plates 21, 22, 23 in the stack 20. The height of the separation device 40 is the same as the height of the central space 24 in the stack 20. A flow divider 42 extends diagonally from an upper part of the cylinder 41 to a lower part of the cylinder 41 and separates the interior of the cylinder 41 into a first cylinder section 43 and a second cylinder section 44. The flow divider 42 separates the first cylinder section 43 from second cylinder section 44, such that fluid do not (apart for some leakage, if this occurs) flow directly between the sections 43, 44. Instead, fluid flow from the first cylinder section 43 to the second cylinder section 44 via the heat transfer plates in the stack 20.

[0021] The separation device 40 has a first opening 45 in the first cylinder section 43 and a second opening 46 in the second cylinder section 44. The first opening 45 is arranged opposite the second opening 46 with the flow divider 42 symmetrically arranged between the openings 45, 46.

[0022] With reference to Fig 5 one of the heat transfer plates 21 that is used for the stack 20 is shown. The heat transfer plate 21 has a central opening 31 and a number of rows 32, 33 with alternating ridges and grooves. Flat plate section 38 separates the rows 32, 33 from each other. The heat transfer plate 21 has a central opening 31 that, together with central openings of other heat transfer plates in the stack 20, forms the central space 24 in the plate stack 20 and in which the fluid separation device 40 is arranged. Then a first part 34 of the central opening 31 acts as a fluid inlet 34 for the first fluid F1 and a second part 35 of the central opening 31 acts as a fluid outlet 35 for the first fluid F1. The inlet 34 allows the first fluid F1 to enter spaces in between every second heat transfer plate and the outlet 35 allows the fluid to exit the same spaces in between every second heat transfer plate. The outlet 35 is, as seen across a center C of the heat transfer plate 21, located opposite the inlet 34. The heat transfer plate 21 has also a first side 36, or first section 36, that acts as a fluid entry 36 for the second fluid F2, and a second 37 side, or second section 37, that acts as a fluid exit 37 for the second fluid F2. The fluid exit 37 is arranged opposite the fluid entry 36. All heat transfer plates in the stack 20 may have the form of the heat transfer plate 21 shown in Fig. 5, with every other heat transfer plate turned 180º around an axis A1 that extend along a plane of the heat transfer plate and though the center C of the heat transfer plate.

[0023] With further reference to Fig. 6 a principal view of the heat transfer plates 21, 22, 23 are shown together with a further heat transfer plate, along a cross section that extends from the center C of the heat transfer plate 21 to a peripheral edge (periphery) 39 of the heat transfer plate 21. The periphery 39 of the heat transfer plate 21 is along its full length joined with a corresponding periphery of the upper heat transfer plate 22. The plates 22, 23 have central planes P2, P3 that are parallel to a central plane P1 of plate 21. The interspace between the plates 21, 22 forms part of the first flow path 11 for the first fluid F1. The central plane P1 extend through the heat transfer plate 21, in parallel to the top surface (seen in Fig. 5) and the bottom surface of the heat transfer plate 21.

[0024] The central opening 31 of the heat transfer plate 21 may be joined with a similar central opening of the upper heat transfer plate 22 except for the sections of the opening where the fluid inlet 34 and fluid outlet 35 are located. The inlet 34 and outlet 35 are defined by a respective angle α (the angle α is shown only for the outlet 35). The inlet and outlet 34, 35 are arranged symmetrically opposite each other. Optionally, the plates 22, 23 are not joined at their central openings 31. Then the openings 45, 46 in the separation device 40 limits a flow of the first fluid F1, such that the fluid enters and exits the plates at the fluid inlet 34 and fluid outlet 35. The openings 45, 46 of the separation device 40 then subtends a respective angle $\alpha°$.

[0025] The central opening 31 of the heat transfer plate 21 is along its full length joined with a corresponding central opening of the lower heat transfer plate 23. The interspace between the plates 21, 23 forms part of the second flow path 12 for the second fluid F2.

[0026] The heat transfer plate 21 may be partly joined with the lower heat transfer plate 23 at the periphery 39 of the heat transfer plate 21, i.e. the periphery 39 of the heat transfer plate 21 may be partly joined with a similar periphery of the lower heat transfer plate 23. The fluid entry 36 and the fluid exit 37 at the plate periphery 31 are not joined with the lower heat transfer plate 23. The parts, i.e. the entry and exit 36, 37, that are not joined are defined by a respective angle of β degrees. The parts 36, 37 are symmetrical and are arranged opposite each other and forms acts as a fluid entry and exit for the second fluid F2. It is not necessary to join the heat transfer plates 21, 23 at their periphery. In this case the first side 36 still acts as a fluid entry 36 for the second fluid F2 and the second 37 side as a fluid exit 37 for the second fluid F2. Gaskets may be arranged to prevent the second fluid F2 from entering and exiting the plates at sections outside the entry and exit. 36, 37.

[0027] To prevent too much of the second fluid F2 to pass the plate stack 20 by flowing e.g. in a possible gap between the cylindrical shell 3 and the plate stack 20, gaskets or some other by pass blocker (not shown) may be arranged between the shell 3 and the plate stack 20. Of course, these gaskets or blockers are located outside the fluid entry 36 and fluid exit 37.

[0028] The joining of the heat transfer plates 21, 22, 23 is typically accomplished by welding. The heat transfer plate 21 may have a central edge 52 that is folded towards and joined with a corresponding folded, central edge of the lower adjacent heat transfer plate 23. The heat transfer plate 21 may also have a peripheral edge 51 that is folded towards and joined with a corresponding folded, peripheral edge of the other, upper adjacent heat transfer plate 22.

[0029] The heat transfer plates 21, 22, 23 may then be joined at to each other at their folded edges. A seal may be arranged between the separation device 40 and the heat transfer plates for sealing plates like plates 21 and 22 along their central openings 31 at all sections but at the inlet 34 and the outlet 35.

[0030] Turning back to Figs 1-4 the flow over the heat transfer plates may be seen. The flow of the first fluid follows the path indicated by "F1". By virtue of the separation device 40 and its flow divider 42, the flow of the first F1 fluid passes the first fluid inlet 6, enters the first cylinder section 43 and flows out through the first opening 45 in the separation device 40, into first plate inlets 34 of the heat transfer plates 21 in the stack 20. The first fluid F1 then "turns around" when it flows across the heat transfer plates, as indicated by the path F1 in Fig. 1, leaves the heat transfer plates via first plate outlets 35 of the heat transfer plates 21 in the stack 20 and enters the second cylinder section 44 via the second opening 46. From the second cylinder section 44 the first fluid F1 flows to the first fluid outlet 7 where it leaves the heat exchanger 101.

[0031] As may be seen, the first section 43 of the flow divider 40 faces the fluid inlets 34 at the central openings 31 of a set (a number) of heat transfer plates in the stack 20 and the second section 44 of the flow divider 42 faces fluid outlets 35 at the central openings 31 of the same set of heat transfer plates in the stack.

[0032] The flow of the second fluid follows the path indicated by "F2". The flow of the second fluid F2 passes the second fluid inlet 8 and into second plate inlets 36 of the heat transfer plates 21 in the stack 20. For facilitating distribution of the fluid into all second plate inlets 36 of the heat transfer plates, the heat exchanger 101 may at the second fluid inlet 8 comprise a distributor that is formed as a channel between the shell 3 and the plate stack 20. This distributor, or channel, is accomplished by arranging a cut out 28 in the heat transfer plate 21, such that a space is created between the heat transfer plate 21 and the shell 3 at the inlet 8. In a similar manner may a collector that has a similar shape as the distributor be arranged at the second fluid outlet 7. The collector is then formed as a channel between the shell 3 and the plate stack 20, and is accomplished by arranging a cut out 29 in the heat transfer plate 21, such that a space is created between the heat transfer plate 21 and the shell 3 at the outlet 9. The first side 36, or fluid entry 36 of the heat transfer plate 21 is then formed in the cut out 28, and the second side 37, or fluid exit 37 is then formed in cut-out 29.

[0033] When the second fluid F2 has entered the entries 36 of the plates it flows across the plates in the stack 20, see path F2 in Fig. 1, leaves the heat transfer plates in the stack 20 via the exit 37 and thereafter leaves the heat exchanger 101 via the second fluid outlet 9.

[0034] The separation device 40 is at its upper end welded to the top cover 4 and at its lower part welded to the bottom cover 5. Typically, the cylinder 41 is at its upper circumferential edge welded to the top cover 4, and at its lower circumferential edge welded to the bottom cover 5. Then the separation device 40 extends through the openings 31 in the heat transfer plates 21-23, from the top cover 4 to the bottom cover 5, and acts as a reinforcement element 40. As a result the separation device in form of a reinforcement element 40 supports the covers 4, 5 when the plate heat exchanger is subjected to a pressure from the first fluid F1 and/or the second fluid F2. When the reinforcement element 40 has the form of a separation device it comprises the flow divider 42 and it is separated into the first section 43 and the second section 44.

[0035] Turning to Figs 7 and 8 a second embodiment of a plate heat exchanger 102 is illustrated. The plate heat exchanger 102 is similar to the plate heat exchanger 101 described in connection with Fig. 1, and has a casing 2 that comprises a cylindrical shell 3, a top cover 4 and a bottom cover 5. A fluid separation device 40 with a flow divider 42 is arranged within a space 24 in a stack 20 of heat transfer plates that is arranged within an enclosure 14 within the casing 2. The plate heat exchanger 102 of Fig 7 and 8 is different from the plate heat exchanger 101 of Fig. 1 in that it has a reinforcement element 50 that extends through the openings 31 in the heat transfer plates, from the top cover 4 to the bottom cover 5. The reinforcement element 50 is connected to each of the top cover 4 and the bottom cover 5. The reinforcement element 50 has the form of elongated bars that extend through the space 24 in the plate stack 20 and are connected to the top cover 4 and to the bottom cover 5. In the shown embodiment there are sixteen bars that are symmetrically arranged around the fluid separation device 40. The bars have threaded ends that extend though the covers 4, 5, and nuts are arranged on the threaded bars for fixing the bars to the covers. The openings 45, 46 of the fluid separation device 40 are directly connected to the fluid inlets and fluid outlets 34, 35 of the central opening 31 of the heat transfer plate 21 (see Fig. 5). This connection is accomplished by two flow guiders 451, 461 that extend from the openings 45, 46 of the fluid separation device 40 to the fluid inlets and fluid outlets 34, 35 of the heat transfer plates 21 in the stack 20. The inlet and outlet for the second fluid F2 as well as the flow for the second fluid F2 are the same for the plate heat exchanger 102 of Fig. 7 as for the plate heat exchanger 101 of Fig. 1.

[0036] Turning to Fig. 9 a third embodiment of a plate heat exchanger 103 is illustrated. The plate heat exchanger 103 is similar to the plate heat exchanger 101 described in connection with Fig. 1, and has a casing 2 that comprises a cylindrical shell 3, a top cover 4 and a bottom cover 5. The plate heat exchanger 103 of Figs 7 and 8 is different from the plate heat exchanger 101 of Fig. 1 in that the fluid separation device 40 has the form of a pipe 60 that extends through the covers 4, 5. The pipe 60 acts as a reinforcement element 60 and includes at its ends the fluid inlet 6 and the fluid outlet 7 for the first fluid F1. The reinforcement element 60 has a flow divider 42 and a first section 43 and a second section 44 that are similar to those of the fluid separation device 40 that is used for the plate heat exchanger 101 of Fig. 1. The reinforcement element 60 has elongated openings 45, 46 that faces the fluid inlets 34 and the fluid outlets 35 of the heat transfer plates 20 (see Fig. 5). The reinforcement element 60 extends through the central space 24 in the stack 20, and is at circumferential peripheries welded to both covers 4, 5. This improves the capability of the plate heat exchanger 103 to withstand temperature variations and fluid pressure fluctuations. The inlet and outlet as well as the flow for the second fluid F2 is the same for the plate heat exchanger 103 of Fig. 9 as for the plate heat exchanger 101 of Fig. 1.

[0037] Turning to Figs 9, 10 and 11 a fourth embodiment of a plate heat exchanger 104 and one of its heat transfer plates 212 are illustrated. The plate heat exchanger 104 has a casing 2 that comprises a cylindrical shell 3, a top cover 4 and a bottom cover 5 that are joined to each other. A number of heat transfer plates that are permanently joined to each other form a plate stack 20 that is arranged within an enclosure 14 within the casing 2. The stack 20 has, in between its heat transfer plates, alternating first and second flow paths for a first fluid F1 and for a second fluid F2, i.e. the first fluid F1 flows in between every second pair of heat transfer plates while the second fluid F2 flows in between every other, second pair of heat transfer plates. A reinforcement element 70 in form a pipe extends through the top cover 4, through central openings 31 of the heat transfer plates 212, and through the bottom cover 5. The central openings 31 of several heat transfer plates in the stack 20 together form a central space 24 in the stack 20, and it is through this central space 24 the reinforcement element 70 extends. A first end of the reinforcement element 70 acts as a fluid inlet 6 for the first fluid F1 and a second end of the reinforcement element 70 acts as a fluid outlet 7 for the first fluid F1.

[0038] The reinforcement element 70 has a flow divider 142 that separates the reinforcement element 70 into a first section 43 and a second section 44. The flow divider 142 has the form of a disc that is located in the middle of the pipe that forms the reinforcement element 70 and provides a seal between the two sections 43, 44. The first section 43 has openings 45 towards every second interspace between the heat transfer plates, for a first set 453 of the heat transfer plates in the stack 20. The openings of 45 the first section 43 faces fluid inlets at the central openings 31 of the first set 453 of heat transfer plates. The second section 44 has openings 46 towards every second interspace between the heat transfer plates, for a second set 463 of the heat transfer plates in the stack 20. The openings 46 of the second section 43 faces fluid outlets at the central openings 31 of the second set 463 of heat transfer plates.

[0039] The first fluid F1 enters the plate heat exchanger 104 at the fluid inlet 6, flows into the first section 43 and out from the first section 43 via the openings 45, into every second interspace in the centers of the first set 453 of heat transfer plates. The fluid F1 flows across the heat transfer plates and leaves the heat transfer plates at their peripheral edge, at cut-outs 311, 312 in the plates. The cut outs 311, 312 form channels between the heat transfer plates and the casing 2. The first fluid F1 flows in these channels, towards the second set 463 of heat transfer plates where it enter every second interspace between the heat transfer plates in the second set 463. The first fluid F1 enters the heat transfer plates at the cut-outs 311, 312 in the plates, flows across the heat transfer plates and enters the second section 44 via the openings 46. Thereafter the first fluid F1 leaves the plate heat exchanger 104 via the fluid outlet 7.

[0040] The openings 45 in the first section 43 may have the form of elongated through holes in the reinforcement element 70, and are symmetrically arranged to distribute the first fluid F1 evenly of the heat transfer plates. The openings 46 in the second section 44 are arranged in a similar manner. The reinforcement element 70 is welded to the covers 4, 5, which increases the capability of the plate heat exchanger 104 to withstand temperature variations and fluid pressure fluctuation.

[0041] As may be seen in Fig. 11 the plate heat exchanger 104 has two further pipes 701, 702 that extends from the top cover 4 to the bottom cover 5. A first end of the first pipe 701 forms an inlet 8 for the second fluid F2 and a second end of the first pipe 701 is attached by welding to the bottom cover 5. The first pipe 701 is attached to the top cover 4 by welding along its periphery where it extends through the top cover 4.

[0042] A first end of the second pipe 702 forms an outlet 9 for the second fluid F2 and a second end of the second pipe 702 is attached by welding to the bottom cover 5. The second pipe 702 is attached to the top cover 4 by welding along its periphery where it extends through the top cover 4. Thus, both pipes 701, 702 act as reinforcement elements for the plate heat exchanger 104.

[0043] The first pipe 701 extends though the plate stack 20 via first sections 36 in the heat transfer plate 212, which sections act as a fluid entries 36 for the second fluid F2. The second pipe 702 extends though the plate stack 20 via second sections 37 in the heat transfer plate 212, which sections act as fluid exits 37 for the second fluid F2. The fluid entries 36 have the form of through holes in the heat transfer plate 212, and act as entries for the second fluid F2 in the sense that the second fluid F2, at the fluid entries 36, enters interspaces between the heat transfer plates. The fluid exits 37 have the form of through holes in the heat transfer plates 212, and act as exits for the second fluid F2 in the sense that the second fluid F2, at the fluid exits 37, exits the interspaces between the heat transfer plates. The first pipe 701 has one or more openings 703 that face the fluid entries 36 and the second pipe 702 has one or more openings 704 that face the fluid exits 37.

[0044] The second fluid F2 enters the plate heat exchanger 104 at the fluid inlet 8, flows into the first pipe 701 and out from the first pipe 701 via the opening 703, and into the fluid entries 36 at every other, second interspace between the heat transfer plates. The second fluid F2 then flows over the heat transfer plates and towards the fluid exits 37 where it leaves the heat transfer plates by entering the second pipe 702 via the opening 704. The second fluid F2 then flows in the second pipe 702 from where it leaves via the fluid outlet 9.

[0045] Turning to Figs 13 and 14 a fifth embodiment of a plate heat exchanger 105 and one of its heat transfer plates 213 are illustrated. The plate heat exchanger 105 has a casing 2 that comprises a cylindrical shell 3, a top cover 4 and a bottom cover bottom cover 5 that are joined to each other. A number of heat transfer plates that are permanently joined to each other form a plate stack 20 that is arranged within an enclosure 14 within the casing 2. The stack 20 has, in between its heat transfer plates, alternating first and second flow paths for a first fluid F1 and for a second fluid F2, i.e. the first fluid F1 flows in between every second pair of heat transfer plates and the second fluid F2 flows in between every other, second pair of heat transfer plates.

[0046] A reinforcement element 80 in form of two pipes 81, 82 extends from the top cover 4 to the bottom cover 5. A first end of the first pipe 81 forms a fluid inlet 6 for the first fluid F1 and a second end of the first pipe 81 is attached by welding to the bottom cover 5. The first pipe 81 is attached to the top cover 4 by welding along its periphery where it extends through the top cover 4. A first end of the second pipe 82 forms a fluid outlet 7 for the first fluid F1 and a second end of the second pipe 82 is attached by welding to the bottom cover 5. The second pipe 82 is attached to the top cover 4 by welding along its periphery where it extends through the top cover 4. The reinforcement element 80 in from the pipes 81, 82 improves the capability of the plate heat exchanger 105 to withstand temperature variations and fluid pressure fluctuations.

[0047] The first pipe 81 extends though the plate stack 20, through first openings 31 in the heat transfer plate 213. The first openings 31 form a first space 24 in plate stack 20. The second pipe 82 extends though the plate stack 20, through second openings 131 in the heat transfer plate 213. The second openings 131 form a second space 124 in plate stack 20. The arrangement of the first pipe 81 and the second pipe 82 corresponds to that of the first and second pipes 701, 702 in Fig. 11.

[0048] The first fluid F1 enters the plate heat exchanger 105 at the fluid inlet 6, flows into the first pipe 81 and out from the first pipe 81 via an opening 703 in the first pipe 81, and into the first openings 31 in the heat transfer plates, at every second interspace between the heat transfer plates. The first fluid F1 then flows over the heat transfer plates and towards the second openings 131 in the heat transfer plates, where it leaves the heat transfer plates by entering the second pipe 82 via the second openings 131. The first fluid F1 flow into the second pipe 82 via an opening 704 in the second pipe 82 and leaves the pipe 82 via the fluid outlet 7.

[0049] The flow of the second fluid F2 in the plate heat exchanger 105 is the same as for the flow of the first fluid F1 of the plate heat exchanger 101 of Fig. 1, with the deference that the flow is reversed as compared with the illustrated embodiment. In detail, the flow of the second fluid F2 through the plate heat exchanger 105 starts at a fluid inlet 8 in the middle of cylindrical shell 3. The fluid enters a channel that is formed between the stack and the shell 3, by virtue of cutouts 28 in the heat transfer plates 213. From this channel the second fluid F2 flows into every other, second interspace in the stack 20, at first sections of the heat transfer plates 213 that acts as a fluid entries 36 for the second fluid F2. The second fluid F2 then flows across the heat transfer plates, towards second sections 37 of the heat transfer plates 213. The second sections act as fluid exits 37 for the second fluid F2. The second fluid F2 then leaves the heat transfer plates 213 the fluid exits 37 and enters a channel that is formed between the stack 20 and the shell 3, by virtue of cutouts 29 in the heat transfer plates 213. This channel located on an opposite side of the stack 20 as compared with the channel that is formed by the other cutouts 28. The second fluid F2 flows from the channel at the cutouts 29, towards a fluid outlet 9 where it leaves the plate heat exchanger 105.

[0050] The flows of one or both of the fluids may be reversed for the different embodiments of plate heat exchangers 101, 102, 103, 104, 105. Moreover, the different principles for fluid distribution may be used in any desirable combination. For example, the reinforcement element 60 of Fig. 9 may be used in combination with the pipes 701, 702 of Fig. 11, or in combination with the reinforcement element 80 of Fig. 13.

[0051] From the description above follows that, although various embodiments of the invention have been described and shown, the invention is not restricted thereto, but may also be embodied in other ways within the scope of the subject-matter defined in the following claims.

Claims

1. A plate heat exchanger comprising
a casing (2) that has a shell (3), a top cover (4) and a bottom cover (5) that are joined to form an enclosure (14),
a number of heat transfer plates (21-23) that are permanently joined to each other to form a plate stack (20) that is arranged within the enclosure (14) and has alternating first and second flow paths (11, 12) for a first fluid (F1) and a second fluid (F2) in between the heat transfer plates (21-23),
the heat transfer plates (21-23) having

- openings (31) in form of through holes in the heat transfer plates (21-23), the openings (31) forming a space (24) in the plate stack (20) in which the first fluid (F1) flows,
- first sections (36) that act as a fluid entries for the second fluid (F2), and second sections (37) that are opposite the first sections (36) and act as fluid exits for the second fluid (F2),

wherein
a reinforcement element (40, 50, 60, 70, 80) extends through the openings (31) in the heat transfer plates (21-23), from the top cover (4) to the bottom cover (5), the reinforcement element (40, 50, 60, 70, 80) being connected to each of the top cover (4) and the bottom cover (5) for supporting the covers (4, 5) when the plate heat exchanger is subjected to a pressure from any of the first fluid (F1) and the second fluid (F2).

2. A plate heat exchanger according to claim 1, comprising a flow divider (42, 142) that is located in the space (24) in the plate stack (20), the flow divider (42, 142) comprising a first section (43) from which the first fluid (F1) may flow into the first fluid path (11) in the plate stack (20), and a second section (44) into which the first fluid (F1) may flow from the first fluid path (11) in the plate stack (20).

3. A plate heat exchanger according to claim 1 or 2, wherein the reinforcement element (50) comprises elongated bars that extend through the space (24) in the plate stack (20) and are connected to the top cover (4) and to the bottom cover (5).

4. A plate heat exchanger according to any one of claim 1 - 3, wherein the reinforcement element (60, 70) comprises a pipe that extend through the space (24) in the plate stack (20) and is connected to the top cover (4) and the bottom cover (5).

5. A plate heat exchanger according to any one of claims 1 - 4, wherein the reinforcement element (40, 60, 70) comprises the flow divider (42, 142) and is separated into the first section (43) from which the first fluid (F1) may flow into the first fluid path (11) and the second section (44) into which the first fluid (F1) may flow from the first fluid path (11).

6. A plate heat exchanger according to any one of claims 1 - 5, wherein the first section (43) of the flow divider (42) faces fluid inlets (34) at the openings (31) of a set of heat transfer plates in the stack (20) and the second section (44) of the flow divider (42) faces fluid outlets (35) at the openings (31) of the same set of heat transfer plates in the stack (20).

7. A plate heat exchanger according to any one of claims 1 - 5, wherein the first section (43) of the flow divider (142) faces fluid inlets at the openings (31) of a first set (453) of heat transfer plates in the stack (20) and the second section (44) of the flow divider (142) faces fluid outlets at the openings (31) of a second set (463) of heat transfer plates in the stack (20).

8. A plate heat exchanger according to any one of claims 1 - 7, wherein the openings (31) in the heat transfer plates (21-23) that form the space (24) in the plate stack (20) comprises a first set of openings (31), the heat transfer plates (21-23) having a second set of openings (131) that form a second space (124) in the plate stack (20).

9. A plate heat exchanger according to claim 8, wherein the reinforcement element (80) comprises a first pipe (81) that extends through the first set of openings (31), and a second pipe (82) that extends through the second set of openings (131), each of the pipes (81, 82) being connected to the tope cover (4) and the bottom cover (5).

10. A plate heat exchanger according to any one of claims 1 - 9, wherein the reinforcement element (50, 60, 70, 80) is welded to the top cover (4) and to the bottom cover (5).

11. A plate heat exchanger according to any one of claims 1- 10, wherein the reinforcement element (60, 70, 80) comprises an elongated opening (45, 703) that acts as a fluid outlet from the reinforcement element (60, 70, 80), to let the first fluid (F1) flow into interspaces between the heat transfer plates (21-23).

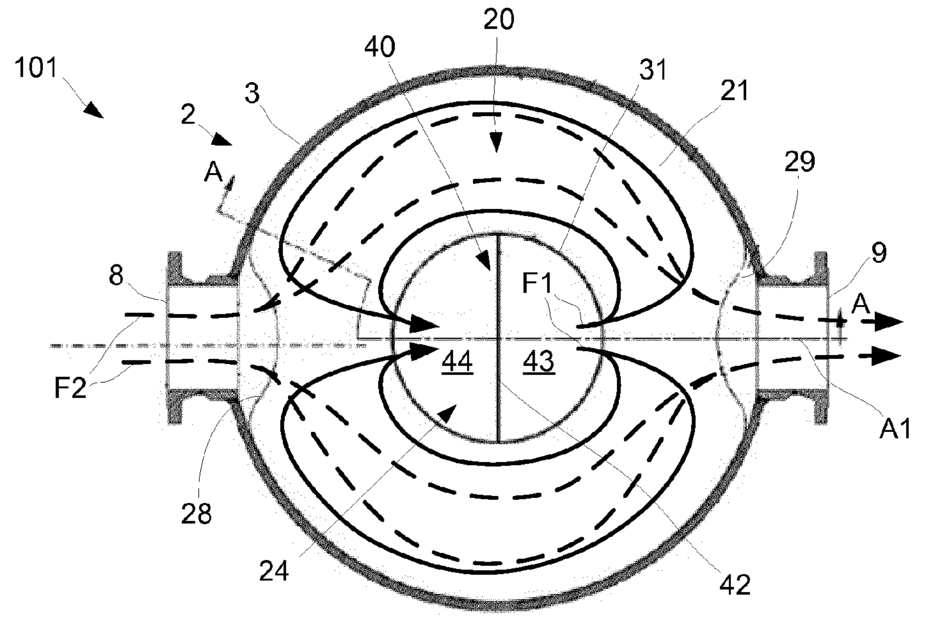


Fig. 1 (B-B)

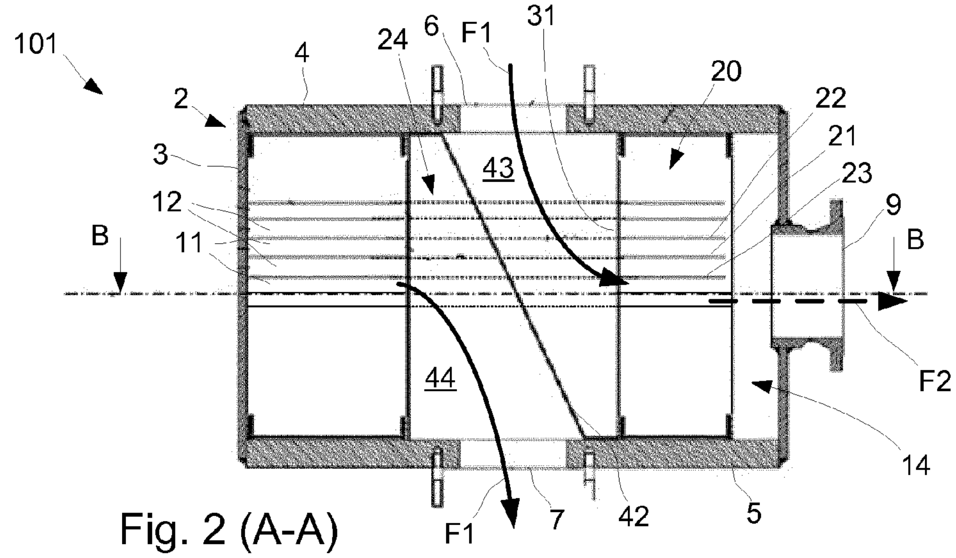


Fig. 2 (A-A)

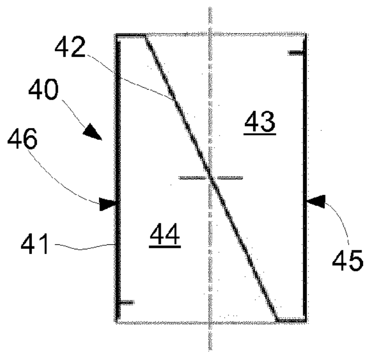


Fig. 3

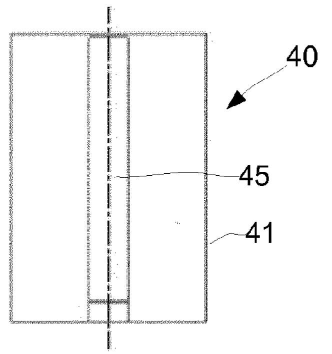


Fig. 4

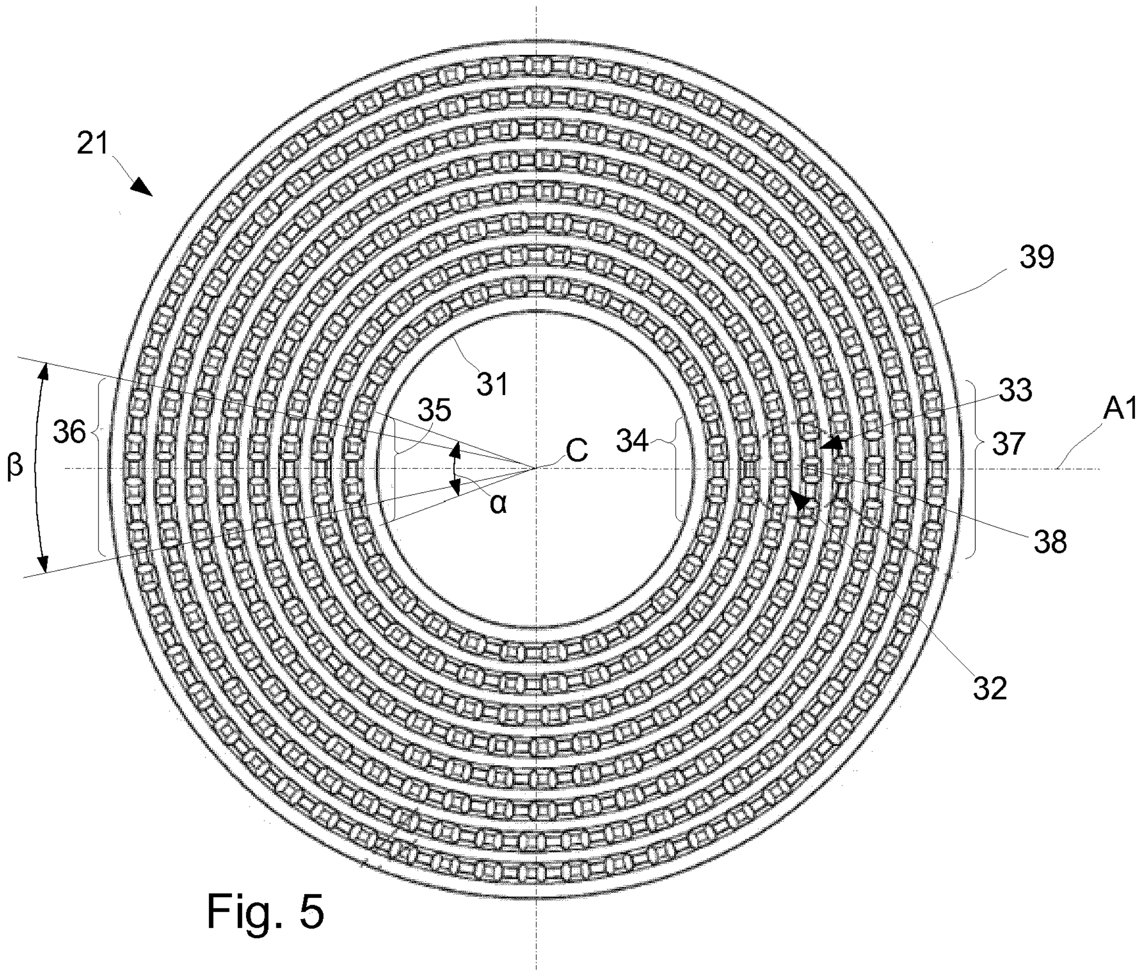


Fig. 5

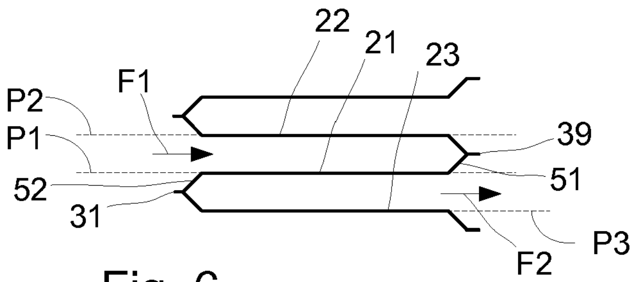


Fig. 6

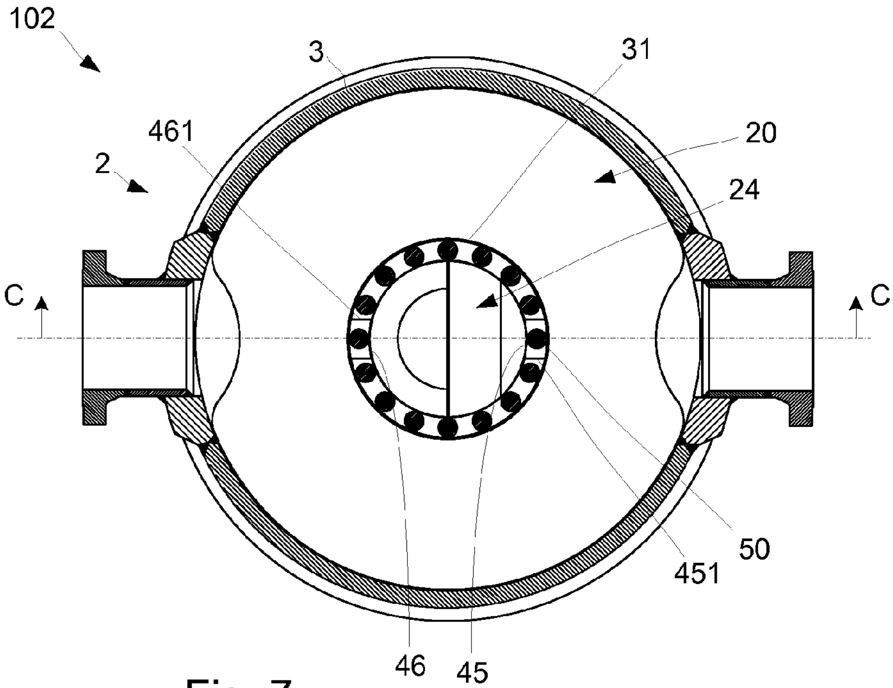


Fig. 7

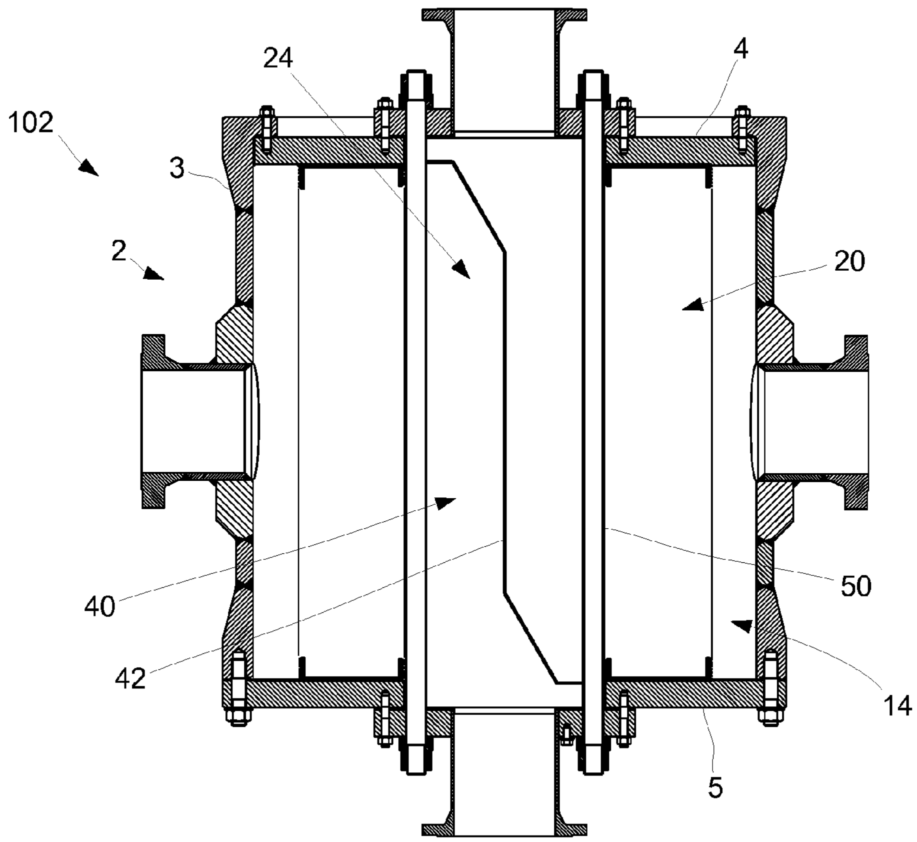


Fig. 8 (C-C)

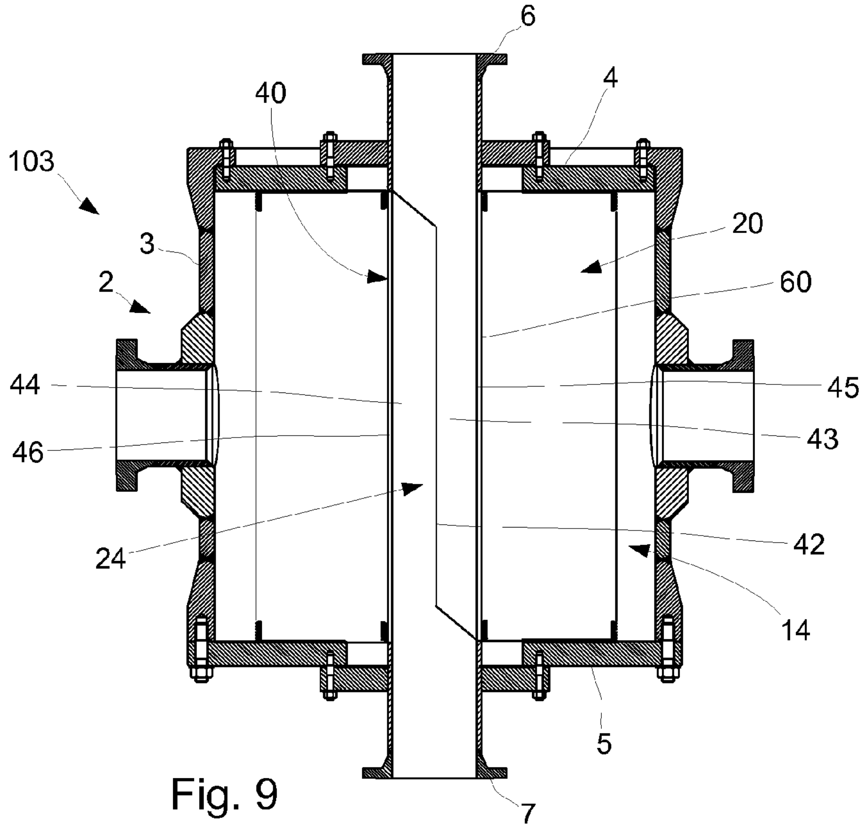

6
40
4
103
20
3
60
2
44
45
46
43
24
42
14
5
7

Fig. 9

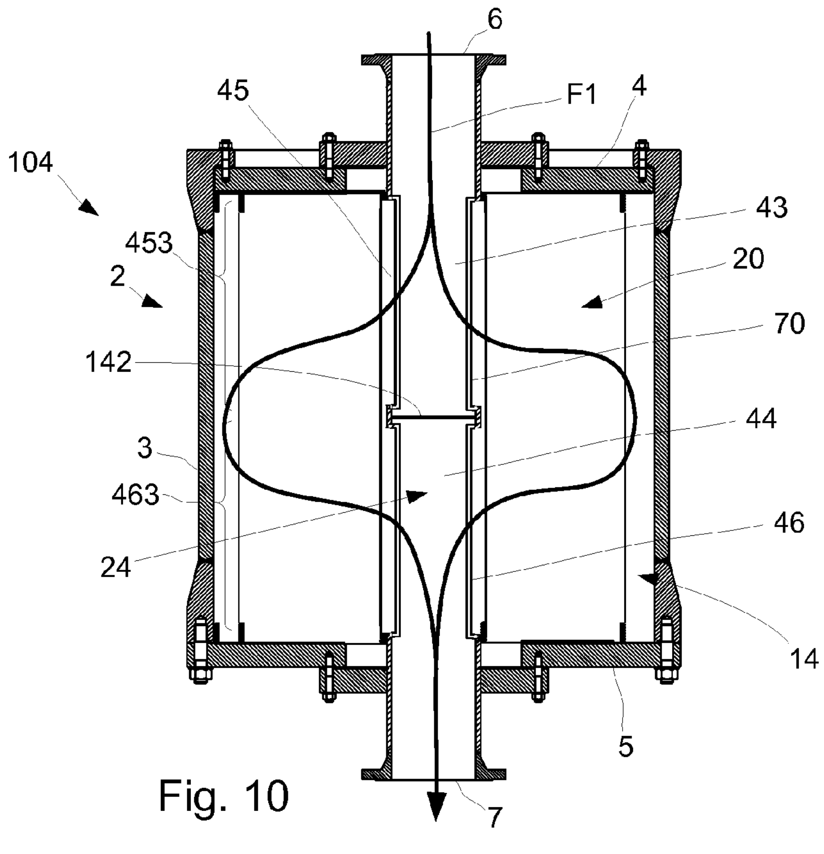
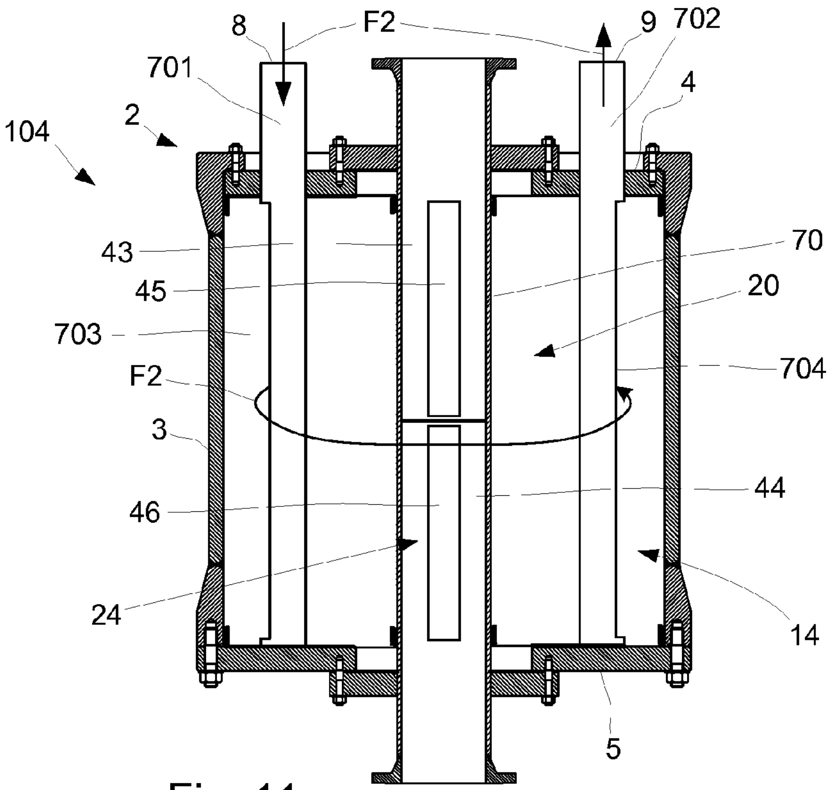

6
45
F1
4
104
43
453
20
2
70
142
44
3
463
46
24
14
5
7

Fig. 10


8
F2
9
702
701
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104
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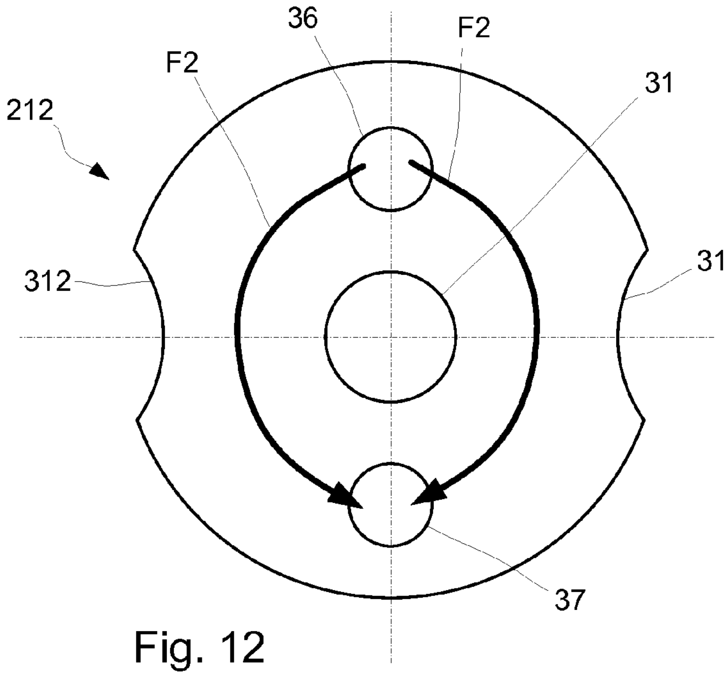
45
20
703
704
F2
3
46
44
24
14
5

Fig. 11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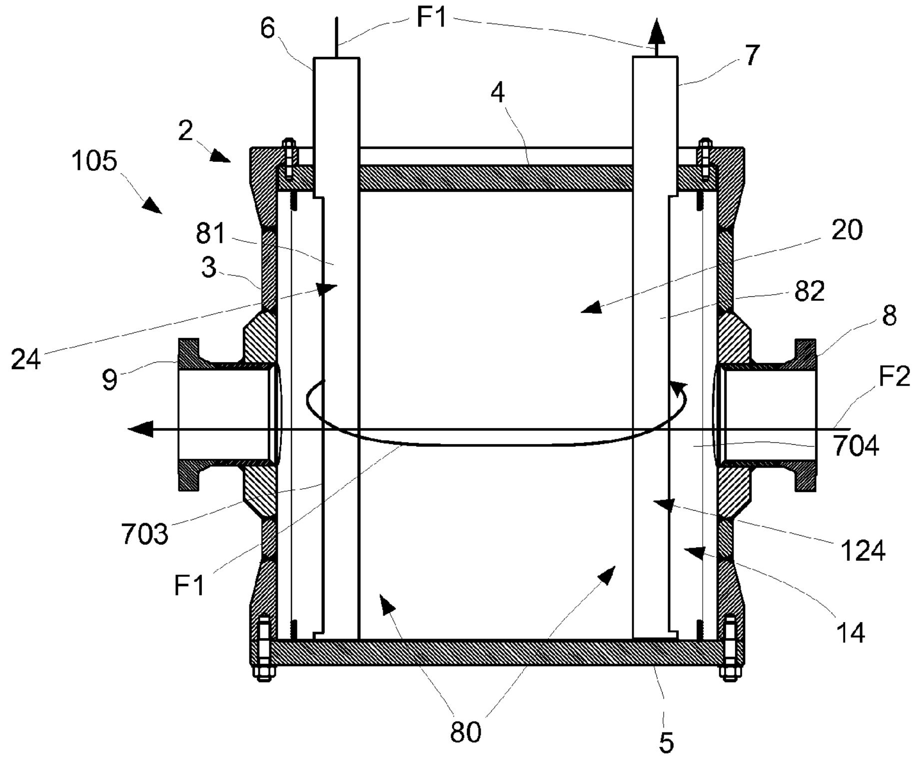
F2
F2
31
212
312
311
37

Fig. 12


F1
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7
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105
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3
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82
8
24
9
F2
704
703
124
F1
14
80
5

Fig. 13

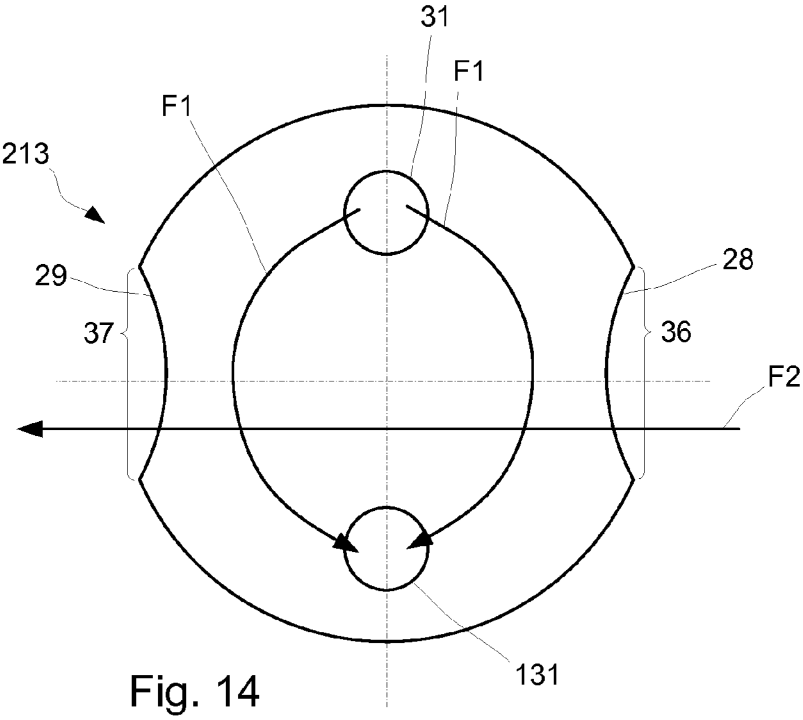
31
F1
F1
213
29
28
37
36
F2
131

Fig. 14

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EUROPEAN SEARCH REPORT

Application Number
EP 15 19 9454

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	FR 2 214 873 A1 (MODINE MFG CO [US]) 19 August 1974 (1974-08-19) * figure 4 * -----	1-11	INV. F28D9/00
A,D	WO 2007/114777 A1 (ALFA LAVAL CORP AB [SE]; BLOMGREN RALF ERIK [SE]) 11 October 2007 (2007-10-11) * figure 6 * -----	1-11	
A	EP 2 837 905 A1 (ALFA LAVAL CORP AB [SE]) 18 February 2015 (2015-02-18) * the whole document * -----	1-11	
A	EP 2 672 214 A1 (ALFA LAVAL CORP AB [SE]) 11 December 2013 (2013-12-11) * the whole document * -----	3	

TECHNICAL FIELDS SEARCHED (IPC)

F28D
F28F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	17 May 2016	Bain, David

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EPO FORM 1503 03.82 (P04C01)

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17-05-2016

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
FR 2214873	A1	19-08-1974	NONE			
WO 2007114777	A1	11-10-2007	BR	PI0709921	A2	26-07-2011
			CN	101416013	A	22-04-2009
			CN	101915512	A	15-12-2010
			EP	2002193	A1	17-12-2008
			JP	4897041	B2	14-03-2012
			JP	2009532659	A	10-09-2009
			RU	2008143985	A	20-05-2010
			US	2009090496	A1	09-04-2009
			US	2012285669	A1	15-11-2012
			WO	2007114777	A1	11-10-2007
EP 2837905	A1	18-02-2015	CN	105431703	A	23-03-2016
			EP	2837905	A1	18-02-2015
			WO	2015022098	A1	19-02-2015
EP 2672214	A1	11-12-2013	AU	2013270820	A1	22-01-2015
			CN	103512419	A	15-01-2014
			CN	203881198	U	15-10-2014
			EP	2672214	A1	11-12-2013
			EP	2856057	A1	08-04-2015
			JP	2015518955	A	06-07-2015
			KR	20150017368	A	16-02-2015
			TW	201413209	A	01-04-2014
			US	2015136371	A1	21-05-2015
			WO	2013182427	A1	12-12-2013

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Patent documents cited in the description

- EP 2002193 A1 **[0010]**