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(54) **HEAT TRANSFER PLATE**

(57) A corrugated heat transfer plate (5, 90, 92). It has opposing front and back sides (7, 9) and comprises a first end portion (11), a center portion (13) and a second end portion (15). It further comprises first and third portholes (17, 19) arranged within the first end portion (11), second and fourth portholes (27, 29) arranged within the second end portion (15), and a heat transfer area (4) comprising alternately arranged elongate ridges (6) and valleys (8) and being arranged within the center portion (13). An outer front field gasket groove (36) extends on the front side (7) and encloses the heat transfer area (4), while a back field sealing area (40) extends on the back side (9) and encloses the heat transfer area (4). The heat transfer plate (5, 90, 92) is characterized in that it further comprises a fifth porthole (21) arranged within the first end portion (11), a first transfer hole (25) arranged within a first half (h1) of the heat transfer plate (5, 90, 92), and a second transfer hole (35) arranged within a second half (h2) of the heat transfer plate (5, 90, 92). The first and second transfer holes (25, 35) are arranged within the outer front field gasket groove (36) and outside the back field sealing area 40. The first and second portholes (17, 27) are arranged within the back field sealing area (40), the third, fourth and fifth portholes (19, 29, 21) are arranged outside the back field sealing area (40), and the first, second, third, fourth and fifth portholes (17, 27, 19, 29, 21) are arranged outside the outer front field gasket groove (36).

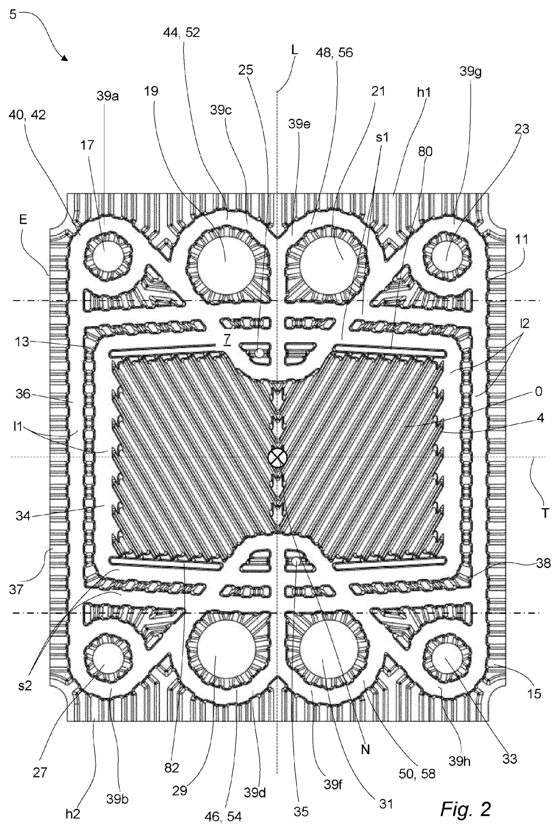

Fig. 2

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Description

Technical Field

[0001] The invention relates to a corrugated heat transfer plate. The heat transfer plate may be comprised in a device used for a heat generating process, such as electrolysis.

Background Art

[0002] Electrolysis is a well known process of using electricity to chemically decompose an electrolyte. For example, electrolysis can be used to split water contained in an electrolyte into hydrogen and oxygen. During electrolysis, heat may be generated, which heat may have to be diverted for maintained electrolysis efficiency.

[0003] EP 4012070 discloses a heat exchanger comprising a stack of heat transfer plates. The heat exchanger is adapted for connection to an electrolyzing device such that fluids circulating in the electrolyzing device are made to pass the heat exchanger for regulation of their temperatures. Typically, the temperature of the fluids gradually increases inside the electrolyzing device. Thus, the heat exchanger receives fluids of relatively high temperature from the electrolyzing device and delivers fluids of relatively low temperature to the electrolyzing device, which means that there will be a temperature difference across the electrolyzing device. This may result in an uneven and non-optimal electrolysis process inside the electrolyzing device. The heat exchanger in EP 4012070 is a so called plate-and-shell heat exchanger. Several other types of heat exchangers exist, for example so-called plate heat exchangers. A plate heat exchanger typically comprises a number of corrugated heat transfer plates arranged aligned in a stack or pack. Sealings between the heat transfer plates define parallel flow channels between the heat transfer plates, one flow channel between each pair of adjacent heat transfer plates. Two fluids of initially different temperatures can be fed alternately through every second flow channel for transferring heat from one fluid to the other.

Summary

[0004] An object of the present invention is to provide a heat transfer plates so as to enable realization of a reliable and mechanically uncomplicated device comprising said heat transfer plate as part of a stack of corrugated heat transfer plates forming alternately arranged first and second plate interspaces, which device may be used for a heat generating process, such as electrolysis, and which device may allow a more uniform and effective cooling of a fluid, such as an electrolyte, and the products formed therefrom, so as to enable a maintained high process efficiency. The basic concept of the invention is to offer a heat transfer plate that may enable cooling in the first interspaces such that a heat generating process can be effectively maintained in the second interspaces, which heat transfer plate allows use of the first interspaces to feed fluids into, and out of, the second interspaces. Thus, the basic concept of the invention is to offer a heat transfer plate that enables a device for performing a heat generating process, such as electrolysis, which device, at the same time, may function as a traditional heat exchanger so as to provide cooling "integrated" in the heat generating process.

[0005] The heat transfer plate may be used in a device for production of hydrogen.

[0006] Since the heat transfer plate according to the invention is not arranged for use on its own, but as a component of a device as described above, the advantages of different features and embodiments of the heat transfer plate appears first when the heat transfer plate is installed in the device.

[0007] A heat transfer plate according to the invention is corrugated and has opposing front and back sides. It comprises a first end portion, a center portion and a second end portion arranged in succession along a longitudinal center axis of the heat transfer plate. The heat transfer plate further comprises first and third portholes arranged within the first end portion, and second and fourth portholes arranged within the second end portion. Further, the heat transfer plate comprises a heat transfer area which is arranged within the center portion. The heat transfer area is provided with a heat transfer corrugation pattern comprising alternately arranged elongate ridges and valleys as seen from the front side of the heat transfer plate. The heat transfer plate also comprises an annular outer front field gasket groove, which extends on the front side and encloses the heat transfer area, and an annular back field sealing area, which extends on the back side and encloses the heat transfer area. The heat transfer plate is characterized in that it further comprises a fifth porthole, which is arranged within the first end portion, a first transfer hole, which is arranged within a first half of the heat transfer plate comprising the first end portion, and a second transfer hole, which is arranged within a second half of the heat transfer plate comprising the second end portion. The first and second transfer holes are arranged within the outer front field gasket groove and outside the back field sealing area. The first and second portholes are arranged within the back field sealing area while the third, fourth and fifth portholes are arranged outside the back field sealing area. The first, second, third, fourth and fifth portholes are arranged outside the outer front field gasket groove.

[0008] The outer front field gasket groove is arranged to receive an outer front field gasket part configured to seal between the heat transfer plate and an adjacent heat transfer plate arranged on the front side of the heat transfer plate. Similarly, the back field sealing area is arranged to accommodate a sealing, such as a weld or a back field gasket part, configured to seal between the heat transfer plate and an adjacent heat transfer plate arranged on the back side of the heat transfer plate.

[0009] The first and second halves of the heat transfer plate are arranged on opposite sides of a transverse center axis of the heat transfer plate.

[0010] The ridges and valleys of the heat transfer corrugation pattern may extend in and between an imaginary first plane and an imaginary second plane, facing the front side and the back side, respectively, of the heat transfer plate.

[0011] It should be stressed that "annular" not necessarily is circular but may be any "closed" shape, such as oval, polygonal or any combination thereof. Similarly, "ring" does not necessarily mean circular but may mean any "closed" shape, such as oval, polygonal or any combination thereof.

[0012] Further, it should be stressed that herein, when it is said that, for example, detail A extends "along" detail B, detail A may extend immediately at, or at a distance from, detail B, parallel or not to detail B.

[0013] Thus, the inventive heat transfer plate enables a device comprising at least five ports which may be necessary for performing a heat generating process, such as electrolysis, with integrated cooling. The provision of the first and second transfer holes within the outer front field gasket groove and outside the back field sealing area enables use of the first interspaces to feed fluids into, and out of, the second interspaces, in a device comprising the heat transfer plate, as will be discussed below.

[0014] The heat transfer plate may be such that a sixth porthole is arranged within the second end portion. The sixth porthole may be arranged outside the outer front field gasket groove and outside the back field sealing area just like the third, fourth and fifth portholes so as to enable the formation of two inlet ports and two outlet ports for a second fluid in a device comprising the heat transfer plate.

[0015] The heat transfer plate may further comprise a seventh porthole arranged within the first end portion and an eighth porthole arranged within the second end portion. The seventh and eighth portholes may be arranged within the back field sealing area and outside the outer front field gasket groove just like the first and second portholes so as to enable the formation of two inlet ports and two outlet ports for a first fluid in a device comprising the heat transfer plate. If the first fluid is a cooling fluid, this configuration may enable a more efficient cooling.

[0016] The first, third, fifth and seventh portholes may be mirrorings, across a transverse center axis of the heat transfer plate, of the second, fourth, sixth and eighth, respectively, portholes. Further, the first, second, third and fourth portholes may be mirrorings, across the longitudinal center axis of the heat transfer plate, of the seventh, eighth, fifth and sixth, respectively, portholes. Such a configuration may enable a device comprising a plurality of heat transfer plates according to the invention "rotated" or "flipped" in relation to each other. In a stack of "rotated" heat transfer plates, the heat transfer plates are arranged back side to front side, and every second heat transfer plate is turned upside down in relation to the rest of the heat transfer plates. In a stack of "flipped" heat transfer plates, the heat transfer plates are arranged front side to front side, and every second heat transfer plate is turned upside down in relation to the rest of the heat transfer plates.

[0017] The outer front field gasket groove of the heat transfer plate may comprise separated first and second long side portions and separated first and second short side portions. The long side portions may extend along the longitudinal center axis of the heat transfer plate and the short side portions may each connect the first and second long side portions. A distance between the first and second short side portions, which distance is measured parallel to the longitudinal center axis, may vary along a transverse center axis of the heat transfer plate. The transverse center axis of the heat transfer plate extends perpendicular to the longitudinal center axis of the heat transfer plate. As an example, depending on the design of the rest of the heat transfer plate, the short side portions of the outer front field gasket groove may be bulging away from, or towards, each other, as seen from a center of the heat transfer plate. Such a design may improve a fluid collection and fluid distribution across the heat transfer plate.

[0018] The heat transfer plate may further comprise annular third, fourth, fifth and sixth back ring sealing areas enclosing the third, fourth, fifth and sixth portholes, respectively. One of the third and the fifth back ring sealing areas may also enclose the first transfer hole, and one of the fourth and sixth back ring sealing areas may also enclose the second transfer hole. Each of the back ring sealing areas may be arranged to accommodate a sealing, such as a weld or a back ring gasket part, configured to seal between the heat transfer plate and an adjacent heat transfer plate arranged on the back side of the heat transfer plate. A sealing enclosing both one of the portholes and one of the transfer holes may define a flow path between these two.

[0019] A heat transfer plate according to any of the preceding claims, wherein the back field sealing area comprises an annular back field gasket groove. The back field gasket groove may be arranged to receive a back field gasket part configured to seal between the heat transfer plate and an adjacent heat transfer plate arranged on the back side of the heat transfer plate. Sealings in the form of gaskets between heat transfer plates may facilitate maintenance of a device comprising the gaskets and the heat transfer plates.

[0020] The front field gasket groove and the back field sealing area may at least partly be aligned and comprise opposite sides of the same section of the heat transfer plate. This section of the heat transfer plate may extend in the second plane if the back field sealing area is arranged to accommodate a weld, and between, possibly halfway between, the first and second planes, if the back field sealing area comprises a back field gasket groove.

[0021] The heat transfer plate may be so designed that the heat transfer area comprises an intermediate part extending along the longitudinal center axis. At least a majority of the ridges extending at least partly within the intermediate part may have a locally reduced height within the intermediate part. Such a design may enable the formation of a recirculation channel at the intermediate part of the heat transfer area on the front side of the heat transfer plate, in a device comprising the heat transfer plate. The recirculation channel may enable recirculation of a second fluid in the second interspaces of the device, which may optimize a heat generating process, such as electrolysis, in the device.

[0022] The intermediate part may extend in different places. According to one embodiment of the invention, the heat transfer area comprises a first and a second field, which first and second fields extend on opposite sides of an imaginary first line which extends along the longitudinal center axis of the heat transfer plate. The first field comprises first ridges and first valleys of said ridges and valleys, and the second field comprises second ridges and second valleys of said ridges and valleys. The first ridges and the first valleys within the first field, and the second ridges and the second valleys within the second field, are inclined, in opposite directions, in relation to the imaginary first line. The intermediate part extends along said imaginary first line and comprises a border between the first and second fields. According to this embodiment, the first and second ridges and the first and second valleys form arrows with arrow heads arranged along said imaginary first line, and the first and second ridges have a lower height at the arrow heads.

[0023] The intermediate part may be at least partly coated with an insulating material on the front side of the heat transfer plate. Such a configuration means that the heat transfer plate is coated where the ridges have a reduced heigh, i.e. at the recirculation channel. In a device comprising the heat transfer plate, the coating may inhibit the heat generating process in the intermediate part which may promote the recirculation of a second fluid in the second interspaces of the device.

[0024] The heat transfer plate may be so designed that at least a majority of the ridges extending from a first outer longitudinal border of the heat transfer area, which first outer longitudinal border extends along the longitudinal center axis, have a locally reduced height within a first outer longitudinal part of the heat transfer area. The first outer longitudinal part may extend along, and comprise, the first outer longitudinal border. Such a design may enable the formation of a recirculation channel at the first outer longitudinal part of the heat transfer area on the front side of the heat transfer plate, in a device comprising the heat transfer plate. The recirculation channel may enable recirculation of a second fluid in the second interspaces of the device, which may optimize a heat generating process, such as electrolysis, in the device.

[0025] The first outer longitudinal part may be at least partly coated with an insulating material on the front side of the heat transfer plate. Such a configuration means that the heat transfer plate is coated where the ridges have a reduced heigh. In a device comprising the heat transfer plate, the coating may inhibit the heat generating process in the first outer longitudinal part which may promote the recirculation of a second fluid in the second interspaces of the device.

[0026] The heat transfer area may comprise a similarly configured opposing second outer longitudinal part extending along, and comprising, a second outer longitudinal border of the heat transfer area.

[0027] The heat transfer plate may be such that at least a majority of the ridges extending from a first outer transverse border of the heat transfer area, which first outer transverse border crosses an imaginary second line extending parallel to the longitudinal center axis, have a locally reduced height within a first outer transverse part of the heat transfer area. The first outer transverse part may extend along, and comprise, the first outer transverse border. Such a design may enable the formation of a transfer channel at the first transverse longitudinal part of the heat transfer area on the front side of the heat transfer plate, in a device comprising the heat transfer plate. The transfer channel may aid in collecting or distributing a second fluid in the second interspaces of the device.

[0028] The heat transfer area may comprise a similarly configured opposing second outer transverse part.

[0029] The heat transfer plate may further comprise a first transverse ridge which crosses an imaginary third line extending parallel to the longitudinal center axis, which first transverse ridge extends outside and borders on the heat transfer corrugation pattern. The first transverse ridge may extend within the outer front field gasket groove. The first transverse ridge may prevent that a second fluid is trapped inside the second interspaces of a device comprising the heat transfer plate. The first transverse ridge may have different configurations. As an example, it may extend, possibly intermittently, all the way between the first and second outer longitudinal borders of the heat transfer area. Further, it may be outwards or inwards bulging as seen from a center of the heat transfer plate.

[0030] The heat transfer plate may comprise a similarly configured opposing second transverse ridge.

[0031] The heat transfer plate may further comprise an annular inner front field gasket groove extending on the front side and enclosing the heat transfer area. The outer front field gasket groove may enclose the inner front field gasket groove, and the first and second transfer holes may be arranged within the inner front field gasket groove. The inner front field gasket groove may be arranged to receive an inner front field gasket part configured to seal between the heat transfer plate and an adjacent heat transfer plate arranged on the front side of the heat transfer plate. Such inner front field gasket part may further be configured to engage with a membrane arranged to extend within a second interspace of the device comprising the heat transfer plate, as will be further elaborated on below.

[0032] The inner front field gasket groove of the heat transfer plate may comprise separated first and second long side portions and separated first and second short side portions. The long side portions may extend along the longitudinal center axis of the heat transfer plate and the short side portions may each connect the first and second long side portions. A distance between the first and second short side portions, which distance is measured parallel to the longitudinal center axis, may vary along a transverse center axis of the heat transfer plate. The transverse center axis of the heat transfer plate extends perpendicular to the longitudinal center axis of the heat transfer plate. As an example, depending on the design of the rest of the heat transfer plate, the short side portions of the inner front field gasket groove may be bulging away from, or towards, each other, as seen from a center of the heat transfer plate. Such a design may improve a fluid collection and fluid distribution across the heat transfer plate.

[0033] The heat transfer may further comprise an intermediate corrugation pattern between the inner and outer front field gasket grooves. This intermediate corrugation pattern may serve as a support for an inner and an outer front field gasket part arranged in the inner and the outer front field gasket groove. Further, this intermediate corrugation of the heat transfer plate may be arranged to abut and support adjacent heat transfer plates in a device comprising the heat transfer plate.

[0034] 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

[0035] The invention will now be described in more detail with reference to the appended schematic drawings, in which

Figs. 1a and 1b are essentially similar perspective views schematically illustrating a part of a device, which comprises heat transfer plates according to the invention, in a disassembled state, and different fluid paths through the device,

Fig. 2 is a schematic plan view of a front side of a heat transfer plate of the device in Fig. 1a,

Fig. 3 is a schematic partial side view of the heat transfer plate in Fig. 2,

Fig. 4 is a schematic plan view of a part of the heat transfer plate in Fig. 2,

Fig. 5 is a schematic partial perspective view of the heat transfer plate in Fig. 2,

Fig. 6 is another schematic partial perspective view of the heat transfer plate in Fig. 2, and part of a sealing arrangement engaging with it,

Fig. 7 is yet another schematic partial perspective view of the heat transfer plate in Fig. 2, and part of a sealing arrangement engaging with it,

Fig. 8 is a schematic plan view of a back side of the heat transfer plate in Fig. 2 and gasket arrangement engaging with it,

Fig. 9 is a schematic plan view of a part of the device in Fig. 1a,

Fig. 10 is schematic partial cross sectional view of a sealing arrangement of the device in Fig. 1a,

Fig. 11 is schematic partial cross sectional perspective view of the sealing arrangement in Fig. 10,

Figs. 12a and 12b are essentially similar perspective views schematically illustrating a part of a device, which comprises heat transfer plates according to another embodiment of the invention, in a disassembled state, and different fluid paths through the device, and

Fig. 13 is a schematic plan view of a front side of a heat transfer plate of the device in Fig. 12a.

Detailed Description

[0036] Fig. 1a illustrates a part of a device 1 used for producing hydrogen through electrolysis, here alkaline water electrolysis. The device 1 comprises a stack 3 (only partly illustrated) of essentially similar heat transfer plates 5 which each has a front side 7 and an opposing back side 9. In the stack 3, the heat transfer plates 5 are flipped in relation to each other, i.e. arranged front side 7 to front side 7 and back side 9 to back side 9 with every second one of the heat transfer plates 5 turned upside down with respect to the rest of the heat transfer plates 5. This means that every second one of the heat transfer plates 5 is rotated 180 degrees around a respective heat transfer plate longitudinal center axis L, and then rotated 180 degrees around a respective heat transfer plate normal axis N (Fig. 2), with respect to the rest of the heat transfer plates 5.

[0037] One of the heat transfer plates 5 is separately illustrated in Fig. 2 and described in further detail below. It has a first end portion 11, a center portion 13 and a second end portion 15 arranged in succession along the longitudinal center axis L of the heat transfer plate 5. The borders between the first end portion 11, the center portion 13 and the second end portion 15 are illustrated with ghost lines in Fig. 2. The first end portion 11 comprises a first porthole 17, a third porthole 19, a fifth porthole 21 and a seventh porthole 23, while the second end portion 15 comprises a second porthole 27, a fourth porthole 29, a sixth porthole 31 and an eighth porthole 33. The first, third, fifth and seventh portholes 17, 19, 21 and 23 are mirrorings, across a transverse center axis T of the heat transfer plate 5, of the second, fourth, sixth and eighth portholes 27, 29, 31 and 33, respectively. The first, second, third and fourth portholes 17, 27, 19 and 29 are mirrorings, across the longitudinal center axis L of the heat transfer plate 5, of the seventh, eighth, fifth and sixth portholes 23, 33, 21 and 31, respectively. Further, a first transfer hole 25 is arranged within a first half h1 of the heat transfer plate 5, and a second transfer hole 35 is arranged within a second half h2 of the heat transfer plate 5, which first and second halves h1 and h2 are arranged on opposite sides of the transverse center axis T. As is clear from Fig. 2, the first and second transfer holes 25 and 35 are arranged within the center portion 13 of the heat transfer plate 5, on opposite sides of the longitudinal center axis L.

[0038] As heat transfer plates normally are, the heat transfer plate 5 is pressed with corrugation patterns of ridges and valleys in relation to a respective central extension plane CP of the heat transfer plate 5, which central extension plane is parallel to the figure plane of Fig. 2 and illustrated in Fig. 3. The corrugation patterns within different areas of the heat transfer plate 5 are different. For example, the center portion 13 comprises a heat transfer area 4 which is pressed with a heat transfer corrugation pattern 0 of so-called herringbone type. As another example, an outer edge portion 37 of the heat transfer plate 5 is pressed with alternately arranged ridges and valleys extending from an outer edge E of the heat transfer plate 5. As is illustrated in Fig. 3, the ridges and valleys of the outer edge portion 37 extends in and between parallel first and second planes p1 and p2. Corrugations are also provided around the first and second transfer holes 25 and 35, as is further illustrated in Fig. 5 for the first transfer hole 25.

[0039] With reference to Fig. 4, as seen from the front side 7 of the heat transfer plate 5, the heat transfer corrugation pattern 0 comprises alternately arranged elongate ridges 6 and valleys 8. The heat transfer area 4 comprises a first field 10 and a second field 12 which extend on opposite sides of an imaginary first line l1 which coincides with the longitudinal center axis L of the heat transfer plate 5. First ridges 6a of the ridges 6 and first valleys 8a of the valleys 8 extend within the first field 10, while second ridges 6b of the ridges 6 and second valleys 8b of the valleys 8 extend within the second field 12. The first ridges 6a and the first valleys 8a within the first field 10, and the second ridges 6b and the second valleys 8b within the second field 12, are inclined, in opposite directions, in relation to the longitudinal center axis L so as to pairwise form arrows with arrowheads arranged along the longitudinal center axis L.

[0040] The ridges 6 and the valleys 8 of the heat transfer corrugation pattern 0 extend in and between the first and second planes p1 and p2 (Fig. 3) everywhere except for within an intermediate part 14, a first outer longitudinal part 16, a second outer longitudinal part 18, a first outer transverse part 20 and a second outer transverse part 22 of the heat transfer area 4. The intermediate part 14 extends parallel to the longitudinal center axis L and comprises a border 24 between the first and second fields 10 and 12, and portions of the first and second fields 10 and 12 arranged adjacent the border 24. The first outer longitudinal part 16 extends parallel to the longitudinal center axis L and comprises a first outer longitudinal border 26 (illustrated with ghost line) of the heat transfer area 4 and a portion of the first field 10 arranged adjacent the first outer longitudinal border 26. The second outer longitudinal part 18 extends parallel to the longitudinal center axis L and comprises a second outer longitudinal border 28 (illustrated with ghost line) of the heat transfer area 4 and a portion of the second field 12 arranged adjacent the second outer longitudinal border 28. The first outer transverse part 20 extends along the transverse center axis T, has a center which is bulging towards a center of the heat transfer plate 5, and comprises a first outer transverse border 30 (illustrated with ghost line) of the heat transfer area 4 and portions of the first and second fields 10 and 12 arranged adjacent the first outer transverse border 30. Also the first outer transverse border 30 has a center which is bulging towards the center of the heat transfer plate 5. Also the first outer transverse border 30 extends along the transverse center axis T and, thus, crosses an imaginary second line l2 coinciding with the longitudinal center axis L. The second outer transverse part 22 extends along the transverse center axis T, has a center which is bulging towards the center of the heat transfer plate 5, and comprises a second outer transverse border 32 (illustrated with ghost line) of the heat transfer area 4 and portions of the first and second fields 10 and 12 arranged adjacent the second outer transverse border 32. Also the second outer transverse border 32 has a center which is bulging towards the center of the heat transfer plate 5. Also the second outer transverse border 32 extends along the transverse center axis T and, thus, crosses the longitudinal center axis L. Within the intermediate part 14, the first outer longitudinal part 16, the second outer longitudinal part 18, the first outer transverse part 20 and the second outer transverse part 22 of the heat transfer area 4, the ridges 6, which comprise the first and second ridges 6a and 6b, locally have a reduced height. More particularly, within these parts of the heat transfer area 4, the ridges 6 and the valleys 8, which comprise the first and second valleys 8a and 8b, extend in and between a third plane p3 and the second plane p2 (Fig. 3), which third plane p3 is arranged between, here halfway between, the first and second planes p1 and p2. (In alternative embodiments, the third plane p3 may be positioned differently than halfway between the first and second planes p1 and p2.) Thus, the valleys 8 do not have a reduced depth to avoid the formation of bypass channels on the back side 9 of the heat transfer plate 5. This is illustrated in Fig. 5 for, above all, the first outer transverse part 20, in Fig. 6 for the intermediate part 14 and in Fig. 7 for the second outer longitudinal part 18.

[0041] As said above, with reference to Fig. 4, the heat transfer plates 5 in the stack 3 are essentially similar. The only difference between the heat transfer plates 5 in the stack is that every second one of them comprises a coating of insulating material, such as a ceramic material or a polymer, on the front side 7 within the intermediate part 14 of the heat transfer area 4, while the rest of them comprises coatings of the same insulating material on the front side 7 within the first and second outer longitudinal parts 16 and 18 of the heat transfer area 4. This will be further discussed below.

[0042] With reference again to Fig. 2, the heat transfer plate 5 further comprises an annular inner front field gasket groove 34, an outer front field gasket groove 36 and annular first, second, third, fourth, fifth, sixth, seventh and eighth front ring gasket grooves 39a-39h, which all extend on the front side 7. Some sections of the outer front field gasket groove 36 also forms part of the first, second, third, fourth, fifth, sixth, seventh and eighth front ring gasket grooves 39a-39h. Further, some sections of some of the front ring gasket grooves 39a-39h also forms part of other ones of the front ring gasket grooves 39a-39h. Thus, the outer front field gasket groove 36 and first, second, third, fourth, fifth, sixth, seventh and eighth front ring gasket grooves 39a-39h are integrally formed. The inner front field gasket groove 34 encloses the heat transfer area 4 and the first and second transfer holes 25 and 35. The outer front field gasket groove 36, in turn, encloses the inner front field gasket groove 34. The first, second, third, fourth, fifth, sixth, seventh and eighth portholes 17, 27, 19, 29, 21, 31, 23 and 33 are all arranged outside the outer front field gasket groove 36 and enclosed by a respective one of the first, second, third, fourth, fifth, sixth, seventh and eighth front ring gasket grooves 39a-39h. An intermediate corrugation pattern 38 is provided between the inner and outer front field gasket grooves 34 and 36.

[0043] The outer front field gasket groove 36, just like the inner front field gasket groove 34, comprises opposing first and second long side portions l1 and l2 which extend on a distance from each other essentially parallel to the longitudinal center axis L of the heat transfer plate 5. Further, outer front field gasket groove 36, just like the inner front field gasket groove 34, comprises opposing first and second short side portions s1 and s2, which extend, on a distance from each other, along the transverse center axis T of the heat transfer plate 5, to connect the long side portions l1 and l2. The first and second short side portions s1 and s2 are outwards bulging as seen from a center of the heat transfer plate 5.

[0044] Further, the heat transfer plate 5 comprises an annular back field sealing area 40 which extends on the back side 9. In Fig. 2, a back of the back field sealing area 40, which is comprised in an annular back field gasket groove 42, is visible. Also, the heat transfer plate 5 comprises third, fourth, fifth and sixth back ring sealing areas 44, 46, 48 and 50 which extend on the back side 9. In Fig. 2, a respective back of the third, fourth, fifth and sixth back ring sealing areas 44, 46, 48 and 50, which are comprised in a respective one of annular third, fourth, fifth and sixth back ring gasket grooves 52, 54, 56 and 58, are visible. Some sections of the back field gasket groove 42 also forms part of the third, fourth, fifth and sixth back ring gasket grooves 52, 54, 56 and 58. Further, some sections of some of the back ring gasket grooves 52, 54, 56 and 58 also forms part of other ones of the back ring gasket grooves 52, 54, 56 and 58. Thus, the back field gasket groove 42 and the third, fourth, fifth and sixth back ring gasket grooves 52, 54, 56 and 58 are integrally formed. The back field gasket groove 42 encloses the heat transfer area 4 and the first, second, seventh and eighth port holes 17, 27, 23 and 33. The first and second transfer holes 25 and 35, as well as the third, fourth, fifth and sixth portholes 19, 29, 21 and 31, are all arranged outside the back field gasket groove 42. The third, fourth, fifth and sixth back ring gasket grooves 52, 54, 56 and 58 enclose a respective one of the third, fourth, fifth and sixth portholes 19, 29, 21 and 31. Additionally, the third back ring gasket groove 52 encloses the first transfer hole 25 while the sixth back ring gasket groove 58 encloses the second transfer hole 35.

[0045] Here (but not necessarily in alternative embodiments of the invention), a bottom of the inner front field gasket groove 34, just like a bottom of the outer front field gasket groove 36, just like respective bottoms of the first, second, third, fourth, fifth, sixth, seventh and eighth front ring gasket grooves 39a-39h, just like a bottom of the back field gasket groove 42, just like respective bottoms of the third, fourth, fifth and sixth back ring gasket grooves 52, 54, 56 and 58, extend halfway between the first and second planes p1 and p2, i.e. in the center plane CP (Fig. 3). Along first and second long sides of the heat transfer plate 5 which extend parallel to the longitudinal center axis L, the outer front field gasket groove 36 is aligned with the back field gasket groove 42 such that the bottom of the outer front field gasket groove 36 coincides with the bottom of the back field gasket groove 42.

[0046] With reference again to Fig. 4, the heat transfer plate 5 further comprises first and second transverse ridges 80 and 82, respectively, which extend along the transverse center axis T so as to cross an imaginary third line l3 extending parallel to the longitudinal center axis L. The first and second transverse ridges 80 and 82 are arranged on opposite sides of the heat transfer area 4, between the heat transfer area 4 and the inner front field gasket groove 34. The first and second transverse ridges 80 and 82 are intermittent so as to not extend in the back field gasket groove 42 and the third, fourth, fifth and sixth back ring gasket grooves 52, 54, 56 and 58. The first and second transverse ridges 80 and 82 extend from the center plane CP to and in the first plane p1 (Fig. 3). As is clear from the figures, the first and second transverse ridges 80 and 82 are outwards bulging as seen from the center of the heat transfer plate 5.

[0047] With reference again to Fig. 1a, the stack 3 of heat transfer plates 5 is arranged between two frame plates F, of which only one is illustrated. The heat transfer plates 5 within the stack 3 are arranged in pairs, wherein heat transfer plates 5b and 5c form one of these pairs, while heat transfer plate 5d forms one of the heat transfer plates of another adjacent one of these pairs. The heat transfer plates of each pair form between them a first interspace 11. Further, a second interspace I2 is formed between each two adjacent pairs of heat transfer plates 5. An outer heat transfer plate 5x, which is similar to the heat transfer plates 5 except for that it lacks the first and second transfer holes 25 and 35, is arranged between the stack 3 and the frame plate F visible in Fig. 1a to form an additional first interspace 11, denoted I1X, as well as a plate pair, with the heat transfer plate 5a. An additional second interspace I2, denoted I2X, is thus formed between the heat transfer plate 5a and the heat transfer plate 5b. An outer heat transfer plate completely lacking holes may be arranged between the stack 3 and the other frame plate which is not visible in Fig. 1a. Further, gaskets, which are not illustrated, may be arranged on the inside of the frame plates F

[0048] An annular back field gasket part 41 is arranged within each of the first interspaces I1 to define a first flow channel C1 therein. An annular inner front field gasket part 43 of rubber is arranged within each of the second interspaces I2 to define a second flow channel C2 therein. A separation means, which closes an inner field gasket area enclosed by the inner front field gasket part 43, comprises a hydroxide ion permeable membrane 45. The membrane 45 extends within the inner front field gasket part 43 and essentially parallel to the heat transfer plates 5 to split the corresponding second flow channel C2 in a second primary sub channel C2P and a second secondary sub channel C2S, which sub channels are parallel and extend on opposite sides of the membrane 45.

[0049] With reference to Fig. 8, the back field gasket part 41 is part of a gasket arrangement G of rubber which also comprises four annular back ring gasket parts 47 formed integrally with the back field gasket part 41. The back field gasket part 41 is arranged in the back field gasket groove 42 of the heat transfer plate 5 while the back ring gasket parts 47 are arranged in a respective one of the third, fourth, fifth and sixth back ring gasket grooves 52, 54, 56 and 58.

[0050] With reference to Fig. 9, the inner front field gasket part 43 and separation means comprising the membrane 45 (not illustrated in Fig. 9) are parts of a sealing arrangement S. The sealing arrangement S also comprises eight annular front ring gasket parts 49, four annular porthole gasket parts 84 arranged within a respective one of the intermediate front ring gasket parts 49, an outer front field gasket part 86, an insulating inner sheet 88 extending between the inner and outer front field gasket parts 43 and 86, and an insulating outer sheet 51 extending around and connecting all the parts of the sealing arrangement S. All the parts of the sealing arrangement S besides the membrane 45 is made of rubber. The inner and outer front field gasket parts 43 and 86 are arranged in a respective one of the inner and outer front field gasket grooves 34 and 36 (Fig. 2) while the front ring gasket parts 49 are arranged in a respective one of the first, second, third, fourth, fifth, sixth, seventh and eighth front ring gasket grooves 39a-39h (Fig. 2).

[0051] The porthole gasket parts 84 all have a similar design which is further illustrated in Figs. 10 and 11. As is clear form these figures, the porthole gasket parts 84 project more from a front side f of the outer sheet 51 of the sealing arrangement S than the other parts of the sealing arrangement S. Further, a number, here three, of fluid flow grooves 95 are comprised in each of the porthole gasket parts 84. The fluid flow grooves 95 extend radially through the porthole gasket parts 84, and from a front side of the sealing arrangement S (illustrated in Fig. 9) towards a backside of the sealing arrangement S. The purpose of this will be clear from below.

[0052] As illustrated in Fig. 1a, in the device 1, each of the heat transfer plates 5 engages with a sealing arrangement S on the front side 7 and with a gasket arrangement G the back side 9. With reference to Figs. 2 and 8 and the gasket arrangement G, the back field gasket part 41 encloses the first, second, seventh and eight portholes 17, 27, 23 and 33 of the heat transfer plate 5, while the back ring gasket parts 47 enclose a respective one of the third, fourth, fifth and sixth portholes 19, 29, 21 and 31 of the heat transfer plate 5, and two of the back ring gasket parts 47 also enclose a respective one of the first and second transfer holes 25 and 35 of the heat transfer plate 5. With reference to Figs. 2 and 9 and the sealing arrangement S, the front ring gasket parts 49 are arranged at a respective one of the first, second, third, fourth, fifth, sixth, seventh and eighth portholes 17, 27, 19, 29, 21, 31, 23 and 33 of the heat transfer plate 5. Further, the porthole gasket parts 84 are arranged at respective one of the third, fourth, fifth and sixth portholes 19, 29, 21 and 31.

[0053] With reference to Figs. 1a and 9, when several heat transfer plates 5, several gasket arrangements G and several sealing arrangements S engage properly with each other in the device 1, each of the porthole gasket parts 84 will project through the aligned portholes of two adjacent ones of the heat transfer plates 5 arranged on the front side f of the outer sheet 51 of the corresponding one of the sealing arrangements S, and abut the back side of another, adjacent porthole gasket part 84. Thereby, the porthole gasket parts 84 will form four rubber tunnels or ports through the device 1, more particularly a second primary inlet port 57p, a second secondary inlet port 57s, a second primary outlet port 59p and a second secondary outlet port 59s, which will be further discussed below. The fluid flow grooves 95 of the porthole gasket parts 84 will allow fluid passage into, and out of, these rubber tunnels, i.e. the second primary inlet port 57p, the second secondary inlet port 57s, the second primary outlet port 59p and the second secondary outlet port 59s.

[0054] When the device 1 is ready for use, the heat transfer plates 5 and the interposed gasket arrangements G and sealing arrangements S are compressed between the frame plates F so as to form the first and second flow channels C1 and C2 and also port means for conveying first and second fluids through the device 1. Compressed like that, the heat transfer plates 5 of each of the pairs, such as the heat transfer plates 5b and 5c, abut each other in contact areas, while contact between adjacent pairs of heat transfer plates 5, such as the heat transfer plates 5c and 5d, is prevented by the presence of the sealing arrangements S between the plate pairs. This separation or insulation between the plate pairs is necessary for the device 1 to work properly for electrolysis, which will be further discussed below. The compression is achieved by some kind of tightening means, such as bolts and nuts, which are not illustrated or further described herein. With reference to Fig. 9, the port means comprise first inlet port means 53 and first outlet port means 55 for the first fluid and second inlet port means 57 and second outlet port means 59 for the second fluid. In turn, the first inlet port means 53 comprises a first primary inlet port 53p and a first secondary inlet port 53s, the first outlet port means 55 comprises a first primary outlet port 55p and a first secondary outlet port 55s, the second inlet port means 57 comprises the second primary inlet port 57p and the second secondary inlet port 57s, and the second outlet port means 59 comprises the second primary outlet port 59p and the second secondary outlet port 59s.

[0055] With reference to Fig. 1a, the first fluid, which is a cooling fluid, for example deionized water, is fed into the device 1 via first inlet means 61 and out of the device 1 via first outlet means 63. The first inlet means 61 comprises a first primary inlet 61p and a first secondary inlet 61s, while the first outlet means 63 comprises a first primary outlet 63p and a first secondary outlet 63s. With reference to Fig. 1b, the second fluid, which is an electrolyte, for example a mixture of water and an alkaline agent, such as potassium hydroxide, is fed into the device 1 via second inlet means 65 and out of the device 1 via second outlet means 67. The second inlet means 65 comprises a second primary inlet 65p and a second secondary inlet 65s, while the second outlet means 67 comprises a second primary outlet 67p and a second secondary outlet 67s.

[0056] A first fluid path P1 for conveying the first fluid through the device 1 comprises a first primary fluid path P1p and a first secondary fluid path P1s. With reference to Figs. 1a and 9, and the dashed lines, the first primary fluid path P1p extends from the first primary inlet 61p, into the first primary inlet port 53p, through the first flow channels C1, into the first primary outlet port 55p and to the first primary outlet 63p. The first secondary fluid path P1s extends from the first secondary inlet 61s, into the first secondary inlet port 53s, through the first flow channels C1, into the first secondary outlet port 55s and to the first secondary outlet 63s. A second fluid path P2 for conveying the second fluid through the device 1 comprises a second primary fluid path P2p and a second secondary fluid path P2s. With reference to Figs.1b and 9, and the dashed lines, the second primary fluid path P2p extends from the second primary inlet 65p, into the second primary inlet port 57p, into the first interspaces I1 outside the first flow channels C1, through the respective first transfer hole 25 of every second one of the heat transfer plates, i.e. plates 5a, 5c,..., into the second primary sub channels C2P, through the second primary sub channels C2P, through the respective second transfer hole 35 of every second one of the heat transfer plates, i.e. plates 5a, 5c..., into the first interspaces I1 outside the first flow channels C1, into the second primary outlet port 59p and to the second primary outlet 67p. The second secondary fluid path P2s extends from the second secondary inlet 65s, into the second secondary inlet port 57s, into the first interspaces I1 outside the first flow channels C1, through the respective second transfer hole 35 of every second one of the heat transfer plates, i.e. plates 5b, 5d,..., into the second secondary sub channels C2S, through the second secondary sub channels C2S, through the respective first transfer hole 25 of every second one of the heat transfer plates, i.e. plates 5b, 5d,..., into the first interspaces I1 outside the first flow channels C1, into the second secondary outlet port 59s and to the second secondary outlet 67s.

[0057] With reference again to Fig. 9, the first fluid, i.e. the cooling fluid, is conveyed through the device 1 in the ports 53s, 53p, 55s and 55p, while the second fluid, i.e. the electrolyte, is conveyed through the device 1 in the ports 57p, 57s, 59p and 59s. The ports 53s, 53p, 55s and 55p are arranged on a larger distance from a longitudinal center plane of the device 1 than the ports 57p, 57s, 59p and 59s. This means that the cooling fluid is conveyed on the outside of the electrolyte.

[0058] Thus, a method for electrolysis is performed by means of the device 1. The method comprises the step of applying a current to the device 1 to turn every second one of the heat transfer plate of the device 1, including the heat transfer plates 5a and 5c, into anodes and the rest of the heat transfer plates of the device 1, including the heat transfer plates 5b and 5d, into cathodes. As mentioned above, sealing arrangements S insulating between the heat transfer plates 5 are arranged in the second interspaces I2 of the device 1, i.e. between the heat transfer plates 5a and 5b, and between the heat transfer plates 5c and 5d, etc., and split the second flow channels C2 into second primary sub channels C2P and second secondary sub channels C2S. Thereby, electrolysis may be performed within the second flow channels C2 of the device 1. As also explained above, the ports 57p, 57s, 59p and 59s for the second fluid, i.e. the electrolyte, are "lined" with rubber which minimizes the risk of short circuits between the heat transfer plates 5, 5a, which short circuits could cause malfunctioning of the device 1.

[0059] As described above, there are two fluid paths for the second fluid, i.e. the electrolyte, through the device 1. Accordingly, the method comprises the step of feeding a first part of the second fluid into the first interspaces I1 outside the first flow channels C1 and through the first transfer holes 25 of the heat transfer plates 5a, 5c, etc., into the second primary sub channels C2P, and feeding a second part of the second fluid into the first interspaces I1 outside the first flow channels C1 and through the second transfer holes 35 of the heat transfer plates 5b, 5d, etc., into the second secondary sub channels C2S. Further, the method comprises the step of feeding the first and second parts of the second fluid through the second flow channels C2, whereby water in the electrolyte is split into hydrogen and oxygen and a primary fraction is formed in the second primary sub channels C2P and a secondary fraction is formed in the second secondary sub channels C2S, the primary fraction containing more oxygen and less hydrogen than the second fraction. The primary fraction of the second fluid is fed through the second transfer holes 35 of the heat transfer plates 5a, 5c, etc. into the first interspaces I1 outside the first flow channels C1, while the secondary fraction of the second fluid is fed through the first transfer holes 25 of the heat transfer plates 5b, 5d, etc. into the first interspaces I1 outside the first flow channels C1. The primary and secondary fractions are separately discharged from the device 1 via the second primary outlet 67p and the second secondary outlet 67s, respectively. When electrolysis is performed in the second flow channels C2, heat is generated. The method comprises the step of feeding the first fluid, i.e. the deionized water, through the first flow channels C1, i.e. on both sides of the electrolysis channels C2, to effectively and uniformly divert the heat generated through the electrolysis from the device 1.

[0060] The hydrogen and the oxygen that is obtained during the electrolysis is released in gaseous form as hydrogen bubbles and oxygen bubbles which, guided by the heat transfer corrugation pattern 0 of the heat transfer plates 5, strive to rise, while second fluid in liquid form falls, so as to create a recirculation within the second flow channels C2. With reference to Fig. 4, in the second secondary subchannels C2S, the hydrogen bubbles rise within the first and second outer longitudinal parts 16 and 18, while the second fluid in liquid form falls in the intermediate part 14, of the heat transfer area 4 of the heat transfer plates 5b, 5d, etc. To promote the recirculation inside the second secondary subchannels C2S, the amount of hydrogen bubbles the intermediate part 14 should be minimized. Therefore, the intermediate part 14 of the heat transfer area 4 of the heat transfer plates 5b, 5d, etc. is coated with a ceramic material or a polymer for local inhibition of electrolysis. The second transverse ridge 82 together with the second outer transverse part 22 of the heat transfer plates 5b, 5d, etc. forms a transfer channel which helps to distribute the second fluid entering from the second transfer hole 35 across the width of the heat transfer plates 5b, 5d, etc., while the first outer transverse part 20 together with the first transverse ridge 80 forms a transfer channel which helps to collect the second fluid from across the heat transfer plates 5b, 5d, etc. and convey it towards the first transfer hole 25.

[0061] In the second primary subchannels C2P, the oxygen bubbles rise within the intermediate part 14, while second fluid in liquid form falls in the first and second outer longitudinal parts 16 and 18, of the heat transfer area 4 of the heat transfer plates 5a, 5c, etc. To promote the recirculation inside the second primary subchannels C2P, the amount of oxygen bubbles in the first and second outer longitudinal parts 16 and 18 should be minimized. Therefore, the first and second outer longitudinal parts 16 and 18 of the heat transfer area 4 of the heat transfer plates 5a, 5c, etc. are coated with a ceramic material or a polymer for local inhibition of electrolysis. The first transverse ridge 80 together with the first outer transverse part 20 of the heat transfer plates 5a, 5c, etc. forms a transfer channel which helps to distribute the second fluid entering from the first transfer hole 25 across the width of the heat transfer plates 5a, 5c, etc., while the second outer transverse part 22 together with the second transverse ridge 82 forms a transfer channel which helps to collect the second fluid from across the heat transfer plates 5a, 5c, etc. and convey it towards the second transfer hole 35.

[0062] It should be stressed that the second fluid is referred to as second fluid even if its characteristics changes when it is fed through the device, and that both the primary fraction and the secondary fraction of the second fluid are referred to as second fluid even if their separate compositions vary and differ from each other and from the original second fluid.

[0063] It should be stressed that all components necessary to make the device work properly, such as power sources, connections, wiring, control units, valves, pumps, gaskets, sensors, pipes, dosing equipment, etc., are not described herein or illustrated in the figures. Further, characteristics of the different components of the device which are not relevant to the present invention are not described or illustrated herein.

[0064] Fig. 12a schematically illustrates a part of another device 2 used for producing hydrogen through electrolysis. There are similarities between the devices 1 and 2 and the above description is, to some extent, valid also for the device 2. The device 2 comprises a stack 3 of heat transfer plates 90 of a first type and heat transfer plates 92 of a second type. One of the heat transfer plates 90 is separately illustrated in Fig. 13. The heat transfer plates 90 and 92 differ from the heat transfer plates 5 of the device 1 which means that also other components of the device 2 differ from the corresponding components of the device 1. However, hereinafter, the differences of the heat transfer plates 90 and 92 as compared to the heat transfer plate 5 will be focused on.

[0065] The heat transfer plate 90 comprises a first end portion 11 provided with a first porthole 17, a third porthole 19 and a fifth porthole 21, and a second end portion 15 provided with a second porthole 27, a fourth porthole 29, and a sixth porthole 31. The heat transfer plate 90 further comprises a first transfer hole 25 and a second transfer hole 35 arranged on the same side of a longitudinal center axis L of the heat transfer plate 90. A respective center of the first and second portholes 17 and 27 are arranged along the longitudinal center axis L. The first, third and fifth portholes 17, 19 and 21, and the first transfer hole 25 are mirrorings, across a transverse center axis T of the heat transfer plate 90, of the second, fourth and sixth portholes 27, 29 and 31, and the second transfer hole 35, respectively. Further, the third and fourth portholes 19 and 29 are mirrorings, across the longitudinal center axis L, of the fifth and sixth portholes 21 and 31, respectively. Further, the heat transfer plate 90 comprises a heat transfer area 4 comprising first, second, third and fourth parallel fields 10, 12, 94 and 96 instead of only first and second fields 10 and 12 as the heat transfer plate 5 does. Thereby, the ridges and valleys 6 and 8 of the heat transfer corrugation pattern 0 form arrows with arrowheads arranged along three parallel lines, of which one coincides with the longitudinal center axis L, instead of only along the longitudinal center axis L. Further, three intermediate parts 14, instead of only one, within which the ridges 6 of the heat transfer pattern 0 have a locally reduced height, are present on the heat transfer plate 90. The center intermediate part 14 just like the first and second outer longitudinal parts 16 and 18 of the heat transfer area 4 are coated while the two outer ones of the intermediate parts 14 are not.

[0066] The heat transfer plate 92 differs from the heat transfer plate 90 in that the outer intermediate parts 14 of the heat transfer area 4 are coated while the center intermediate part 14 and the first and second outer longitudinal parts 16 and 18 are not. Further, the first and second transfer holes 25 and 35 are arranged on the opposite side of the longitudinal center axis L on the heat transfer plate 92 than on the heat transfer plate 90.

[0067] There is one single first fluid path P1 for conveying the first fluid through the device 2. With reference to Figs. 12a, and the dashed lines, the first fluid path P1 extends from the first inlet 61, into the first inlet port 53, through the first flow channels C1, into the first outlet port 55 and to the first outlet 63. A second fluid path P2 for conveying the second fluid through the device 1 comprises a second primary fluid path P2p and a second secondary fluid path P2s. With reference to Fig. 12b and the dashed lines, the second primary fluid path P2p extends from the second primary inlet 65p, into the second primary inlet port 57p, into the first interspaces I1 outside the first flow channels C1, through the respective first transfer hole 25 of every second one of the heat transfer plates, i.e. the heat transfer plates 92, into the second primary sub channels C2P, through the second primary sub channels C2P, through the respective second transfer hole 35 of every second one of the heat transfer plates, i.e. the heat transfer plates 92, into the first interspaces I1 outside the first flow channels C1, into the second primary outlet port 59p and to the second primary outlet 67p. The second secondary fluid path P2s extends from the second secondary inlet 65s, into the second secondary inlet port 57s, into the first interspaces I1 outside the first flow channels C1, through the respective second transfer hole 35 of every second one of the heat transfer plates, i.e. the heat transfer plates 90, into the second secondary sub channels C2S, through the second secondary sub channels C2S, through the respective first transfer hole 25 of every second one of the heat transfer plates, i.e. the heat transfer plates 90, into the first interspaces I1 outside the first flow channels C1, into the second secondary outlet port 59s and to the second secondary outlet 67s.

[0068] Thus, in the device 2, the first fluid is conveyed in the ports 53 and 55, while the second fluid is conveyed in the ports 57p, 57s, 59p and 59s. The ports 57p, 57s, 59p and 59s are arranged on a larger distance from a longitudinal center plane of the device 2 than the ports 53 and 55. This means that the second fluid is conveyed on the outside of the first fluid.

[0069] The above described embodiments of the present invention should only be seen as examples. A person skilled in the art realizes that the embodiments discussed can be varied in a number of ways without deviating from the inventive conception.

[0070] In the above described embodiments, the heat transfer plates comprise six or eight portholes. A heat transfer plate according to the invention could, however, comprise more or less portholes, even an odd number of portholes, for example in connection with devices having a second inlet port means that doesn't comprise second primary and secondary inlet ports, like in the above described embodiments, but one single second inlet port only communicating with the second primary and secondary outlet ports.

[0071] In the above described embodiments, the heat transfer plates have heat transfer areas comprising two or four fields. A heat transfer plate according to the invention could, however, comprise more or less or three fields.

[0072] The heat transfer plates of the device 1 differ from each other in that they are differently coated. The device 1 could, according to an alternative embodiment, comprise heat transfer plates which are all similar and coated in the same way. Such heat transfer plates could be coated at the intermediate part as well as at the first and second outer longitudinal parts.

[0073] In the above described embodiments, the heat transfer plates are "flipped" in relation to each other. A heat transfer plate according to the invention could also be designed to be comprised in a stack with heat transfer plates "rotated" in relation to each other.

[0074] In the above described embodiments, the heat transfer plates are arranged to non-permanently engage with gaskets at the front side as well as the back side for sealing between the heat transfer plates and adjacent heat transfer plates in a device. A heat transfer plate according to the invention could instead be arranged to be attached, with a permanent sealing, at the back side, to an adjacent heat transfer plate. On such a plate, a bottom of the back field gasket groove could extend in the second plane, i.e. in so-called bottom plane.

[0075] In the above described embodiments, the heat transfer plates comprises inner and outer front field gasket grooves for cooperation with a sealing arrangement comprising inner and outer front field gasket parts and a membrane arranged to engage with the inner front field gasket part. The inner front field gasket groove could be omitted on a heat transfer plate according to the invention arranged to cooperate with a sealing arrangement lacking inner front field gasket part and instead comprising a membrane being arranged to engage directly with the outer front field gasket part.

[0076] In the above described embodiments, contact between adjacent pairs of heat transfer plates is prevented by the presence of the sealing arrangements between the plate pairs, which sealing arrangements comprises insulating outer sheets connecting the front ring gasket parts and the outer front field gasket parts. In alternative embodiments, the insulating outer sheets, and possibly also other parts of the sealing arrangements, could be omitted and the heat transfer plates could instead be suitably locally coated with insulating material to prevent contact between adjacent pairs of heat transfer plates.

[0077] In the above described embodiment, the heat transfer plates 5a and 5c, etc., function as anodes while the heat transfer plates 5b and 5d, etc., function as cathodes, so as to produce a primary fraction containing more oxygen and less hydrogen than the secondary fraction. In an alternative embodiment, the heat transfer plates 5a and 5c, etc., could instead function as cathodes while the heat transfer plates 5b and 5d, etc., could function as anodes so as to produce a secondary fraction containing more oxygen and less hydrogen than the primary fraction.

[0078] The heat transfer plates may be pressed with other corrugation patterns than specified above. As an example, the heat transfer area of the heat transfer plate need not be pressed with a corrugation pattern of so-called herringbone type but could instead be pressed with a corrugation pattern comprising alternately arranged ridges and valleys extending essentially parallel to the longitudinal center axis of the heat transfer plate.

[0079] The heat transfer plate may be comprised in a device used for another type of electrolysis than alkaline water electrolysis, for example chlor-alkali electrolysis. Further, the heat transfer plate may be comprised in a device for other applications than electrolysis, for example a device in the form of a fuel cell.

[0080] It should be stressed that the attributes first, second, third, ... , primary, secondary, and A, B, C, ..., etc. are used herein just to distinguish between species and not to express any kind of mutual order between, or attribute any special characteristics to, the species.

[0081] It should be stressed that "receiving", "feeding", "communicating" etc., throughout the text, means "receiving directly or indirectly" and "feeding directly or indirectly" and "communicating directly or indirectly", respectively.

[0082] It should be stressed that a description of details not directly relevant to the present invention has been omitted and that the figures are just schematic and not drawn according to scale. It should also be said that some of the figures have been more simplified than others. Therefore, some components may be illustrated in one figure but left out on another figure.

Claims

1. A heat transfer plate (5, 90, 92) which is corrugated, has opposing front and back sides (7, 9) and comprises a first end portion (11), a center portion (13) and a second end portion (15) arranged in succession along a longitudinal center axis (L) of the heat transfer plate (5, 90, 92), the heat transfer plate (5, 90, 92) further comprising first and third portholes (17, 19) arranged within the first end portion (11), second and fourth portholes (27, 29) arranged within the second end portion (15), a heat transfer area (4), which is provided with a heat transfer corrugation pattern (0) comprising, as seen from the front side (7), alternately arranged elongate ridges (6) and valleys (8), arranged within the center portion (13), an annular outer front field gasket groove (36) extending on the front side (7) and enclosing the heat transfer area (4), and an annular back field sealing area (40) extending on the back side (9) and enclosing the heat transfer area (4), **characterized in** further comprising a fifth porthole (21) arranged within the first end portion (11), a first transfer hole (25) arranged within a first half (h1) of the heat transfer plate (5, 90, 92) comprising the first end portion (11), and a second transfer hole (35) arranged within a second half (h2) of the heat transfer plate (5, 90, 92) comprising the second end portion (15), wherein the first and second transfer holes (25, 35) are arranged within the outer front field gasket groove (36) and outside the back field sealing area 40, the first and second portholes (17, 27) are arranged within the back field sealing area (40), the third, fourth and fifth portholes (19, 29, 21) are arranged outside the back field sealing area (40), and the first, second, third, fourth and fifth portholes (17, 27, 19, 29, 21) are arranged outside the outer front field gasket groove (36).

2. A heat transfer plate (5, 90, 92) according to claim 1, further comprising a sixth porthole (31) arranged within the second end portion (15), wherein the sixth porthole (31) is arranged outside the outer front field gasket groove (36) and outside the back field sealing area (40).

3. A heat transfer plate (5, 90, 92) according to any of the preceding claims, further comprising a seventh porthole (23) arranged within the first end portion (11) and an eighth porthole (33) arranged within the second end portion (15), wherein the seventh and eighth portholes (23, 33) are arranged within the back field sealing area (40) and outside the outer front field gasket groove (36).

4. A heat transfer plate (5, 90, 92) according to any of the preceding claims, wherein the outer front field gasket groove (36) comprises separated first and second long side portions (l1, l2) which extend along

the longitudinal center axis (L) of the heat transfer plate (5, 90, 92), and separated first and second short side portions (s1, s2), which each connects the first and second long side portions (l1, l2), wherein a distance between the first and second short side portions (s1, s2), which distance is measured parallel to the longitudinal center axis (L), varies along a transverse center axis (T) of the heat transfer plate (5, 90, 92).

5. A heat transfer plate (5, 90, 92) according to any of claim 3-4, further comprising annular third, fourth, fifth and sixth back ring sealing areas (44, 46, 48, 50) enclosing the third, fourth, fifth and sixth portholes (19, 29, 21, 31), respectively, wherein one of the third and the fifth back ring sealing areas (44, 48) also encloses the first transfer hole (25) and one of the fourth and sixth back ring sealing areas (46, 50) also encloses the second transfer hole (35).

6. A heat transfer plate (5, 90, 92) according to any of the preceding claims, wherein the back field sealing area (40) is comprised in an annular back field gasket groove (42).

7. A heat transfer plate (5, 90, 92) according to any of the preceding claims, wherein the heat transfer area (4) comprises an intermediate part (14) extending along the longitudinal center axis (L), and wherein at least a majority of the ridges (6) extending at least partly within said intermediate part (14) has a locally reduced height within said intermediate part (14).

8. A heat transfer plate (5, 90, 92) according to claim 7, wherein the heat transfer area (4) comprises a first and a second field (10, 12), which first and second fields (10, 12) extend on opposite sides of an imaginary first line (l1) which extends along the longitudinal center axis (L) of the heat transfer plate (5, 90, 92), wherein the first field (10) comprises first ridges (6a) and first valleys (8a) of said ridges (6) and valleys (8), and the second field (12) comprises second ridges (6b) and second valleys (8b) of said ridges and valleys (6, 8), wherein the first ridges (6a) and the first valleys (8a) within the first field (10), and the second ridges (6b) and the second valleys (8b) within the second field (12), are inclined, in opposite directions, in relation to the imaginary first line (l1), wherein said intermediate part (14) extends along said imaginary first line (l1) and comprises a border (24) between the first and second fields (10, 12).

9. A heat transfer plate (5, 90, 92) according to any of claims 7-8, wherein said intermediate part (14) is at least partly coated with an insulating material on the front side (7) of the heat transfer plate (5, 90, 92).

10. A heat transfer plate (5, 90, 92) according to any of the preceding claims, wherein at least a majority of the ridges (6) extending from a first outer longitudinal border (26) of the heat transfer area (4), which first outer longitudinal border (26) extends along the longitudinal center axis (L), have a locally reduced height within a first outer longitudinal part (16) of the heat transfer area (4), which first outer longitudinal part (16) extends along, and comprises, the first outer longitudinal border (26).

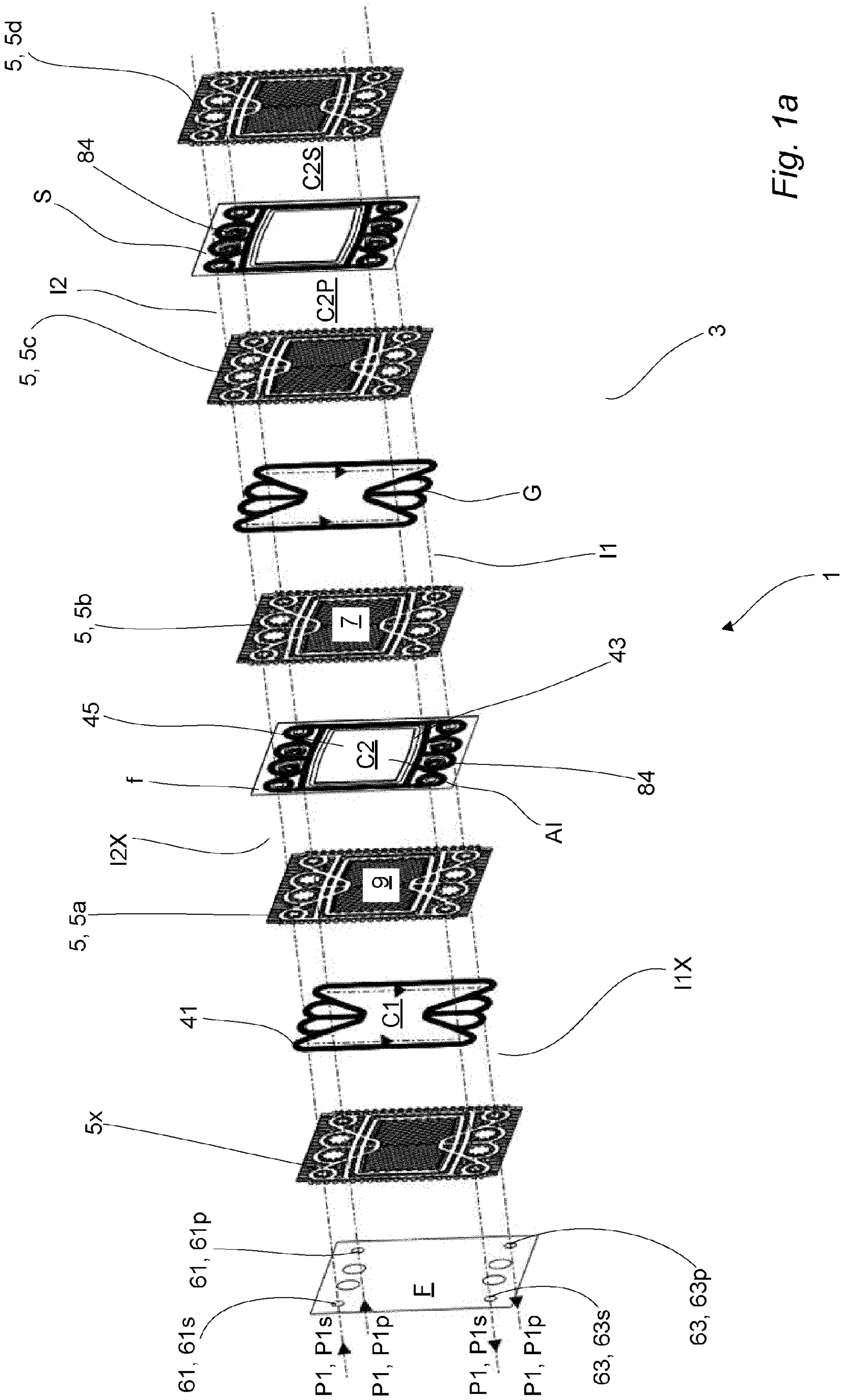
11. A heat transfer plate (5, 90, 92) according to claim 10, wherein said first outer longitudinal part (16) is at least partly coated with an insulating material on the front side (7) of the heat transfer plate (5, 90, 92).

12. A heat transfer plate (5, 90, 92) according to any of the preceding claims, wherein at least a majority of the ridges (6) extending from a first outer transverse border (30) of the heat transfer area (4), which first outer transverse border (30) crosses an imaginary second line (l2) extending parallel to the longitudinal center axis (L), have a locally reduced height within a first outer transverse part (20) of the heat transfer area (4), which first outer transverse part (20) extends along, and comprises, the first outer transverse border (30).

13. A heat transfer plate (5, 90, 92) according to any of the preceding claims, further comprising a first transverse ridge (80) crossing an imaginary third line (l3) extending parallel to the longitudinal center axis (L), which first transverse ridge (80) extends outside and borders on the heat transfer corrugation pattern (0) and extends within the outer front field gasket groove (36).

14. A heat transfer plate (5, 90, 92) according to any of the preceding claims, further comprising an annular inner front field gasket groove (34) extending on the front side (7) and enclosing the heat transfer area (4), wherein the outer front field gasket groove (36) encloses the inner front field gasket groove (34) and the first and second transfer holes (17, 27) are arranged within the inner front field gasket groove (34).

15. A heat transfer plate (5, 90, 92) according to claims 14, further comprising an intermediate corrugation pattern (38) between the inner and outer front field gasket grooves (34, 36).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C2P
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5, 5b
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f
Al
I2X
9
5, 5a
I1X
41
C1
5x
61, 61p
E
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P1, P1s
P1, P1p
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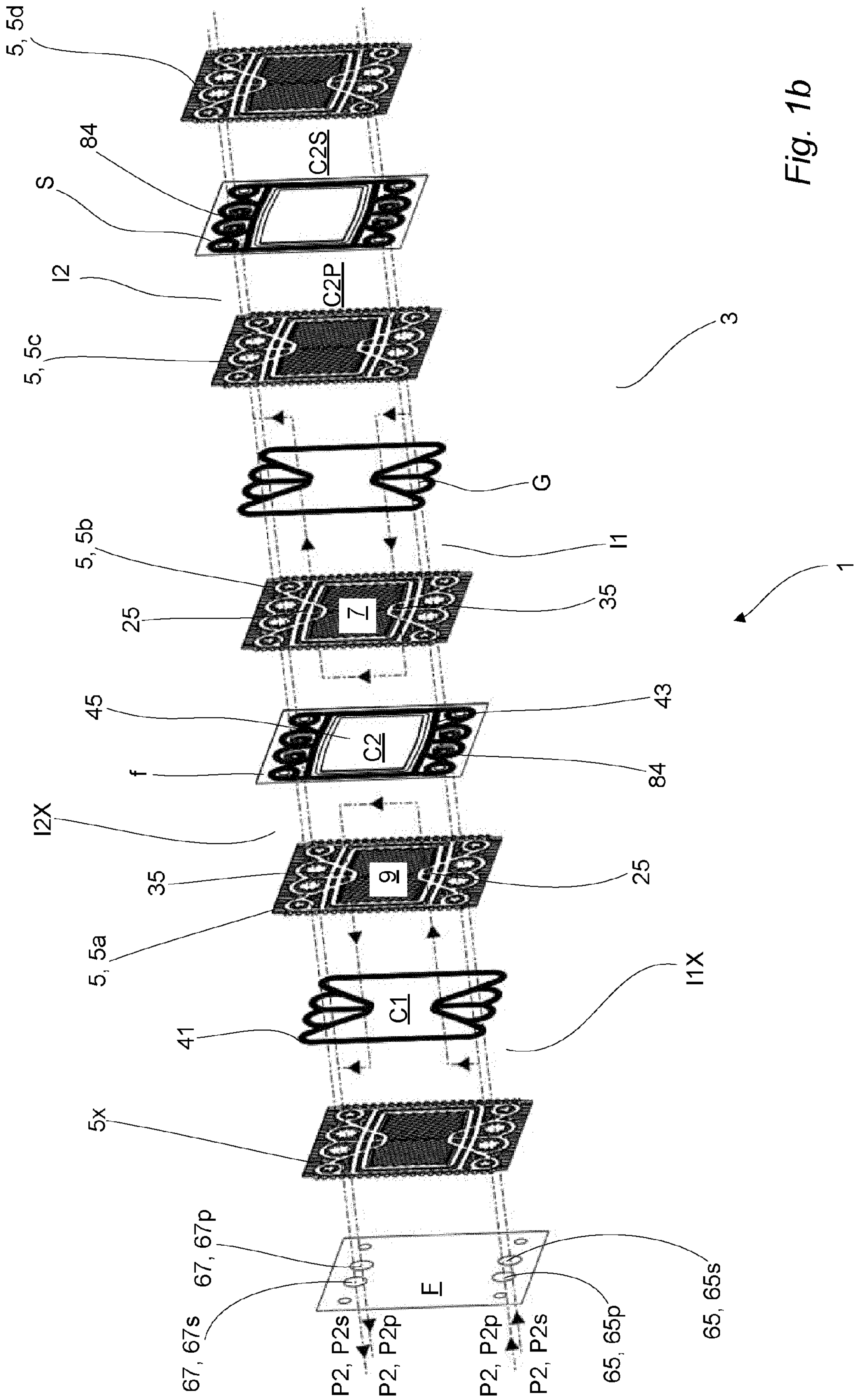
63, 63s

Fig. 1a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I1X
C1
41
5x
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65, 65p
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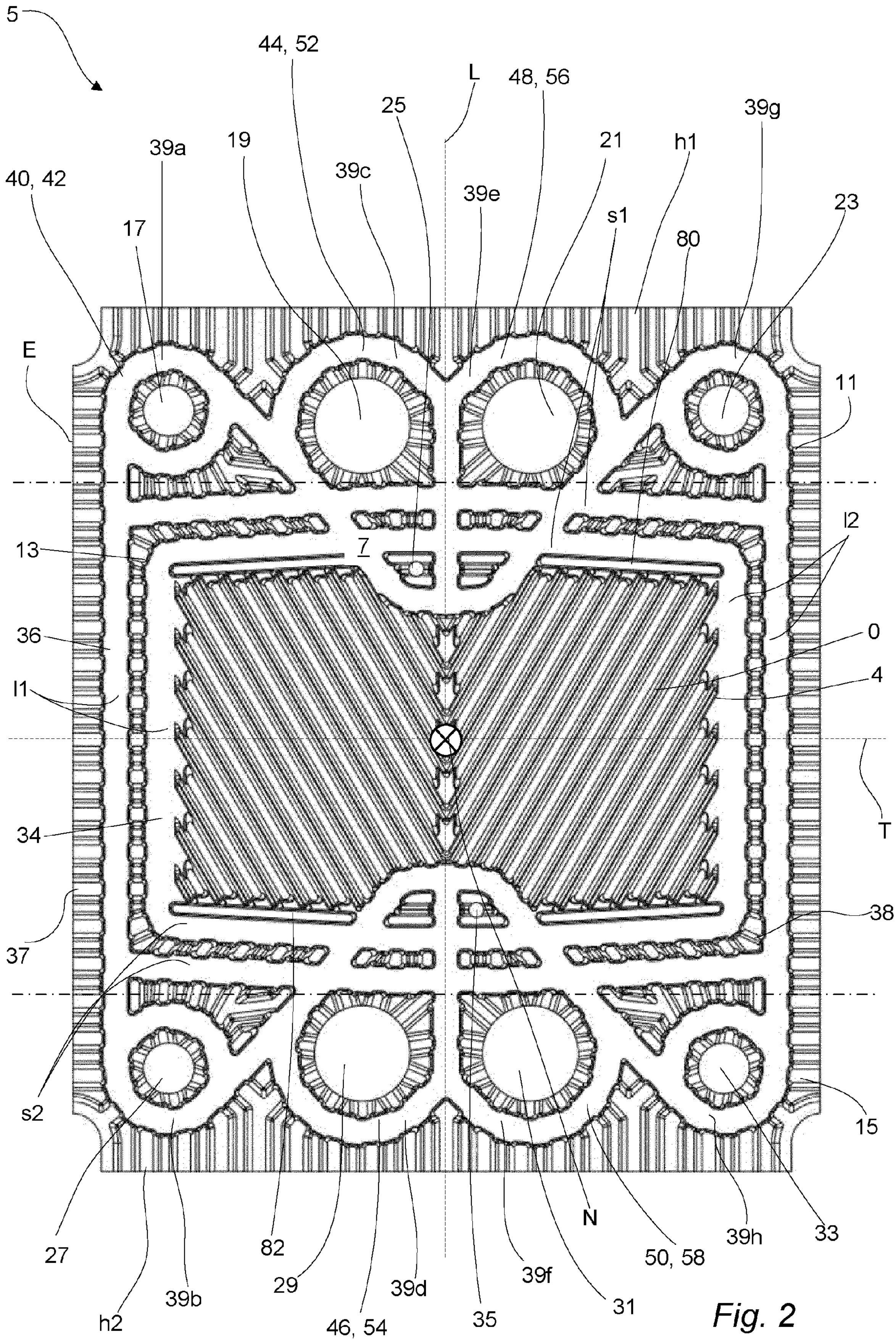
P2, P2p
P2, P2p
P2, P2s

Fig. 1b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l2
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7
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l1
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34
38
37
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h2
46, 54
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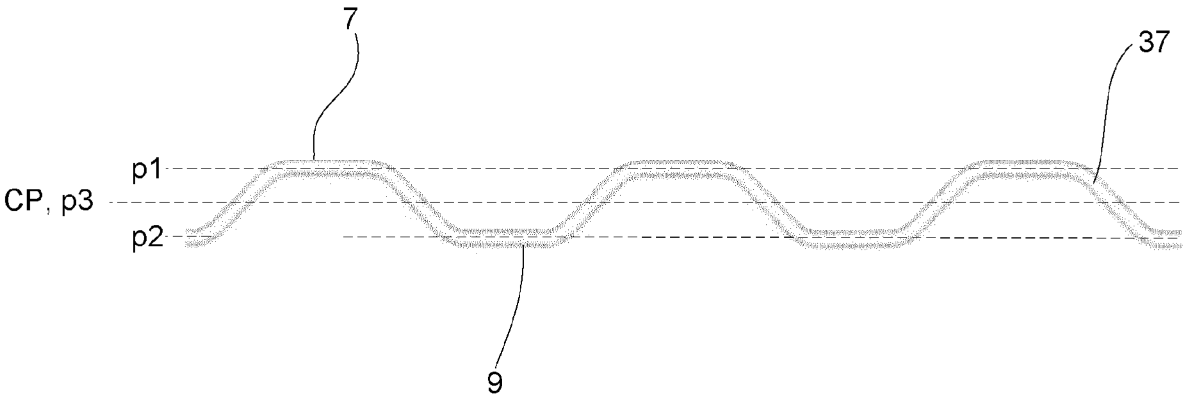
Fig. 2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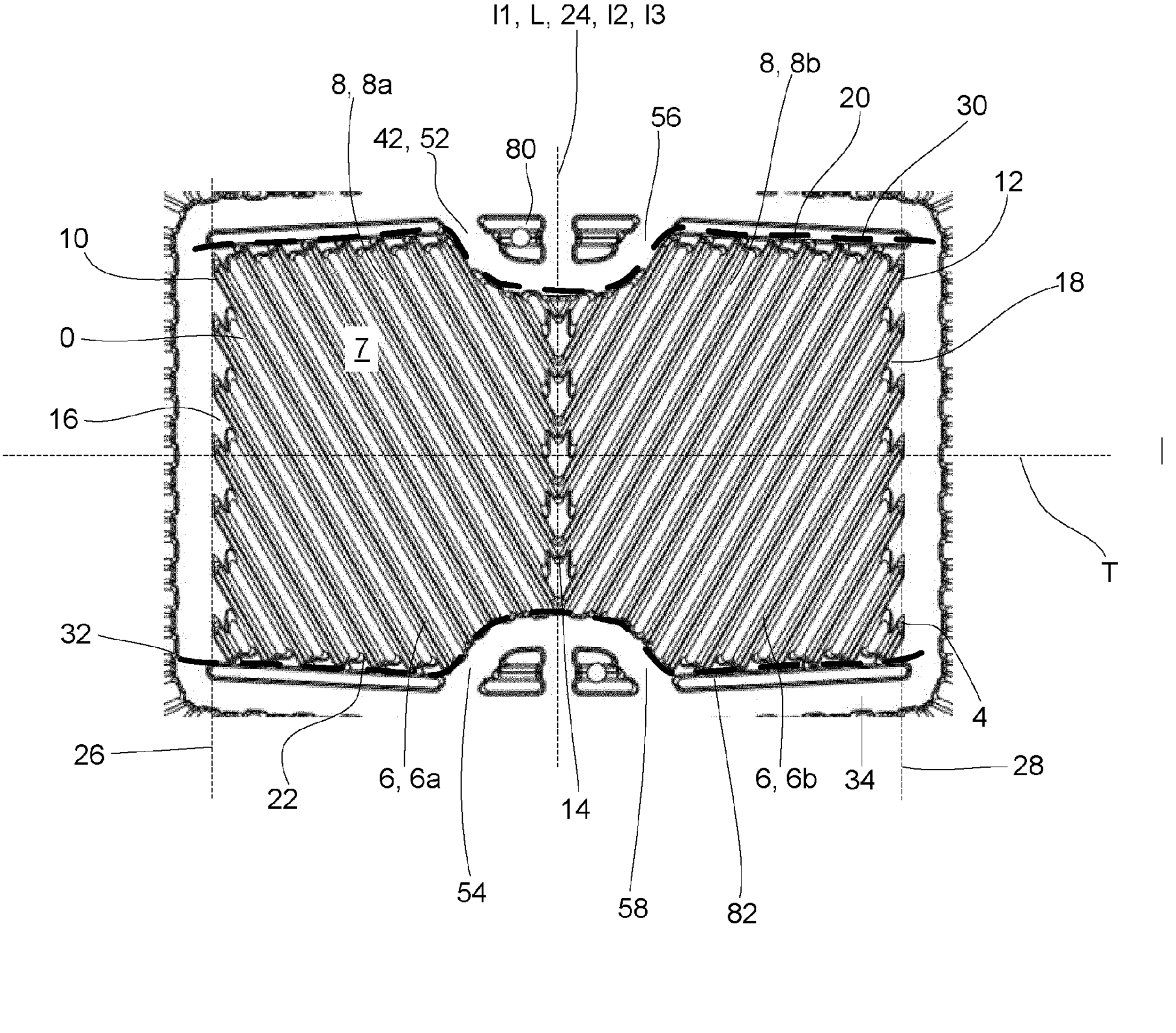
37
p1
CP, p3
p2
9

Fig. 3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8, 8b
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30
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42, 52
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12
10
18
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16
I
T
32
4
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22
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14
6, 6b
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28
54
58
82

Fig. 4

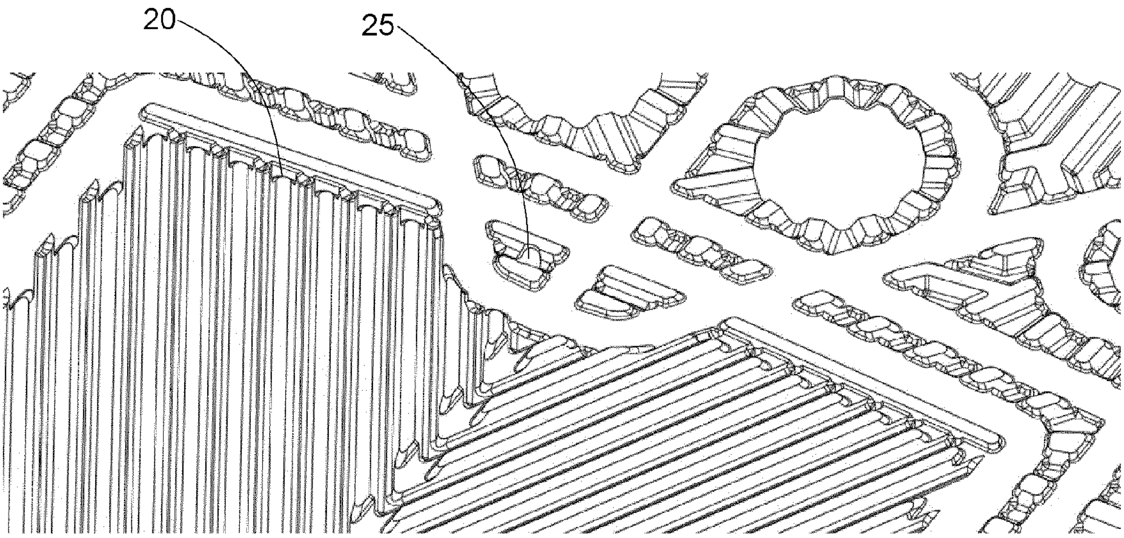


Fig. 5

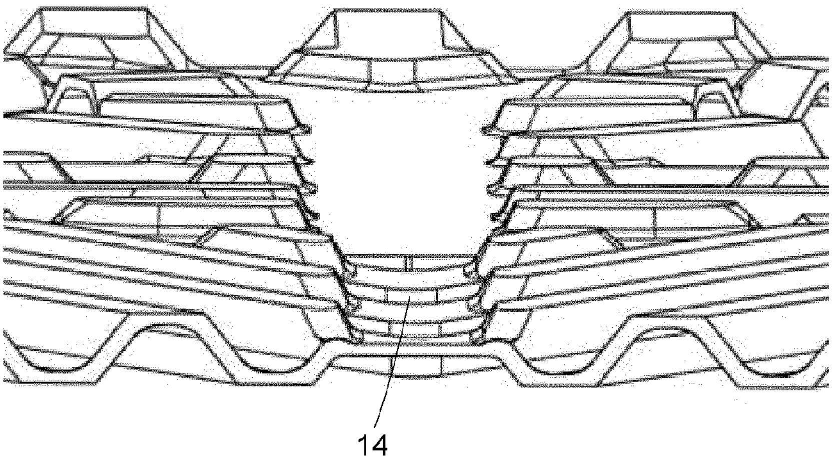


Fig. 6

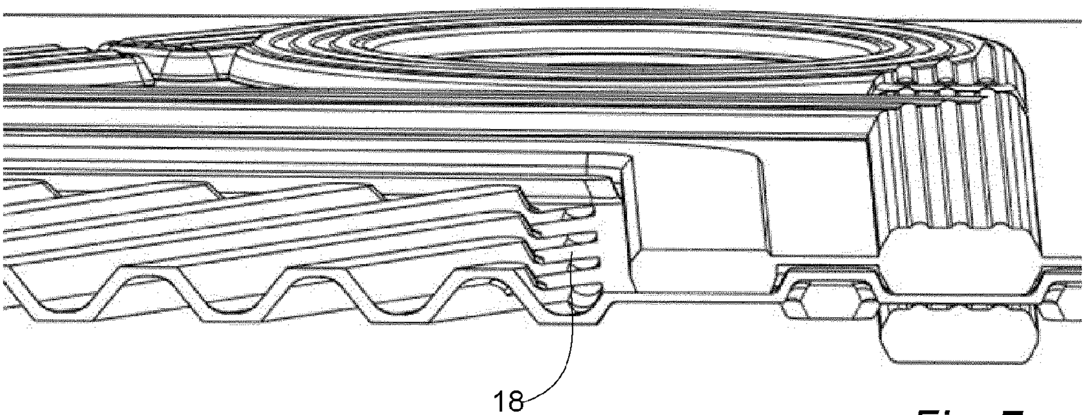


Fig. 7

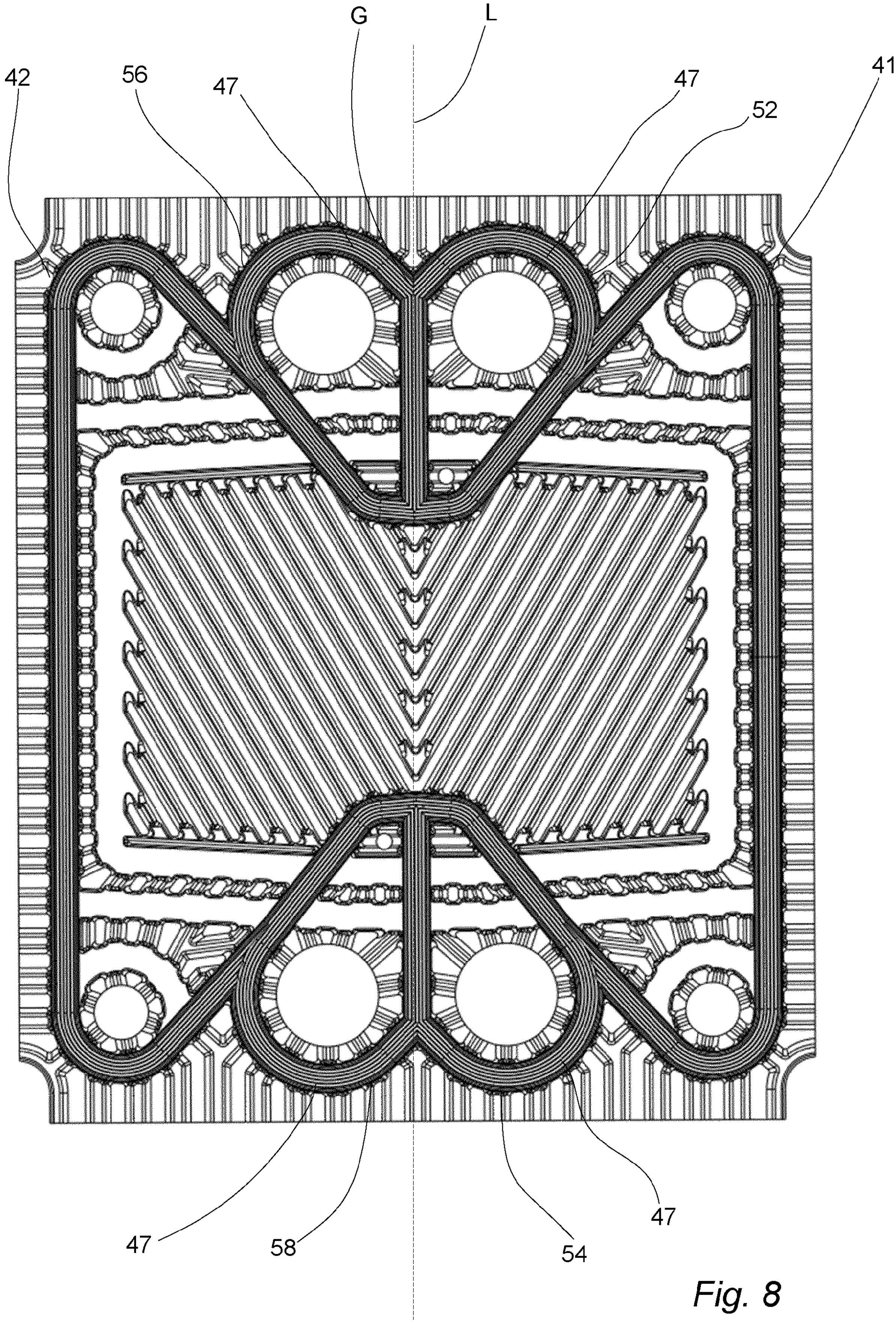
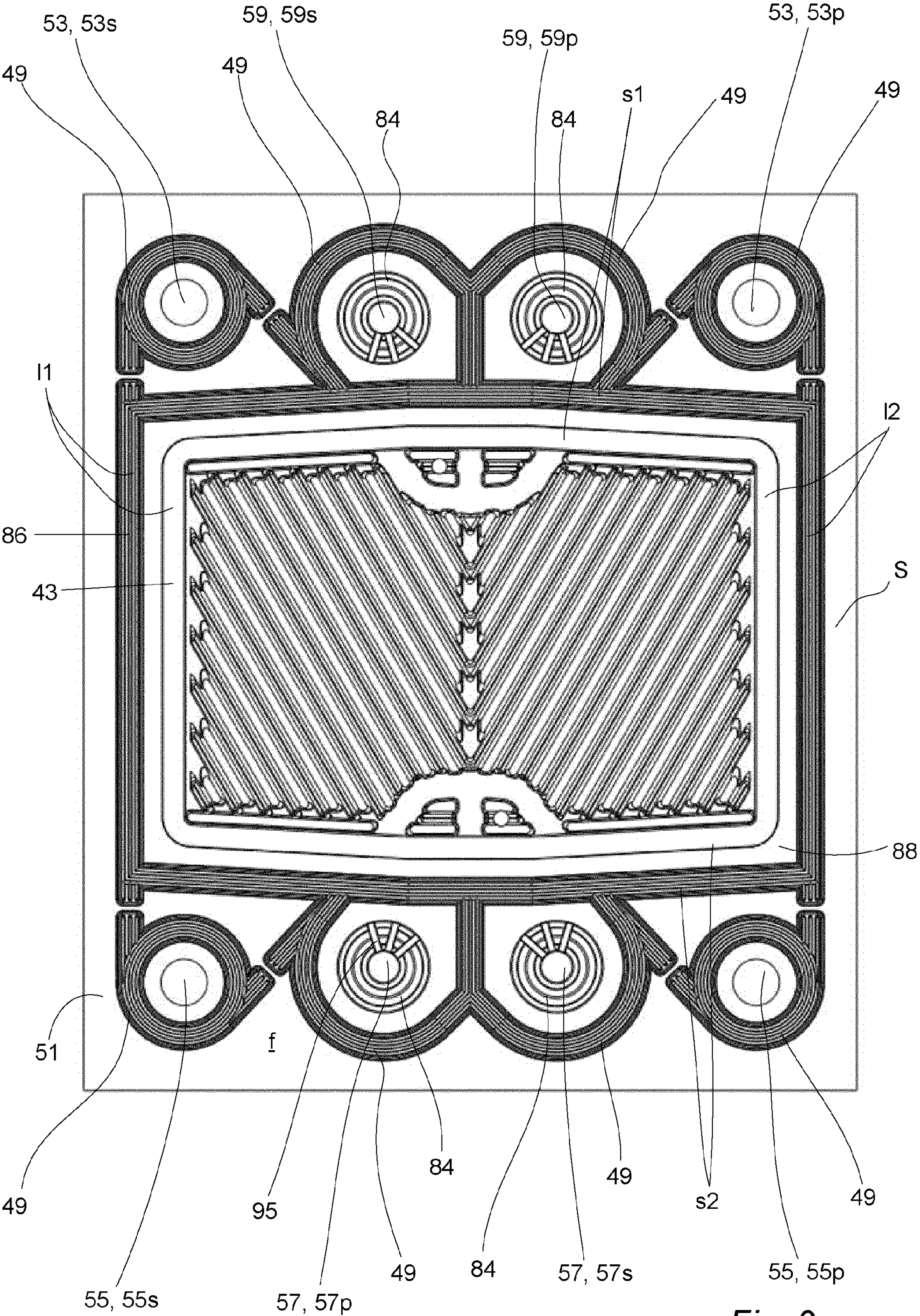


Fig. 8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s1
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l1
l2
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S
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49
57, 57s
s2
49
55, 55s
55, 55p

Fig. 9

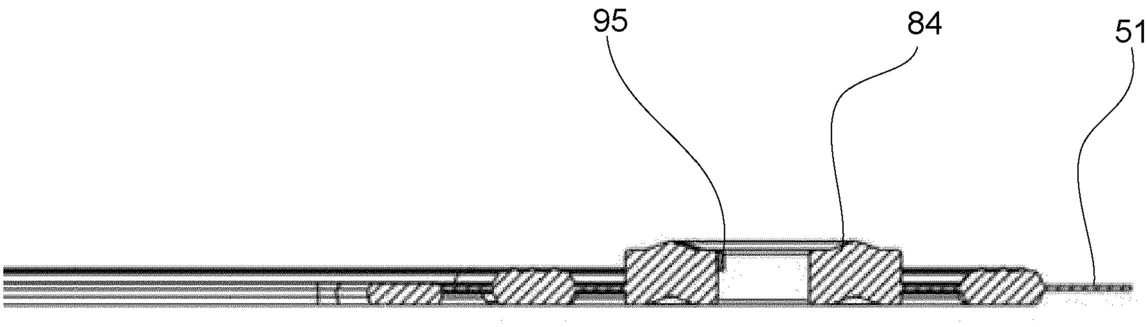


Fig. 10

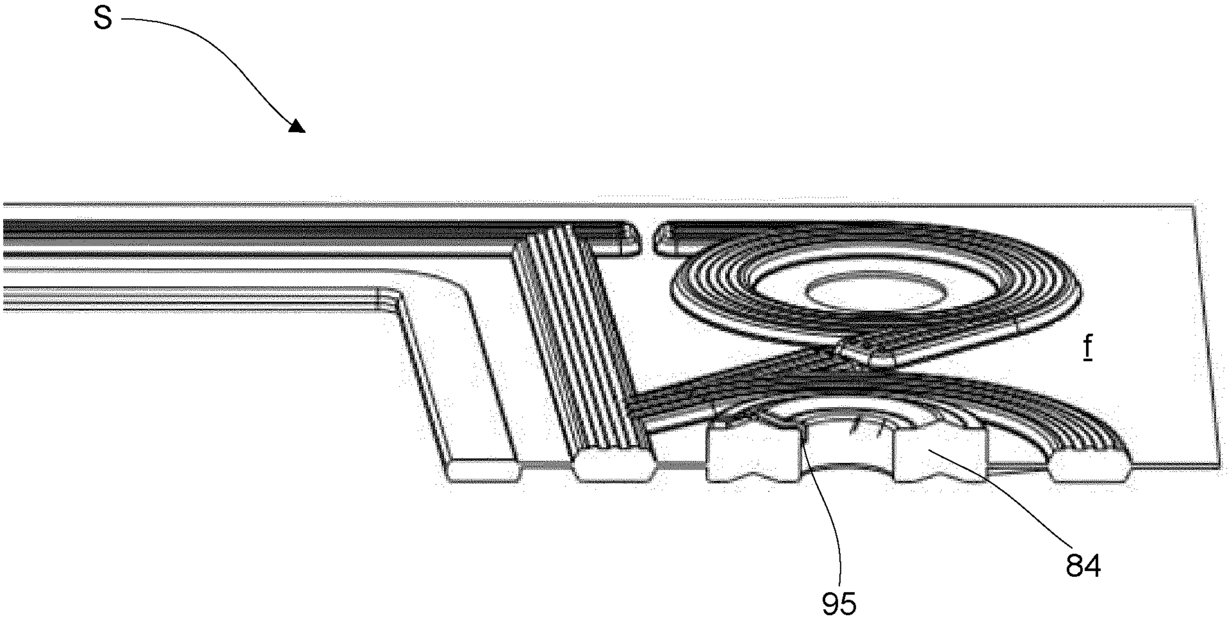


Fig. 11

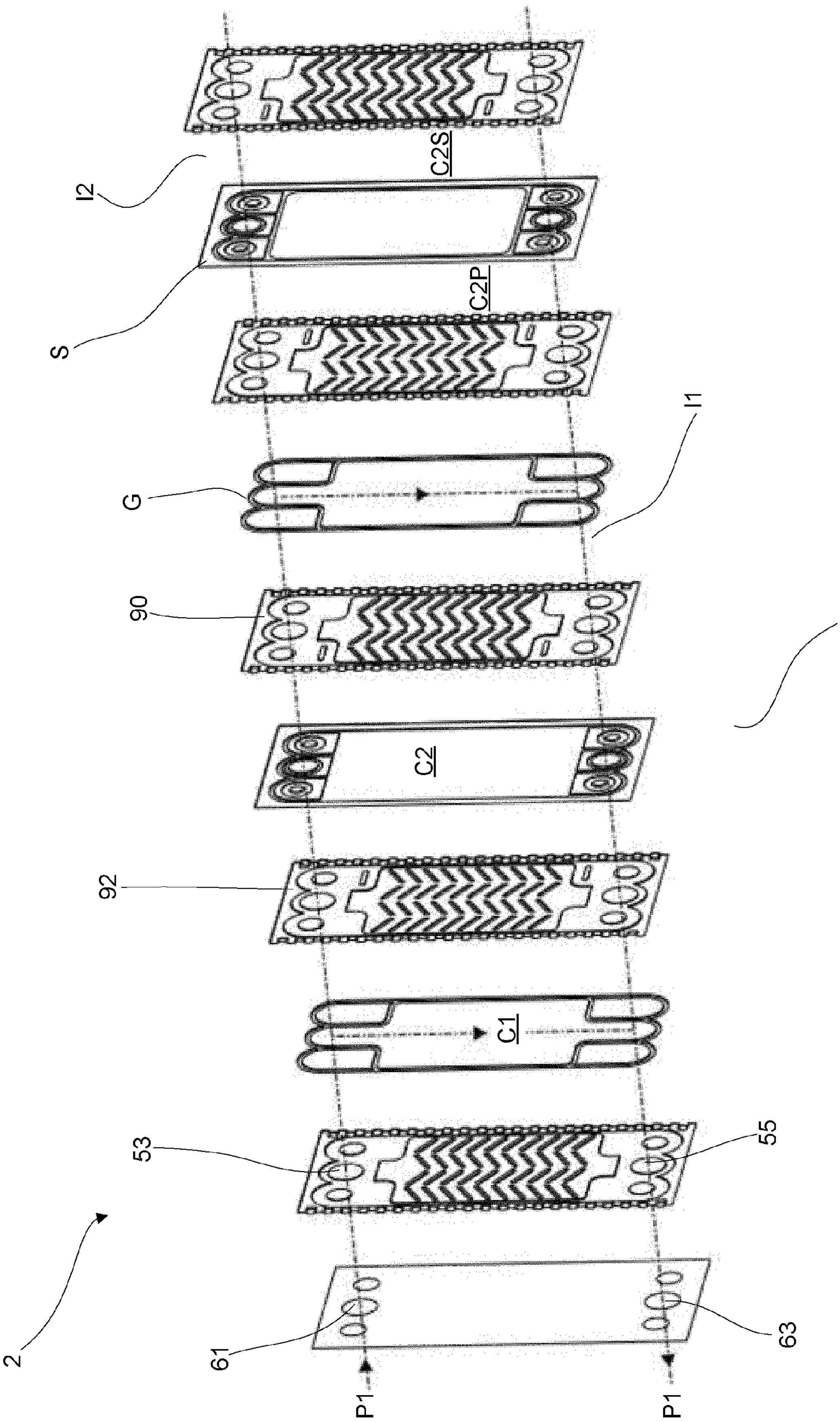
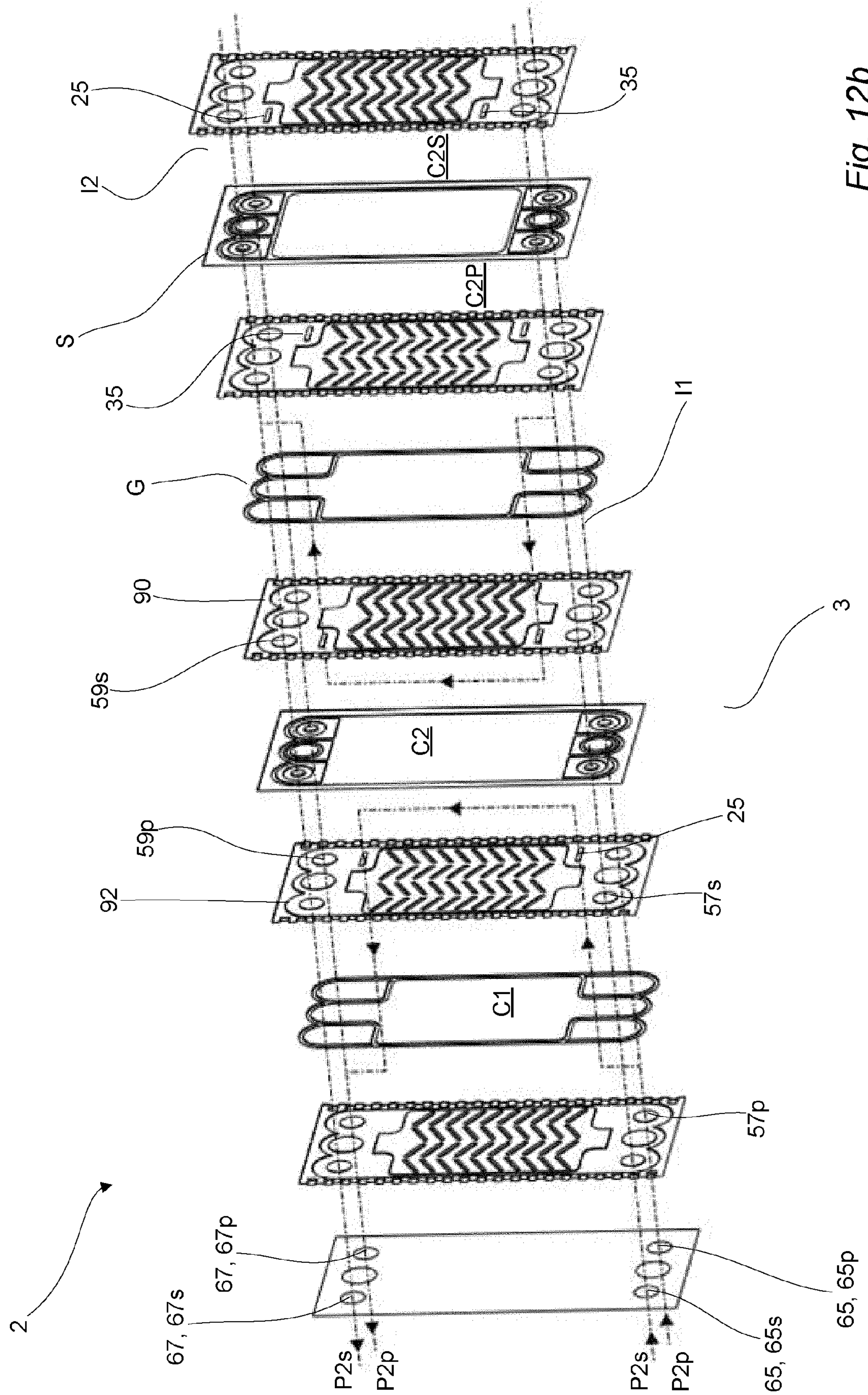


Fig. 12a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C2S
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C2
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92
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65, 65p
65, 65s
P2s
P2p
P2s
P2p

Fig. 12b

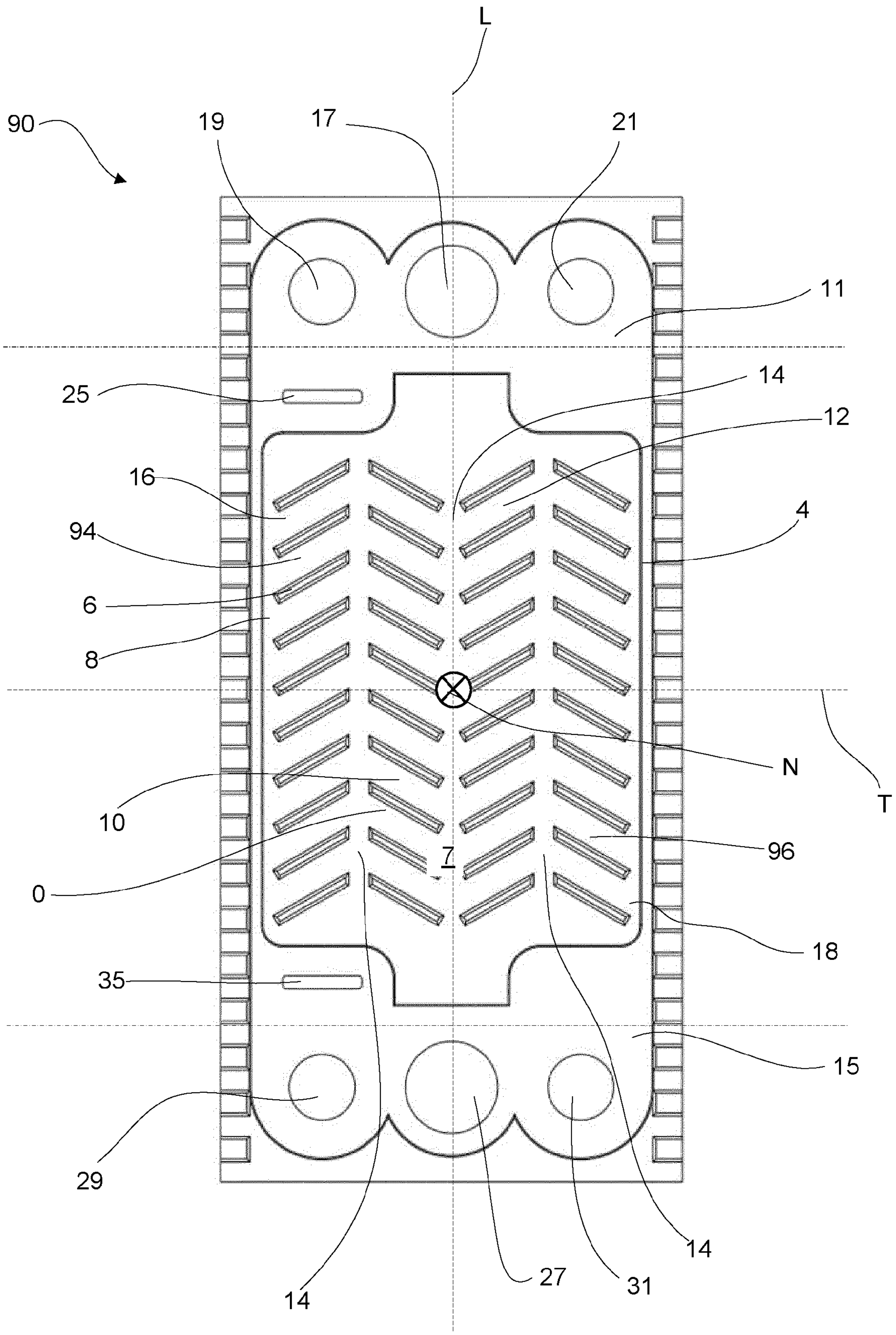

Fig. 13

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EUROPEAN SEARCH REPORT

Application Number
EP 22 21 5787

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A	WO 2006/104443 A1 (ALFA LAVAL CORP AB [SE]; JOENSEN HJALMAR [DK] ET AL.) 5 October 2006 (2006-10-05) * the whole document * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC): C25B F28F F28D H01M

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	27 October 2023	Leu, Oana

CATEGORY OF CITED DOCUMENTS

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