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(54) **PLATE HEAT EXCHANGER**

(57) A plate heat exchanger comprising a casing (2), a fluid separation device (40), a number of heat transfer plates (21-23) that are permanently joined to each other and have central openings (31) that that form a central space (24) in the plate stack (20) and in which the fluid separation device (40) is arranged, such that a first part (34) of the central opening (31) may act as a fluid inlet and a second part (35) of the central opening (31) may act as a fluid outlet for a first fluid (F1), opposite sides (36, 37) of the plates (21-23) act fluid entries and exits for a second fluid (F2), wherein two end plates (71, 72) have central through holes (73, 74) the ends of the plate stack (20), each of the end plates (71, 72) being thicker than the heat transfer plates (21-23), providing increased mechanical support for the plate stack (20), and having a slower thermal expansion.

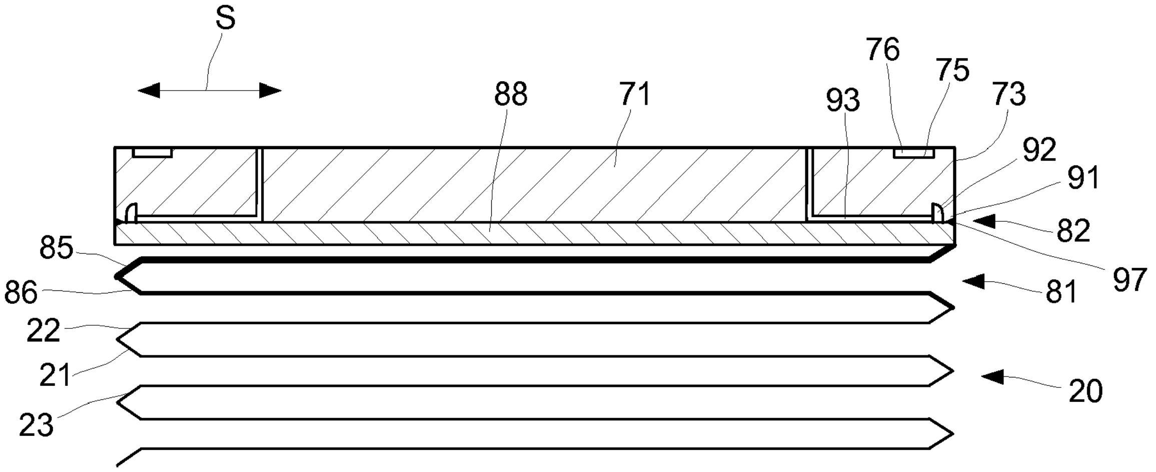

Fig. 8

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Description

Technical Field

[0001] The invention relates to a heat transfer plate of a type that has a central opening for receiving a fluid separation device that allows a first part of the central opening to act as a fluid inlet and a second part of the central opening to act as a fluid outlet.

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] For one type of plate heat exchangers, the so called central-port plate heat exchanger, each heat transfer plate has a central opening (central port) for the first fluid path. Fluid in the first fluid path enters a heat transfer plate at an inlet section of the central opening in the heat transfer plate, flows across the plate and leaves the plate at an outlet section of the same central opening. The outlet section is opposite the inlet section and a fluid separation device is inserted in the central opening for separating the fluid flow to the inlet section from the fluid flow from the outlet section. Thus, the same port is, by virtue of the separation device, used both as a fluid inlet and a fluid outlet for a fluid that flows over the heat transfer plate. Basically, the first fluid makes a 180° turn over the heat transfer plate, such that the first fluid leaves the plate at a location that is, as seen across the central opening, opposite the location where the first fluid entered the plate.

[0004] The second fluid 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.

[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 sealed to each other along their entire peripheries while the plates of a plate pair that have an inlet and outlet for the second fluid are sealed to each other at their central openings.

[0006] Since the heat transfer plates are surrounded by the casing, the central-port plate heat exchanger may withstand high pressure levels in comparison with many other types of plate heat exchangers. Still, the central-port plate heat exchanger is compact, it has good heat transfer properties and may withstand hard operation conditions without breaking.

[0007] The joined 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 an internal, central through hole that is characteristic for the central-port plate heat exchanger. The stack of heat transfer plates may be all-welded such that rubber gaskets may be omitted between heat transfer plates. This makes the central-port plate heat exchanger suitable for operation with a wide range of aggressive fluids, at high temperatures and at high pressures.

[0008] During maintenance of the central-port plate 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 central-port 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] The design of the central-port plate heat exchanger with its stack of heat transfer plates provides, as indicated, a combination of advantages and properties that are quite specific for the type. A number of embodiments of central-port plate heat exchangers have been disclosed, such as those found in patent document EP2002193A1. In comparison to several other types of plate heat exchangers, the central-port plate heat exchanger has a compact design and may withstand high pressure levels. However, it is estimated that the central-port plate heat exchanger may be improved in respect of its capability to handle internal stresses due du temperature changes that occur during operation of the heat exchanger.

Summary

[0011] It is an object of the invention to provide improved durability of a central-port plate heat exchanger. In particular, it is an object to improve the capability to handle temperature variations that cause parts of the heat exchangers to change volumes due to thermal expansion.

[0012] To solve these objects a plate heat exchanger is provided. The plate heat exchanger comprises: a casing; a fluid separation device; and a number of heat transfer plates that are joined to each other to form a plate stack that is arranged within the sealed 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 having: central openings that form a central space in the plate stack and in which the fluid separation device is arranged, such that a first part of the central opening may act as a fluid inlet and a second part of the central opening may act as a fluid outlet for the first fluid; and first sides that act as a fluid entries for the second fluid, and second sides that are opposite the first sides and act as fluid exits for the second fluid. A first end plate that has a central through hole is arranged at a first end of the plate stack. The end plate is thicker than the heat transfer plates for providing increased mechanical support for the plate stack, the end plate thereby, in response to a change in temperature and due to thermal expansion, expanding slower than the heat transfer plates.

[0013] 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

[0014] 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 central-port 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, as seen from a first side,

Fig. 4 is a side view of the flow divider of Fig. 3, as seen from a second side,

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 side view of a plate stack for the heat exchanger of Fig. 1,

Fig. 8 is an enlarged view of section D of Fig. 7, showing a part of the plate stack, including a first and a second embodiment of a thermal expansion catcher,

Fig. 9 is an enlarged view of section D of Fig. 7, showing a part of the plate stack, including the first and a third embodiment of a thermal expansion catcher,

Fig. 10 is an enlarged view of section D of Fig. 7, showing a part of the plate stack, including the first and a fourth embodiment of a thermal expansion catcher, and

Fig. 11 is an enlarged view of section D of Fig. 7, showing a part of the plate stack, including the first and the fourth embodiment of a thermal expansion catcher, but without an intermediate element.

Detailed description

[0015] With reference to Figs 1 and 2 a central-port plate heat exchanger 1 is illustrated. The heat exchanger 1 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 in 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.

[0016] The top cover 4 has a fluid inlet 6 for the first fluid F1 which passes through the heat exchanger 1 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 1 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. Thus, the first fluid inlet 6 and the first fluid outlet 7 are located opposite each other in the casing 2.

[0017] The cylindrical shell 3 has a fluid inlet 8 for the second fluid F2 which passes through the heat exchanger 1 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 1 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.

[0018] 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 form together a central space 24 in the stack 20.

[0019] 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 cylinder sections 43, 44. Instead, fluid flows from the first cylinder section 43 to the second cylinder section 44 via the heat transfer plates in the stack 20.

[0020] 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.

[0021] 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 sections 38 separate 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 34 for the first fluid F1. The first opening 45 of the separation device 40 faces the fluid inlet 34 and the second opening 46 of the separation device 40 faces the fluid outlet 46.

[0022] 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 that acts as a fluid entry for the second fluid F2, and a second 37 side 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 180° 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 three 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 lower heat transfer plate 23. The plates 22, 23 have central planes P2, P3 that correspond to a central plane P1 of plate 21. The interspace between the plates 21, 22 forms part of the first flow path 12 for the second fluid F2. The central plane P1 extends 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 heat transfer plate 21 may be partly joined with the upper heat transfer plate 22 at the central opening 31 of the heat transfer plate 21, i.e. the central opening 31 of the heat transfer plate 21 is partly joined with a similar central opening of the upper heat transfer plate 22. The central opening 31 of the heat transfer plate 21 is joined with the lower heat transfer plate 23 except for a first part (section) 34 and a second part (section) 35. The parts 34, 35 of the central openings that are not joined are defined by a respective angle α (the angle α is shown only for the second part 35). The parts 34, 35 are arranged symmetrically opposite each other and form the fluid inlet 34 for the first fluid F1 and fluid outlet 35 for the first fluid F1. Optionally, the plates 21, 23 are not joined at their central openings 31. Then the openings 45, 46 in the separation device 40 limit 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 upper heat transfer plate 22. The interspace between the plates 21, 22 forms part of the second flow path 12 for the second fluid F2.

[0026] The heat transfer plate 21 may also 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 is partly joined with a similar periphery of the upper heat transfer plate 22. A first part (section) 36 and a second part (section) 37 of the periphery 39 are not joined with the upper heat transfer plate 22. The parts 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 form the afore mentioned first side 36 that acts as a fluid entry for the second fluid F2, and the second 37 side that acts as a fluid exit 37 for the second fluid F2. It is not necessary to join the heat transfer plates 21, 22 at their peripheries. 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, even though some of the second fluid F2 might enter and exit the plates at sections outside the indicated sides 36, 37 of the plates.

[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. These gaskets or blockers should be located beyond the fluid entry 36 and the 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 upper adjacent heat transfer plate 22.

[0029] The heat transfer plates 21, 22, 23 may then be joined 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 23 along their central openings 31 at all sections but at the inlet 34 and the outlet 35. A seal may also be arranged between the cylindrical shell 3 and the heat transfer plates for sealing plates like plates 21 and 22 along their peripheries 39 at all peripheral sections but at the inlet 36 and the outlet 37.

[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 1.

[0031] 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 1 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, may accomplished by arranging a cut out 28 (see Fig. 1) 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 may be 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 cutout 29.

[0032] When the second fluid F2 has entered the fluid 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 fluid exits 37 and thereafter leaves the heat exchanger 1 via the second fluid outlet 9.

[0033] With reference to Fig. 7 a first end plate 71 that has a central through hole 73, i.e. a central opening 73, is arranged at a first end of the plate stack 20. A second end plate 72 that also has a central through hole 74 is arranged at a second end of the plate stack 20. The first end plate 71 abuts the top cover 4 and the second end plate 5 abuts the bottom cover 5 when the stack 20 is installed in the plate heat exchanger 1. With further reference to Fig. 8, each end plate 71, 72 has circular grooves in which gaskets are arranged, preferably at both the circumferential periphery of the end plate and at the center hole of the end plate, such as groove 75 and gasket 76 at the through hole 73 in the first end plate 72. The plate stack 20 is centered around an axis A3 that extends through the inlet 6, through the center C of the heat transfer plates and through the outlet 7.

[0034] Basically, the end plates 71, 72 have the same shape as the heat transfer plate 21 shown in Fig. 5 i.e. the form of a circular disc with a circular through hole in the center of the disc. Each of the end plates 71, 72 is thicker than the heat transfer plates 21-23 in the plate stack 20, which provides increased mechanical support and improved durability for the plate stack 20. Since the end plates 71,72 are thicker than heat transfer plates 21, 22, 23, the end plates 71, 72 change, in response to a change in temperature and due to thermal expansion, their volume slower than the heat transfer plates 21-23 change their volume.

[0035] Turning to Fig. 8, the plate heat exchanger 1 has a thermal expansion catcher 81 that is arranged between the first end plate 71 and the plate stack 20. The thermal expansion catcher 81 catches stresses along a direction S that is parallel to a plane of the heat transfer plates 21 in the stack 20, such as plane P1, P2 or P3 (see Fig. 6). Such stresses occur e.g. when the heat transfer plates 21 change their individual volume due to thermal expansion during a rise of temperature, since they expand faster than the thicker end plate 71 by virtue of having a lower mass.

[0036] The expansion catcher 81 has a reinforcing heat transfer plate 85 that is thicker than the heat transfer plates 21-23 but thinner than the end plates 71, 72. Apart from the thickness of the reinforcing heat transfer plate 85, it may have the same shape as the heat transfer plate 21. For example, the heat transfer plate 21 may be 1 mm thick and the reinforcing heat transfer plate 85 may be 2 mm thick. The expansion catcher 81 may have an additional reinforcing heat transfer plate 86 that is arranged between the reinforcing heat transfer plate 85 and the plate stack 20. The additional reinforcing heat transfer plate 86 is thicker than the heat transfer plates 21-23 but thinner than the reinforcing heat transfer plate 85. Apart from the thickness of the additional reinforcing heat transfer plate 86, it may have the same shape as the heat transfer plate 21. The additional reinforcing heat transfer plate 86 may be 1,5 mm thick. The end plate 71 is typically at least 10 mm thick.

[0037] Since the thickens of the plates 21, 85, 86 determines the mass of the plates, thicker plates change their volume slower than thinner ones due to a slower thermal expansion in response temperature changes. This means that stresses at weld joints at the peripheries and central openings of the plates are subjected to less stress, in comparison with e.g. the case where a heat transfer plate 21 is welded directly to the end plate 71. The reinforcing heat transfer plate 85 and the additional reinforcing heat transfer plate 86 are welded to adjacent heat transfer plate in a manner just like the heat transfer plates 21-23 are welded to each other. The reinforcing heat transfer plate 85 it typically welded at its central opening to the end plate 71. However, in the illustrated embodiment the reinforcing heat transfer plate 85 is welded at its central opening to an intermediate element 88, or flat plate 88 that is located between the end plate 71 and the reinforcing heat transfer plate 85. Thus, as may be seen, the end plate 71 is welded to the plate stack 20, either directly or via the thermal expansion catcher 81, along the central through hole 73.

[0038] The intermediate element 88 has the shape of a flat, circular disk, with a hole through its center. The size of the intermediate element 88 corresponds to the size of the heat transfer plate 21, including the hole in the center, which corresponds to the central opening 31 of the heat transfer plate. The intermediate element 88 is at its peripheral edge welded to the end plate 71, see weld joint 97. When the intermediate element 88 is used it is preferably thicker than the heat transfer plates 21-23 but thinner than the end plates 71, 72. When used in combination with the reinforcing heat transfer plate 85, 86, it is preferably thicker than those plates 85, 86. Since the intermediate element 88 has such thickness relative the other elements, it acts as an expansion catcher as well, and it can be used in any combination with the other expansion catching elements described herein.

[0039] The thermal expansion catcher 81 can be used alone, i.e. the reinforcing heat transfer plate 85 may be welded to the intermediate element 88 or directly to the end plate 71 if the intermediate plate is omitted, but is in the illustrated embodiment combined with a second thermal expansion catcher 82. The second thermal expansion catcher 82 has a peripheral lip 91 that extends from the end plate 71, towards the plate stack 20 and into, via the intermediate element 88, contact with the plate stack 20 to which the lip 91 is, via the intermedia element 88, fixedly attached. Thus, the peripheral lip 91 is in contact with and connected to the plate stack 20 via the intermedia element 88. A groove 92 is located behind the lip 91 for allowing the lip 91 to flex in the direction S when the heat transfer plates 21-23 change their volume due to thermal expansion. A channel 93 extends from the groove 92. The second thermal expansion catcher 82 may be used alone, i.e. without the (first) thermal expansion catcher 81. Then the peripheral lip 91 is welded directly to the intermediate element 88, which in turn is welded to the adjacent heat transfer plate in the plate stack 20. If the intermediate element 88 is omitted, then the peripheral lip 91 is welded directly to the adjacent heat transfer plate in the plate stack 20.

[0040] With reference to Fig. 9 a third thermal expansion catcher 83 is illustrated, which can be used alone or in combination with one or both of the other thermal expansion catchers 81, 82. The third thermal expansion catcher 83 has a gasket 96 that is located in a groove 95 that is oriented towards the plate stack 20. The gasket 96 and groove 95 are located near the central through hole 73. A corresponding gasket and groove are located at the peripheral edge of the end plate. When the third thermal expansion catcher 83 is used, then the end plate 71 is not welded to the intermediate element 88. Instead the end plate 71 is movable relative the intermediate element 88 in the direction S of flexing, i.e. the direction S in which the thermal expansion should be caught.

[0041] With reference to Fig. 10 a fourth thermal expansion catcher 84 is illustrated together with the first expansion catcher 81. The fourth thermal expansion catcher 84 has the form of a ring 98 that is located at the through hole 73 of the end plate 71. The ring 98 has a hole that is aligned with the through hole 73 of the end plate 71. The fourth thermal expansion catcher 84 has a peripheral lip 91 that extends from the end plate 71, towards the plate stack 20 and into contact with a protrusion 99 that extends from the ring 98. The protrusion 99 and the peripheral lip 91 are at their contact surfaces welded to each other, such that a circular weld is formed around the through hole 73 of the end plate 71. The ring 99 has a surface 100 that abuts the end plate 71 and is moveable relative the end plate 71. The ring 98 is fixedly attached to the plate stack 20 via the intermediate element 88. Specifically, the ring 98 is in the illustrated embodiment welded to the intermediate element 88 by weld 97. The intermediate element 88 is welded to the uppermost heat transfer plate 85 by a weld around the central opening 31 of the plate 85. A groove 92 is located behind the lip 91 and the protrusion 99 for allowing both the lip 91 and the protrusion 99 to flex in the direction S when the heat transfer plates 21-23 change their volume due to thermal expansion. Another groove 101 is located between the ring 98 and the end plate 71, as seen in the direction S of the flexing of the lip 91 and the protrusion 99. The direction S is thus the direction in which thermal expansion shall be caught.

[0042] The fourth thermal expansion catcher 84 may be used alone, i.e. without the first thermal expansion catcher 81. It is also possible to omit the intermediate element 88. Then the expansion catcher 81 may arranged as shown in Fig. 11, where the ring 98 is directly welded to the end plate 71 at its protrusion 99, and to the uppermost heat transfer plate 85 at its lower side that abuts the edge of the heat transfer plate 85 that forms the central opening 31 of the plate 85, i.e. at weld 97 (see Fig. 11). The intermediate element 88 may be omitted for the other thermal expansion catchers 81, 82, 83 as well, in which case the end plate 71 is directly welded to the uppermost heat transfer plate in the plate stack 20, i.e. to the heat transfer plate that is adjacent the end plate 71. When the intermediate element 88 is omitted, then the heat transfer plates that abut an end plate may be given a flat portion around its central opening, such that the flat portion closely abuts the adjacent endplate. A corresponding flat portion may be arranged at the periphery of the plate if a thermal expansion catcher is used there as well.

[0043] All gaskets and groves that are used for the end plate 71 and the thermal expansion catchers typically have the shape of circular rings. The same type of thermal expansion catcher that has been described as located at the through hole 73 may be located at the outer periphery of the end plate, but as arranged as a mirror reflection to the expansion catcher that is located at the through hole 73. The same expansion catcher(s) is preferably implemented for the second end plate 72, i.e. the second end plate 71 may be arranged in the same way as the first end plate 71 apart from being located at another end of the plate stack 20. The second end plate 72 may thus comprise the same features as the first end plate, which means that one or more expansion catcher like the above described expansion catchers 81-84 may be arranged between the second end plate 72 and the plate stack 20.

[0044] Even if it is possible to have expansion catchers both at the central openings 31 and the peripheries 39 of the heat transfer plate 21, it may suffice to have expansion catchers at the one of the central openings 31 and the peripheries 39. For the illustrated central-port plate heat exchanger 1 it is enough to have an expansion catcher at the central openings 31, between the plate stack 20 and the one or two end plates 71,72 that are used.

[0045] 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 forms an enclosure (14),
a fluid separation device (40),
a number of heat transfer plates (21-23) that are 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

    - central openings (31) that form a central space (24) in the plate stack (20) and in which the fluid separation device (40) is arranged, such that a first part (34) of the central opening (31) may act as a fluid inlet and a second part (35) of the central opening (31) may act as a fluid outlet for the first fluid (F1),
    - first sides (36) that act as a fluid entries for the second fluid (F2), and second sides (37) that are opposite the first sides (36) and act as fluid exits for the second fluid (F2),

    wherein
    an end plate (71) that has a central through hole (73) is arranged at a first end of the plate stack (20),
    the end plate (71) being thicker than the heat transfer plates (21-23) for providing increased mechanical support for the plate stack (20), the end plate (71) thereby, in response to a change in temperature and due to thermal expansion, expanding slower than the transfer plates (21-23).

2. A plate heat exchanger according to claim 1, wherein a thermal expansion catcher (81-84) is arranged between the end plate (71) and the plate stack (20).

3. A plate heat exchanger according to claim 1 or 2, wherein the expansion catcher (81) comprise a reinforcing heat transfer plate (85) that is thicker than the heat transfer plates (21-23) and thinner than the end plate (71).

4. A plate heat exchanger according to claim 3, wherein the expansion catcher (81) comprises a respective additional reinforcing heat transfer plate (86) that is arranged between the reinforcing heat transfer plate (85) and the plate stack (20), and which is thicker than the heat transfer plates (21-23) and thinner than the reinforcing heat transfer plate (85).

5. A plate heat exchanger according to any one of claims 2 - 4, wherein the expansion catcher (82) comprises a peripheral lip (91) that extends from the end plate (71), towards the plate stack (20) and into direct or indirect, via an intermediate element (88, 98), contact with the plate stack (20) to which the lip (91) is, directly or via the intermediate element (88, 98), fixedly attached, a groove (92) being located behind the lip (91) for allowing the lip (91) to flex when the

heat transfer plates (21-23) change their volume due to thermal expansion.

6. A plate heat exchanger according to claim 5, wherein the expansion catcher (84) comprises a ring (98) to which the peripheral lip (91) is connected, the ring (98) having a surface (100) that abuts the end plate (71) and is moveable relative the end plate (71), the ring (98) being directly or via the intermediate element (88) fixedly attached to the plate stack (20).

7. A plate heat exchanger according to any one of claims 2 - 6, wherein the expansion catcher (83) comprises a gasket (96) that is located in a groove (95) that is oriented towards the plate stack (20).

8. A plate heat exchanger according to any one of claims 2 - 7, wherein the expansion catcher (81-83) comprise a flat plate (88) that is thicker than the heat transfer plates (21-23) and thinner than the end plate (71).

9. A plate heat exchanger according to any one of claims 1 - 8, wherein the end plate (71) is welded to the plate stack (20), either directly or via the thermal expansion catcher (81-83).

10. A plate heat exchanger according to claim 10, wherein the end plate (71) is welded to the plate stack (20), either directly or via the thermal expansion catcher (81-83), along the central through hole (73) of the end plate (71).

11. A plate heat exchanger according to claim 10, wherein the a thermal expansion catcher (81-83) catches stresses along a direction that is parallel to a plane (P1) of the heat transfer plates (21-23), when the heat transfer plates (21-23) change their volume due to thermal expansion.

12. A plate heat exchanger according to any one of claims 1 - 11, wherein a second end plate (72) that has a central through hole (74) is arranged at a second end of the plate stack (20).

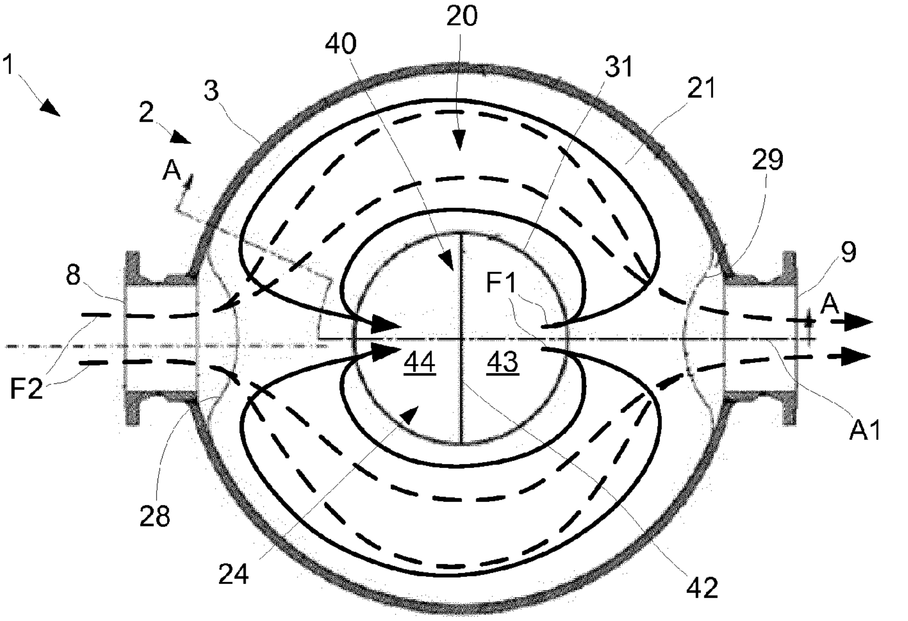


Fig. 1 (B-B)

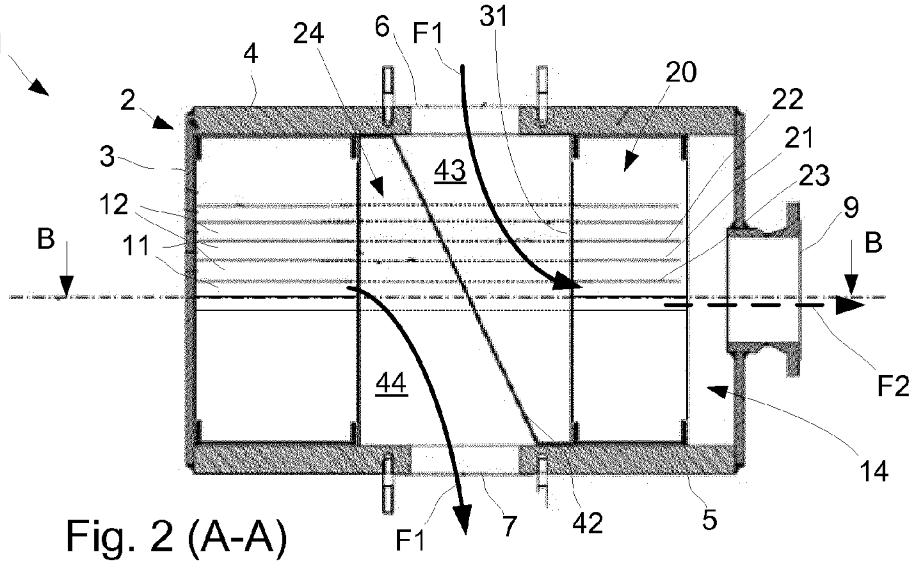
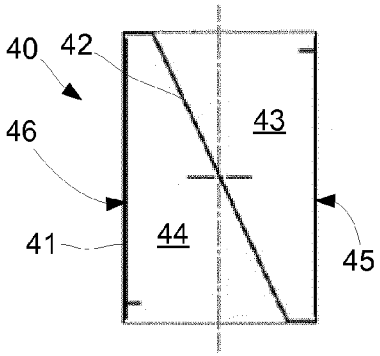


Fig. 2 (A-A)



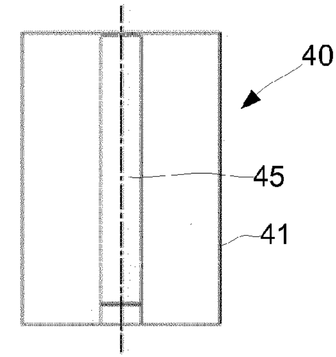


Fig. 3

Fig. 4

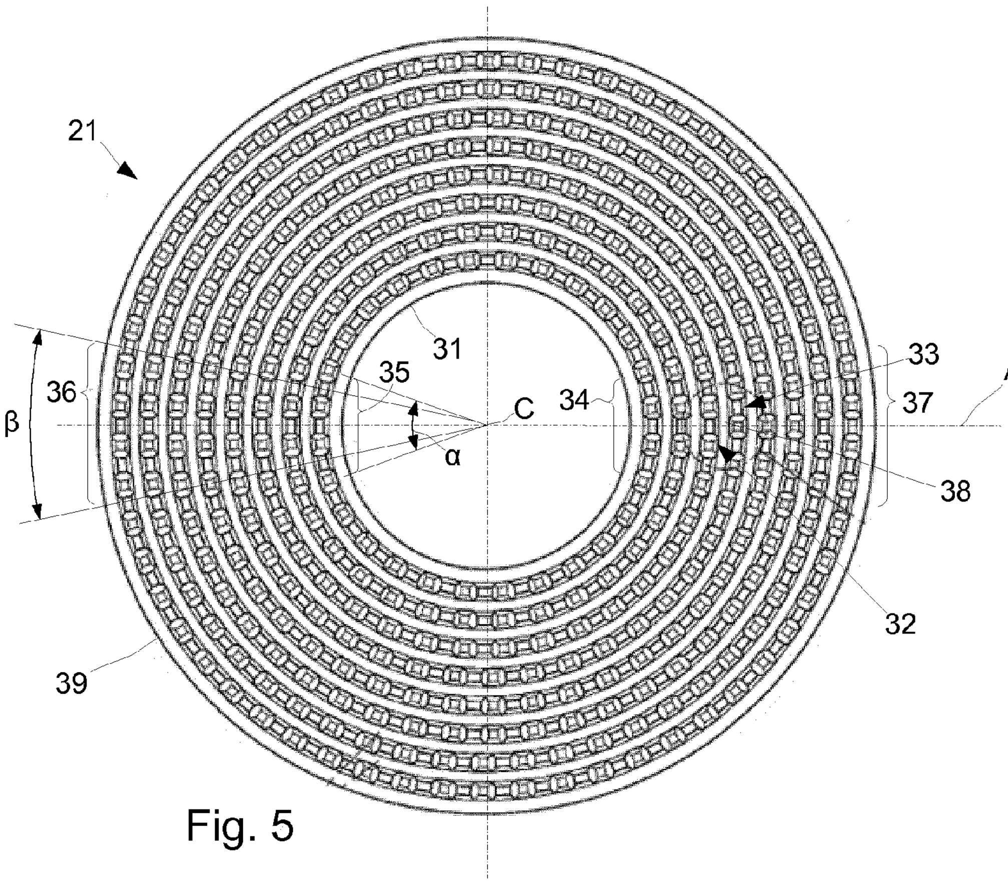


Fig. 5

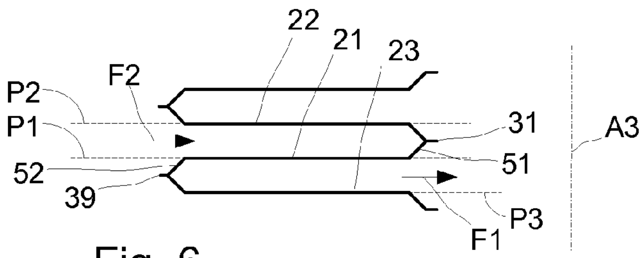


Fig. 6

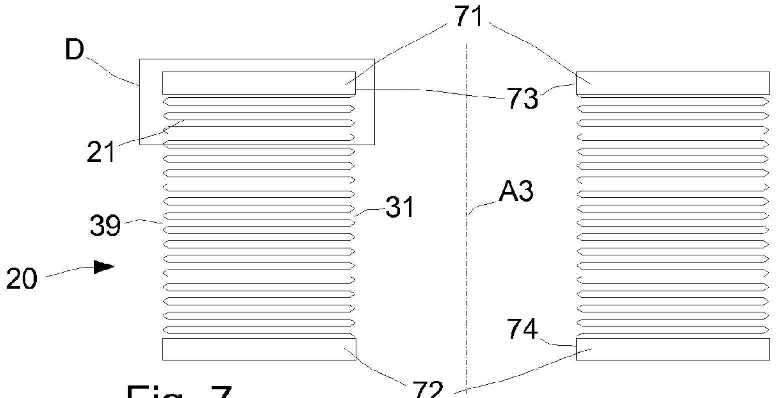


Fig. 7

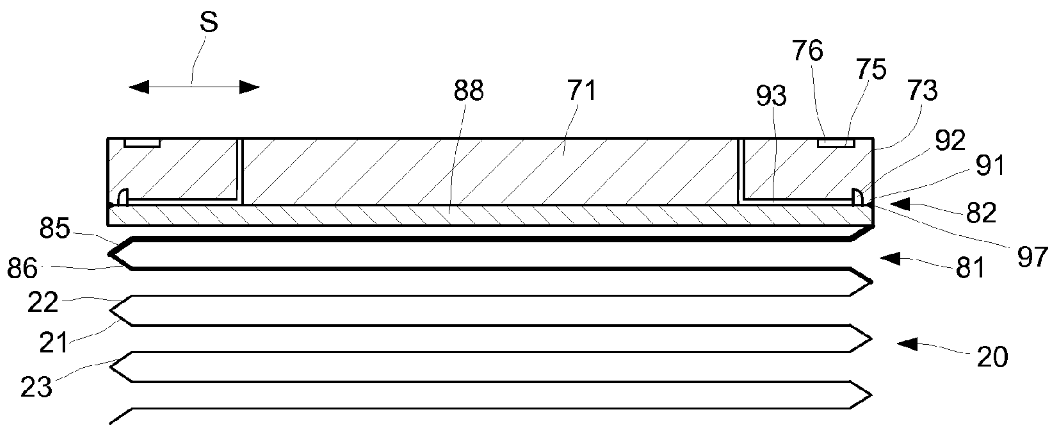


Fig. 8

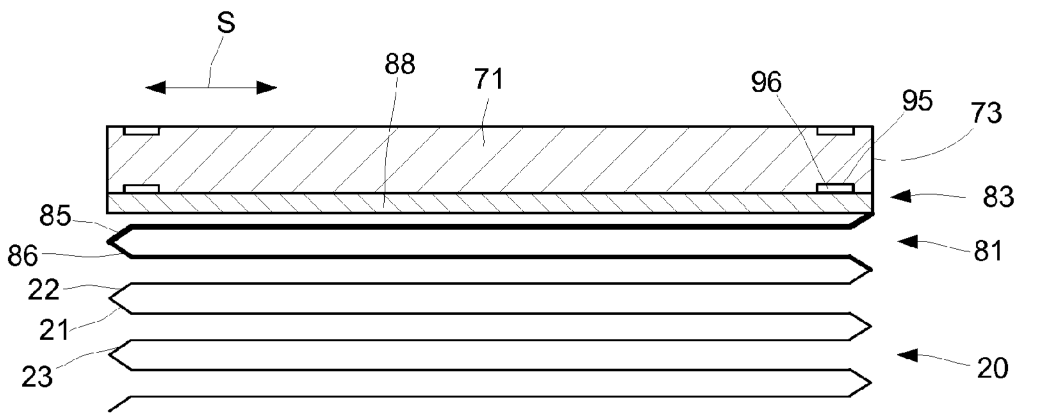


Fig. 9

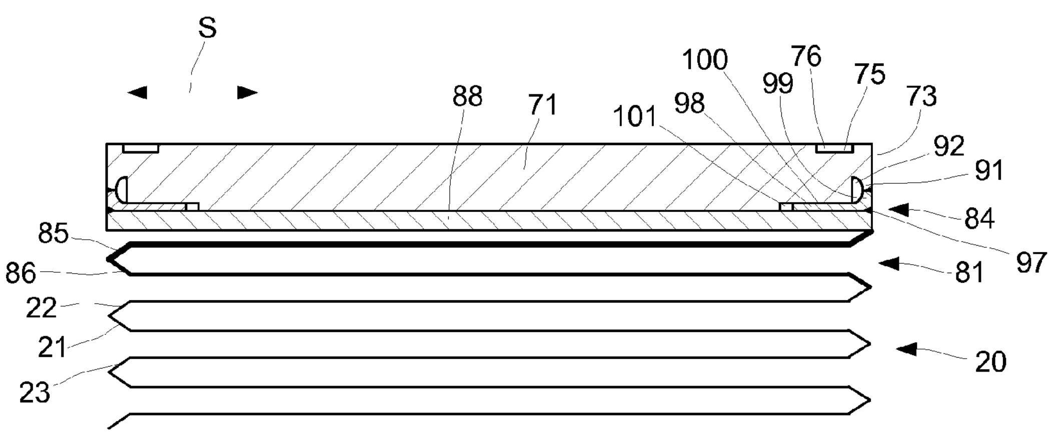


Fig. 10

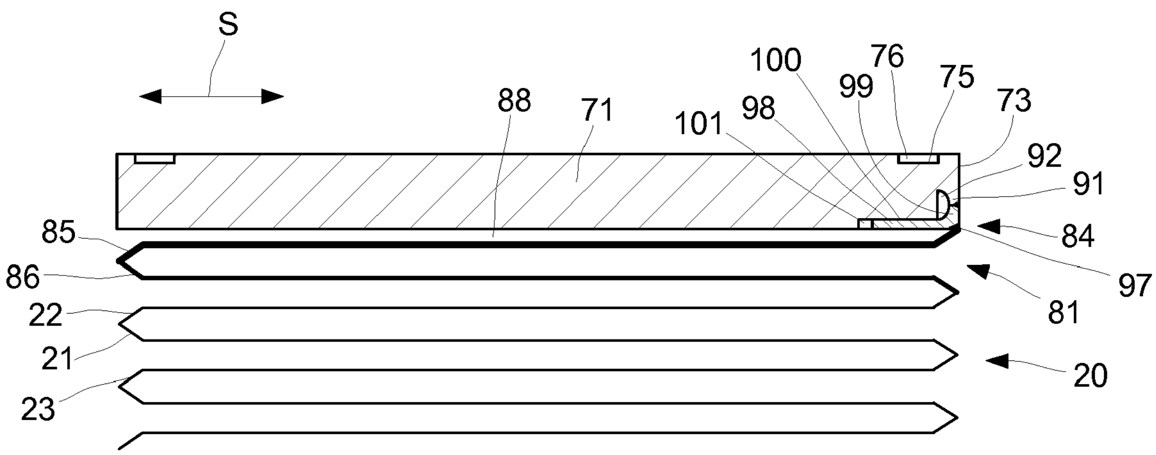


Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 15 17 4726

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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	8 December 2015	Bain, David

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