



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
31.05.2017 Bulletin 2017/22

(51) Int Cl.:
F24H 1/38 (2006.01) **F24H 9/00 (2006.01)**
F28F 13/08 (2006.01)

(21) Application number: **15196332.9**

(22) Date of filing: **25.11.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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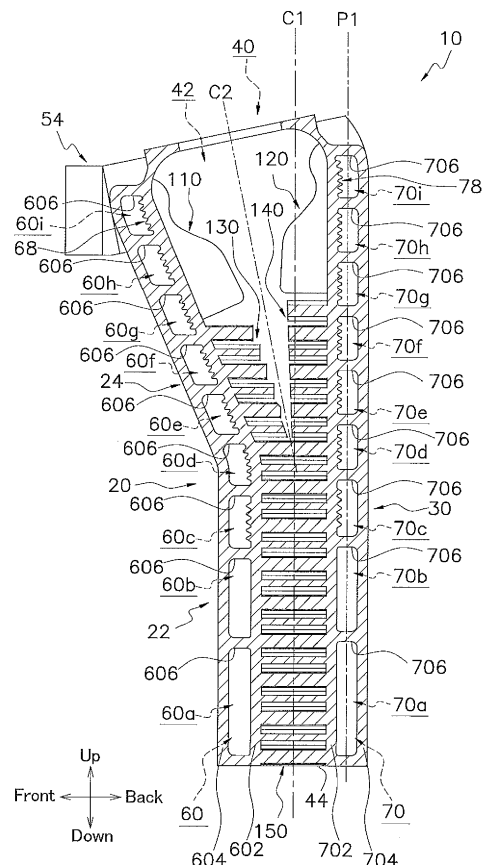
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(54) **HEAT EXCHANGER**

(57) A heat exchanger (10) comprises a front wall (20) and a back wall (30) to form a space (40) for a flue gas, and a front channel (60) and a back channel (70) formed in the front wall (20) and the back wall (30), respectively, in which a fluid is to flow. The heat exchanger (10) is configured such that the fluid in the front and back channels (60, 70) can exchange heat with the flue gas, in use. The entire back wall (30) extends along a first plane (P1). The front wall (20) includes a lower portion (22) and an upper portion (24). The lower portion (22) extends upwardly along the back wall (30). The upper portion (24) extends upwardly from the upper end of the lower portion (22) and extends outwardly away from the back wall (30) so as to form a combustion space (42) of a flammable gas between the upper portion (24) and the back wall (30). The heat exchanger (10) is further configured such that the volume flow rate and/or mass flow rate of the fluid in the front channel (60) is greater than the back channel (70), in use.

【FIG5】



Description

Field of the Invention

[0001] The invention relates to a heat exchanger, especially a heat exchanger in which heat is transferred from a flue gas to a flowing liquid.

Background

[0002] Such a heat exchanger is known from WO 2009/053248. This heat exchanger is provided with a front wall and a back wall. A combustion space is formed in the upper part of the space between the front wall and the back wall. Flammable gas is injected and combusted by a burner mounted on a top of the heat exchanger. Channels in which water flows are respectively formed in the front wall and the back wall. Heat generated by gas combustion is transferred to water flowing in the channels. The walls are arranged symmetrically with respect to the center line in side view. In the heat exchanger, since the walls are arranged symmetrically, the fluid flowing both of the channels is heated almost equally when the channels are equally designed.

[0003] The known heat exchanger mentioned above has certain efficiency in heat exchange, although further improvement is required in aspect of downsizing a system equipped with the heat exchanger. However, if the arrangement of the walls is changed for downsizing the system equipped with the heat exchanger, there is a possibility that the fluid flowing through both of the channels is heated unequally even though the channels are symmetrically designed. The heat exchange efficiency is thereby deteriorated.

[0004] It is the object of the present invention to provide a heat exchanger which contributes to the miniaturization of the system equipped with the heat exchanger while maintaining heat exchange efficiency.

Summary

[0005] A first aspect of the present invention provides a heat exchanger comprising a front wall and a back wall to form a space for a flue gas, and a front channel and a back channel formed in the front wall and the back wall, respectively, in which a fluid is to flow. The heat exchanger is configured such that the fluid in the front and back channels can exchange heat with the flue gas, in use. The entire back wall extends along a first plane. The front wall includes a lower portion and an upper portion. The lower portion extends upwardly along the back wall. The upper portion extends upwardly from the upper end of the lower portion and extends outwardly away from the back wall so as to form a combustion space of a flammable gas between the upper portion and the back wall. The heat exchanger is further configured such that the volume flow rate and/or mass flow rate of the fluid in the front channel is greater than the back channel, in use.

[0006] Volume flow rate means the volume of fluid which passes per unit time. Mass flow rate means mass of a fluid which passes per unit of time.

[0007] "The volume flow rate and/or mass flow rate of the fluid in the front channel is greater than the back channel" means that the average volume flow rate and/or average mass flow rate of the fluid in the front channel is greater than the back channel. Average volume/mass flow rate means volume/mass flow over the entire front or back channel.

[0008] Volume/mass flow rate is generally measured at the inlet/outlet of each channel.

[0009] With this configuration mentioned above, the heat exchanger can contribute the downsizing of a heat exchanging system accommodated in a housing and equipped with the heat exchanger. This is because the back wall extending along the first plane without extending outwardly can minimize a useless space between the heat exchanger and the housing.

[0010] The heat transfers on the front wall side and back wall side have different characteristic because of the unsymmetrical design of the walls. Specifically, the fluid in the front channel of the front wall can obtain more heat from the flue gas than the fluid in the back channel of the back wall. The volume flow rate or mass flow rate of the fluid is adjusted to be different on each side. Thereby the temperature of the fluid at the outlet of each channel can reach to substantially the same temperature.

[0011] In this way, high space efficiency and high heat exchange efficiency can be achieved.

[0012] According to a preferred embodiment of the heat exchanger mentioned above, the back channel is configured to have a higher fluid resistance than the front channel.

[0013] With the above configuration, it is possible to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel.

[0014] According to another preferred embodiment of any one of the heat exchangers mentioned above, a minimum cross section in the back channel is smaller than the minimum cross section in the front channel with respect to cross sections intersecting with the direction of the fluid flow.

[0015] With the above configuration, the heat exchanger is configured so that the back channel has a higher fluid resistance than the front channel. It is therefore possible to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel.

[0016] According to a preferred embodiment of any one of the heat exchangers mentioned above, an average cross-sectional area of the back channel is smaller than the an average cross-sectional area of the front channel with respect to cross sections intersecting with the direction of the fluid flow.

[0017] With the above configuration, the higher fluid resistances in the front and back channels are controlled by adjusting the average cross-sectional areas of the

front and back channels. It is therefore possible to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel in a more accurate manner.

[0018] According to a preferred embodiment of any one of the heat exchangers mentioned above, the front channel includes a plurality of front sub channels which are arranged in substantially parallel to each other and are connected in series. The back channel includes a plurality of back sub channels which are arranged in substantially parallel to each other. The back sub channels are connected in series, and each of which faces to one of the first sub channels. With respect to cross sections intersecting with the direction of the fluid flow, at least one of the back sub channel has the minimum cross section smaller than the minimum cross section of the corresponding front sub channel, and/or an average cross-sectional area smaller than an average cross-sectional area of the corresponding front sub channel.

[0019] With the above configuration, it is therefore possible to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel in a more accurate manner.

[0020] According to a preferred embodiment of any one of the heat exchangers with the front channel including a plurality of the front sub channels and the back channel including a plurality of the back sub channels mentioned above, with respect to cross sections intersecting with the direction of the fluid flow, each of the back sub channels has the minimum cross section smaller than the minimum cross section of the corresponding front sub channel, and/or an average cross-sectional area smaller than an average cross-sectional area of the corresponding front sub channel.

[0021] With the above configuration, it is therefore possible to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel in a more accurate manner.

[0022] According to a preferred embodiment of any one of the heat exchangers mentioned above, the volume of the entire back channel is smaller than the volume of the entire front channel.

[0023] With the above configuration, it is therefore possible to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel in a more accurate manner.

[0024] According to a preferred embodiment of any one of the heat exchangers mentioned above, a flow suppression means is arranged in the back channel.

[0025] In general, it is preferable to reduce the fluid resistance of the channel in view of reducing the energy necessary for flowing the fluid. However, in this configuration, a flow suppression mean is provided in the back channel to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel so as to maintain the high heat exchange efficiency.

[0026] Examples of such a flow suppression means

are obstacles arranged in the back channel such as protrusions extending from the walls forming the back channel.

[0027] According to a preferred embodiment of any one of the heat exchangers mentioned above, the heat exchanger further comprises a distribution mechanism connected to the inlets of each of the front channel and the back channel. The distribution mechanism is configured to distribute the fluid to the front channel and the back channel, in use. The distribution mechanism is further configured to distribute more fluid to the front channel than to the back channel.

[0028] With the above configuration, it is possible to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel by providing more fluid to the front channel.

[0029] According to a preferred embodiment of any one of the heat exchangers mentioned above, the heat exchanger further comprises a converging mechanism connected to the outlets of each of the front channel and the back channel. The converging mechanism is configured to converge the fluid from the front channel and the back channel and output therefrom, in use. The converging mechanism is configured to control the fluid resistance of the fluid flowing from the back channel higher than the fluid resistance of the fluid flowing from the front channel, in use.

[0030] With the above configuration, it is possible to adjust the volume flow rate and/or mass flow rate of the fluid in the front channel greater than the back channel in an easier manner.

[0031] According to a preferred embodiment any one of the heat exchangers mentioned above, the heat exchanger is configured such that the temperature of the fluid at each outlet of each channel is substantially the same, in use.

[0032] With the above configuration, the volume flow rate and/or mass flow rate of the fluid in the front channel is controlled so that the temperature of the fluid at each outlet of each channel is adjusted substantially the same. As a result, high heat exchange efficiency can be achieved.

Brief Description of the Drawings

[0033]

FIG. 1 is a schematic diagram of the heat exchange system equipped with the heat exchanger according to an embodiment of the present invention;

FIG. 2 is a perspective view of the heat exchanger according to FIG. 1;

FIG. 3 is a side view of the heat exchanger on which the burner is mounted according to FIG. 1;

FIG. 4 is a front view of the heat exchanger according to FIG. 1;

FIG. 5 is a cross section view of the heat exchanger viewing from the arrow direction of the V-V line of

FIG.4;

FIG. 6 is a cross section view of the heat exchanger viewing from the arrow direction of the VI-VI line of FIG.4;

FIG. 7 is a cross section view of the heat exchanger viewing from the arrow direction of the VII-VII line of FIG.3;

FIG. 8 is a cross section view of the heat exchanger viewing from the arrow direction of the VIII-VIII line of FIG.3;

FIG. 9 is a partial enlarged view of FIG. 8;

Fig. 10 is a schematic diagram of the heat exchanger according to another embodiment of the present invention;

Fig. 11 is a schematic diagram of the heat exchanger according to another embodiment of the present invention; and

Fig. 12 is a schematic diagram of the heat exchanger according to another embodiment of the present invention.

Detailed Description of Preferred Embodiments

[0034] Preferred embodiments of the heat exchanger according to the present invention will be described with reference to the drawings.

[0035] It should be understood that the detailed explanation are provided merely for the purpose of explanation, and are in no way to be construed as limiting of the present invention. While the present invention will be described with reference to exemplary preferred embodiments, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. Changes may be made, within the purview of the appended claims, as presently stated and as amended, without departing from the scope and spirit of the present invention in its aspects. Although the present invention will be described herein with reference to preferred structures, materials and embodiments, the present invention is not intended to be limited to the particulars disclosed herein; rather, the present invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

[0036] FIG. 1 shows a schematic diagram of a heat exchange system 1 equipped with a heat exchanger 10 according to a preferred embodiment of the present invention.

[0037] The heat exchange system 1 is used for heating medium fluid which is used for space heating and heating domestic water, while the heat exchange system 1 may be used only for heating the medium fluid for space heating or only for heating the domestic water.

[0038] As shown in FIG. 1, the heat exchange system 1 is mainly provided with the heat exchanger 10, a fan 2a, a burner 3, a siphon 4b, a pump 5a, a heat exchanger 6, and a housing 9. As shown in FIG. 1, the heat exchange system 1 has a gas inlet connector 9a to which a fuel gas

supply pipe (not shown) is connected, a condensate outlet connector 9b to which a drain outlet pipe (not shown) is connected, medium fluid water inlet/outlet connectors 9c, 9d to which medium fluid inlet/outlet pipes (not shown) are respectively connected, and DHW (domestic heat water) inlet/outlet connectors 9e, 9f to which DHW inlet/outlet pipes (not shown) are respectively connected.

[0039] The housing 9 shown in FIG. 1 has a box-like shape such as a cuboid shape. The housing 9 accommodates the heat exchanger 10, the fan 2a, the burner 3, the siphon 4b, the pump 5a, and the heat exchanger 6 as shown in FIG. 1.

[0040] The fan 2a intakes a fuel gas, such as natural gas, supplied from the fuel gas supply pipe (not shown) via the gas inlet connector 9a and a gas pipe 2 as shown in FIG. 1. The fan 2a also intakes air from the outside of the housing 9. The fan 2a then supplies the mixture gas with the fuel gas and the air to the burner 3.

[0041] The burner 3 is mounted on the heat exchanger 10 as shown in FIG. 3. Specifically, the burner 3 is mounted on the top of the heat exchanger 10. A burner port 3a of the burner 3, from which flammable gas is injected, is arranged in a combustion space 42 formed in the heat exchanger 10 as shown in FIG. 6. The burner 3 injects the flammable gas (mixture gas with the fuel gas and the air) into the combustion space 42 and combusts the flammable gas in the combustion space 42.

[0042] The heat exchanger 10 has a flue gas space 40 including the combustion space 42 and two channels 60, 70 as shown in FIG. 5. The heat exchanger 10 is configured such that the medium fluid in the two channels 60, 70 can exchange heat with the flue gas flowing in the flue gas space 40, in use.

[0043] As mentioned above, the burner port 3a of the burner 3 is arranged over the combustion space 42 and the flammable gas is combusted in the combustion space 42. Flue gas generated by the combustion of the flammable gas flows downward in the flue gas space 40.

[0044] The channels 60, 70 constitute a part of a medium fluid circuit 5 in which a medium fluid circulates. The medium fluid circuit 5 further includes an inlet pipe 5b, an outlet pipe 5c, and the medium fluid inlet/outlet pipes (not shown) which are arranged outside the heat exchange system 1 and are connected to the medium fluid water inlet/outlet connectors 9c, 9d. The medium fluid circuit 5 also includes space heating devices (not shown), such as floor heating devices and radiators, which are arranged outside the heat exchange system 1 and which are connected to the medium fluid outlet pipe and the medium fluid inlet pipe. For example, the medium fluid circulating in the medium fluid circuit 5 is an aqueous medium.

[0045] In the medium fluid circuit 5, the medium fluid is supplied to the medium fluid inlet connector 9c from the medium fluid inlet pipe (not shown). The medium fluid then flows in each of the channels 60, 70 from the inlet of each of the channels 60, 70 through the inlet pipe 5b. On the inlet pipe 5b, the pump 5a is arranged to circulate

the medium fluid in the medium fluid circuit 5. In the heat exchanger 10, the medium fluid flows in the channels 60, 70 and exchanges heat with the flue gas flowing in the flue gas space 40. After passing through the channels 60, 70, the medium fluid in each of the channels 60, 70 flows out from an outlet of each of the channels 60, 70. The medium fluid then flows out to the medium fluid outlet pipe (not shown) through the outlet pipe 5c and the medium fluid outlet connector 9d and is sent to space heating devices (not shown) through the medium fluid outlet pipe.

[0046] The configuration of the heat exchanger 10 will be explained in detail later.

[0047] After the flue gas has passed through the flue gas space 40, the flue gas is exhausted out of the housing 9 through a gas duct 8. Condensate from the flue gas is corrected at a drain collecting part 4 located below the heat exchanger 10. The drain collecting part 4 includes a drain pipe 4a. The end portion of the drain pipe 4a is connected to the siphon 4b. The siphon 4b allows the condensate from the flue gas to drain to the drain outlet pipe (not shown) which is connected to the condensate outlet connector 9b while preventing the release of the flue gas.

[0048] The medium fluid circuit 5 includes a connecting pipe 5d which connects the inlet pipe 5b and the outlet pipe 5c of the medium fluid circuit 5 via a medium fluid channel 6a formed in the heat exchanger 6. The connecting pipe 5d is configured so that the medium fluid can flow from the outlet pipe 5c to the inlet pipe 5b through the medium fluid channel 6a.

[0049] The heat exchanger 6 also has a domestic water channel 6b formed therein. An inlet pipe 7a of the domestic water is connected to an inlet of the domestic water channel 6b. An outlet pipe 7b of the domestic water is connected to an outlet of the domestic water channel 6b. The inlet pipe 7a of the domestic water is connected to DHW inlet connector 9e. The outlet pipe 7b of the domestic water is connected to DHW outlet connector 9f. The inlet/outlet pipes 7a, 7b of the domestic water are configured so that domestic water flows in the domestic water channel 6b from the inlet of the domestic water channel 6b, and flows out to the outlet pipe 7b from the outlet of the domestic water channel 6b after the domestic heat water passes through the domestic water channel 6b. In the heat exchanger 6, domestic heat water flowing in domestic water channel 6b exchanges heat with the medium fluid flowing the medium fluid channel 6a, in use.

[0050] The operation of the heat exchange system 1 is briefly explained.

[0051] Fuel gas is supplied via the gas inlet connector 9a. Fuel gas and air taken from the outside of the housing 9 are mixed. The mixture gas is supplied to the burner 3. The flammable gas (mixture gas) is injected into the combustion space 42 from the burner 3 and is combusted in the combustion space 42. Flue gas then flows downwardly in the flue gas space 40.

[0052] Medium fluid is circulated in the medium fluid circuit 5. During circulation, relatively low temperature

medium fluid flows into the channels 60, 70 via medium fluid inlet connector 9c and the inlet pipe 5b. Medium fluid flowing in the channels 60, 70 exchanges heat with the flue gas in the flue gas space 40 in use. The medium fluid heated at the heat exchanger 10 flows out from the medium fluid outlet connector 9d through the outlet pipe 5c and is sent to the space heating devices (not shown). The heat of the medium fluid is used for the space heating devices and cooled medium fluid (the medium fluid taken its heat by the space heating devices) then returns to the heat exchange system 1. By changing the direction of the flowing direction of the medium fluid, the medium fluid heated at the heat exchanger 10 is sent to the heat exchanger 6 to heat the domestic water. The heated domestic water is sent to the usage point such as bath room and kitchen.

[0053] The flue gas flowing out of the flue gas space 40 is exhausted through the gas duct 8. The condensate from the flue gas is drained to the drain outlet pipe through the siphon 4b.

[0054] A heat exchanger 10 according to a preferred embodiment of the present invention will be described in detail.

[0055] FIG. 2 shows a perspective view of the heat exchanger 10. FIG. 3 shows a side view of the heat exchanger 10 on which the burner is mounted. FIG. 4 shows a front view of the heat exchanger 10.

[0056] The heat exchanger 10 is preferably manufactured by corrosion resistant metal such as aluminum alloy. For example, heat exchanger 10 is manufactured as monoblock sand-cast, although manufacturing method is not limited to this. The heat exchanger 10 is designed so that the burner 3 is mounted on the top of the heat exchanger 10 as shown in FIG. 3.

[0057] The heat exchanger 10 mainly includes a front wall 20, a back wall 30, side walls 50, an inlet distribution pipe 52, and an outlet converging pipe 54 as shown in FIG. 2.

[0058] The front wall 20 and the back wall 30 form a flue gas space 40 for a flue gas. The flue gas space 40 is formed by a space defined by the front wall 20, the back wall 30 and the side walls 50 which are attached to lateral ends of the front wall 20 and the back wall 30. The flue gas space 40 includes the combustion space 42 of the flammable gas. The combustion space 42, in which the burner port 3a of the burner 3 is installed, is arranged at the upper part of the flue gas space 40 as shown in FIG. 5. The flue gas flows downwardly in the flue gas space 40 from the combustion space 42 and flows out from an opening 44 arranged at the bottom of the heat exchanger 10, in use.

[0059] A front channel 60 is formed in the front wall 20 and a back channel 70 is formed in the back wall 30 as shown in FIG. 5. The medium fluid flows in the front channel 60 and back channel 70, in use.

[0060] The inlet distribution pipe 52 has a tube-shape which has an inlet opening 52a in the front side as shown in FIG. 4. The inlet pipe 5b of the medium fluid circuit 5

is connected at the inlet opening 52a. The inlet distribution pipe 52 is also connected to the inlets of each of the front channel 60 and the back channel 70. The inlet distribution pipe 52 is configured to distribute the fluid to the front channel 60 and the back channel 70, in use. The medium fluid flows into the front channel 60 and the back channel 70 through the inlet distribution pipe 52, in use.

[0061] The outlet converging pipe 54 has a tube-shape which has an outlet opening 54a in the front side as shown in FIG. 4. The outlet pipe 5c of the medium fluid circuit 5 is connected at the outlet opening 54a. The outlet converging pipe 54 is also connected to the outlets of each of the front channel 60 and the back channel 70. The outlet converging pipe 54 is configured to converge the fluid from the front channel 60 and the back channel 70, and output therefrom, in use. The converged medium fluid flows in the outlet pipe 5c of the medium fluid circuit 5, in use.

[0062] Now, the back wall 30 and the front wall 20 will be described in more detail.

[0063] The back wall 30 has a tabular shape. The back wall 30 extends along a first plane P1 as shown in FIG. 5. The heat exchanger 10 is arranged on a horizontal plane and the first plane P1 is a vertical plane in this embodiment, although the arrangement of the heat exchanger 10 is not limited to this. In the heat exchange system 1, the heat exchanger 10 is preferably accommodated such that the back wall 30 extends along one of the walls of the housing 9. Due to the shape of the back wall 30, a dead space between the back surface of the heat exchanger 10 and the inner surface of the wall of the housing 9 can be minimized.

[0064] The front wall 20 includes a lower portion 22 and an upper portion 24 as shown in FIG. 2. The lower portion 22 extends upwardly along the back wall 30 as shown in FIG. 3. In other word, the lower portion 22 of the front wall extends in parallel with the back wall 30. The lower portion 22 preferably has a plane-like shape. The upper portion 24 extends upwardly from the upper end of the lower portion 22 as shown in FIG. 3. More specifically, the upper portion 24 extends upwardly from the upper end of the lower portion 22 in a planar fashion. The upper portion 24 of the front wall 20 has a plane-like shape. Furthermore, the upper portion 24 extends outwardly away from the back wall 30 so as to form a combustion space 42 of a flammable gas between the upper portion 24 of the front wall 20 and the back wall 30. The length L2 of the upper portion 24 along the longitudinal direction thereof is preferably longer than the length L1 of the lower portion 22 along the longitudinal direction thereof as shown in FIG. 3. Each of the longitudinal direction of the upper portion 24 and the lower portion 22 is a direction along which each of the upper portion 24 and the lower portion 22 extends in side view.

[0065] The space formed under the upper portion 24 is effectively used for arranging elements of the heat exchange system 1 such as the fan 2a to achieve the downsizing of the housing 9 of the heat exchange system 1

as shown in FIG. 3. The space formed under the upper portion 24 may also be used for arranging the other elements of the heat exchange system 1 such as valve, pipe, and venturi device.

[0066] Next, the structures which are arranged on the inner surface of the front wall 20 and the inner surface of the back wall 30 will be described with reference to FIG. 5 to FIG. 7. The inner surface of the upper portion 24 is a surface which faces the back wall 30. The inner surface of the back wall 30 is a surface which faces the front wall 20.

[0067] FIG. 5 is a cross section view of the heat exchanger viewing from the arrow direction of the V-V line of FIG.4. FIG. 6 is a cross section view of the heat exchanger viewing from the arrow direction of the VI-VI line of FIG.4. FIG. 7 is a cross section view of the heat exchanger viewing from the arrow direction of the VII-VII line of FIG.3.

[0068] The upper portion 24 of the front wall 20 is provided with front fins 110 as shown in FIG. 5. The front fins 110 are formed to protrude from the inner surface of the front wall 20. A plurality of the front fins 110 is arranged along the lateral direction (left-right direction) of the front wall 20 on the inner surface of the upper portion 24 at a predetermined interval. The number of the front fins 110 and the interval between the front fins 110 depend on the various factors such as the amount of heat transferred from the flue gas to the medium fluid, materials of the walls, and the power of the burner to be installed.

[0069] In addition to the front fins 110, the front wall 20 is provided with front pins 130, 150 as shown in FIG. 5. The front pins 130, 150 are arranged on the downstream side of the front fins 110 with respect to the flue gas flow direction. In other words, the front pins 130, 150 are arranged below the front fins 110. The cross-sectional of the front pins 130, 150 with respect to its main axis has a circular shape, or preferably an elliptic shape which is longer in the longitudinal direction than the lateral direction of the front wall. Each of the pins 130, 150 has larger surface area per unit volume than the front fins 110. The front pins 130, 150 extend backwardly from the inner surface of the front wall 20. A part of the front pins (pins 130) is arranged at the upper portion 24 of the front wall 20 below the front fins 110. A plurality of the front pins 130 is preferably arranged along the lateral direction (left-right direction) of the front wall 20 on the inner surface of the upper portion 24 at a predetermined interval. Several lines of the front pins 130 are preferably arranged at the upper portion 24 along the longitudinal direction at a predetermined interval. The rest of the front pins 150 are arranged at the lower portion 22 of the front wall. A plurality of the front pins 150 is arranged along the lateral direction (left-right direction) of the front wall 20 on the inner surface of the lower portion 22 at a predetermined interval. Several lines of the front pins 150 are arranged at the lower portion 22 along the longitudinal direction at a predetermined interval. The number of the front pins

130, 150, and the interval between the front pins 130, 150 depend on the various factors such as the amount of heat transferred from the flue gas to the medium fluid, materials of the walls, and the power of the burner to be installed.

[0070] The back wall 30 is provided with back fins 120 as shown in FIG. 5. The back fins 120 are formed to protrude from the inner surface of the back wall 30. A plurality of the back fins 120 is arranged along the lateral direction (left-right direction) of the back wall 30 on the inner surface of the back wall 30 at a predetermined interval as shown in FIG. 7. The number of the back fins 120 and the interval between the back fins 120 depend on the various factors such as the amount of heat transferred from the flue gas to the medium fluid, materials of the walls, and the power of the burner to be installed.

[0071] The number of the back fins 120 and the interval between the back fins 120 are preferably the same as those of the front fins 110. Each of the back fins 120 preferably corresponds to one of the front fins 110 such that the corresponding front and back fins face to each other. The front fin 110 and the corresponding back fin 120 are arranged symmetrically with respect to a virtual line C2 along which the flammable gas is to be injected into the combustion space 42 as shown in FIG. 5.

[0072] The shapes of the front fins 110 and the back fins 120 are described in detail with reference to FIG. 6.

[0073] Most of the front fins 110 and the corresponding back fins 120, except for fins 110, 120 arranged under the outlet converging pipe 54 (refer to FIG. 7), include respectively a first portion 112, 122 and a second portion 114, 124 arranged below the first portion 112, 122 as shown in FIG. 6. The height H1 of the first portion 112, 122 from the inner surface of the corresponding wall 20, 30 is smaller than the height H2 of the second portion 114, 124 from the inner surface of the corresponding wall 20, 30 as shown in FIG. 6.

[0074] Preferably, each of the fins 110, 120 includes the first portion 112, 122 and the second portion 114, 124.

[0075] Most of the front fins 110 and the corresponding back fins 120, except for fins 110, 120 arranged under the outlet converging pipe 54 (refer to FIG. 7), include an inwardly bulged portion 112a, 122a which bulges toward the virtual line C2 and an outwardly curved portion 112b, 122b which curves away from the virtual line C2 as shown in FIG. 6. The outwardly curved portion 112b, 122b is arranged below the inwardly bulged portion 112a, 122a as shown in FIG. 6.

[0076] The inwardly bulged portion 112a, 122a and the outwardly curved portion 112b, 122b are formed so as to keep a predetermined distance between the burner 3, more specifically the burner port 3a of the burner 3, to be installed on the heat exchanger 10 and the fin 110, 120. The predetermined distance depends on various factors such as the desired power of the burner 3 and the material of the fins 110, 120.

[0077] Preferably, each of the fins 110, 120 includes the inwardly bulged portion 112a, 122a and the outwardly

curved portion 112b, 122b.

[0078] Each of the most of the front fins 110 and the corresponding back fins 120, except for fins 110, 120 arranged under the converging pipe 54 (refer to FIG. 7), has a tapered portion 112c, 122c where the height of the fin 110, 120 from the inner surface of the corresponding wall 20, 30 gradually decreases towards an upper end of the fin 110, 120 as shown in FIG. 6.

[0079] The tapered portion 112c, 122c is formed so as to keep a predetermined distance between the burner 3, more specifically the burner port 3a of the burner 3, to be installed in the heat exchanger 10 and the fin 110, 120. The predetermined distance depends on various factors such as the desired power of the burner 3 and the material of the fins 110, 120.

[0080] Preferably, each of the fins 110, 120 has the tapered portion 112c, 122c.

[0081] In addition to the back fins 120, the back wall 30 is provided with back pins 140, 150 as shown in FIG. 5. The cross-sectional of the back pins 140, 150 with respect to its main axis has a circular shape, or preferably an elliptic shape which is longer in the longitudinal direction than the lateral direction of the back wall 30. Each of the pins 140, 150 has larger surface area per unit volume than the back fins 120. The back pins 140, 150 extends forwardly from the inner surface of the back wall 30. A plurality of the back pins 140, 150 is arranged in the lateral direction (left-right direction) of the back wall 30 on the inner surface of the back wall 30 at a predetermined interval. Several lines of the back pins 140, 150 are arranged on the back wall 30 along the longitudinal direction at a predetermined interval. The number of the back pins 140, 150 and the interval between the back pins 140, 150 depend on the various factors such as the amount of heat transferred from the flue gas to the medium fluid, materials of the walls, and the power of the burner to be installed.

[0082] The front pins 150 arranged at the lower portion 22 of the front wall 20 are preferably connected to the corresponding back pins 150. In this embodiment, each of the pins 150 extends from the front wall 20 to the back wall 30. In other words, front pins 150 arranged at the lower portion 22 of the front wall 20 are integrated with the back pins 150.

[0083] The front pins 130 arranged at the upper portion 24 of the front wall 20 so as to face to the corresponding back pins 140. In other words the front pins 130 are arranged at the upper portion 24 of the front wall 20 is not connected to the corresponding the back pins 140 so as to make a space between them.

[0084] As explained above, the upper portion of the front wall 20 and the corresponding part of the back wall 30, which forms the combustion space 42 of heat exchanger 10 therebetween, is designed symmetrically with respect to the virtual line C2 which tilts against a virtual line C1. The lower portion 22 of the front wall 20 and the back wall 30 is arranged symmetrical with respect to the virtual line C1. With this configuration, flammable

gas can be combusted under proper condition and the concentration of CO and NO_x contained in the emission gas can be lowered.

[0085] Next, the front channel 60 formed in the front wall 20 and the back channel 70 formed in the back wall 30 will be described in detail with reference to FIG. 5 and FIG. 8. FIG. 8 is a cross section view of the heat exchanger viewing from the arrow direction of the VIII-VIII line of FIG. 3.

[0086] The front wall 20 has an inside wall 602 and an outside wall 604 which face to each other and form the front channel 60 therebetween. The front wall 20 also has wall elements 606 which connect the inside wall 602 and the outside wall 604 and define the front channel 60. The back wall 30 has an inside wall 702 and an outside wall 704 which face to each other and form the back channel 70 therebetween. The back wall 30 has wall elements 706 which connect the inside wall 702 and outside wall 704 and define the back channel 70.

[0087] The front channel 60 includes straight portions 60a, 60b, 60c, 60d, 60e, 60f, 60g, 60h, and 60i which are arranged in substantially parallel to each other and are connected in series as shown in FIG. 8. The medium fluid supplied from the inlet of the front channel 60 flows the straight portions 60a, 60b, 60c, 60d, 60e, 60f, 60g, 60h, and 60i in this order and flows out from the outlet of the front channel 60. In this paragraph, parallel means that the two straight portions are connected with an angle such that the speed of the turning fluid in the channel drops to nearly zero on the inner side in the connecting area 61 a, 61 b, 61 c, 61 d, 61 e, 61 f, 61 g, and 61 h. For example, in the vicinity of an inner part T1 of a joint 60ab in the connected area 61 a of the straight portions 60a and the straight portions 60b, the fluid nearly stops upon turning.

[0088] A plurality of pins 62 extending from the inside wall 602 is arranged in the straight portions 60a, 60b so as to improve the heat transfer efficiency between the medium fluid flowing in the straight portions 60a, 60b and the flue gas which flows along the inside wall 602. The straight portions 60a, 60b require higher strength against burst than the straight portions 60c-60i since the straight portions 60a, 60b has the larger surface area compared with the straight portions 60c-60i. A plurality of pins 62 can also improve the strength against burst of the straight portions 60a, 60b. In the straight portions 60c-60i, a plurality of grooves 68 extending along the longitudinal direction of the straight portions 60c-60i is formed on the inside wall 602. Thereby the heat transfer area is increased between the medium fluid flowing in the straight portions 60c-60i and the flue gas which flows along the inside wall 602.

[0089] Preferably, the cross-sectional area of the straight portion 60a arranged on the most upstream side is larger than the cross-sectional area of the other straight portions 60b-60i arranged on downstream side with respect to the fluid flow as shown in FIG. 5.

[0090] The back channel 70 also includes straight por-

tions 70a, 70b, 70c, 70d, 70e, 70f, 70g, 70h, and 70i as shown in FIG. 5. The straight portions 70a-70i are arranged in substantially parallel to each other and are connected in series. The medium fluid flowing from the inlet of the back channel 70 flows the straight portions 70a, 70b, 70c, 70d, 70e, 70f, 70g, 70h, and 70i in this order and flows out from the outlet of the back channel 70. In this paragraph, parallel has the same meaning with the previous paragraph for the front channel 60. In a manner similar to the above, a plurality of pins (not shown) extending from the inside wall 702 is arranged in the straight portions 70a, 70b and a plurality of grooves 78 extending along the longitudinal direction of the straight portions 70c-70i are formed on the inside wall 702 in the straight portions 70c-70i. The cross-sectional area of the straight portion 70a arranged on the most upstream side is larger than the cross-sectional area of the other straight portions 70b-70i arranged on downstream side with respect to the fluid flow.

[0091] The front channel 60 is further explained with reference to FIG. 8.

[0092] In the front channel 60, stagnation prevention means 64, 66 are preferably arranged in each of the connecting area 61 a-61 h of the straight portions 60a-60i as shown in FIG. 8. The stagnation prevention means 64, 66 connects the inside wall 602 and the outside wall 604 of the front wall 20.

[0093] In this embodiment, stagnation prevention means 64, 66 are arranged in each of the connecting area 61 a-61 h of the straight portions 60a-60i, but it is not limited to this configuration. It is preferable that at least the first stagnation prevention means 64 is arranged in the connecting area 61 a of the straight portions 60a and the straight portion 60b which locates on the most upstream side in the channel 60 with respect to a fluid flow.

[0094] The first stagnation prevention means 64 is arranged in the connecting area 61 a of the straight portions 60a and the straight portion 60b which locates on the most upstream side in the channel 60 with respect to the fluid flow. The first stagnation prevention means 64 is arranged in the vicinity of the inner part T1 of the joint 60ab of the straight portions 60a, 60b around which the fluid is to turn as shown in FIG. 8. The first stagnation prevention means 64 is formed in a hook-like shape when seen from the direction perpendicular to the front wall 20 as shown in FIG. 8.

[0095] At least one or more second stagnation prevention means 66 are preferably arranged in the connecting area 61b-61h of the straight portions 60b-60i in the channel 60. In other words, the second stagnation prevention means 66 are arranged in the connecting areas other than the connecting area 61 a which locates on the most upstream side in the channel 60 with respect to the fluid flow. The second stagnation prevention means 66 are formed in an arc-like shape when seen from the direction perpendicular to the front wall 20 as shown in FIG. 8. The arc-like shaped second stagnation prevention means 66

are arranged in the front channel 60 such that the arc-like shaped surface is substantially along the fluid flow.

[0096] Each of the second stagnation prevention means 66 is arranged in the vicinity of an inner part of a joint of the straight portions 60b-60i around which the fluid is to turn. For example, one of the second stagnation prevention means 66 is arranged in the vicinity of an inner part T2 of a joint 60bc of the straight portions 60b, 60c around which the fluid is to turn as shown in FIG. 8.

[0097] The first stagnation prevention means 64 is arranged so as to partially surround the inner part T1 of the joint 60ab of the straight portions 60a, 60b around which the fluid is to turn when seen from the direction perpendicular to the wall 20 as shown in FIG. 8. Specifically the first stagnation prevention means 64 is preferably arranged so as to surround the inner part T1 of the joint 60ab of the straight portions 60a, 60b over an angle range of more than 90 degrees, and more preferably over an angle range of more than 180 degrees when seen from the direction perpendicular to the wall 20 as shown in FIG. 8.

[0098] The one or more second stagnation prevention means 66 are also arranged so as to partially surround the inner part of the joint of the straight portions around which the fluid is to turn when seen from the direction perpendicular to the wall 20 as shown in FIG. 8. For example, the second stagnation prevention means 66 are arranged so as to partially surround the inner part T2 of the joint 60bc of the straight portions 60b, 60c around which the fluid is to turn when seen from the direction perpendicular to the wall 20 as shown in FIG. 8. The second stagnation prevention means 66 are arranged so as to surround the inner part T2 of the joint 60bc of the straight portions 60b, 60c over an angle range of more than 90 degrees when seen from the direction perpendicular to the wall 20.

[0099] The wall elements 606 which connects the inside wall 602 and the outside wall 604 include extending wall elements W1, W2 which respectively extend along the main axis A1, A2 of the straight portion 60a, 60b. The wall elements W1, W2 extend from the inner part T1 of the joint 60ab of the straight portions 60a, 60b around which the fluid is to turn as shown in FIG. 9. The main axes A1, A2 are axes along which the straight area of the straight portion 60a, 60b extends. The first stagnation prevention means 64 includes a first portion 64a which is arranged on the upstream side and a second portion 64b which is arranged on the downstream side with respect to the fluid flow as shown in FIG. 9. A maximum distance D1 between the second portion 64b and the extending wall element W2 is shorter than a maximum distance D2 between the first portion 64a and the extending wall element W2. The distance between the second portion 64b and the extending wall element W2 may be almost equal at any points.

[0100] The first stagnation prevention means 64 is arranged in the connecting area 61 a in the straight portion 60b which is located on the downstream side among the

two straight portions 60a, 60b connected. Each of the straight portions 60a, 60b has a straight area which has a straight tube-like shape. The first stagnation prevention means 64 is arranged to extend from the connecting area 61 a into part of the straight area in the straight portion 60b. The first stagnation prevention means 64 may extend into the connecting area 61 a located in the straight portion 60a at the upstream side with respect to the fluid flow.

[0101] The second stagnation prevention means 66 are arranged in the straight portion which is located at the downstream side with respect to the fluid flow among the straight portions connected. More specifically, the second stagnation prevention means 66 are arranged in the connecting area in the straight portion which is located on the downstream side among the two straight portions connected. Each of the straight portions 60c-60i has a straight area which has a straight tube-like shape. The second stagnation prevention means 66 may be arranged to extend from a connecting area into the straight area of the straight portion located on the downstream side.

[0102] The front channel 60 is explained above in detail with reference to FIG. 8. To avoid the redundancy of the explanation, the explanation of the back channel 70 is omitted regarding the common feature between the front channel 60 and the back channel 70. Only the difference between the front channel 60 and the back channel 70 will be explained below.

[0103] The heat transfers on the side of the front wall 20 and the side of the back wall 30 have different characteristic because of the unsymmetrical design of the walls. Specifically, the medium fluid in the front channel 60 of the front wall 20 can obtain more heat from the flue gas than the medium fluid in the back channel 70 of the back wall 30. However, the heat exchanger 10 is configured such that the temperature of the medium fluid at each outlet of each channel 60, 70 is substantially the same, in use.

[0104] The heat exchanger 10 is therefore configured such that the volume flow rate and/or mass flow rate of the fluid in the front channel 60 is greater than the back channel 70, in use. It is preferable that the heat exchanger 10 is configured such that at least the mass flow rate of the fluid in the front channel 60 is greater than the back channel 70, in use. Volume flow rate means the volume of fluid which passes per unit time. Mass flow rate means mass of a fluid which passes per unit of time. The volume flow rate and mass flow rate of the fluid in the front channel 60 is greater than the back channel 70 means that the average volume flow rate and average mass flow rate of the fluid in the front channel 60 is greater than the back channel 70. Average volume/mass flow rate means volume/mass flow over the entire front or back channel 60, 70. Volume/mass flow rate is generally measured at the inlet/outlet of each channel 60, 70.

[0105] To achieve this, the back channel 70 is configured to have a higher fluid resistance than the front chan-

nel 60.

[0106] Preferably, the minimum cross section in the back channel 70 is smaller than the minimum cross section in the front channel 60 with respect to cross sections intersecting with the direction of the fluid flow.

[0107] Preferably, an average cross-sectional area of the back channel 70 is smaller than the an average cross-sectional area of the front channel 60 with respect to cross sections intersecting with the direction of the fluid flow.

[0108] The front channel 60 includes a plurality of the straight portions 60a-60i as front sub channels which are arranged in substantially parallel to each other and are connected in series. The back channel 70 includes a plurality of the straight portions 70a-70i as back sub channels which are arranged in substantially parallel to each other. The straight portions 70a-70i are connected in series, and each of which faces to one of the straight portions 60a-60i. With respect to cross sections intersecting with the direction of the fluid flow, at least one of the straight portions 70a-70i has a minimum cross section smaller than a minimum cross section of the corresponding straight portions 60a-60i and/or an average cross-sectional area smaller than an average cross-sectional area of the corresponding straight portions 60a-60i.

[0109] Preferably, each of the straight portions 70a-70i has a minimum cross section smaller than a minimum cross section of the corresponding straight portions 60a-60i and/or an average cross-sectional area smaller than an average cross-sectional area of the corresponding straight portions 60a-60i.

[0110] The volume of the entire back channel 70 is smaller than the volume of the entire front channel 60.

Other embodiments

[0111] Other embodiments will be described below. Some or all of the embodiments can be combined except they are not contrary to each other.

(1) In the above embodiment, the cross section of the back channel 70 is different from that of the front channel 60 at least partially with respect to cross sections intersecting with the direction of the fluid flow. With this configuration, the heat exchanger 10 is configured such that the volume flow rate and/or mass flow rate of the fluid in the front channel 60 is greater than the back channel 70, in use,

In another preferable embodiment, in addition to the above mentioned configuration or instead of the above mentioned configuration, a flow suppression means 75 is arranged in the back channel 70 as shown in FIG. 10. An example of such a flow suppression means 75 is obstacles arranged in the back channel such as protrusions extending from the inside wall 702, and/or outside wall 704, and/or wall elements in the back channel 70.

(2) In the above embodiment, the cross section of

the back channel 70 is different from that of the front channel 60 at least partially with respect to cross sections intersecting with the direction of the fluid flow. With this configuration, the heat exchanger 10 is configured such that the volume flow rate and/or mass flow rate of the fluid in the front channel 60 is greater than the back channel 70, in use,

In another preferable embodiment, in addition to the above mentioned configuration or instead of the above mentioned configuration, the distribution pipe 52 as an example of the distribution mechanism is arranged to distribute more fluid to the front channel 60 than to the back channel 70. For example, the distribution pipe 52 branches off into a passage 52f and another passage 52b connected to the front channel 60 and the back channel 70, respectively. Specifically the distribution pipe 52 may be formed so that the passage 52b to the back channel 70 has the minimum and/or an average cross section smaller than that of the passage 52 to the front channel 60 with respect to cross sections intersecting with the direction of the fluid flow. In addition, or alternatively, the distribution pipe 52 may have a flow suppression means 52a such as obstacles which is arranged in the passage 52b to the back channel 70 as shown in FIG. 11.

(3) In the above embodiment, the cross section of the back channel 70 is different from that of the front channel 60 at least partially with respect to cross sections intersecting with the direction of the fluid flow. With this configuration, the heat exchanger 10 is configured such that the volume flow rate and/or mass flow rate of the fluid in the front channel 60 is greater than the back channel 70, in use,

In another preferable embodiment, in addition to the above mentioned configuration or instead of the above mentioned configuration, the converging pipe 54 as an example of the converging mechanism is arranged to control the fluid resistance of the fluid flowing from the back channel 70 higher than the fluid resistance of the fluid flowing from the front channel 60, in use. For example, the converging pipe 54 branches off into a passage 54f and another passage 54b connected to the front channel 60 and back channel 70, respectively. Specifically the converging pipe 54 may be formed so that the passage 54b from the back channel 70 has the minimum and/or an average cross section smaller than that of the passage 54f from the front channel 60 with respect to cross sections intersecting with the direction of the fluid flow. In addition, or alternatively, the converging pipe 54 may have a flow suppression means 54a such as an obstacle arranged in the passage 54b from the back channel 70 as shown in FIG. 12.

[0112] The present invention is not limited to the above described embodiments, and various variations and modifications may be possible without departing from the

scope of the present invention.

Claims

1. A heat exchanger (10) comprising

a front wall (20) and a back wall (30) to form a space (40) for a flue gas, and a front channel (60) and a back channel (70) formed in the front wall (20) and the back wall (30), respectively, in which a fluid is to flow, wherein

the heat exchanger (10) is configured such that the fluid in the front and back channels (60, 70) can exchange heat with the flue gas, in use, the entire back wall (30) extends along a first plane (P1), the front wall (20) includes

a lower portion (22) extending upwardly along the back wall (30), and an upper portion (24) extending upwardly from the upper end of the lower portion (22), extending outwardly away from the back wall (30) so as to form a combustion space (42) of a flammable gas between the upper portion (24) and the back wall (30), and

the heat exchanger (10) is further configured such that the volume flow rate and/or mass flow rate of the fluid in the front channel (60) is greater than the back channel (70), in use.

2. The heat exchanger (10) according to the claim 1, wherein

the back channel (70) is configured to have a higher fluid resistance than the front channel (60).

3. The heat exchanger (10) according to the claim 1 or 2, wherein

a minimum cross section in the back channel (70) is smaller than the minimum cross section in the front channel (60) with respect to cross sections intersecting with the direction of the fluid flow.

4. The heat exchanger (10) according to the claim 1, 2 or 3, wherein

an average cross-sectional area of the back channel (70) is smaller than an average cross-sectional area of the front channel (60) with respect to cross sections intersecting with the direction of the fluid flow.

5. The heat exchanger (10) according to any one of the claims 1 to 4, wherein

the front channel (60) includes a plurality of front sub channels (60a, 60b, 60c, 60d, 60e, 60f, 60g,

60h, 60i) which are arranged in substantially parallel to each other and are connected in series, the back channel (70) includes a plurality of back sub channels (70a, 70b, 70c, 70d, 70e, 70f, 70g, 70h, 70i) which are arranged in substantially parallel to each other and are connected in series, and each of which faces to one of the first sub channels (60a, 60b, 60c, 60d, 60e, 60f, 60g, 60h, 60i), and with respect to cross sections intersecting with the direction of the fluid flow, at least one of the back sub channel (70a, 70b, 70c, 70d, 70e, 70f, 70g, 70h, 70i) has

a minimum cross section smaller than a minimum cross section of the corresponding front sub channel (60a, 60b, 60c, 60d, 60e, 60f, 60g, 60h, 60i), and/or an average cross-sectional area smaller than an average cross-sectional area of the corresponding front sub channel (60a, 60b, 60c, 60d, 60e, 60f, 60g, 60h, 60i).

6. The heat exchanger (10) according to claim 5, wherein, with respect to cross sections intersecting with the direction of the fluid flow, each of the back sub channels (70a, 70b, 70c, 70d, 70e, 70f, 70g, 70h, 70i) has

a minimum cross section smaller than a minimum cross section of the corresponding front sub channel (60a, 60b, 60c, 60d, 60e, 60f, 60g, 60h, 60i), and/or an average cross-sectional area smaller than an average cross-sectional area of the corresponding front sub channel (60a, 60b, 60c, 60d, 60e, 60f, 60g, 60h, 60i).

7. The heat exchanger (10) according to any one of the claims 1 to 6, wherein

the volume of the entire back channel (70) is smaller than the volume of the entire front channel (60).

8. The heat exchanger (10) according to any of the claims 1 to 7, wherein

a flow suppression means (75) is arranged in the back channel (70).

9. The heat exchanger (10) according to any of the claims 1 to 8, further comprising,

a distribution mechanism (5c) connected to the inlets of each of the front channel (60) and the back channel (70), the distribution mechanism (52) being configured to distribute the fluid to the front channel (60) and the back channel (70), in use, wherein the distribution mechanism (52) is further configured to distribute more fluid to the front channel (60) than to the back channel (70).

10. The heat exchanger (10) according to any of the

claims 1 to 9, further comprising,
a converging mechanism (54) connected to the outlets of each of the front channel and the back channel, the converging mechanism (54) being configured to converge the fluid from the front channel (60) and the back channel (70) and output therefrom, in use,
wherein the converging mechanism (54) is configured to control the fluid resistance of the fluid flowing from the back channel (70) higher than the fluid resistance of the fluid flowing from the front channel (60), in use.

11. The heat exchanger (10) according to any of the claims 1 to 10, wherein,
the heat exchanger (10) is configured such that the temperature of the fluid at each outlet of each channel is substantially the same, in use.

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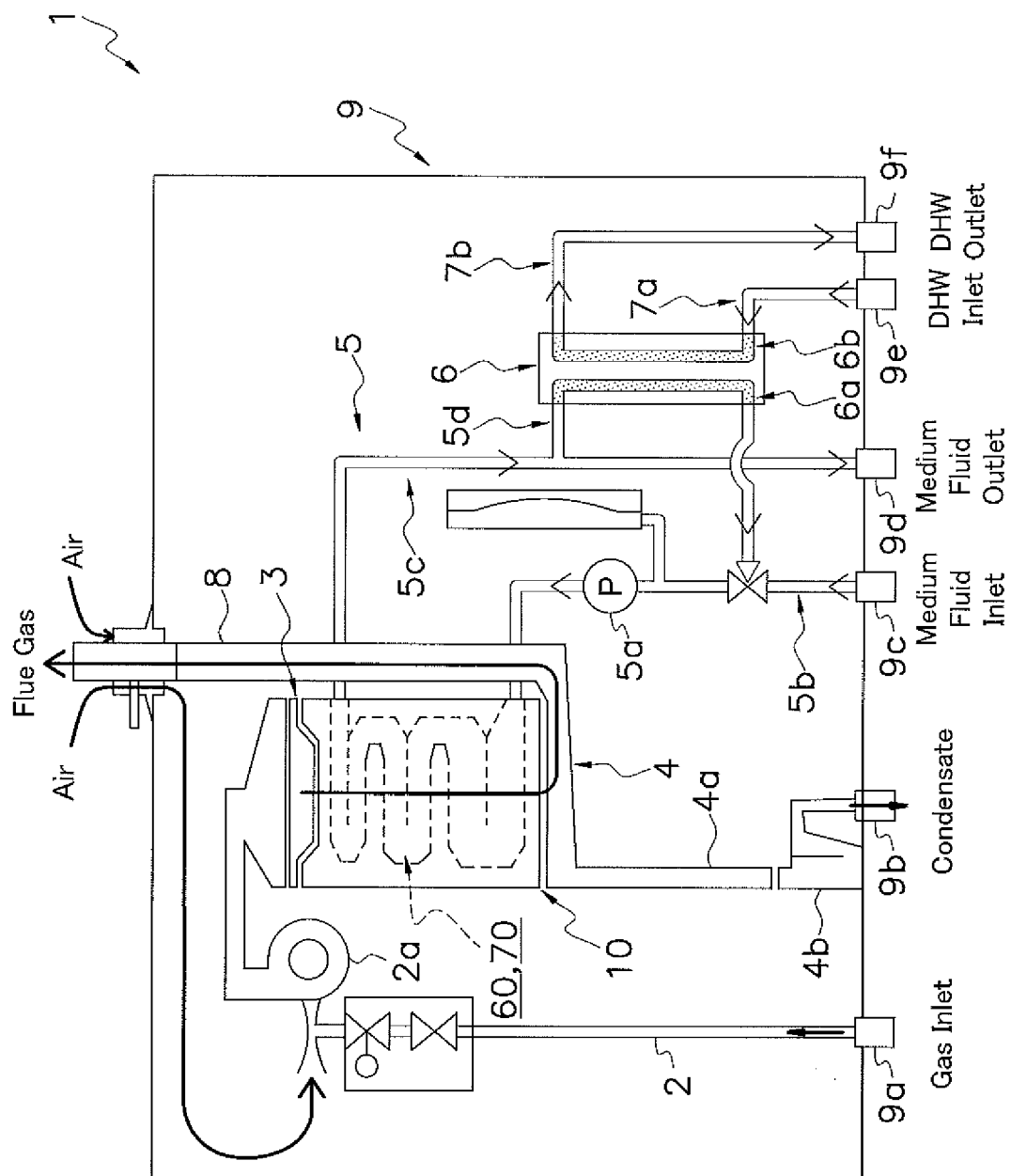
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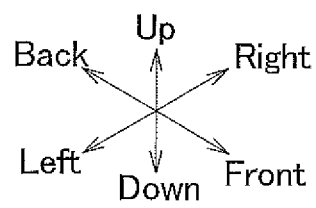
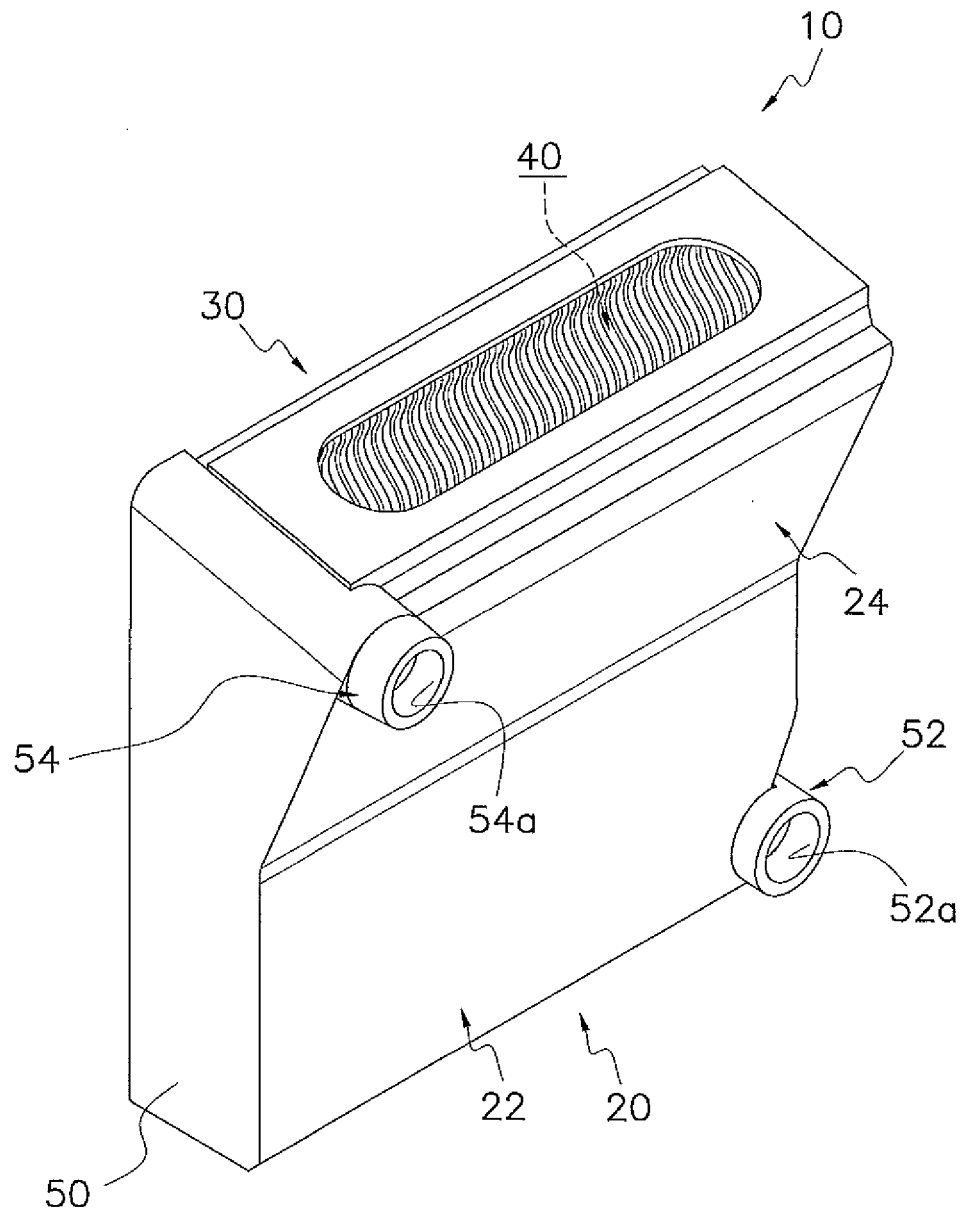
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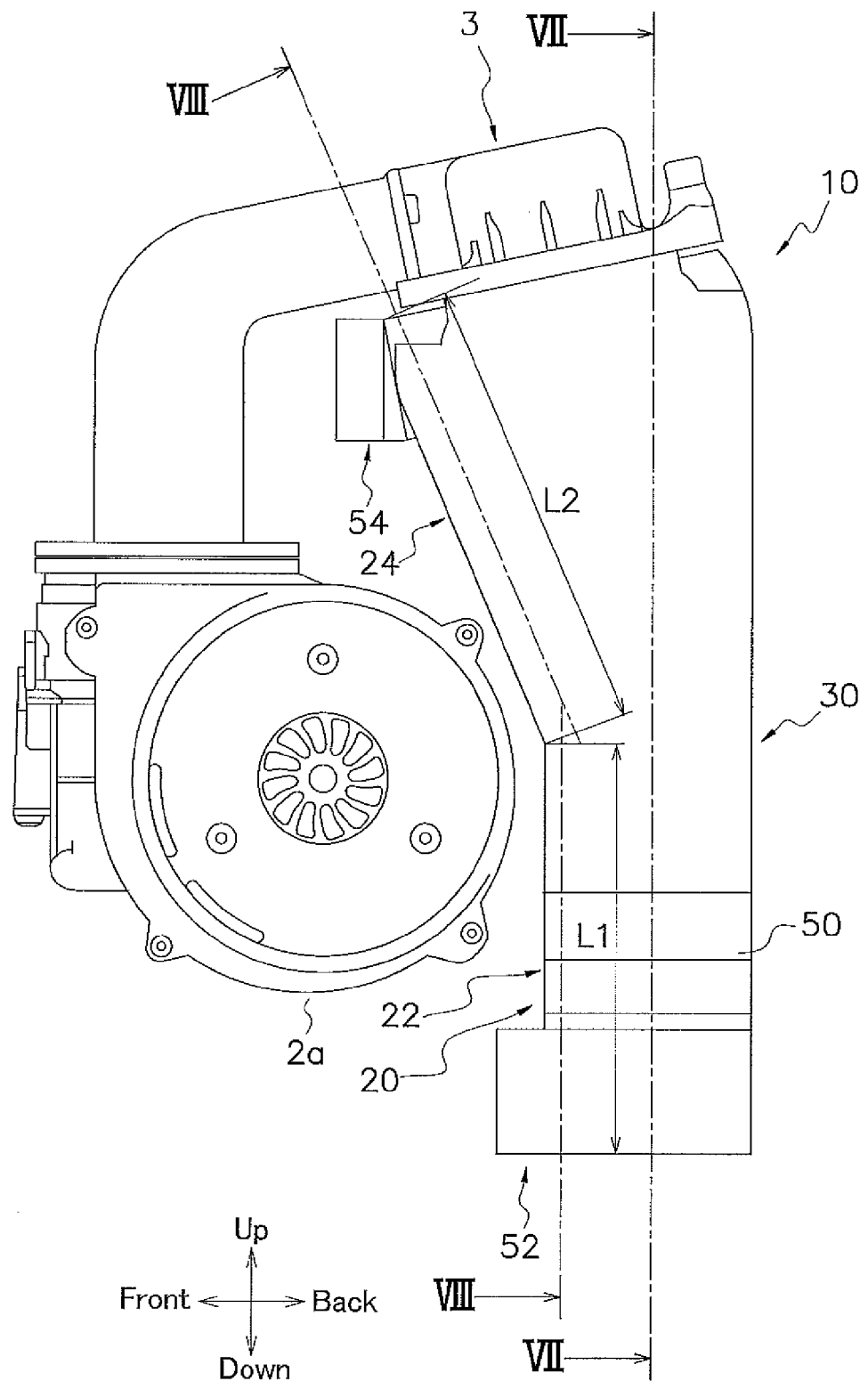
【FIG1】



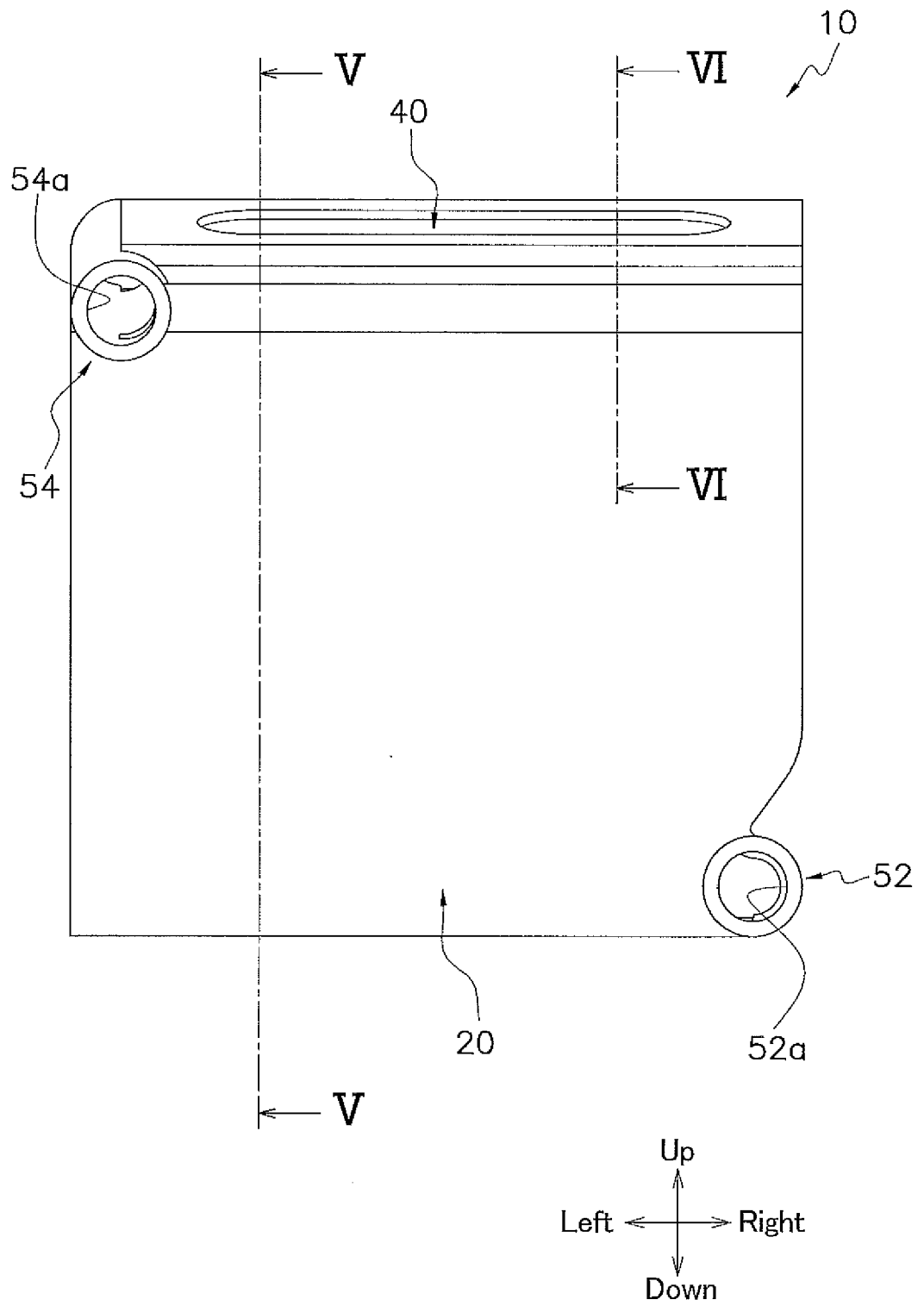
【FIG2】



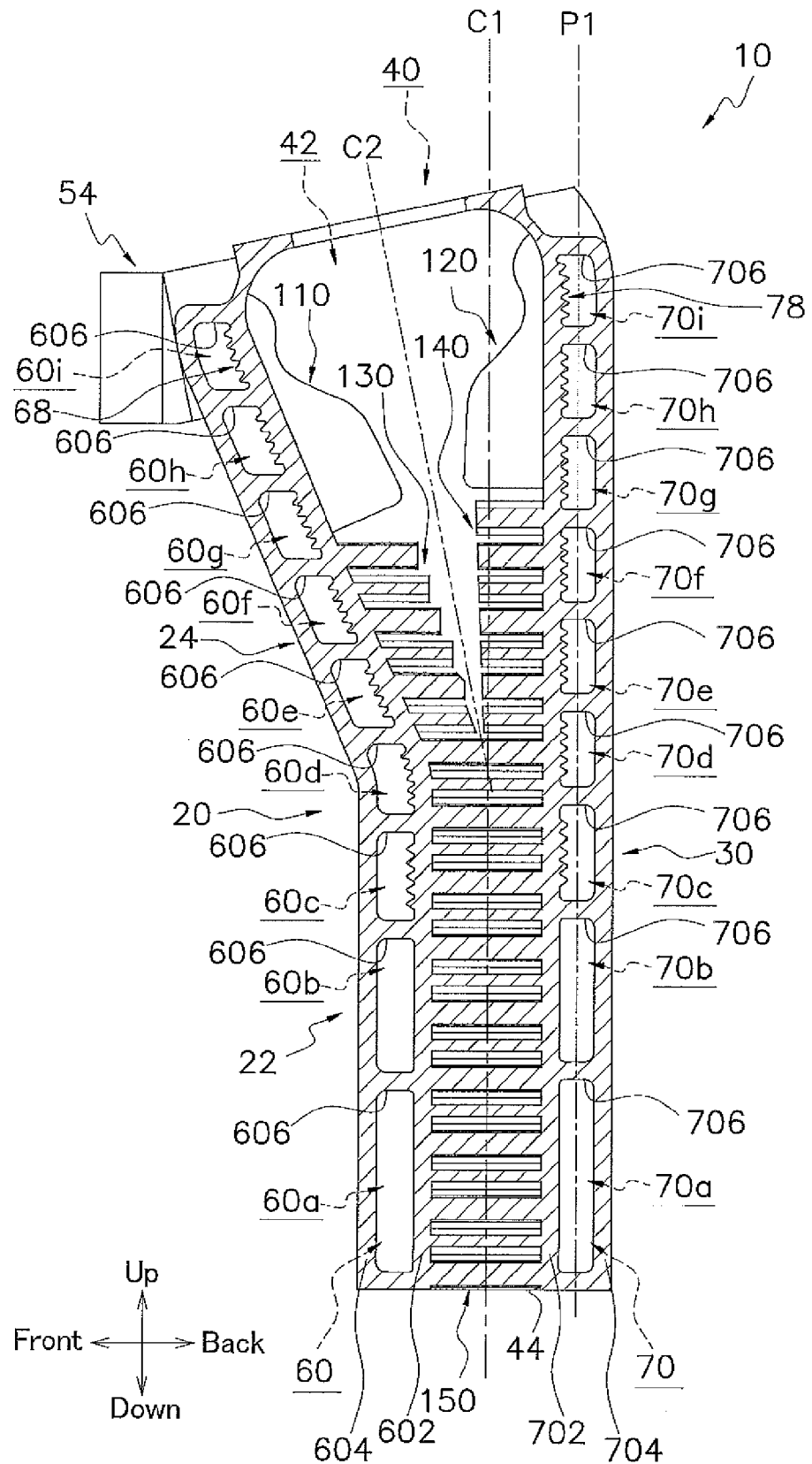
【FIG3】



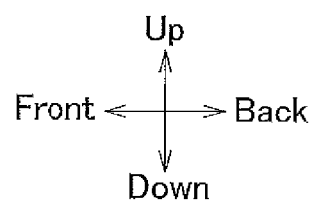
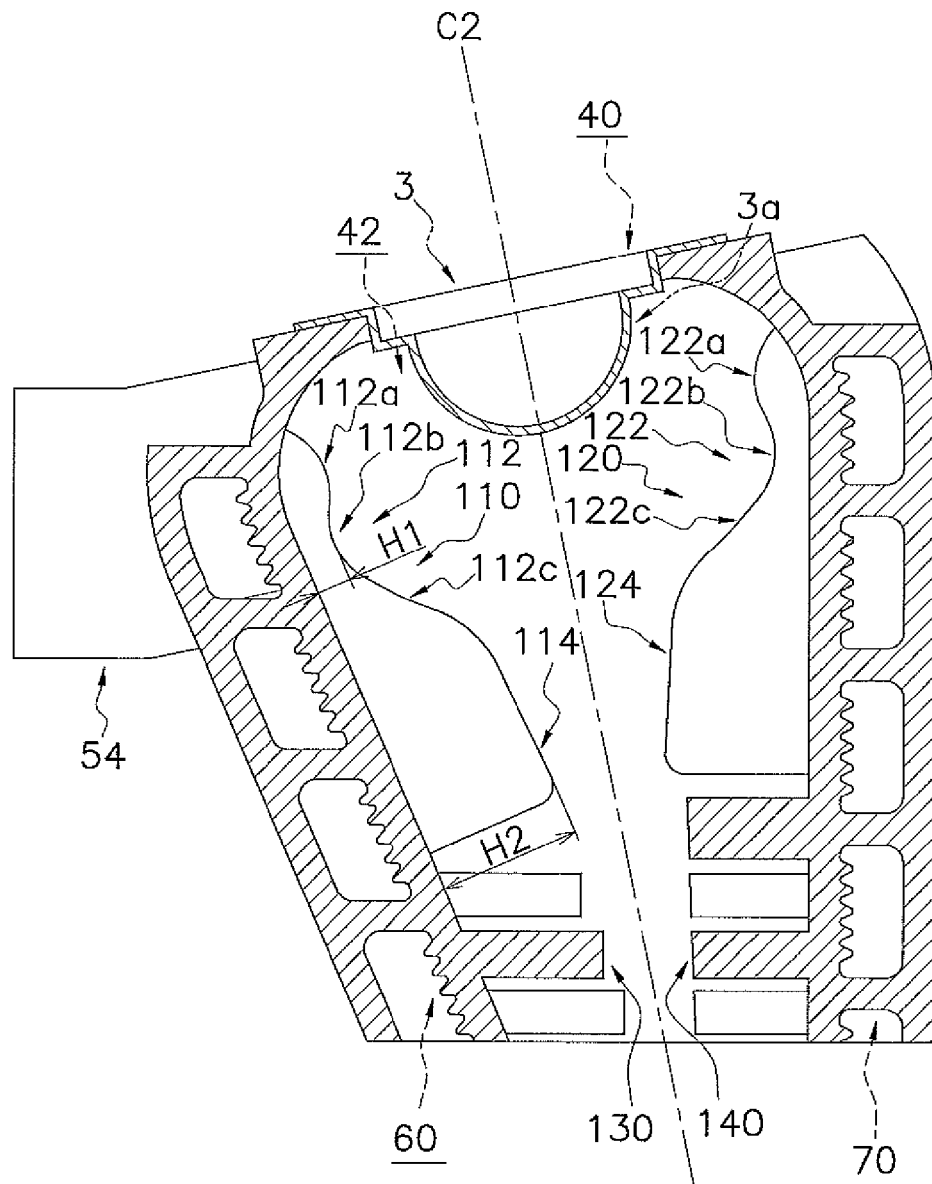
【FIG4】



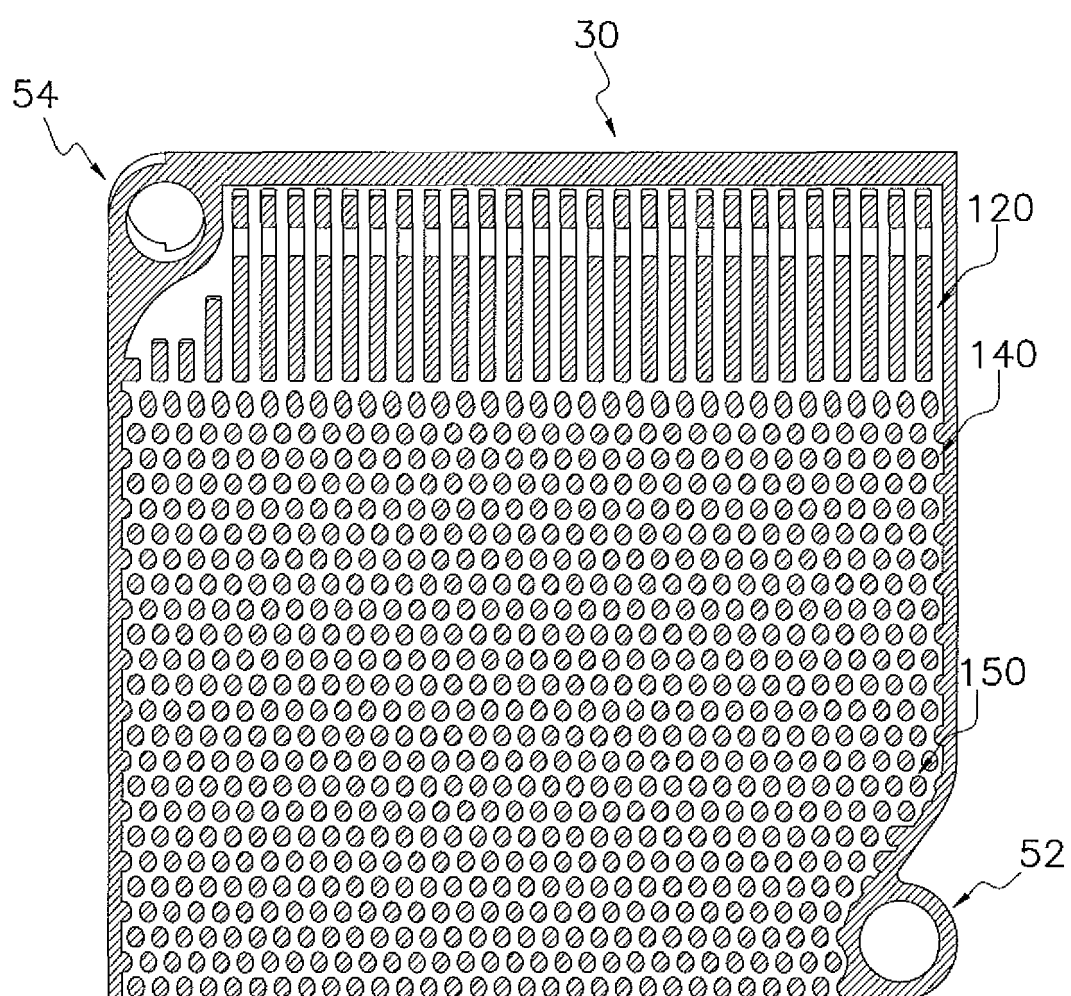
【FIG5】



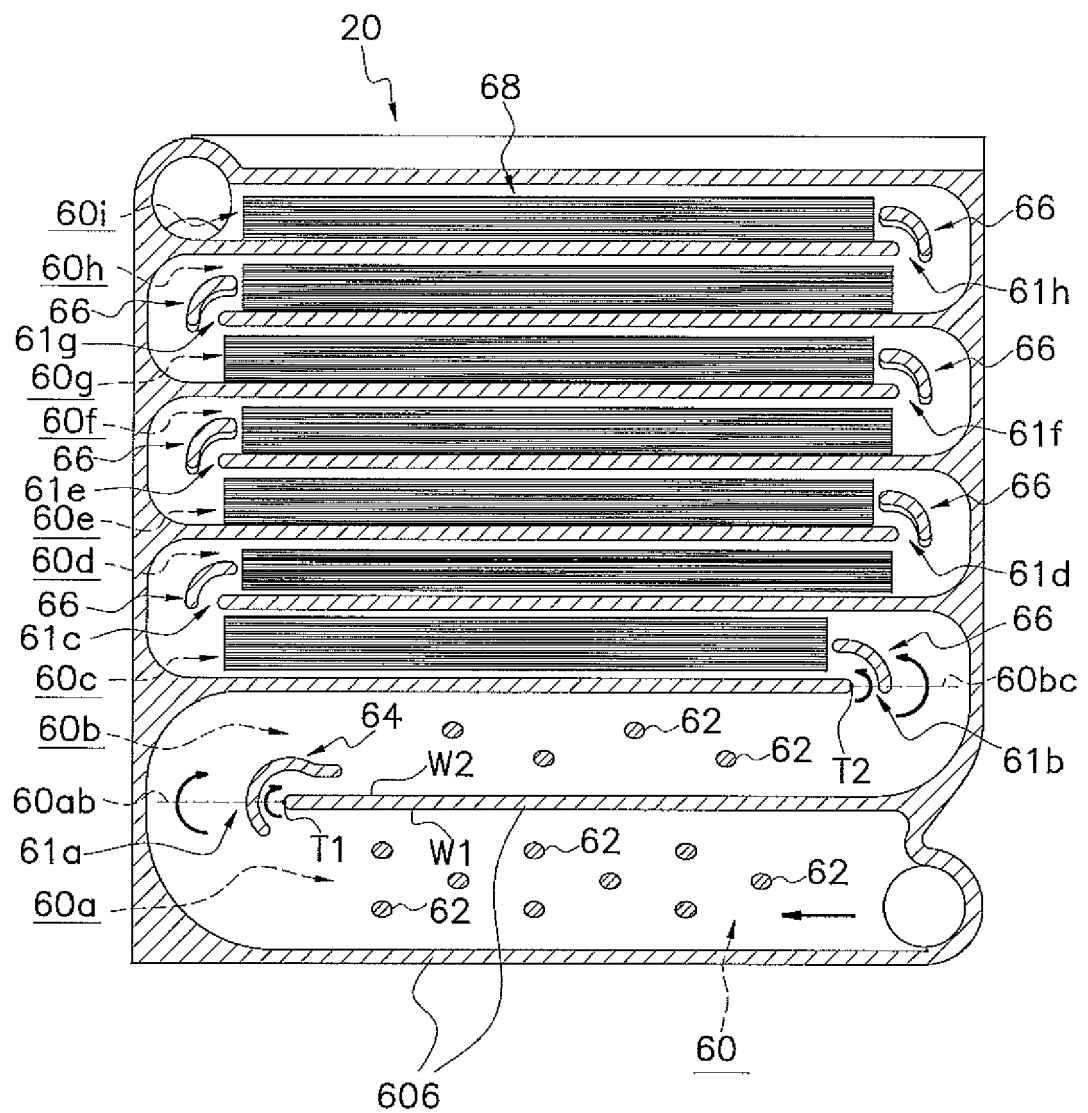
【FIG6】



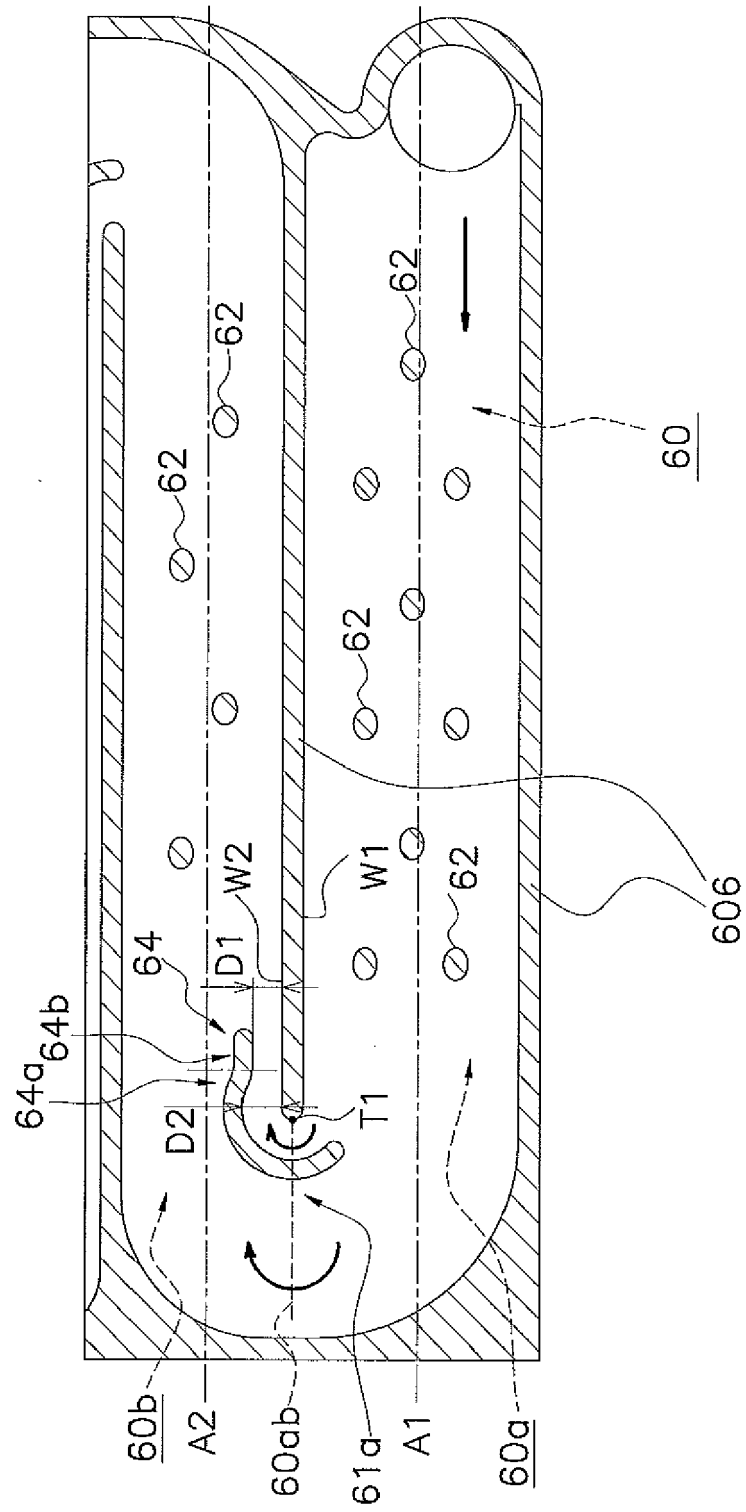
【FIG7】



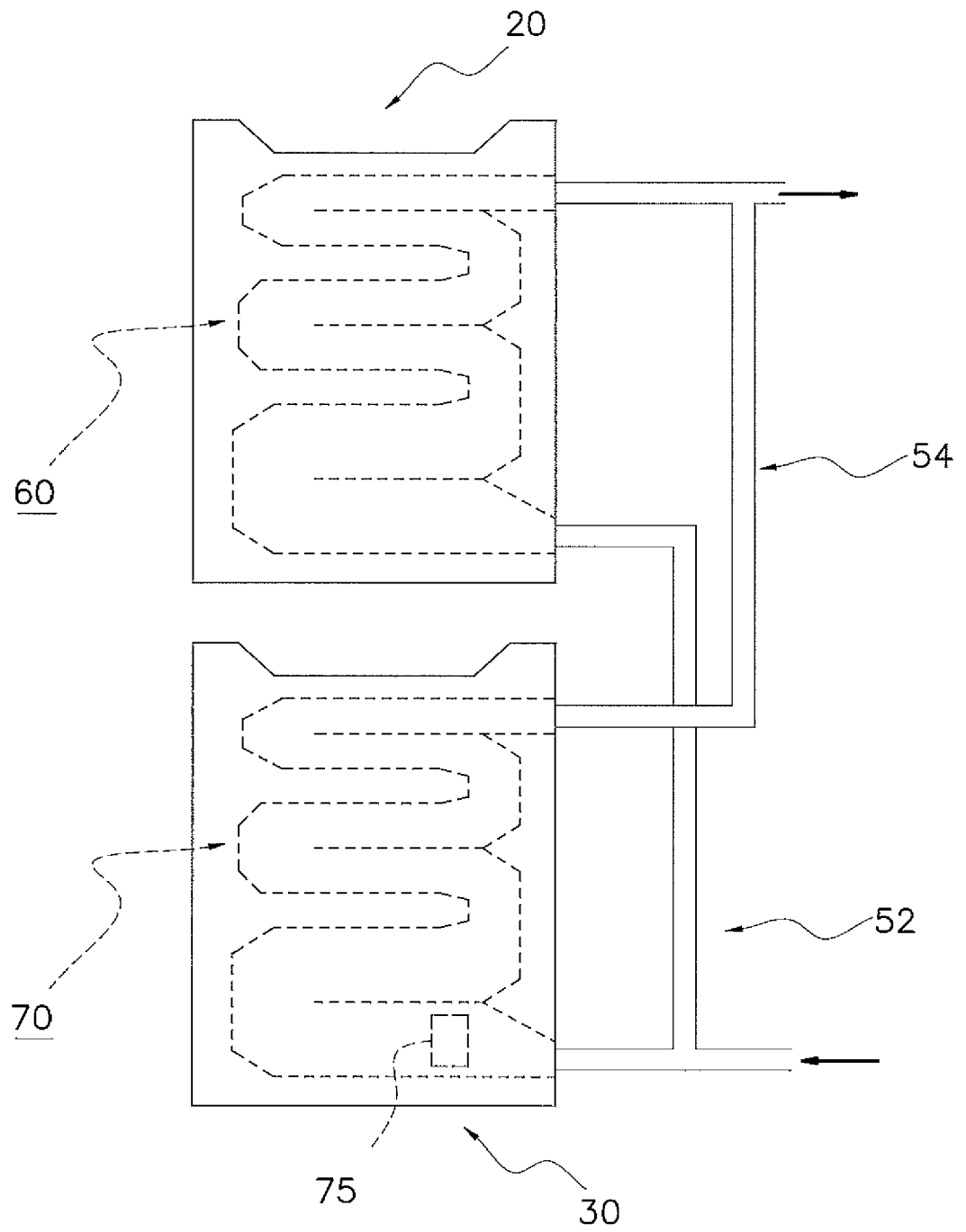
【FIG8】



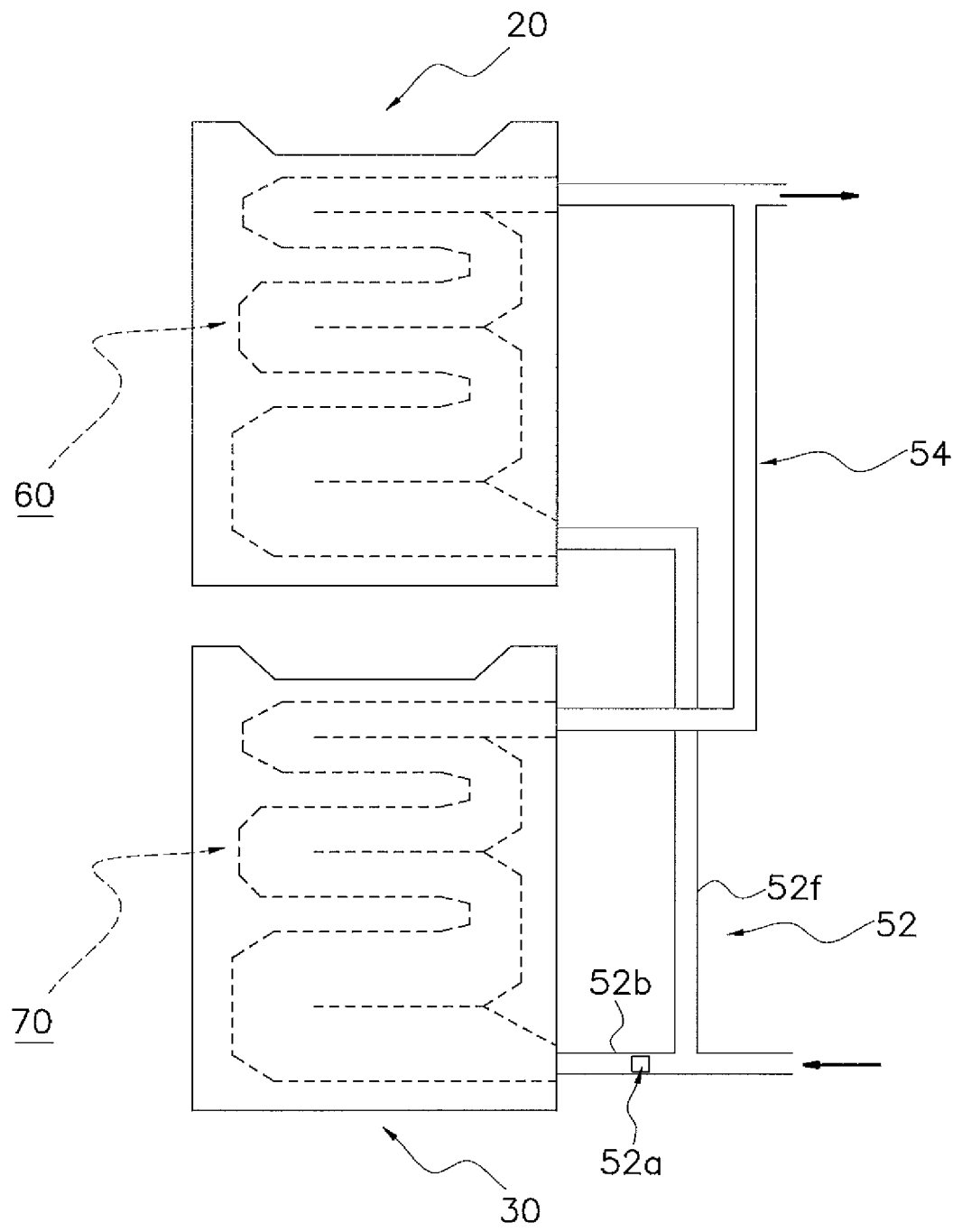
【FIG9】



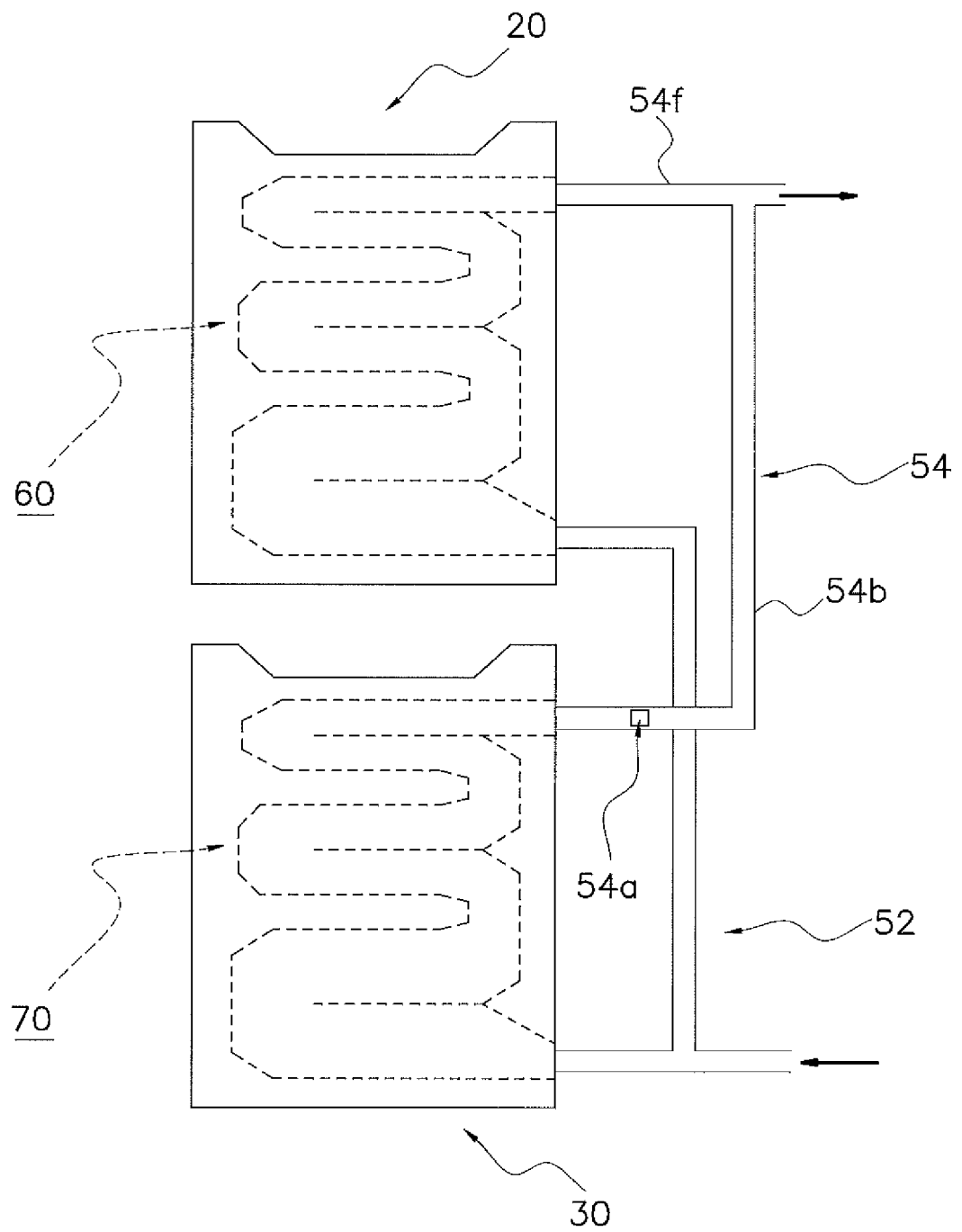
【FIG10】



【FIG11】



【FIG12】





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Application Number
EP 15 19 6332

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Place of search Munich		Date of completion of the search 9 May 2016	Examiner Schwaiger, Bernd
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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The members are as contained in the European Patent Office EDP file on
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