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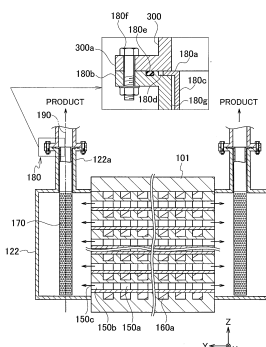
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(54) **HEAT TREATMENT APPARATUS**

(57) A heat treatment apparatus (1) includes: a heat exchange unit (101); a space-forming part (122) having a space facing channel openings (150c); a first opening (122a) located in the space-forming part (122) and having a first aperture (181g); a flow-regulating part (170) installed in the space in the space-forming part (122) to regulate a flow of the first fluid; and an attachment part (180) for removably attaching the flow-regulating part (170) through the first aperture (181g), wherein the space in the space-forming part (122) is a space in which the first fluid led out of the respective channel openings (150c) flows together, or a space from which the first fluid flowing together is introduced to the respective channel openings (150c), and in a state in which the flow-regulating part (170) is fixed in the space-forming part (122), the flow-regulating part (170) is opposed to the plural channel openings (150c).

FIG. 4



Description

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to a heat exchanger-type heat treatment apparatus.

BACKGROUND ART

10 **[0002]** Heat treatment apparatuses such as heat exchangers or reactors using heat exchange between fluids include flow-regulating plates for equalizing the flow of the fluids so as to improve treatment efficiency. Japanese Unexamined Patent Application Publication No. 2010-216749 (Patent Literature 1) discloses a heat exchanger including a plurality of flow-regulating plates made of perforated plates and arranged in an expanded part of a duct.

CITATION LIST

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PATENT LITERATURE

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2010-216749

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SUMMARY

[0004] When the distribution of a fluid is required to be changed or when the condition of flow-regulating plates is changed because of the fluid having corrosiveness, the flow-regulating plates need to be replaced or inspected. In the heat treatment apparatus as disclosed in Patent Literature 1, when the expanded part of the duct can open outward from an apparatus body housing a heat-transfer tube bundle, the operator opens the expanded part of the duct, so as to replace the flow-regulating plates installed inside thereof.

[0005] A heat treatment apparatus serving as a reactor in which a chemical reaction proceeds in a heat exchange unit leads a product to flow outward via a fluid chamber serving as a space-forming part located on the downstream side of the heat exchange unit. The reactor is preferably provided with flow-regulating plates arranged in the fluid chamber as appropriate in order to regulate a back pressure of a fluid in the fluid chamber so as to have desirable distribution of the fluid flowing into a plurality of flow channels on the upstream side. Such a reactor typically entirely has an integrated structure because the reactor should ensure airtightness so as to prevent leakage of the fluid. Therefore, the fluid chamber cannot open outward from the heat exchange unit. Thus, it is difficult to replace the flow-regulating plates once installed in the fluid chamber afterward. When the reactor is configured such that the fluid chamber can open outward from the heat exchange unit in order to facilitate the replacement of the flow-regulating plates, the entire structure of the reactor is complicated accordingly.

[0006] An object of the present disclosure is to provide a heat treatment apparatus having a structure capable of easily replacing a flow-regulating part without the entire structure of the apparatus complicated.

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SOLUTION TO PROBLEM

[0007] An aspect of the present disclosure is a heat treatment apparatus using heat exchange between a first fluid and a second fluid, the apparatus including: a heat exchange unit including a plurality of first channels through which the first fluid flows and a plurality of second channels through which the second fluid flows; a space-forming part having a space facing channel openings of the respective first channels; a first opening located in the space-forming part and having a first aperture; a flow-regulating part installed in the space in the space-forming part to regulate a flow of the first fluid; and an attachment part for removably attaching the flow-regulating part through the first aperture, wherein the space in the space-forming part is a space in which the first fluid led out of the respective channel openings flows together, or a space from which the first fluid flowing together is introduced to the respective channel openings, and in a state in which the flow-regulating part is fixed in the space-forming part, the flow-regulating part is opposed to the plural channel openings.

BRIEF DESCRIPTION OF DRAWINGS

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[0008]

FIG. 1 is a side view showing a structure of a reactor according to an embodiment of the present disclosure.

FIG. 2 is a plan view showing the structure of the reactor according to an embodiment of the present disclosure.

FIG. 3 is a cross-sectional view showing a structure of a heat exchange unit according to an embodiment.

FIG. 4 is a view showing a flow-regulating part and an attachment part for attaching the flow-regulating part according to a first embodiment.

FIG. 5 is a view showing a flow-regulating part and an attachment part for attaching the flow-regulating part according to a second embodiment.

DESCRIPTION OF EMBODIMENTS

[0009] Embodiments according to the present disclosure will be described in detail below with reference to the drawings. The following dimensions, materials, and specific numerical values described in the embodiments are shown for illustration purposes only, and the present disclosure is not limited thereto unless otherwise specified. The elements having substantially the same functions and structures illustrated in the Specification and the drawings are designated by the same reference numerals, and overlapping explanations are not repeated below. The elements described below but not related directly to the present disclosure are not shown in the drawings. In the following explanations of the drawings, a vertical direction is defined as a Z-axis, an extending direction of a plurality of branch channels 150a of reaction channels 150 described below on a plane perpendicular to the Z-axis is defined as an X-axis, and a direction vertical to the X-axis is defined as a Y-axis.

(First embodiment)

[0010] A heat treatment apparatus according to a first embodiment of the present disclosure is described below. The heat treatment apparatus according to the present disclosure utilizes heat exchange between a first fluid and a second fluid. Although the heat treatment apparatus according to the present embodiment is illustrated as a reactor, the present embodiment is also applicable to a heat exchanger, for example.

[0011] FIG. 1 is a schematic side view showing a structure of a reactor 1 according to the present embodiment. FIG. 2 is a schematic plan view showing the structure of the reactor 1. The reactor 1 is of a heat exchanger-type in which a reaction fluid in a gas state or in a liquid state containing a reaction raw material as a reactant is heated or cooled so as to promote a reaction of the reactant. The reactor 1 includes a heat exchange unit 101 as a main body, a reaction fluid introduction part 120 and a product drain part 122, and a heating medium introduction part 130 and a heating medium drain part 132.

[0012] FIG. 3A to 3C are cross-sectional views showing the structure of the heat exchange unit 101. FIG. 3A is a cross-sectional view taken along line A-A in FIG. 1, FIG. 3B is a cross-sectional view taken along line B-B in FIG. 1, and FIG. 3C is a cross-sectional view taken along line C-C in FIG. 1. The heat exchange unit 101 includes a plurality of first heat transfer bodies 210, a plurality of second heat transfer bodies 220, and a lid body 230. The heat exchange unit 101 has a counter flow-type structure in which a reaction fluid or a product as a first fluid flows in a direction opposite to a flowing direction of a heating medium as a second fluid. The first heat transfer bodies 210 and the second heat transfer bodies 220 are each a rectangular plate-like member made of a heat transfer material having thermal resistance.

[0013] The first heat transfer bodies 210 receive heat or cooled air supplied from the heating medium or the second heat transfer bodies 220 to supply the received heat or cooled air to the reaction fluid. The first heat transfer bodies 210 include a plurality of grooves composing reaction channels 150, more particularly, branch channels 150a and merging channels 150b which are first channels. The branch channels 150a include a reaction region in which the reaction fluid is reacted to generate a product. The reaction region corresponds to an area in the branch channels 150a inside the heat exchange unit 101 as shown in FIG. 1, that is, a region between the heating medium drain part 132 and the product drain part 122 described below in the extending direction of the branch channels 150a. The merging channels 150b correspond to a region communicating with the branch channels 150a on the downstream side, as described below with reference to FIG. 4. The branch channels 150a are provided with catalyst bodies 140 for promoting the reaction of the reactant.

[0014] The second heat transfer bodies 220 supply heat or cooled air supplied from the heating medium directly to and indirectly to the reaction fluid via the first heat transfer bodies 210. The second heat transfer bodies 220 include a plurality of grooves composing heating medium channels 160, more particularly, branch channels 160a and merging channels which are second channels. As described in the present embodiment, when the first heat transfer bodies 210 include a plurality of branch channels 150a, the second heat transfer bodies 220 also preferably include a plurality of branch channels 160a arranged in parallel at regular intervals corresponding to the positions of the branch channels 150a of the reaction channels 150. The heating medium channels 160 are provided with heat transfer promoters 141 for increasing the contact area with the heating medium to promote the heat transfer between the heating medium and the heat exchange unit 101. The heat transfer promoters 141 may be formed into an angularly-corrugated plate-like shape as illustrated in FIG. 3B, for example, in order to ensure the contact area with the heat exchange unit 101. The heat transfer material used for the heat transfer promoters 141 may be metal such as aluminum, copper, stainless steel,

and iron-based plated steel.

[0015] The first heat transfer bodies 210 and the second heat transfer bodies 220, which are arranged alternately, and the lid body 230 are stacked in the vertical direction with the flat plate surfaces parallel to the horizontal plane, so as to form the heat exchange unit 101 as a stacked body. When the heat exchange unit 101 is assembled, the respective members are fixed to each other by a bonding method such as tungsten inert gas (TIG) welding or diffusion bonding, so as to suppress a reduction in heat transfer derived from poor contact between the respective members.

[0016] The heat transfer material used for the respective elements included in the heat exchange unit 101 is preferably thermally-resistant metal such as an iron alloy or a nickel alloy. More particularly, the thermally-resistant alloy may be an iron alloy such as stainless steel, or a nickel alloy such as Inconel alloy 625 (registered trademark), Inconel alloy 617 (registered trademark), and Haynes alloy 230 (registered trademark). These heat transfer materials are preferable because such alloys have durability or corrosion resistance with respect to combustion gas which may be used for promoting the reaction or used as a heating medium in the reaction channels 150. However, the present embodiment is not limited to these materials. Alternatively, the heat transfer material may be iron-based plated steel, metal covered with thermally-resistant resin such as fluororesin, or carbon graphite.

[0017] Although the heat exchange unit 101 may be composed of a single first heat transfer body 210 and a single second heat transfer body 220, a larger number of the respective heat transfer bodies can improve the heat exchange performance. The heat exchange unit 101 according to the present embodiment thus includes a plurality of first heat transfer bodies 210 and a plurality of second heat transfer bodies 220. The number of the second heat transfer bodies 220 is set to be larger by one than the number of the first heat transfer bodies 210. The second heat transfer bodies 220 are positioned at the uppermost end and the lowermost end on both sides of the heat exchange unit 101 in the vertical direction, so that all of the first heat transfer bodies 210 are held between the second heat transfer bodies 220. The number of the branch channels 150a provided in each first heat transfer body 210 is not particularly limited, and may be determined as appropriate in view of the conditions for designing the heat exchange unit 101 and the heat transfer efficiency of the heat exchange unit 101. In addition, the grooves composing the reaction channels 150 and the heating medium channels 160 may be arranged on both sides of the respective first heat transfer bodies 210 and second heat transfer bodies 220 in the vertical direction, so as to provide vertically-collective grooves in the stacked state. Although the heat exchange unit 101 is a main body of the reactor 1 in the present embodiment, the heat exchange unit 101 may be covered with a housing or a heat insulating material so as to suppress thermal radiation from the heat exchange unit 101 to prevent heat loss.

[0018] The reaction fluid introduction part 120 is a hemispheric casing covering the side surface of the heat exchange unit 101 on the upstream side on which the plural branch channels 150a provided in the first heat transfer bodies 210 are open, so as to provide a space between the heat exchange unit 101 and the reaction fluid introduction part 120. The reaction fluid introduction part 120 is detachable or openable with respect to the heat exchange unit 101. The detachable or openable reaction fluid introduction part 120 allows the operator to insert or remove the catalyst bodies 140 into or from the plural branch channels 150a of the reaction channels 150, for example. The reaction fluid introduction part 120 includes an introduction pipe 120a from which the reaction fluid is externally introduced to the inside of the heat exchange unit 101. The introduction pipe 120a is located substantially in the middle with respect to the side surface of the heat exchange unit 101, in other words, located in the middle on the Y-Z plane, and integrated with the reaction fluid introduction part 120 in the same direction as the open direction of the plural branch channels 150a, as shown in FIG. 1, for example. The introduction pipe 120a thus can distribute the well-balanced amount of the reaction fluid to the respective branch channels 150a open as illustrated in FIG. 3A.

[0019] FIG. 4 is a cross-sectional view taken along line D-D in FIG. 1. The branch channels 150a provided in the first heat transfer bodies 210 communicate with the merging channels 150b vertical to the branch channels 150a and extending in the Y-axis direction on the downstream side of the reaction region. The merging channels 150b include flow-out parts 150c serving as channel openings open outward through which the product flows out of the heat exchange unit 101.

[0020] The product drain part 122 is a vertically-elongated box-shaped casing covering a part of the side surface of the heat exchange unit 101 in the vertical direction at which the plural flow-out parts 150c are located, so as to serve as a space-forming part providing a space between the heat exchange unit 101 and the product drain part 122. The box shape of the casing is an example, and the casing may be formed into a semicylindrical shape or curved into a concaved shape similar to the semicylindrical shape. The product drain part 122 is integrally fixed to the side surface of the heat exchange unit 101. The product drain part 122 is provided on its wall portion with an opening 122a having an aperture for draining the product to the outside of the heat treatment apparatus. The extending direction of the central axis of the aperture provided in the opening 122a is different from the open direction of the flow-out parts 150c. Although the present embodiment is illustrated with the case in which the opening 122a has a pipe-like body, the opening 122a may be merely a flange not provided with a pipe portion. The opening 122a communicates with external equipment outside the heat treatment apparatus, and is connected to an external pipe 300 from which the product is introduced. While the external pipe 300 is integrally provided with a flange 300a serving as a connection part, the opening 122a is integrally provided with a flange 180b serving as a first connection part connected to and released from the flange 300a. When the opening

122a is not provided with a pipe portion, the opening 122a itself serves as a flange. In the space provided between the product drain part 122 and the heat exchange unit 101, the product led out of the respective flow-out parts 150c flows together before introduced into the opening 122a. A space inside the product drain part 122 thus serves as a fluid chamber.

[0021] The reactor 1 further includes a flow-regulating part 170 installed in the product drain part 122, and an attachment part 180 for attaching the flow-regulating part 170 to the product drain part 122.

[0022] The flow-regulating part 170 equalizes a back pressure of the reaction fluid in the product drain part 122 located on the downstream side of the branch channels 150a so as to distribute the reaction fluid flowing into the respective branch channels 150a more equally. The flow-regulating part 170 includes a circumferential portion extending into a shaft-like shape in the axial direction into which the product is introduced, and an end portion through which the product introduced into the circumferential portion flows toward the aperture of the opening 122a in the axial direction. The flow-regulating part 170 may be a porous member serving as a resistant body provided with a plurality of holes so that the product can penetrate the entire surface of the circumferential portion. Such a porous member can easily be manufactured and exhibit a good regulating effect. The present embodiment is illustrated with the case in which the flow-regulating part 170 has a cylindrical shape having a circular cross section as viewed in the axial direction. The material used for the flow-regulating part 170 is preferably metal having high thermal resistance and also high corrosion resistance when the product is easily corroded.

[0023] The flow-regulating part 170 fixed to the product drain part 122 is located on the same axis as the opening 122a. As used herein, the term "the same axis" refers to an axis which is the same as the central axis 190 of the aperture 180g of the opening 122a, as indicated by the dashed and dotted line shown in FIG. 4, but is not necessarily exactly the same, and may be an axis slightly offset within a range capable of achieving the operations and effects described below. The outer diameter of the flow-regulating part 170 is smaller than the inner diameter of the aperture 180g. The flow-regulating part 170 thus can enter the product drain part 122 through the aperture 180g with the respective axial directions conforming to each other.

[0024] As described above, the flow-regulating part 170 extends in the extending direction of the central axis 190 of the aperture 180g which is different from the open direction of the respective flow-out parts 150c. As shown in FIG. 4, the flow-regulating part 170 fixed to the product drain part 122 is arranged such that the entire circumferential portion is located inside the space described above, and at least part of the circumferential portion is opposed to the plural flow-out parts 150c. The flow-regulating part 170 can therefore entirely regulate the flow of the product in the Z-axis direction flowing out of the respective flow-out parts 150c aligned in the Z-axis direction. The flow-regulating part 170 can further regulate the flow of the product in the emitting direction on the X-Y plane perpendicular to the extending direction of the circumferential portion. Accordingly, the product flowing out of the respective flow-out parts 150c can be led to the flow-regulating part 170 with high efficiency.

[0025] The flow-regulating part 170 is preferably arranged such that the axial direction is parallel to the aligned direction of the flow-out parts 150c and preferably has a length sufficient to be opposed to all of the flow-out parts 150c so as to further improve the efficiency. The product out of the plural flow-out parts 150c thus all flows toward the circumferential portion of the flow-regulating part 170, as indicated by the arrows in FIG. 4, and directly reach the circumferential portion. As used herein, the phrase "directly reach" refers to a state in which the product flowing out of the flow-out parts 150c reaches the flow-regulating part 170 while hardly circulating in the product drain part 122, namely, without being scattered. Such a state is preferable since the back pressure can be equalized more efficiently than the case in which the product circulates intricately. In order to improve the accuracy of the direct reach, one end of the flow-regulating part 170 is preferably located inside the opening 122a, and the other end preferably has a sufficient length so as to be in contact with the inner wall of the product drain part 122 on the opposite side of the opening 122a.

[0026] The attachment part 180 includes an engaging part 180a integrally connected to the one end of the flow-regulating part 170, and an engaged part 180d provided at the flange 180b on the opening 122a side. The engaging part 180a projects outward from the flow-regulating part 170. More particularly, the length of the engaging part 180a from the central axis of the flow-regulating part 170 fixed to the product drain part 122 is longer than the radius of the aperture 180g of the opening 122a. The engaging part 180a may have a circular shape as viewed in the axial direction, or may be provided with a plurality of projections projecting radially. The engaging part 180a may be connected to the flow-regulating part 170 via a cylindrical member 180c having substantially the same diameter as the flow-regulating part 170. The cylindrical member 180c may be a member independent of the flow-regulating part 170 and connected to the end of the flow-regulating part 170 by welding, or may be a member integrated with the flow-regulating part 170, namely, a part of the circumferential portion without holes.

[0027] In order to distribute the flow described above more efficiently and equally, it is preferable to prevent the product from flowing into the aperture 180a of the opening 122a without passing through the flow-regulating part 170, or minimize the amount of the product flowing into the aperture 180a of the opening 122a without passing through the flow-regulating part 170. As described above, the product is preferably prevented from circulating in the product drain part 122 as much as possible. In view of this, a gap between the cylindrical member 180c or the circumferential portion of the flow-regulating part 170 and the inner wall of the opening 122a is reduced as much as possible. The engaging part 180a preferably has

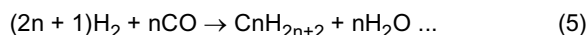
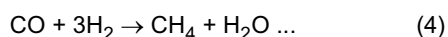
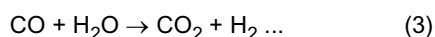
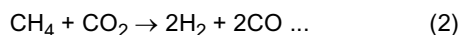
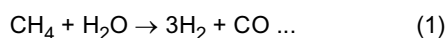
a circular shape rather than has a plurality of radial projections so as to eliminate the gap.

[0028] The engaged part 180d is a groove or a notch engaged with the engaging part 180a in the state in which the flow-regulating part 170 is inserted to the product drain part 122 externally through the aperture of the opening 122a.

[0029] The heating medium introduction part 130 is a hemispheric casing covering the side surface of the heat exchange unit 101 on the upstream side on which the plural branch channels 160a provided in the second heat transfer bodies 220 are open, so as to provide a space between the heat exchange unit 101 and the heating medium introduction part 130. The heating medium introduction part 130 may be detachable or openable with respect to the heat exchange unit 101, but is not necessarily detachable or openable as described in the present embodiment when the heat transfer promoters 141 are preliminarily provided in the plural branch channels 160a of the heating medium channels 160 at the time of assembling the heat treatment apparatus. The heating medium introduction part 130 includes an introduction pipe 130a from which the heating medium is externally introduced to the inside of the heat exchange unit 101. The introduction pipe 130a is located substantially in the middle with respect to the side surface of the heat exchange unit 101, in other words, located in the middle on the Y-Z plane, and integrated with the heating medium introduction part 130 in the same direction as the open direction of the plural branch channels 160a, as shown in FIG. 1, for example. The introduction pipe 130a thus can distribute the well-balanced amount of the heating medium to the respective branch channels 160a open as illustrated in FIG. 3C.

[0030] The heating medium drain part 132 is a vertically-elongated box-shaped casing covering a part of the side surface of the heat exchange unit 101 at which a plurality of flow-out parts for leading out the heating medium are located, so as to serve as a space-forming part providing a space between the heat exchange unit 101 and the heating medium drain part 132. The heating medium drain part 132 may also be a casing formed into a semicylindrical shape and the like. The branch channels 160a provided in the second heat transfer bodies 220 communicate with merging channels (not shown) vertical to the branch channels 160a and extending in the Y-axis direction on the downstream side of a part corresponding to the reaction region, as in the case of the first heat transfer bodies 210. The merging channels are open to the outside of the heat exchange unit 101 at flow-out parts (not shown) serving as channel openings. The heating medium drain part 132 is also integrally fixed to the side surface of the heat exchange unit 101, and provided on its wall portion with an opening 132a having an aperture for draining the heating medium to the outside of the heat treatment apparatus. Although the present embodiment is illustrated with the case in which the opening 132a has a pipe-like body, the opening 132a may be merely a flange not provided with a pipe portion. In the space provided between the heating medium drain part 132 and the heat exchange unit 101, the heating medium led out of the respective flow-out parts provided in the second heat transfer bodies 220 flows together before introduced into the opening 132a. A space inside the heating medium drain part 132 thus serves as a fluid chamber.

[0031] The heat exchange unit 101 may be any of a liquid-liquid heat exchanger, a gas-gas heat exchanger, and a gas-liquid heat exchanger, and the reaction fluid and the heating medium supplied to the reactor 1 may either gas or liquid. The reactor 1 can cause chemical synthesis through various kinds of thermal reactions such as an endothermic reaction and an exothermic reaction. Examples of such thermal reactions causing synthesis include: a steam reforming reaction of methane as represented by the following chemical equation (1); an endothermic reaction such as a dry reforming reaction of methane as represented by the following chemical equation (2); a shift reaction as represented by the following chemical equation (3); a methanation reaction as represented by the following chemical equation (4); and a Fischer tropesch synthesis reaction as represented by the following chemical equation (5). The reaction fluid used in these reactions is in a gas state.



[0032] The reactor 1 may also be used for causing other reactions not described above, such as an acetylation reaction, an addition reaction, an alkylation reaction, a dealkylation reaction, a hydrodealkylation reaction, a reductive alkylation reaction, an amination reaction, an aromatization reaction, an arylation reaction, a self-heating reforming reaction, a carbonylation reaction, a decarbonylation reaction, a reductive carbonylation reaction, a carboxylation reaction, a reductive carboxylation reaction, a reductive coupling reaction, a condensation reaction, a cracking reaction, a hydrocracking reaction, a cyclization reaction, a cyclooligomerization reaction, a dehalogenation reaction, a dimerization reaction, an epoxidation reaction, an esterification reaction, an exchange reaction, a halogenation reaction, a hydrogenation

reaction, a hydrohalogenation reaction, a homologation reaction, a hydration reaction, a dehydration reaction, a hydrogenation reaction, a dehydrogenation reaction, a hydrocarboxylation reaction, a hydroformylation reaction, a hydrogenolysis reaction, a hydrometalation reaction, a hydrosilylation reaction, a hydrolyzation reaction, a hydroprocessing reaction, an isomerization reaction, a methylation reaction, a demethylation reaction, a metathesis reaction, a nitration reaction, an oxidation reaction, a partial oxidation reaction, a polymerization reaction, a reduction reaction, a reverse water gas shift reaction, a sulfonation reaction, a telomerization reaction, a transesterification reaction, and a trimerization reaction.

[0033] The reactor 1 uses a substance such as a raw material involved in the chemical reaction as described above as a reactant, and uses a fluid including such a reactant as a reaction fluid. The reaction fluid flowing through the branch channels 150a receives heat or cooled air of the heating medium passing through the heating medium channels 160, and is heated or cooled to promote the reaction, so that the reactant is converted into a target product. The reaction fluid may contain a carrier not involved in the reaction. Such a carrier may be selected as appropriate from substances not influencing the promotion of the reaction while taking account of the chemical reaction to be induced. The carrier usable for the reaction fluid particularly in a gas state may be a gas carrier of inert gas or a gaseous substance with low reactivity. The heating medium is preferably a fluid substance not corroding the constituent materials of the reactor 1, and may be a liquid substance such as water or oil, or a gaseous substance such as combustion gas. The gaseous substance used as the heating medium is easier to handle than the liquid medium.

[0034] A catalyst included in the catalyst bodies 140 is selected as appropriate from substances mainly containing active metal effective in the chemical reaction as described above, and suitable for the promotion of the reaction based on the synthesis reaction executed in the reactor 1. Examples of active metal as a catalytic component include nickel (Ni), cobalt (Co), iron (Fe), platinum (Pt), ruthenium (Ru), rhodium (Rh), and palladium (Pd). These metals may be used singly, or may be used in combination as long as the combination is effective in the promotion of the reaction. The catalyst bodies 140 are prepared such that the catalyst is supported on a structure material. The structure material is selected as appropriate from thermally-resistant metals which can be molded and support the catalyst. The structure, used as the catalyst bodies 140, may have a corrugated plate-like shape having a wave-like form in cross section or a jaggedly corrugated shape, so as to increase the contact area with the reaction fluid. Examples of such thermally-resistant metals include iron (Fe), chromium (Cr), aluminum (Al), yttrium (Y), cobalt (Co), nickel (Ni), magnesium (Mg), titanium (Ti), molybdenum (Mo), tungsten (W), niobium (Nb), tantalum (Ta), and a thermally-resistant alloy mainly containing some of these metals. The catalyst bodies 140 may be obtained such that a thin plate structure made of a thermally-resistant alloy such as Fecralloy (registered trademark) is molded. A method of supporting the catalyst may be a method of directly supporting the catalyst on the structure material by surface modification or the like, or a method of indirectly supporting the catalyst on the structure material via a carrier. Practically, the use of the carrier facilitates the process of supporting the catalyst. The carrier is selected as appropriate from materials having durability without impeding the promotion of the reaction and capable of supporting the catalyst satisfactorily in view of the reaction executed in the reactor 1. The carrier may be a metal oxide such as alumina (Al_2O_3), titania (TiO_2), zirconia (ZrO_2), ceria (CeO_2), or silica (SiO_2). These metal oxides may be used singly, or some of these metal oxides may be selected and combined together. The supporting method by use of the carrier may include a process of forming a mixed layer of the catalyst and the carrier on the surface of the structure material molded, or a process of forming a support layer and then supporting the catalyst on the support layer by surface modification or the like.

[0035] Next, the process of attaching and removing the flow-regulating part 170 is described below. The flange 180b on the opening 122a side and the flange 300a on the external pipe 300 side are typically fastened together with a bolt 180f via an O-ring 180e. With regard to the attachment, the operator detaches the bolt 180f to release the fastened state, and moves the external pipe 300 to open the aperture 180g of the opening 122a. The operator then inserts the flow-regulating part 170 into the product drain part 122 through the aperture 180g. The flow-regulating part 170 stops at a regular position at which the engaging part 180a engages with the engaged part 180d. The operator then puts back the external pipe 300 and fastens the bolt 180f again, so that the engaging part 180a is held and fixed between the two flanges 180b and 300a in the axial direction of the opening 122a to complete the operation of attachment of the flow-regulating part 170. The operator can also easily remove the flow-regulating part 170 from the product drain part 122 through the steps opposite to the steps in the attaching operation. Although the reactor 1 preferably equalizes the distribution of the reaction fluid flowing into the plural branch channels 150a as much as possible, a variation in the distribution of the flow may be caused, and as a result, the reaction fluid may flow out of the respective flow-out part 150c of the branch channels 150a at an uneven flow velocity. In order to deal with such a variation, the flow-regulating part 170 is installed in the product drain part 122 to gradually equalize the back pressure such that the reaction fluid flowing into the product drain part 122 at an uneven flow velocity sequentially hits the flow-regulating part 170. Accordingly, the distribution of the reaction fluid flowing into the plural branch channels 150a is gradually equalized. According to the present embodiment, since the flow-regulating part 170 configured as described above is installed on the same axis as the opening 122a, the circulation of the product in the product drain part 122 can be minimized, so as to equalize the back pressure, namely, equalize the distribution of the reaction fluid with high efficiency.

[0036] The regulating performance of the flow-regulating part 170 installed may be insufficient to ensure a desirably regulated distribution depending on the degree of the variation in the distribution of the reaction fluid. According to the present embodiment, since the flow-regulating part 170 can easily be removed, the operator can replace the flow-regulating part 170 with another flow-regulating part 170 having appropriate regulating performance as necessary. For example, when the flow-regulating part 170 is made of a porous member as described above, the flow-regulating part 170 may be replaced with another one having a different pore size. While the flow-regulating part 170 can regulate the distribution of the flow appropriately at first, the regulating performance may be deteriorated gradually with the passage of time or because of corrosion of the reaction fluid. The present embodiment can also deal with such a case by replacing the flow-regulating part 170 to another one as appropriate as described above.

[0037] The present embodiment as described above can provide the heat treatment apparatus having a structure capable of easily replacing the flow-regulating part without the entire structure of the apparatus complicated.

(Second embodiment)

[0038] A heat treatment apparatus according to a second embodiment of the present disclosure is described below. The reactor 1 according to the first embodiment includes the flow-regulating part 170 removably installed in the product drain part 122 through the aperture 180g of the opening 122a. When an opening to which the flow-regulating part 170 is inserted and fixed is defined as a first opening, the opening 122a from which a product is drained to the outside of the heat treatment apparatus corresponds to the first opening in the first embodiment. A reactor according to the present embodiment is characterized by including another opening defined as a first opening, instead of the opening 122a, but not used for draining a product to the outside of the heat treatment apparatus.

[0039] FIG. 5 is a view showing a flow-regulating part 171 and an attachment part 181 for attaching the flow-regulating part 171 according to the present embodiment, and corresponds to the cross-sectional view of FIG. 4 taken along line D-D in FIG. 1 according to the first embodiment. The flow-regulating part 171 has a structure similar to the flow-regulating part 170 according to the first embodiment. The attachment part 181 includes an engaging part 181a integrally connected to one end of the flow-regulating part 171 in the same manner as in the first embodiment. The product drain part 122 includes an opening 122b having an aperture 181g penetrating the product drain part 122 so that the inside and the outside of the product drain part 122 communicate with each other. When the opening 122a communicating with the external equipment outside the heat treatment apparatus described in the first embodiment is defined as a second opening, the product drain part 122 includes at least two openings: the opening 122b as a first opening and the opening 122a as a second opening. The opening 122b is opposed to the opening 122a on the same axis. Namely, the central axis of the first aperture 181g and the central axis of the second aperture 180g substantially conform to each other. The outer diameter of the flow-regulating part 171 is also smaller than the inner diameter of the aperture 181g of the opening 122b.

[0040] The opening 122b is connected with a shielding plate 301 for shielding the aperture 181g. The opening 122b is integrally provided with a flange 181b serving as a second connection part connected to and released from the shielding plate 301. Although the present embodiment is illustrated with the case in which the opening 122b has a short pipe-like body, the opening 122b may also be merely a flange not provided with a pipe portion. The attachment part 181 also includes an engaged part 181d provided in the flange 181b. The engaged part 181d is a groove or a notch engaged with the engaging part 181a in the state in which the flow-regulating part 171 is inserted to the product drain part 122 externally through the aperture 181g of the opening 122b. A cylindrical member 181c, an O-ring 181e, and a bolt 181f are the same as those in the first embodiment. Accordingly, the flow-regulating part 171 is held and fixed between the flange 181b and the shielding plate 301 in the same manner as in the first embodiment.

[0041] The flow-regulating part 171 having the structure described above preferably has a sufficient length in the axial direction so that the other end, that is, the end on the side on which the product is drained can be introduced into the aperture 180g of the opening 122a, as shown in FIG. 5. Accordingly, the amount of the product not passing through the flow-regulating part 170 can be minimized. The present embodiment thus can improve the accuracy of direct reach of the product to the flow-regulating part 170, as in the case of the first embodiment.

[0042] The present embodiment can achieve the effects similar to those in the first embodiment, and is suitably applicable particularly to the case in which the connection between the opening 122a and the external pipe 300 is not easily released. Although the opening 122b needs to be provided in the product drain part 122, the structure of the present embodiment is simplified as compared with a case of including a mechanism which allows the product drain part 122 to open out from the heat exchange unit 101. The operation of removal of the flow-regulating part is easier than that in the first embodiment since the operator is only required to remove the shielding plate 301 without moving the external pipe 300.

(Other embodiments)

[0043] The respective embodiments described above have exemplified the flow-regulating part 170 having a cylindrical shape. The cylindrical shape is preferable in order that the shape of the flow-regulating part 170 in cross section, namely, the outline at the end from which the product is drained conforms to the shape of the opening 180g, so as to minimize the circulation of the product in the product drain part 122 while minimizing the amount of the product not passing through the flow-regulating part 170. However, the present disclosure is not limited to the flow-regulating part 170 having a cylindrical shape, and may employ a flow-regulating part formed into a prism of which the outline at the end is a polygon in cross section as long as a back pressure can be equalized. In such a case, the longest diagonal line at the end of the flow-regulating part needs to be smaller than the inner diameter of the drain pipe 122a.

[0044] While the respective embodiments described above have exemplified the flow-regulating part 170 made of a porous member, the present disclosure is not limited to this, and may employ a filter-like member prepared such that thin strings of the same material are woven.

[0045] The respective embodiments described above have been illustrated with the reactor 1 as a heat treatment apparatus. The reactor 1 includes the shaft-like flow-regulating part 170 installed in the product drain part 122 located on the downstream side of the flow of the reaction fluid or product, so as to appropriately equalize the back pressure on the downstream side to efficiently distribute the reaction fluid on the upstream side accordingly. However, the present disclosure is not limited to such a reactor.

[0046] For example, the heat treatment apparatus serving as a reactor may need to equally distribute the reaction fluid by regulating the flow directly on the upstream side. The upstream side of the reaction fluid in such a case may be the opening 122a side which is opposite to that in the respective embodiments. When the heat treatment apparatus of the present disclosure serves as a heat exchanger, a part from which the first fluid and the second fluid are introduced to the heat exchanger and a part from which the first fluid and the second fluid are led out of the heat exchanger both may have a structure similar to the product drain part 122 according to the respective embodiments. Thus, according to the heat treatment apparatus of the present disclosure, the space-forming part in which the flow-regulating part is installed by use of the attachment part may be located on either the upstream side or the downstream side of the flow of the respective fluids. In other words, in the reactor 1 having the structure as illustrated above, the introduction and leading-out directions of the respective fluids are not particularly limited.

[0047] In view of the other embodiments described above, the first fluid and the second fluid may be different substances or the same substance depending on the heat treatment apparatus employed. In the first and second embodiments described above, the first fluid may be a heating medium, and the second fluid may be a reaction fluid or product, depending on the operations required for the flow-regulating part 170. When the heat treatment apparatus to which the present disclosure is applied is a heat exchanger, the first fluid and the second fluid both may be a heating medium.

[0048] While the respective embodiments have exemplified the heat exchange unit 101 in which two kinds of plate-like heat transfer bodies are stacked on one another, the heat exchange unit is not necessarily a stacked body. The present disclosure is applicable to a reactor including a heat exchange unit having straight reaction channels such as circular pipes.

[0049] It should be noted that the present disclosure includes various embodiments which are not disclosed herein. Therefore, the scope of the present disclosure is defined only by the matters according to the claims reasonably derived from the description described above.

Claims

1. A heat treatment apparatus using heat exchange between a first fluid and a second fluid, the apparatus comprising:
 - a heat exchange unit including a plurality of first channels through which the first fluid flows and a plurality of second channels through which the second fluid flows;
 - a space-forming part having a space facing channel openings of the respective first channels;
 - a first opening located in the space-forming part and having a first aperture;
 - a flow-regulating part installed in the space in the space-forming part to regulate a flow of the first fluid; and
 - an attachment part for removably attaching the flow-regulating part through the first aperture,
 wherein the space in the space-forming part is a space in which the first fluid led out of the respective channel openings flows together, or a space from which the first fluid flowing together is introduced to the respective channel openings, and
 in a state in which the flow-regulating part is fixed in the space-forming part, the flow-regulating part is opposed to the plural channel openings.

2. The heat treatment apparatus according to claim 1, wherein an extending direction of a central axis of the first aperture is different from an open direction of the respective channel openings.

3. The heat treatment apparatus according to claim 1 or 2, wherein the flow-regulating part has a cylindrical shape.

4. The heat treatment apparatus according to any one of claims 1 to 3, wherein the flow-regulating part is a porous member provided with a plurality of holes through which the first fluid can flow.

5. The heat treatment apparatus according to any one of claims 1 to 4, wherein the first opening includes a first connection part connected to and released from an external pipe outside the apparatus through which the first fluid flows.

6. The heat treatment apparatus according to claim 5, wherein:

the attachment part includes an engaging part integrally provided at one end of the flow-regulating part so as to have a length from a central axis of the flow-regulating part greater than a radius of the first aperture, and an engaged part provided in the first connection part and engaged with the engaging part; and in a state in which the engaging part engages with the engaged part, the first connection part is connected to the external pipe outside the apparatus so as to fix the flow-regulating part.

7. The heat treatment apparatus according to any one of claims 1 to 4, further comprising:

a second opening including a first connection part connected to and released from an external pipe outside the apparatus through which the first fluid flows; and a shielding plate capable of shielding the first aperture, wherein the first opening includes a second connection part connected to and released from the shielding plate.

8. The heat treatment apparatus according to claim 7, wherein:

the attachment part includes an engaging part integrally provided at one end of the flow-regulating part so as to have a length from a central axis of the flow-regulating part greater than a radius of the first aperture, and an engaged part provided in the second connection part and engaged with the engaging part; and in a state in which the engaging part engages with the engaged part, the second connection part is connected to the shielding part so as to fix the flow-regulating part.

9. The heat treatment apparatus according to claim 7, wherein:

the first opening is opposed to the second opening on an identical axis; and another end of the flow-regulating part is introduced into a second aperture of the second opening in the state in which the flow-regulating part is fixed in the space-forming part.

FIG. 1

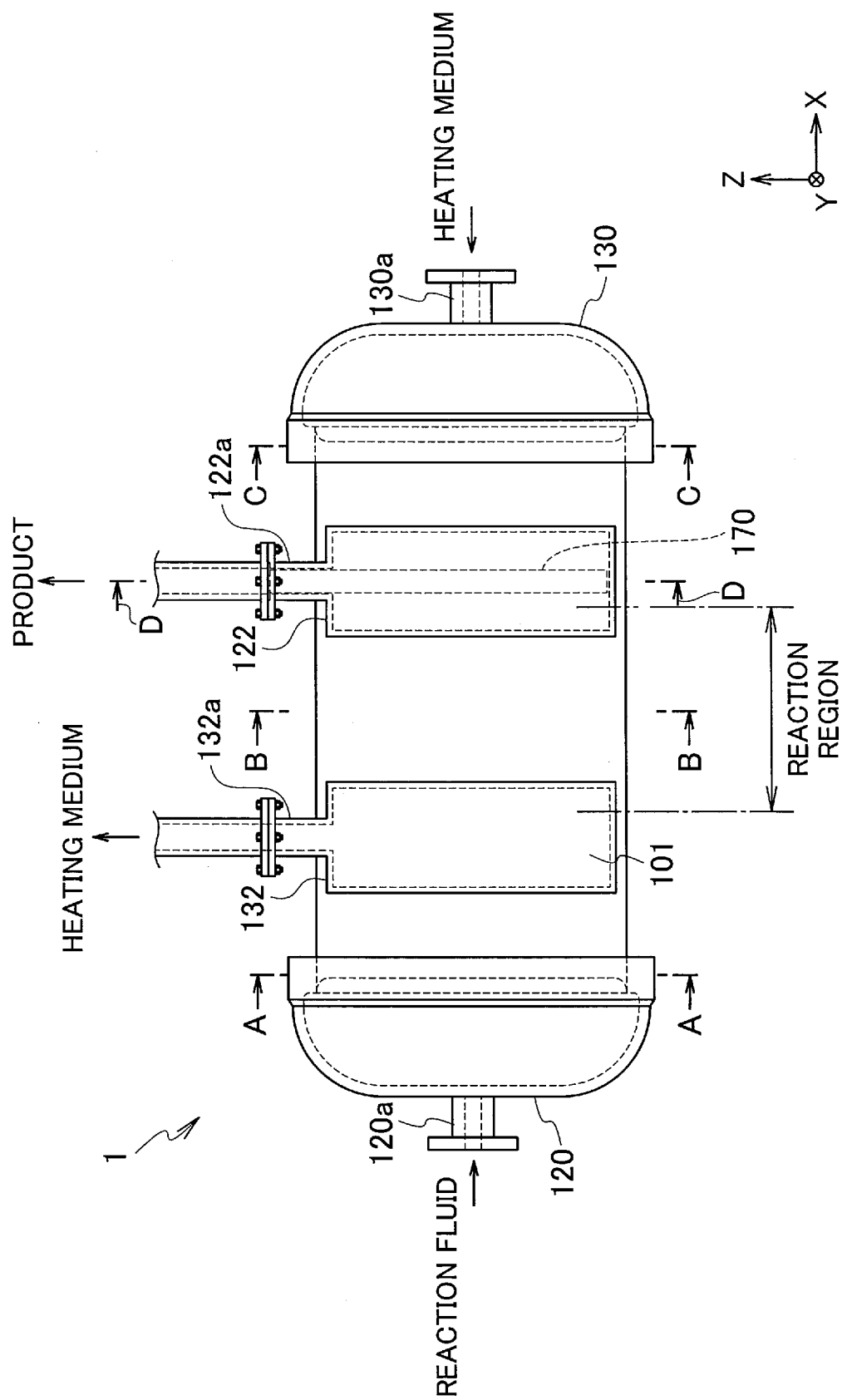


FIG. 2

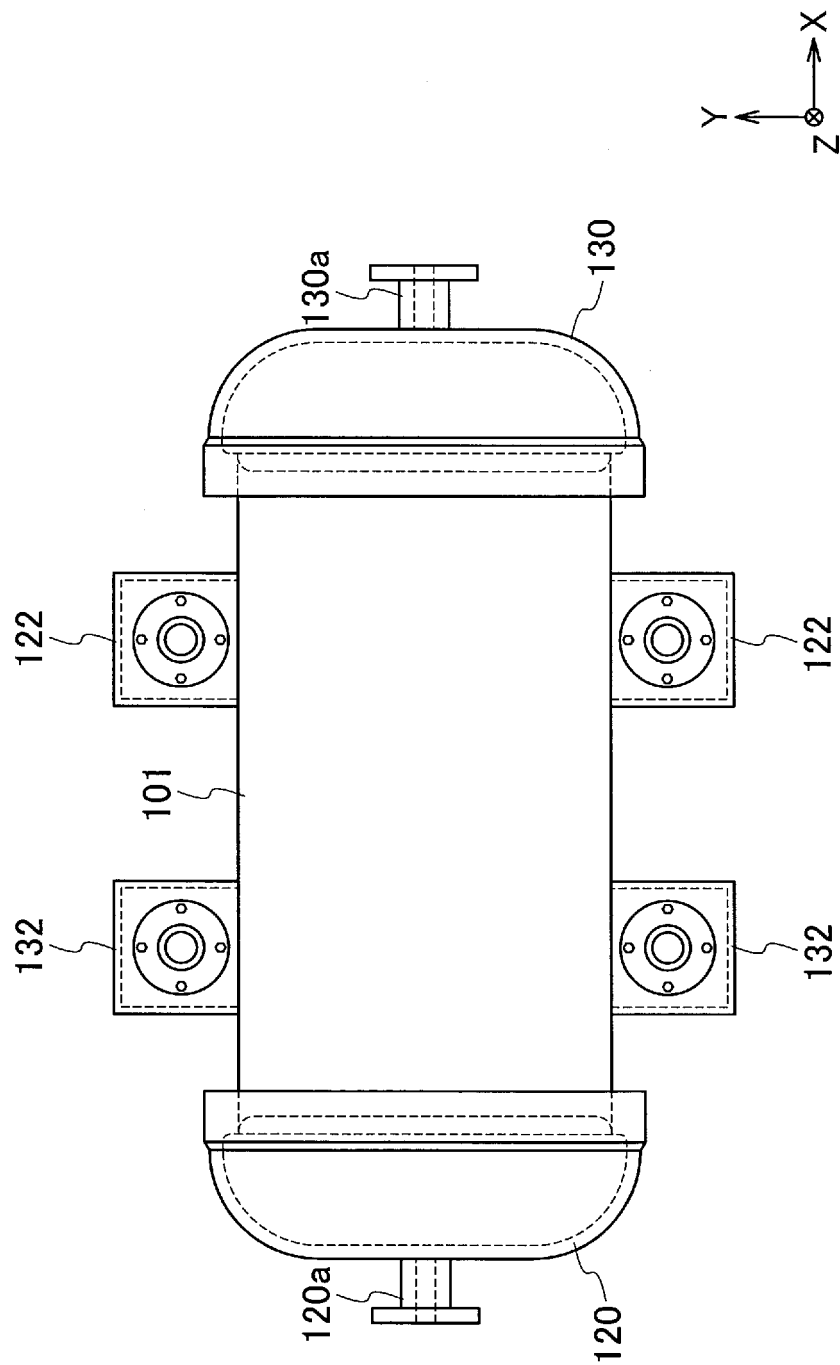


FIG. 3A

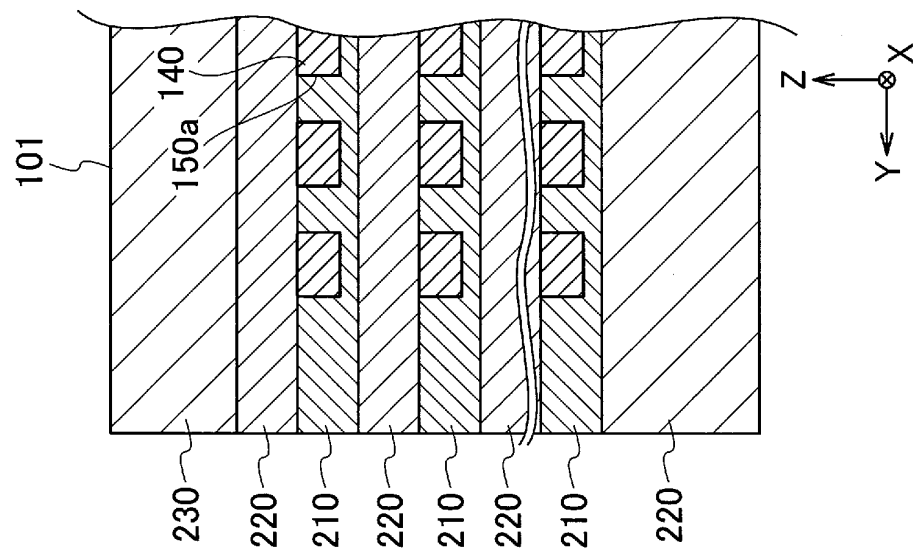


FIG. 3B

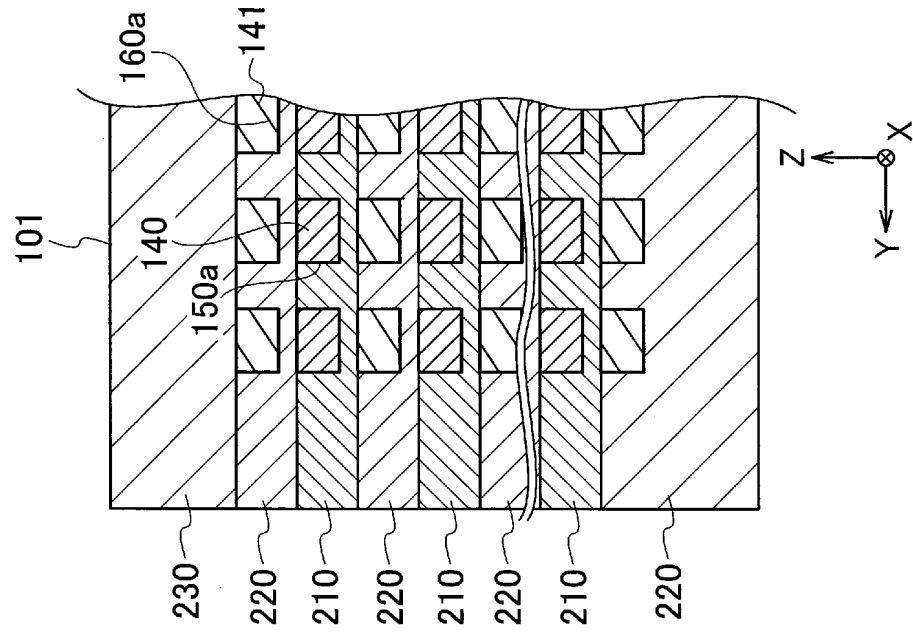


FIG. 3C

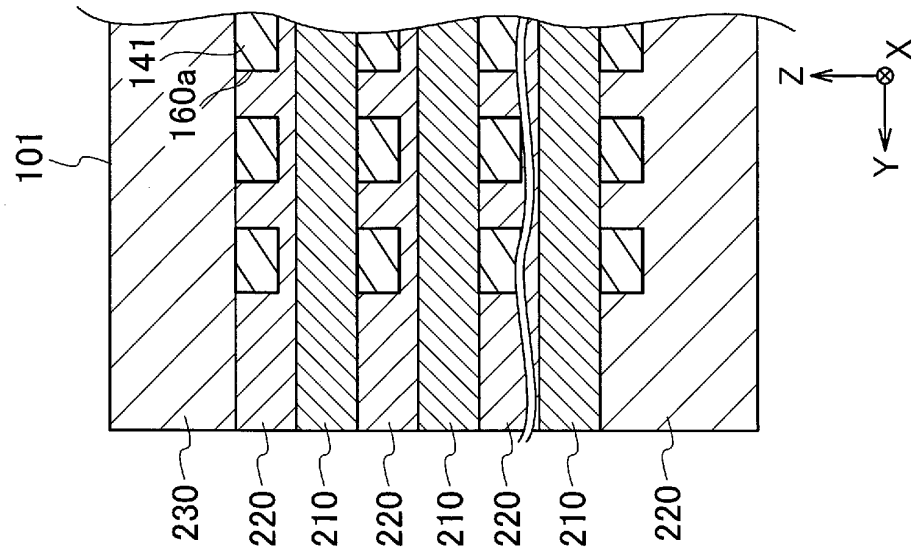


FIG. 4

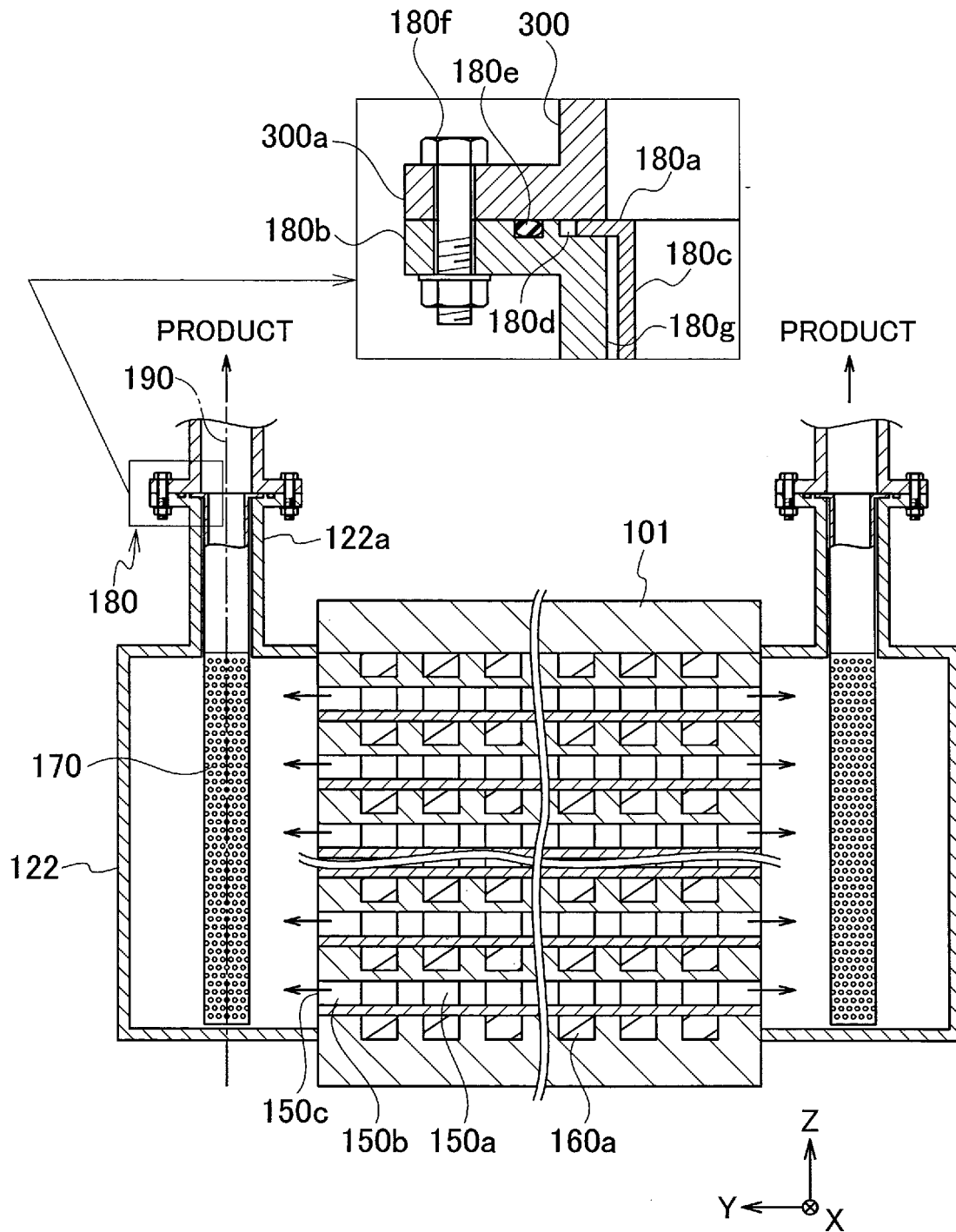
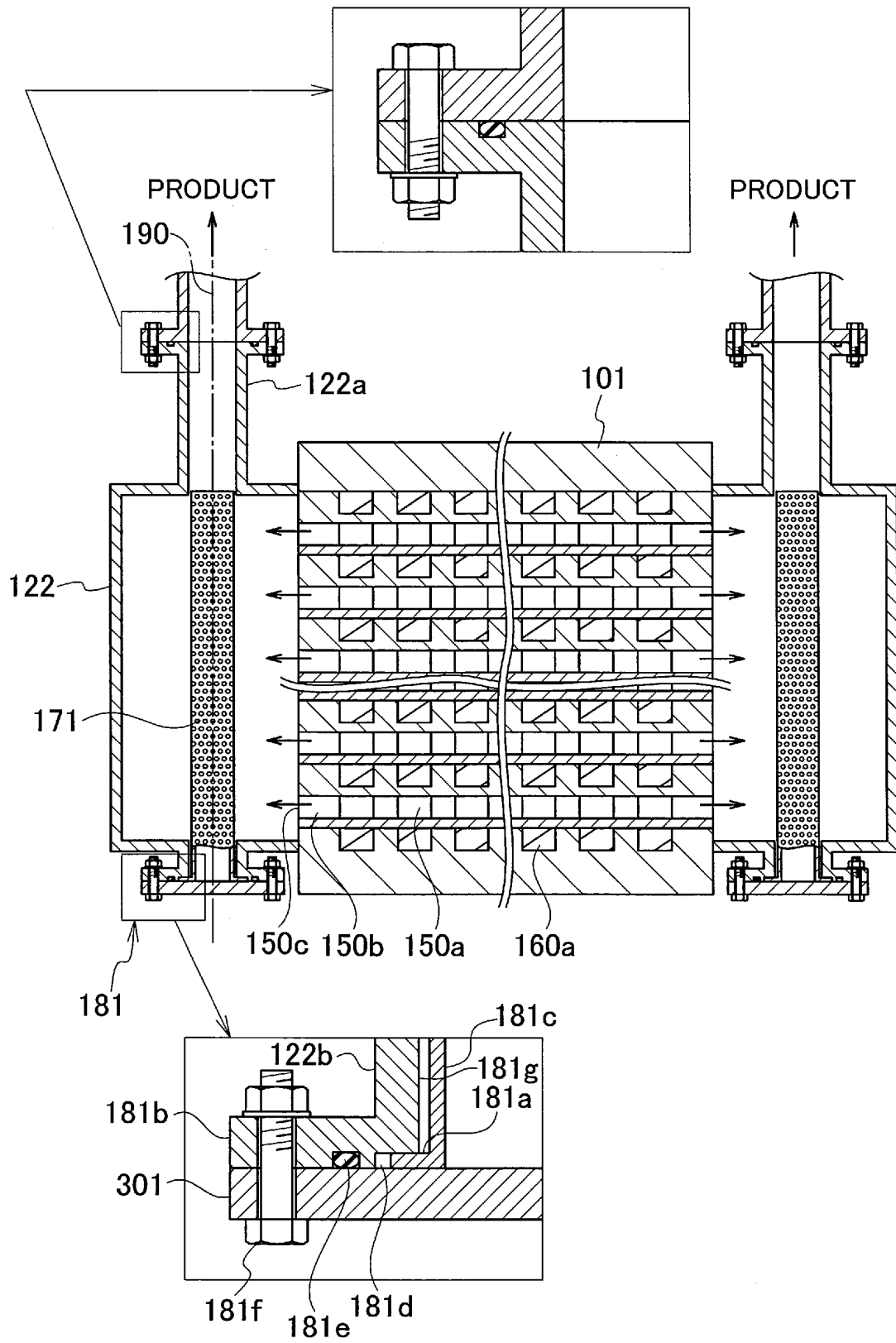


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/005532

A. CLASSIFICATION OF SUBJECT MATTER

F28F9/02(2006.01)i, F28F3/08(2006.01)i, F28F9/22(2006.01)i, C07C1/04
(2006.01)n, C07C9/04(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28F9/02, F28F3/08, F28F9/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2012-172534 A (Tokyo Roki Co., Ltd.),	1-6
A	10 September 2012 (10.09.2012), paragraphs [0029] to [0033], [0036], [0057], [0058], [0063]; fig. 2 to 4, 8 to 11 (Family: none)	7-9
A	WO 2014/152239 A2 (THAR ENERGY LLC), 25 September 2014 (25.09.2014), entire text; all drawings & JP 2016-512320 A	1-9
A	JP 2013-188640 A (Kobe Steel, Ltd.), 26 September 2013 (26.09.2013), paragraphs [0001], [0025] to [0028]; fig. 2, 3 & US 2013/0233525 A1 paragraphs [0045] to [0048]; fig. 2, 3	1-9

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"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

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Date of the actual completion of the international search
25 April 2017 (25.04.17)

Date of mailing of the international search report
09 May 2017 (09.05.17)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/005532

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-16083 A (Sumitomo Precision Products Co., Ltd.), 30 January 2014 (30.01.2014), paragraph [0039]; fig. 1, 2 & US 2015/0136366 A1 paragraph [0047]; fig. 1A, 1B, 2 & EP 2889570 A1 & CN 104428622 A	1-9

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010216749 A [0002] [0003]