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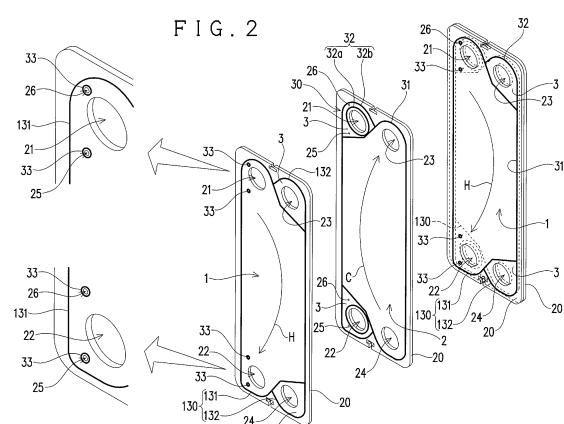
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(54) **PLATE HEAT EXCHANGER**

(57) Heat transfer plates are stacked, each being provided with a plurality of passage holes, a flow-path forming gasket is interposed between peripheries of each adjacent ones of the heat transfer plates, thereby alternately forming a first flow path to pass a high-temperature fluid, a second fluid to pass a low-temperature fluid, and communicating paths to cause the fluids to flow in and out of the first flow path and the second flow path on opposite sides of each heat transfer plate, and communicating-path forming gaskets surrounding the passage holes are interposed between adjacent ones of the heat transfer plates, thereby forming a communicating path to cause a fluid to flow in and out of the first flow path and a communicating path to cause a fluid to flow in and out the second flow path. Each communicating-path forming gasket is made up of inner and outer gasket members arranged in two lines, the inner gasket member surrounding the passage holes while the outer gasket member surrounding the inner gasket member.

F I G . 2



## Description

### CROSS REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims the priority to Japanese Patent Application No. 2011-233098, the disclosure of which is incorporated herein by reference in its entirety.

### FIELD OF THE INVENTION

**[0002]** The present invention relates to a plate heat exchanger for exchanging heat between a high-temperature fluid and a low-temperature fluid. More particularly, the present invention relates to a plate heat exchanger in which by stacking plural heat transfer plates and interposing a gasket between peripheries or the like of each adjacent ones of the heat transfer plates, a flow path adapted to pass a high-temperature fluid and a flow path adapted to pass a low-temperature fluid are formed alternately between each adjacent heat transfer plates.

### RELATED ART

**[0003]** In a plate heat exchanger, plural heat transfer plates 20 are stacked in an upright posture between a plate-shaped rectangular fixed frame 11 in an upright posture and a plate-shaped rectangular movable frame 12 in an upright posture as shown in FIG. 8, a first flow path 1 and a second flow path 2 are formed alternately between the heat transfer plates 20 as shown in FIG. 9, and a high-temperature fluid H is passed through the first flow path 1 while a low-temperature fluid C is passed through the second flow path 2, thereby exchanging heat between the high-temperature fluid H and low-temperature fluid C.

**[0004]** Passage holes 11a to 11d serving as inlet ports and outlet ports for the fluids H and C are provided in four corners of the fixed frame 11, whereas no passage hole is provided in the movable frame 12. Also, respective dedicated plates (hereinafter referred to as a "D plate" and "E plate") 31 and 32 are overlaid on the fixed frame 11 and the movable frame 12. Passage holes (not numbered) are provided in four corners of the D plate 31, and a gasket (hereinafter referred to as a "D gasket") 140 is interposed between the D plate 31 and the fixed frame 11, surrounding the passage holes. Note that no passage hole is provided in the E plate 32.

**[0005]** Also, passage holes 21 to 24 serving as inlet ports and outlet ports for the fluids H and C are provided in four corners of each of the heat transfer plates 20, a heat transfer portion (not numbered) is provided in an intermediate portion of the heat transfer plate 20, and a gasket 130 is interposed between each adjacent ones of the heat transfer plates 20, for example, such that the upper and lower left passage holes 21 and 22 are communicated with the heat transfer portion while the upper and lower right passage holes 23 and 24 are closed to the heat transfer portion, or vice versa.

**[0006]** The gasket 130 is made up of a flow-path forming gasket 131 configured to surround a periphery (inner side of an outer peripheral edge) of each heat transfer plate 20 and communicating-path forming gaskets 132 configured to surround circumferences of the passage holes 21 to 24, where the flow-path forming gasket 131 and communicating-path forming gaskets 132 may be formed either separately or integrally (not shown).

**[0007]** In the plate heat exchanger, the upper and lower right communicating-path forming gaskets 132 surround the upper and lower right passage holes 23 and 24, thereby forming communicating paths 3 isolated from the upper and lower left passage holes 21 and 22 as well as from the first flow path 1, and the flow-path forming gasket 131 surrounds the upper and lower left passage holes 21 and 22 as well as the heat transfer portion, thereby forming the first flow path 1 adapted to pass the high-temperature fluid H.

**[0008]** Also, in the plate heat exchanger, the upper and lower left communicating-path forming gaskets 132 surround the upper and lower left passage holes 21 and 22, thereby forming communicating paths 3 isolated from the upper and lower right passage holes 23 and 24 as well as from the second flow path 2, and the flow-path forming gasket 131 surrounds the upper and lower right communicating-path forming gaskets 132 as well as the heat transfer portion, thereby forming the second flow path 2 adapted to pass the low-temperature fluid C therethrough.

**[0009]** Thus, in FIG. 9, the high-temperature fluid H flows downward through the first flow path 1 from the upper left passage hole 21 and is discharged through the lower left passage hole 22 while the low-temperature fluid C flows upward through the second flow path 2 from the lower right passage hole 24 and is discharged through the upper right passage hole 23, thereby exchanging heat between the two fluids H and C.

**[0010]** Also, although not illustrated, Patent Literature 1 and the like describe a joined plate heat exchanger in which plural cassette plates constructed by permanently joining peripheries or other portions of two heat transfer plates by laser welding, brazing, or the like are stacked in an upright posture and gaskets are interposed on peripheries of the cassette plates, thereby forming a first flow path or second flow path in the cassette plates and forming the second flow path or first flow path between the cassette plates.

**[0011]** On the other hand, Patent Literature 2 describes a plate heat exchanger comprising a flow-path forming gasket and a communicating-path forming gasket which are integrated into a single gasket and interposed between heat transfer plates, in which part of the flow-path forming gasket and part of the communicating-path forming gasket are arranged side-by-side to provide double (two) gaskets in a border between a heat transfer portion and passage holes. In the plate heat exchanger, the double gaskets are firmly fixed to the heat transfer plates without using an adhesive and in other part, the gasket

is bonded to the heat transfer plates using an adhesive.

**[0012]** The double gaskets are interposed between every other pair of the stacked heat transfer plates (alternately), thereby forming a flow path configured to communicate the heat transfer portion and passage holes without double gaskets. Those heat transfer plates which lack double gaskets are subject to deformation due to internal pressure, but since the double gaskets are not bonded to the heat transfer plates with an adhesive, pressure tightness of the plate heat exchanger is improved.

#### CITATION LIST

##### Patent Literature

###### **[0013]**

Patent Literature 1: JP 2005-106412 A  
 Patent Literature 2: JP 9-72686 A

**[0014]** However, the conventional plate heat exchanger shown above in FIGS. 8 and 9 have problems such as described below.

**[0015]** In the plate heat exchanger, as shown in FIG. 9, the high-temperature fluid H flowing into the first flow path 1 flows through the communicating path 3 formed by the communicating-path forming gasket 132 which surrounds the passage hole 21. Since the communicating-path forming gasket 132 which forms the communicating path 3 through which the high-temperature fluid H flows has its inner side (wetted side) placed in contact with the high-temperature fluid H in a hot, humid environment as shown in FIG. 10, thermal degradation such as hardening or softening proceeds with long-term use.

**[0016]** Also, main component of the communicating-path forming gasket 132 is polymer (RH). Consequently, when the communicating-path forming gasket 132 is heated by the high-temperature fluid H, the polymer reacts with oxygen ( $O_2$ ) to generate alkyl radicals ( $R \bullet$ ). Since an outer side (non-wetted side) of the flow-path forming gasket 131 contacts the atmosphere, alkyl radicals ( $R \bullet$ ) react with oxygen to generate peroxy radicals ( $ROO \bullet$ ). The peroxy radicals ( $ROO \bullet$ ) react with polymer (RH) to generate peroxide ( $ROOH$ ). The peroxide ( $ROOH$ ) is unstable and readily decomposes itself into alkoxy radicals ( $RO \bullet$ ) and hydroxyl radicals ( $OH \bullet$ ).

**[0017]** In short, the communicating-path forming gasket 132 which forms the communicating path 3 through which the high-temperature fluid H flows has its wetted side placed in contact with the high-temperature fluid H, and its non-wetted side placed in contact with the atmosphere. Consequently, high molecules which make up a main component break down due to oxidative degradation reactions, increasing the number of radicals and causing breakage of molecular chains and cross-linking reactions to proceed. This results in a loss of elasticity intrinsic to rubber. At the same time, since the communicating-path forming gasket 132 is structurally in a com-

pressive environment, compression set increases, resulting in insufficient surface pressure, and cracks develop, resulting in a rupture. Then, as a result of the rupture, the high-temperature fluid H may leak from the communicating path 3 into the second flow path, mixing with the low-temperature fluid C.

**[0018]** Also, double gaskets are interposed inside the plate heat exchanger described in Patent Literature 2. However, the communicating-path forming gasket 132 which forms the communicating path 3 through which the high-temperature fluid H flows does not have two lines, and thus oxidative degradation can occur, resulting in external leakage of the high-temperature fluid H.

**[0019]** When the high-temperature fluid H is a dangerous chemical solution, leaking out of the high-temperature fluid H from the plate heat exchanger may cause secondary accidents. If the gaskets are replaced a little earlier to prevent secondary accidents, this will increase running costs. Also, a method is conceivable which inhibits oxidative degradation and prevents the high-temperature fluid H from flowing out, by covering the entire plate heat exchanger with an airtight sheet or the like or inserting rubber or the like into gaps among outer peripheral portions of the stacked heat transfer plates, but such a method is not adopted because of problems in terms of costs and quality.

#### DISCLOSURE OF THE INVENTION

##### **30 PROBLEMS TO BE SOLVED BY THE INVENTION**

**[0020]** Thus, an object of the present invention is to provide a plate heat exchanger that is less likely to cause degradation of communicating-path forming gaskets which form a communicating path through which a high-temperature fluid flows.

#### MEANS FOR SOLVING PROBLEMS

**[0021]** In a plate heat exchanger according to the present invention, a plurality of heat transfer plates are stacked, each being provided with a plurality of passage holes; a flow-path forming gasket is interposed between peripheries of each adjacent ones of the plurality of heat transfer plates, thereby alternately forming a first flow path adapted to pass a high-temperature fluid and a second fluid adapted to pass a low-temperature fluid on opposite sides of each heat transfer plate; communicating-path forming gaskets surrounding the passage holes are each interposed between each adjacent ones of the plurality of heat transfer plates, thereby forming a communicating path adapted to cause a fluid to flow in and out of the first flow path and a communicating path adapted to cause a fluid to flow in and out the second flow path; and each of the communicating-path forming gaskets is made up of an inner gasket member and an outer gasket member arranged in two lines, the inner gasket member surrounding the passage holes while the outer gasket

member surrounding the inner gasket member.

**[0022]** Here, as one aspect of the plate heat exchanger according to the present invention, the communicating-path forming gasket may be arranged in two parallel lines only between the heat transfer plates which form the communicating path through which the high-temperature fluid flows.

**[0023]** In a plate heat exchanger according to the present invention different from the one described above, a plurality of cassette plates are stacked, each being made up of two heat transfer plates which are provided with a plurality of passage holes and are permanently joined on peripheries; a flow-path forming gasket is interposed between peripheries of each adjacent ones of the plurality of cassette plates; communicating-path forming gaskets surrounding the passage holes are each interposed between each adjacent ones of the plurality of heat transfer plates, thereby alternately forming a first flow path adapted to pass a high-temperature fluid and a second flow path adapted to pass a low-temperature fluid inside each cassette plate and between the cassette plates, wherein each of the communicating-path forming gaskets is made up of an inner gasket member and an outer gasket member arranged in two lines, the inner gasket member surrounding the passage holes while the outer gasket member surrounding the inner gasket member.

**[0024]** Also, as one aspect of the plate heat exchanger according to the present invention, a configuration can be adopted in which a drain hole is formed in the heat transfer plates between the inner gasket member and the outer gasket member of each of the communicating-path forming gaskets.

**[0025]** Also, as another aspect of the plate heat exchanger according to the present invention, a configuration can be adopted in which a gas supply hole is formed in the heat transfer plates between the inner gasket member and the outer gasket member of each of the communicating-path forming gaskets; and an enclosed space surrounded by the inner gasket member, the outer gasket member, and the heat transfer plates is filled with an inert gas.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0026]**

FIG. 1 is a schematic exploded perspective view showing a plate heat exchanger according to first and second embodiments of the present invention.

FIG. 2 is a schematic exploded perspective view showing principal part of the plate heat exchanger according to the first and second embodiments of the present invention.

FIG. 3 is a schematic exploded perspective view showing principal part of the plate heat exchanger according to a variation of the first and second embodiments of the present invention.

FIG. 4 is a perspective view showing the plate heat exchanger according to the second embodiment of the present invention.

FIG. 5 is an enlarged exploded perspective view showing principal part of the plate heat exchanger according to the second embodiment of the present invention.

FIG. 6 is an enlarged sectional view along the line V-V in FIG. 5, showing principal part of the plate heat exchanger according to the second embodiment of the present invention.

FIG. 7 is an enlarged sectional view showing principal part of the plate heat exchanger according to the third embodiment of the present invention.

FIG. 8 is a schematic perspective view showing a conventional plate heat exchanger.

FIG. 9 is a schematic exploded perspective view showing the conventional plate heat exchanger.

FIG. 10 is an enlarged sectional view of principal part showing principal part of the conventional plate heat exchanger.

#### DESCRIPTION OF EMBODIMENTS

**[0027]** A plate heat exchanger according to a first embodiment of the present invention is described below with reference to FIGS. 1 to 3. The same components as conventional components are described by the same reference numerals as the corresponding conventional components. In the following description, terms such as upper, lower, right, and left are exemplary in each embodiment, and, needless to say, may represent different positions depending on actual usage.

**[0028]** As is conventionally the case, the plate heat exchanger according to the first embodiment is an apparatus in which a first flow path 1 and a second flow path 2 are formed alternately between heat transfer plates 20 as shown in FIGS. 1 to 3, a high-temperature fluid H is passed through the first flow path 1 while a low-temperature fluid C is passed through the second flow path 2. The first flow paths 1 and the second flow paths 2 are formed by respective gaskets 30 interposed between the heat transfer plates 20.

**[0029]** The gaskets 30 each are made up of a flow-path forming gasket 31 configured to surround a periphery of each heat transfer plate 20 and a communicating-path forming gasket 32 configured to surround circumferences of the passage holes 21 to 24, so that the flow-path forming gasket 31 and the communicating-path forming gasket 32 may be formed either integrally (shown in FIGS. 1 and 2) or separately (shown in FIG. 3). The gasket 30 in which the flow-path forming gasket 31 and the communicating-path forming gasket 32 are formed integrally is based on shared use of a border between a heat transfer portion and the passage holes 21 to 24, as shown in FIG. 2.

**[0030]** In the plate heat exchanger according to the first embodiment, as shown in FIG. 2, the communicat-

ing-path forming gasket (hereinafter, referred to as "double-line gasket") 32 provided with a communicating path 3 through which a high-temperature fluid H is passed is made up of an inner gasket member 32a and an outer gasket member 32b arranged in two lines. Consequently, each heat transfer plate 20 is double-grooved to correspond to the inner gasket member 32a and the outer gasket member 32b of the double-line gasket 32.

**[0031]** The inner gasket member 32a is formed annularly so as to surround the passage holes 21 and 22. The outer gasket member 32b is formed in the shape of a modified trapezoid and its border with the second flow path 2 is shared with the flow-path forming gasket 31.

**[0032]** As shown in FIG. 3, when the flow-path forming gasket 31 and the communicating-path forming gasket 32 are formed separately, the double-line gasket 32 is configured by arranging the annular inner gasket member 32a and the annular outer gasket member 32b concentrically in two parallel lines, the inner gasket member 32a surrounding the passage holes 21 and 22 while the outer gasket member 32b surrounding the inner gasket member 32a. Therefore, no part of the outer gasket member 32b is shared with the flow-path forming gasket 31.

**[0033]** Thus, the double-line gasket 32 surrounds the upper and lower left passage holes 21 and 22, thereby forming the communicating path 3 through which the high-temperature fluid H flows. The communicating path 3 through which the low-temperature fluid C flows is formed by the communicating-path forming gasket 132, which is a conventionally-used typical gasket (hereinafter referred to as a "single-line gasket") 130, surrounding the upper and lower right passage holes 23 and 24. However, the communicating path 3 may be formed by the double-line gasket 32 surrounding the upper and lower right passage holes 23 and 24.

**[0034]** Then, the first flow path 1 adapted to pass the high-temperature fluid H is formed by the communicating-path forming gasket 132, which is a single-line gasket 130, being interposed between a pair of heat transfer plates 20 such that the communicating-path forming gasket 132 isolates the upper and lower right passage holes 23 and 24 and that the flow-path forming gasket 131 surrounds the upper and lower left passage holes 21 and 22, and the heat transfer portion.

**[0035]** Note that although not illustrated, the flow-path forming gasket 131 which forms the first flow path 1 may also be made up of an inner gasket member and an outer gasket member arranged in two parallel lines. This can prevent the gasket which forms the first flow path from oxidative degradation. Furthermore the flow-path forming gasket 131 which forms the second flow path 2 may be also made up of an inner gasket member and an outer gasket member arranged in two parallel lines. This makes it possible to assemble the first flow path 1 and the second flow path 2 without distinguishing therebetween.

**[0036]** As the gasket 30 and the single-line gasket 130 are interposed between adjacent heat transfer plates 20

alternately, the high-temperature fluid H flows through the first flow path 1 from the upper left passage hole 21 and is discharged through the lower left passage hole 22 while the low-temperature fluid C flows through the second flow path 2 from the lower right passage hole 24 and is discharged through the upper right passage hole 23, thereby exchanging heat between the high-temperature fluid H and the low-temperature fluid C.

**[0037]** In so doing, the high-temperature fluid H flows into the first flow path 1 by passing through the upper left communicating path 3. The high-temperature fluid H in the communicating path 3 contacts the inner gasket member 32a of the double-line gasket 32, but the inner gasket member 32a, whose circumferences are surrounded by the outer gasket member 32b, does not contact the atmosphere, and is thus less prone to oxidative degradation reactions.

**[0038]** Since the high-temperature fluid H flowing through the lower left communicating path 3 has been lowered in temperature by exchanging heat with the low-temperature fluid C, the gasket 32 which forms the lower left communicating path 3 may be configured to have a single line rather than two lines. Even if the communicating paths 3 used to communicate the upper and lower right passage holes 23 and 24 is formed by the communicating-path forming gasket 132 configured to be a single-line gasket 130, the communicating paths 3, through which the low-temperature fluid C flows, do not get so hot as to cause oxidative degradation of the communicating-path forming gaskets 132.

**[0039]** Thus, the plate heat exchanger is configured such that the double-line gaskets 32 will not crack and that the high-temperature fluid H will not leak from the communicating paths 3.

**[0040]** Next, a plate heat exchanger according to a second embodiment of the present invention is described below with reference to FIGS. 2 to 6. According to the second embodiment, a drain hole 25 and/or a gas supply hole 26 are provided in the heat transfer plate 20 sandwiched between the inner gasket member 32a and the outer gasket member 32b of the double-line gasket 32.

**[0041]** In order to discharge the high-temperature fluid H leaking from the inner gasket members 32a of the double-line gaskets 32, the drain hole 25 is made continuous by the annular gasket 33 interposed between each pair of heat transfer plates 20 where the first flow path 1 is provided.

**[0042]** Then, as shown in FIG. 4, a nozzle 13 continuous with each drain hole 25 is mounted on the fixed frame 11, making it possible to detect any leakage of the high-temperature fluid H from the nozzle 13 and hence detect any leakage from the inner gasket members 32a due to cracks, as shown in FIG. 6.

**[0043]** FIGS. 5 and 6 also show how the double-line gasket 32 shown in FIG. 2 is interposed between each pair of the heat transfer plates 20 and how the communicating hole 21 is surrounded by double-line D gaskets 41 and 42 interposed between the fixed frame 11 and a

D plate 20d, but the plate heat exchanger according to the second embodiment can use the double-line gasket 32 shown in FIG. 3 as well.

**[0044]** In either case, the gas supply hole 26 is formed to make the inner gasket member 32a still less prone to oxidative degradation reactions. In other words, an inert gas such as nitrogen is supplied from the gas supply hole 26 to an enclosed space surrounded by the inner gasket member 32a and the outer gasket member 32b of the double-line gasket 32 and the two heat transfer plates 20 so that the inner gasket member 32a does not contact oxygen at all.

**[0045]** Regarding the enclosed space, since the first flow paths 1 are placed next to one another via the heat transfer plates 20, by interposing the annular gasket 33 continuous with the gas supply hole 26 between each pair of heat transfer plates 20 where the first flow path 1 is provided, an inert gas is supplied into the enclosed space through each nozzle 14 mounted on the fixed frame 11 and communicated with the gaskets 33. As shown in FIG. 4, the nozzles 14 for use to supply the inert gas are mounted on the fixed frame 11.

**[0046]** The drain hole 25 and the gas supply hole 26 may be provided only in the upper left communicating path 3 through which the high-temperature fluid H flows at a high temperature, but when the drain hole 25 and the gas supply hole 26 are provided also in the double-line gasket 32 forming the lower left communicating path 3 through which the high-temperature fluid H flows at a lowered temperature, the heat transfer plate 20 can be assembled upside down. Thus, when the drain hole 25 and the gas supply hole 26 are provided in the upside-down position, the drain hole 25 is formed to serve as the gas supply hole 26 and the gas supply hole 26 is formed to serve as the drain hole 25.

**[0047]** Next, a plate heat exchanger according to a third embodiment of the present invention is described below with reference to FIG. 7. According to the third embodiment, double-line gaskets 32 are interposed between plural cassette plates 200 stacked in an upright posture.

**[0048]** The cassette plate 200 is constructed by permanently joining peripheries of two heat transfer plates 20 by laser welding, brazing, or the like (indicated by black dots in FIG. 7), and the first flow path 1 adapted to pass the high-temperature fluid H or the second flow path 2 adapted to pass the low-temperature fluid C is provided therein.

**[0049]** Plural cassette plates 200 are stacked, and the second flow path 2 adapted to pass the low-temperature fluid C or the first flow path 1 adapted to pass the high-temperature fluid H is provided between each adjacent ones of the cassette plates 200. The gaskets 30 are interposed between the peripheries of the stacked cassette plates 200.

**[0050]** The gasket 30 is a combination of the flow-path forming gasket (not shown) interposed in the permanently joined peripheries of the cassette plate 200 and the

double-line gasket 32 forming the communicating path 3. The double-line gasket 32 is configured by arranging the annular inner gasket member 32a and the annular outer gasket member 32b concentrically in two lines, the inner gasket member 32a surrounding the passage holes 21 and 22 while the outer gasket member 32b surrounding the inner gasket member 32a. The outer gasket member 32b is installed inside the permanently joined portions as illustrated.

**[0051]** Alternatively, although not illustrated, the outer gasket member 32b may be installed in a space 201 between the permanently joined portions and the inner gasket member 32a may be installed inward from the permanently joined portion (a line on which the outer gasket member 32b is installed in FIG. 7).

**[0052]** Since the high-temperature fluid H is passed through the first flow path 1 in the cassette plate 200, the high-temperature fluid H also flows through the communicating paths 3. The communicating paths 3 are formed by the double-line gaskets 32 which surround the passage holes 21 and 22. Although the inner gasket members 32a of the double-line gaskets 32 are placed in contact with the high-temperature fluid H, reactions with oxygen in the atmosphere are inhibited, thereby inhibiting oxidative degradation.

**[0053]** Therefore, the plate heat exchanger configured by assembling the cassette plates 200 is also less prone to early leakage of the high-temperature fluid H, with settling or subsidence of the double-line gaskets 32 inhibited, where the settling could be caused by cracks and aging degradation. The plate heat exchanger can be configured such that the high-temperature fluid H will not leak even if the low-temperature fluid C is passed through the cassette plates 200 and the high-temperature fluid H is passed between the cassette plates 200.

**[0054]** Thus, in the plate heat exchanger according to the present embodiment, the plurality of heat transfer plates 20 are stacked, each being provided with the plurality of passage holes 21, 22, 23, and 24; the flow-path forming gasket 31 is interposed between peripheries of each adjacent ones of the heat transfer plates 20, thereby alternately forming the first flow path 1 adapted to pass the high-temperature fluid H and the second fluid 2 adapted to pass the low-temperature fluid C on opposite sides of each heat transfer plate 20; the communicating-path forming gaskets 32 surrounding the passage holes 21, 22, 23, and 24 are interposed between adjacent ones of the heat transfer plates 20, thereby forming the communicating path 3 adapted to cause the fluid H to flow in and out of the first flow path 1 and the communicating path 3 adapted to cause the fluid C to flow in and out the second flow path 2; and each of the communicating-path forming gaskets 32 is made up of the inner gasket member 32a and the outer gasket member 32b arranged in two lines, the inner gasket member 32a surrounding the passage holes 21, 22, 23, and 24 while the outer gasket member 32b surrounding the inner gasket 32a. Therefore, since the communicating-path forming gaskets 32, each made

up of the inner gasket member 32a and the outer gasket member 32b arranged in two parallel lines, surround the passage holes 21, 22, 23, and 24, forming the communicating paths 3, although the inner gasket member 32a is exposed to the high-temperature fluid H, reactions with oxygen in the atmosphere are inhibited. Therefore, breakage of molecular chains and cross-linking reactions due to oxidative degradation reactions do not proceed in the inner gasket member 32a which maintains sealing and consequently increases in compression set and cracks are suppressed. Thus, the high-temperature fluid H flowing through the communicating paths 3 formed by the communicating-path forming gaskets 32 can be made less prone to leakage.

**[0055]** Also, in the plate heat exchanger according to the present embodiment, the communicating-path forming gasket 32 is arranged in two parallel lines only between the heat transfer plates 20 which form the communicating path 3 through which the high-temperature fluid H flows. Thus, in view of the fact that the communicating-path forming gasket 32 which forms the communicating path 3 through which the high-temperature fluid H flows is prone to degradation due to oxidative degradation reactions, only the communicating-path forming gasket 32 is configured to have two-line arrangement and the communicating-path forming gasket 32 which forms a flow path through which the low-temperature fluid C flows is configured to have a single-line arrangement.

**[0056]** Also, in the plate heat exchanger according to the present embodiment, the plurality of cassette plates 200 are stacked, each of the cassette plates 200 being made up of two heat transfer plates 20 which are provided with the plurality of passage holes 21, 22, 23, and 24 and are permanently joined along peripheries; the flow-path forming gasket 31 is interposed between peripheries of each adjacent ones of the cassette plates 200; the communicating-path forming gasket 32 surrounding the passage holes 21, 22, 23, and 24 is interposed between the adjacent heat transfer plates 200, thereby alternately forming the first flow path 1 adapted to pass the high-temperature fluid H and the second flow path 2 adapted to pass the low-temperature fluid C inside each cassette plate 200 and between the cassette plates 200, wherein each of the communicating-path forming gaskets 32 is made up of an inner gasket member 32a and an outer gasket member 32b arranged in two lines, the inner gasket member 32a surrounding the passage holes while the outer gasket member 32b surrounding the inner gasket 32a. Since the communicating-path forming gasket 32 interposed between the cassette plates 200 is made up of the inner gasket member 32a and the outer gasket member 32b arranged in two lines, when the first flow path 1 adapted to pass the high-temperature fluid H is provided in the cassette plates 200 the communicating-path forming gasket 32 is less prone to oxidative degradation reactions, and consequently progress of gasket degradation can be suppressed, and leakage of the high-temperature fluid H from the communicating path 3 can

be prevented from being easily caused.

**[0057]** Also, in the plate heat exchanger according to the present embodiment, the drain hole 25 is formed in the heat transfer plate 20 between the inner gasket member 32a and the outer gasket member 32b of the communicating-path forming gasket 32. Since the drain hole 25 is formed in the heat transfer plate between the inner gasket member 32a and the outer gasket member 32b, even if the inner gasket undergoes settling or subsidence due to thermal degradation or aging degradation, the high-temperature fluid H leaking from the inner gasket member 32a can be discharged through the drain hole 25 in the outer gasket member 32b.

**[0058]** Also, in the plate heat exchanger according to the present embodiment, the gas supply hole 26 is formed in the heat transfer plate 20 between the inner gasket member 32a and the outer gasket member 32b of the communicating-path forming gaskets 32 and an enclosed space surrounded by the inner gasket member 32a and the heat transfer plates 20 is filled with an inert gas. Since the enclosed space surrounded by the inner gasket member 32a, the outer gasket member 32b, and the heat transfer plates 20 is filled with an inert gas, it is possible to minimize oxidative degradation reactions of the inner gasket member 32a by eliminating air in the enclosed space.

**[0059]** Note that the present invention is not limited to the first to third embodiments described above and that various changes can be made to the embodiments. For example, the plate heat exchanger described in the third embodiment in which the cassette plates 200 are stacked may be provided with the exhaust hole and the gas supply hole 26 described in the second embodiment. Also, the communicating-path forming gasket 30 may be arranged in two lines only on the upstream side of the first flow path 1 as described in the first embodiment. Also, the nozzle 13 continuous with the drain hole 25 and the nozzle 14 continuous with the gas supply hole 26 may be installed on the movable frame 12 rather than on the fixed frame 11.

#### REFERENCE SIGNS LIST

##### **[0060]**

|    |                |  |
|----|----------------|--|
| 45 | 1              | First flow path  |
|    | 2              | Second flow path                                       |
|    | 3              | Communicating path                                     |
|    | 20             | Heat transfer plate                                    |
| 50 | 21, 22, 23, 24 | Passage hole   |
|    | 25             | Drain hole   |
|    | 26             | Gas supply hole  |
|    | 30             | Gasket   |
|    | 31             | Flow-path forming gasket                               |
| 55 | 32             | Communicating-path forming gasket (double-line gasket) |
|    | 32a            | Inner gasket member                                    |
|    | 32b            | Outer gasket member                                    |

|     |                        |
|-----|------------------------|
| 200 | Cassette plate         |
| C   | Low-temperature fluid  |
| H   | High-temperature fluid |

5

**Claims****1. A plate heat exchanger wherein:**

a plurality of heat transfer plates are stacked, 10  
 each being provided with a plurality of passage holes;  
 a flow-path forming gasket is interposed between peripheries of each adjacent ones of the plurality of heat transfer plates, thereby alternately forming a first flow path adapted to pass a high-temperature fluid and a second fluid adapted to pass a low-temperature fluid on opposite sides of each heat transfer plate; 15  
 communicating-path forming gaskets surrounding the passage holes are each interposed between each adjacent ones of the plurality of heat transfer plates, thereby forming a communicating path adapted to cause a fluid to flow in and out of the first flow path and a communicating path adapted to cause a fluid to flow in and out 20  
 the second flow path; and  
 each of the communicating-path forming gaskets is made up of an inner gasket member and an outer gasket member arranged in two lines, 25  
 the inner gasket member surrounding the passage holes while the outer gasket member surrounding the inner gasket member.

**2. The plate heat exchanger according to claim 1, 35  
 wherein the communicating-path forming gasket is arranged in two parallel lines only between the heat transfer plates which form the communicating path through which the high-temperature fluid flows.**

40

**3. A plate heat exchanger wherein:**

a plurality of cassette plates are stacked, each being made up of two heat transfer plates which are provided with a plurality of passage holes 45  
 and are permanently joined on peripheries;  
 a flow-path forming gasket is interposed between peripheries of each adjacent ones of the plurality of cassette plates;  
 communicating-path forming gaskets surrounding the passage holes are each interposed between each adjacent ones of the plurality of heat transfer plates, thereby alternately forming a first flow path adapted to pass a high-temperature fluid and a second flow path adapted to pass a low-temperature fluid inside each cassette plate 50  
 and between the cassette plates;  
 wherein each of the communicating-path form-

ing gaskets is made up of an inner gasket member and an outer gasket member arranged in two lines, the inner gasket member surrounding the passage holes while the outer gasket member surrounding the inner gasket member.

- 4. The plate heat exchanger according to any one of claims 1 to 3,**  
 wherein a drain hole is formed in the heat transfer plates between the inner gasket member and the outer gasket member of each of the communicating-path forming gaskets.
- 5. The plate heat exchanger according to any one of claims 1 to 4,**  
 wherein a gas supply hole is formed in the heat transfer plates between the inner gasket member and the outer gasket member of each of the communicating-path forming gaskets; and an enclosed space surrounded by the inner gasket member, the outer gasket member, and the heat transfer plates is filled with an inert gas.

1  
G.  
E.

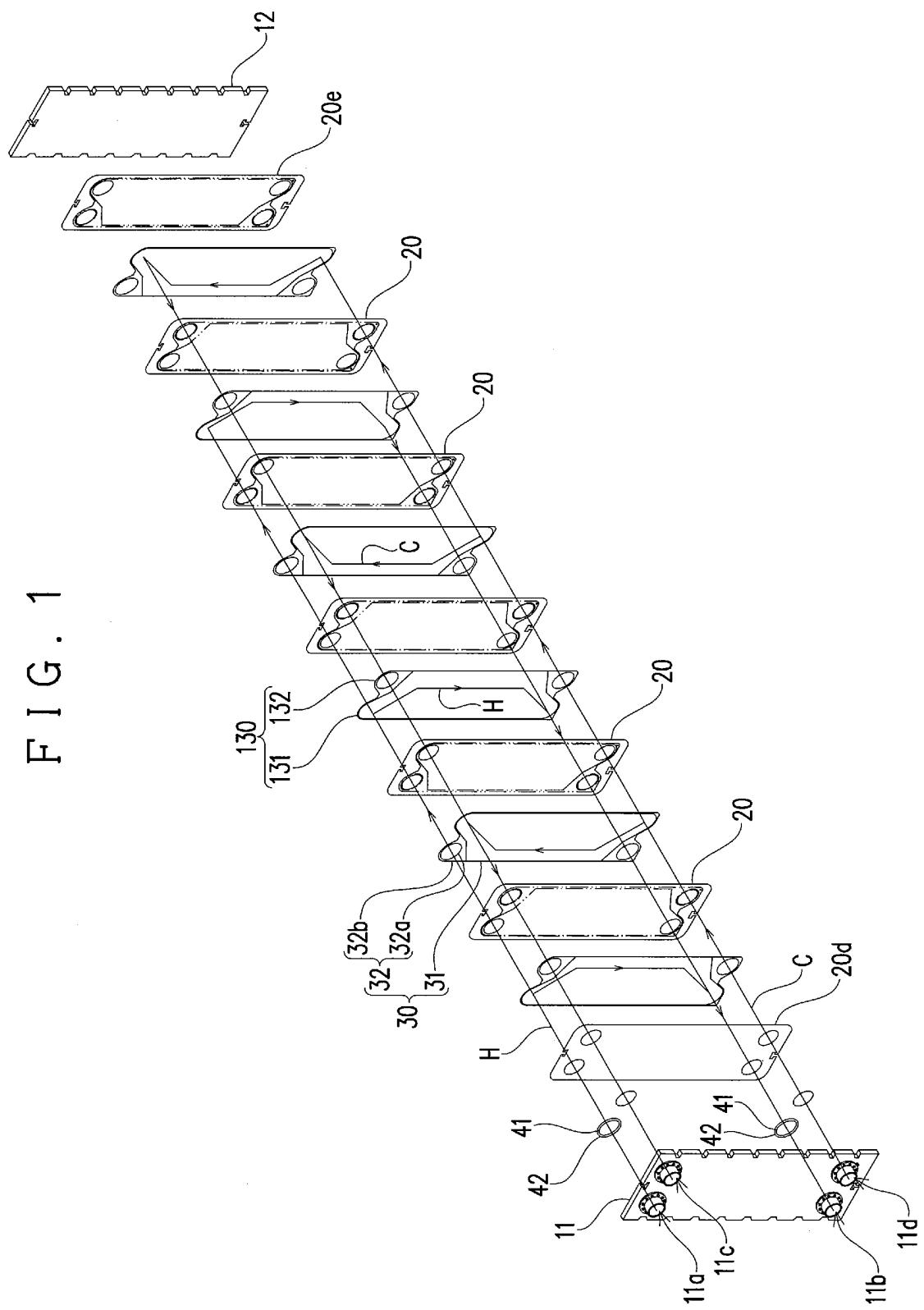


FIG. 2

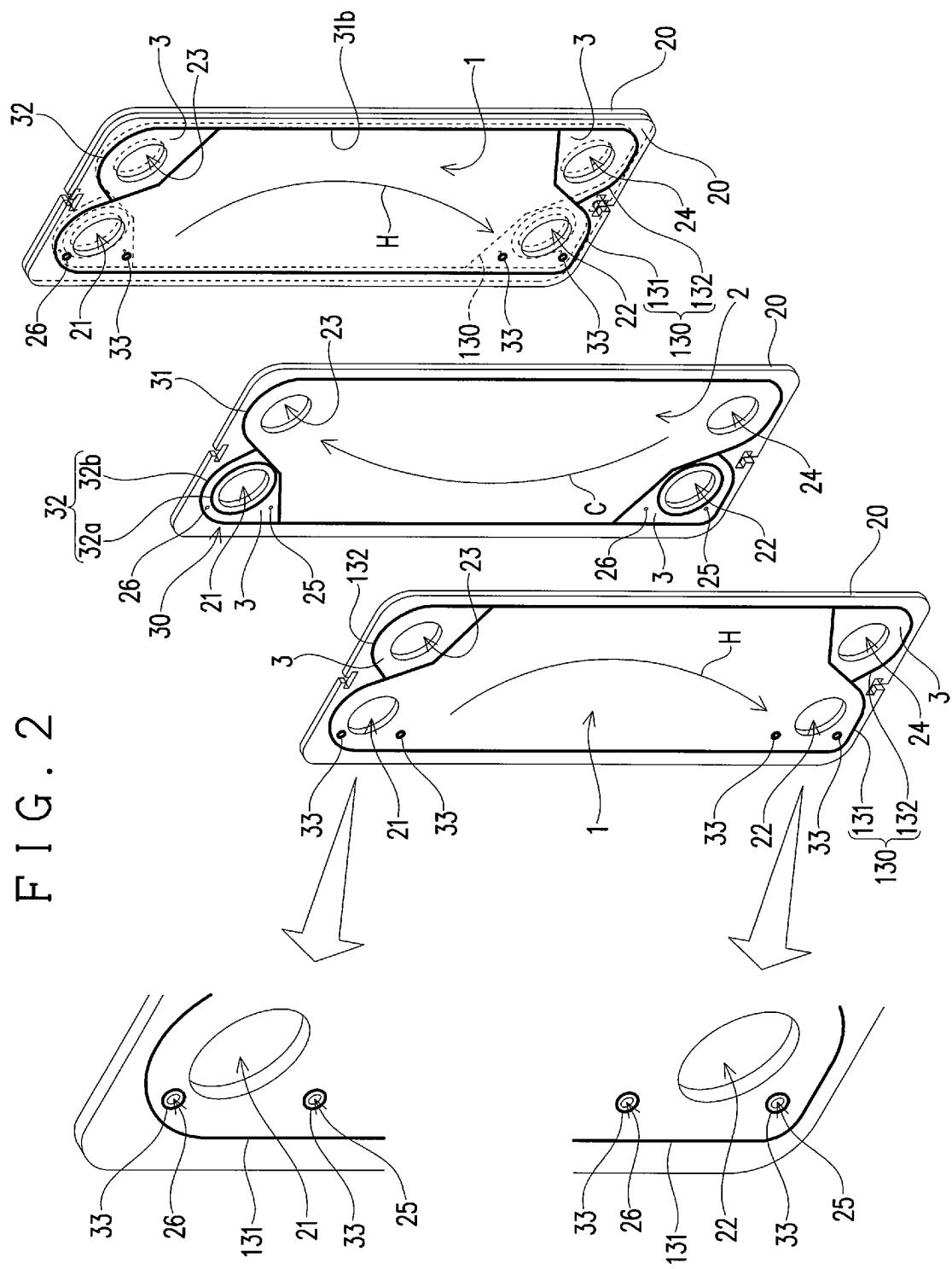


FIG. 3

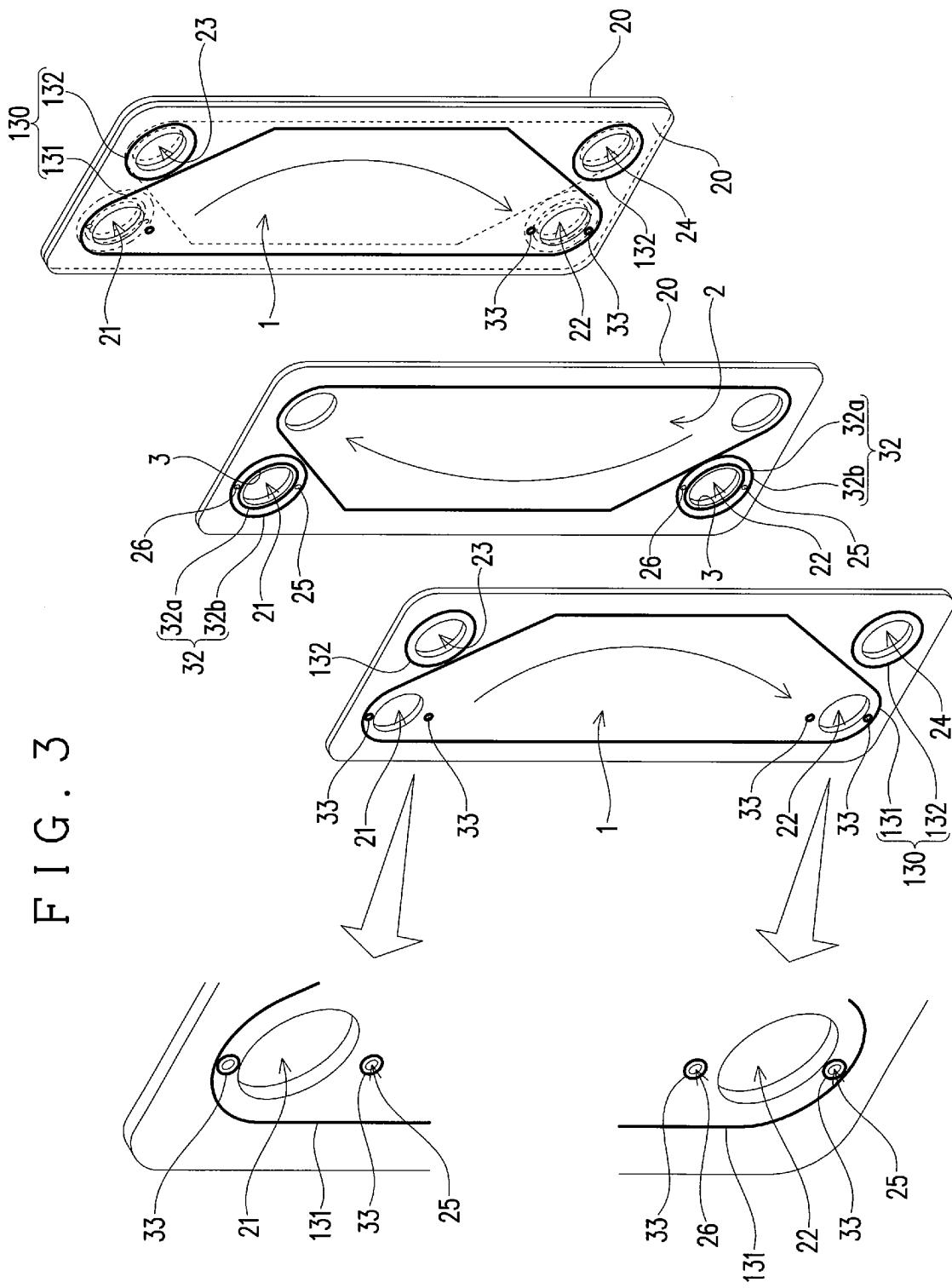


FIG. 4

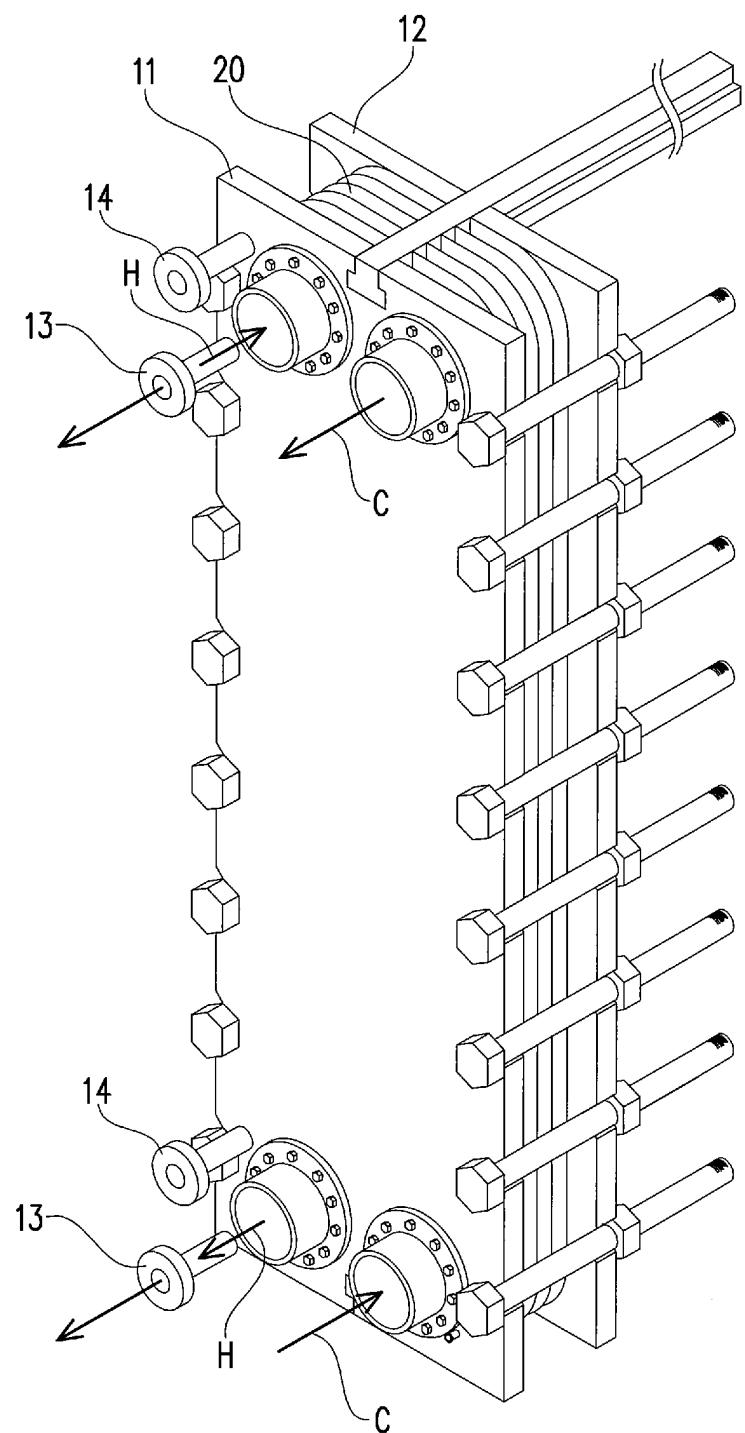
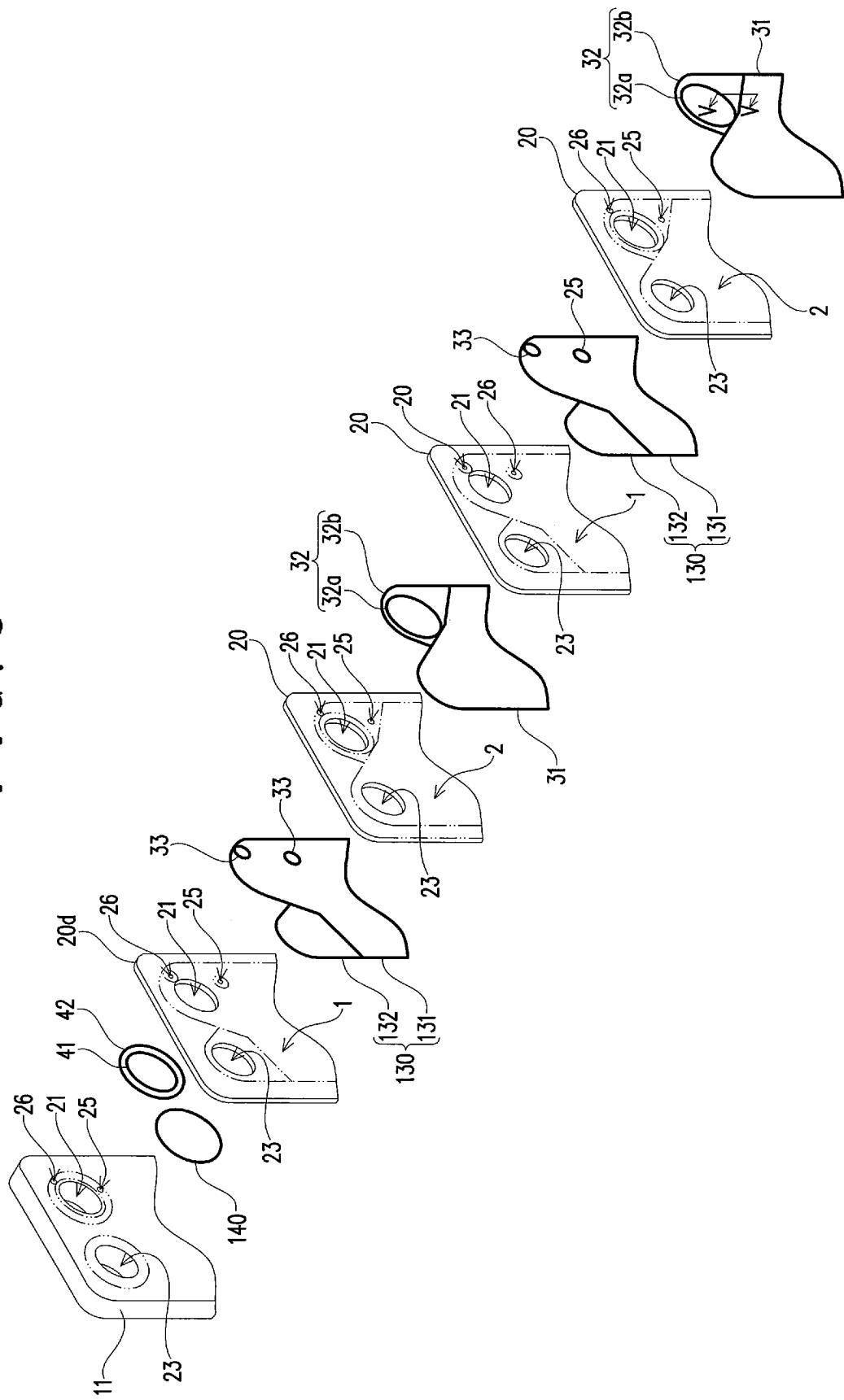


FIG. 5



F I G . 6

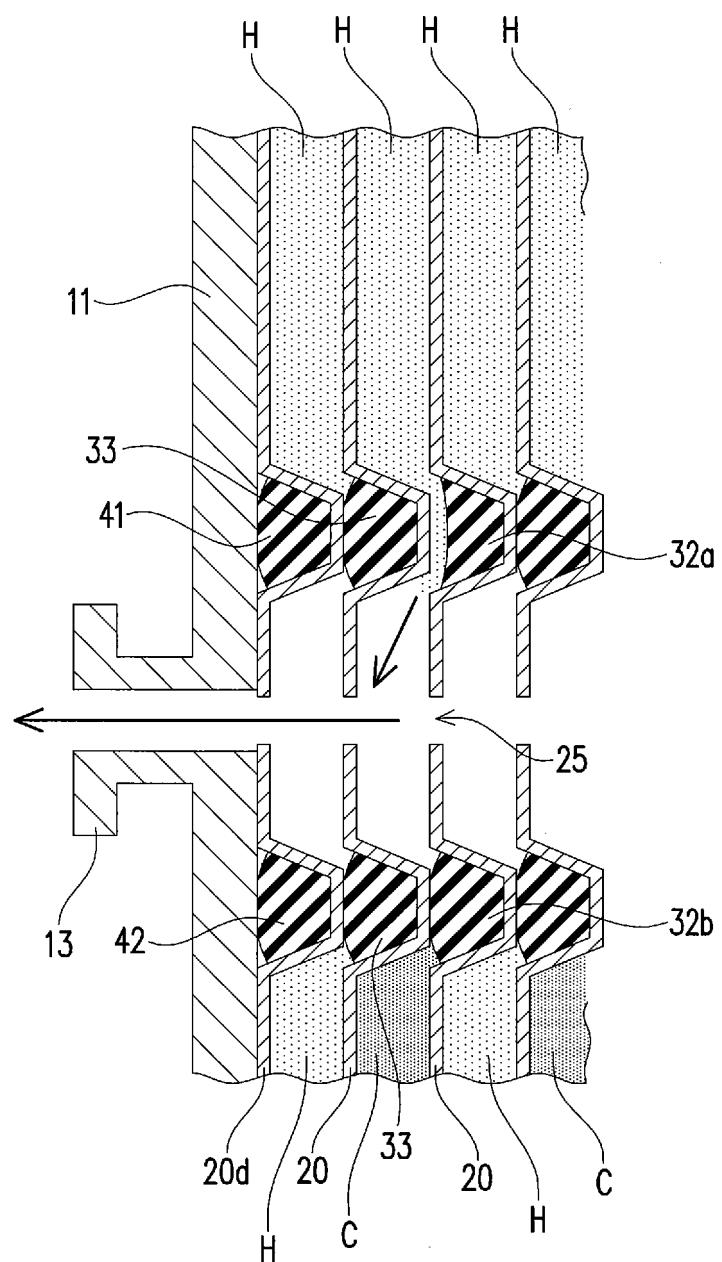
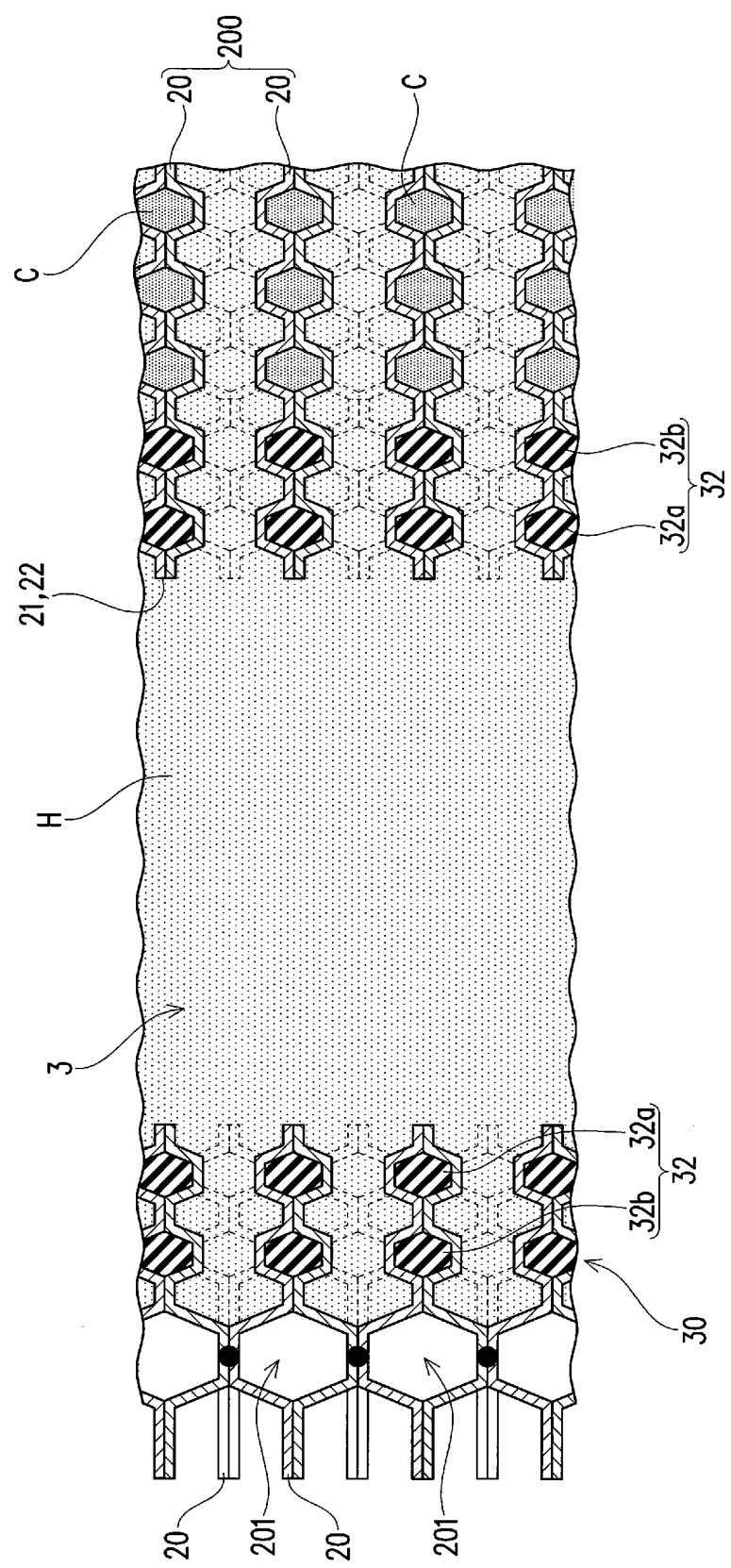


FIG. 7



F I G . 8

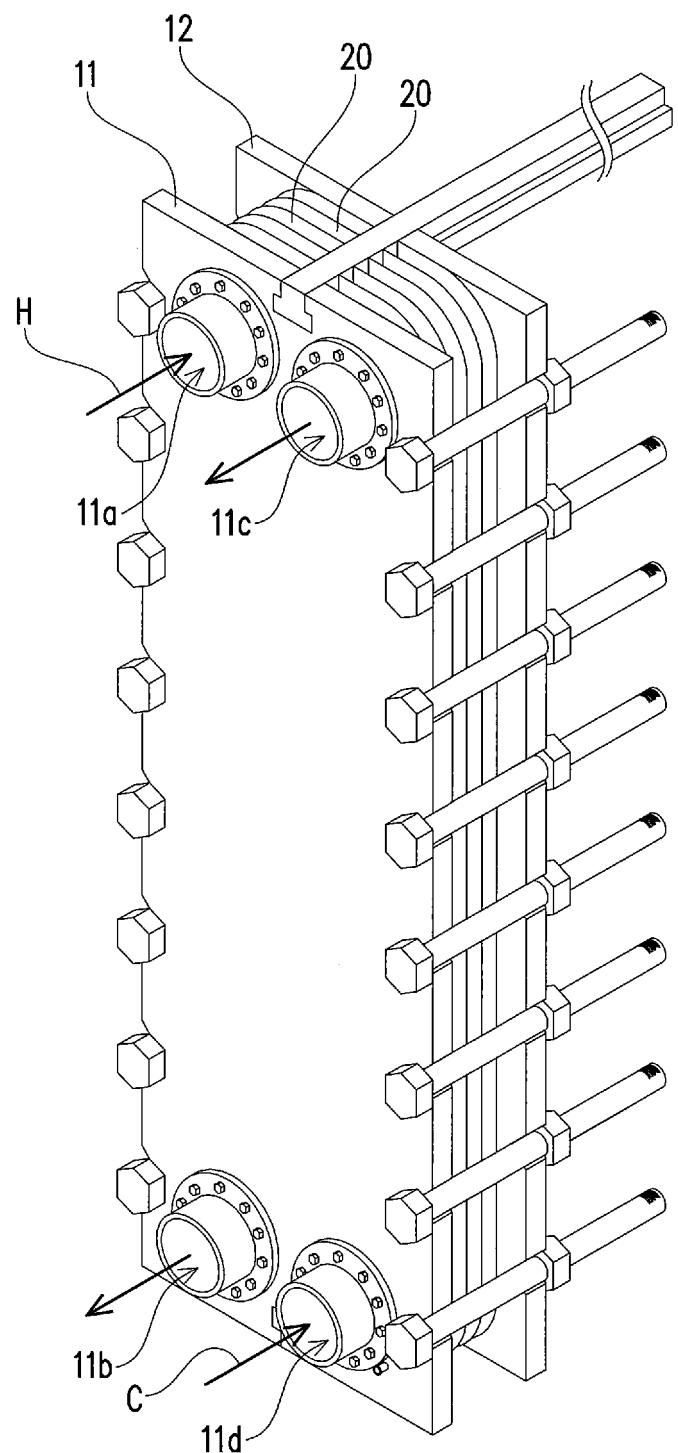


FIG. 9

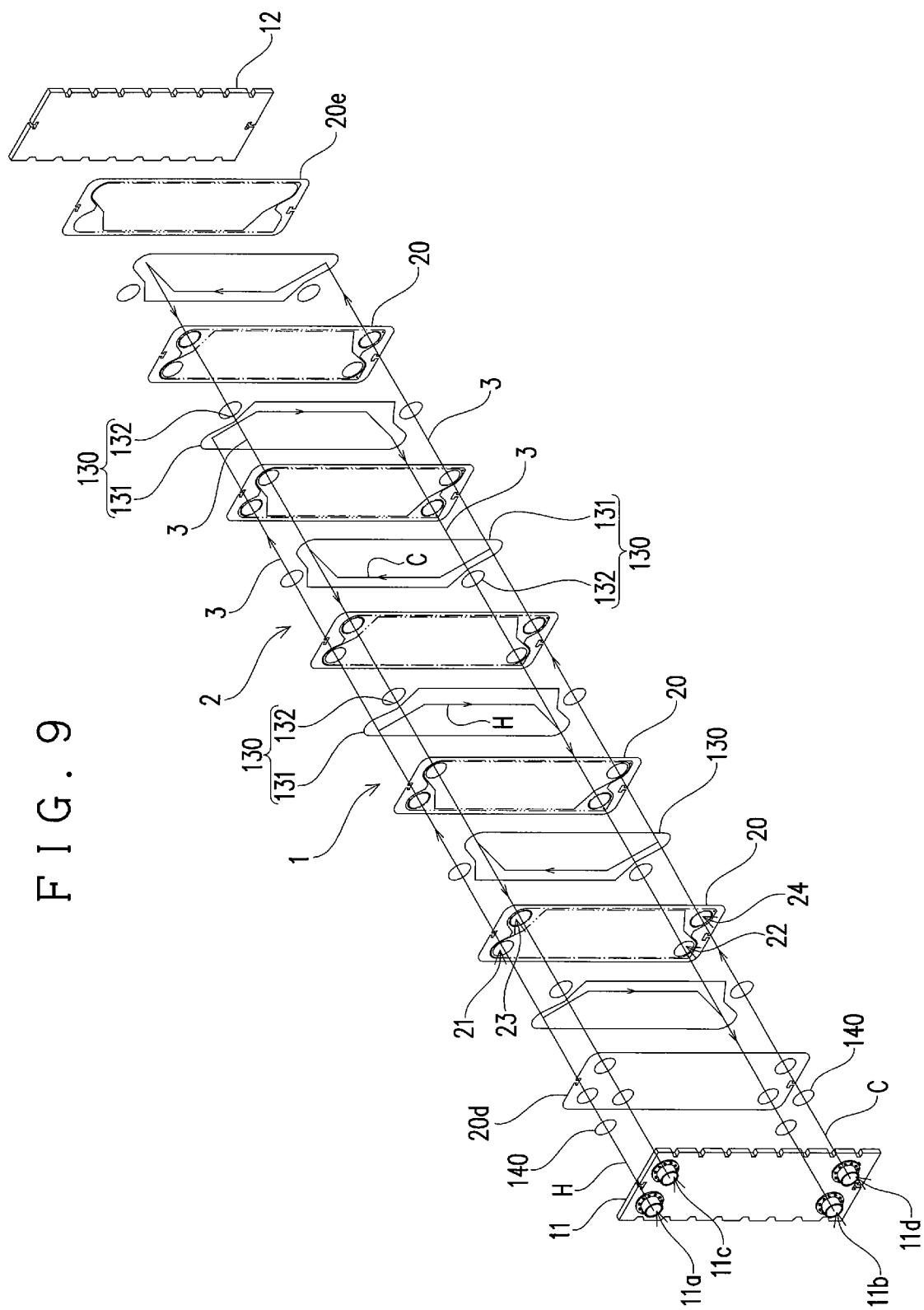
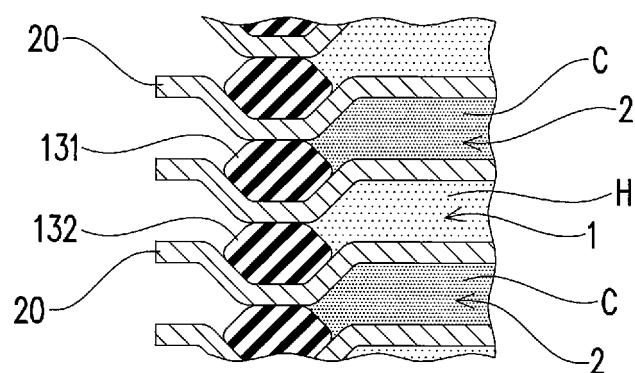


FIG. 10



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/077362

|    |   |  |                          |                          |
|----|---|--|--------------------------|--------------------------|
| 5  | A. CLASSIFICATION OF SUBJECT MATTER<br>F28F3/10 (2006.01) i, F28F3/04 (2006.01) i, F28F3/08 (2006.01) i, F28F11/00 (2006.01) i  |  |                          |                          |
| 10 | According to International Patent Classification (IPC) or to both national classification and IPC   |  |                          |                          |
| 15 | B. FIELDS SEARCHED<br>Minimum documentation searched (classification system followed by classification symbols)<br>F28F3/10, F28F3/04, F28F3/08, F28F11/00  |  |                          |                          |
| 20 | Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br>Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013<br>Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013   |  |                          |                          |
| 25 | Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  |  |                          |                          |
| 30 | C. DOCUMENTS CONSIDERED TO BE RELEVANT  |  |                          |                          |
| 35 | Category*   | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No.    |                          |
| 40 | <input checked="" type="checkbox"/>   | Further documents are listed in the continuation of Box C.                         | <input type="checkbox"/> | See patent family annex. |
| 45 | <p>* Special categories of cited documents:</p> <p>“A” document defining the general state of the art which is not considered to be of particular relevance</p> <p>“E” earlier application or patent but published on or after the international filing date</p> <p>“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>“O” document referring to an oral disclosure, use, exhibition or other means</p> <p>“P” document published prior to the international filing date but later than the priority date claimed</p> <p>“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>“&amp;” document member of the same patent family</p> |  |                          |                          |
| 50 | Date of the actual completion of the international search<br>18 January, 2013 (18.01.13)  | Date of mailing of the international search report<br>29 January, 2013 (29.01.13)  |                          |                          |
| 55 | Name and mailing address of the ISA/<br>Japanese Patent Office  | Authorized officer   |                          |                          |
|    | Facsimile No.   | Telephone No.  |                          |                          |

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/077362

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|-----------|--|-----------------------|
| Y         | JP 5-264192 A (Hisaka Works, Ltd.),<br>12 October 1993 (12.10.1993),<br>paragraphs [0003] to [0010], [0027]; fig. 1 to 9<br>(Family: none)   | 1-5                   |
| Y         | JP 2006-520883 A (Behr GmbH & Co. KG.),<br>14 September 2006 (14.09.2006),<br>paragraph [0027]<br>& US 2008/0202724 A1 & EP 1608865 A<br>& WO 2004/083758 A2 & DE 10312788 A<br>& CN 1761809 A | 2, 4, 5               |
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| Y         | JP 2-192598 A (Hisaka Works, Ltd.),<br>30 July 1990 (30.07.1990),<br>page 2, upper right column, line 18 to lower<br>right column, line 5; fig. 1 to 3<br>(Family: none)                       | 4, 5                  |
| Y         | JP 2006-303262 A (Mitsubishi Electric Corp.),<br>02 November 2006 (02.11.2006),<br>paragraphs [0011] to [0013]<br>(Family: none)   | 4, 5                  |
| Y         | JP 55-145873 A (Power Reactor and Nuclear Fuel<br>Development Corp.),<br>13 November 1980 (13.11.1980),<br>column 2, line 3 to column 4, line 17<br>& DE 3016080 A & FR 2455233 A              | 5                     |

**REFERENCES CITED IN THE DESCRIPTION**

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- JP 2005106412 A [0013]
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