(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 476 969 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
18.07.2012 Bulletin 2012/29

(21) Application number: **10813527.8**

(22) Date of filing: **06.09.2010**

(51) Int Cl.:
F24H 1/10 *(2006.01)* ***E03D 9/08*** *(2006.01)*

(86) International application number:
PCT/JP2010/005459

(87) International publication number:
WO 2011/027576 (10.03.2011 Gazette 2011/10)

(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 SE SI SK SM TR

(30) Priority: **07.09.2009 JP 2009206223**
07.09.2009 JP 2009206224
23.03.2010 JP 2010066171
19.05.2010 JP 2010114910

(71) Applicant: **Panasonic Corporation**
Kadoma-shi
Osaka 571-8501 (JP)

(72) Inventor: **KOGA, Ryoichi**
Osaka 540-6207 (JP)

(74) Representative: **Leinweber & Zimmermann**
Rosental 7, II. Aufgang
80331 München (DE)

(54) **HEAT EXCHANGER**

(57) Provided is a heat exchanger capable of suppressing formation and adhesion of scale while achieving a higher heat transfer rate, and having a longer life. A heat exchanger 10 includes throttle passages 37 and 47 having smaller flow passage cross-sectional areas than another portion between an upstream space 25a and a downstream space 25b, and a plate heater 20 configured in such a manner that a heat generation density is lower in a portion closer to a water outlet 25b than in a portion closer to a water inlet 25a. This makes it possible to suppress a temperature from rising to a high temperature at which local boiling will take place, even in a boundary layer between a portion of the plate heater 20 which is closer to the water outlet 25b, where the temperature of the washing water tends to be high, and washing water contacting the portion of the plate heater 20 which is closer to the water outlet 25b, while improving the heat transfer rate. As a result, generation of air bubbles is suppressed, and the generated air bubbles are guided quickly to the water outlet 25b. Thus, a heat exchanger which can prevent formation of scale and adhesion of the scale onto the plate heater 20 and has a longer like is provided.

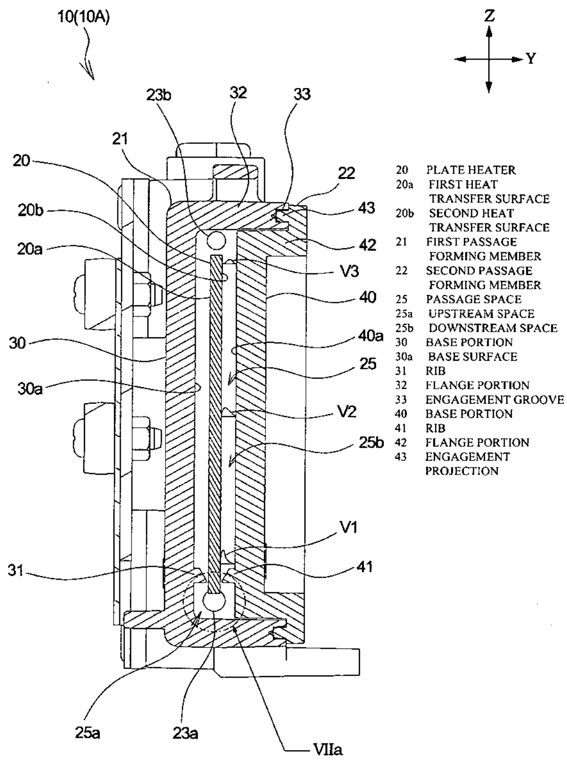


Fig.3

EP 2 476 969 A1

Description

Technical Field

[0001] The present invention relates to a heat exchanger of an instantaneous heating type, for use with a sanitary washing device capable of washing a private part of a human body using hot water, after a user expels stools.

Background Art

[0002] A sanitary washing device includes a heat exchanger for increasing the temperature of washing water up to a suitable temperature when a private part of a human body is washed using the water, after a user expels stools. There are various types of heat exchangers. One exemplary heat exchanger is a plate type heat exchanger which is disclosed in Patent Literature 1. This heat exchanger is configured in such a manner that a heater of a plate type (plate heater) is stored into a casing of a rectangular parallelepiped shape with a small width and placed to be oriented vertically, the heat exchanger having two passages which extend upwardly and sinuously horizontally along heat transfer surfaces of the plate heater, respectively. When the plate heater is being actuated, the washing water is flowed through the passages to raise its temperature up to a suitable temperature. The heat exchanger disclosed in Patent Literature 1 has advantages that since the passages have small flow passage cross-sectional areas, the washing water can be flowed at a high and uniform speed, a heat transfer rate can be improved, and its configuration can be made compact.

Citation Lists

Patent Literature

[0003] Patent Literature 1: Japanese Laid-Open Patent Application Publication No. Hei. 10-220876 (particularly, see Fig. 2)

Summary of the Invention

Technical Problem

[0004] However, in the above stated conventional heat exchanger, water flowing into the heat exchanger through a water inlet of the casing is heated on the surface of the plate heater, when it is flowing through the passages extending from the water inlet to a water outlet. The temperature of water flowing in the passages becomes higher as the water gets closer to the water outlet, and the water is likely to be locally boiled on the surface of a portion of the plate heater which is closer to the water outlet. If a high-temperature portion is formed locally on the surface of a boundary between the plate heater and the water in this way, scale is likely to be generated from a calcium component and the like contained in the washing water flowing in the passages and is likely to adhere to the surface of the plate heater. On the portion of the surface of the plate heater of the heat exchanger, to which the scale is adhering, heat transfer to the water is impeded due to the scale. This causes a local temperature rise in the surface temperature of the plate heater, and adhering of the scale onto the surface progresses. The resulting accumulated scale might increase a passage resistance, which would make it difficult to ensure a necessary amount of the washing water. In a case where the plate heater is a ceramic heater, a crack or a break of the plate heater might be caused by thermal distortion due to a partial temperature difference generated due to the scale.

[0005] The conventional plate heat exchanger provided with the passages extending along the heat transfer surfaces of the plate heater, is designed on the ground that the amount of heat transferred to the washing water is substantially equal between one of the heat transfer surfaces and the other heat transfer surface in the plate heater. Because of this, if a great difference in the amount of heat transferred to the water is generated between the heat transfer surfaces, the washing water in the passage corresponding to one of the heat transfer surfaces is likely to be locally boiled and air bubbles are likely to be generated. The generated air bubbles increase a flow resistance of the washing water flowing in the passages, and hence a good balance of the amount of the washing water between the heat transfer surfaces of the plate heater cannot be maintained, which results in an increase in the difference in the amount of heat transferred to the water. In a case where a thermistor which is actuated responsively to the temperature of the outflowing water is provided in the vicinity of a water outlet of a heat exchanger, air bubbles grown to a great size may make it difficult to actuate the thermistor properly.

[0006] If the above air bubbles adhere onto the heat transfer surface of the plate heater and are grown to a great size between the heat transfer surface of the plate heater and the washing water, the heat transfer surface and the washing water get separated from each other, because of the presence of the air bubbles. In this case, it becomes difficult to transfer the heat from the plate heater to the washing water, which significantly elevates the temperature of the heat transfer surface of the plate heater. If the temperature of only one heat transfer surface of plate heater increases significantly, and hence a temperature difference between the heat transfer surfaces increases, deformation or the like of the plate heater occurs due to a thermal stress.

[0007] A dominant factor of the adhesion of the scale to the heat transfer surface is the temperature of the heat transfer surface. Typically, a desired temperature of the heat transfer surface is suitably determined depending on a concentration of the scale of tap water, a desired endurance time of the heater, etc., that is, for example, the temperature is not higher than 100 degrees C at which the water is boiled, preferably, not higher than 80 degrees C. If the temperature of even a portion of the heat transfer surface exceeds the desired temperature, then the scale would adhere onto that portion and would impede heat transfer, which must be averted. To avert this, the area of the heat transfer surface may be possibly increased. This undesirably results in a cost increase of the heat exchanger. To satisfy a desired temperature of the heat transfer surface while minimizing the area of the heat transfer surface of the heat exchanger, it is necessary to configure the heat exchanger so as to set local distributions of a watt density of the plate heater or local distributions of a heat transfer rate so that local temperature distributions of the heat transfer surface become substantially uniform over the entire heat transfer surface.

[0008] By increasing the flow speed of the washing water, the heat transfer rate can be improved and generation of the air bubbles can be suppressed, or the generated air bubbles can be quickly discharged to outside through a water outlet. Also, by improving the heat transfer rate, the area of the heat transfer surface can be reduced. However, in general, in the heat exchanger for use with a hot water washing toilet seat, the amount of washing water per usage is small. Therefore, to increase the flow speed of the washing water inside the heat exchanger, a passage width is required to be set very small to ensure the flow speed. Typically, a maximum value of the flow rate is set to about 500cc/min. To increase the flow speed of the heat exchanger in correspondence with this flow rate, a gap of the passage formed along the heat transfer surface of the plate heater is required to be set to a value less than 0.5mm. However, in this structure, the width of the passage is extremely small, and therefore the flow speed tends to become locally non-uniform. Furthermore, as a result of increasing the flow speed of the washing water inside the heat exchanger, a pressure loss of the heat exchanger increases. Because of this, it is difficult to increase the flow speed significantly in the heat exchanger. In the case of the passage extending sinuously horizontally as disclosed in Patent Literature 1, a distance between the water inlet and the water outlet is large. Therefore, a long time is required to move the air bubbles generated inside to the water outlet. In addition, because of the small flow passage cross-sectional area, the washing water tends to get stagnant due to the generated air bubbles.

[0009] In order to solve the above mentioned problems associated with the prior arts, an object of the present invention is to provide a heat exchanger which is capable of suppressing formation and adhesion of scale and has a longer life, by configuring a plate heater such that a watt density is lower at a water outlet side where a water temperature is relatively higher than at a water inlet side where the water temperature is relatively lower, to make a temperature of a heat transfer surface uniform and to suppress a highest surface temperature of the heater. Another object of the present invention is to provide a heat exchanger capable of suppressing generation of air bubbles inside thereof, and guiding the generated air bubbles quickly to the water outlet.

Solution to Problem

[0010] A heat exchanger of the present invention comprises a casing having a water inlet and a water outlet; a heater disposed inside the casing and having surfaces serving as heat transfer surfaces; and a passage space provided inside the heater, to guide a fluid which has flowed into the heat exchanger through the water inlet to the water outlet, the fluid being guided to the water outlet while exchanging heat with the heat transfer surfaces of the heater; characterized in that the heater is configured in such a manner that a heat generation density in a portion closer to the water outlet is lower than a heat generation density in a portion closer to the water inlet (Claim 1).

[0011] In accordance with this configuration, the fluid (e.g., washing water) which has flowed into the heat exchanger through the water inlet of the casing is heated by the heat transfer surface of the heater, and thereby a temperature of the fluid gradually increases as it is getting closer to the water outlet. The surface temperature of a portion of the heater which is closer to the water inlet is likely to rise due to the higher heat generation density of the heater, but a large amount of heat is taken away from that portion by the fluid which has not been heated yet and still has a lower temperature (i.e., a degree of sub-cooling is great). Therefore, in the portion of the heater closer to the water inlet, the surface temperature does not rise up to a high temperature at which local boiling will take place. By comparison, the surface temperature of a portion of the heater which is closer to the water outlet tends to become higher as compared to the surface temperature of the portion of the heater which is closer to the water inlet, because the fluid contacting the surface of the heater has already been heated. Heat taken away from the surface of the heater by the fluid is lessened in amount, and the degree of the sub-cooling becomes less. However, the heater is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet than in the portion closer to the water inlet. As a result, in the portion of the heater closer to the water outlet, the surface temperature does not rise up to a high temperature at which local boiling will take place.

[0012] As described above, since the heater is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet than in the portion closer to the water inlet, the temperature is suppressed from rising up to a high temperature at which local boiling will take place, even on a surface of a boundary between the water and the portion of the heater which is closer to the water outlet where the temperature of the fluid tends to become higher. Thus, the heat exchanger is allowed to prevent formation and adhesion of the scale, and have a longer life. Since the heat generation density is set higher in the portion of the heater which is closer to the water inlet, where the temperature of the fluid is relatively lower and the flow speed of the fluid typically tends to be higher than at the water outlet, the heat transfer rate in the portion of the heat exchanger in the vicinity of the water inlet can be improved.

[0013] In the heat exchanger of the present invention, the heater may be a plate heater placed to be oriented in a direction substantially parallel to a vertical direction, and may have an obverse main surface and a reverse main surface which are the heat transfer surfaces; and the passage space may extend from the water inlet at a lower portion to the water outlet at an upper portion along the obverse and reverse heat transfer surfaces of the plate heater (Claim 2).

[0014] In the case of a normal plate heater in which local distributions of the heat generation density are uniform over the entire heat transfer surface, the temperature becomes highest at a portion of the plate heater which is closer to the water outlet, and the scale is initially generated on this portion. However, the heat generation density of the plate heater of the present invention is set lower in the portion closer to the water outlet than in the portion closer to the water inlet. Therefore, a heat flux of the heat exchanger is higher in the portion of the heater which has a higher heat generation density and is lower in the portion of the heater which has a lower heat generation density. This can make the temperature of the heat transfer surface uniform. As a result, the temperature does not rise up to a high temperature in a localized portion to an extent that the scale will adhere onto the localized portion.

[0015] In such a configuration, heat exchange is carried out in such a manner that the heat is transferred from the plate heater to the washing water flowing while contacting the obverse and reverse main surfaces of the plate heater and a heat efficiency is high without a substantial heat release loss. Since the obverse and reverse main surfaces of the plate heater are used as the heat transfer areas, the heat exchanger can be made compact.

[0016] In the heat exchanger of the present invention, the heater may be a ceramic heater including a ceramic base body, a heat generation resistive element formed by printing a pattern of a resistive element on the ceramic base body, and an electrode, and the printed pattern may have a line width greater in a portion of the heater which is closer to the water outlet than in a portion of the heater which is closer to the water inlet (Claim 3).

[0017] In such a configuration, as the line width of the printed pattern which is a heat generation resistive element increases, an electric resistance generated by flowing a current is lower and a heat generation amount decreases. Therefore, it is possible to provide a ceramic heater configured in such a manner that the heat generation amount is greater (i.e., heat generation density is higher) in the portion of the heater which is closer to the water inlet, in which the line width of the printed pattern is smaller, while the heat generation amount is smaller (i.e., heat generation density is lower) in the portion of the heater which is closer to the water outlet, in which the line width of the printed pattern is greater. Because of this structure, it is possible to suppress the temperature from rising up to a high temperature at which local boiling will take place, on the surface of the boundary between the fluid and the portion of the ceramic heater which is closer to water outlet where the temperature of the fluid tends to be higher, and possible to prevent formation and adhesion of the scale. As a result, a heat exchanger constituted by ceramic which has a smaller heat capacity, but tends to get more easily cracked, as compared to metal materials, can prevent a crack and have a longer life while maintaining a high heat exchange efficiency.

[0018] In the heat exchanger of the present invention, the heater may be a ceramic heater including a ceramic base body, a heat generation resistive element formed by printing a pattern of a resistive element on the ceramic base body, and an electrode, and the printed pattern may have a line interval (in-line gap) greater in a portion of the heater which is closer to the water outlet than in a portion of the heater which is closer to the water inlet (Claim 4).

[0019] In such a configuration, it is possible to provide a ceramic heater configured in such a manner that the heat generation amount is greater (i.e., heat generation density is higher), in the portion closer to the water inlet in which the line interval of the printed pattern is smaller, while the heat generation amount is smaller (i.e., heat generation density is lower), in the portion closer to the water outlet in which the line interval of the printed pattern is greater. Because of the above stated reason, it is possible to achieve a heat exchanger which can prevent formation and adhesion of the scale, prevent a crack of the ceramic heater, and have a longer life.

[0020] In the heat exchanger of the present invention, the passage space may include an upstream space including an opening of the water inlet and a downstream space including an opening of the water outlet, and a throttle passage having a smaller flow passage cross-sectional area than another space may be provided between the upstream space and the downstream space (Claim 5).

[0021] In such a configuration, when the fluid is flowing from the upstream space toward the downstream space, the flow speed of the fluid becomes a highest speed just after the fluid has exited the throttle passage, and thereafter gradually decreases. Because of this, the heat transfer rate on the heat transfer surface associated with this throttle passage tends to be highest when the flow speed of the fluid becomes the highest speed just after the fluid has exited the throttle passage, and then be gradually lowered. As compared to a heat transfer rate provided only by a normal natural convection, the value of the heat transfer rate increases significantly. Therefore, the rate of heat transfer from the plate heater to the fluid in the downstream space can be improved, and the air bubbles can be guided to the water outlet quickly along with the fluid flowing at a high speed through the throttle passage.

[0022] In the heat exchanger of the present invention, the passage space at one heat transfer surface side of the plate heater and the passage space at the other heat transfer surface side of the plate heater may be symmetric (Claim 6).

[0023] In such a configuration, a balance of a heat transfer amount of the heat transfer surfaces of the heater can be ensured, and deformation of the heater due to a thermal stress can be prevented.

[0024] In the present invention, the state where "two passage spaces at one heat transfer surface side of the plate heater and at the other heat transfer surface side of the plate heater are symmetric" refers to a state in which the plate heater is disposed between the two passage spaces and the two passage spaces are disposed to face each other to be substantially plane-symmetric with respect the heat transfer surface (at least one of the two heat transfer surfaces) of the plate heater." A specific example of this is, for example, a positional relationship between two passage spaces 25 disposed to face each other to be plane-symmetric with respect to a heat transfer surface (first transfer surface 20a or second heat transfer surface 20b), as shown in Figs. 2 and 3 as described later.

[0025] In the heat exchanger of the present invention, the downstream space may have a greater volume than the upstream space (Claim 7).

[0026] In such a configuration, since the flow speed of the fluid can be increased in the downstream space having a greater volume, the heat transfer rate can be further improved.

[0027] In the heat exchanger of the present invention, the throttle passage may have a horizontal throttle passage extending substantially horizontally from a portion of the heat exchanger which is closer to the water inlet, to flow the fluid in an upward direction toward the downstream space (Claim 8).

[0028] In such a configuration, the fluid which has passed through the horizontal throttle passage migrates upward as in the case where the fluid which has been heated up by the heater and has a relatively high temperature migrates upward by a natural convection. Since the fluid which has passed through the horizontal throttle passage migrates upward as in the case of the natural convection, in this way, the flow speed of the fluid can be further improved.

[0029] In the heat exchanger of the present invention, the throttle passage may have a vertical throttle passage extending substantially vertically upward, from one end portion of the horizontal throttle passage which is farther from the water inlet than the other end portion of the horizontal throttle passage, to flow the fluid horizontally toward the downstream space (Claim 9).

[0030] In such a configuration, the fluid which has passed through the vertical throttle passage is mixed with the fluid which has passed through the horizontal throttle passage to generate a disordered flow, which allows the fluid to be agitated. As a result, the heat transfer rate can be improved.

[0031] In the heat exchanger of the present invention, the throttle passage may have a slit shape; and the throttle passage may have an increased-width portion having a greater opening width than another portion (Claim 10).

[0032] In such a configuration, a difference is generated between flow speed of the fluid which has passed through the increased-width portion of the throttle passage and the flow speed of the fluid which has passed through a portion of the throttle passage which is other than the increased-width portion. When the fluids flow into the downstream space at different flow speeds, they form a disordered flow and agitate the fluid in the downstream space, so that the heat transfer rate can be improved.

[0033] In the heat exchanger of the present invention, an agitating wall for agitating the fluid may be provided in the downstream space to extend in a substantially upward and downward direction along the plate heater; and the agitating wall may be corrugated to have a horizontal amplitude (Claim 11).

[0034] In such a configuration, since the fluid in the downstream space is further agitated by the agitating walls, the heat transfer rate can be further improved. In addition, since the agitating walls extend in the upward and downward direction, the generated air bubbles can migrate upward quickly to the water outlet, by a buoyancy force, and are discharged therethrough, without being impeded.

[0035] In the heat exchanger of the present invention, a buffer wall extending substantially horizontally along the plate heater may be provided in the downstream space (Claim 12).

[0036] In such a configuration, the fluid flowing through the downstream space is held back just before each buffer wall and is diffused when it is passing through a narrow space between the buffer wall and the plate heater. By agitating the fluid in this way, the heat transfer rate can be improved.

[0037] In the heat exchanger of the present invention, the buffer wall has a plurality of buffer walls arranged in the upward and downward direction; and the buffer walls are provided with remaining portions formed (left) by cutting portions of the buffer walls such that positions of the remaining portions are different between adjacent upper and lower buffer walls when viewed from above (Claim 13).

[0038] In such a configuration, since the space between the remaining portion of the buffer wall and the plate heater has a great flow passage cross-sectional area, a part of the fluid is likely to migrate substantially horizontally toward the remaining portion. Therefore, in the downstream space, a water flow migrating substantially horizontally toward the remaining portion and a water flow migrating vertically upward beyond the buffer wall are mixed and formed into a disordered flow, which allows the fluid to be agitated. As a result, the heat transfer rate can be improved.

[0039] The heat exchanger of the present invention comprises a pair of passage forming members disposed to sandwich the plate heater; each of the passage forming members may include a base portion of a plate shape disposed to face the plate heater, and a rib protruding from a surface of the base portion which faces the plate heater; and the slit-shape throttle passage may be defined by the rib and the plate heater which faces the rib and provided between the rib and the plate heater which faces the rib (Claim 14).

[0040] In such a configuration, a heat exchanger including a throttle passage with a relatively simple configuration can be provided.

[0041] In the heat exchanger of the present invention, the heater may be a plate heater placed to be oriented in a direction substantially parallel to a vertical direction, and has an obverse main surface and a reverse main surface which are the heat transfer surfaces; and the passage space may be formed in a sinuous passage extending from the water inlet at a lower portion to the water outlet at an upper portion along the obverse and reverse heat transfer surfaces of the plate heater (Claim 15).

[0042] In such a configuration, heat exchange is carried out in such a manner that the heat is transferred from the plate heater to the washing water flowing while contacting the obverse and reverse main surfaces of the plate heater and a heat efficiency is high without a substantial heat release loss. Since the obverse and reverse main surfaces of the plate heater are used as the heat transfer areas, the heat exchanger can be made compact. Since the sinuous passage can provide an increased passage length and a higher flow speed of the fluid, a layer (temperature boundary layer) of the fluid to which heat is substantially transferred from the surface of the heater is thinned. Therefore, the heat transfer rate is improved, and the temperature of the surface of the heater is lowered. Thus, local boiling can be suppressed more effectively, and hence formation and adhesion of the scale can be prevented more effectively.

[0043] In the heat exchanger of the present invention, wherein the sinuous passage may be defined by a plurality of wall portions arranged vertically to extend substantially horizontally, and the sinuous passage may have in a range from the water inlet to the water outlet, a passage for guiding the fluid in one direction in a substantially horizontal direction, and a passage for guiding the fluid in an opposite direction in the substantially horizontal direction such that the passages are arranged alternately from a lower side to an upper side; and a bypass passage is provided in an upward and downward direction on a portion of each of the wall portions in a longitudinal direction thereof to provide communication between adjacent upper and lower passages (Claim 16).

[0044] In such a configuration, the air bubbles can be guided quickly to the water outlet through the bypass passages formed in an upward and downward direction in the sinuous passage while improving the heat transfer rate by the high-speed flow of the washing water. In other words, since the sinuous passage makes the flow passage cross-sectional area smaller, the flow speed of the washing water can be made high and uniform. As described above, the heater is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet than in the portion closer to the water inlet, the temperature of a portion of the heat transfer surface is prevented from rising up to a high temperature at which local boiling of the washing water will take place, and generation of the air bubbles is suppressed. If the air bubbles are generated, the generated air bubbles are allowed to migrate quickly to the water outlet through the bypass passage having a shorter length than the overall sinuous passage. This makes it possible to prevent an event in which a passage resistance at one heat transfer surface side becomes higher than that at the other heat transfer surface side, or the temperature of one heat transfer surface becomes much higher than that of the other heat transfer surface, due to the air bubbles. Thus, local boiling which would lead to formation and adhesion of the scale can be further suppressed. Since the air bubbles generated on the surface of the heater migrate through the bypass passages and are discharged quickly through the water outlet, the air bubbles are prevented from growing to a great size. Thus, a problem that the operation of a thermistor located in the vicinity of the water outlet is impeded due to the air bubbles with a great size, will not occur.

[0045] In the heat exchanger of the present invention, the sinuous passage at one heat transfer surface side of the plate heater and the sinuous passage at the other heat transfer surface side of the plate heater may be symmetric, and the bypass passage at one heat transfer surface side of the plate heater and the bypass passage at the other heat transfer surface side of the plate heater may be symmetric (Claim 17).

[0046] In such a configuration, in addition to the above advantages, a balance of a heat transfer amount between the obverse and reverse heat transfer surfaces of the heater is properly maintained, and deformation of the heater due to a thermal stress can be prevented.

[0047] In the present invention, the state where "two sinuous passages at one heat transfer surface side of the plate heater and at the other heat transfer surface side of the plate heater are symmetric" refers to a state in which the plate heater is disposed between the two sinuous passage spaces and the two sinuous passage spaces are disposed to face each other to be substantially plane-symmetric with respect the heat transfer surface (at least one of the two heat transfer surfaces) of the plate heater." A specific example of this is, for example, a positional relationship between two sinuous passages (sinuous passage 135 and sinuous passage 145) disposed to face each other to be substantially plane-symmetric with respect to a heat transfer surface (first transfer surface 120a or second heat transfer surface 120b), as shown in Figs. 15 and 16 as described later.

[0048] In the present invention, the state where "two bypass passages at one heat transfer surface side of the plate heater and at the other heat transfer surface side of the plate heater are symmetric" refers to a state in which the plate heater is disposed between the two bypass passages and the two sinuous passages are disposed to face each other to be substantially plane-symmetric with respect the heat transfer surface (at least one of the two heat transfer surfaces) of the plate heater."

[0049] In the heat exchanger of the present invention, bypass passages formed on the plurality of wall portions may substantially conform in position to each other when viewed from above (Claim 18).

[0050] In such a configuration, in addition to the above advantages, the air bubbles can migrate straightly upward through the bypass passages and reach the water outlet quickly.

[0051] The heat exchanger of the present invention may comprise a pair of passage forming members disposed to sandwich the plate heater; and each of the passage forming members may include a base portion of a plate shape disposed to face the plate heater, and a plurality of ribs protruding from a surface of the base portion which faces the plate heater to form the wall portions; and a remaining portion formed by cutting a portion of each of the plurality of ribs may be provided on a portion of each of the plurality of ribs in a longitudinal direction thereof such that a tip end of the rib is dented with respect to another portion to form the bypass passage (Claim 19).

[0052] In such a configuration, in addition to the above advantages, the bypass passages can be formed by cutting portions of tip ends of the ribs in a heat exchanger including a plate heater and a pair of passage forming members.

[0053] In the heat exchanger of the present invention, the remaining portion of the rib may have a tapered shape when viewed from above such that a cut portion width of the remaining portion decreases as a cut portion depth of the remaining portion increases (Claim 20).

[0054] In the heat exchanger of the present invention, the remaining portion of the rib may have a circular-arc shape when viewed from above such that a cut portion depth of a center portion of a cut portion width is great (Claim 21).

[0055] In such a configuration, in addition to the above advantages, air bubbles having a great diameter can pass through the remaining portions (bypass passages).

[0056] In the heat exchanger of the present invention, the remaining portion of the rib provided at a relatively upper side may have a greater cut portion width than the remaining portion of the rib provided at a relatively lower side (Claim 22).

[0057] In such a configuration, in addition to the above advantages, the flow speed can be increased by reducing the cut portion width of the remaining portion, because the water temperature is not sufficiently high and the air bubbles are less likely to be generated in a lower region (i.e., upstream side). In contrast, in an upper region (i.e., downstream side) where the water temperature tends to be high, the air bubbles are allowed to surely pass through the remaining portion by setting the cut portion width of the remaining portion greater.

[0058] The heat exchanger of the present invention, the remaining portion may not be provided on the rib provided at a relatively lower side; and the remaining portion may be provided on the rib provided at a relatively upper side (Claim 23).

[0059] In such a configuration, in addition to the above advantages, the flow speed can be further increased without providing the remaining portion in the lower region where the air bubbles are less likely to be generated, while the air bubbles are allowed to surely pass through the remaining portion provided in the upper region where the air bubbles are easily generated.

Advantageous Effects of the Invention

[0060] In accordance with the present invention, it is possible to provide a heat exchanger which is capable of suppressing a temperature from rising up to a high temperature at which local boiling will take place, suppressing generation of air bubbles inside thereof, preventing formation and adhesion of scale, and having a longer life, while improving a heat transfer rate. Also, it is possible to provide a heat exchanger which is capable of suppressing generation of air bubbles inside passages, and guiding the generated air bubbles quickly to a water outlet.

Brief Description of the Drawings

[0061]

[Fig. 1] Fig. 1 is a perspective view showing an external appearance of a sanitary washing device including a heat exchanger according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a front view showing a configuration of an external appearance of a heat exchanger according to Embodiment 1.

[Fig. 3] Fig. 3 is a cross-sectional view of the heat exchanger taken along B-B of Fig. 2.

[Fig. 4] Fig. 4 is a plan view showing an example of a pattern of a resistive element formed on a plate heater of the heat exchanger of Fig. 3.

[Fig. 5] Fig. 5 is a plan view showing another example of the pattern of the resistive element formed on the plate heater of the heat exchanger of Fig. 3.

[Fig. 6] Fig. 6 is an exploded view of the heat exchanger. Fig. 6(a) is a plan view of the heat exchanger in a state where a second passage forming member and the plate heater are removed, when viewed from a base surface side of a first passage forming member, and Fig. 6(b) is a plan view showing the second passage forming member when viewed from a base surface side thereof.

[Fig. 7] Fig. 7 shows a configuration of a region near ribs in an assembled heat exchanger along a direction of X, to shown a configuration of throttle passages. Fig. 7(a) is an enlarged view of a portion VIIa of Fig. 3, and Fig. 7(b) is an enlarged view showing a modified example of throttle passages.

[Fig. 8] Fig. 8 is a view showing a configuration of a heat exchanger according to Embodiment 2. Fig. 8 (a) is a plan view of the heat exchanger in a state where a second passage forming member is removed, when viewed from a base surface side of a first passage forming member, and Fig. 8(b) is a plan view showing an example of a flow of washing water.

[Fig. 9] Fig. 9 is a view showing a configuration of a heat exchanger according to Embodiment 3. Fig. 9 (a) is a plan view of the heat exchanger in a state where a second passage forming member is removed, when viewed from a base surface side of a first passage forming member, and Fig. 9(b) is a plan view showing an example of a flow of washing water.

[Fig. 10] Fig. 10 is a view showing a configuration of a heat exchanger according to Embodiment 4. Fig. 10(a) is a plan view of the heat exchanger in a state where a second passage forming member is removed, when viewed from a base surface side of a first passage forming member, and Fig. 10(b) is a plan view showing an example of a flow of washing water.

[Fig. 11] Fig. 11 is a view showing a configuration of a heat exchanger according to Embodiment 5. Fig. 11(a) is a plan view of the heat exchanger in a state where a second passage forming member is removed, when viewed from a base surface side of a first passage forming member. Fig. 11(b) is a cross-sectional view of the heat exchanger taken along B-B. Fig. 11(c) is a cross-sectional view of the heat exchanger taken along C-C.

[Fig. 12] Fig. 12 is a view showing a configuration of a heat exchanger according to Embodiment 6. Fig. 12(a) is a plan view of the heat exchanger in a state where a second passage forming member is removed, when viewed from a base surface side of a first passage forming member. Fig. 12(b) is a cross-sectional view of the heat exchanger taken along B-B.

[Fig. 13] Fig. 13 is a view showing a configuration of a heat exchanger according to Embodiment 7. Fig. 13(a) is a plan view of the heat exchanger in a state where a second passage forming member is removed, when viewed from a base surface side of a first passage forming member. Fig. 13(b) is a cross-sectional view of the heat exchanger taken along B-B.

[Fig. 14] Fig. 14 is a view showing a modified example of the heat exchanger of Embodiment 1 and showing the heat exchanger in a state where a second passage forming member and a plate heater are removed, when viewed from a base surface side of a first passage forming member.

[Fig. 15] Fig. 15 is a front view showing a configuration of a heat exchanger according to Embodiment 8. Fig. 15(a) is a front view showing a configuration of an external appearance of the heat exchanger. Fig. 15(b) is a cross-sectional view of the heat exchanger taken along B-B.

[Fig. 16] Fig. 16 is an exploded view of the heat exchanger. Fig. 16(a) is a plan view of the heat exchanger in a state where a second passage forming member and a heater are removed, when viewed from a base surface side of a first passage forming member, and Fig. 6(b) is a plan view showing the second passage forming member when viewed from a base surface side thereof.

[Fig. 17] Fig. 17 is a cross-sectional view of the heat exchanger, taken along XVII-XVII of Fig. 16.

[Fig. 18] Fig. 18 is a view showing a configuration of a rib and a remaining portion. Fig. 18(a) is an enlarged view of a portion XVIIIa of Fig. 17 to show a configuration of the remaining portion taken along Z-direction. Fig. 18(b) is an enlarged view of a portion XVIIIb of Fig. 15 to show a configuration of the remaining portion taken along X-direction.

[Fig. 19] Fig. 19 is a view showing a flow of washing water and air bubbles in the heat exchanger of Embodiment 8, and is a plan view showing a configuration of the heat exchanger when viewed from a base surface side of a first passage forming member.

[Fig. 20] Fig. 20 is an enlarged view of a remaining portion taken along Z-direction, to show another configuration of the remaining portion. Fig. 20(a) is an enlarged view showing a remaining portion having a tapered deepest portion. Fig. 20(b) is an enlarged view showing a remaining portion having a circular-arc deepest portion. Fig. 20(c) is an enlarged view showing a remaining portion having a deepest portion defined by a tilted surface.

[Fig. 21] Fig. 21 is a view showing a configuration of a heat exchanger according to Embodiment 10, and is a plan view showing the heat exchanger when viewed from a base surface side of a first passage forming member.

[Fig. 22] Fig. 22 is a view showing a configuration of a heat exchanger according to Embodiment 11, and is a plan view showing the heat exchanger when viewed from a base surface side of a first passage forming member.

Description of the Embodiments

[0062] Hereinafter, a heat exchanger according to an embodiment of the present invention will be described with reference to the drawings, using an example in which the heat exchanger is incorporated into a sanitary washing device. The present invention is not limited to the embodiment.

[Sanitary washing device]

[0063] Fig. 1 is a perspective view showing an external appearance of a sanitary washing device including a heat exchanger according to an embodiment of the present invention. As shown in Fig. 1, a sanitary washing device 1 is provided on the upper surface of a toilet bowl 2, and includes a base portion 3, a toilet seat 4, a toilet cover 5, an operating unit 6, and others. The base portion 3 is disposed behind the toilet seat 4 (behind from the perspective of a user seated). In the interior of a casing 3a which is elongated in a lateral direction and hollow, a washing unit (not shown), a drying unit (not shown), a control unit (not shown) for controlling the operation of these units, a heat exchanger 10 (indicated by a broken line) according to the present embodiment, etc., are stored. Into the heat exchanger 10, tap water (fluid, liquid, washing water) is introduced from water utilities incorporated in a building structure attached with the toilet bowl 2, and is warmed up to a suitable temperature inside thereof. When the user operates the operating unit 6 to input a predetermined command, the washing unit is actuated to eject the washing water to a private part of a human body in the form of a shower from a nozzle included in the washing unit.

(Embodiment 1)

[Heat exchanger]

[0064] Figs. 2 and 3 show a configuration of the heat exchanger 10 (10A). Fig. 2 is a front view showing an external appearance of the heat exchanger 10 (10A). Fig. 3 is a cross-sectional view of the heat exchanger 10 (10A) taken along B-B of Fig. 2. As shown in Figs. 2 and 3, in its external appearance, the heat exchanger 10A is formed by a flat plate having a small thickness and having a rectangular shape as viewed from front. As shown in Fig. 3, the heat exchanger 10A includes a plate heater 20 of a rectangular plate shape, a first passage forming member 21 disposed to face one surface (first heat transfer surface) 20a, a second passage forming member 22 disposed to face the other surface (second heat transfer surface) 20b, and a casing 23 accommodating the plate heater 20, the first passage forming member 21 and the second passage forming member 22, and having a water inlet 23a and a water outlet 23b. The plate heater 20 is made of ceramic, while the first passage forming member 21 and the second passage forming member 22, are made of reinforced ABS resin formed by compounding glass fiber into ABS resin.

[0065] Hereinafter, a description will be given of a state where the heat exchanger 10A is placed to be oriented vertically such that the heat transfer surfaces of the plate heater 20 are parallel to a vertical direction, except for cases specially noted. As shown in Fig. 2, the vertical direction is Z-direction, a direction perpendicular to Z-direction and parallel to the heat transfer surfaces of the plate heater 20 is X-direction, and a direction (direction perpendicular to the first heat transfer surface 20a) perpendicular to these two directions is Y-direction.

[0066] As shown in Fig. 3, the first passage forming member 21 includes a base portion 30 of a rectangular plate shape which faces the first heat transfer surface 20a, and a rib 31 protruding from a surface (base surface) 30a of the base portion 30 which faces the first heat transfer surface 20a. Likewise, the second passage forming member 22 includes a base portion 40 of a rectangular plate shape which faces the second heat transfer surface 20b, and a rib 41 protruding from a surface (base surface) 40a of the base portion 40 which faces the second heat transfer surface 20b.

[0067] A wall-like flange portion 32 is provided to extend along the peripheral edge portion of the base portion 30 of the first passage forming member 21. The flange portion 32 is extended by a predetermined dimension toward the second passage forming member 22. An engagement groove 33 is formed at the tip end portion of the flange portion 32 so as to extend along the periphery of the flange portion 32. A wall-like flange portion 42 is provided to extend along the peripheral edge portion of the base portion 40 of the second passage forming member 22. The flange portion 42 is extended by a predetermined dimension away from the first passage forming member 21. The tip end portion of the flange portion 42 is bent back toward the first passage forming member 21. An engagement projection 43 is formed at the tip end portion of the flange portion 42 so as to extend along the periphery of the flange portion 42.

[0068] The first passage forming member 21 is externally fitted to the second passage forming member 22 such that the base surface 30a faces the base surface 40a. To be more specific, the flange portion 32 of the first passage forming member 21 is externally fitted to the flange portion 42 of the second passage forming member 22, and the engagement projection 43 of the second passage forming member 22 is fitted into the engagement groove 33 of the first passage forming member 21 (e.g., the engagement projection 43 is secured to the engagement groove 33 by ultrasonic fusion-bonding.) This allows the first passage forming member 21 and the second passage forming member 22 to be joined together in a sealed state, thereby forming a passage space 25 inside the first passage forming member 21 and the second passage forming member 22.

[0069] As shown in Figs. 2 and 3, the water inlet 23a is provided at the lower portion of one end portion of the casing 23 in X-direction, while the water outlet 23b is provided at the upper portion of one end portion of the casing 23 in X-direction. As shown in Fig. 3, the water inlet 23a and the water outlet 23b communicate with the passage space 25.

[0070] Fig. 4 is a plan view showing an example of a pattern of a resistive element formed on the plate heater 20 of the heat exchanger of Fig. 3. As shown in Fig. 4, the plate heater 20 is configured in such a manner that a resistive element (heater line) pattern 20p is printed on a ceramic base body 20k. The resistive element pattern 20p is configured in such a manner that a heater line width 20s is smaller in a portion of the plate heater 20 which is closer to the water inlet 23a and is greater in a portion of the plate heater 20 which is closer to water outlet 23b. In brief, according to the resistive element pattern 20p, the heater line width 20s is smaller and a resistance value is higher in the portion of the plate heater 20 which is closer to water inlet 23a, while the heater line width 20s is greater and a resistance value is lower in the portion of the plate heater 20 which is closer to water outlet 23b. In other words, the plate heater 20 is configured in such a manner that a heat generation density is lower in the portion closer to the water outlet 23b than in the portion closer to the water inlet 23a.

[0071] Fig. 5 is a plan view showing another example of the pattern of the resistive element formed on the plate heater 20 of the heat exchanger of Fig. 3. Like the resistive element (heater line) pattern 20p of Fig. 4, the resistive element (heater line) pattern 20p is printed on the ceramic base body 20k in the plate heater 20. By comparison, the resistive element pattern 20b of Fig. 5 is configured in such a manner that a heater line interval 20h between adjacent heater lines is smaller in a portion of the plate heater 20 which is closer to water inlet 23a and is greater in a portion of the plate heater 20 which is closer to water outlet 23b. That is, the plate heater 20 is configured in such a manner that the heater line interval 20h is smaller and a heat generation density is higher in the portion closer to the water inlet 23a, while the heater line interval 20h is greater and a heat generation density is lower in the portion closer to the water outlet 23b.

[0072] The configuration of the plate heater 20 including the resistive element pattern 20p, shown in Figs. 4 and 5, is similar to those of plate heaters 20 of heat exchangers of Embodiments 2 - 7 as described later, and those of plate heaters 120 of heat exchangers of Embodiments 8 - 11 as described later, as well as Embodiment 1.

[0073] Fig. 6 is an exploded view of the heat exchanger 10A. Fig. 6(a) shows the heat exchanger 10A in a state where the second passage forming member 22 and the plate heater 20 are removed, when viewed from the base surface 30a side of the first passage forming member 21, and Fig. 6(b) shows the second passage forming member 22 when viewed from the base surface 40a side thereof. As shown in Fig. 6(a), a single rib 31 is provided on the base surface 30a of the base portion 30 of the first passage forming member 21 to extend substantially horizontally (in X-direction).

[0074] To be more specific, one end portion 31a of the rib 31 in X-direction is located in the vicinity of a region above an opening of the water inlet 23a at the passage space side, and is in contact with the inner wall surface of one end portion of the flange portion 32 in X-direction. The rib 31 extends along X-direction from one end portion 31a in X-direction on the base surface 30a, and an opposite end portion 31b thereof in X-direction is in contact with the inner wall surface of an opposite end portion of the flange portion 32 in X-direction.

[0075] As shown in Fig. 6(b), a single rib 41 is provided on the base surface 40a of the base portion 40 of the second passage forming member 22 to extend substantially horizontally (in X-direction). The first passage forming member 21 and the second passage forming member 22 are symmetric with respect to the ribs 31 and 41. To be specific, like the rib 31, the rib 41 is configured in such a manner that one end portion 41a in X-direction is in the vicinity of a region above the water inlet 23a, and is in contact with the inner wall surface of one end portion of the flange portion 32 in X-direction, in a state where the passage forming members 21 and 22 are joined together. The rib 41 extends along X-direction from one end portion 41a in X-direction on the base surface 40a, and an opposite end portion 41b thereof in X-direction is in contact with the inner wall surface of an opposite end portion of the flange portion 32 in X-direction, in a state where the passage forming members 21 and 22 are joined together.

[0076] The above stated ribs 3 and 41 separates the passage space 25 into an upstream space 25a located at the relatively lower side and a downstream space 25b located at the relatively upper side. As shown in Fig. 3, in addition to Fig. 6, the water inlet 23a opens in the upstream space 25a, while the water outlet 23b opens in the downstream space 25b. The downstream space 25b has a greater volume than the upstream space 25a. Since the passage forming members 21 and 22 are joined together such that the plate heater 20 is sandwiched therebetween, each of the upstream space 25a and the downstream space 25b is separated into a space at the first heat transfer surface 20a side and a space at the second heat transfer surface 20b side with respect to the plate heater 20 located at the center in a thickness direction (Y-direction) thereof (see Fig. 3).

[0077] The ribs 31 and 41 form throttle passages (horizontal throttle passages) 37 and 47, respectively, which are smaller in flow passage cross-sectional area than the upstream space 25a and the downstream space 25b. Fig. 7 shows a configuration of a region closer to the ribs 31 and 41 in the assembled heat exchanger 10A along X-direction. Fig. 7(a) is an enlarged view of a portion VIIa of Fig. 3, and Fig. 7(b) shows a modified example of the throttle passages 37 and 47.

[0078] As shown in Fig. 7(a), the ribs 31 and 41 of Embodiment 1 have end surfaces 50 at tip end portions thereof (end portions in Y-direction which are closer to the plate heater 20), which are not parallel to the heat transfer surfaces 20a and 20b, respectively. That is, the end surfaces 50 of the ribs 31 and 41 are tilted surfaces which are open upward. To be more specific, the end surfaces 50 are tilted at a predetermined angle A and their upper portions are more distant from the heat transfer surfaces 20a and 20b, respectively, than their lower portions. Because of this, the tip end portion of the rib 31 has a triangular shape in which its lower portion has a tip portion 51 protruding in an acute angle form. The tip end of the tip portion 51 of the rib 31 and the tip end of the tip portion 51 of the rib 41 are distant a predetermined dimension D 1 from the heat transfer surfaces 20a and 20b of the plate heater 20, respectively.

[0079] Between the rib 31 and the heat transfer surface 20a of plate heater 20, the throttle passage 37 which has an opening width D 1 and has a slit shape is provided, while between the rib 41 and the heat transfer surface 20b of plate heater 20, the throttle passage 47 which has an opening width D1 and has a slit shape is provided. The upstream space 25a of the heat exchanger 10A of the present embodiment is a closed space, except for the water inlet 23a and the throttle passages 37 and 47. The downstream space 25b of the heat exchanger 10A of the present embodiment is a closed space, except for the water outlet 23b and the throttle passages 37 and 47. Therefore, the upstream space 25a communicates with the downstream space 25b only via the throttle passages 37 and 47 having the small opening width D 1.

[0080] Subsequently, the flow of the washing water inside the above heat exchanger 10A will be described. As shown in Fig. 6(a), the washing water is introduced into the passage space 25 of the heat exchanger 10A through the water inlet 23a, and enters the upstream passage 25a. The upstream space 25a serves to make a pressure uniform to allow the washing water to flow into the downstream space 25b uniformly. Since the upstream space 25a is a closed space, except for the water inlet 23a and the throttle passages 37 and 47, as described above, the washing water in the upstream space 25a generates a relatively high inner pressure. Since the high-pressure washing water flows into the downstream space 25b through the throttle passages 37 and 47, the flow speed of the washing water in the downstream space 25b can be increased.

[0081] The flow speed pattern of the washing water in the downstream space 25b in this case is schematically indicated by reference symbols V1, V2, and V3 in Fig. 3. As shown in Fig. 3, the flow speed pattern of the washing water which has just exited the throttle passages 37 and 47 is a flow speed pattern indicated by V1, in which the flow speed is higher particularly in a region closer to surface of the plate heater 20. The flow speed pattern is changed into a flow speed pattern (flow speed pattern in which a highest speed portion is getting closer to an intermediate position between the second heat transfer surface 20b and the base surface 40a) in which the flow speed is gradually averaged as it is closer to the water outlet 23b, as indicated by V2 and V3. In any region of the downstream spaces 25b sandwiching the plate heater 20, the similar flow speed pattern is formed. In the above described manner, since the flow speed pattern of the washing water which has just exited the throttle passages 37 and 47 is the flow speed pattern indicated by V1, a rate of heat transfer from the heat transfer surfaces 20a and 20b of the plate heater can be improved. Furthermore, since the flow speed near the surface of the heater gradually decreases in a direction from the water inlet 23a toward the water outlet 23b, the heat transfer rate is higher at the water inlet 23a side and is lower at the water outlet 23b side.

[0082] The direction of the flow by the above forced convection in the downstream space 25b (i.e., flow of the washing water which has passed through the throttle passages 37 and 47 and migrates upward toward the downstream space 25b) is the same as that of the flow of the washing water by natural convection which is generated by heating of the plate heater 20. These two flows enhance the flow speed, thereby further improving the heat transfer rate.

[0083] As shown in Fig. 7(a), since the tip end portion of the rib 31 and the tip end portion of the rib 41 have the tip portions 51 protruding in the acute angle form at their lower portions, respectively, the washing water which has just exited the throttle passages 37 and 47 collides with the washing water in the downstream space 25b, for example, thereby generating a disordered flow. By generating the disturbed flow of the washing water in the downstream space 25b, the washing water can be agitated. Thus, the rate of heat transfer from the heat transfer surfaces 20a and 20b of the plate heater 20 can be improved.

[0084] When the water is flowing from the upstream space 25a into the downstream space 25b, its flow is narrowed rapidly, so that the water flows into the downstream space 25b in a state where it is smaller in dimension than a space between the plate heater 20 and the tip portion 51. Because of this, the flow speed is further increased, and the heat transfer rate can be improved.

[0085] As described above with reference to Figs. 4 and 5, the plate heater 20 is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet 23b than in the portion closer to the water inlet 23a, and the flow speed of the washing water flowing while contacting the heat transfer surfaces 20a and 20b of the plate heater 20 is increased by the presence of the throttle passages 37 and 47 provided in the passage space 25, in the portion closer to the water inlet 23a. This allows a great amount of heat to be transferred efficiently to the washing water in the portion closer to the water inlet 23a, where the washing water having a relatively low temperature flows, while excess heat is prevented from being transferred to the washing water in the portion closer to the water outlet 23b, where the washing water having a relatively high temperature flows. As a result, a heat generation distribution of the plate heater 20 can be made compatible with a heat exchange efficiency distribution, and local boiling on the surface of the plate heater 20 and the resulting generation of air bubbles are suppressed.

[0086] Since the downstream space 25b including the water outlet 23b is formed as a relatively wide space in which there is no obstacle, air bubbles can migrate upward toward the water outlet 23b along with the water flow, by a buoyancy force, if the air bubbles are generated. Therefore, even in a case where the air bubbles are generated, they can be discharged to outside quickly. Thus, the heat exchanger 10A of the present embodiment can improve a heat transfer rate while accomplishing quick discharging of the air bubbles.

[0087] Although in the present embodiment, the throttle passages 37 and 47 have the shape shown in Fig. 7 (a), the present invention is not limited to this. For example, a structure shown in Fig. 7(b) may be used.

[0088] To be more specific, as shown in Fig. 7(b), end surfaces 54 of the tip end portions (end portions in Y-direction which are closer to the plate heater 20) of the ribs 31 and 41 are not parallel to the heat transfer surfaces 20a and 20b of the plate heater 20, respectively. To be specific, the end surfaces 54 of the ribs 31 and 41 are tilted surfaces open downward. To be more specific, the end surfaces 54 are tilted surfaces having a predetermined angle A, in which their lower portions are more distant from the heat transfer surfaces 20a and 20b than their upper portions. Because of this, the tip end portion of the rib 31 has a triangular shape in which its upper portion has a tip portion 55 protruding in an acute angle form. The tip end of the tip portion 55 of the rib 31 and the tip end of the tip portion 55 of the rib 41 are distant a predetermined dimension D 1 from the heat transfer surfaces 20a and 20b of the plate heater 20, respectively. Because of this structure, between the rib 31 and the heat transfer surface 20a of the plate heater 20, a throttle passage 38 which has an opening width D1 and has a slit shape is formed, while between the rib 41 and the heat transfer surface 20b of plate heater 20, a throttle passage 48 which has an opening width D 1 and has a slit shape is formed.

[0089] Like the case where the throttle passages 37 and 47 are provided, the high-pressure washing water migrates from the upstream space 25a to the downstream space 25b through the throttle passages 38 and 48. In the case of the throttle passages 38 and 48, since the end surfaces 54 of the ribs 31 and 41 are the tilted surfaces open downward (toward the upstream space 25a), high-speed flow of the washing water flowing in close proximity to heat transfer surfaces 20a and 20b of the plate heater 20 can be formed. This can suppress the washing water from getting stagnant in the vicinity of heat transfer surfaces 20a and 20b, and hence improve the heat transfer rate.

As described above, in the present embodiment, the plate heater 20 is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet 23b than in the portion closer to the water inlet 23a. The passage space 25 has the upstream space 25a including the opening of the water inlet 23a, and the downstream space 25b including the opening of the water outlet 23b. Between the upstream space 25a and the downstream space 25b, the throttle passages 37 and 47 having smaller flow passage cross-sectional areas than another portion are provided. Because of these, the washing water which has flowed into the heat exchanger 10A through the water inlet 23a of the casing 23 is heated while flowing through the passage space 25 defined by the heat transfer surfaces of the plate heater 20, so that the temperature of the washing water gradually increases as the washing water is flowing toward the water outlet 23b.

[0090] In this case, the surface temperature of a portion of the plate heater 20, which is closer to water inlet 23a, is going to rise due to the relatively high heat generation density, but a large amount of heat is taken away from that portion by the washing water which has not been heated yet and has a low temperature. Therefore, the surface temperature does not rise up to a high temperature at which local boiling will take place. In addition, the washing water flowing from the upstream space 25a toward the downstream space 25b increases its flow speed by passing through the throttle passages 37 and 47. Because of this, particularly in the downstream space 25b, the rate of heat transfer from the plate heater 20 to the washing water can be improved, a heat transfer rate distribution can be optimized, and the air bubbles can be guided quickly to the water outlet 23b. In the portion closer to the water outlet 23b, since the washing water contacting the surface of the plate heater 20 has already been heated up to a high temperature, the amount of heat taken away from that portion by the washing water is lessened, assuming that the surface temperature of the plate heater 20 is constant in that portion. However, the plate heater 20 is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet 23b than in the portion closer to the water inlet 23a. Therefore, the surface temperature does not rise up to a high temperature at which local boiling will take place.

[0091] As described above, between the upstream space 25a and the downstream space 25b, the throttle passages 37 and 47 having smaller flow passage cross-sectional areas than another portion are provided, and the plate heater 20 is configured in such a manner that the heat generation density is lower in in the portion closer to the water outlet 23b than that in the portion closer to the water inlet 23a. Because of this, the heat transfer rate can be improved, and the heat transfer rate distribution can be optimized. In addition, it is possible to suppress the temperature from rising up to a high temperature at which local boiling will take place, on the surface of the boundary between the washing water and the portion of the plate heater 20 which is closer to water outlet 23b, where the temperature of the washing water tends to be high. As a result, generation of the air bubbles is suppressed, and the generated air bubbles are guided quickly to the water outlet 23b. In this way, it is possible to prevent the scale from being generated and from adhering to the plate heater 20. As a result, a heat exchanger which has a longer life can be realized.

(Embodiment 2)

[0092] Fig. 8 is a view showing another configuration of the heat exchanger 10. Fig. 8(a) shows the heat exchanger 10 in a state where the second passage forming member 22 is removed, when viewed from the base surface 30a side of the first passage forming member 21, and Fig. 6(b) shows an example of a flow of washing water. As shown in Fig. 8(a), the heat exchanger 10 (10B) has a rib 61 extending horizontally from a region closer to the water inlet 23a. The rib 61 is bent at a position and then extends vertically upward.

[0093] To be more specific, one end portion 61a of the rib 61 in X-direction is located in the vicinity of a region above the opening of the water inlet 23a at the passage space side, and is in contact with the inner wall surface of one end portion of the flange portion 32 in X-direction. The rib 61 extends along X-direction from one end portion 61a in X-direction on the base surface 30a, while an opposite end portion 61b thereof in X-direction is located apart a predetermined distance from the inner wall surface of an opposite end portion of the flange portion 32 in X-direction. The rib 61 is bent at the opposite end portion 61b and extends upward, and an upper end portion 61c of the rib 61 is in contact with the inner wall surface of an upper portion of the flange portion 32. The rib 61 separates the passage space 25 into the upstream space 25a having a substantially-L shape and the downstream space 25b of a rectangular shape.

[0094] The upstream space 25a includes a space (horizontal space) 62 defined by a portion between the end portions 61a and 61b of the rib 61 and extending horizontally, and a space (vertical space) 63 defined by a portion between the end portions 61b and 61c of the rib 61 and extending vertically, thereby forming the above substantially-L shape. The second passage forming member 22 has a rib symmetric with the rib 61.

[0095] Because of the presence of the rib 61, there is provided a throttle passage (horizontal throttle passage and vertical throttle passage) 65 having a smaller flow passage cross-sectional area than the upstream space 25a and the downstream space 25b. By combining the passage forming member 21, the passage forming member 22, and the plate heater 20, a slit-shape horizontal throttle passage 65a is provided between the portion between the end portions 61a and 61b of the rib 61 and the first heat transfer surface 20a of the plate heater 20, and a slit-shape vertical throttle passage 65b is provided between the portion between the end portions 61b and 61c of the rib 61 and the first heat transfer surface 20a of the plate heater 20.

[0096] In the present embodiment, the rib 61 has a constant height from the base surface 30a over the entire length from the end portion 61a to the end portion 6 1 c, and the base surface 30a and the first heat transfer surface 20a are placed in parallel. Therefore, the horizontal throttle passage 65a and the vertical throttle passage 65b have substantially the same opening width.

[0097] As shown in Fig. 8(b), in the heat exchanger 10B including the throttle passage 65 configured as described above, high-speed water flows from the horizontal space 62 to the downstream space 25b through the horizontal throttle passage 65a, and flows vertically upward as described in Embodiment 1. In the heat exchanger 10B of the present embodiment, in addition, the high-speed water flows from the vertical space 63 into the downstream space 25b through the vertical throttle passage 65b, and then flows horizontally. Therefore, in the downstream space 25b, vertically upward water flow and horizontal water flow are mixed, and thereby disordered water flow is generated. The disordered water flow causes the washing water to be agitated. As a result, the heat transfer rate can be improved. Like Embodiment 1, the plate heater 20 is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet 23b than in the portion closer to the water inlet 23a, and the air bubbles can be discharged quickly to outside through the water outlet 23b.

(Embodiment 3)

[0098] Fig. 9 is a view showing another configuration of the heat exchanger 10. Fig. 9(a) shows the heat exchanger 10 in a state where the second passage forming member 22 is removed, when viewed from the base surface 30a side of the first passage forming member 21, and Fig. 9(b) shows an example of a flow of washing water. As shown in Fig. 9(a), the heat exchanger 10(10C) includes the straight and horizontal rib 31 similar to that described in Embodiment 1. In addition, inside the downstream space 25, a plurality of agitating walls 67 which are corrugated in shape are provided.

[0099] To be more specific, the rib 31 protrudes from the base surface 30a of the first passage forming member 21 so as to extend horizontally from the inner wall surface of one end side of the flange portion 32 in X-direction to the inner wall surface of an opposite end side of the flange portion 32 in X-direction. Therefore, the rib 31 forms the throttle passage 37 similar to that of Embodiment 1. The agitating walls 67 extend from the rib 31 upward along the base surface 30a. The agitating walls 67 extend upward such that they are curved in a circular-arc shape like a sine waveform having a specified amplitude in X-direction. The plurality (six in the present embodiment) of agitating walls 67 are arranged at substantially equal intervals in X-direction.

[0100] The height of the agitating walls 67 from the base surface 30a is substantially equal to or a little smaller than the height of the rib 31. Adjacent two agitating walls 67 are spaced apart from each other so as not to overlap with each other when viewed from above along Z-direction. In other words, between the adjacent two agitating walls 67, there is a route through which the washing water can migrate straightly from the lower side to the upper side without migrating horizontally to avert the agitating walls 67.

[0101] In accordance with the heat exchanger 10C, as shown in Fig. 9(b), the water which has flowed from the throttle passage 37 at a high speed into the downstream space 25b collides against the agitating walls 67 and is agitated. This results in an improved heat transfer rate. Even though the washing water is agitated by the agitating walls 67, the air bubbles are allowed to migrate quickly toward the water outlet 23b. That is, since the route through which the washing water migrates straightly in the upward and downward direction is formed between the adjacent two agitating walls 67 as described above, the air bubbles which are going to migrate upward by a buoyancy force or the like, are less likely to be impeded by the agitating walls 67, and therefore can migrate upward quickly.

(Embodiment 4)

[0102] Fig. 10 shows another configuration of the heat exchanger 10. Fig. 10(a) shows the heat exchanger 10 in a state where the second passage forming member 22 is removed, when viewed from the base surface 30a side of the first passage forming member 21, and Fig. 10 (b) shows an example of a flow of washing water. As shown in Fig. 10(a), the heat exchanger 10(10D) includes the rib 61 of a substantially-L shape similar to that of Embodiment 2, while inside the downstream space 25, the agitating walls 67 similar to those of Embodiment 3 are provided.

[0103] In accordance with the heat exchanger 10D, as shown in Fig. 10(b), the water flow migrating vertically upward from the throttle passage 65a and the water flow migrating horizontally from the throttle passage 65b cause a disordered flow to be generated in the downstream space 25b. The disordered flow agitates the water flow. In addition, the agitating walls 67 also agitate the water flow. Therefore, the heat transfer rate can be further improved. The air bubbles are less likely to be impeded by the agitating walls 67. Therefore, the air bubbles can migrate upward quickly and can be discharged to outside from the water outlet 23b.

(Embodiment 5)

[0104] Fig. 11 is a view showing another configuration of the heat exchanger 10. Fig. 11(a) shows heat exchanger 10 in a state where the second passage forming member 22 is removed, when viewed from the base surface 30a side of the first passage forming member 21. Fig. 11 (b) is a cross-sectional view of the heat exchanger 10 taken along B-B. Fig. 11(c) is a cross-sectional view of the heat exchanger 10 taken along C-C. As shown in Figs. 11(a), the heat exchanger 10(10E) of the present embodiment has the same configuration in a larger part as that of Embodiment 1, but includes a rib 71 which is a little different from the rib 31 of Embodiment 1. Therefore, the rib 71 will now be described in detail.

[0105] As shown in Fig. 11(a), like the rib 31 of Embodiment 1, one end portion 71a of the rib 71 in X-direction is located in the vicinity of a region above an opening of the water inlet 23a at the passage space side, and is in contact with the inner wall surface of one end portion of the flange portion 32 in X-direction. The rib 71 extends along X-direction from one end portion 71a in X-direction on the base surface 30a, and an opposite end portion 71b thereof in X-direction is in contact with the inner wall surface of an opposite end portion of the flange portion 32 in X-direction.

[0106] The rib 71 is provided with a plurality of remaining portions 72 formed (left) by cutting portions of the rib 71 at a tip end portion thereof. These remaining portions 72 are, as shown in Fig.11 (a), arranged at substantially equal intervals along the longitudinal direction of the rib 71. As shown in Fig. 11(c),
an end surface 74 of the tip end portion (end portion of the rib 71 in Y-direction which is closer to the heat transfer surface 20a of the plate heater 20) of the rib 71 is a tilted surface open downward and the tip end portion of the rib 71 has a triangular shape in which the upper portion of the tip end portion has a tip portion 75 protruding in an acute angle form like the structure shown in Fig. 7(b). The remaining portions 72 having a predetermined depth are formed on the tip portion 75.

[0107] As a result of the above, as shown in Fig. 11 (b), between the rib 71 and the first heat transfer surface 20a (indicated by two-dotted line) of the plate heater 20, a slit-shape throttle passage 78 having an opening width D1 is formed. In addition, because of the presence of the remaining portions 72, increased-width portions 78a having an opening width D2 greater than the dimension D1 of a portion other than the increased-width portions 78a. Although not shown, the second passage forming member 22 is provided with the rib 71 having the above structure and being symmetric with the rib 71. The throttle passage 78 having the above structure is formed between the rib 71 and the second heat transfer surface 20b of the plate heater 20.

[0108] In accordance with the heat exchanger 10E of the present embodiment, the opening width of the throttle passage 78 is not constant, but the throttle passage 78 has portions of the dimension D 1 and portions defined by the increased-width portions 78a of the dimension D2 (> D1). Because of this structure, when the washing water is flowing from the upstream space 25a to the downstream space 25b through the throttle passage 78, there is a speed difference between the water flowing through the increased-width portions 78a and the water flowing through the portions other than the increased-width portions 78a. As a result, the washing water is agitated by a plurality of water flows with different speeds in the downstream space 25b, thereby improving the heat transfer rate.

[0109] Although the rib 71 has the tip portion 75 at the upper portion of the tip end portion thereof like the rib 31 of Fig. 7(b), the present invention is not limited to this.

For example, the remaining portions may be formed at the tip portions of the lower portion of the tip end portion, as shown in Fig. 7(a).

(**Embodiment 6**)

[0110] Fig. 12 is a view showing another configuration of the heat exchanger 10. Fig. 12(a) shows heat exchanger 10 in a state where the second passage forming member 22 is removed, when viewed from the base surface 30a side of the first passage forming member 21. Fig. 12 (b) is a cross-sectional view of the heat exchanger 10 taken along B-B.

[0111] As shown in Fig. 12(a), the heat exchanger 10 (10F) has a configuration similar to that of the heat exchanger 10E having the rib 71 described in Embodiment 5 (Fig. 11). In addition, each of the first passage forming member 21 and the second passage forming member 22 of the heat exchanger 10F is provided with a plurality of buffer walls 81 arranged in the upward and downward direction (in Z-direction) so as to extend horizontally (in X-direction) in a region corresponding to the downstream space 25b.

[0112] The buffer walls 81 of the first passage forming member 21 protrude from the base surface 30a with a dimension substantially equal to that of the rib 71, and extends from one end portion of the flange portion 32 in X-direction to an opposite end portion of the flange portion 32 in X-direction like the rib 71. As shown in Fig. 12 (b), the downstream space 25b is separated into a plurality of buffer spaces 82 (in the present embodiment, three buffer spaces 82a - 82c) by the buffer walls 81 such that the buffer spaces 82a - 82c are arranged in the upward and downward direction. The adjacent upper and lower buffer spaces 82 communicate with each other only through the slit-shape throttle passage 83 formed between the buffer wall 81 and the first transfer surface 20a of the plate heater 20. The second passage forming member 22 is provided with the buffer walls 81 having the same structure.

[0113] The buffer walls 81 have a smaller height than the rib 71.

[0114] In accordance with the heat exchanger 10F, the washing water flows into the lowermost buffer space 82a of the downstream space 25b through the throttle passage 78 formed by the rib 71, where the water flow is disordered and agitated. Since the buffer wall 81 is located relatively closer to the rib 71, the water flow with a relatively high speed which has passed through the throttle passage 78 collide with the buffer wall 81, thereby promoting generation of a disturbed flow in the buffer space 82a.

[0115] Then, the washing water flows from the buffer space 82a into the buffer space 82b located above and adjacent to the buffer space 82a, while increasing its speed by passing through the narrower throttle passage 83. Since the water flow contacts the first heat transfer surface 20a of the plate heater 20 at a higher speed, the rate of heat transfer from the first heat transfer surface 20a to the washing water can be improved. Furthermore, since generation of a disordered flow in the buffer space 82b is promoted by the fact that the high-speed water flow collides against the buffer wall 81 located next, the heat transfer rate can also be improved. Thereafter, in the same manner, similar phenomenon occurs and the heat transfer rate can be improved in the buffer space 82c.

[0116] Since the buffer walls 81 have a smaller height than the rib 71 as described above, the generated air bubbles can be discharged in an upward direction.

(**Embodiment 7**)

[0117] Fig. 13 is a view showing another configuration of the heat exchanger 10. Fig. 13(a) shows the heat exchanger 10 in a state where the second passage forming member 22 is removed, when viewed from the base surface 30a side of the first passage forming member 21. Fig. 13(b) is a cross-sectional view of the heat exchanger 10 taken along B-B. As shown in Fig. 13(a), the heat exchanger 10 (10G) has a configuration similar to that of the heat exchanger 10 (10F) described in Embodiment 6 (Fig. 12), and is configured in such a manner that the buffer walls 81 is provided with remaining portions 88 formed by cutting portions of the buffer walls 81 at suitable locations.

[0118] To be more specific, as shown in Fig. 13(a), the heat exchanger 10G according to the present embodiment includes three buffer walls 81 (81a ~ 81c) arranged in the upward and downward direction. The buffer walls 81a ~ 81c are provided with remaining portions 88 formed (left) by cutting portions of the buffer walls 81a~ 81c such that the remaining portions 88 are different in position between adjacent upper and lower buffer walls 81a and 81b when viewed from above (when viewed in Z-direction), and between adjacent upper and lower buffer walls 81b and 81c when viewed from above.

[0119] To be specific, the lowermost buffer wall 81 a is provided with one remaining portion 88 in the vicinity of a center portion in the longitudinal direction thereof (X-direction). The buffer wall 81b located above the buffer wall 81 a is provided with remaining portions 88 at two positions which are in the vicinity of one end portion thereof in the longitudinal direction and in the vicinity of an opposite end portion thereof in the longitudinal direction. The buffer wall 81c located above the buffer wall 81b is provided with one remaining portion 88 in the vicinity of a center portion in the longitudinal direction, like the buffer wall 81a. The above illustrated number and positions of the remaining portions 88 are exemplary, but the remaining portions 88 may be provided at positions different from those as described above so long as they do not overlap with each other between the adjacent upper and lower buffer walls 81 as viewed above. In addition, the cut portion depth and cut portion length of the remaining portions 88 are not particularly limited.

[0120] In accordance with the heat exchanger 10G as described above, in the buffer spaces 82a- 82c, there are generated a flow of the washing water which is migrating upward through the narrower portions of the throttle passage 78 which are not provided with the remaining portions 88 and a flow of the washing water which is migrating horizontally toward the remaining portions 88 to flow through the increased-width portions defined by the remaining portions 88. Since the vertically upward water flow and the horizontal water flow are mixed, generation of a disordered flow in the downstream space 25b is promoted. As a result, the rate of heat transfer from the plate heater 20 to the washing water can be improved.

[0121] To quickly guide the air bubbles generated in the passage space 25 toward the water outlet 23b, a ceiling surface defining the downstream space 25b may be a tilted surface. Fig. 14 is a view showing a modified example of the heat exchanger 10A of Embodiment 1, and showing the heat exchanger 10A in a state where the second passage forming member 22 and the plate heater 20 are removed, when viewed from the base surface 30a side of the first passage forming member 21.

[0122] As shown in Fig. 14, the ceiling surface (in this modified example, inner upper surface of the first passage forming member 21) defining the downstream space 25b is formed as a tiled surface which is lower as it is away from the region in the vicinity of the water outlet 23b. In such a configuration, the air bubbles migrating upward due to the flow of the washing water or a buoyancy force in the downstream space 25b are guided smoothly toward the water outlet 23b along the tilted ceiling surface 21a. This makes it possible to discharge the air bubbles in the downstream space 25b quickly through the water outlet 23b. The tilted ceiling surface 21s may be applied to heat exchangers 10H ~ 10J described below and the above described heat exchangers 10B ~ 10G, as well as the heat exchanger 10A of Embodiment 1.

[Configuration in which a bypass passage is provided]

[0123] Next, a description will be given of heat exchangers of Embodiments 8 ~ 11, each of which includes, in a passage space, a sinuous passage extending from the water inlet to the water outlet, the sinuous passage having a passage for guiding the washing water in one direction in a horizontal direction and a passage for guiding the washing water in an opposite direction in the horizontal direction such that they are arranged alternately from the lower side to the upper side, and bypass passages each of which is provided in the upward and downward direction and allows adjacent upper and lower passages in the sinuous passage to communicate with each other. Note that any one of the heat exchangers 10 of these embodiments may be incorporated into the sanitary washing device 1 of Fig. 1 as the heat exchanger 10. A plate heater 120 included in each heat exchanger 10 described below has a configuration similar to that of the plate heater 20 (especially configuration of the pattern 20p of the resistive element) described with reference to Figs. 4 and 5.

(Embodiment 8)

[Heat exchanger]

[0124] Fig. 15 is a view showing a configuration of a heat exchanger 10(10H). Fig. 15(a) is a front view showing a configuration of an external appearance of the heat exchanger 10. Fig. 15(b) is a cross-sectional view of the heat exchanger 10 taken along B-B. As shown in Figs. 15(a) and 15(b), in its external appearance, the heat exchanger 10H has a small thickness and a rectangular plate shape when viewed from the front. As shown in Fig. 15(b), the heat exchanger 10H includes a rectangular plate heater 120, a first passage forming member 121 disposed to face one surface (first heat transfer surface) 120a, a second passage forming member 122 disposed to face an opposite surface (second heat transfer surface) 120b, and a casing 123 accommodating, the plate heater 120, the first passage forming member 121 and the second passage forming member 122, and having a water inlet 123a and a water outlet 123b. The plate heater 120 is made of ceramic, while the first passage forming member 121 and the second passage forming member 122, are made of reinforced ABS resin formed by compounding glass fiber into ABS resin.

[0125] Hereinafter, a description will be given of a state where the heat exchanger 10H is placed to be oriented vertically such that the heat transfer surfaces of the plate heater 120 are parallel to the vertical direction, except for cases specially noted. As shown in Fig. 15, the vertical direction is Z-direction, a direction perpendicular to Z-direction and parallel to the heat transfer surfaces of the plate heater 20 is X-direction, and a direction (direction perpendicular to the first heat transfer surface 120a) perpendicular to X-direction and Z-direction is Y-direction.

[0126] As shown in Fig. 15(b), the first passage forming member 121 includes a base portion 130 of a rectangular plate shape which faces the first heat transfer surface 120a, and a plurality of wall portions (ribs) 131 protruding from a surface (base surface) 130a of the base portion 130 which faces the first heat transfer surface 120a. Likewise, the second passage forming member 122 includes a base portion 140 of a rectangular plate shape which faces the second heat transfer surface 120b, and a plurality of wall portions (ribs) 141 protruding from a surface (base surface) 140a of the base portion 140 which faces the second heat transfer surface 120b.

[0127] A wall-like flange portion 132 is provided to extend along the peripheral edge portion of the base portion 130 of the first passage forming member 121. The flange portion 132 extends a predetermined dimension toward the second passage forming member 122. An engagement groove 133 is formed at the tip end portion of the flange portion 132 so as to extend along the flange portion 132. A wall-like flange portion 142 is provided to extend along the peripheral edge portion of the base portion 140 of the second passage forming member 122. The flange portion 142 is extended by a predetermined dimension in a direction away from the first passage forming member 121. The tip end portion of the flange portion 142 is turned back toward the first passage forming member 121. An engagement projection 143 is formed at the end portion of the flange portion 142 so as to extend along the flange portion 142.

[0128] The first passage forming member 121 is externally fitted to the second passage forming member 122 such that the base surface 130a faces the base surface 140a. To be more specific, the flange portion 132 of the first passage forming member 121 is externally fitted to the flange portion 142 of the second passage forming member 122, and the engagement projection 143 of the second passage forming member 122 is fitted into the engagement groove 133 of the first passage forming member 121 (e.g., the engagement projection 143 is secured to the engagement groove 133 by ultrasonic fusion-bonding.) This allows the first passage forming member 121 and the second passage forming member 122 to be joined in a sealed state, thereby forming a passage space 125.

[0129] As shown in Fig. 5(a), the water inlet 123a is provided at the lower portion of one end portion of the casing 123 in X-direction, while the water outlet 123b is provided at the upper portion of one end portion of the casing 123 in X-direction. As shown in Fig. 15(b), the water inlet 123a and the water outlet 123b communicate with the passage space 125.

[0130] Fig. 16 is an exploded view of the heat exchanger 10H. Fig. 16(a) shows the heat exchanger 10H in a state where the second passage forming member 122 and the plate heater 120 are removed, when viewed from the base surface 130a side of the first passage forming member 121, and Fig. 16(b) shows the second passage forming member 122 when viewed from the base surface 140a side thereof. As shown in Fig. 16(a), a plurality of (in the present embodiment, seven) wall portions (ribs) 131 (131a ~ 131g) are arranged in the upward and downward direction (in Z-direction) extending substantially horizontally (in X-direction) on the base surface 130a of the base portion 130 of the first passage forming member 121.

[0131] Among the wall portions (ribs) 131a ~ 131g, the wall portions (ribs) 131a, 131c, and 131e which are in odd-numbered orders from the bottom are each configured in such a manner that one end portion (one end portion in X-direction) in the longitudinal direction thereof is in contact with the inner wall surface of the flange portion 132 and an opposite end portion in the longitudinal direction is apart a predetermined dimension from the inner wall surface of the flange portion 132. The wall portions 131b, 131d, and 131 f which are in even-numbered orders from the bottom are each configured in such a manner that one end portion in the longitudinal direction (one end portion in X-direction) is apart from the inner wall surface of the flange portion 132 and an opposite end portion thereof in the longitudinal direction is in contact with the inner wall surface of the flange portion 132. In the passage space 125, a sinuous passage 135 is defined by the wall portions (ribs) 131a ~ 131g.

[0132] To be more specific, a passage 135a defined by the lower portion of the flange portion 132 as its lower side and the lowermost wall portion (rib) 131 a as its upper side serves to guide the washing water in a direction from one side in X-direction where the water inlet 123a is located, toward an opposite side in X-direction. The washing water reaches the downstream end of the passage 135a and then its flow is turned back at the downstream end. The washing water is guided from the opposite side in X-direction to one side in X-direction through a passage 135b defined by the wall portion (rib) 131a as its lower side and the wall portion (rib) 131b as its upper side, which is located above the wall portion 131a. After that, in the same manner, the washing water is turned back and guided in the opposite direction, along the passages 135c~ 135h, and finally to the water outlet 123b. The sinuous passage 135 is constituted by the passages 135a - 135h (see Fig. 19 as described later).

[0133] As shown in Fig. 16(b), the wall portions (ribs) 141 of the second passage forming member 122 have the same structure as aforesaid wall portions (ribs) 131 of the first passage forming member 121, except that the wall portions (ribs) 141 are symmetric with the wall portions (ribs) 131, and they will not be described in detail. In a similar manner, the wall portions 141 form a sinuous passage 145 extending from the water inlet 123a to the water outlet 123b. The plate heater 120 having a substantially constant width and a rectangular shape is sandwiched between the first passage forming member 121 and the second passage forming member 122 (see the plate heater 20 in Figs. 4 and 5).

[0134] Fig. 17 is a cross-sectional view of the heat exchanger 10 taken along XVII-XVII of Fig. 16(a). As shown in Fig. 17, the wall portion (rib) 131 has a structure in which a longitudinal dimension (dimension in X-direction) is L1, and a height H1 from the base surface 130a along the longitudinal direction is substantially constant. Note that a remaining portion 136 having an opening dimension (dimension in X-direction) L2 and a depth H2 is formed at a portion (in the present embodiment, center portion) in the longitudinal direction.

[0135] Fig. 18 is a view showing a structure of the wall portion (rib portion) 131 and the remaining portion 136. Fig. 18(a) is an enlarged view of a portion XVIIIa in Fig. 17, to show the remaining portion 136 taken along Z-direction. Fig. 18(b) is an enlarged view of a portion XVIIIb in Fig. 15, to show the remaining portion 136 taken along X-direction. As shown in Fig. 18(a), the remaining portion 136 has a shape in which the tip end portion of the wall portion (rib) 131 is cut in a rectangular shape, and is dented with respect to another portion of the wall portion (rib) 131. A deepest portion 136a of the remaining portion 136 is substantially parallel to the upper end of the wall portion (rib) 131. In the heat exchanger 10H of the present embodiment, an opening dimension L2 of the remaining portion 136 is set to satisfy the following formula (1) with respect to the length L1 of the wall portion (rib) 131:

$$1/2 \geqq (L2/L1) \geqq 1/5 \ldots (1).$$

For example, L2 = 20mm.

[0136] As shown in the cross-sectional view of Fig. 18 (b), the tip end surface of the wall portion (rib) 131 is not parallel to the surface (first heat transfer surface 120a) of the plate heater 120, but is a tilted surface having a predetermined angle A. The tip end portion of the wall portion (rib) 131 has a triangular shape in which its lower portion forms a tip portion 137 having an acute angle shape in cross-section. The remaining portion 136 is formed in the tip portion 137. The remaining portion 136 constitutes the bypass passage 138 which allows communication between a lower passage defined by the wall portion (rib) 131 and an upper passage defined by the wall portion (rib) 131.

[0137] As shown in Fig. 18(b), in a state where the first passage forming member 121 and the second passage forming member 122 are disposed to sandwich the plate heater 120, a portion of the tip end portion other than the remaining portion 136 in the wall portion (rib) 131 is a dimension H3 apart from the first heat transfer surface 120a of the plate heater 120. In the heat exchanger 10H of the present embodiment, the dimension H3 is set to satisfy the following formula (2), with respect to a dimension H4 from the base surface 130a of the first passage forming member 121 to the first heat transfer surface 120a :

$$1/4 \geqq (H3/H4) \geqq 1/10 \ldots (2).$$

For example, H3 = 0.2mm, and H4 = 1.9mm.

[0138] The wall portion (rib) 141 of the second passage forming member 122 has the same cross-sectional shape as that of the wall portion (rib) 131 and is set to satisfy the formula (2). And, the wall portion (rib) 141 is provided with a remaining portion 146 having a depth H2 (see Fig. 18(b)). The remaining portion 146 forms a bypass passage 148 which allows communication between adjacent upper and lower passages sandwiching the wall portion (rib) 131.

[0139] By setting (L2/L1) to (1/2) or less in the formula (1), it is possible to more easily and sufficiently ensure water (water amount) flowing from upstream to downstream through the sinuous passage 135 (or sinuous passage 145) than water (water amount) flowing from upstream to downstream through the bypass passage 138 (or bypass passage 148). This allows the heat exchanger 10H to perform its original heat exchange function well.

[0140] By setting (L2/L1) to (1/5) or more in the formula (1), the flow passage cross-sectional area of the bypass passage 138 (or bypass passage 148) is more sufficiently ensured relative to the sinuous passage 135 (or sinuous passage 145). This allows the air bubbles to be guided to the water outlet 123b and discharged to outside more easily and surely through the bypass passage 138 (or bypass passage 148).

[0141] By setting (H3/H4) to (1/4) or less in the formula (2) described above, it is possible to more easily and sufficiently ensure water (water amount) flowing from upstream to downstream through the passage 135a located at mostupstream side of the sinuous passage 135 (or a passage which is located at mostupstream side of the sinuous passage 145 and is plane-symmetric with respect to the passage 135a, and hereinafter this passage is referred to as "passage 145a"), rather than water (water amount) flowing out into a space between the wall portion (rib) 131 (or 141) and the first heat transfer surface 120a (or second heat transfer surface 120b). Since water (water amount) flowing from upstream to downstream through the passage 135a located at mostupstream side of the sinuous passage 135 (or the passage 145a located at mostupstream side of the sinuous passage 145) can be ensured more easily and sufficiently, water (water amount) flowing from upstream to downstream through the sinuous passage 135 (or sinuous passage 145) can be ensured more easily and efficiently. This allows the heat exchanger 10H to perform its original heat exchange function better.

[0142] By setting (H3/H4) to (1/10) or more in the formula (2), a wider space is provided between the wall portion (rib) 131 (or 141) and the first heat transfer surface 120a (or second heat transfer surface 120b). This makes it possible to easily and surely prevent thermal effect (thermal dissolution, thermal deformation, etc.,) from the first heat transfer surface 120a (or second heat transfer surface 120b) to the wall portion (rib) 131 (or 141).

[0143] As shown in Fig. 18(b), the lower end portion of the plate heater 120 is apart from the lower inner wall surface of the flange portion 132 of the first passage forming member 121. Therefore, a space below the lower end portion of the plate heater 120 is a common space (upstream common space) 125a for the sinuous passage 135 at the first heat transfer surface 120a side of the plate heater 120 and the sinuous passage 145 side of the second heat transfer surface 120b side of the plate heater 120. The washing water which has flowed into the passage space 125 through the water inlet 123a is divided to flow to the sinuous passages 135 and 145 through the upstream common space 125a. Likewise, as shown in Fig. 15(b), the upper end portion of the plate heater 120 is apart from the upper inner wall surface of the flange portion 132 of the first passage forming member 121. A space above the upper end portion of the plate heater

120 is a common space (downstream common space) 125b for the sinuous passages 135 and 145. Therefore, the washing water flowing through the sinuous passage 135 and the washing water flowing through the sinuous passage 145 are joined together in the downstream common space 125b, and the resulting washing water flows toward the water outlet 123b.

[0144] Fig. 19 is a view showing the flow of the washing water and the flow of the air bubbles in the heat exchanger 10H configured as described above. Like the configuration shown in Fig. 16(a), the flow of the washing water and the flow of the air bubbles are viewed from the perspective of the base surface 130a side of the first passage forming member 121. As shown in Fig. 19, a most part of the washing water with a low temperature (e.g., 5 degrees C) which has flowed into the heat exchanger 10H through the water inlet 123a flows upward along the sinuous passage 135 (and sinuous passage 145) such that its flow direction is inverted from one direction in X-direction to an opposite direction in X-direction or from the opposite direction to the one direction in the order of the passages 135a - 135h (see solid-line arrows in Fig. 19). When the washing water is flowing through the passages 135a to 135h, the temperature of the washing water is raised up to a suitable temperature (e.g., 40 degrees C) by heat transfer from the plate heater 120, and then is discharged to outside through the water outlet 123b. The washing water, the temperature of which has been raised in this way, is ejected in a shower form to the private part of the human body through the nozzle of the washing unit as described above.

[0145] Hereinafter, a description will be given of the operation and action of the heat exchanger configured as described above. The washing water flowing into the heat exchanger 10H through the water inlet 123a of the casing 123 is heated while flowing through the passage 135 defined by the heat transfer surface of the plate heater 120. The temperature of the washing water gradually increases as it is getting closer to the water outlet 123b. The surface temperature of the portion of the plate heater 120 which is closer to water inlet 123a is going to rise due to a relatively high heat generation density. But, a large amount of heat is taken away from that portion by the washing water which has not been heated yet. Therefore, the surface temperature of the plate heater 120 does not rise up to a high temperature at which local boiling will take place.

[0146] In a portion of the heat exchanger 10H which is closer to water outlet 123b, the washing water is in a higher-temperature condition than the washing water in a portion of the heat exchanger 10H which is closer to the water inlet 123a. Therefore, heat taken away by the washing water from the surface of the plate heater 120 corresponding to this portion is lessened. But, the plate heater 120 is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet 123b than in the portion closer to water inlet 123a, and the temperature of that portion does not rise up to a high temperature at which local boiling will take place.

[0147] Since the plate heater 120 is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet 123b than in the portion closer to water inlet 123a, its temperature is suppressed from rising up to a high temperature at which local boiling will take place, on the surface of the boundary between the plate heater 120 and the water in the portion of the plate heater 120 which is closer to water outlet 123b where the temperature of the washing water tends to be higher. As a result, formation and adhesion of the scale can be prevented, and a heat exchanger having a longer life can be realized.

[0148] In accordance with the heat exchanger 10H of the present embodiment, heat exchange is performed in such a manner that heat of the plate heater 120 is transferred to the washing water flowing while contacting the obverse and reverse heat transfer surfaces of the plate heater 120, and a heat efficiency is high without a substantial heat release loss. Therefore, the heat exchanger 10H can be small-sized. In addition, the sinuous passage 135 and the sinuous passage 145 can increase the passage length and increase the flow speed. Therefore, in the washing water flowing through the sinuous passage 135 and 145, a boundary layer to which heat is substantially transferred from the surface of the plate heater 120 is thinned. Because of this, the heat transfer rate can be improved, and the temperature of the surface of the heater is suppressed from rising. As a result, local boiling can be suppressed, and formation and adhesion of the scale can be prevented more effectively.

[0149] As described above, the plate heater 120 of the present embodiment is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet 123b than in the portion closer to the water inlet 123a. In such a configuration, the heat exchanger 10H of the present invention can achieve the same advantages as those described in Embodiment 1.

[0150] In the heat exchanger 10H of the present embodiment, the sinuous passage 135 (or sinuous passage 145) is defined by the plurality of wall portions 131 arranged vertically to extend substantially horizontally. The sinuous passage 135 (or sinuous passage 145) is configured in such a manner that the passage 135a for guiding the washing water in one direction in the substantially horizontal direction and the passage 135b for guiding the washing water in the opposite direction in the substantially horizontal direction are arranged alternately from the lower side to the upper side, in a range from the water inlet 123a to the water outlet 123b. Furthermore, in an intermediate portion of each wall portion 131 in the longitudinal direction, the bypass passage 138 (or bypass passage 148) is provided in the upward and downward direction to allow communication between adjacent upper and lower passages 135. This allows the washing water to flow at a high speed, which can improve the heat transfer rate. In addition, the air bubbles can be guided quickly to the water outlet 123b through the bypass passages 138 (or bypass passages 148) provided in the upward and downward direction at the sinuous passages 135 (or sinuous passages 145).

[0151] Since the heat exchanger 10H is provided with the sinuous passages 135 to have smaller flow passage cross-sectional areas, the flow speed of the washing water can be made high and uniform. Since the plate heater 120 is configured in such a manner that the heat generation density is lower in the portion closer to the water outlet 123b than in the portion closer to the water inlet 123a, the temperature is suppressed from rising up to a high-temperature at which local boiling will take place, and the generation of the air bubbles is suppressed. Even if the air bubbles are generated, the generated air bubbles can migrate quickly to the water outlet 123b through the bypass passages 138 (or bypass passages 148) with a passage length shorter than the overall passage length of the sinuous passage 135, the bypass passages 138, 148 being provided in the upward and downward direction on the sinuous passage 135, 145 having a long passage length for guiding the washing water from the water inlet 123a to the water outlet 123b, to allow the air bubbles to take a short cut.

[0152] As a result, a passage resistance at one of the heat transfer surface sides (120a or 120b) of the plate heater 120 can be prevented from becoming much higher than that at the other heat transfer surface side (120a or 120b), or only the temperature at the heat transfer surface (120a or 120b) of the plate heater 120 from increasing significantly, which would be caused by the air bubbles. Thus, the local boiling which would lead to formation and adhesion of the scale can be further suppressed. Since the air bubbles generated on the surface of the plate heater 120 are guided quickly to the water outlet 123b through the bypass passages 138 (or the bypass passages 148), the air bubbles can be suppressed from growing to a great size. As a result, a problem that the operation of a thermistor provided in the vicinity of the water outlet 123b is impeded by the air bubbles of a great size, will not arise.

[0153] In the heat exchanger 10H of the present embodiment, the sinuous passage 135 at the heat transfer surface 120a side of the plate heater 120 and the sinuous passage 136 at the heat transfer surface 120b side of the plate heater 120 are symmetric, and the bypass passage 138 at the heat transfer surface 120a side of the plate heater 120 and the bypass passage 148 at the heat transfer surface 120b side of the plate heater 120 are symmetric. This allows a balance of a heat transfer amount between the obverse and reverse heat transfer surfaces of the plate heater 120 to be suitably be maintained As a result, deformation of the plate heater 120 due to a thermal stress can be prevented.

[0154] In the heat exchanger 10H of the present embodiment, the bypass passages 138 provided on the plurality of wall portions 131 arranged in the upward and downward direction substantially conform in position to each other when viewed from above. In the same manner, the bypass passages 148 provided on the plurality of wall portions 141 arranged in the upward and downward direction substantially conform in position to each other when viewed from above. This allows the air bubbles to migrate straightly upward through the bypass passages 138 and 148 and reach the water outlet quickly.

[0155] Since the washing water is heated by the plate heater 120, gaseous component dissolved into the washing water may vaporize to generate air bubbles, in some cases. The flow (see while arrows in Fig. 19) of the air bubbles will be discussed. For example, the air bubbles generated in the passage 135a of the sinuous passage 135 flows through the passage 135a along with the washing water. However, a buoyancy force acts on the air bubbles and causes them to migrate upward. Therefore, before reaching the downstream end of the passage 135a, the air bubbles take a short cut to its upper adjacent passage 135b through the bypass passage 138 defined by the remaining portion 136 formed on the wall portion (rib) 131a. Then, the air bubbles migrate to the uppermost passage 135h through the bypass passages 138 defined by the remaining portions 136 of the wall portions (ribs) 131b ~ 131g, respectively. Then, the air bubbles migrate along with the washing water in the passage 135h, and are discharged to outside through the water outlet 123b. In the same manner, the air bubbles generated in the passages 135b ~ 135g other than the passage 135a migrate to the corresponding upper passages through the bypass passages 138. In the same manner, the air bubbles generated in the sinuous passage 145 take a short cut and migrate upward through the bypass passages 148.

[0156] In accordance with the heat exchanger 10H as described above, the air bubbles generated inside the heat exchanger 10H can be guided quickly to the water outlet 123b and discharged to outside.

(Embodiment 9)

[0157] Fig. 20 is an enlarged view of a remaining portion taken along Z-direction, to show another configuration of a remaining portion formed (left) by cutting a portion of a rib. Fig. 20(a) is an enlarged view showing a remaining portion having a tapered deepest portion. Fig. 20(b) is an enlarged view showing a remaining portion having a circular-arc deepest portion. Fig. 20(c) is an enlarged view showing a remaining portion having a deepest portion defined by a tilted surface.

[0158] As shown in Fig. 20(a), a remaining portion 150 of Fig. 20(a) has a cut portion width (dimension in X-direction) which decreases as a cut portion depth (dimension in Y-direction) from the tip end of the wall portion (rib) 131 increases. When viewed from above along the Z-direction, the deepest portion 151 has a tapered shape. In other words, when viewed from above, the remaining portion 150 has the deepest portion 151 which is lower in level than the tip end portion of the wall portion (rib) 131. The deepest portion 151 has a tilted profile such that a depth of a substantially center portion in X-direction is greatest.

[0159] As shown in Fig. 20(b), a remaining portion 153 has a deepest portion 154 of a circular-arc shape when viewed from above such that a cut portion depth (dimension in Y-direction) in a center portion of a cut portion width (dimension in X-direction) is greater.

[0160] As shown in Fig. 20(c), a remaining portion 156 has a deepest portion 157 defined by a tilted surface such that a cut portion depth increases in a direction from an upstream end portion 157a toward a downstream end portion 157b in a flow direction of the washing water.

[0161] If bypass passages are formed by using the remaining portions 150, 153, and 156, air bubbles with a relatively great diameter, as well as air bubbles with a small diameter, can pass through the deepest portions 151, 154, and 157. When using the remaining portion 156 having the cut portion depth which increases toward downstream end in the flow direction, the air bubbles migrating along with the washing water can be surely captured by the portion having the greater cut portion depth, and are allowed to take a short cut to the upper passage through the remaining portion 156.

(Embodiment 10)

[0162] Fig. 21 is a view showing another configuration of the heat exchanger, and showing a configuration of the heat exchanger when viewed from the base surface 130a side of the first passage forming member 121. In the heat exchanger 10 (101) shown in Fig. 21, an opening dimension L2 of the remaining portion 136 is made different among wall portions (ribs) 131a ~ 131g. To be more specific, the remaining portion 136 of the wall portion (rib) 131 a located at the lowermost side has a smallest opening dimension L2. The opening dimension L2 of the remaining portion 136 is increased in the order of the wall portions (ribs) 131b ~ 131f, and the remaining portion 136 of the wall portion (rib) 131 g located at the uppermost side has a greatest opening dimension L2. The other configuration is identical to that of the heat exchanger 10H of Embodiment 9, and will not be described in repetition.

[0163] In accordance with the heat exchanger 101 having such a configuration, the flow speed of the washing water flowing along the sinuous passage 135 and 145 can be increased, and a heat transfer property or a carrying efficiency of the air bubbles can be improved. To be specific, in some occasions, the washing water as well as the air bubbles take a short cut through the bypass passages 138 and 148 defined by the remaining portions 136. Since the temperature of the washing water has not been raised adequately in the vicinity of the water inlet 123a, the air bubbles generated are less in the vicinity of the water inlet 123a. Therefore, the opening dimension L2 of the remaining portion 136 formed on the wall portion (rib portion) 131 defining the passage located at the relatively lower side where the air bubbles generated are less is set smaller. This suppresses the washing water from passing through the remaining portion 136, and improves the flow speed of the washing water. The wall portion (rib) 131 defining the passage located at relatively upper side where the air bubbles are more likely to be generated, have a relatively great opening dimension L2. This allows the generated air bubbles to surely take a short cut to the upper passage.

[0164] Although in the example shown in Fig. 21, the opening dimension L2 is made different between the remaining portions 136 provided on all of the wall portions (ribs)131, the present invention is not limited to this. For example, the opening dimension L2 of the remaining portions 136 of the two wall portions (ribs) 131a and 131b located at the lower side is set to a smallest and equal value, the opening dimension L2 of the remaining portions 136 of the two wall portions (ribs) 131f and 131g located at the upper side is set to a greatest and equal value, and the opening dimension L2 of the remaining portions 136 of the three wall portions (ribs) 131c ~ 131e located at the middle is set to a predetermined equal value (predetermined value between the smallest value and the greatest value). In brief, other setting may be made so long as the opening dimension L2 of the remaining portion 136 of the uppermost wall portion (rib) 131g is greater than the opening dimension L2 of the remaining portion 136 of the lowermost wall portion (rib) 131a, and the opening dimension L2 of the remaining portion 136 of the wall portion (rib) 131 located at the upper side is not smaller than the opening dimension L2 of the remaining portion 136 of the wall portion (rib portion) 131 located at the lower side, regarding the wall portions (ribs) 131b ~ 131f located between the wall portions (ribs) 131a and 131g.

(Embodiment 11)

[0165] Fig. 22 is a view showing another configuration of the heat exchanger, and showing a configuration of the heat exchanger when viewed from the base surface 130a side of the first passage forming member 121. As shown in Fig. 22, in the heat exchanger 10(10J), the remaining portions 136 are formed on a part of the wall portions (ribs) 131 located at the upper side (upper two wall portions (ribs) 131f, 131g), while the remaining portions 136 are not formed on the other wall portions (ribs) 131 (131a ~ 131e).

[0166] In accordance with the heat exchanger 10J having such a configuration, in the passage located at the lower side where the air bubbles are less likely to be generated, the flow speed of the washing water is improved while preventing the washing water from migrating through the remaining portion 136, while the air bubbles generated in the upper passage where the temperature of the washing water tends to be higher can migrate upward through the remaining portion 136, and can be discharged quickly to outside through the water outlet 123b.

[0167] The wall portions (ribs) 131 on which the remaining portions 136 are formed are not limited to an example shown in Fig. 22, in which the remaining portions 136 are formed on the two wall portions (ribs) 131. The number of wall portions (ribs) 131 provided with the remaining portions 136 may be suitably set depending on the degree to which the air bubbles are generated in the passages, the flow speed of the washing water, etc.. That is, the remaining portion 136 may be formed on only the uppermost wall portion 131g, the upper three wall portions (ribs) 131e ~ 131g, or more wall portions (ribs) 131.

Industrial Applicability

[0168] The present invention is applicable to a plate type heat exchanger having a longer life which can suppress formation and adhesion of scale and guide generated air bubbles quickly to a water outlet while improving a heat transfer rate.

Reference Signs Lists

[0169]

1 sanitary washing device
10, 10A ~ 10J heat exchanger
20, 120 plate heater
20a, 120a first heat transfer surface
20b, 120b second heat transfer surface
20h heater line interval
20k ceramic base body
20p pattern
20s heater line width
21, 121 first passage forming member
22, 122 second passage forming member
23, 123 casing
23a, 123a water inlet
23b, 123b water outlet
25 passage space
25a upstream space
25b downstream space
30, 40 base portion
31,41,61,71 rib
31a, 31b, 61a, 61b, 61c, 71a, 71b end portion
37, 38, 47, 48, 65, 78, 83 throttle passage
65a horizontal throttle passage
65b vertical throttle passage
67 agitating wall
72, 88, 136, 150, 153, 156 remaining portion
78a increased-width portion
81, 81a, 81b, 81c buffer wall
131, 131a~ 131g, 141 wall portion (rib)
135, 135a ~ 135h, 145 sinuous passage
138, 148 bypass passage

Claims

1. A heat exchanger comprising:

   a casing having a water inlet and a water outlet;
   a heater disposed inside the casing and having surfaces serving as heat transfer surfaces; and
   a passage space provided inside the casing, to guide a fluid which has flowed into the heat exchanger through the water inlet to the water outlet, the fluid being guided to the water outlet while exchanging heat with the heat transfer surfaces of the heater;
   characterized in that the heater is configured in such a manner that a heat generation density in a portion closer to the water outlet is lower than a heat generation density in a portion closer to the water inlet.

2. The heat exchanger according to Claim 1,
   wherein the heater is a plate heater placed to be oriented in a direction substantially parallel to a vertical direction, and has an obverse main surface and a reverse main surface which are the heat transfer surfaces; and
   the passage space extends from the water inlet at a lower portion to the water outlet at an upper portion along the obverse and reverse heat transfer surfaces of the plate heater.

3. The heat exchanger according to Claim 1 or 2,
   wherein the heater is a ceramic heater including a ceramic base body, a heat generation resistive element formed by printing a pattern of a resistive element on the ceramic base body, and an electrode, and the printed pattern has a line width greater in a portion of the heater which is closer to the water outlet than in a portion of the heater which is closer to the water inlet.

4. The heat exchanger according to Claim 1 or 2,
   wherein the heater is a ceramic heater including a ceramic base body, a heat generation resistive element formed by printing a pattern of a resistive element on the ceramic base body, and an electrode, and the printed pattern has a line interval smaller in a portion of the heater which is closer to the water outlet than in a portion of the heater which is closer to the water inlet.

5. The heat exchanger according to any one of Claims 2 to 4,
   wherein the passage space includes an upstream space including an opening of the water inlet and a downstream space including an opening of the water outlet, and a throttle passage having a smaller flow passage cross-sectional area than another space is provided between the upstream space and the

downstream space.

6. The heat exchanger according to Claim 5, wherein the passage space at one heat transfer surface side of the plate heater and the passage space at the other heat transfer surface side of the plate heater are symmetric.

7. The heat exchanger according to Claim 5 or 6, wherein the downstream space has a greater volume than the upstream space.

8. The heat exchanger according to any one of Claims 5 to 7, wherein the throttle passage has a horizontal throttle passage extending substantially horizontally from a portion of the heat exchanger which is closer to the water inlet, to flow the fluid in an upward direction toward the downstream space.

9. The heat exchanger according to Claim 8, wherein the throttle passage has a vertical throttle passage extending substantially vertically upward, from one end portion of the horizontal throttle passage which is farther from the water inlet than the other end portion of the horizontal throttle passage, to flow the fluid horizontally toward the downstream space.

10. The heat exchanger according to any one of Claims 5 to 9, wherein the throttle passage has a slit shape; and the throttle passage has an increased-width portion having a greater opening width than another portion.

11. The heat exchanger according to any one of Claims 5 to 10, wherein an agitating wall for agitating the fluid is provided in the downstream space to extend in a substantially upward and downward direction along the plate heater; and the agitating wall is corrugated to have a horizontal amplitude.

12. The heat exchanger according to any one of Claims 5 to 11, wherein a buffer wall extending substantially horizontally along the plate heater is provided in the downstream space.

13. The heat exchanger according to Claim 12, wherein the buffer wall has a plurality of buffer walls arranged in the upward and downward direction; and the buffer walls are provided with remaining portions formed by cutting portions of the buffer walls such that positions of the remaining portions are different between adjacent upper and lower buffer walls when viewed from above.

14. The heat exchanger according to any one of Claims 5 to 13, comprising:

a pair of passage forming members disposed to sandwich the plate heater; wherein each of the passage forming members includes a base portion of a plate shape disposed to face the plate heater, and a rib protruding from a surface of the base portion which faces the plate heater; and the slit-shape throttle passage is defined by the rib and the plate heater which faces the rib, and is provided between the rib and the plate heater which faces the rib.

15. The heat exchanger according to Claim 1, wherein the heater is a plate heater placed to be oriented in a direction substantially parallel to a vertical direction, and has an obverse main surface and a reverse main surface which are the heat transfer surfaces; and the passage space is formed in a sinuous passage extending from the water inlet at a lower portion to the water outlet at an upper portion along the obverse and reverse heat transfer surfaces of the plate heater.

16. The heat exchanger according to Claim 15, wherein the sinuous passage is defined by a plurality of wall portions arranged vertically to extend substantially horizontally; the sinuous passage has, in a range from the water inlet to the water outlet, a passage for guiding the fluid in one direction in a substantially horizontal direction, and a passage for guiding the fluid in an opposite direction in the substantially horizontal direction such that the passages are arranged alternately from a lower side to an upper side; and a bypass passage is provided in an upward and downward direction on a portion of each of the wall portions in a longitudinal direction thereof to provide communication between adjacent upper and lower passages.

17. The heat exchanger according to Claim 16, wherein the sinuous passage at one heat transfer surface side of the plate heater and the sinuous passage at the other heat transfer surface side of the plate heater are symmetric; and the bypass passage at one heat transfer surface side of the plate heater and the bypass passage at the other heat transfer surface side of the plate heater are symmetric.

18. The heat exchanger according to Claim 16 or 17, wherein bypass passages formed on the plurality of wall portions substantially conform in position to each other when viewed from above.

19. The heat exchanger according to any one of Claims 16 to 18, comprising:

a pair of passage forming members disposed to sandwich the plate heater;
wherein each of the passage forming members includes a base portion of a plate shape disposed to face the plate heater, and a plurality of ribs protruding from a surface of the base portion which faces the plate heater to form the wall portions; and
a remaining portion formed by cutting a portion of each of the plurality of ribs is provided on a portion of each of the plurality of ribs in a longitudinal direction thereof such that a tip end of the rib is dented with respect to another portion to form the bypass passage.

20. The heat exchanger according to Claim 19, wherein the remaining portion of the rib has a tapered shape when viewed from above such that a cut portion width of the remaining portion decreases as a cut portion depth of the remaining portion increases.

21. The heat exchanger according to Claim 19, wherein the remaining portion of the rib has a circular-arc shape when viewed from above such that a cut portion depth of a center portion of a cut portion width is greater.

22. The heat exchanger according to any one of Claims 19 to 21,
wherein the remaining portion of the rib provided at a relatively upper side has a greater cut portion width than the remaining portion of the rib provided at a relatively lower side.

23. The heat exchanger according to any one of Claims 19 to 21,
wherein the remaining portion is not provided on the rib provided at a relatively lower side; and
the remaining portion is provided on the rib provided at a relatively upper side.

1 SANITARY WASHING DEVICE
2 TOILET BOWL
3 BASE BODY
3a CASING
4 TOILET SEAT
5 TOILET COVER
6 OPERATING UNIT
10 HEAT EXCHANGER

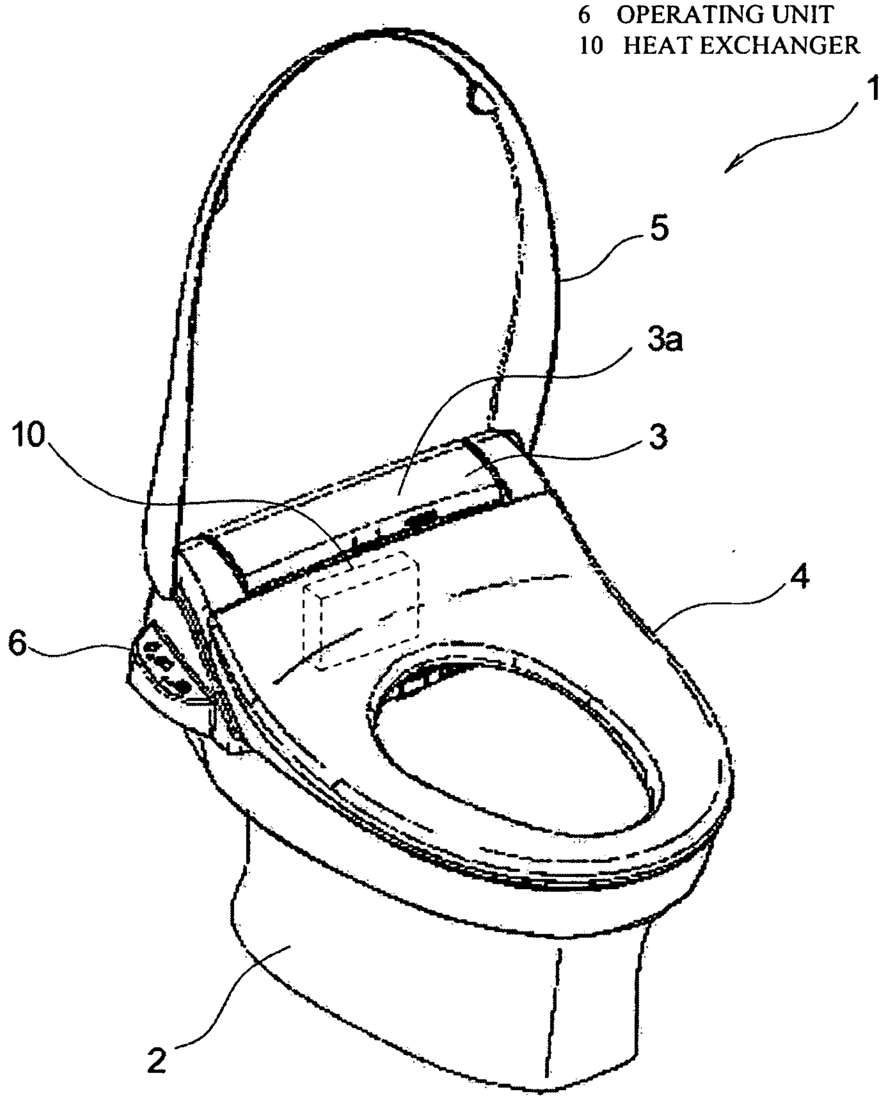


Fig.1

10A HEAT EXCHANGER
23 CASING
23a WATER INLET
23b WATER OUTLET

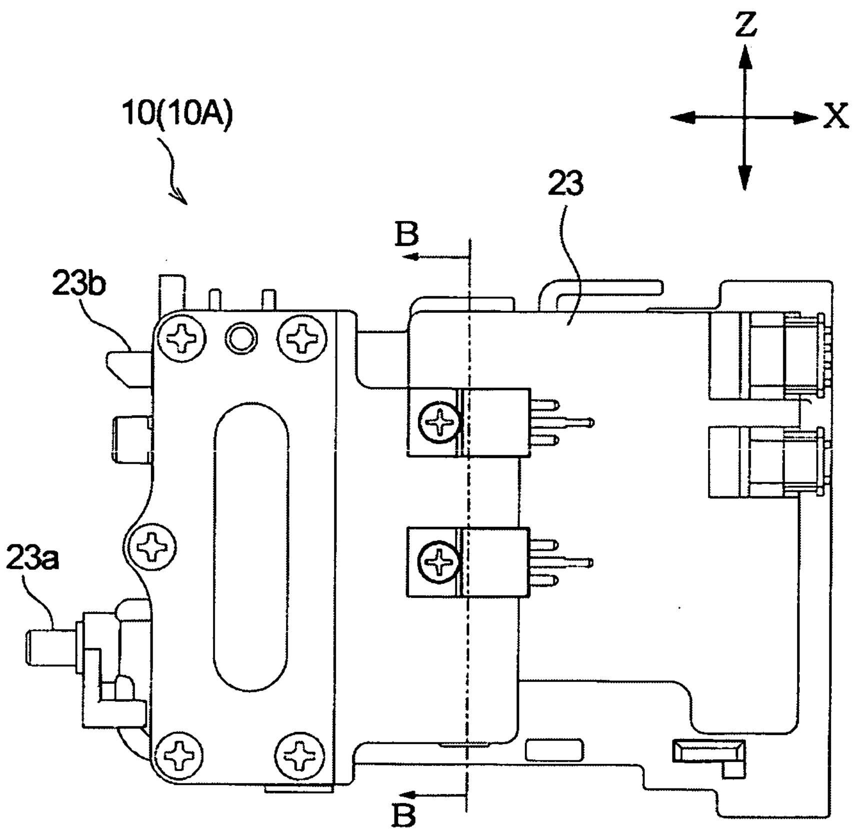
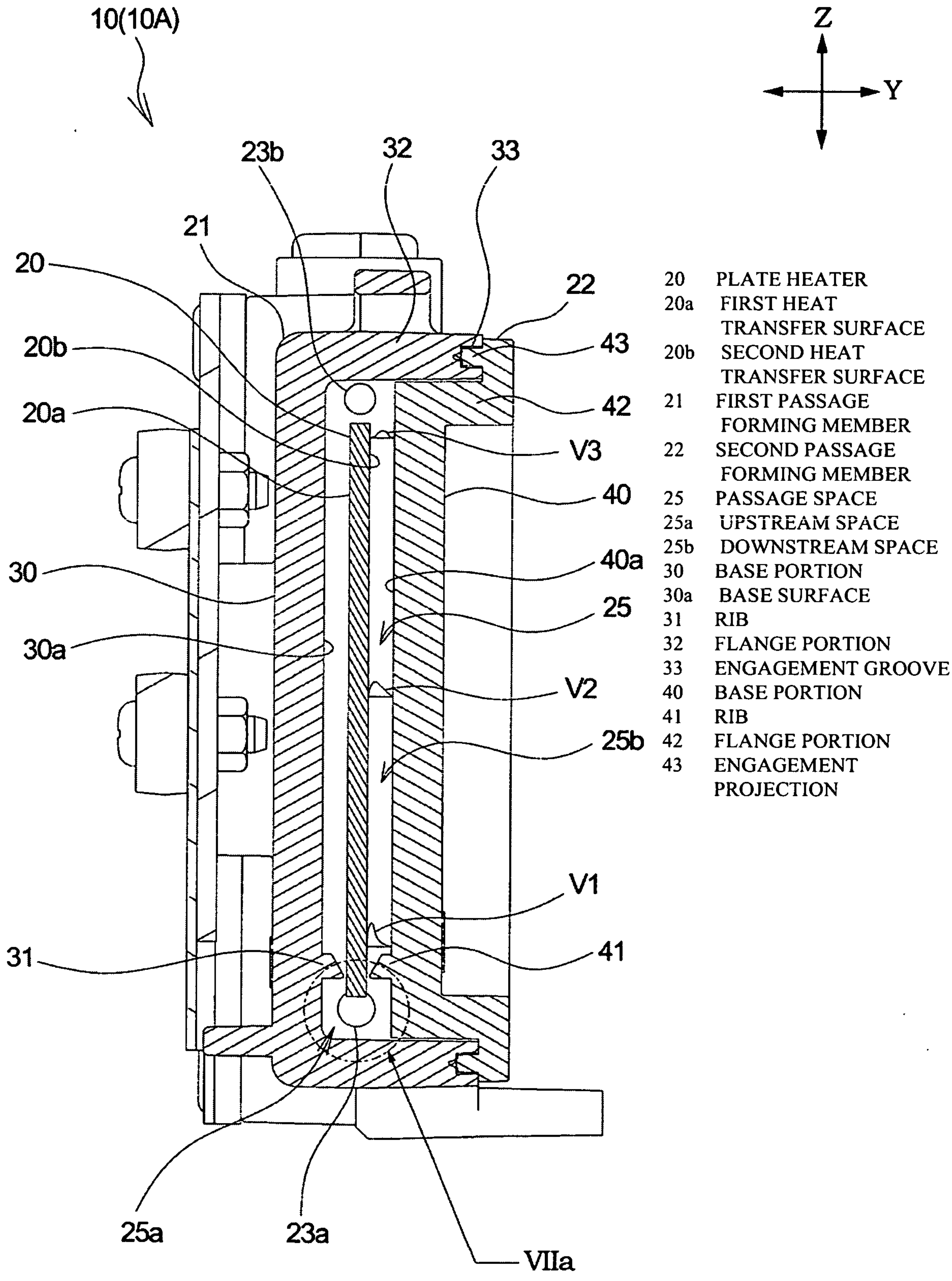


Fig.2



20 PLATE HEATER
20a FIRST HEAT TRANSFER SURFACE
20b SECOND HEAT TRANSFER SURFACE
21 FIRST PASSAGE FORMING MEMBER
22 SECOND PASSAGE FORMING MEMBER
25 PASSAGE SPACE
25a UPSTREAM SPACE
25b DOWNSTREAM SPACE
30 BASE PORTION
30a BASE SURFACE
31 RIB
32 FLANGE PORTION
33 ENGAGEMENT GROOVE
40 BASE PORTION
41 RIB
42 FLANGE PORTION
43 ENGAGEMENT PROJECTION

Fig.3

20k CERAMIC BASE BODY
20p PATTERN
20s HEATER LINE WIDTH

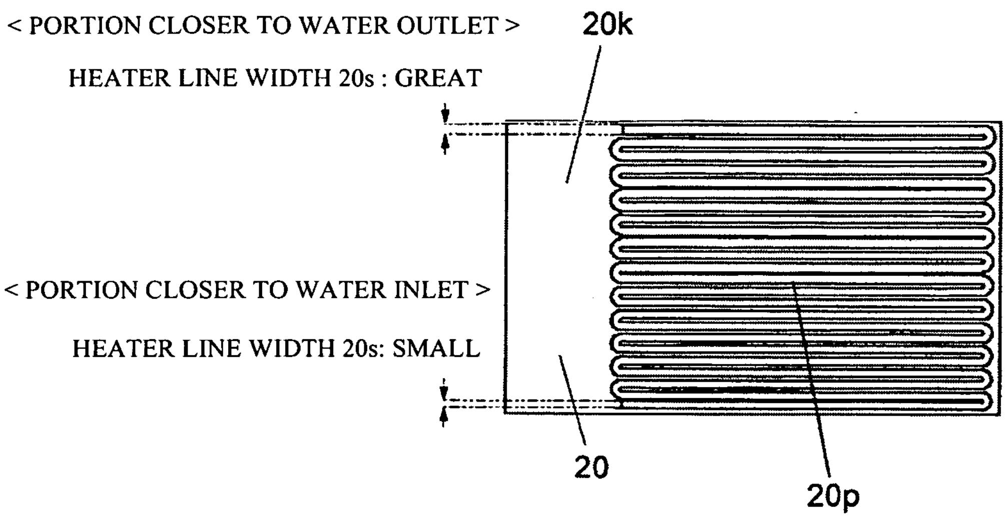


Fig.4

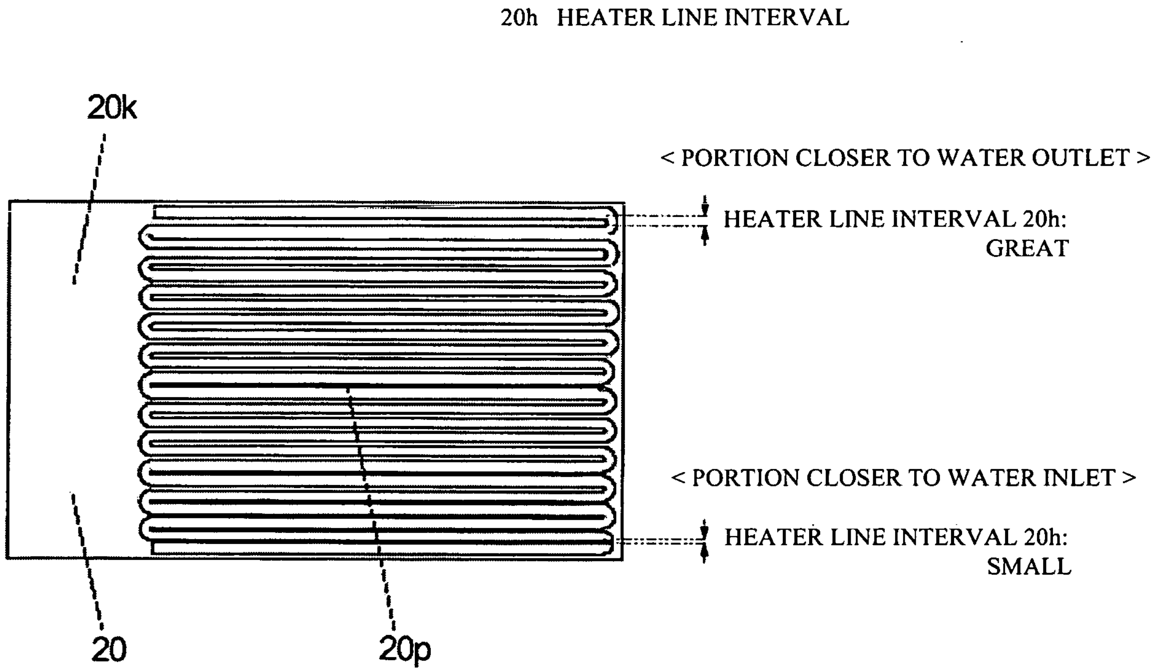
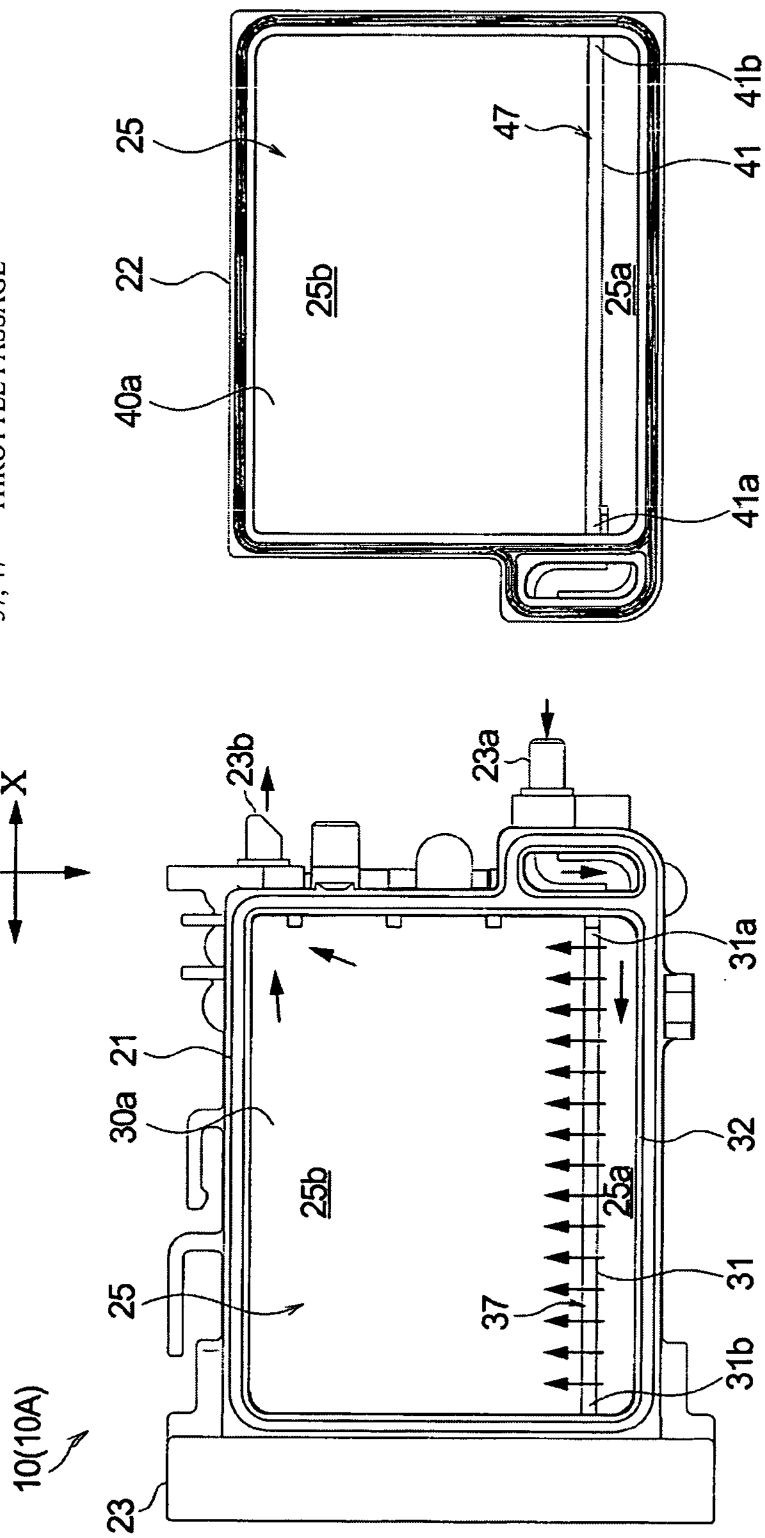

20h HEATER LINE INTERVAL
20k
< PORTION CLOSER TO WATER OUTLET >
HEATER LINE INTERVAL 20h: GREAT
< PORTION CLOSER TO WATER INLET >
HEATER LINE INTERVAL 20h: SMALL
20
20p

Fig.5

21 FIRST PASSAGE FORMING MEMBER
22 SECOND PASSAGE FORMING MEMBER
31a, 41a ONE END PORTION IN X-DIRECTION
31b, 41b OPPOSITE END PORTION IN X-DIRECTION
37, 47 THROTTLE PASSAGE



(a) (b)

Fig. 6

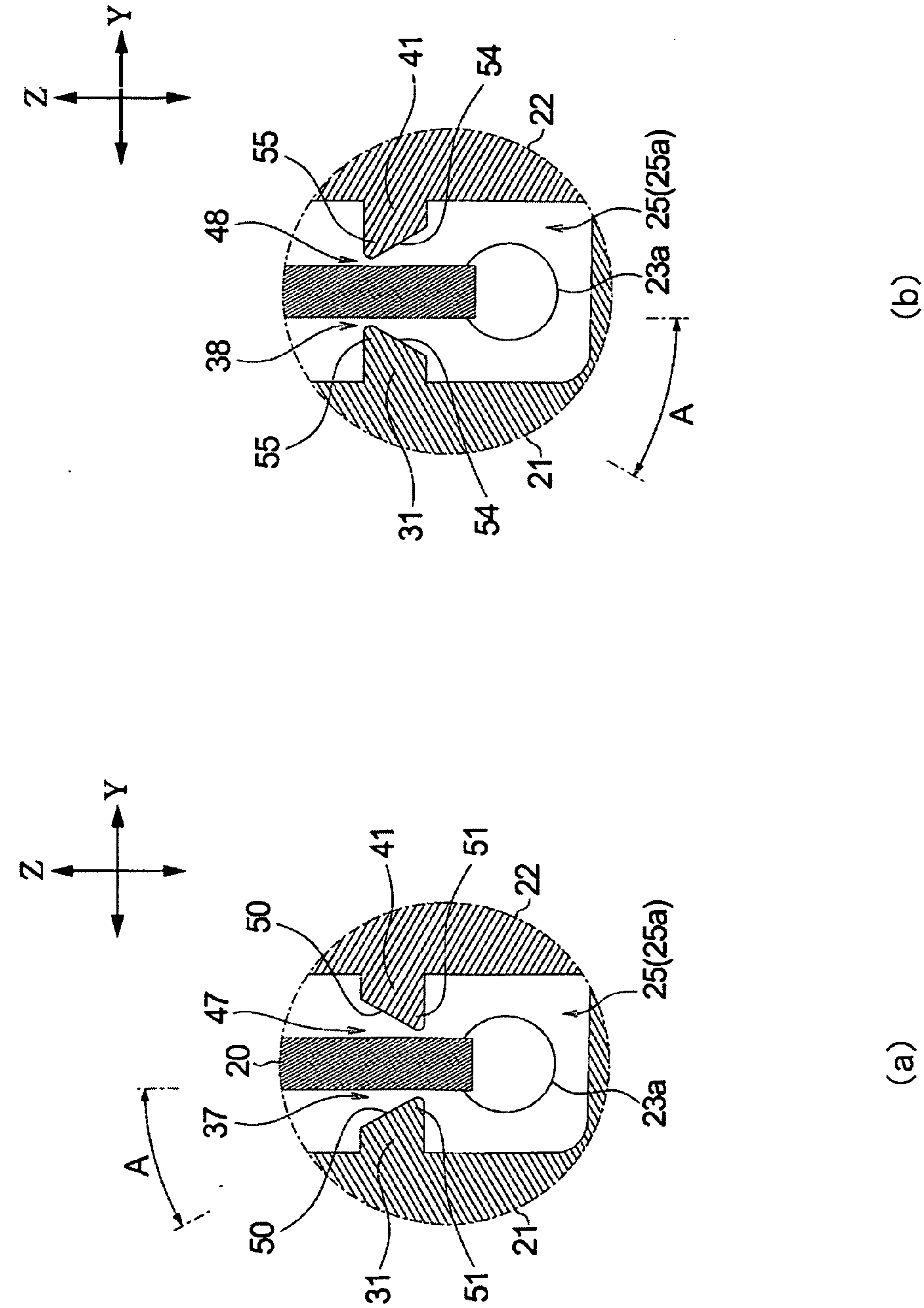

Z
Y
55
48
38
41
54
22
25(25a)
23a
55
31
54
21
A
(b)
Z
Y
50
47
20
37
41
51
22
25(25a)
23a
A
50
31
51
21
(a)

Fig. 7

61 RIB
61a ONE END PORTION IN X-DIRECTION
61b OPPOSITE END PORTION IN X-DIRECTION
62 HORIZONTAL SPACE
63 VERTICAL SPACE
65 THROTTLE PASSAGE
65a HORIZONTAL THROTTLE PASSAGE
65b VERTICAL THROTTLE PASSAGE
67 AGITATING WALL
10B HEAT EXCHANGER

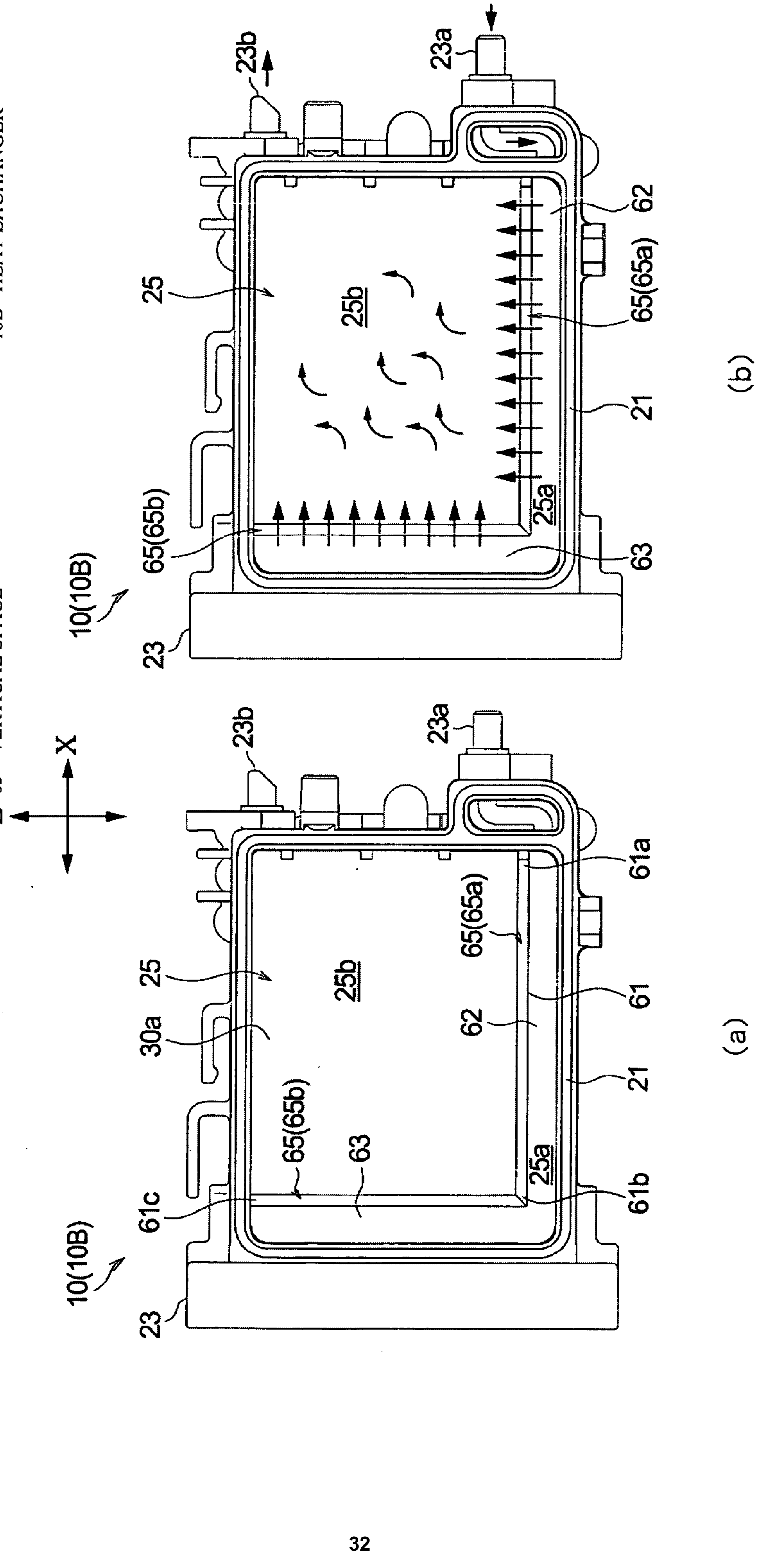


Fig. 8

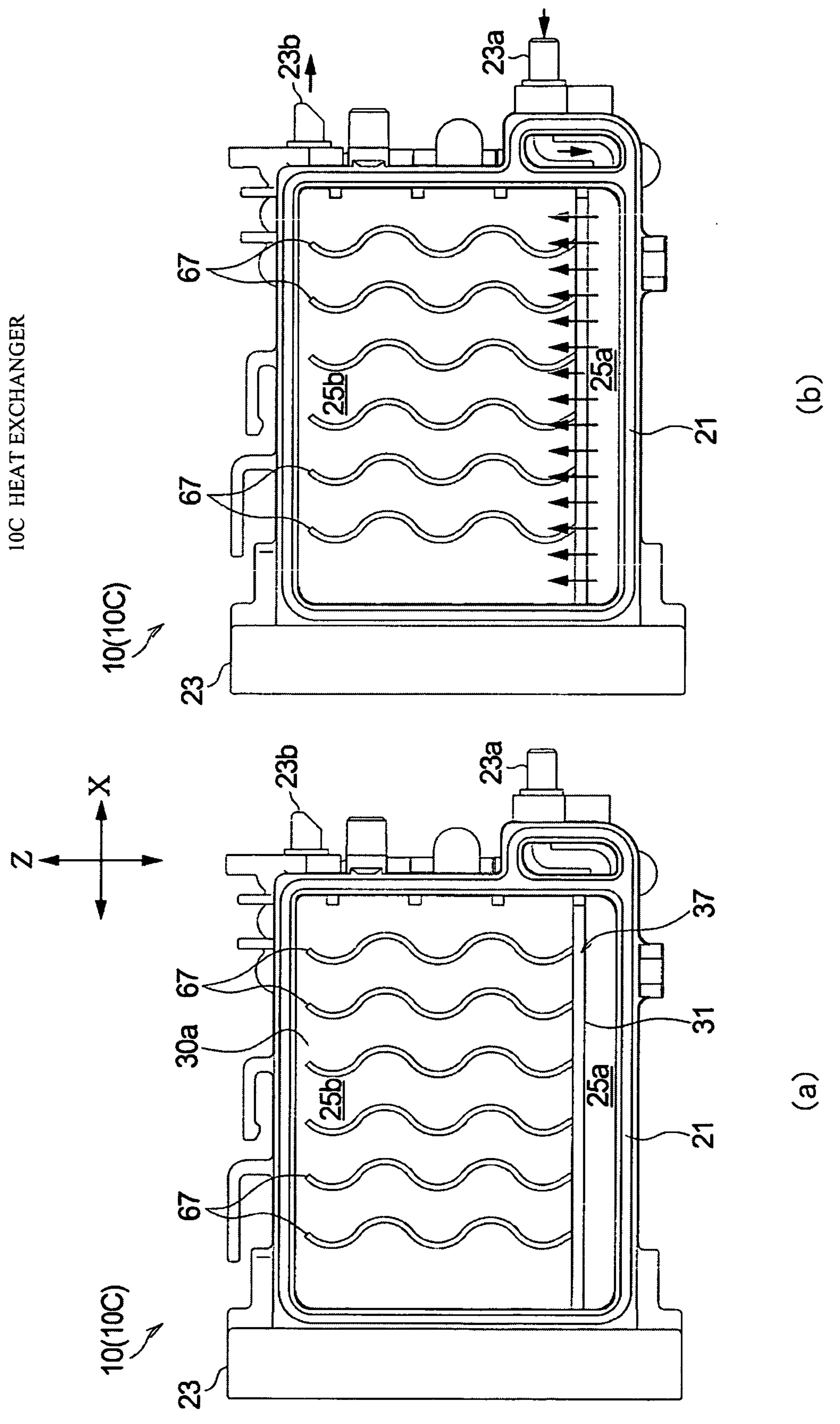

10C HEAT EXCHANGER
10(10C)
23
23a
23b
67
67
25b
25a
21
(b)
Z
X
10(10C)
23
23b
23a
67
30a
25b
67
25a
21
31
37
(a)

Fig. 9

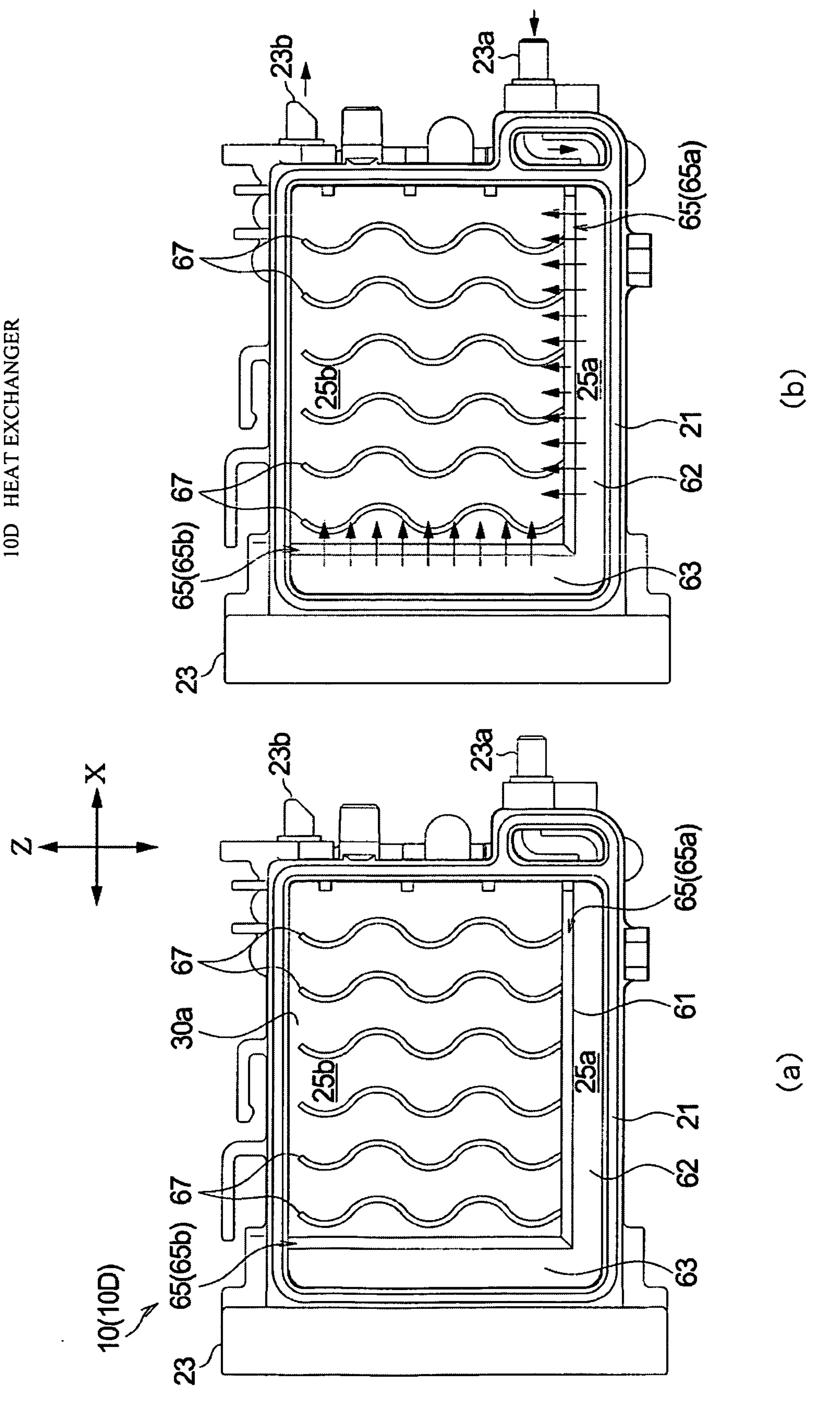
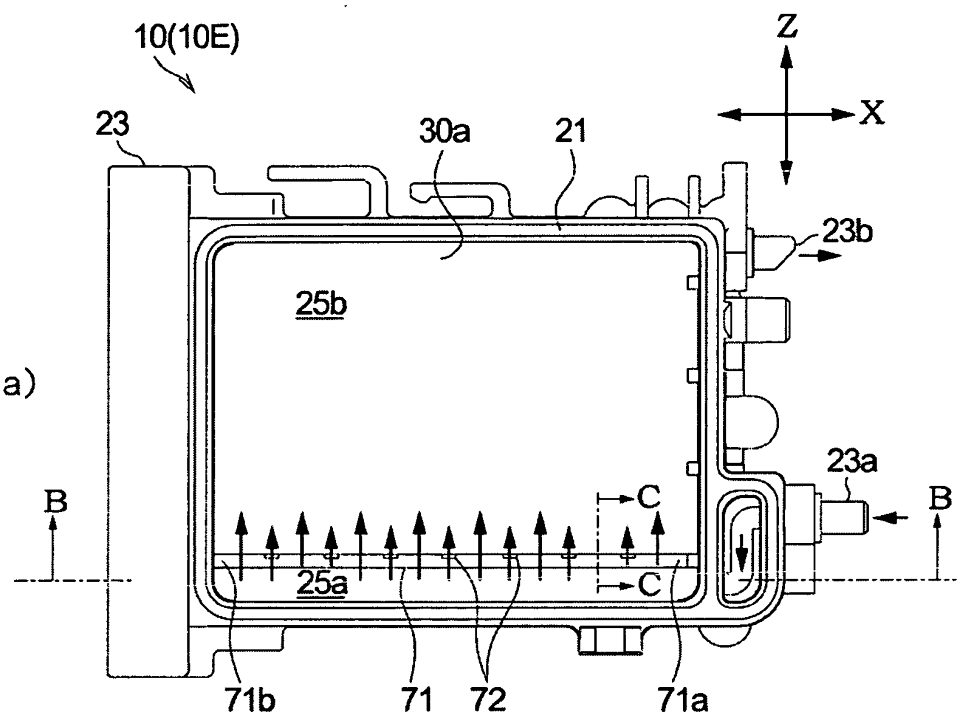
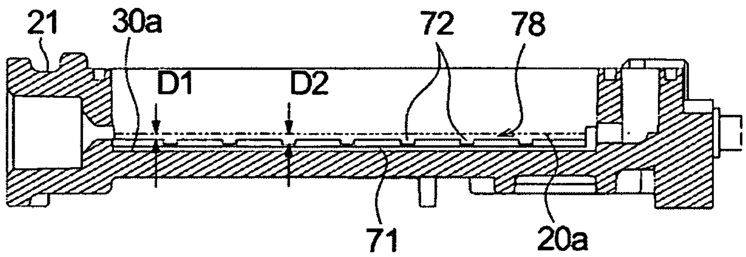

10D HEAT EXCHANGER
23b
23a
67
65(65a)
25b
25a
21
62
63
65(65b)
23
(b)
Z
X
30a
61
(a)
10(10D)

Fig. 10

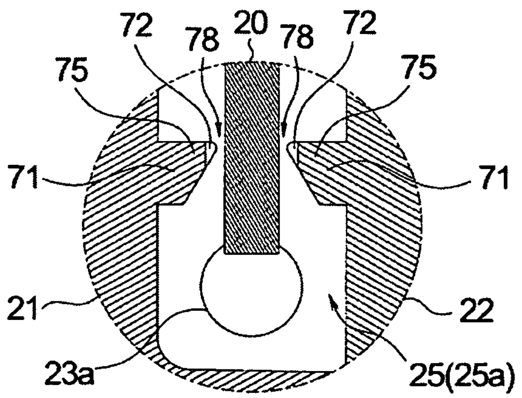
(a)



(b)



(c)



71 RIB
71a ONE END PORTION IN X-DIRECTION
71b OPPOSITE END PORTION IN X-DIRECTION
72 REMAINING PORTION
74 END SURFACE
75 TIP PORTION
78 THROTTLE PASSAGE
78a INCREASED-WIDTH PORTION
10E HEAT EXCHANGER

Fig.11

10E	HEAT EXCHANGER
81, 81a ~ 81c	BUFFER WALL
82, 82a ~ 82c	BUFFER SPACE
83	THROTTLE PASSAGE
88	REMAINING PORTION

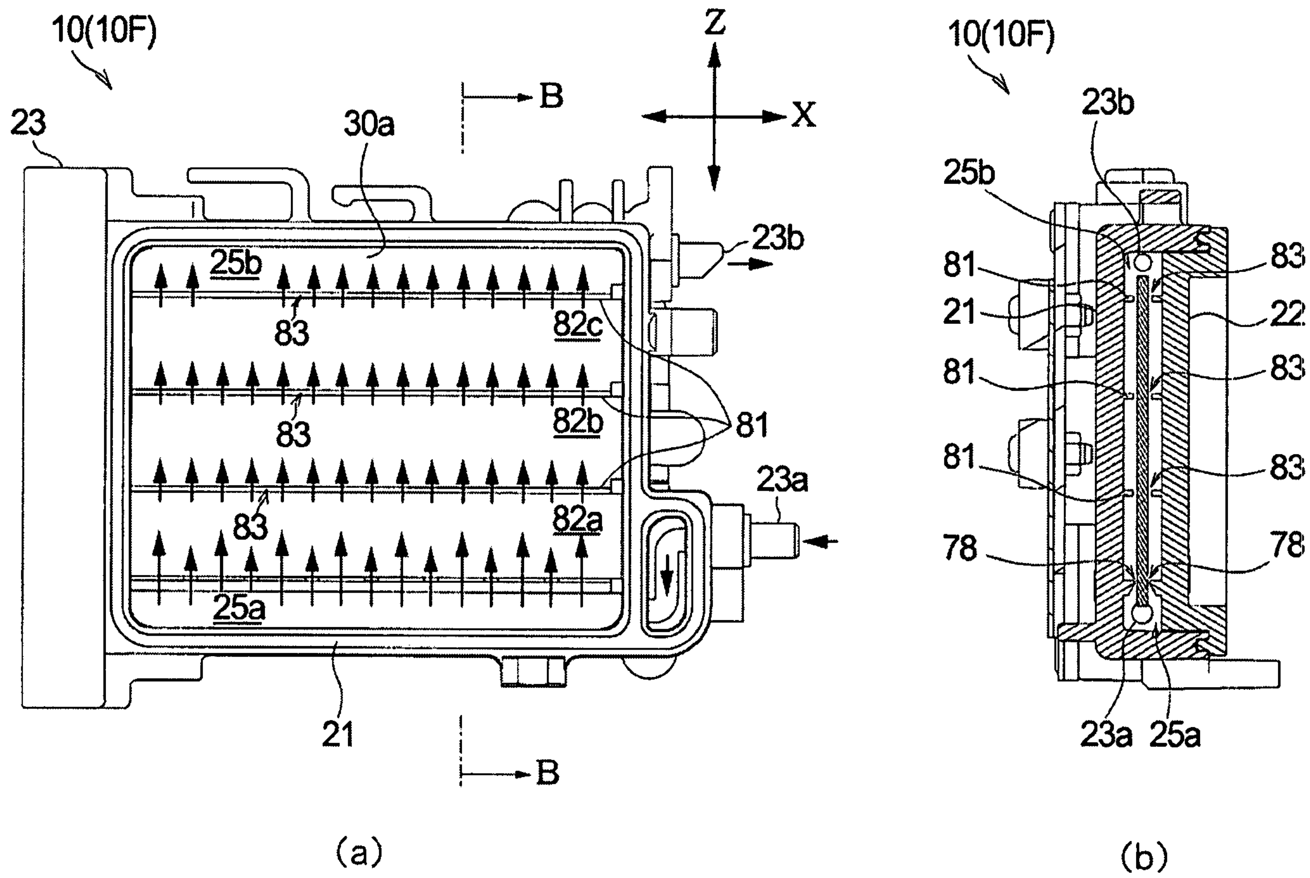


Fig. 12

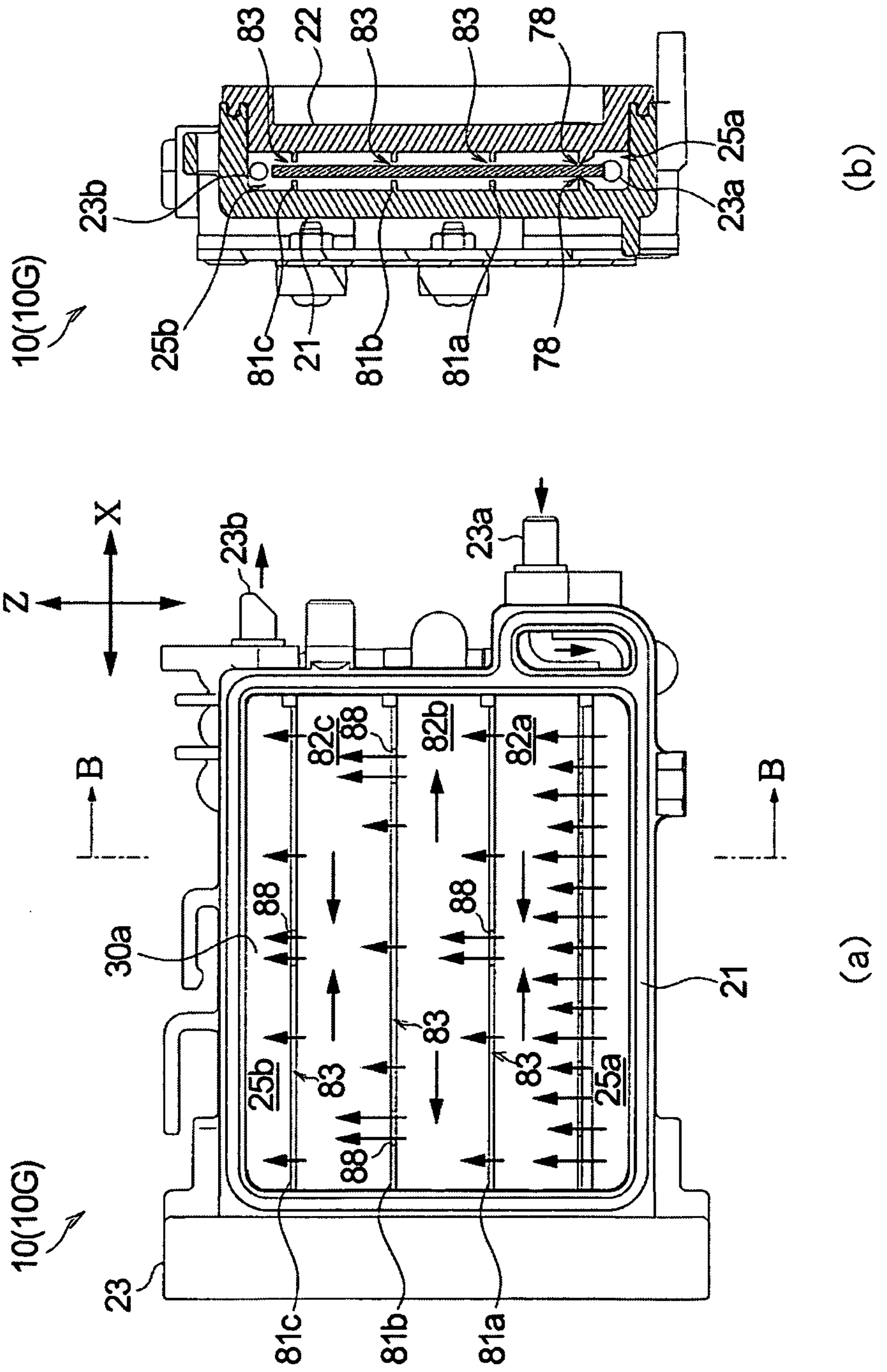

10(10G)
83
22
83
83
78
23b
25a
25b
81c
21
81b
81a
78
23a
(b)
Z
X
23b
23a
B
B
82c
88
82b
82a
30a
88
88
83
83
83
25b
25a
88
21
(a)
10(10G)
23
81c
81b
81a

Fig. 13

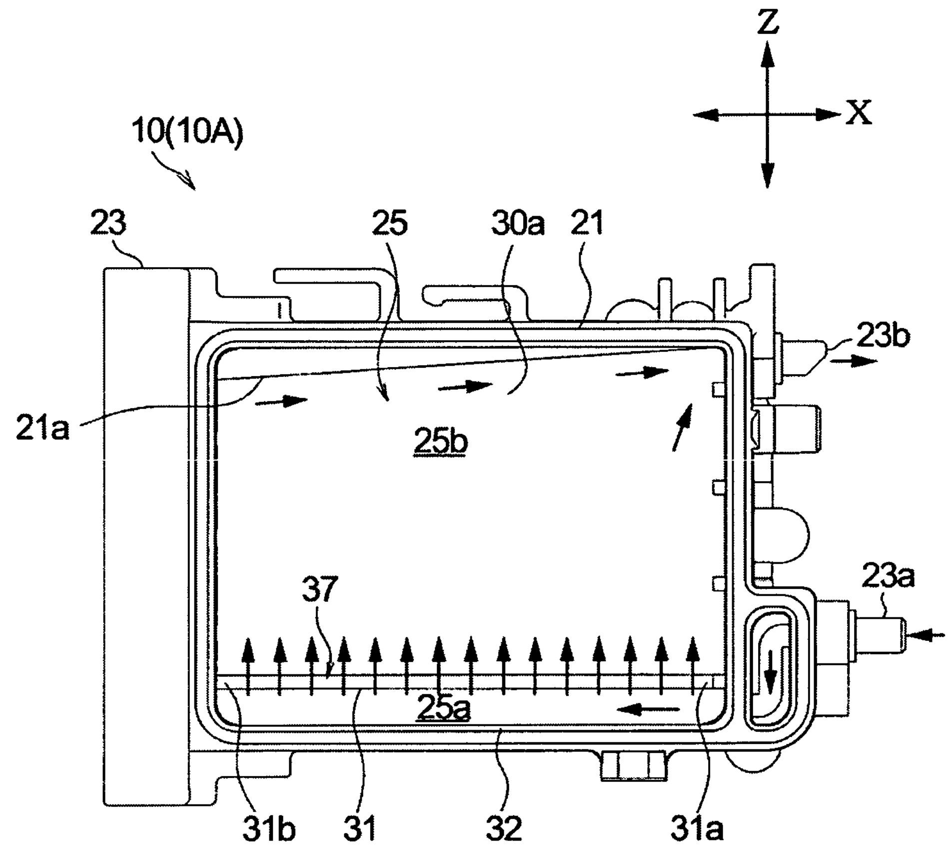


Fig.14

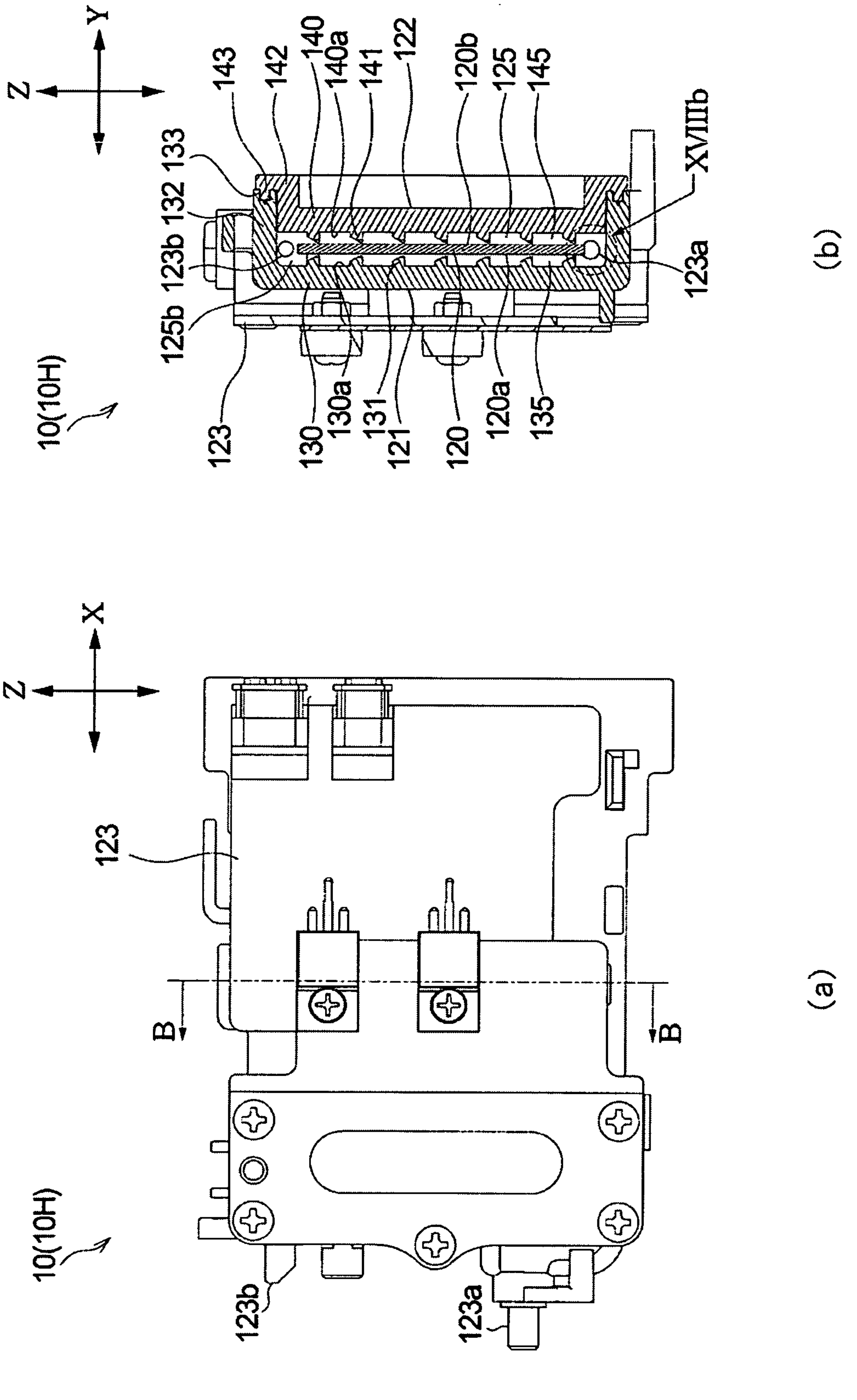

10(10H)
Z
Y
143
142
140
140a
141
122
120b
125
145
133
132
123b
125b
XVIIIb
123
130
130a
131
121
120
120a
135
123a
(b)
Z
X
123
B
B
10(10H)
123b
123a
(a)

Fig. 15

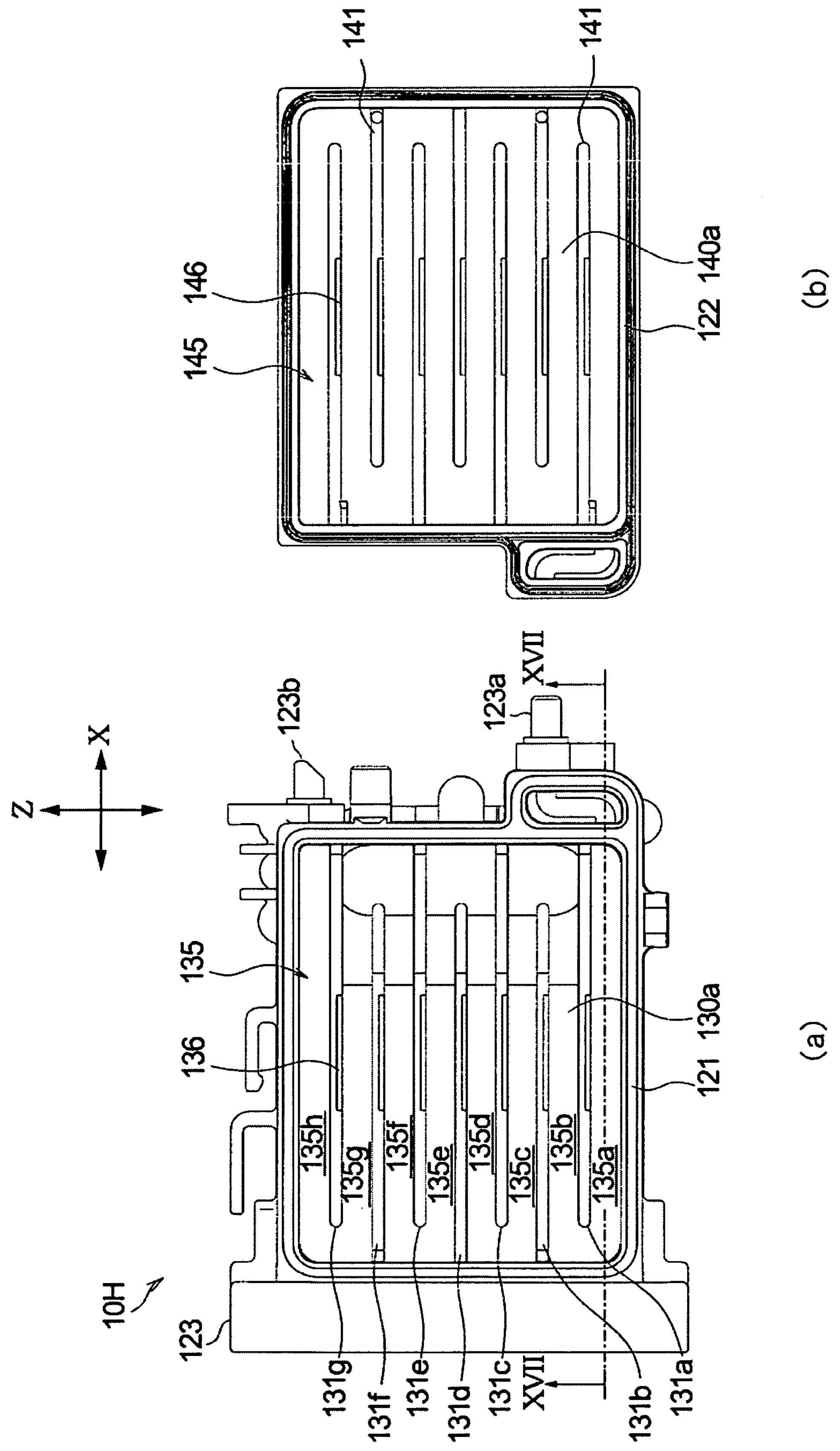

141
141
146
145
140a
122
(b)
Z
X
123b
123a
XVII
135
136
130a
121
(a)
135h
135g
135f
135e
135d
135c
135b
135a
10H
123
131g
131f
131e
131d
131c
XVII
131b
131a

Fig. 16

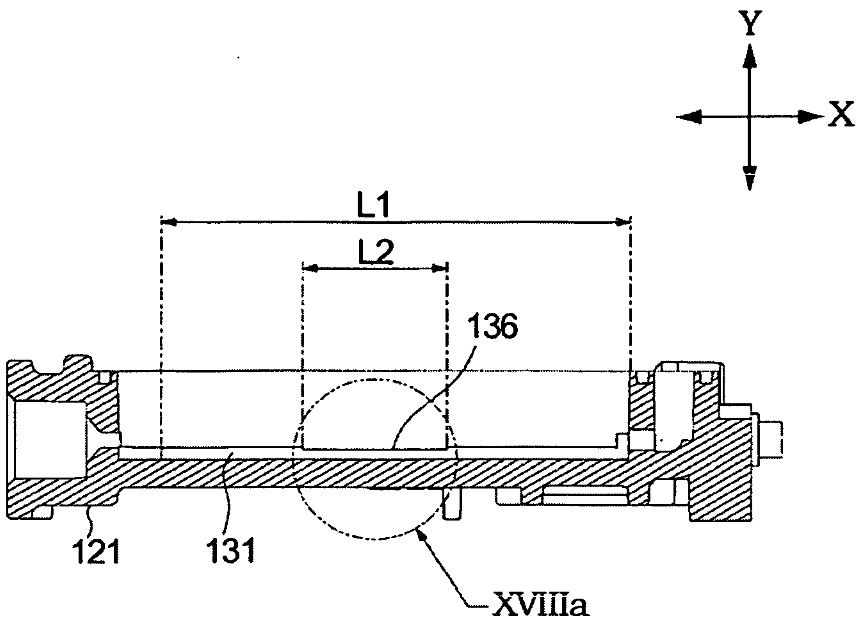
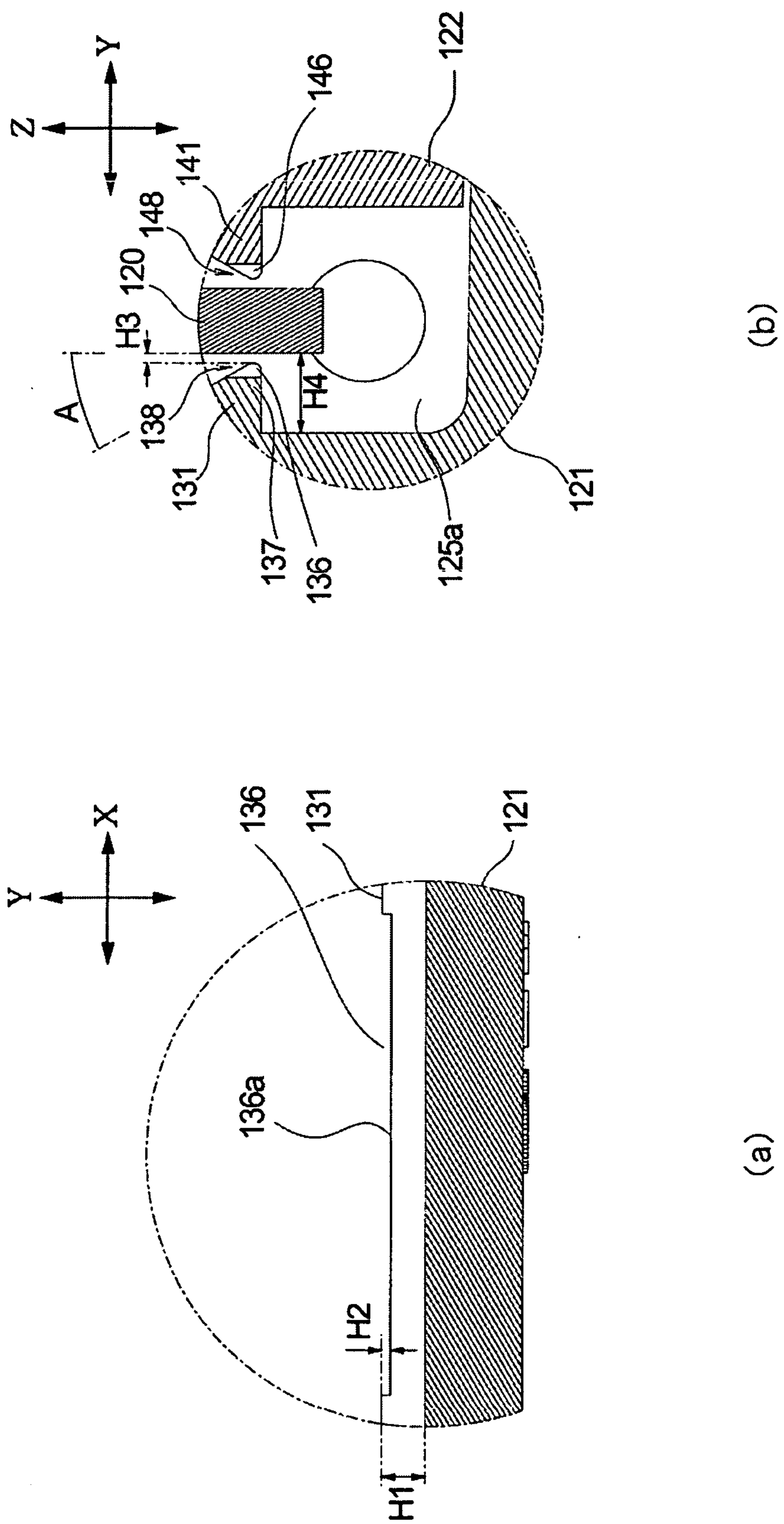


Fig.17



Z
Y
146
122
141
148
120
H3
A
138
H4
131
137
136
125a
121
(b)
Y
X
136
131
121
136a
H2
H1
(a)

Fig. 18

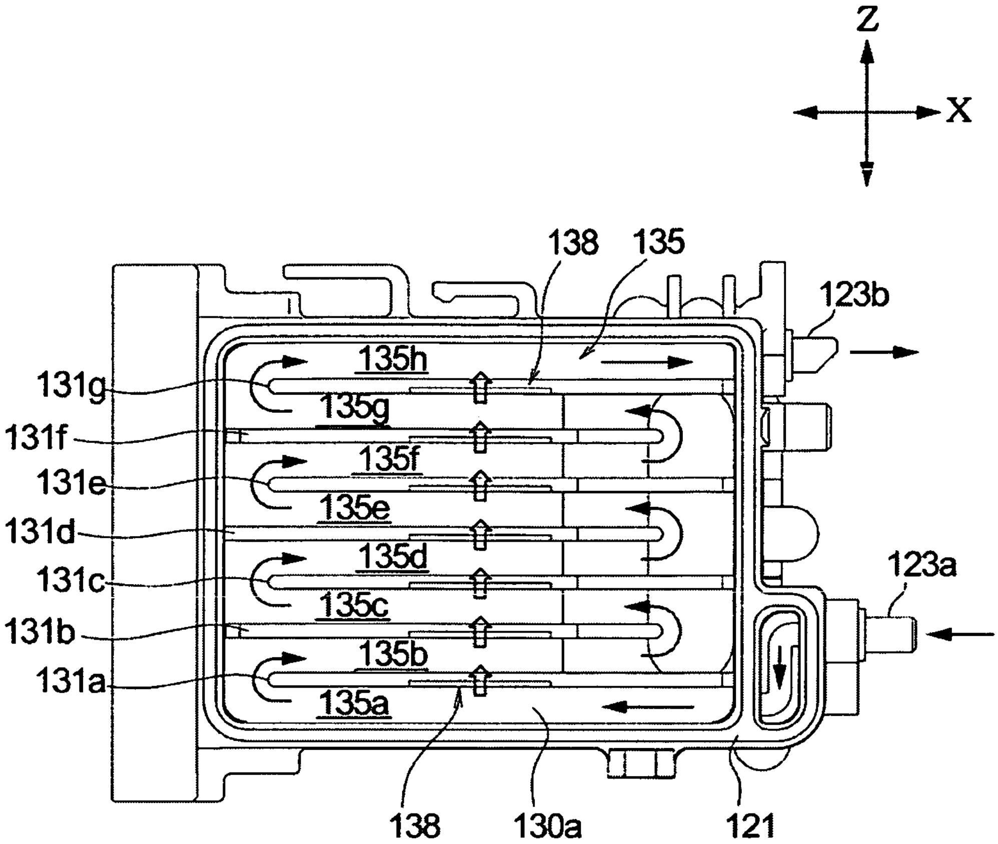

Z
X
138
135
123b
131g
135h
135g
131f
135f
131e
135e
131d
135d
131c
135c
131b
135b
131a
135a
123a
138
130a
121

Fig. 19

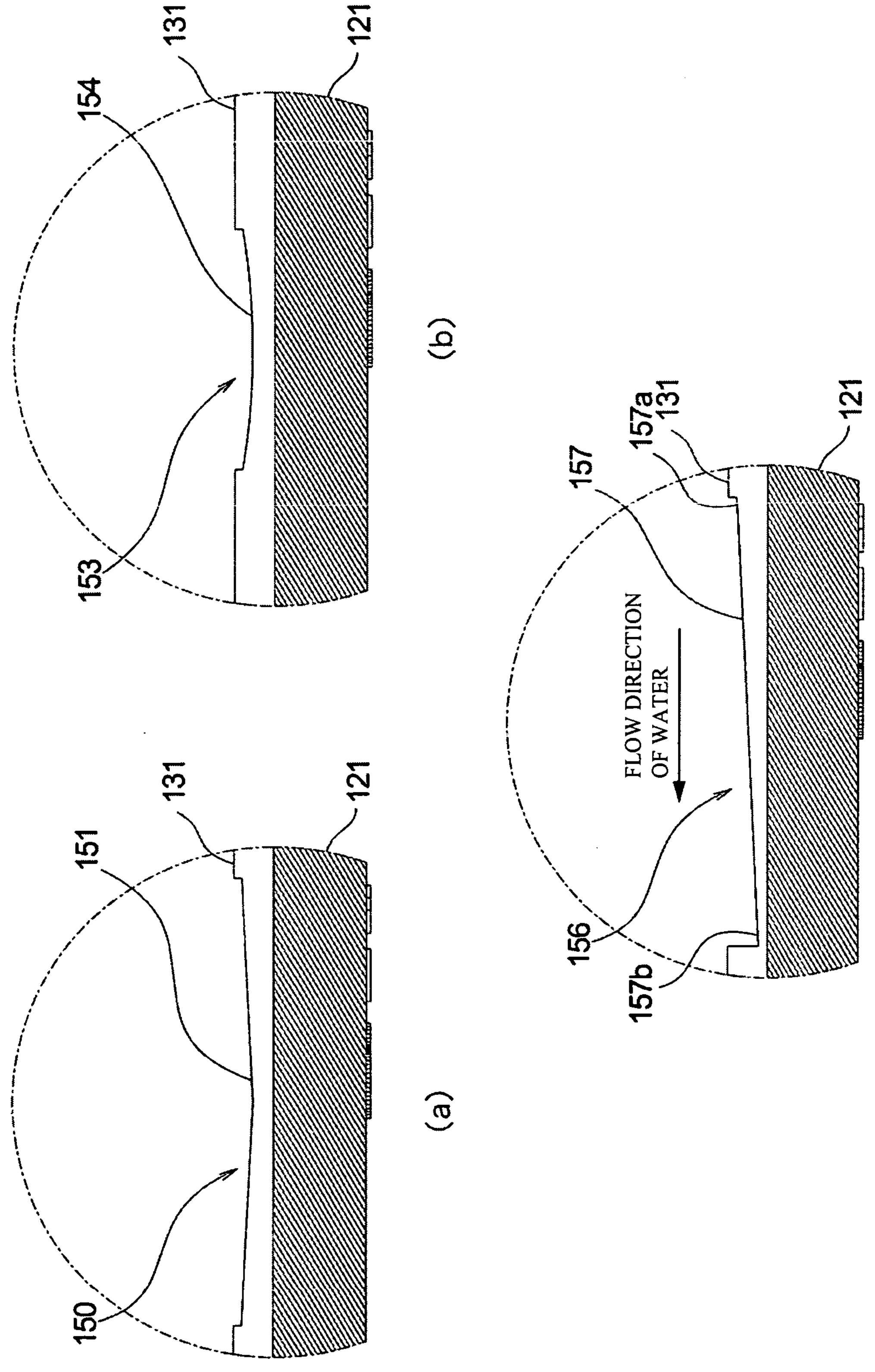

154
131
121
153
(b)
151
131
121
150
(a)
157
157a
131
121
FLOW DIRECTION
OF WATER
156
157b
(c)

Fig. 20

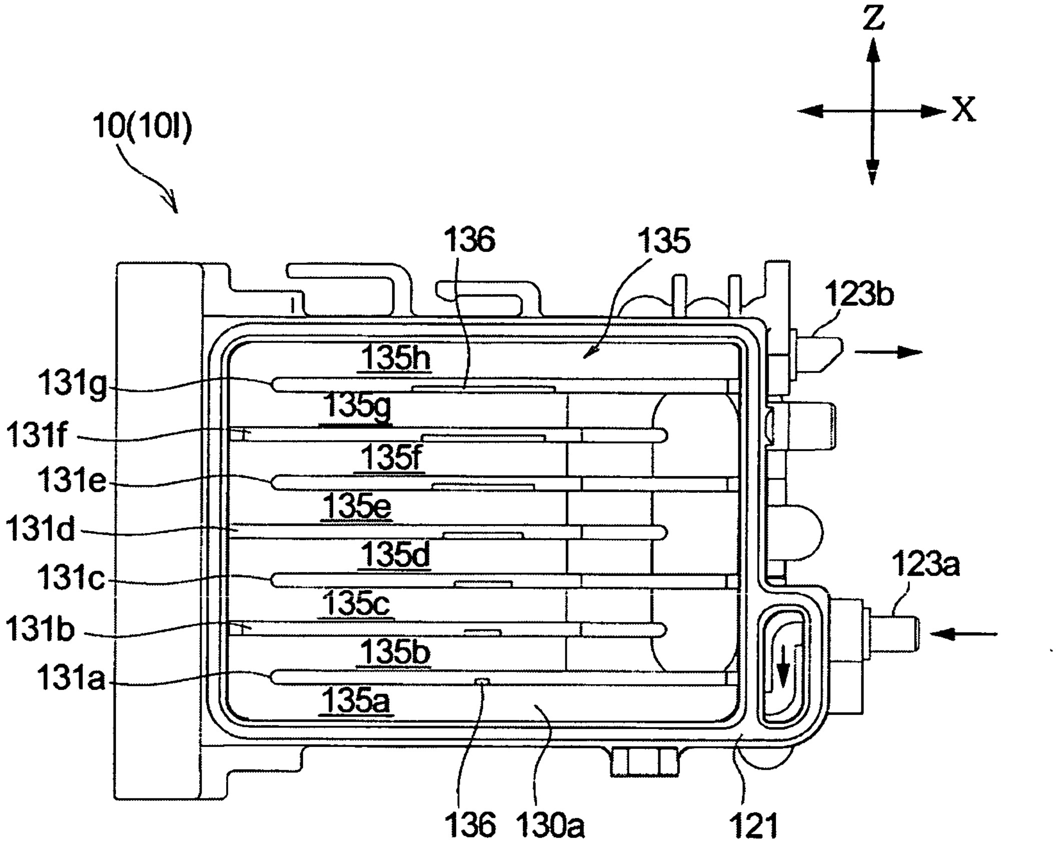

Z
X
10(10l)
136
135
123b
135h
131g
135g
131f
135f
131e
135e
131d
135d
131c
123a
135c
131b
135b
131a
135a
136
130a
121

Fig. 21

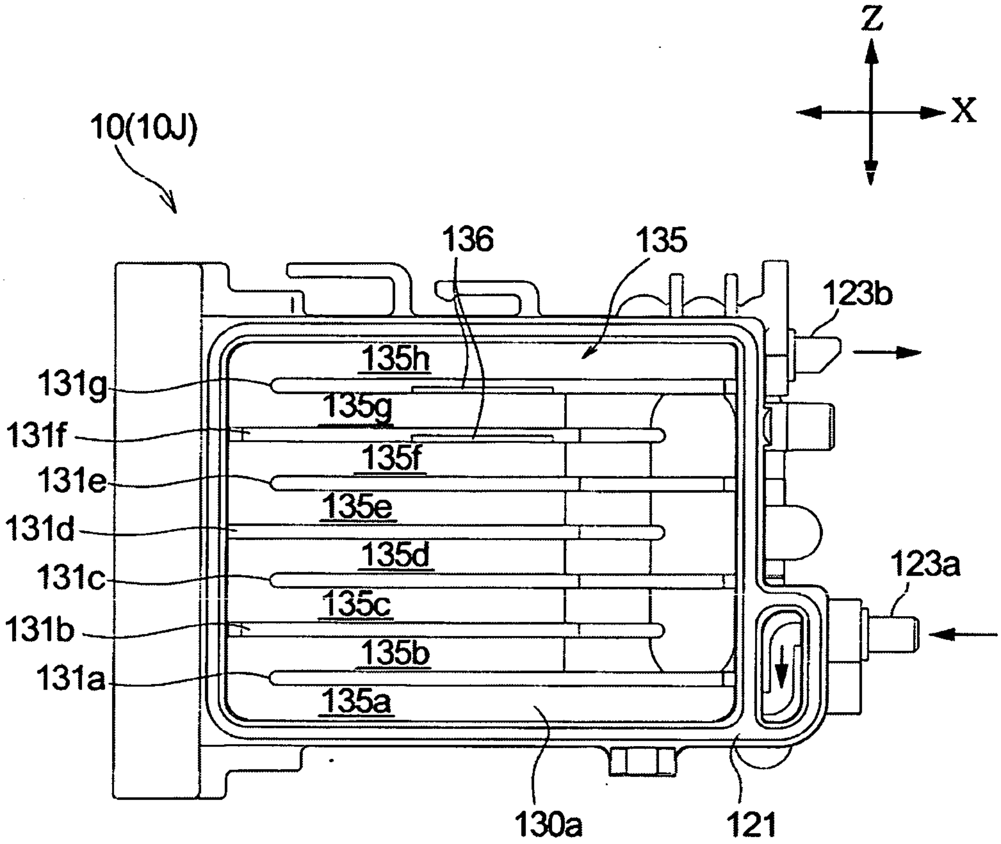

Z
X
10(10J)
136
135
123b
135h
131g
135g
131f
135f
131e
135e
131d
135d
131c
135c
131b
135b
131a
135a
123a
130a
121

Fig. 22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/005459

A. CLASSIFICATION OF SUBJECT MATTER
F24H1/10(2006.01)i, *E03D9/08*(2006.01)i

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)
F24H1/10-1/16, E03D9/08, H05B3/40-3/82

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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.
A	JP 2005-226283 A (Matsushita Electric Industrial Co., Ltd.), 25 August 2005 (25.08.2005), entire text; fig. 1 to 13 & US 2007/0143914 A1 & EP 1731849 A1 & WO 2005/057090 A1	1-23
A	JP 2005-226897 A (Matsushita Electric Industrial Co., Ltd.), 25 August 2005 (25.08.2005), entire text; fig. 1 to 11 & US 2007/0143914 A1 & EP 1731849 A1 & WO 2005/057090 A1	1-23

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 October, 2010 (04.10.10)	12 October, 2010 (12.10.10)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/005459

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 2005-171580 A (Matsushita Electric Industrial Co., Ltd.), 30 June 2005 (30.06.2005), entire text; fig. 1 to 14 & US 2007/0143914 A1 & EP 1731849 A1 & WO 2005/057090 A1	1-23
A	JP 1-25238 Y2 (Matsushita Electric Industrial Co., Ltd.), 28 July 1989 (28.07.1989), entire text; fig. 1 to 5 (Family: none)	1-23
A	JP 1-47703 B2 (Matsushita Electric Industrial Co., Ltd.), 16 October 1989 (16.10.1989), entire text; fig. 1 to 3 (Family: none)	1-23
A	JP 1-14499 B2 (Gambro Lundia AB.), 13 March 1989 (13.03.1989), entire text; fig. 1 to 5 & US 4356383 A & EP 12123 A1 & DE 2964847 D & SE 414707 B & AT 2479 E & SE 7812016 A & AT 2479 T	1-23
A	JP 2004-177092 A (Taico Co., Ltd.), 24 June 2004 (24.06.2004), entire text; fig. 1 to 2 (Family: none)	1-23

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP HEI10220876 B **[0003]**