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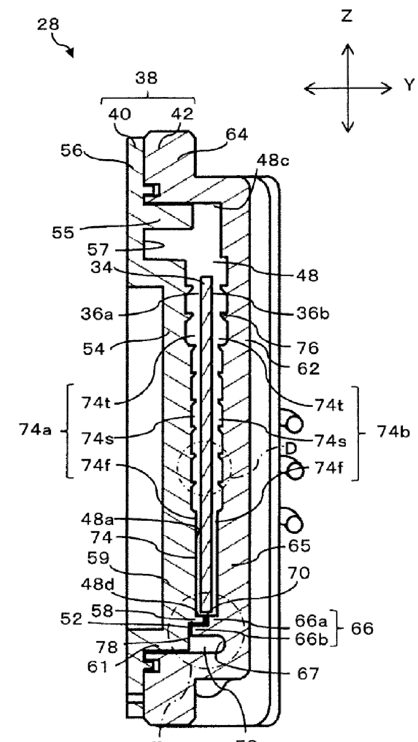
(54) **HEAT EXCHANGER AND SANITARY CLEANING DEVICE WITH SAME**

(57) A heat exchanger (28) includes a planar heater (34) and a casing (38). A heater housing space (48) includes a flow passage space (74). The casing has an inflow port (70), an outflow port (72), an inflow passage (50), a communication passage (52), first ribs (76), and a second rib (53). The first ribs project from main surfaces (48a) toward heat transfer surface (36) in the flow passage space and are extended between two side surfaces (48b). The second rib is extended in the communication passage in a direction orthogonal to a direction in which a lower end of the planar heater extends.

FIG. 6A



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Description

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger and a sanitary washing device including the heat exchanger. More particularly, the invention relates to a heat exchanger and a sanitary washing device including the heat exchanger to be disposed in a water supply passage with an upstream end to be connected to a water supply and a downstream end connected to a nozzle.

BACKGROUND ART

[0002] As a heat exchanger that is installable in a limited space, e.g., a sanitary washing device to be installed in a toilet, and is operable with a considerably smaller flow rate, there is known so far, for example, a heat exchanger disclosed in Patent Document 1. This heat exchanger includes a flow passage space between a heat transfer surface of a planar heater and a casing, as well as a header portion between the flow passage space and a water inlet. Guide ribs are arranged inside the header portion. Washing water that enters from the water inlet into the header portion is guided by the guide ribs inside the header portion to flow into the flow passage space. The washing water that flows into the flow passage space runs across the heat transfer surface of the planar heater in laminar flow due to free convection.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Patent Laid-open Publication No. 2012-233677

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] However, in the heat exchanger disclosed in Patent Document 1, laminar flow of washing water caused by free convection runs slowly and flows straightly across the heat transfer surface. Thus, little change takes place between the washing water flowing closer to the heat transfer surface and the washing water flowing farther from the heat transfer surface. Hence, the washing water flowing closer to the heat transfer surface is exposed to constant heat from the heat transfer surface, which significantly brings up the temperature of the washing water in the vicinity of the heat transfer surface. For this reason, especially in a case of hard water containing a high concentration of, for example, calcium ions causing scale, boiling of water in the vicinity of the heat transfer surface tends to cause scale to grow over the heat transfer surface.

[0005] The present invention was made to give solutions to the foregoing circumstances, and it is an object of the invention to provide a compact heat exchanger that is operable to restrict generation of scale, and a sanitary washing device including the heat exchanger.

SOLUTION TO THE PROBLEMS

[0006] A heat exchanger according to an aspect of the present invention includes: a planar heater having a vertically extending heat transfer surface; and a casing having a heater housing space defined by main surfaces opposite the heat transfer surface of the planar heater, a lower surface located below the planar heater, an upper surface located above the planar heater, and two side surfaces with the planar heater interposed therebetween. The heater housing space includes a flow passage space provided in a gap between the heat transfer surface and the main surfaces opposite the heat transfer surface. The casing has: an inflow port that opens in the lower surface and is extended in a direction in which a lower end of the planar heater extends, the inflow port communicating with the heater housing space; an outflow port provided above the inflow port, the outflow port communicating with the heater housing space; an inflow passage extended below the heater housing space in the direction in which the lower end of the planar heater extends; a communication passage connected to the inflow passage and, through the inflow port, to the heater housing space; a plurality of first ribs projecting from the main surfaces toward the heat transfer surface in the flow passage space, the first ribs being extended between the two side surfaces; and a second rib extended in the communication passage in a direction orthogonal to the direction in which the lower end of the planar heater extends.

EFFECTS OF THE INVENTION

[0007] The present invention has an effect of providing a compact heat exchanger that has the above-described structures and is operable to restrict generation of scale, and a sanitary washing device including the heat exchanger.

[0008] The above objects, other objects, features, and advantages of the present invention will become clear from the detailed description of preferred embodiments to be given below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a perspective view depicting a sanitary washing device according to Embodiment 1 of the present invention.

Fig. 2 is a schematic diagram of a structure of a washing unit in the sanitary washing device depicted in

Fig. 1.

Fig. 3 is an appearance view of a heat exchanger of Fig. 2 as viewed from the front side.

Fig. 4 is an appearance view of the heat exchanger of Fig. 2 as viewed from a lateral side.

Fig. 5 is a cross-sectional view depicting the heat exchanger taken along line B-B in Fig. 4.

Fig. 6A is a cross-sectional view depicting the heat exchanger taken along line C-C in Fig. 5.

Fig. 6B is an enlarged view of scope D of Fig. 6A.

Fig. 7 is an enlarged view of scope E of Fig. 6A.

Fig. 8 is an appearance view of a first flow passage forming member for use in the heat exchanger of Fig. 3 as viewed from the inner side.

Fig. 9 is a perspective view depicting the first flow passage forming member of Fig. 9.

Fig. 10 is an appearance view of a second flow passage forming member for use in the heat exchanger of Fig. 3 as viewed from the inner side.

Fig. 11 is a perspective view depicting the second flow passage forming member of Fig. 10.

Fig. 12A is an appearance view schematically depicting a planar heater for use in the heat exchanger of Fig. 3.

Fig. 12B is an appearance view schematically depicting a planar heater for use in the heat exchanger of Fig. 3.

Fig. 13A schematically depicts flows in a heater housing space of Fig. 6A.

Fig. 13B schematically depicts flows in a heater housing space without buffer ribs.

Fig. 14 depicts velocity distribution of flows in a flow passage space of Fig. 6A.

Fig. 15 is a graph illustrating a relationship between the height and the distance from a heat transfer surface of a flow at a maximum speed and a flow at a minimum speed in the flow passage space of Fig. 13A.

EMBODIMENTS OF THE INVENTION

[0010] A heat exchanger according to a first aspect of the present invention includes: a planar heater having a vertically extending heat transfer surface; and a casing having a heater housing space defined by main surfaces opposite the heat transfer surface of the planar heater, a lower surface located below the planar heater, an upper surface located above the planar heater, and two side surfaces with the planar heater interposed therebetween. The heater housing space includes a flow passage space provided in a gap between the heat transfer surface and the main surfaces opposite the heat transfer surface. The casing has: an inflow port that opens in the lower surface and is extended in a direction in which a lower end of the planar heater extends, the inflow port communicating with the heater housing space; an outflow port provided above the inflow port, the outflow port communicating with the heater housing space; an inflow passage extended below the heater housing space in the direction in which the lower end of the planar heater extends; a communication passage connected to the inflow passage and, through the inflow port, to the heater housing space; a plurality of first ribs projecting from the main surfaces toward the heat transfer surface in the flow passage space, the first ribs being extended between the two side surfaces; and a second rib extended in the communication passage in a direction orthogonal to the direction in which the lower end of the planar heater extends.

[0011] A heat exchanger according to a second aspect of the present invention may be such that, in the first aspect, the first ribs have a cross-sectional shape with a projecting dimension from the main surfaces higher on a side of the outflow port than on a side of the inflow port.

[0012] A heat exchanger according to a third aspect of the present invention may be such that, in the first or second aspect, the flow passage space includes a first flow passage communicating with the inflow port, and a second flow passage closer to the side of the outflow port than the first flow passage, the second flow passage being larger in gap dimension than the first flow passage, and the first ribs are arranged in the second flow passage.

[0013] A heat exchanger according to a fourth aspect of the present invention may be such that, in the third aspect, the first ribs and the heat transfer surface of the planar heater have therebetween a distance that is larger than the gap dimension of the first flow passage.

[0014] A heat exchanger according to a fifth aspect of the present invention may be such that, in any of the first to fourth aspects, the first ribs are provided such that the first ribs and the heat transfer surface of the planar heater have a larger distance therebetween than the first ribs arranged closer to the side of the inflow port than the aforementioned first ribs and the heat transfer surface of the planar heater have.

[0015] A heat exchanger according to a sixth aspect of the present invention may be such that, in any of the first to fifth aspects, the inflow passage includes a water inlet opening perpendicularly relative to the direction in which the lower end of the planar heater extends.

[0016] A sanitary washing device according to a seventh aspect of the present invention includes: the heat exchanger according to any one of claims 1 to 6; a water supply passage having the heat exchanger provided therein, the water supply passage having an upstream end to be connected to a water supply; and a nozzle connected to a downstream end of the water supply passage.

[0017] Embodiments of the present invention are specifically described below with reference to the drawings.

[0018] It is to be noted that like or corresponding parts are given like reference numerals throughout the drawings hereinafter, and description thereof is not given redundantly.

EMBODIMENT 1

STRUCTURE OF SANITARY WASHING DEVICE

[0019] Fig. 1 is a perspective view depicting a sanitary washing device according to Embodiment 1 of the present invention. As depicted in Fig. 1, a sanitary washing device 10 is installed on a trim 12 in a toilet and includes a main body 16, a seat 18, a lid 20, and an operator 22. The main body 16 is located on the back side of the seat 18, namely, at the rear side when viewed from a seated user. The main body 16 is a casing that is longer widthwise and has thereinside a substantially cuboidal heat exchanger 28 serving as a washing unit.

[0020] Fig. 2 is a schematic diagram of a structure of the washing unit in the sanitary washing device depicted in Fig. 1. As depicted in Fig. 2, the washing unit has a water supply passage 24, the heat exchanger 28, and a nozzle 32 and may further include a tank 26 and a solenoid valve 27. The features of the washing unit are controlled by a controller 29. The water supply passage 24 includes an upstream end to be connected to a water supply 30 and a downstream end connected to the nozzle 32. The heat exchanger 28, the tank 26, and the solenoid valve 27 are arranged sequentially toward the downstream side along the water supply passage 24. Thus, tap water from the water supply 30 (fluid, liquid, washing water) is led along the water supply passage 24 via the heat exchanger 28 and the tank 26 into the nozzle 32. Then, when a user operates on the operator 22 (Fig. 1) to open the solenoid valve 27, warm water that has been heated by the heat exchanger 28 and adjusted to an appropriate temperature in the tank 26 is discharged from the nozzle 32 in the form of a jet toward the opening of the trim 12 (Fig. 1).

STRUCTURE OF HEAT EXCHANGER

[0021] Fig. 3 is an appearance view depicting the heat exchanger 28 as viewed from the front side. As depicted in Fig. 3, the heat exchanger 28 includes a cuboidal casing 38, and a water inlet 80 and a water outlet 82 are arranged on a side surface of the casing 38. The casing 38 is substantially rectangular in front view and has a horizontal lengthwise dimension that is larger than the vertical heightwise dimension. The water outlet 82 is positioned above the water inlet 80, and the water inlet 80 and the water outlet 82 stick out from the side surface of the casing 38. In the description given below, the "lengthwise direction" of the heat exchanger 28 is also referred to as "X direction" or the "horizontal direction," and the "heightwise direction" is also referred to as "Z direction" or the "vertical direction".

[0022] Fig. 4 is an appearance view depicting the structure of the heat exchanger 28 as viewed in the direction of the arrow in Fig. 3 (from a lateral side). As depicted in Fig. 4, the casing 38 of the heat exchanger 28 has a vertically longer, substantially rectangular side surface and has a thickwise dimension that is smaller than the heightwise dimension. In the description given below, the "thickwise direction" of the heat exchanger 28 is also referred to as "Y direction" or the "longitudinal direction".

[0023] Fig. 5 is a cross-sectional view depicting the structure of the heat exchanger 28 taken along line B-B in Fig. 4. Fig. 6A is a cross-sectional view depicting the structure of the heat exchanger 28 taken along line C-C in Fig. 5. As depicted in these Figs. 5 and 6A, a planar heater 34 is placed inside the casing 38.

[0024] The planar heater 34 is a member for heating washing water and is housed in a heater housing space 48 in the casing 38. The planar heater 34 has a rectangular plate shape and has two surfaces (two surfaces facing the front side and the rear side when housed in the heater housing space 48) that are configured by heat transfer surfaces 36 including a first heat transfer surface 36a and a second heat transfer surface 36b. The first and second heat transfer surfaces 36a and 36b are controlled so as not to locally exceed a predetermined temperature. The predetermined temperature is set to not higher than 100°C, which is the boiling point of water, and preferably, to not higher than 80°C. It is to be noted that the predetermined temperature may also be appropriately decided according to the ion concentration of calcium or magnesium that is contained in the water or the estimated duration of the heater.

[0025] The casing 38 houses in its inner space, i.e., the heater housing space 48, the planar heater 34. The casing 38 has its interior an inflow passage 50 and a communication passage 52 in addition to the heater housing space 48, and has its side portion the water inlet 80 connected to the inflow passage 50 and the water outlet 82 connected to an upper portion of the heater housing space 48. The casing 38 is configured by, for example, a combination of a first flow passage forming member 40 and a second flow passage forming member 42 that are divided by X-Z plane.

[0026] The heater housing space 48 is substantially plate-shaped and is defined by inner surfaces of the casing 38, i.e., two, front and rear main surfaces 48a, two, right and left side surfaces 48b, an upper surface 48c, and a lower surface 48d. The two, front and rear main surfaces 48a face the first and second heat transfer surfaces 36a and 36b of the planar heater 34, respectively, and spread in parallel to the heat transfer surfaces 36a and 36b. The two, right and left side surfaces 48b spread perpendicularly relative to the heat transfer surfaces 36a and 36b with the planar heater 34 interposed therebetween. The upper surface 48c is positioned above the planar heater 34 and extends in a direction in which the upper end of the planar heater 34 extends, i.e., X direction (the horizontal direction). The lower surface 48d is positioned below the planar heater 34, faces the lower end of the planar heater 34, and extends in a direction in which the lower end extends, i.e., X direction (the horizontal direction).

[0027] An inflow port 70, an outflow port 72, and a flow passage space 74 are provided in the heater housing space 48. As depicted in Fig. 6A, the inflow port 70 is opened in the lower surface 48d that defines a lower portion of the heater housing space 48 and extends in the direction in which the lower end of the planar heater 34 extends, i.e., X direction (the horizontal direction). As depicted in Fig. 5, the outflow port 72 is positioned above the inflow port 70 and is opened in, for example, a side surface 48b that defines a lateral portion of the heater housing space 48 to communicate with the water outlet 82 of the casing 38. The lower portion of the heater housing space 48 communicates with the inflow port 70, and the upper portion communicates with the outflow port 72.

[0028] The flow passage space 74 is provided in a gap between the main surfaces 48a that define the heater housing space 48 and the heat transfer surfaces 36 of the planar heater 34. More specifically, the flow passage space 74 has a first flow passage space 74a in a gap between one (front or forward side) of the main surfaces 48a and the first heat transfer surface 36a, and a second flow passage space 74b in a gap between the other (rear or backward side) main surface 48a and the second heat transfer surface 36b.

[0029] The flow passage space 74 is divided vertically into a plurality of spaces (three in the present embodiment) based on variation in widthwise (thickwise) dimension of the gap between the main surfaces 48a and the heat transfer surfaces 36. More specifically, the flow passage space 74 is configured by a lower flow passage 74f, an intermediate flow passage 74s, and an upper flow passage 74t. While these three flow passages 74f, 74s, and 74t have an equal dimension horizontally (in X direction), the flow passages on the upper side have larger widthwise dimensions (longitudinal dimensions). Because of this structure, the widthwise dimension and the cross-sectional area taken along X-Y plane of the flow passage space 74 incrementally increase in the order of the lower flow passage 74f, the intermediate flow passage 74s, and the upper flow passage 74t. Specifically, widthwise dimension w1 of the lower flow passage 74f is larger than either the widthwise dimension of the inflow port 70 or the distance from either heat transfer surface 36 of a flow at a maximum speed, which is described later, and is set to, for example, 0.5 mm to 1.0 mm. Widthwise dimension w2 of the intermediate flow passage 74s is larger than either widthwise dimension w1 or a widthwise dimension at which air bubbles go therethrough, and is set to, for example, to 1.5 mm to 3.0 mm. Widthwise dimension w3 of the upper flow passage 74t is set larger than either widthwise dimension w2 or the widthwise dimension at which air bubbles go therethrough.

[0030] Buffer ribs 76 are disposed in the intermediate flow passage 74s and the upper flow passage 74t that are larger widthwise, and configure first ribs for mixing flows inside these flow passages 74s and 74t. In this embodiment, six buffer ribs 76 are arranged on the main surfaces 48a configuring the intermediate flow passage 74s, and two buffer ribs 76 are arranged on the main surfaces 48a configuring the upper flow passage 74t. The buffer ribs 76 are extended in, for example, the horizontal direction (X direction) and are arranged in parallel to each other so as to be equidistant in the vertical direction (Z direction). The buffer ribs 76 project from the main surfaces 48a configuring the heater housing space 48 toward the heat transfer surfaces 36 and extend across the entire extent between the two side surfaces 48b of the heater housing space 48. The height of the buffer ribs 76 from the main surfaces 48a is set such that the distance between the buffer ribs 76 and each heat transfer surface 36 is larger than widthwise dimension w1 of the lower flow passage 74f and also is smaller than half widths w2 and w3 of the intermediate flow passage 74s and the upper flow passage 74t. Further, the height (the projecting dimension) of the buffer ribs 76 from the main surfaces 48a is set such that the flow at a maximum speed to be described later is positioned between the buffer ribs 76 and each heat transfer surface 36. Too large a heightwise dimension of the buffer ribs 76 impedes bubbles from passing between the buffer ribs 76 and the heat transfer surfaces 36. Meanwhile, too small a heightwise dimension of the buffer ribs 76 hinders sufficient mixing of flows inside the flow passages 74s and 74t as well as accelerating of flows inside the flow passages 74s and 74t.

[0031] As depicted in Fig. 5, the inflow passage 50 extends in the direction of extension of the lower end (the horizontal direction) of the planar heater 34 and has an end connected to the water inlet 80. As depicted in Fig. 6A, an opening 78 is provided at an upper portion of the inflow passage 50. The opening 78 is provided over the entire length of the inflow passage 50 and extends in the direction of extension of the lower end of the planar heater 34. The widthwise dimension of the opening 78 (the longitudinal dimension) is smaller than the widthwise dimension of the lower flow passage 74f of the flow passage space 74, and specifically, is defined based on the flow rate per unit time period of the washing water that flows in from the water inlet 80. Too small a width of the opening 78 increases the pressure loss of washing water that passes through the opening 78. Meanwhile, too large a width of the opening 78 makes it difficult for washing water to pass upward through the opening 78 when the longitudinal speed of washing water that flows in from the water inlet 80 is sufficiently reduced in the inflow passage 50.

[0032] The communication passage 52 connects the inflow port 70 of the heater housing space 48 with the opening 78 of the inflow passage 50 to accelerate the washing water that flows upward from the opening 78 toward the inflow port 70. The communication passage 52 extends in the direction of extension of the lower end of the planar heater 34 and also extends upward from the opening 78 to the inflow port 70 while bending longitudinally. To describe more specifically, the communication passage 52 extends upward from the opening 78, then bends at a substantially right angle to extend longitudinally, and subsequently bends further at a substantially right angle to extend upward, so as to reach the inflow port 70 (see also Fig. 7 to be described later). The communication passage 52 is smaller in widthwise dimension and cross-sectional area taken along X-Y plane than the inflow passage 50 and the lower flow passage 74f of the flow passage space 74.

[0033] Fig. 6B is an enlarged view of scope D of Fig. 6A. As depicted in Fig. 6B, the buffer ribs 76 have a substantially right triangle-shaped or trapezoidal cross section taken along Y-Z plane, and the heightwise dimension from the main surfaces 48a is larger on the side of the outflow port 72 (Fig. 5) as compared to the side of the inflow port 70 (Fig. 6A). The buffer ribs 76 each have a slant surface 76a, a vertex portion 76b, and a perpendicular surface 76c. The slant surfaces 76a stand obliquely upward from the main surfaces 48a to the vertex portions 76b smoothly at a blunt angle. Specifically, the slant surfaces 76a are planes that extend upward in the direction approaching the heat transfer surfaces 36 to reach the vertex portions 76b. The vertex portions 76b are the farthest from the main surfaces 48a in the buffer ribs 76; in other words, the vertex portions 76b are positioned closest to the heat transfer surfaces 36. The perpendicular surfaces 76c are planes that extend perpendicularly relative to the heat transfer surfaces 36 and the main surfaces 48a from the vertex portions 76b. It is to be noted that the cross-sectional shape taken along Y-Z plane of the buffer ribs 76 is not limited to the right triangular shape or the trapezoidal shape as depicted in Fig. 6B. However, the cross-sectional shape is preferably such that surfaces on the upstream side of the flow of washing water, i.e., the above-described "slant surfaces 76a," and the main surfaces 48a make an angle larger than the angle made by surfaces on the downstream side, i.e., the above-described "perpendicular surfaces 76c," and the main surfaces 48a. The buffer ribs 76 that project from the main surfaces 48a toward the heat transfer surfaces 36 have at least slant surfaces that have a larger heightwise dimension from the main surfaces 48a toward the upper end of the planar heater 34 in Y-Z plane that is perpendicular to the heat transfer surfaces 36. The slant surfaces preferably slant in such a way as to guide the flow of washing water from the side of the inflow port 70 toward the outflow port 72.

[0034] Fig. 7 is an enlarged view of scope E of Fig. 6A. As depicted in Fig. 7, guide ribs 53 are second ribs for guiding the washing water flowing through the communication passage 52 to regulate the stream into the upward direction, and are each configured by a first guide rib portion 60 and a second guide rib portion 68. The L-shaped first guide rib portions 60 extend upward from the opening 78 of the inflow passage 50 and bend in the longitudinal direction along the communication passage 52. The second guide rib portions 68 extend upward from the vicinity of the first guide rib portions 60 toward the inflow port 70 of the heater housing space 48. As depicted in Fig. 5, these guide ribs 53 are arranged, being spaced in the horizontal direction. The intervals at which the guide ribs 53 are arranged are set according to the flow rate of the washing water that flows from the inflow passage 50 into the communication passage 52. For example, in a case where washing water flows in at a substantially even flow rate in the horizontal direction, the guide ribs 53 are arranged equidistantly. In a case where washing water flows in at a larger flow rate on the side of the water inlet 80 in the horizontal direction, the intervals at which the guide ribs 53 are arranged are set narrower with the smaller distance to the water inlet 80.

[0035] Fig. 8 is an appearance view depicting a structure of the first flow passage forming member 40 as viewed from the inner side (from the rear side). Fig. 9 is a perspective view of the first flow passage forming member 40. As depicted in these Figs. 8 and 9, the first flow passage forming member 40 includes an inner surface and an outer surface that are parallel to X-Z plane. The inner surface refers to one of two surfaces of the first flow passage forming member 40 that includes the main surface 48a defining the heater housing space 48. Meanwhile, the outer surface refers to the other surface of the two surfaces of the first flow passage forming member 40. The first flow passage forming member 40 is made of a resin with high heat resistance, shock resistance, and processability, e.g., a reinforced acrylonitrile-butadiene-styrene (ABS) resin that is a compound of glass fiber with an ABS resin.

[0036] The first flow passage forming member 40 has a first plate-shaped portion 54 that mainly forms the inner space of the casing 38, i.e., the heater housing space 48, the inflow passage 50, and the communication passage 52, and a first flange 56 that is disposed to surround the first plate-shaped portion 54. In the description to be given below about the first flow passage forming member 40, the rearward-facing surfaces of the portions are appropriately referred to as a "top surface" or a "bottom surface".

[0037] A first projection 55 is disposed at an upper portion of the first plate-shaped portion 54 and below the first flange 56. The first projection 55 sticks out rearward from one of the surfaces of the first plate-shaped portion 54 and extends in the horizontal direction. Further, the first projection 55 curves downward at a horizontal end, i.e., an end closer to the water outlet 82, with the result that the projection makes substantially an L-shape as a whole. A substantially L-shaped first recess 57 is provided below the first projection 55 along the first projection 55. The first recess 57 has a bottom surface that is recessed frontward relative to the top surface of the first projection 55.

[0038] A first wall upper portion 59 is disposed below the first recess 57. The first wall upper portion 59 has a substantially oblong top surface, and the top surface provides the main surface 48a as described later. Thus, as described earlier, the plurality of buffer ribs 76 is extended over the entire area in the horizontal direction on the top surface, i.e., the main surface 48a, of the first wall upper portion 59. A horizontally extending first lateral projection 58 is disposed below the first wall upper portion 59. The first lateral projection 58 sticks out further rearward from the top surface of the first wall upper portion 59 and, as depicted in Fig. 7, has a rectangular cross section along Y-Z plane.

[0039] A first wall lower portion 61 is disposed below the first lateral projection 58. The first wall lower portion 61 has a bottom surface that is recessed frontward relative to the top surface of the first lateral projection 58, and the bottom surface is extended along the first lateral projection 58 in the horizontal direction. First vertical projections 60 are arranged on the first lateral projection 58 and the first wall lower portion 61. More specifically, the first vertical projections 60 are each configured by a portion that projects downward from the lower surface of the first lateral projection 58 and a portion that projects rearward from the bottom surface of the first wall lower portion 61, and are substantially L-shaped in side view (see Fig. 7).

[0040] Fig. 10 is an appearance view depicting a structure of the second flow passage forming member 42 as viewed from the inner side (from the front side). Fig. 11 is a perspective view of the second flow passage forming member 42. As depicted in these Figs. 10 and 11, the second flow passage forming member 42 includes an inner surface and an outer surface that are parallel to X-Z plane. The inner surface refers to one of two surfaces of the second flow passage forming member 42 that includes the main surface 48a defining the heater housing space 48. Meanwhile, the outer surface refers to the other surface of the two surfaces of the second flow passage forming member 42. Similar to the first flow passage forming member 40, the second flow passage forming member 42 is made of a resin with high heat resistance, shock resistance, and processability.

[0041] The second flow passage forming member 42 has a second plate-shaped portion 62 that mainly forms the inner space of the casing 38, i.e., the heater housing space 48, the inflow passage 50, and the communication passage 52, and a second flange 64 that is disposed to surround the second plate-shaped portion 62. The second flange 64 is provided to project frontward relative to the second plate-shaped portion 62. In the description to be given below about the second flow passage forming member 42, the frontward-facing surfaces of the portions are appropriately referred to as a "top surface" or a "bottom surface".

[0042] The second plate-shaped portion 62 has a second wall portion 65 that takes most of the area surrounded by the second flange 64. The second wall portion 65 has a substantially oblong top surface, and the top surface provides the main surface 48a as described later. Thus, as described earlier, the plurality of buffer ribs 76 is extended over the entire area in the horizontal direction on the top surface, i.e., the main surface 48a, of the second wall portion 65. A horizontally extending second lateral projection 66 is disposed below the second wall portion 65. The second lateral projection 66 is shaped stepwise and has a lower portion 66a with a smaller frontward-projecting dimension and a higher portion 66b that is positioned below the lower portion 66a and has a larger frontward-projecting dimension.

[0043] A plurality of second vertical projections 68 is arranged on the second lateral projection 66. The second vertical projections 68 are arranged on the top surface of the lower portion 66a of the second lateral projection 66, and project frontward from the top surface and extend in the vertical direction. A second recess 67 that extends in the horizontal direction is provided below the second lateral projection 66. The second recess 67 has a bottom surface that is recessed rearward relative to the top surface of the second lateral projection 66.

[0044] As depicted in Fig. 6A, the first flange 56 of the first flow passage forming member 40 and the second flange 64 of the second flow passage forming member 42 are joined by ultrasonic welding in an watertight manner, such that the first projection 55 and the first wall lower portion 61 of the first flow passage forming member 40 both fit on the inner side of the second flange 64 of the second flow passage forming member 42. In this manner, the casing 38 is formed. In the casing 38, the top surface and the lower surface of the first projection 55, the bottom surface of the first recess 57, the upper surface and the top surface of the first wall upper portion 59, and the upper surface of the first lateral projection 58 of the first flow passage forming member 40 define a portion of the heater housing space 48. The lower surface of the second flange 64, the top surface of the second wall portion 65, the upper surface of the lower portion 66a of the second lateral projection 66 of the second flow passage forming member 42 define another portion of the heater housing space 48. The top surface of the first wall upper portion 59 provides the main surface 48a that is opposite the first heat transfer surface 36a of the planar heater 34, and the top surface of the second wall portion 65 provides the main surface 48a that is opposite the second heat transfer surface 36b of the planar heater 34. Further, the upper surface of the first lateral projection 58 and the upper surface of the lower portion 66a of the second lateral projection 66 provide the lower surface 48d that is opposite the lower end of the planar heater 34. The distance between the top surface of the first lateral projection 58 and the top surface of the lower portion 66a of the second lateral projection 66, the distance between the lower surface of the first lateral projection 58 and the upper surface of the higher portion 66b of the second lateral projection 66, and the distance between the bottom surface of the first wall lower portion 61 and the top surface of the higher portion 66b of the second lateral projection 66 define the communication passage 52. A lower portion of the top surface of the first wall lower portion 61 covers the opening of the second recess 67 to define the inflow passage 50. The first vertical projections 60 provide the first guide rib portions 60 of the guide ribs 53, whereas the second vertical projections 68 provide the second guide rib portions 68 of the guide ribs 53.

[0045] Figs. 12A and 12B are appearance views schematically depicting the planer heater. As depicted in Figs. 12A and 12B, the planar heater 34 includes a ceramic substrate 44, a heater line 46, and electrodes (not shown). The heater line 46 is a resistive pattern printed on the ceramic substrate 44, and the two ends are connected with the electrodes. Electric conduction through the heater line 46 from the electrodes produces heat in the heater line 46, and the ceramic substrate 44 with a high heat transfer property transmits the heat, such that the heat transfer surfaces 36 become high-temperature. The heater line 46 is arranged on the ceramic substrate 44 in such a manner that the heat quantity per unit area of the heat transfer surfaces 36 increases toward the lower side. For example, as depicted in Fig. 12A, in a case where the cross-sectional area of the heater line 46 becomes smaller toward the lower side, the resistance value of the heater line 46 increases toward the lower side, and the heat quantity per unit area of the heat transfer surfaces 36 increases toward the lower side. As another example, as depicted in Fig. 12B, in a case where the distance among the heater line 46 arranged in a meandering manner becomes smaller toward the lower side, the heat quantity per unit area of the heat transfer surfaces 36 increases toward the lower side.

FLOWS OF WASHING WATER IN HEAT EXCHANGER

[0046] As depicted in Figs. 5 and 6A, in the heat exchanger 28, washing water flows in from the water inlet 80 connected to the water service line into the inflow passage 50. At this point, the washing water flows through the inflow passage 50 lengthwise due to the water supply pressure of the water service line. It is to be noted here that the cross-sectional area of the opening 78 along X-Y plane is smaller compared to the cross-sectional area of the inflow passage 50 along X-Y plane. For this reason, the washing water flows from the opening 78 into the communication passage 52 with the horizontal (X direction) speed reduced in the inflow passage 50.

[0047] Since the cross-sectional area along X-Y plane of the communication passage 52 remains smaller, the washing water is accelerated in the upward direction to pass the communication passage 52 rapidly. Because of this, air bubbles contained in the washing water passes without staying through the communication passage 52 with the rapid flow of the washing water. It is to be noted here that washing water passes between the guide ribs 53 in the communication passage 52. At this point, the vertically extending guide ribs 53 guides the washing water upward perpendicularly relative to the horizontal direction, and the flow rate of the washing water that flows from the communication passage 52 into the heater housing space 48 becomes approximately even in the horizontal direction.

[0048] The washing water that flows in from the inflow port 70 into the heater housing space 48 branches evenly to the first flow passage space 74a and to the second flow passage space 74b. The shapes of the portions of the flow passage spaces 74 are designed such that the Reynolds number of the fluid (washing water) in the lower flow passage 74f, the intermediate flow passage 74s, and the upper flow passage 74t is about 200 or less at this point. More specifically, the washing water that flows in the flow passage spaces 74 has the Reynolds number that is greatly smaller than the critical Reynolds number of 2300, so as to flow in the state of laminar flow.

[0049] Further, since the cross-sectional area along X-Y plane is comparatively small in the lower flow passage 74f, the washing water flows rapidly, such that forced convection occurs. Thus, the washing water flows faster widthwise (in the longitudinal direction) relative to the heat transfer surfaces 36, such that the heat transfer rate from the heat transfer surfaces 36 to the washing water increases, enabling effective heating of the washing water. The heat transfer surfaces 36 impart heat to the washing water and thus the temperature thereof lowers, which prevents overheat of the heat transfer surfaces 36. The flow is faster in the lower flow passage 74f, and air bubbles contained in the washing water is carried upward rapidly with the flow. Further, even though the heat quantity per unit area of the heat transfer surfaces 36 in the lower flow passage 74f is set at a high value, the washing water that flows in from the inflow port 70 into the lower flow passage 74f remains in a low-temperature state, and the heat transfer rate is still high because of the high flow speed of the washing water. For this reason, retention and local heating of washing water are suppressed, preventing generation of air bubbles due to boiling of washing water.

[0050] Fig. 13A schematically depicts the flow of washing water in the heater housing space 48. Fig. 13B schematically depicts the flow of washing water in a heater housing space without buffer ribs. As depicted in this Fig. 13A, washing water flows in from the lower flow passage 74f into the intermediate flow passage 74s of the heater housing space 48. As can be seen, the flow passage space 74 abruptly widens with the main surfaces 48a of the casing 38 extending away from the heat transfer surfaces 36 in the border portion from the lower flow passage 74f toward the intermediate flow passage 74s. At this point, separation of flow occurs, such that the flows along the main surfaces 48a deviate to the side of the heat transfer surfaces 36. Thus, the separated flows merge with the flows of free convection along the heat transfer surfaces 36, and the flows on the side of the heat transfer surfaces 36 pick up speed. In this manner, the heat transfer rate increases, and the washing water is heated rapidly. Further, since the flows separating from the main surfaces 48a are lower in temperature than the flows along the heat transfer surfaces 36, the flows mix into each other, such that the flows along the heat transfer surfaces 36 are restrained from becoming so hot as to boil.

[0051] Since the intermediate flow passage 74s has a greater width and a larger cross-sectional area along X-Y plane, the washing water flows in laminar flow due to free convection. Thus, as depicted in Fig. 13B, in a flow passage space 74 without the buffer ribs 76, the washing water flows parallel along the heat transfer surfaces 36. As the flow due to free convection flows at a significantly slower speed, the washing water especially in the vicinity of the heat transfer surfaces 36 tends to heat up and boil.

[0052] On the other hand, as depicted in Fig. 13A, in the intermediate flow passage 74s provided with the buffer ribs 76, the flows that are farther from the heat transfer surfaces 36 and proceed along the main surfaces 48a remain in laminar flow and smoothly flow following the slant surfaces 76a of the buffer ribs 76, so as to be brought closer to the side of the heat transfer surfaces 36. Thus, the flows farther from the heat transfer surfaces 36 merge with the flows in the vicinity of the heat transfer surfaces 36, and the low-temperature washing water farther from the heat transfer surfaces 36 restrains excessive rise in temperature of the washing water in the vicinity of the heat transfer surfaces 36. In this manner, the washing water is prevented from boiling in the vicinity of the heat transfer surfaces 36.

[0053] Further, the washing water flowing through the intermediate flow passage 74s flows in the velocity distribution as depicted in Fig. 14. Curve F in Fig. 14 schematically represents the velocity of washing water at positions on virtual straight line S drawn widthwise of the heater housing space. The washing water has a faster speed at a position on straight line S as the lengthwise dimension between straight line S and curve F is larger at the position. Specifically, the velocity of the washing water is slower at positions closer to the heat transfer surfaces 36 and the main surfaces 48a, and the velocity of the washing water becomes the fastest at positions that are closer to the heat transfer surfaces 36 than the widthwise centers. The length of the arrow depicted between straight line S and curve F schematically represents the velocity of the washing water at proximal end position Sm of the arrow representing this flow at the maximum speed.

[0054] Fig. 15 is a graph illustrating a relationship between the position in the vertical direction (the horizontal axis) and the distance from the heat transfer surfaces of a flow at a maximum speed and a flow at a minimum speed (the vertical axis) in the flow passage space of Fig. 13A. It is to be noted that, in the graph of Fig. 15, the range from 0 mm to 15 mm corresponds to the lower flow passage 74f, the range from 15 mm to 40 mm corresponds to the intermediate flow passage 74s, and the range from 40 mm to 50 mm corresponds to the upper flow passage 74t. Further in this graph, the line labeled with max denotes the positions of the maximum speed flow. As depicted in this Fig. 15, the maximum speed flow with the fastest speed of washing water is positioned within about 0.5 mm from the heat transfer surfaces 36.

[0055] According to the line labeled with "max", the maximum speed flow is positioned within about 0.5 mm from either heat transfer surface 36 and in the vicinity of the heat transfer surface 36. However, the distance from the heat transfer surface 36 of the maximum speed flow is slightly larger as the position in the vertical direction in the flow passage space 74 is higher. As can be seen, the width of the flow passage space 74 is increased incrementally in the upward direction, and the maximum speed flow proceeds away from the heat transfer surface 36 accordingly. Meanwhile, since the height of the buffer ribs 76 is set such that the maximum speed flow is positioned between the buffer ribs 76 and the heat transfer surfaces 36, the maximum speed flow is not obstructed by the buffer ribs 76. Hence, the maximum speed flow in the vicinity of the heat transfer surfaces 36 is allowed to maintain its higher speed.

[0056] As has been described, the speed flows in the vicinity of the heat transfer surfaces 36 are faster, and, as described with reference to Fig. 13A, the flows on the side of the main surfaces 48a mix into the speed flows in the vicinity of the heat transfer surfaces 36. Thus, the flow speed of washing water becomes faster at the vertex portions 76b of the buffer ribs 76 at which the flow passage has a smaller cross-sectional area, and the maximum speed flow at a position closer to either heat transfer surface 36 becomes even faster. Hence, the heat transfer rate from the heat transfer surfaces 36 to washing water increases, enabling the washing water to be effectively heated. Further, since the height of the buffer ribs 76 is set such that air bubbles go therethrough, bubbles are pushed up by this rapid flow to rise without staying in the intermediate flow passage 74s.

[0057] As the washing water passes the vertex portions 76b of the buffer ribs 76, the intermediate flow passage 74s widens abruptly because of the perpendicular surfaces 76c. For this reason, separation of flow occurs, and the flows on the side of the main surfaces 48a proceed away to the side of the heat transfer surfaces 36. Thus, the flows are mixed again, such that the temperature of the washing water is lowered on the side of the heat transfer surfaces 36, attaining a uniform temperature of washing water in the widthwise direction of the flow passage.

[0058] In this manner, the washing water that has gone through the intermediate flow passage 74s flows into the upper flow passage 74t and, as depicted in Fig. 5, makes its way through the flow passage space 74 toward the outflow port 72 in the same manner as in the intermediate flow passage 74s while being heated by the heat transfer surfaces 36 with the flows intermixing. Thus, the washing water that is heated approximately uniformly flows out through the outflow port 72 from the water outlet 82.

EFFECT

[0059] The communication passage 52 and the guide ribs 53 create a faster flow of washing water in the heightwise direction, and the buffer ribs 76 maintain the flow speed inside the flow passage space 74. Thus, bubbles are rapidly discharged upward without staying, the heat transfer rate from the heat transfer surfaces 36 is enhanced, and overheat of the heat transfer surfaces 36 is prevented. As a result, the heat exchanger 28 is downsized, and generation of scale is prevented. Moreover, the flow passage space 74 that enlarges incrementally furthers these effects.

[0060] More specifically, the washing water that flows in along the lengthwise direction by the action of the guide ribs 53 in the communication passage 52 is guided in the heightwise direction. The washing water then flows into the flow passage space 74 evenly along the lengthwise direction and runs rapidly in laminar flow in the heightwise direction through the flow passage space 74. Thus, the washing water exchanges heat effectively with the heat transfer surfaces 36 uniformly in the heightwise direction in the flow passage space 74, such that the temperature distribution over the heat transfer surfaces 36 becomes uniform. Hence, the planar heater 34 is protected from, for example, cracks and fracture due to heat stress that could be caused by difference in temperature in the planar heater.

[0061] Further, washing water flows in laminar flow in the upward direction in the flow passage space 74, such that bubbles are smoothly carried upward with the laminar flow. Thus, bubbles are prevented from adhering to the heat transfer surfaces 36, which could otherwise lead to growth of scale over the heat transfer surfaces 36, and the heat transfer surfaces 36 are kept from becoming locally high-temperature.

[0062] Further, in a case where the water supply pressure from the water inlet 80 is high, the size of the inflow passage 50 is often increased or the width of the communication passage 52 is often greatly narrowed in order to decelerate the washing water in the lengthwise direction. Enlarging the inflow passage 50 leads to increase in size of the heat exchanger 28. Greatly narrowing the width of the communication passage 52 leads to growth in pressure loss. On the other hand, since the lengthwise speed of washing water is reduced by the guide ribs 53, downsizing of the inflow passage 50 and decrease in pressure loss are thus achieved.

[0063] The width of the flow passage space 74 is increased incrementally in the order of the lower flow passage 74f, the intermediate flow passage 74s, and the upper flow passage 74t, such that separation of flow occurs from the main surfaces 48a, and that the high-temperature flows in the vicinity of the heat transfer surfaces 36 merge with the low-temperature flows on the side of the main surfaces 48a. Thus, the temperatures of the washing water in the vicinity of the heat transfer surfaces 36 as well as the heat transfer surfaces 36 themselves are lowered, restraining generation of bubbles due to boiling and generation of scale.

[0064] Further, the maximum speed flows in the vicinity of the heat transfer surfaces 36 merge with the flows on the side of the main surfaces 48a, such that the flows in the vicinity of the heat transfer surfaces 36 become faster. Thus, the heat transfer rate from the heat transfer surfaces 36 to washing water is enhanced, and washing water is heated effectively from the heat transfer surfaces 36. Moreover, since bubbles are carried quickly upward by the rapid flow, scale to be caused by attachment of bubbles is prevented from being generated over the heat transfer surfaces 36.

[0065] The buffer ribs 76 are arranged in the intermediate flow passage 74s and the upper flow passage 74t where free convection takes place, and the buffer ribs 76 cause the flows on the side of the main surfaces 48a to be merged with the flows in the vicinity of the heat transfer surfaces 36. Thus, the temperature of the high-temperature washing water in the vicinity of the heat transfer surfaces 36 is lowered by the low-temperature washing water on the side of the main surfaces 48a, thus preventing boiling of washing water, generation of bubbles, and generation of scale.

[0066] Further, the buffer ribs 76 are arranged at such positions as not to impede the maximum speed flows. Hence, the flows on the side of the main surfaces 48a merge with the maximum speed flows in the vicinity of the heat transfer surfaces 36, causing the maximum speed flows to pick up speed. Thus, in the vicinity of the heat transfer surfaces 36, the heat transfer rate from the heat transfer surfaces 36 to the washing water is enhanced, and the washing water is effectively heated. Moreover, bubbles are quickly carried upward by the rapid flow along the heat transfer surfaces 36, preventing adhering of bubbles and generation of scale over the heat transfer surfaces 36.

[0067] Further, the substantially right triangle shape of the buffer ribs 76 promotes smooth mixing of flows, acceleration of flows, and movement of bubbles.

EMBODIMENT 2

[0068] In the foregoing Embodiment 1, the buffer ribs 76 have an equal height from the main surfaces 48a in the heater housing space 48. On the other hand, the buffer ribs 76 may have heights that lower toward the outflow port 72. With this configuration, the distance between the buffer ribs 76 and the heat transfer surfaces 36 increases toward the outflow port 72. Thus, even if bubbles are heated and bloated toward the outflow port 72, the bubbles pass smoothly between the buffer ribs 76 and the heat transfer surfaces 36. Hence, adhering of bubbles and generation of scale over the heat transfer surfaces 36 are further restrained.

OTHER VARIANTS

[0069] In the foregoing embodiments, the water inlet 80 is provided at a lengthwise end of the inflow passage 50; however, the position is not limited thereto. For example, the water inlet 80 may be provided at a lateral portion or a lower portion of the inflow passage 50.

[0070] In the foregoing embodiments, the width of the communication passage 52 is set constantly from the inflow passage 50 to the heater housing space 48. On the other hand, the communication passage 52 may be formed such that the width thereof narrows from the inflow passage 50 toward the heater housing space 48. In this case, as the width becomes narrower, the velocity of the washing water becomes faster. Thus, bubbles are quickly discharged upward without staying in the communication passage 52.

[0071] In the foregoing embodiments, the guide ribs 53 are configured by the first guide rib portions 60 and the second guide rib portions 68. On the other hand, guide ribs may be configured by either the first guide rib portions 60 or the second guide rib portions 68. Further, guide ribs may be formed by connection of the first guide rib portions 60 with the second guide rib portions 68. Moreover, the first guide rib portions 60 are L-shaped and the second guide rib portions 68 are straight, but the shapes are not limited thereto.

[0072] In the foregoing embodiments, the buffer ribs 76 have, but not limited to, a cross section in the shape of a substantially right triangle along Y-Z plane. For example, the cross-sectional shape may be other triangular shape such as an equilateral triangle, a polygonal shape such as rectangle, or a shape enclosed with curves.

[0073] In the foregoing embodiments, the outflow port 72 is opened in the side surfaces 48b of the heater housing space 48, but the position is not limited thereto. The outflow port 72 may be positioned at any position insofar as the position is above the inflow port 70, such as in the upper surface 48c of the heater housing space 48.

[0074] Moreover, the foregoing embodiments may be wholly combined with each other insofar as there is no contradiction.

[0075] Many improvements and other embodiments of the present invention are apparent from the foregoing description to those skilled in the art. Therefore, the foregoing description should be interpreted only by way of illustration and is presented for the purpose of teaching the best mode for carrying out the present invention to those skilled in the art. The details of the structures and/or functions can be substantially modified without departing from the spirit of the present invention.

INDUSTRIAL APPLICABILITY

[0076] The heat exchanger and the sanitary washing device including the heat exchanger, according to the present invention are useful as, for example, a compact heat exchanger that is operable to restrain generation of scale, and a sanitary washing device including the heat exchanger.

DESCRIPTION OF REFERENCE SIGNS

[0077]

10: Sanitary washing device
24: Water supply passage
28: Heat exchanger
30: Water supply
32: Nozzle
34: Planar heater
36: Heat transfer surface
38: Casing
48: Heater housing space (housing space)
48a: Main surface
48b: Side surface
48d: Lower surface
50: Inflow passage
52: Communication passage
53: Guide rib (second rib)
70: Inflow port
72: Outflow port
74: Flow passage space
74f: Lower flow passage (first flow passage)
74s: Intermediate flow passage (second flow passage)
74t: Upper flow passage (second flow passage)
76: Buffer rib (first rib)
78: Opening
80: Water inlet

Claims

1. A heat exchanger comprising:

a planar heater having a vertically extending heat transfer surface; and
a casing having a heater housing space defined by main surfaces opposite the heat transfer surface of the planar heater, a lower surface located below the planar heater, an upper surface located above the planar heater, and two side surfaces with the planar heater interposed therebetween,
the heater housing space including a flow passage space provided in a gap between the heat transfer surface and the main surfaces opposite the heat transfer surface,
the casing having:

an inflow port that opens in the lower surface and is extended in a direction in which a lower end of the planar heater extends, the inflow port communicating with the heater housing space;
an outflow port provided above the inflow port, the outflow port communicating with the heater housing space;
an inflow passage extended below the heater housing space in the direction in which the lower end of the planar heater extends;
a communication passage connected to the inflow passage and, through the inflow port,

to the heater housing space;
a plurality of first ribs projecting from the main surfaces toward the heat transfer surface in the flow passage space, the first ribs being extended between the two side surfaces; and
a second rib extended in the communication passage in a direction orthogonal to the direction in which the lower end of the planar heater extends.

2. The heat exchanger according to claim 1, wherein the first ribs have a cross-sectional shape with a projecting dimension from the main surfaces higher on a side of the outflow port than on a side of the inflow port.

3. The heat exchanger according to claim 1 or 2, wherein
the flow passage space includes a first flow passage communicating with the inflow port, and a second flow passage closer to the side of the outflow port than the first flow passage, the second flow passage being larger in gap dimension than the first flow passage, and
the first ribs are arranged in the second flow passage.

4. The heat exchanger according to claim 3, wherein the first ribs and the heat transfer surface of the planar heater have therebetween a distance that is larger than the gap dimension of the first flow passage.

5. The heat exchanger according to any one of claims 1 to 4, wherein
the first ribs are provided such that the first ribs and the heat transfer surface of the planar heater have a larger distance therebetween than the first ribs arranged closer to the side of the inflow port than said first ribs and the heat transfer surface of the planar heater have.

6. The heat exchanger according to any one of claims 1 to 5, wherein
the inflow passage includes a water inlet opening perpendicularly relative to the direction in which the lower end of the planar heater extends.

7. A sanitary washing device comprising:

the heat exchanger of any one of claims 1 to 6;
a water supply passage having the heat exchanger provided therein, the water supply passage having an upstream end to be connected to a water supply; and
a nozzle connected to a downstream end of the water supply passage.

FIG. 1

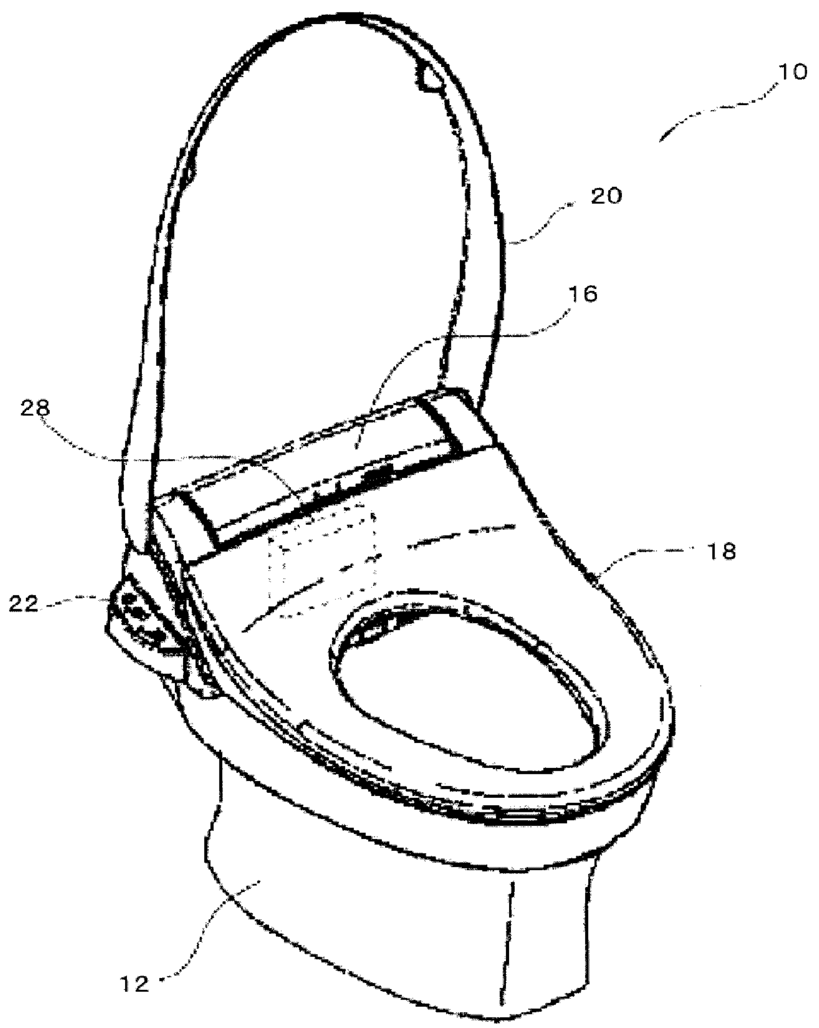


FIG. 2

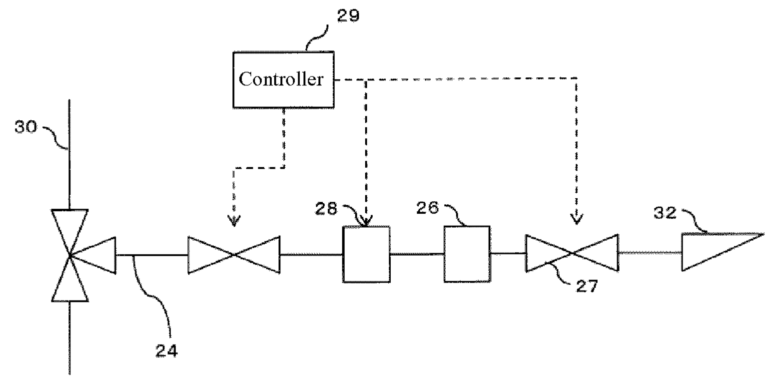


FIG. 3

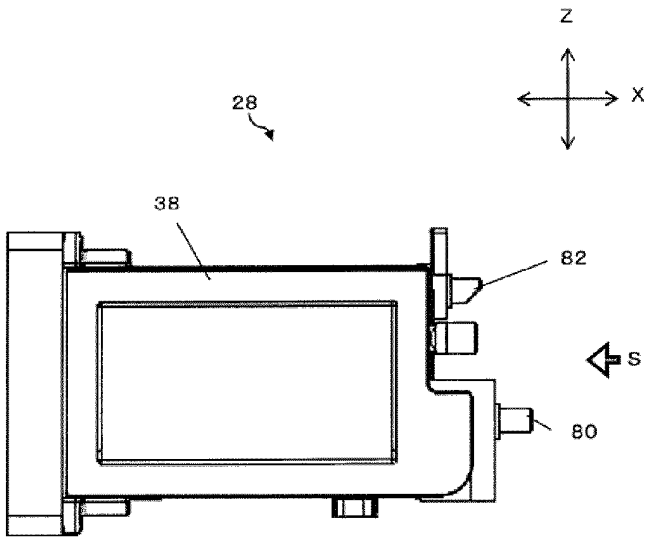


FIG. 4

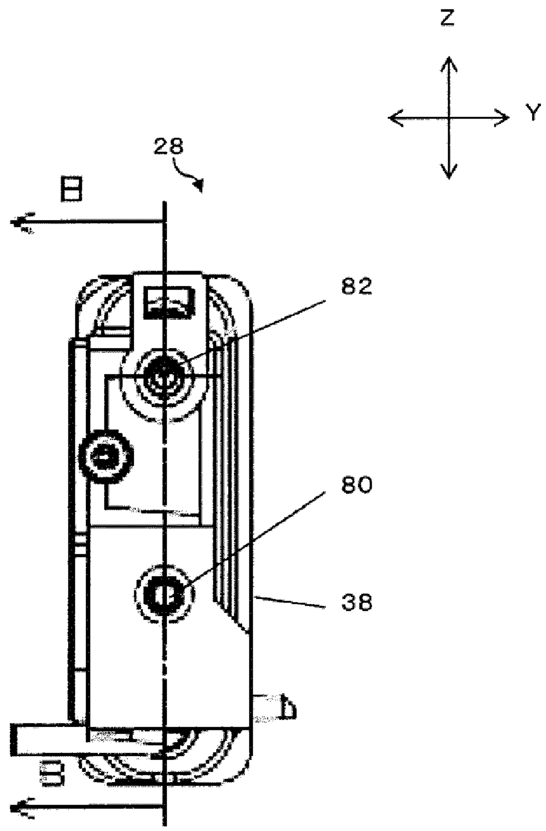


FIG. 5

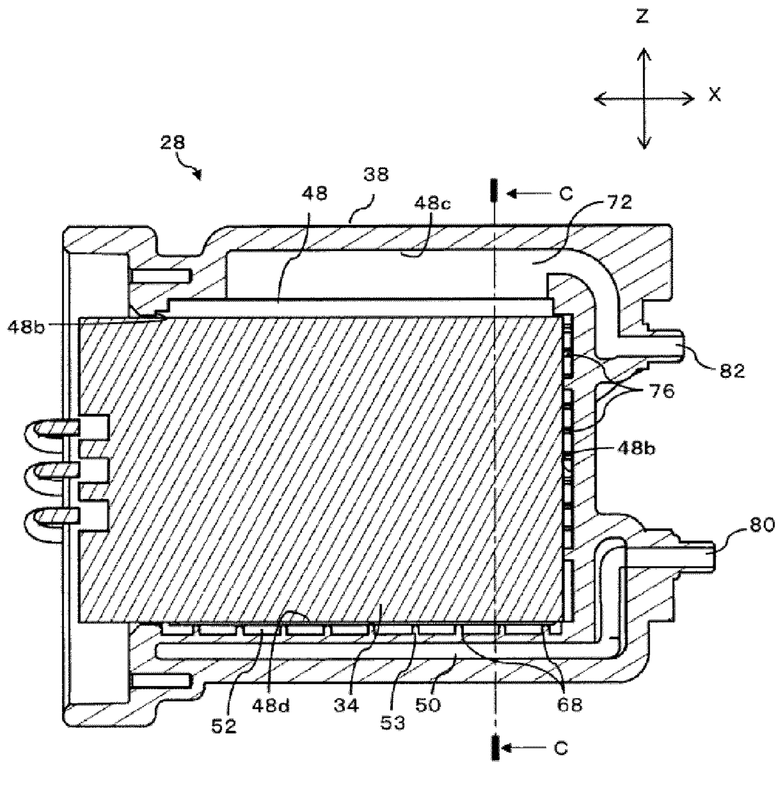
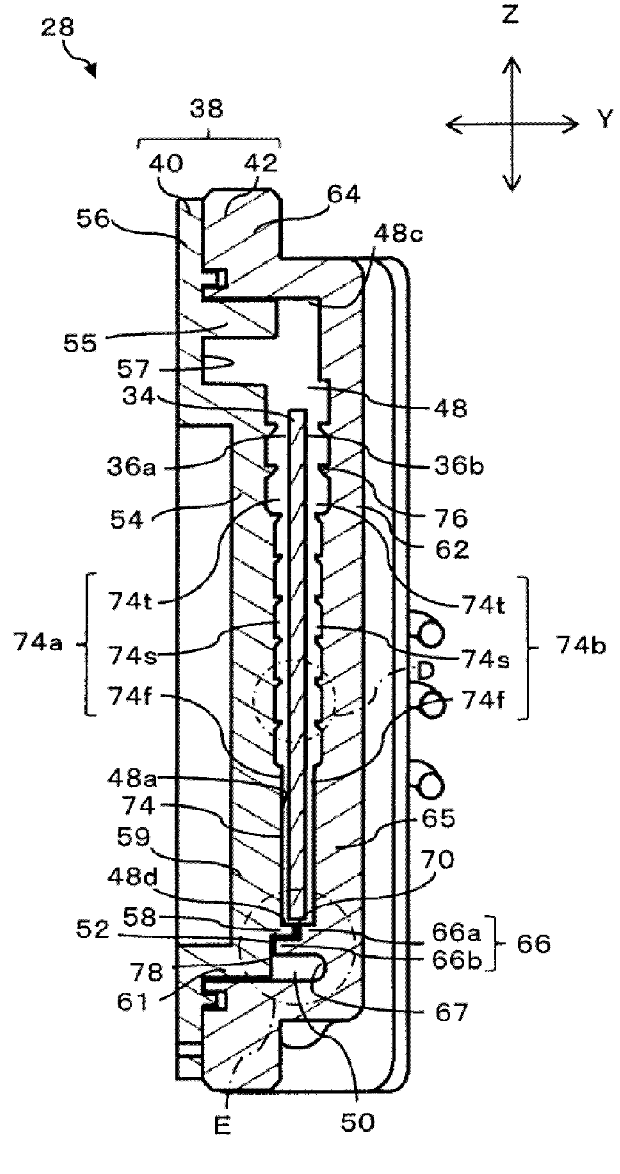


FIG. 6A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36b
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74s
74s
74b
D
74f
74f
48a
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E
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Z
Y

FIG. 6B

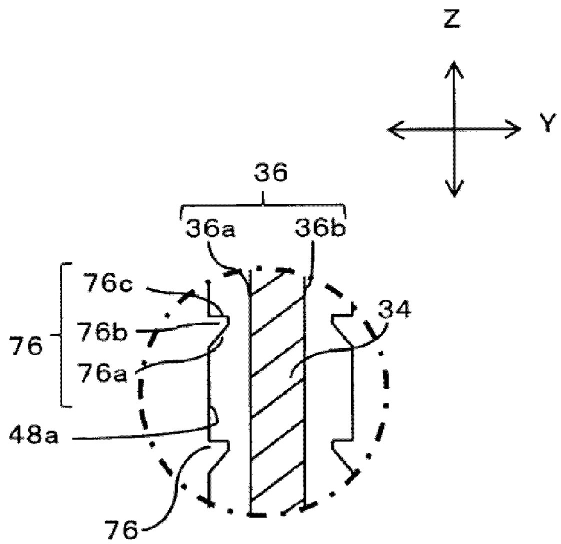

FIG. 7

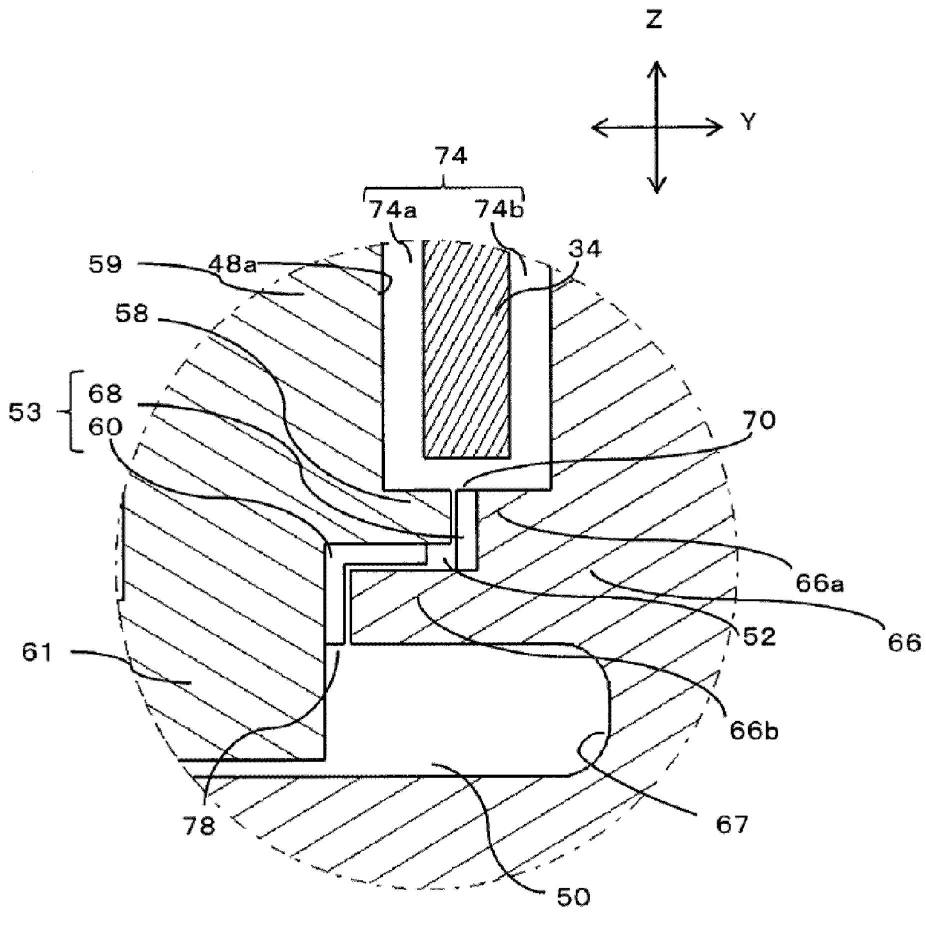

FIG. 8

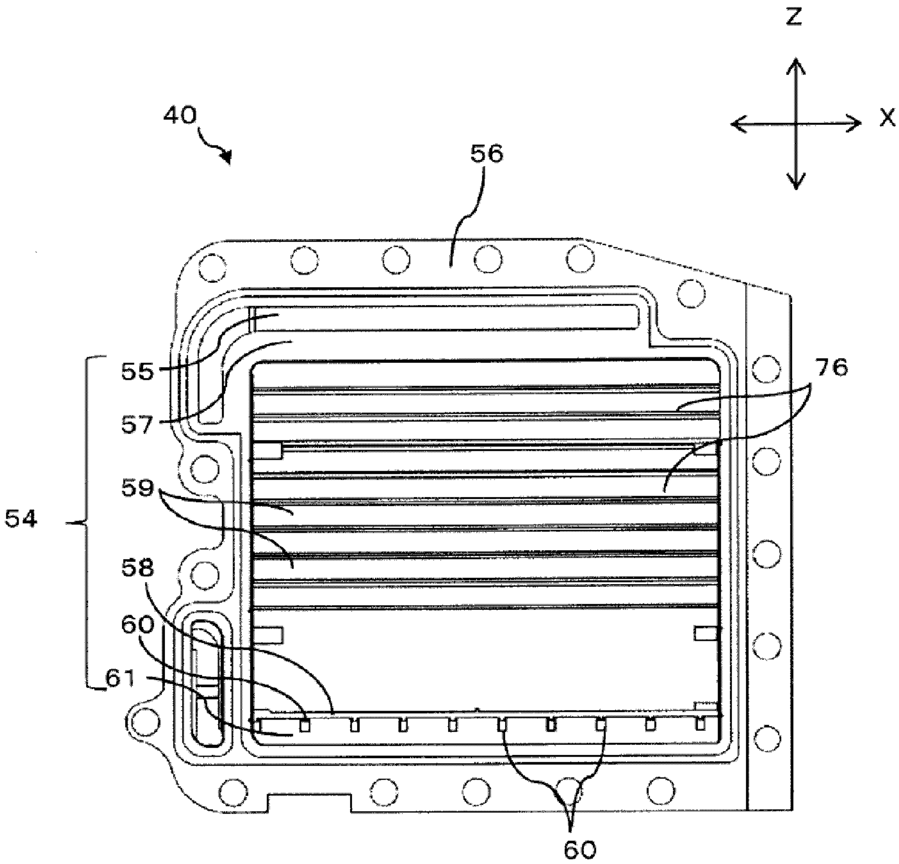

FIG. 9

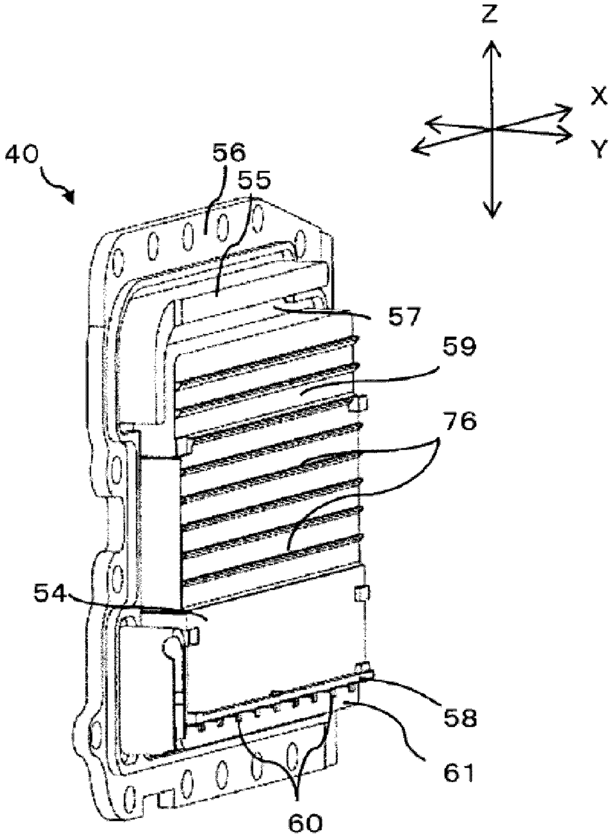

FIG. 10

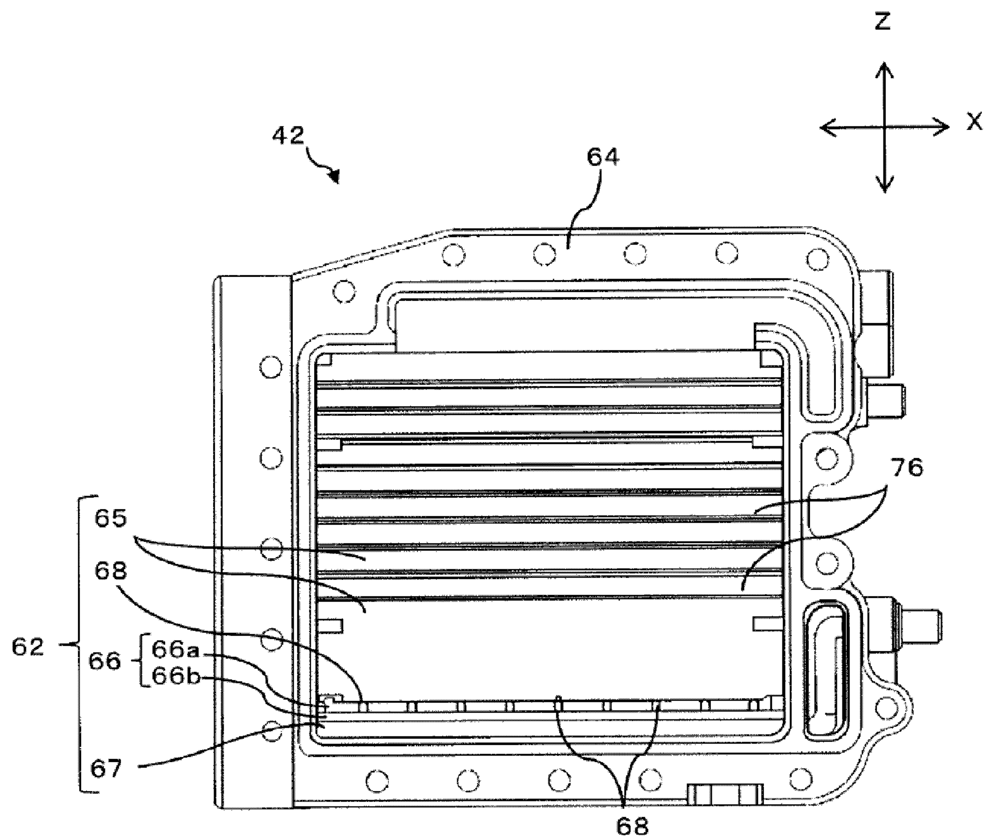

FIG. 11

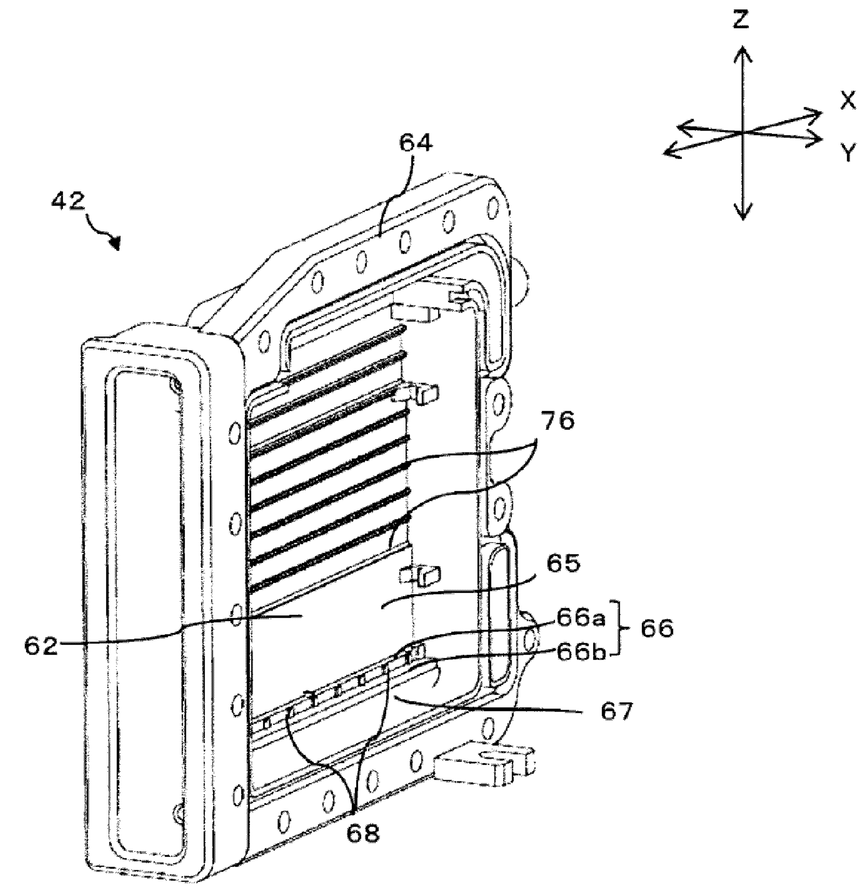

FIG. 12A

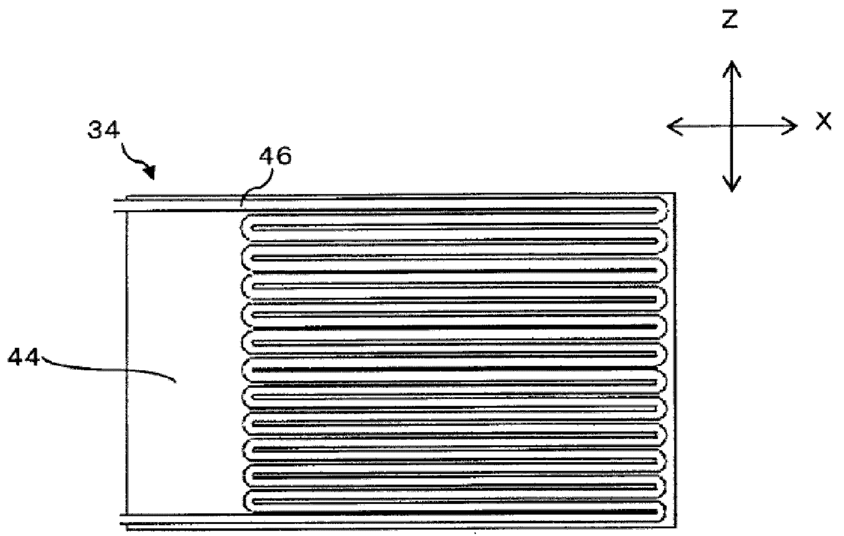

FIG. 12B

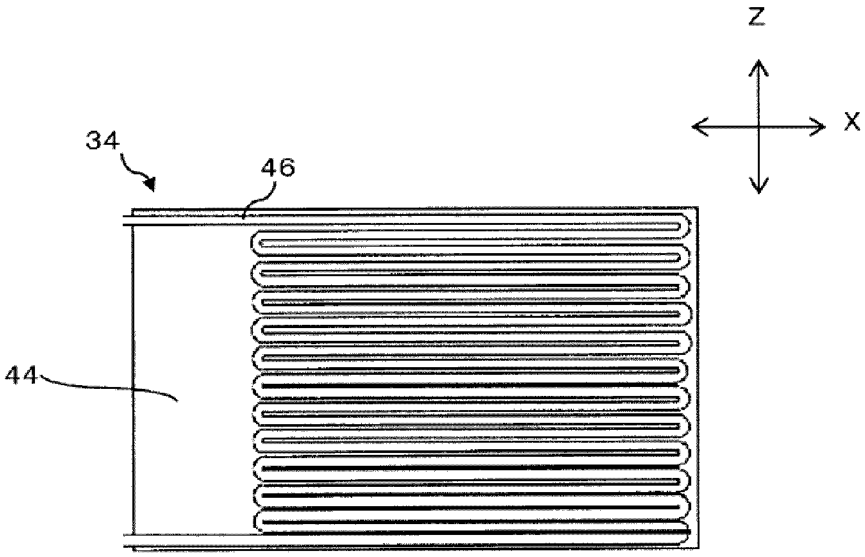

FIG. 13A

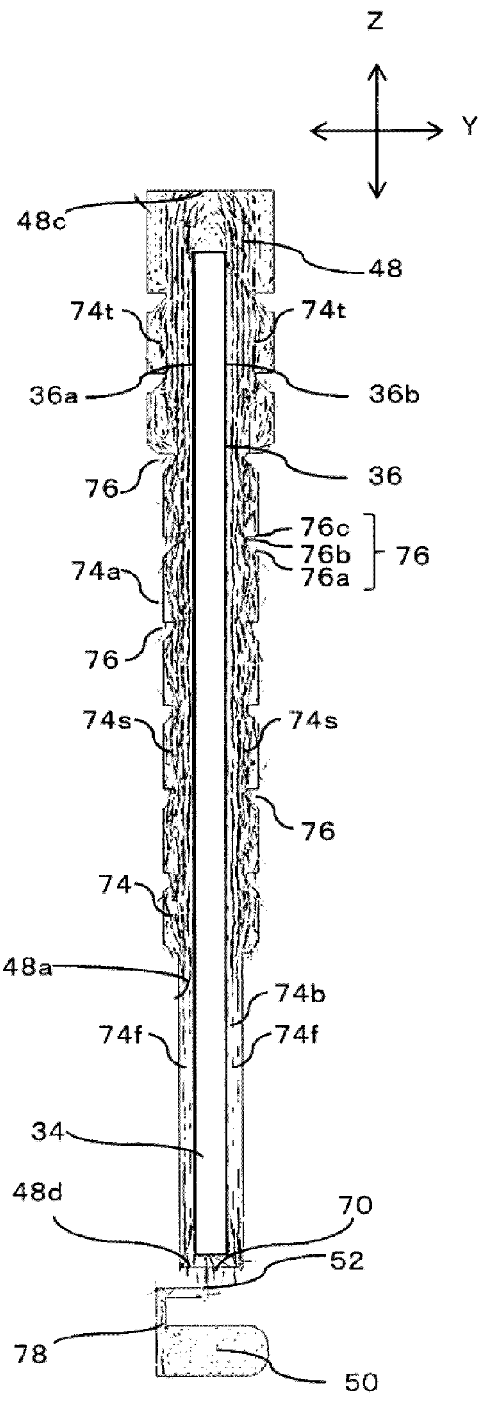
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FIG. 13B

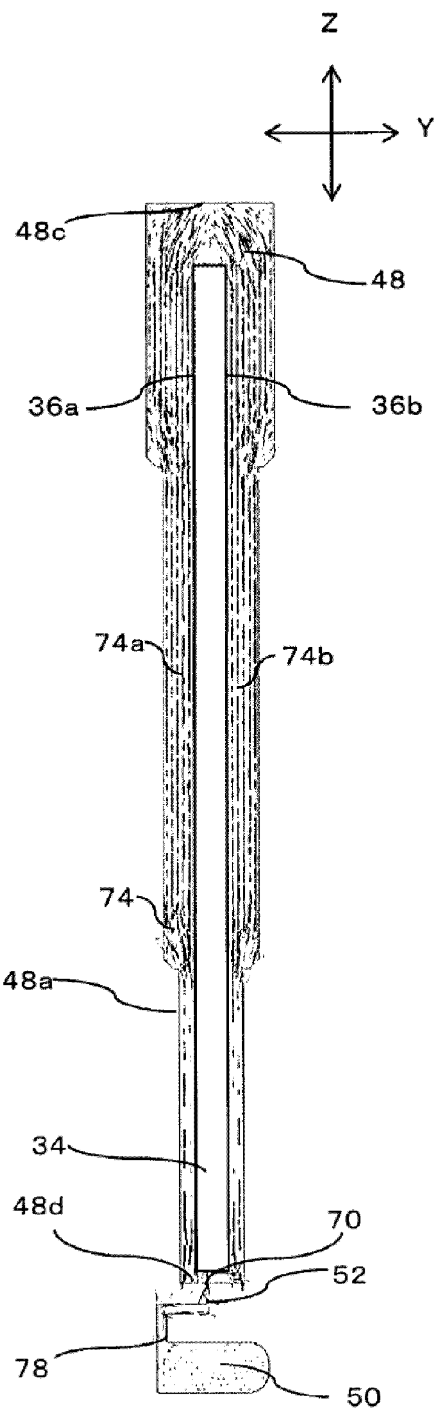
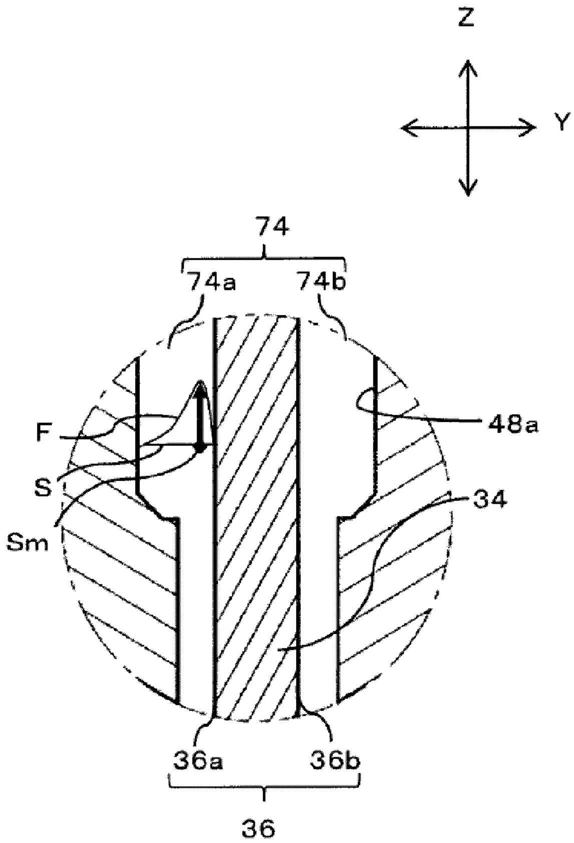


FIG. 14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74a
74b
F
S
Sm
48a
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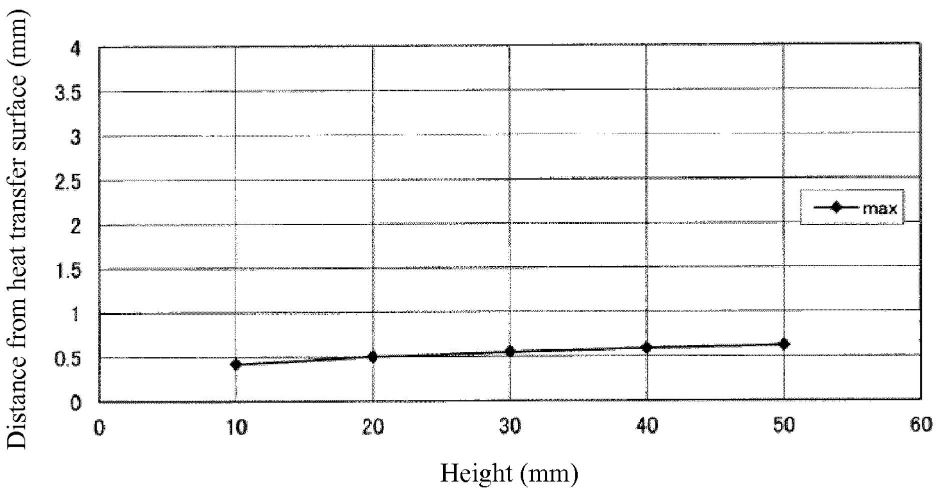
36a
36b
36

FIG. 15


Distance from heat transfer surface (mm)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
60
max
Height (mm)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/008053

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, E03D9/08

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	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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.
Y A	JP 2012-233677 A (Panasonic Corp.), 29 November 2012 (29.11.2012), paragraph [0065]; fig. 9, 10 (Family: none)	1,3,6,7 2,4,5
Y A	WO 2011/027576 A1 (Panasonic Corp.), 10 March 2011 (10.03.2011), paragraphs [0110] to [0156]; fig. 12, 13, 15 & JP 2012-2491 A & EP 2476969 A1 & CN 102483260 A & KR 10-2012-0060226 A & TW 201114398 A1	1,3,6,7 2,4,5

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

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Date of the actual completion of the international search	Date of mailing of the international search report
30 January, 2013 (30.01.13)	12 February, 2013 (12.02.13)

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/008053

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 58-40 A (Matsushita Electric Industrial Co., Ltd.), 05 January 1983 (05.01.1983), page 2, upper right column, line 3 to page 2, lower left column, line 6; fig. 2 to 4 (Family: none)	1,3,6,7 2,4,5

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REFERENCES CITED IN THE DESCRIPTION

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