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(54) **WATER HEAT EXCHANGER AND HOT-WATER HEAT SOURCE DEVICE**

(57) An object of the present invention is to provide a water heat exchanger that can efficiently exchange heat between water and a refrigerant and that is simple to manufacture. A water heat exchanger **(22, 52)** of the present invention is a water heat exchanger **(22, 52)** that exchanges heat between a refrigerant and water and comprises a pair of refrigerant pipes **(22a, 52a)** and a water pipe **(22b, 52b)**. The pair of refrigerant pipes **(22a, 52a)** each are a many holed flat pipe **(41A, 41B, 71A, 71B)** that has a plurality of refrigerant passageway holes **(47)** wherethrough the refrigerant can flow. The water pipe **(22b, 52b)** is a sparely holed flat pipe **(42, 82, 92)**. The sparely holed flat pipe **(42, 82, 92)**, wherethrough the water can flow, has fewer water passageway holes **(48)** than the refrigerant pipes have refrigerant passageway holes. Furthermore, in a cross section, the long side surfaces of the water pipe **(22b, 52b)** and one of the long side surfaces of each of the pair of refrigerant pipes **(22a, 52a)** are in tight contact with one another. Furthermore, the water pipe **(22b, 52b)** is interposed by the pair of refrigerant pipes **(22a, 52a)**.

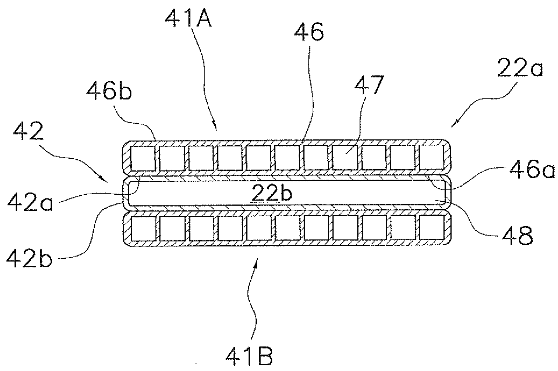

FIG. 6

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Description

TECHNICAL FIELD

[0001] The present invention relates to a water heat exchanger that exchanges heat between a refrigerant and water.

BACKGROUND ART

[0002] In the conventional art, among refrigeration apparatuses within heat pump type hot water supply apparatuses, those that comprise a compression type refrigerant circuit are widely used. A refrigerant circuit uses, for example, CO_2 as the refrigerant and comprises a water heat exchanger. The water heat exchanger comprises a refrigerant pipe, therethrough the refrigerant flows, and a water pipe, wherethrough the water flows; furthermore, heat is exchanged between these fluids by disposing their pipes such that they are opposed to one another. Specifically, the water is heated by exchanging heat between the high temperature and high pressure refrigerant and the low temperature and low pressure water. As a result, it is possible to output high temperature water by taking advantage of the characteristics of CO_2 in the supercritical region.
[0003] As an example of the conventional art of water heat exchangers, a structure is known, as disclosed in Patent Document 1 (i.e., Japanese Unexamined Patent Application Publication No. 2004-218946), wherein a flat pipe is used as the water pipe and, furthermore, multiple refrigerant pipes are brought into tight contact with one another.

SUMMARY OF THE INVENTION

<Technical Problem>

[0004] Nevertheless, in the art disclosed in Patent Document I (i.e., Japanese Unexamined Patent Application Publication No. 2004-218946), in a working example 1, a large portion of the water pipe (i.e., at least half the surface of the water pipe) does not contact the refrigerant pipe, and consequently there is a risk that the heat of the water flowing through the water pipe, which was obtained from the refrigerant, will dissipate externally. In addition, while in a working example 2 of the Patent Document 1 (i.e., Japanese Unexamined Patent Application Publication No. 2004-218946), the water pipe has a cross shaped cross section and is brought into tight contact with four refrigerant pipes disposed therearound, and therefore a smaller portion of the water pipe than in the working example 1 does not contact the refrigerant pipes, the number of components is greater than in the working example 1, and therefore the structure is more complicated. Consequently, the manufacture of the heat exchanger according to the working example 2 is not simple and is more costly.
[0005] An object of the present invention is to provide a water heat exchanger that can efficiently exchange heat between water and a refrigerant and that is simple to manufacture.

<Solution to Problem>

[0006] A water heat exchanger according to a first aspect of the invention is a water heat exchanger that exchanges heat between a refrigerant and water and comprises a pair of refrigerant pipes and a water pipe. The pair of refrigerant pipes each are a many holed flat pipe that has a plurality of refrigerant passageway holes wherethrough the refrigerant can flow. The water pipe is a sparely holed flat pipe. The sparely holed flat pipe, wherethrough the water can flow, has fewer water passageway holes than the refrigerant pipes have refrigerant passageway holes. Furthermore, in a cross section, the long side surfaces of the water pipe and one of the long side surfaces of each of the pair of refrigerant pipes are in tight contact with one another. Furthermore, the water pipe is interposed by the pair of refrigerant pipes.
[0007] The water heat exchanger of the present invention is configured such that the water pipe is interposed by the pair of the refrigerant pipes. Furthermore, in a cross section, the long side surfaces of the water pipe interposed by the pair of the refrigerant pipes and one of the long side surfaces of each of the refrigerant pipes are in tight contact with another.
[0008] Thus, because configuring the water heat exchanger in this manner brings most of the periphery of the water pipe into tight contact with the refrigerant pipes, it is possible to maximally prevent any heat transmitted to the water from the refrigerant from being transmitted to any substance surrounding the water heat exchanger (e.g., the air around the water heat exchanger). In addition, because the pair of refrigerant pipes and the water pipe are brought into tight contact with one another along their long side surfaces, which are flat surfaces, in a cross section, the configuration is simple and assembly is easy.
[0009] In addition, because the water heat exchanger of the present invention comprises the many holed flat pipe wherein the refrigerant pipe has a plurality of the refrigerant passageway holes, the coefficient of heat transfer on the

refrigerant side can be increased by reducing the pipe diameter.

[0010] A water heat exchanger according to a second aspect of the invention is the water heat exchanger according to the first aspect of the invention, wherein the number of the water passageway holes of the sparely holed flat pipe is one or two.

[0011] In the water heat exchanger of the present invention, the number of the water passageway holes formed inside the sparely holed flat pipe, which is the water pipe, is one or two. Thus, reducing the number of the water passageway holes to one or two makes it possible to simplify the formation of the sparely holed flat pipe and to adopt, for example, various methods as needed to form the sparely holed flat pipe.

[0012] A water heat exchanger according to a third aspect of the invention is the water heat exchanger according to the first or second aspect of the invention, wherein the water pipe and each of the pair of refrigerant pipes are joined by brazing using a brazing filler material or by adhesives.

[0013] In the water heat exchanger of the present invention, in a cross section, the long side surfaces of the water pipe and one of the long side surfaces of the pair of refrigerant pipes are joined to one another (i.e., their flat surfaces are joined to one another) by brazing or by the application of the adhesive. Accordingly, it is possible to achieve a state wherein there is virtually no thermal resistance caused by the contact between the pair of refrigerant pipes and the water pipe. Consequently, the heat exchanging efficiency between the refrigerant and the water can be improved.

[0014] A water heat exchanger according to a fourth aspect of the invention is the water heat exchanger according to any one aspect of the first through third aspects of the invention, wherein the refrigerant pipes and/or the water pipe is formed by drawing or extruding.

[0015] Accordingly, the refrigerant pipes or the water pipe, or both, can be formed easily.

[0016] A water heat exchanger according to a fifth aspect of the invention is the water heat exchanger according to any one aspect of the first through fourth aspects of the invention, wherein the sparely holed flat pipe is formed by bending a flat plate.

[0017] In the water heat exchanger of the present invention, the sparely holed flat pipe is formed by bending the flat plate. For example, the flay pipe is formed after the flat plate is fabricated into a pipe shape by bending.

[0018] Accordingly, the flat pipe can be formed after performing some kind of fabrication (e.g., drilling, embossing, or forming a multilayer structure of different materials) on the flat plate. Namely, the prescribed fabrication can be performed easily on the sparely holed flat pipe.

[0019] A water heat exchanger according to a sixth aspect of the invention is the water heat exchanger according to the fifth aspect of the invention, wherein the sparely holed flat pipe is an electro-resistance welded pipe that is formed by bringing two sides of the flat plate into contact by the bending, and then joining the two sides.

[0020] In the water heat exchanger of the present invention, the sparely holed flat pipe is formed as a member whose cross section is C shaped by bending the flat plate so that the two sides that constitute the end parts of the flat plate mate with one another. Furthermore, subsequently, the pipe shaped member is formed by joining (e.g., by electro-resistance welding or brazing) the two mated sides.

[0021] Accordingly, the flat pipe can be formed after performing some kind of fabrication (e.g., embossing, drilling, or forming a multilayer structure of different materials) on the flat plate. Thereby, it is possible to make, for example, the axial cross sectional shape of the sparely holed flat pipe (particularly the shape of the inner surface of the sparely holed flat pipe) into a shape that varies with its position in the direction of water flow. Consequently, turbulence can be created in the flow of water inside the sparely holed flat pipe, which makes it possible to improve the coefficient of heat transfer. In addition, for example, it is possible to easily perform a corrosion prevention process on the interior of the sparely holed flat pipe. Consequently, corrosion of the sparely holed flat pipe owing to water can be prevented.

[0022] A water heat exchanger according to a seventh aspect of the invention is the water heat exchanger according to the fifth or sixth aspect of the invention, wherein the flat plate is embossed prior to the bending.

[0023] In the water heat exchanger of the present invention, the sparely holed flat pipe is formed by bending the flat plate. Furthermore, the flat plate can be embossed before the bending.

[0024] Accordingly, the flat pipe can be formed after the embossing of the flat plate. Thereby, it is possible to make, for example, the axial cross sectional shape of the sparely holed flat pipe (particularly the shape of the inner surface of the sparely holed flat pipe) into a shape that varies with its position in the direction of water flow. Consequently, turbulence can be created in the flow of water inside the sparely holed flat pipe, which promotes water convection; furthermore, the sparely holed flat pipe can be shaped so as to promote heat exchange efficiency.

[0025] A water heat exchanger according to an eighth aspect of the invention is the water heat exchanger according to any one aspect of the first through seventh aspects of the invention, wherein the refrigerant that flows through the interior of the refrigerant pipes and the water that flows through the interior of the water pipe flow in mutually opposing directions.

[0026] Accordingly, it is possible to secure a temperature differential between the refrigerant and the water. In addition, the temperature differential between the refrigerant and the water can be made nearly uniform over the entire water heat exchanger, which can improve heat exchanging efficiency, particularly if, as in the case wherein the refrigerant is a supercritical refrigerant, temperature changes occur over the entire heat exchanging area and the temperature at the beginning of the heat exchanger and the temperature at the end of the heat exchanger differ greatly.

[0027] A water heat exchanger according to a ninth aspect of the invention is the water heat exchanger according to any one aspect of the first through eighth aspects of the invention, wherein the refrigerant is CO_2.

[0028] In the present invention, CO_2 refrigerant is used as the refrigerant. CO_2 refrigerant is a so-called supercritical refrigerant wherein the high pressure side in the refrigeration cycle is in the supercritical region. For example, if the water heat exchanger of the present invention is adapted to a heat pump type water heater, then the water heat exchanger functions as a radiator. Unlike the use of a fluorocarbon based refrigerant, the use of a supercritical refrigerant gives rise to temperature changes over the entire area inside the water heat exchanger; consequently, if, for example, the vicinity of the outlet of the water pipe contacts the center part of the refrigerant pipe, then the refrigerant temperature at that portion might decrease to a temperature lower than the temperature in the vicinity of the outlet of the water, leading to a heat loss.

[0029] In the water heat exchanger of the present invention, a structure is adopted wherein the single sparely holed flat pipe is interposed by the two many holed flat pipes. Consequently, there is hardly any difference between the temperature of the refrigerant inside one of the many holed flat pipes and the temperature of the refrigerant inside the other many holed flat pipe, which makes it possible to produce high temperature water with hardly any drop in the heat exchanging efficiency between the refrigerant and the water.

[0030] In addition, the global warming coefficient of CO_2 refrigerant is 1, which is approximately several hundred to ten thousand times far lower than that of conventional refrigerants, for example, fluorocarbon refrigerant.

[0031] Thus, the use of CO_2 refrigerant, which carries only a small environmental load, can help to reduce degradation of the global environment.

[0032] A hot water heat source apparatus according to a tenth aspect of the invention is a hot water heat source apparatus that uses a refrigerant circuit, which uses a supercritical refrigerant wherein the high pressure side of a refrigeration cycle is in the supercritical region, and that comprises: a compressor, a water heat exchanger, an expansion mechanism, and an evaporator. The compressor compresses the supercritical refrigerant. The water heat exchanger cools the supercritical refrigerant and heats water by exchanging heat between the water and the high temperature and high pressure supercritical refrigerant compressed by the compressor. The expansion mechanism reduces the pressure of the supercritical refrigerant cooled by the water heat exchanger. The evaporator evaporates the refrigerant whose pressure was reduced by the expansion mechanism. The water heat exchanger comprises a pair of refrigerant pipes, a water pipe, a refrigerant inlet header, and a refrigerant outlet header. The pair of refrigerant pipes each are a many holed flat pipe. Each of the many holed flat pipe has a plurality of refrigerant passageway holes wherethrough the refrigerant can flow. The water pipe is a sparely holed flat pipe. The sparely holed flat pipe, wherethrough the water can flow, has fewer water passageway holes than the refrigerant pipes have refrigerant passageway holes. The inlets of the pair of refrigerant pipes are connected to the refrigerant inlet header. The outlets of the pair of refrigerant pipes are connected to the refrigerant outlet header. In a cross section, the long side surfaces of the water pipe and one of the long side surfaces of each of the pair of refrigerant pipes are in tight contact with one another. The water pipe is interposed by the pair of refrigerant pipes. The refrigerant that flows through the interior of the refrigerant pipes and the water that flows through the interior of the water pipe flow in mutually opposing directions.

[0033] In the hot water heat source apparatus of the present invention, the working refrigerant is a so-called supercritical refrigerant, wherein the high pressure side in the refrigeration cycle is in the supercritical region. For example, if the water heat exchanger of the present invention is adapted to a heat pump type water heater, then the water heat exchanger functions as a radiator. Unlike the use of a fluorocarbon based refrigerant, the use of a supercritical refrigerant gives rise to temperature changes over the entire area of the water heat exchanger.

[0034] In the hot water heat source apparatus of the present invention, a structure is adopted wherein the single sparely holed flat pipe is interposed between the two many holed flat pipes. In the pair of refrigerant pipes, the refrigerant flows from the refrigerant inlet header into the inlets of the pair of refrigerant pipes, passes through the outlets of the pair of refrigerant pipes, and then flows out from the refrigerant outlet header. The refrigerant that flows through the interior of the refrigerant pipes and the water that flows through the interior of the water pipe flow in mutually opposing directions. The inlets of the many holed flat pipes, which are the pair of refrigerant pipes, are both connected to the refrigerant inlet header.

[0035] Accordingly, it is possible to exchange heat between the high temperature refrigerant, which flows from the refrigerant inlet header into the pair of the refrigerant pipes, and the water inside the water pipe. Consequently, unlike the case wherein, for example, one refrigerant pipe that has been folded into a zigzag and one water pipe are combined, the amount of heat dissipated from the water pipe into the atmosphere is small and virtually no temperature differences arise in the refrigerant on both sides of the water pipe, which makes it possible to obtain high temperature water efficiently.

<Advantageous Effects of Invention>

[0036] In the water heat exchanger according to the first through third aspects of the invention, the heat exchanging efficiency between the refrigerant and the water can be improved.
[0037] In the water heat exchanger according to the fourth aspect of the invention, the refrigerant pipes or the water pipe, or both, can be formed easily.
[0038] In the water heat exchanger according to the fifth aspect of the invention, the prescribed fabrication can be performed easily on the sparely holed flat pipe.
[0039] In the water heat exchanger according to the sixth aspect of the invention, the flat pipe can be formed after performing some kind of fabrication on the flat plate.
[0040] In the water heat exchanger according to the seventh aspect of the invention, turbulence can be created in the flow of water inside the sparely holed flat pipe, which promotes water convection; furthermore, the sparely holed flat pipe can be shaped so as to promote heat exchange efficiency.
[0041] In the water heat exchanger according to the eighth aspect of the invention, it is possible to secure a temperature differential between the refrigerant and the water.
[0042] In the water heat exchanger according to the ninth aspect of the invention, the use of CO_2 refrigerant, which carries only a small environmental load, can help to reduce degradation of the global environment.
[0043] In the water heat exchanger according to the tenth aspect of the invention, it is possible to obtain high temperature water efficiently.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044]

FIG. 1 is a system diagram of a heat pump type hot water supplying apparatus that comprises a refrigeration apparatus according to a first embodiment.
FIG. 2 is a cross sectional view that shows the internal structure of the refrigeration apparatus.
FIG 3 is a block diagram of a control apparatus of the refrigeration apparatus.
FIG. 4 is an oblique view that shows the configuration of a water heat exchanger of the refrigeration apparatus.
FIG. 5(a) is a schematic diagram that shows a portion of a refrigerant inlet header and a water outlet header of the water heat exchanger.
FIG. 5(b) is a schematic diagram that shows a portion of a refrigerant outlet header and a water inlet header of the water heat exchanger.
FIG. 6 is a cross sectional view of the water heat exchanger.
FIG. 7 is a schematic diagram of a water heat exchanger joining method.
FIG. 8 is an internal piping diagram of the water heat exchanger according to a modified example (1).
FIG. 9 is a schematic diagram of a water heat exchanger joining method according to a modified example (4).
FIG. 10 is a cross sectional view of the water heat exchanger according to a modified example (7).
FIG 11 is a diagram that shows a process of forming protruding parts by embossing a flat plate according to a modified example (8).
FIG. 12 is a diagram that shows a process of forming a single hole flat pipe by bending the flat plate formed with the protruding parts according to the modified example (8).
FIG. 13 is a diagram that shows a process of forming a single hole flat pipe by bending the flat plate formed with the protruding parts according to a modified example (9).
FIG. 14 is a schematic diagram of a water heat exchanger joining method according to a modified example (10).
FIG. 15 is a hot water circulation system that comprises a refrigeration apparatus according to a second embodiment.

DESCRIPTION OF EMBODIMENTS

<1> First Embodiment

<configuration of a Heat Pump Type Hot Water Supplying Apparatus>

[0045] **FTG. 1** shows a system of a heat pump type hot water supplying apparatus that comprises a refrigeration apparatus according to a fist embodiment. A heat pump type hot water supplying apparatus **1** comprises a refrigeration apparatus **2,** which is a hot water heat source apparatus, and a hot water storage apparatus **3.** The refrigeration apparatus **2** comprises a compression type refrigerant circuit **20** wherein a compressor **21,** refrigerant pipes **22a** inside a water heat exchanger **22,** an expansion valve **23** that serves as a pressure reducing means, and an air heat exchanger **24**

are connected in a ring by a refrigerant piping **25.**

[0046] Furthermore, a gas heat exchanger **26,** which is for exchanging heat between a high pressure and high temperature refrigerant that exits the water heat exchanger **22** and a low pressure and low temperature refrigerant that exits the air heat exchanger **24,** is disposed in the refrigerant circuit **20.** Specifically, heat is exchanged between a refrigerant passageway that links the water heat exchanger **22** and the expansion valve **23** and a refrigerant passageway that links the air heat exchanger **24** and the compressor **21.**

[0047] The hot water storage apparatus **3** comprises a water circulation circuit **30,** wherein a hot water storage tank **31,** a water pipe **22b** inside the water heat exchanger **22,** and a water circulating pump **32** are connected in a ring by a water piping **35.**

[0048] The refrigeration apparatus **2** is provided with an outdoor air temperature sensor **8,** which detects the outdoor air temperature of the installation location, a discharge pipe temperature sensor **9,** which detects the discharge pipe temperature of the compressor **21,** and a temperature sensor **10,** which detects the temperature of the air heat exchanger **24;** furthermore, the detection signals of these sensors are input to a microcontroller **6.**

[0049] The water circulating pump **32** controls the amount of circulation of the water such that the temperature of the water heated by the water heat exchanger **22** is, for example, 85°C. The microcontroller **6** controls the opening degree of the expansion valve **23** to secure the refrigerant temperature needed to obtain water of 85°C.

<Structure of Refrigeration Apparatus>

[0050] **FIG. 2** is a cross sectional view that shows the internal structure of the refrigeration apparatus **2.** In **FIG. 2,** the section on the right side of a heat insulating wall **2c** is a machine chamber **2a,** and the section on the left side of the heat insulating wall **2c** is a fan chamber **2b.** The compressor **21** and the expansion valve **23** are disposed in the machine chamber **2a.**

[0051] In the front view of **FIG. 2,** a fan **27** is disposed in and to the front of the fan chamber **2b.** A motor that drives the fan **27** is disposed behind the fan **27** in the state wherein the motor is fixed to a motor support platform **28.** The water heat exchanger **22** is disposed below the fan chamber **2b** separated by a heat insulating wall **2d**. Inside the water heat exchanger **22,** heat is exchanged between the refrigerant that flows through the refrigerant pipes **22a** (refer to **FIG**. **1**) and the water that flows through the water pipe **22b** (refer to **FIG**. **1**).

[0052] In addition, in **FIG. 2,** the air heat exchanger **24** is disposed along a left side wall and a rear surface wall of the fan chamber **2b,** and a right end of the air heat exchanger **24** protrudes as far as the center of the machine chamber **2a.** A control box **4** is disposed such that it spans an upper part of the machine chamber **2a** and an upper part of the fan chamber **2b.** A control apparatus **5**, wherein the microcontroller **6** (refer to **FIG. 3**) and an inverter **7** (refer to **FIG. 3**) are installed, is built into the control box **4.**

<Controlling the Operation of the Refrigeration Apparatus>

[0053] **FIG. 3** is a control block diagram of the refrigeration apparatus **2.** In the micro controller **6,** a target discharge pipe temperature setting unit **62** sets a target discharge pipe temperature based on detection signals from the outdoor air temperature sensor **8** and the temperature sensor **10** of the air heat exchanger **24.** Furthermore, the microcontroller **6** controls the opening degree of the expansion valve **23** via an expansion valve opening degree control unit **63** such that the discharge pipe temperature detected by the discharge pipe temperature sensor **9** approaches the target discharge pipe temperature. Furthermore, data needed to set the target discharge pipe temperature is prestored inside the target discharge pipe temperature setting unit **62.**

[0054] Furthermore, the microcontroller **6** controls the operating frequency of the compressor **21** via an inverter control unit **64,** taking into consideration the effect that the outdoor air temperature has upon the fire-up capability of the refrigeration apparatus **2** as well as the fact that the hot water supply load varies with the time of day. For example, to prevent hot water from running out at a time when the outdoor air temperature is low and the hot water supply load is large, the operating frequency of the compressor **21** is increased, ignoring efficiency. Moreover, at a time when the outdoor air temperature is high and the hot water supply load is small, the operating frequency of the compressor **21** may be set to a high efficiency point.

[0055] When the hot water supply load is large, the microcontroller **6** controls the operation of the compressor **21** such that, with a view toward protecting the compressor **21,** the discharge pipe temperature does not exceed 120°C. In actuality, when the discharge pipe temperature is 120°C, the internal temperature of the compressor **21** reaches 140-145°C; furthermore, if the internal temperature rises and exceeds 150°C, then the magnetic force of the internal magnet of the compressor **21** will decrease and the oil will deteriorate, leading to a breakdown. Accordingly, in the present embodiment, the upper limit of the discharge pipe temperature is set to 120°C.

[0056] However, when an outdoor air temperature *t1* is equal to or less than -20°C, then the compressor **21** tends to become overloaded; therefore, as an additional safety measure, it is necessary to set an ample amount of compensation for the detection value of the discharge pipe temperature sensor **9** and to set the detection value of the discharge pipe temperature sensor **9** to 120°C before the actual discharge pipe temperature reaches 120°C. Accordingly, the amount of compensation for when the outdoor air temperature *t1* is equal to or less than 20°C is derived empirically, and is stored in a second compensating means **61b** of a temperature compensating unit **61** of the microcontroller **6.**

[0057] Furthermore, a first compensating means **61a** performs compensation when the outdoor air temperature *t1* > -20°C.

<Structure of Water Heat Exchange>

[0058] **FIG. 4** is an oblique view that shows the configuration of the water heat exchanger **22.** In this figure, the water heat exchanger **22** is represented schematically.

[0059] The water heat exchanger **22** comprises the refrigerant pipes **22a**, the water pipe **22b,** a refrigerant inlet header **53,** a refrigerant outlet header **54,** a water inlet header **55,** and a water outlet header **56.** The water heat exchanger **22** exchanges heat between the fluid that flows through the refrigerant pipes **22a** and the fluid that flows through the water pipe **22b.** As a specific structure, the water heat exchanger **22** principally comprises: a pair of many holed flat pipes **41A, 41B,** which constitutes the refrigerant pipes **22a**; a single hole flat pipe **42,** which serves as a sparely holed flat pipe that constitutes the water pipe **22b;** the refrigerant inlet header **53;** the refrigerant outlet header **54;** the water inlet header **55;** and the water outlet header **56.**

[0060] **FIG. 5(a)** is a schematic diagram that shows a portion of the refrigerant inlet header **53** and the water outlet header **56** of the water heat exchanger **22. FIG**. **5(b)** is a schematic diagram that shows a portion of the refrigerant outlet header **54** and the water inlet header **55** of the water heat exchanger **22.** As shown in **FIG. 5(a)**, in the water heat exchanger **22**, the refrigerant inlet header **53** is connected to inlet sides of the refrigerant pipes **22a**, and the refrigerant outlet header **54** is connected to outlet sides of the refrigerant pipes **22a**. In addition, as shown in **FIG**. **5(b),** in the water heat exchanger **22,** the water inlet header **55** is connected to an inlet side of the water pipe **22b,** and the water outlet header **56** is connected to an outlet side of the water pipe **22b.** In the water heat exchanger **22** of the present embodiment, the water heat exchanger **22** shown in **FIG**. **4** is stacked in three stages (not shown) and each of the headers **53-56** extends in its axial directions.

[0061] As shown in **FIG. 6,** each of the many holed flat pipes **41A, 41B** comprises a flat part main body **46**. Each of the flat part main bodies **46** extends lengthwise, as shown in **FIG**. **4.** Each of the flat part main bodies **46** has an opposing surface **46a** and an opposite side surface **46b** on the opposite side of the opposing surface **46a;** furthermore, the opposing surface **46a** and the opposite side surface **46b** oppose one another. Inside each of the flat part main bodies **46,** a plurality of (in the present embodiment, 11) refrigerant passageway holes **47,** which are holes wherethrough the refrigerant can flow, is formed in one row. Making the refrigerant pipe by forming a plurality of holes in a flat pipe in this manner improves the coefficient of heat transfer on the refrigerant side.

[0062] Each of the many holed flat pipes **41A, 41B** is made of, for example, aluminum. Furthermore, the many holed flat pipes **41A, 41B** may be manufactured by drawing, extruding, and the like.

[0063] The single hole flat pipe **42** is a member that extends along the pair of the many holed flat pipes **41A, 41B;** as can be seen in the figure, in a cross section the single hole flat pipe **42** comprises two opposing linear portions **42a** and two curved portions **42b,** which connect the two linear portions **42a.** Furthermore, it also comprises one water passageway hole **48,** which is different from the many holed flat pipes **41A, 41B** and wherethrough the water is capable of flowing. The length of the linear portions **42a** is the same as that of the opposing surfaces **46a.**

[0064] The single hole flat pipe **42** is made of aluminum and the like.

[0065] As shown in **FIG. 7,** the many holed flat pipes **41A, 41B** and the single hole flat pipe **42** are brought into tight contact with one another by brazing, wherein brazing filler material **49** is interposed between the single hole flat pipe **42** and each of the many holed flat pipes **41A, 41B.** Thereby, most of the surface of the single hole flat pipe **42** (i.e., most of the linear portions **42a)** can be brought into tight contact with the many holed flat pipes **41A, 41B,** which makes it possible to maximally prevent the dissipation of heat from the single hole flat pipe **42** to the surrounding air.

[0066] As shown in **FIG. 4,** the pair of many holed flat pipes **41A, 41B** is folded into a zigzag shape such that the zigs and the zags are parallel to one another. For example, in **FIG. 4,** zigzag shape refers to a shape wherein the linear portions that extend linearly and the bent portions that are bent in a hairpin shape alternate repeatedly and, as a result, the plurality of the linear portions are disposed such that they are proximate to one another. In other words, the plurality of the linear portions are disposed such that they overlap one another. Thus, a compact structure can be achieved because the overall shape of the water heat exchanger **22** is a zigzag.

[0067] In the water heat exchanger **22,** CO_2 flows inside the refrigerant pipes **22a,** and water flows inside the water pipe **22b** in a direction that opposes that of the CO_2 (refer to the solid arrows and the broken arrow, respectively, in **FIG. 5**). As a result, heat is exchanged between the fluids flowing therethrough, and thereby the water is heated. Here, because the heat transfer area is enlarged by the use of flat pipes, the heat exchange performance is high.

[0068] In addition, the linear portions of each of the many holed flat pipes **41A**, **41B** are adjacent to one another in the stacking directions; however, gaps **43** are established therebetween. The size of the gaps **43** is set such that heat is not exchanged between portions of adjacent flat pipes (i.e., between pipes of differing temperatures) owing to heat conduction. Thereby, the overall heat exchanging efficiency of the water heat exchanger **22** does not decline and, as a result, the water heat exchanger **22** can output hot water of a high temperature. In addition, the effects of thermal deformation can be reduced and, consequently, reliability is improved.

<Characteristics>

[0069]

(1)
The water heat exchanger **22** of the present embodiment is configured such that the single hole flat pipe **42** is interposed by the pair of the many holed flat pipes **41A, 41B.** Furthermore, in a cross section, the long side surfaces of the single hole flat pipe **42** interposed by the pair of the many holed flat pipes **41A, 41B** are in tight contact with the many holed flat pipes **41A, 41B.** Furthermore, the many holed flat pipes **41A, 41B** and the single hole flat pipe **42** are joined by brazing or by coating with an adhesive.
Thus, because configuring the water heat exchanger brings most of the periphery of the single hole flat pipe **42** into tight contact with the many holed flat pipes **41A, 41B,** it is possible to maximally prevent any heat transmitted to the water from the refrigerant from being transmitted to any substance surrounding the water heat exchanger (e.g., the air around the water heat exchanger). In addition, because the pair of many holed flat pipes **41A, 41B** and the single hole flat pipe **42** are brought into tight contact with one another along their long side surfaces, which are flat surfaces, in a cross section, the configuration is simple and assembly is easy. In addition, because the pair of many holed flat pipes **41A, 41B** and the single hole flat pipe **42** are joined by brazing, it is possible to create a state wherein there is virtually no thermal resistance between the pair of the many holed flat pipes **41A, 41B** and the single hole flat pipe **42.** Consequently, the heat exchanging efficiency between the refrigerant and the water can be improved.
(2)
In the water heat exchanger **22** of the present embodiment, CO_2, which is a supercritical refrigerant, is used as the working refrigerant. If a supercritical refrigerant like CO_2 refrigerant is used in the heat pump type hot water supplying apparatus **1,** then the water heat exchanger **22** will function as a radiator. Unlike the temperature of a fluorocarbon based refrigerant, the temperature of CO_2 refrigerant varies over the entire area of the water heat exchanger. In addition, in the water heat exchanger **22** of the present embodiment, the structure wherein the singular single hole flat pipe **42** is interposed by the two many holed flat pipes **41A**, **41B** is connected in parallel by the headers **53-56.**

[0070] Accordingly, it is possible to exchange heat between the high temperature refrigerant, which flows from the refrigerant inlet header **53** into the pair of the refrigerant pipes **22a,** and the water inside the water pipe **22b.** Consequently, unlike the case wherein, for example, one refrigerant pipe that has been folded into a zigzag and one water pipe are combined, the amount of heat dissipated from the water pipe into the atmosphere is small and virtually no temperature differences arise in the refrigerant on both sides of the water pipe, which makes it possible to obtain high temperature water.

<Modified Examples>

[0071] The text above explains the first embodiment of the present invention, but the present invention is not limited to the above embodiment, and it is understood that variations and modifications may be effected without departing from the spirit and scope of the invention.

(1)
In the abovementioned embodiment, the water heat exchanger **22** is folded into a zigzag such that its zigs and zags are parallel to one another as shown in **FIG 4,** but the present invention is not limited thereto; for example, as shown in **FIG. 8,** the water heat exchanger **22** may have a spiral shape. Spiral shape refers to a shape wherein, for example, in a water heat exchanger **52** in **FIG 8,** linear portions that extend linearly and right angle portions that are bent at right angles alternate repeatedly, the bending directions of the right angle portions are all in the same rotational directions, and the linear portions become shorter as the number of folded locations, namely, the right angle portions, increases. In other words, in the spiral, too, as in the zigzag, the plurality of the linear portions are disposed such that they overlap one another, and thereby a compact structure can be achieved. Furthermore, in the water heat exchanger **52,** too, as in the water heat exchanger **22** of the abovementioned embodiment, the refrigerant inlet header **53** is connected to the inlet sides of refrigerant pipes **52a,** and the refrigerant outlet header **54** is connected to the outlet sides of the refrigerant pipes **52a,** as shown in **FIG. 5(a).** In addition, in the water heat exchanger **52,** as shown in **FIG. 5(b),** the water inlet header **55** is connected to the inlet side of a water pipe **52b,** and the water

outlet header **56** is connected to the outlet side of the water pipe **52b.**
In addition, because the angle of the folded portion (i.e., the bent part) is larger in the spiral water heat exchanger **52** than in the zigzag water heat exchanger **22,** it is possible to minimize any deformation in the thickness directions of each of the flat pipes **41, 42** at the bent parts. Consequently, in the water heat exchanger **52** of the present modified example (1), it is possible to reduce the amount of deformation in the cross sectional shape of each of the flat pipes **41, 42** (particularly the single hole flat pipe **42**). Furthermore, in **FIG. 8,** the refrigerant pipes **52a** of the water heat exchanger **52** correspond to the refrigerant pipes **22a** of the water heat exchanger **22** in the abovementioned embodiment, and the water pipe **52b** of the water heat exchanger **52** corresponds to the water pipe **22b** of the water heat exchanger **22** in the abovementioned embodiment.
(2)
In the abovementioned embodiment, the single hole flat pipe **42** comprises, in a cross section, two linear portions **42a** and two curved portions **42b,** which connect the two linear portions **42a,** but the present invention is not limited thereto; for example, the two portions that connect the two linear portions **42a** do not have to be curved. For example, they may be linear portions that are shorter than the two linear portions **42a.**
(3)
In the abovementioned embodiment, the 11 refrigerant passageway holes **47** are arrayed in one row inside the flat part main body **46** of each of the many holed flat pipes **41A, 41B,** but the present invention is not limited thereto. For example, the number and arrangement of the holes **47** may be set arbitrarily.
(4)
In the abovementioned embodiment, the many holed flat pipes **41A, 41B** and the single hole flat pipe **42** are joined by brazing, but the present invention is not limited thereto. For example, the surfaces of each of the many holed flat pipes **41A, 41B** on the single hole flat pipe **42** side may be coated with an adhesive **50,** as shown in **FIG. 9,** and the members may then be joined together; conversely, the surfaces of the single hole flat pipe **42** on the linear portion sides in a cross section may be coated with the adhesive **50,** and the members may then be joined together.
(5)
In the abovementioned embodiment, as shown in **FIG. 4** and the like, the two linear portions **42a** of the single hole flat pipe **42** are disposed such that they are oriented in the horizontal directions, but the present invention is not particularly limited to those directions. For example, the two linear portions **42a** may be disposed such that they are oriented in the vertical directions.
(6)
In the abovementioned embodiment, each of the many holed flat pipes **41A, 41B** has a many holed structure wherein the flat pipe is formed into an integral member, but the structure is not limited to an integral member. For example, in **FIG. 10**, a many holed flat pipe **71A,** which is disposed on one of the linear portion side surfaces of the single hole flat pipe **42,** comprises two, arrayed many holed flat pipes **71a, 71b,** and a many holed flat pipe **71B,** which is disposed on the other linear portion side surface of the single hole flat pipe **42,** comprises two arrayed many holed flat pipes **71c, 71d.** Thus, the many holed flat pipe on one side of the single hole flat pipe **42** may comprise a plurality of many holed flat pipes. In addition, a single many holed flat pipe may be formed by joining multiple capillary tubes together. However, in the case wherein the many holed flat pipe is configured by a plurality of members in this manner, too, it is still possible to prevent the dissipation of heat from the single hole flat pipe **42** to the surrounding air by bringing the many holed flat pipe into tight contact with the two linear portion side surfaces of the single hole flat pipe **42.**
(7)
In the abovementioned embodiment, the single hole flat pipe **42** is formed by extruding or drawing, but the present invention is not limited thereto; for example, as shown in **FIGS. 11, 12,** protruding parts **81** may be embossed on a flat plate **80** (refer to **FIG. 11),** after which a single hole flat pipe **82,** whose cross section is flat, may be formed. **FIG. 11** is a diagram that shows the process of forming the protruding parts **81** by embossing the flat plate **80.** In so doing, the plurality of the protruding parts **81** are distributed on the flat plate **80** at fixed intervals. In the present modified example (7), six rows of protruding parts **81a-81f** (refer to the portions enclosed by broken lines in **FIG. 11)** are formed such that they are arrayed in the direction of the water flow. Furthermore, the first row protruding parts **81a** through the third row protruding parts **81c** are disposed in a first area **A1,** which forms one of the long side surfaces of the single hole flat pipe **82** in a cross section; furthermore, the fourth row protruding parts **81d** through the sixth row protruding parts **81f** are disposed in a second area **A2,** which forms the other long side surface of the single hole flat pipe **82** in a cross section. More specifically, the area of the flat plate **80** from a centerline **L1** (refer to the chain line in **FIG. 11**) in the short side directions to a side **80a** (discussed below) is the first area **A1,** and the area of the flat plate **80** from the centerline **L1** to a side **80b** (discussed below) is the second area **A2.**
The flat plate **80,** whereon the protruding parts **81** are formed, is bent into a member **83** such that it is C shaped in a cross section. The member **83,** which is C shaped in a cross section, is formed such that the surface of the flat plate **80,** whereon the protruding parts **81** are formed, is on the inner side (refer to **FIG. 12**). **FIG**. **12** is a diagram

that shows the process of forming the single hole flat pipe **82** by bending the flat plate **80**, whereon the protruding parts **81** are formed. Furthermore, the uppermost drawing in **FIG. 12** is a cross section taken along the XII-XII line of the flat plate 80 in **FIG**. **11**. Both ends of the flat plate **80,** namely, the sides **80a**, **80b**, are mated to one another by bending the flat plate **80** as shown in **FIG. 12.** The mated side **80a** and side **80b** on both ends of the flat plate **80** are joined by electro-resistance welding. An electro-resistance welded pipe **84** joined by electro-resistance welding is squashed from both side surfaces such that the electro-resistance welded portion is interposed therebetween. Furthermore, the single hole flat pipe **82,** wherein the first area **A1** and the second area **A2** of the flat plate **80** are disposed on the long side surfaces of the flat pipe **82** in a cross section such that they oppose one another, is formed.

The multiple rows of the protruding parts **81a-81f** formed in the single hole flat pipe **82** are disposed as described below. The tips of the first row protruding parts **81a** disposed in the first area **A1** and the tips of the sixth row protruding parts **81f** disposed in the second area **A2** oppose one another. The tips of the second row protruding parts **81** b disposed in the first area **A1** and the tips of the fifth row protruding parts **81e** disposed in the second area **A2** oppose one another. The tips of the third row protruding parts **81c** disposed in the first area **A1** and the tips of the fourth row protruding parts **81d** disposed in the second area **A2** oppose one another. Namely, the protruding parts **81a-81c** formed in the first area **A1** and the protruding parts **8d-81f** formed in the second area **A2** are disposed at positions at which they mate with one another.

Thereby, by bending the single hole flat pipe **82,** the tips of the protruding parts **81a-81c** and the tips of the protruding parts **81d-81f** mate with one another even if the single hole flat pipe **82** deforms in the thickness directions. Consequently, it is possible to minimize any deformation and crushing of the single hole flat pipe **82** in the thickness directions. In addition, providing the protruding parts **81** inside the single hole flat pipe **82** produces turbulence in the flow of water, which makes it possible to improve the coefficient of heat transfer.

(8)

In the modified example (7), the single hole flat pipe **82** has a structure that reduces deformation by the embossing of the flat plate **80,** but methods other than embossing can also be used. For example, as shown in **FIG. 13,** a single hole flat pipe **92** may be formed by bending a flat plate **90.** The flat plate **90** is bent in its short side directions, and thereby a member **93** (refer to the drawing in the middle in **FIG. 13**), whose cross section is B shaped, is formed such that sides **90a, 90b** on both ends of the flat plate **90** face the inside of the single hole flat pipe **92.** In so doing, portions in the vicinities of the sides **90a, 90b** on both ends of the flat plate **90** become support parts **91,** which extend along the direction of water flow in the single hole flat pipe **92.** Furthermore, in the member **93,** whose cross section is B shaped, the single hole flat pipe **92** is formed by pinching the portions at which the support parts **91** are formed and the side surface on the opposite side thereof, and then crushing the member **93,** whose cross section is B shaped, from both side surfaces. By performing the fabrication described above, the single hole flat pipe **92,** wherein the support parts **91** are formed in order to reduce deformation, may be formed. Furthermore, in this case, the portion at which the two support parts **91** contact one another does not have to be joined by electro-resistance welding and the like, as described in the modified example (7) discussed above. This is because, in this single hole flat pipe **92,** even if the process of joining by electro-resistance welding and the like is not performed, the single hole flat pipe **92** is interposed between the many holed flat pipes **41A, 41B** and brazed, and thereby the water passageway holes are formed.

Thus, providing the support parts **91** to the single hole flat pipe **92** makes it possible for the support parts **91** to minimize deformation of the single hole flat pipe **92** even if deformation should occur owing to bending of the single hole flat pipe **92** in its thickness directions. Furthermore, in the modified example (8), the single hole flat pipe **92** has one water passageway hole, but that water passageway hole may be divided into two water passageway holes by the support parts **91.** Thus, in a case wherein the support parts **91** divide the water passageway hole into two water passageway holes, the water pipe **22b** would become the two holed flat part **92.**

(9)

In modified examples (7), (8), no particular reference is made to whether the material of the flat plates **80, 90** is monolayered or multilayered. However, as shown in **FIG. 14,** for example, a material that is pre-clad with brazing filler materials **85b, 95b** (i.e., a cladding material), which is an alloy whose melting point is lower than that of base materials **85a, 95a** of the flat plates **80, 90,** may be used on one surface or both surfaces of the flat plates **80, 90,** and thereby the single hole flat pipes **82, 92** may be formed; at least their outer surface sides are clad with the brazing filler materials **85b, 95b.** Furthermore, in the many holed flat pipes **41A, 41B** shown in **FIG. 14,** parts that are the same as those in the abovementioned embodiment are assigned the same symbols.

Thereby, because the material on the outer surface sides of the single hole flat pipes **82, 92** consists of the brazing filler materials **85b**, **95b,** the outer surface sides can be brazed as in the abovementioned embodiment without separately interposing the brazing filler materials **49** between the single hole flat pipe **42** and each of the many holed flat pipes **41A, 41B.** In addition, although not shown, it is also possible to make the structure of the single hole flat pipes **82, 92** such that corrosion owing to water is prevented inside the single hole flat pipes **82, 92** by, for example, coating the inner surface sides of the single hole flat pipes **82, 92** with a coating agent for corrosion prevention or by using a material that has a three-layer structure that incorporates a material resistant to corrosion by water. Furthermore, in **FIG. 14,** for the sake of explanatory convenience, the protruding parts **81,** the support parts **91,** and the like are omitted.

(10)

In the abovementioned embodiment, the many holed flat pipes **41A, 41B** and the single hole flat pipe **42** are brought into tight contact with one another by hard soldering, wherein the brazing filler materials **49** are interposed between the single hole flat pipe **42** and each of the many holed flat pipes **41A. 41B,** after which brazing (i.e., in-furnace brazing) is performed; however, the brazing method is not limited thereto; for example, soft soldering, wherein, for example, solder is used as the brazing filler material, may be performed; furthermore, even in the case of hard soldering, the brazing method may be induction brazing, resistance brazing, atmosphere brazing, vacuum brazing, infrared brazing, preplaced brazing, aluminum brazing using a high frequency heating apparatus (e.g., ultrasonic soldering), and the like.

<2> Second Embodiment

<Configuration of Hot Water Circulation System>

[0072] **FIG. 15** is a schematic block diagram of a hot water circulation system **101** according to a second embodiment of the present invention.

[0073] The hot water circulation system **101** comprises a heat pump circuit **110,** a hot water circulation circuit **160,** a hot water supply circuit **190,** an intermediate pressure water heat exchanger **140,** and a high pressure water heat exchanger **150.** The hot water circulation system **101** uses the heat obtained by the heat pump circuit **110** not only as the heat for heating via the hot water circulation circuit **160** but also as the heat for supplying hot water via the hot water supply circuit **190.** Furthermore, the heat pump circuit **110** is provided to a heat pump apparatus **102,** which is a hot water heat source apparatus.

(Water Heat Exchangers)

[0074] The intermediate pressure water heat exchanger **140** and the high pressure water heat exchanger **150** exchange heat between the CO_2 refrigerant, which serves as the primary refrigerant and circulates through the heat pump circuit **110,** and the water, which serves as the secondary refrigerant and circulates through the hot water circulation circuit **160.** Furthermore, a configuration the same as that of, for example, the water heat exchanger **22** in the first embodiment and the water heat exchanger **52** in the modified example (1) is adopted for the intermediate pressure water heat exchanger **140** and the high pressure water heat exchanger **150.**

(Heat Pump Circuit)

[0075] The heat pump circuit **110** uses CO_2 refrigerant, which is a natural refrigerant, as the primary refrigerant. The heat pump circuit **110** comprises a low pressure stage compressor **121,** a high pressure stage compressor **125,** an economizer heat exchanger **107,** an injection passageway **170,** a primary refrigerant heat exchanger **108,** a primary bypass **180,** an expansion valve **105a,** an evaporator **104,** a fan **104f,** and a control unit **111.** The evaporator **104** is installed, for example, in the outdoor space.

[0076] The intermediate pressure water heat exchanger **140** is connected to the discharge side of the low pressure stage compressor **121** and the intake side of the high pressure stage compressor **125.** In addition, refrigerant piping from the injection passageway **170** (discussed below) joins with the refrigerant piping between a downstream side end part of the intermediate pressure water heat exchanger **140** and the intake side of the high pressure stage compressor **125.**

[0077] The high pressure water heat exchanger **150** is connected to the discharge side of the high pressure stage compressor **125** and an upstream side end part in the flow direction of the primary refrigerant that flows toward the expansion valve **105a** side via the primary refrigerant heat exchanger **108.** The downstream side end part of the economizer heat exchanger **107** in the flow direction of the primary refrigerant that flows toward the expansion valve **105a** side is connected to the upstream side end part of the primary refrigerant heat exchanger **108** in the flow direction of the primary refrigerant that flows toward the expansion valve **105a.**

[0078] The primary refrigerant heat exchanger **108** exchanges heat between the primary refrigerant that exits the economizer heat exchanger **107** and flows toward the expansion valve **105a** and the refrigerant after it has been evaporated by the evaporator **104.** Furthermore, in the primary refrigerant heat exchanger **108,** the passageway wherethrough the former refrigerant flows is a primary heat exchange high pressure side passageway **108a,** and the passageway wherethrough the latter refrigerant flows is a primary heat exchange low pressure side passageway **108b.** In the primary refrigerant heat exchanger **108,** the downstream side end part of the primary heat exchange high pressure side passageway **108a** is connected to the expansion valve **105a.** In addition, in the primary refrigerant heat exchanger **108,** the upstream side end part of the primary heat exchange low pressure side passageway **108b** is connected to the downstream side end part of the evaporator **104,** and the downstream side end part of the primary heat exchange low pressure side passageway **108b** is connected to the intake side of the low pressure stage compressor **121.**

[0079] The expansion valve **105a** is connected to the upstream side end part of the evaporator **104.**

[0080] The downstream side end part of the evaporator **104** is connected to the intake side of the low pressure stage compressor **121** via the primary heat exchange low pressure side passageway **108b** of the primary refrigerant heat exchanger **108.**

[0081] The injection passageway **170** is a refrigerant piping that branches from the refrigerant piping between the refrigerant piping downstream side end part of the high pressure water heat exchanger **150** and the economizer heat exchanger **107.** The injection passageway **170** comprises an injection expansion valve **173.** The economizer heat exchanger **107** exchanges heat between the refrigerant that flows through the injection passageway **170** and whose pressure is reduced by the injection expansion valve **173** and the refrigerant whose heat was dissipated by the high pressure water heat exchanger **150.** Namely, after the pressure of the refrigerant that flows through the injection passageway **170** is reduced by the injection expansion valve **173,** the economizer heat exchanger **107** exchanges heat between that refrigerant and the refrigerant on the high pressure side, and that refrigerant then merges with the intake side of the high pressure stage compressor **125.**

[0082] Thus, in the heat pump circuit **110,** the adoption of the injection passageway **170** makes it possible to improve the coefficient of performance of the heat pump circuit **110.** Furthermore, if, for example, the heating load is small and therefore even if a cooling effect of the primary refrigerant sufficient to improve the efficiency of the heat pump circuit **110** cannot be obtained in the intermediate pressure water heat exchanger **140,** operation efficiency can be improved by increasing the amount of injection passing through the injection passageway **170.** Furthermore, in the heat pump circuit **110,** the injection passageway **170** joins the passageway between the intermediate pressure water heat exchanger **140** and the high pressure stage compressor **125,** and consequently the high temperature primary refrigerant discharged from the low pressure stage compressor **121** can be supplied to, without being cooled prior to reaching, the intermediate pressure water heat exchanger **140**, thereby maintaining the high temperature state as is. Consequently, the temperature of the water for heating that passes through the intermediate pressure water heat exchanger **140** can be made sufficiently high.

[0083] The primary bypass **180** functions as a bypass between the refrigerant piping that is between the downstream side end part of the economizer heat exchanger **107** and the upstream side end part of the primary heat exchange high pressure side passageway **108a** of the primary refrigerant heat exchanger **108** and the refrigerant piping that is between the expansion valve **105a** and the upstream side end part of the evaporator **104.** A primary bypass expansion valve **105b** is provided to the primary bypass **180.**

[0084] Thus, because the primary bypass expansion valve **105b** is provided to the primary bypass **180,** the control unit **111** can regulate the amount of the primary refrigerant that passes through on the primary refrigerant heat exchanger **108** side. Consequently, the primary refrigerant taken in by the low pressure stage compressor **121** can be regulated such that the primary refrigerant has an appropriate degree of superheating. Specifically, if the control unit **111** reduces the valve opening degree of the primary bypass expansion valve **105b,** the flow volume of the primary refrigerant that passes through the primary refrigerant heat exchanger **108** will increase, which makes it possible to increase the degree of superheating of the primary refrigerant taken in by the low pressure stage compressor **121;** thereby, it is possible to reduce the compression ratio needed to make the discharge refrigerant temperature of the low pressure stage compressor **121** reach the target temperature. In addition, if the control unit **111** increases the valve opening degree of the primary bypass expansion valve **105b,** then the flow volume of the primary refrigerant that passes through the primary refrigerant heat exchanger **108** will decrease, which makes it possible to reduce the degree of superheating of the primary refrigerant taken in by the low pressure stage compressor **121;** thereby, it is possible to avoid the situation wherein the density of the refrigerant taken into the low pressure stage compressor **121** decreases markedly, making it impossible to ensure the required amount of circulation.

[0085] Based on values detected by various sensors (not shown) and the like, the control unit **111** controls the low pressure stage compressor **121,** the high pressure stage compressor **125,** the injection expansion valve **173,** the expansion valve **105a,** the primary bypass expansion valve **105b,** the fan **104f,** and the like.

(Hot Water Circulation Circuit)

[0086] Water, which serves as the secondary refrigerant, circulates in the hot water circulation circuit **160.** The hot water circulation circuit **160** comprises radiators **161,** a hot water pump **163,** a hot water mixing valve **164,** a hot water feed pipe **165,** a hot water return pipe **166,** an intermediate pressure side branch passageway **167,** a high pressure side branch passageway **168,** a hot water storage tank **191,** a hot water branching valve **192,** and a hot water supply side branch passageway **195.**

[0087] The hot water branching valve **192** divides the flow of the hot water heated by the intermediate pressure water heat exchanger **140** or the high pressure water heat exchanger **150** between the radiators **161** and the hot water storage tank **191** in accordance with their thermal loads.

[0088] The radiators **161** are installed in the space to be heated, and heating is performed by warming the air of the target space using the flow of the warm water, which serves as the secondary refrigerant, inside the target space. Although not shown, each of the radiators **161** has a feed port, which is for receiving the warm water delivered from the hot water pump **163,** and a return port, which is for delivering the water after its heat has been dissipated in the radiator **161** to the intermediate pressure water heat exchanger **140** and the high pressure water heat exchanger **150.** The hot water return, pipe **166** is connected to the return port of each of the radiators **161.**

[0089] A hot water supply heat exchanging part **191a** inside the hot water storage tank **191** exchanges heat between the water flowed from the hot water supply side branch passageway **195** and the water for the hot water supply stored inside the hot water storage tank **191,** and heat is dissipated by the heating of the water for the hot water supply. The hot water return pipe **166** is connected to a circulation return port of the hot water storage tank **191,** and the water whose heat was dissipated by the hot water supply heat exchanging part **191a** merges with the water in the hot water return pipe **166.** Here, although not shown, a circulation feed port and a circulation return port are provided to the hot water storage tank **191.**

[0090] In the hot water return pipe **166,** the water whose heat has been dissipated in the radiators **161** or the hot water storage tank **191** is diverged to the intermediate pressure side branch passageway **167,** which delivers the water to the intermediate pressure water heat exchanger **140** side, and the high pressure side branch passageway **168,** which delivers the water to the high pressure water heat exchanger **150** side.

[0091] In the hot water storage tank **191,** room temperature water delivered from an external municipal water service (not shown) via a water supply pipe **194** is supplied from the vicinity of a lower end part of the hot water storage tank **191** to the interior of the hot water storage tank **191.**

[0092] A hot water supply pipe **198** guides the hot water that has accumulated inside the hot water storage tank **191** from the vicinity of an upper end part of the hot water storage tank **191** to a location at which it is to be used (not shown). The hot water supply pipe **198** directs the flow from the hot water storage tank **191** toward the location at which it is used. In the water supply pipe **194,** the flow toward the hot water storage tank **191** side is diverged by a hot water supply bypass pipe **199.** The hot water supply bypass pipe **199** is connected to a hot water supply mixing valve **193,** whereto the hot water supply pipe **198** is provided. The hot water supply mixing valve **193** can regulate the mixing ratio between the hot water that is delivered from the hot water storage tank **191** via the hot water supply pipe **198** and the room temperature water that is supplied from the municipal water service via the hot water supply bypass pipe **199.** The temperature of the water delivered to the usage location is regulated by the hot water supply mixing valve **193** regulating the mixing ratio.

[0093] The water diverged to the intermediate pressure side branch passageway **167** is heated by the intermediate pressure water heat exchanger **140** exchanging heat between that water and the CO_2 refrigerant, which is the primary refrigerant, after which that water merges with the water in the hot water feed pipe **165** via the hot water mixing valve **164.** Here, in the intermediate pressure water heat exchanger **140,** the CO_2 refrigerant, which serves as the primary refrigerant, and the water, which serves as the secondary refrigerant for heating and hot water supply, flow in mutually opposing directions.

[0094] The water diverged to the high pressure side branch passageway **168** is heated by the high pressure water heat exchanger **150** exchanging heat between that water and the CO_2 refrigerant, which is the primary refrigerant, after which that water merges with the water in the hot water feed pipe **165** via the hot water mixing valve **164.** Here, in the high pressure water heat exchanger **150,** the CO_2 refrigerant, which serves as the primary refrigerant, and the water, which serves as the secondary refrigerant for heating and hot water supply, flow in mutually opposing directions.

[0095] Furthermore, based on, for example, the temperature detected by the various sensors and the like, the control unit **111** controls the diverging ratio of the hot water mixing valve **164** and the flow volume of the hot water pump **163,** or controls the diverging ratio of the hot water branching valve **192** such that secondary refrigerant of the required temperature can be supplied to the radiators **161.**

<Characteristics>

[0096] Unlike the first embodiment, the intermediate pressure water heat exchanger **140** and the high pressure water heat exchanger **150** according to the second embodiment are used in a closed circuit, wherethrough water circulates as the secondary refrigerant. Consequently, mixing a corrosion prevention agent into the water that circulates as the secondary refrigerant makes it possible to prevent corrosion of the water heat exchangers **22, 52** (particularly the water pipes **22b, 52b),** even if the inner surfaces of the water pipes **22b, 52b** in particular do not undergo a corrosion prevention process.

INDUSTRIAL APPLICABILITY

[0097] The water heat exchanger according to the present invention is used as a water heat exchanger that can prevent a decrease in heat exchanging efficiency, can be configured simply, and can exchange heat between a refrigerant and water.

REFERENCE SIGNS LIST

[0098]

2	Refrigeration apparatus
20	Refrigerant circuit
21	Compressor
22, 52	Water heat exchangers
22a, 52a	Refrigerant pipes
22b, 52b	Water pipes
23	Expansion valve (expansion mechanism)
24	Air heat exchanger (evaporator)
41A, **41B, 71A, 71B**	Many holed flat pipes
42, 82, 92	Single hole flat pipes (sparely holed flat pipes)
47	Refrigerant passageway hole
48	Water passageway hole
49	Brazing filler material
50	Adhesive
53	Refrigerant inlet header
54	Refrigerant outlet header
55	Water inlet header
56	Water outlet header
80, 90	Flat plates
80a, 80b	Sides on both ends (two sides)
102	Heat pump apparatus
104	Evaporator
105a	Expansion valve (expansion mechanism)
105b	Primary bypass expansion valve (expansion mechanism)
110	Heat pump circuit (refrigerant circuit)
121	Low pressure stage compressor (compressor)
125	High pressure stage compressor (compressor)
140	Intermediate pressure water heat exchanger (water heat exchanger)
150	High pressure water heat exchanger (water heat exchanger)

CITATION LIST

PATENT LITERATURE

Patent Document 1

[0099] Japanese Unexamined Patent Application Publication No. 2004-218946

Claims

1. A water heat exchanger (**22, 52**) that exchanges heat between a refrigerant and water, comprising:

a pair of refrigerant pipes (**22a, 52a**), each being a many holed flat pipe (**41A, 41B, 71A, 71B**) that has a plurality of refrigerant passageway holes (**47**) wherethrough the refrigerant can flow; and
a water pipe (**22b, 52b**), wherethrough the water can flow, that is a sparely holed flat pipe (**42, 82, 92**) that has fewer water passageway holes (**48**) than the refrigerant pipes
have refrigerant passageway holes;

wherein,
in a cross section, the long side surfaces of the water pipe (**22b, 52b**) and one of the long side surfaces of each of the pair of refrigerant pipes (**22a, 52a**) are in tight contact with one another; and
the water pipe (**22b, 52b**) is interposed by the pair of refrigerant pipes (**22a, 52a**).

2. The water heat exchanger (**22, 52**) according to claim 1, wherein
the number of the water passageway holes (**48**) of the sparely holed flat pipe (**42, 82, 92**) is one or two.

3. The water heat exchanger (**22, 52**) according to claim 1 or claim 2, wherein
the water pipe (**22b, 52b**) and each of the pair of refrigerant pipes (**22a, 52a**) are joined by brazing using a brazing filler material (**49**) or by adhesives (**50**).

4. The water heat exchanger (**22, 52**) according to any one claim of claim 1 through claim 3, wherein
the many holed flat pipes (**41A, 41B, 71A, 71B**) and/or the sparely holed flat pipe (**42**) is formed by drawing or extruding.

5. The water heat exchanger (**82, 92**) according to any one claim of claim 1 through claim 4, wherein
the sparely holed flat pipe (**82, 92**) is formed by bending a flat plate (**80, 90**).

6. The water heat exchanger (**82**) according to claim 5, wherein
the sparely holed flat pipe (**82**) is an electro-resistance welded pipe (**84**) that is formed by bringing two sides (**80a, 80b**) of the flat plate (**80**) into contact by the bending, and then joining the two sides (**80a, 80b**).

7. The water heat exchanger (**80**) according to claim 5 or claim 6, wherein
the flat plate (**80**) is embossed prior to the bending.

8. The water heat exchanger **(22, 52)** according to any one claim of claim 1 through claim 7, wherein
the refrigerant that flows through the interior of the refrigerant pipes (**22a**, **52a**) and the water that flows through the interior of the water pipe **(22b, 52b)** flow in mutually opposing directions.

9. The water heat exchanger **(22, 52)** according to any one claim of claim 1. through claim **8,** wherein
the refrigerant is CO_2.

10. A hot water heat source apparatus **(2, 102)** that uses a refrigerant circuit **(20, 110),** which uses a supercritical refrigerant wherein the high pressure side of a refrigeration cycle is in the supercritical region, comprising:

a compressor **(21, 121, 125),** which compresses the supercritical refrigerant;
a water heat exchanger **(22, 52, 140, 150)**, which cools the supercritical refrigerant and heats water by exchanging heat between the water and the high temperature and high pressure supercritical refrigerant compressed by the compressor **(21, 121, 125)**;
an expansion mechanism **(23, 105a, 105b),** which reduces the pressure of the supercritical refrigerant cooled by the water heat exchanger **(22, 52, 140, 150);** and
an evaporator **(24, 104),** which evaporates the refrigerant whose pressure was reduced by the expansion mechanism **(23, 105a, 105b);**
wherein,
the water heat exchanger **(22, 52, 140, 150)** comprises:

a pair of refrigerant pipes **(22a, 52a),** each being a many holed flat pipe **(41A, 41B, 71A, 71B)** that has a plurality of refrigerant passageway holes **(47)** wherethrough the refrigerant can flow; and
a water pipe **(22b, 52b),** wherethrough the water can flow, that is a sparely holed flat pipe **(42)** that has fewer water passageway holes **(48)** than the refrigerant pipes have the refrigerant passageway holes;
a refrigerant inlet header **(53),** whereto the inlets of the pair of refrigerant pipes **(22a, 52a)** are connected; and
a refrigerant outlet header **(54),** whereto the outlets of the pair of refrigerant pipes **(22a, 52a)** are connected; and

in a cross section, the long side surfaces of the water pipe **(22b, 52b)** and one of the long side surfaces of each of the pair of refrigerant pipes **(22a, 52a)** are in tight contact with one another;
the water pipe **(22b, 52b)** is interposed by the pair of refrigerant pipes **(22a, 52a);** and

the refrigerant that flows through the interior of the refrigerant pipes **(22a, 52a)** and the water that flows through the interior of the water pipe **(22b, 52b)** flow in mutually opposing directions.

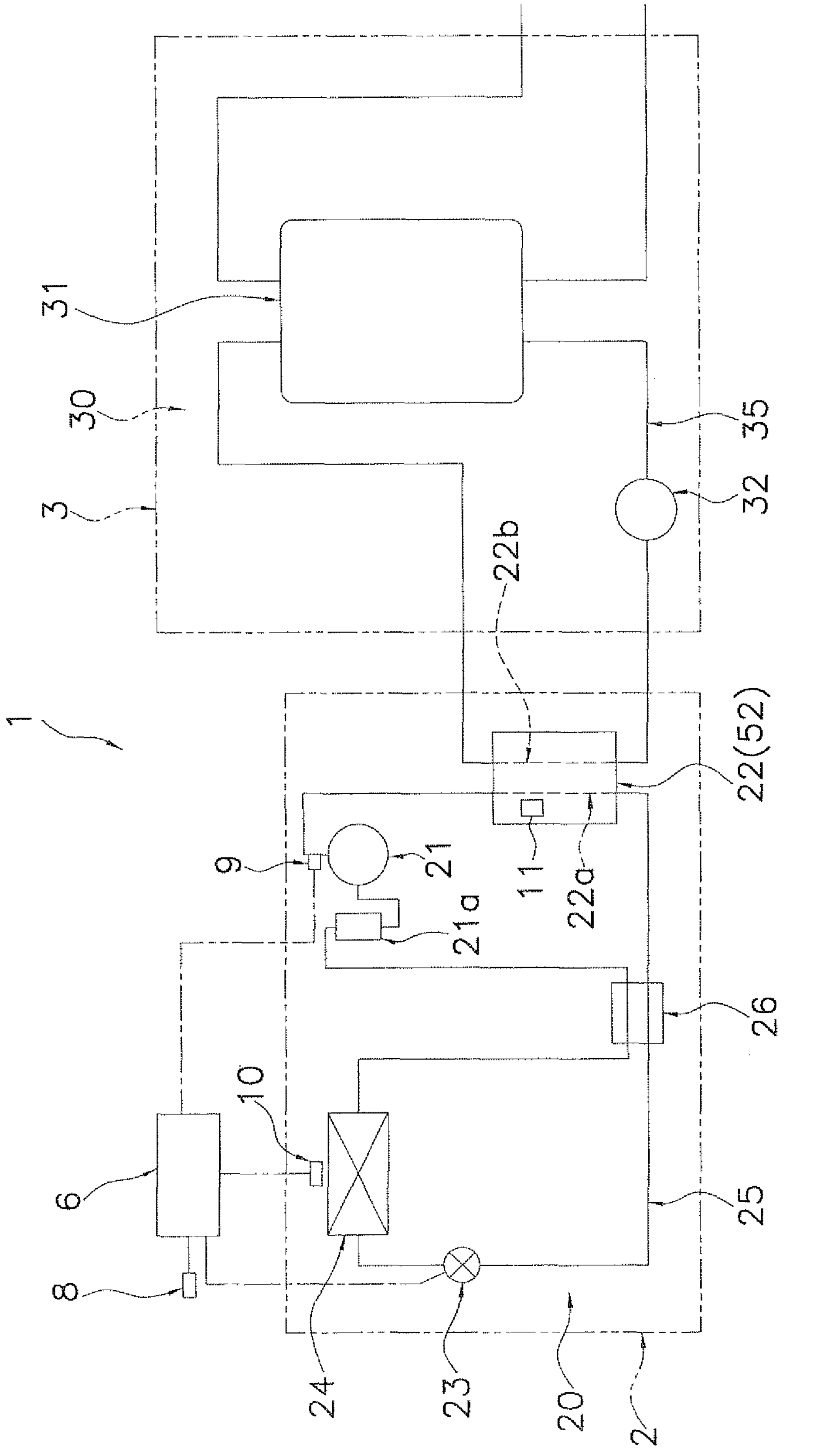

FIG. 1

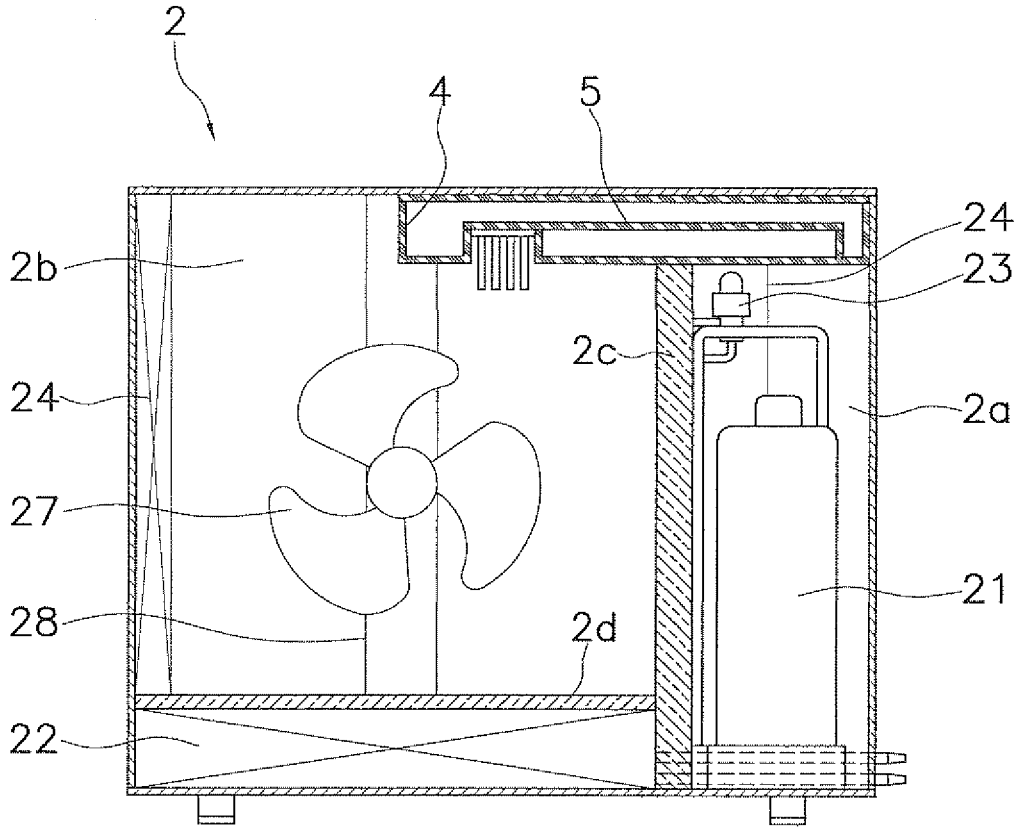

FIG. 2

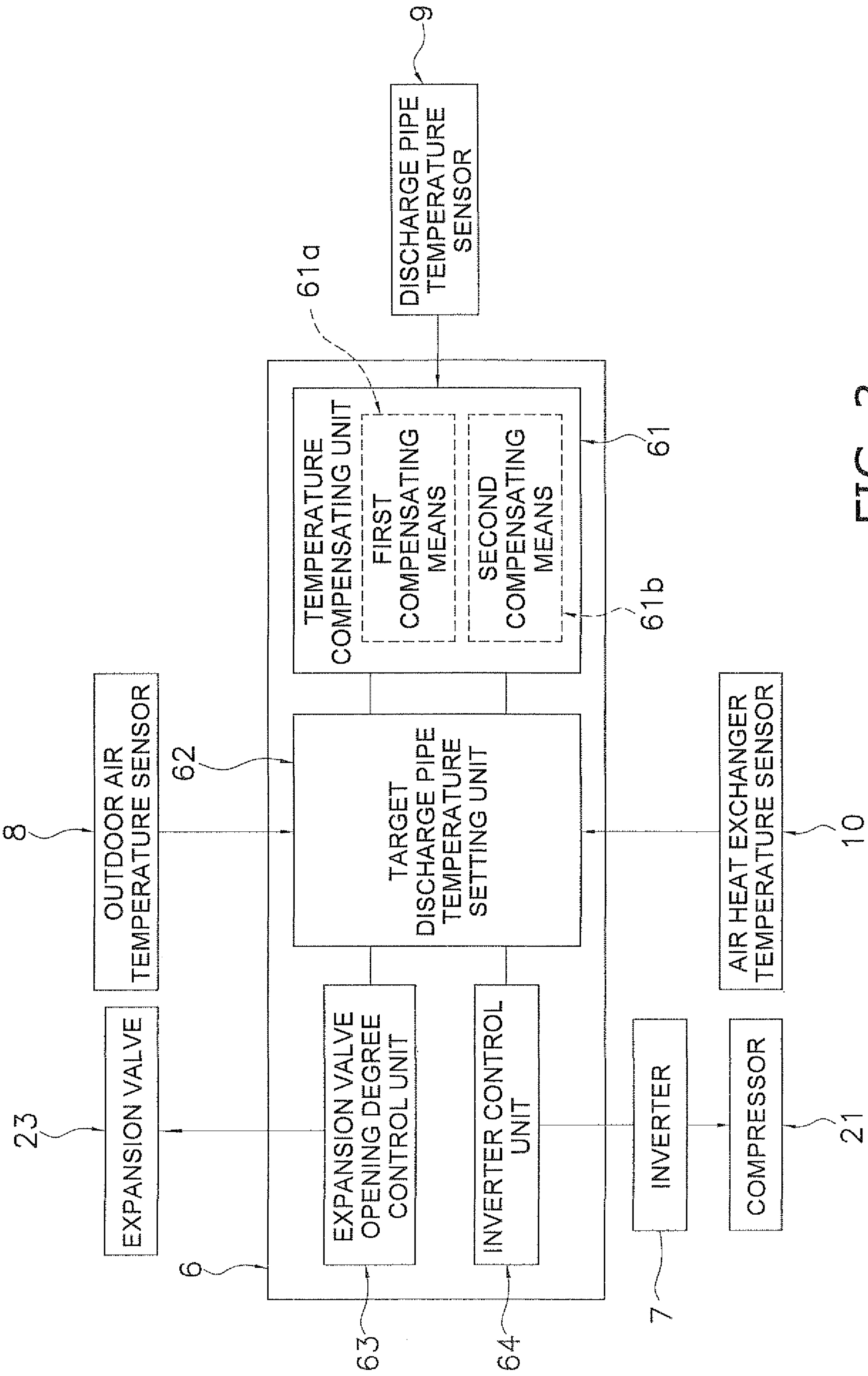
9
DISCHARGE PIPE TEMPERATURE SENSOR
61a
TEMPERATURE COMPENSATING UNIT
FIRST COMPENSATING MEANS
SECOND COMPENSATING MEANS
61
61b
8
OUTDOOR AIR TEMPERATURE SENSOR
62
TARGET DISCHARGE PIPE TEMPERATURE SETTING UNIT
AIR HEAT EXCHANGER TEMPERATURE SENSOR
10
23
EXPANSION VALVE
EXPANSION VALVE OPENING DEGREE CONTROL UNIT
INVERTER CONTROL UNIT
INVERTER
COMPRESSOR
21
6
63
64
7

FIG. 3

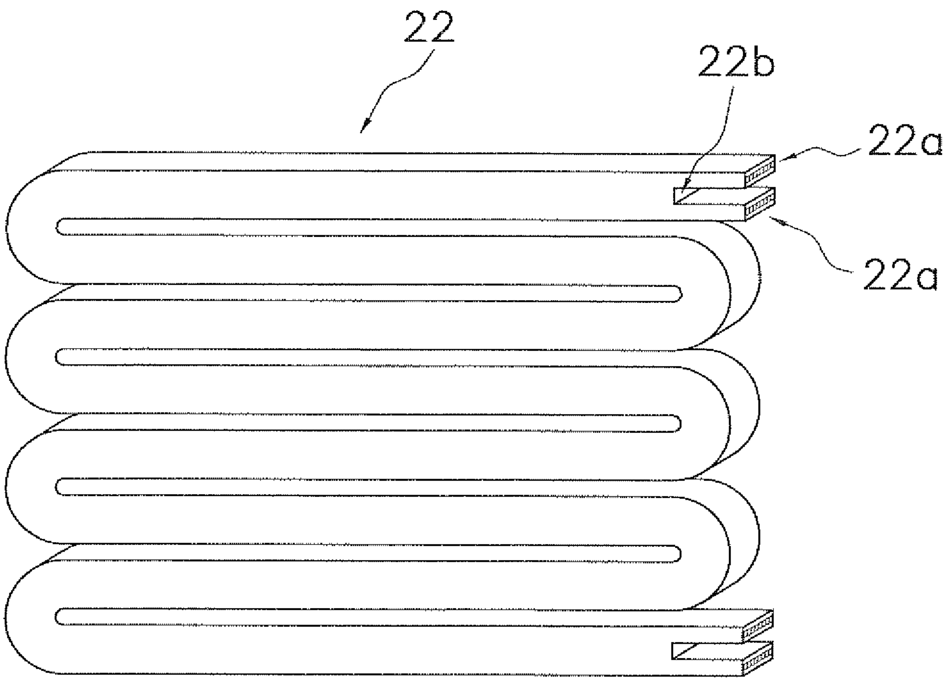

FIG. 4

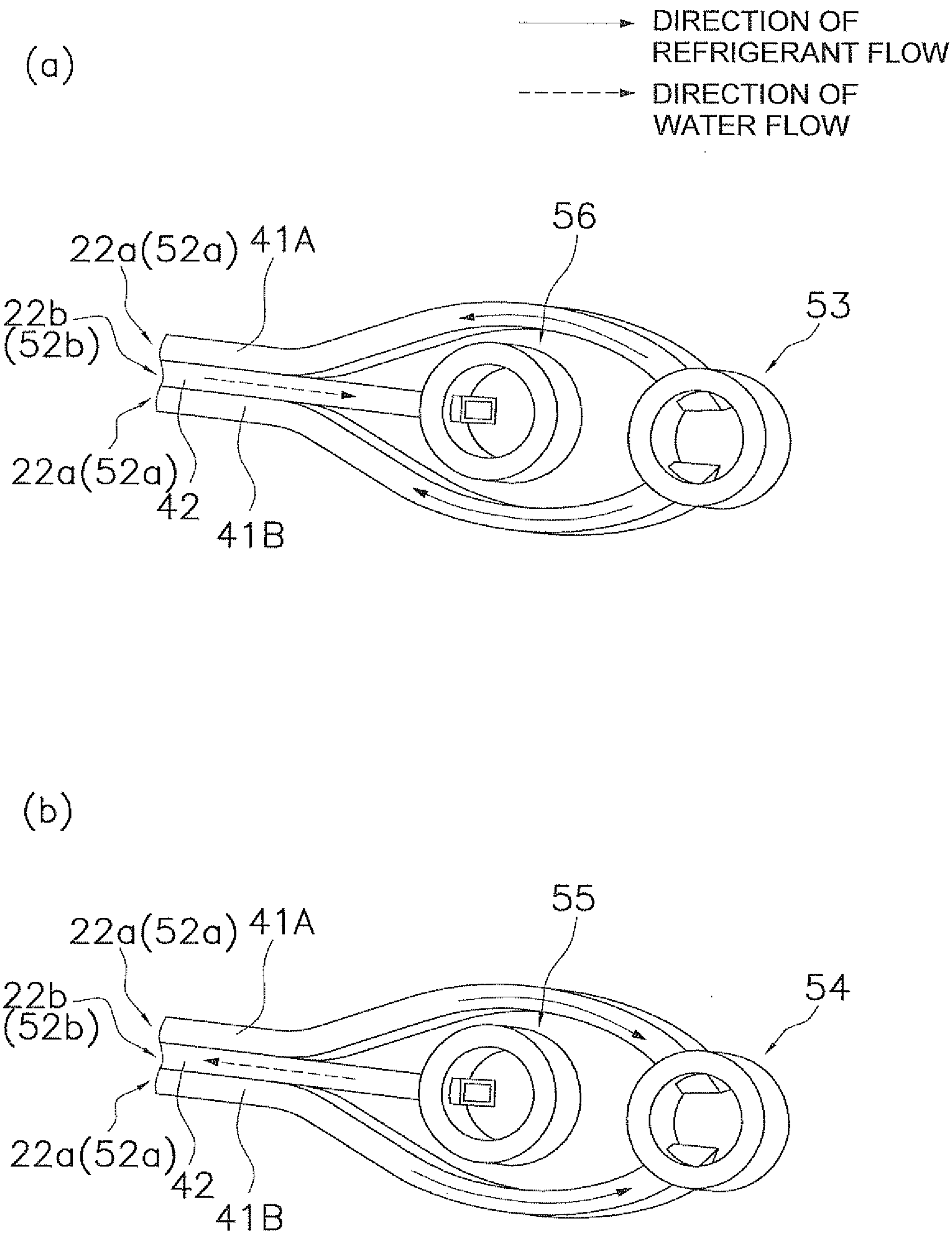
DIRECTION OF REFRIGERANT FLOW
DIRECTION OF WATER FLOW
(a)
22a(52a)
41A
56
53
22b (52b)
22a(52a)
42
41B
(b)
22a(52a)
41A
55
54
22b (52b)
22a(52a)
42
41B

FIG. 5

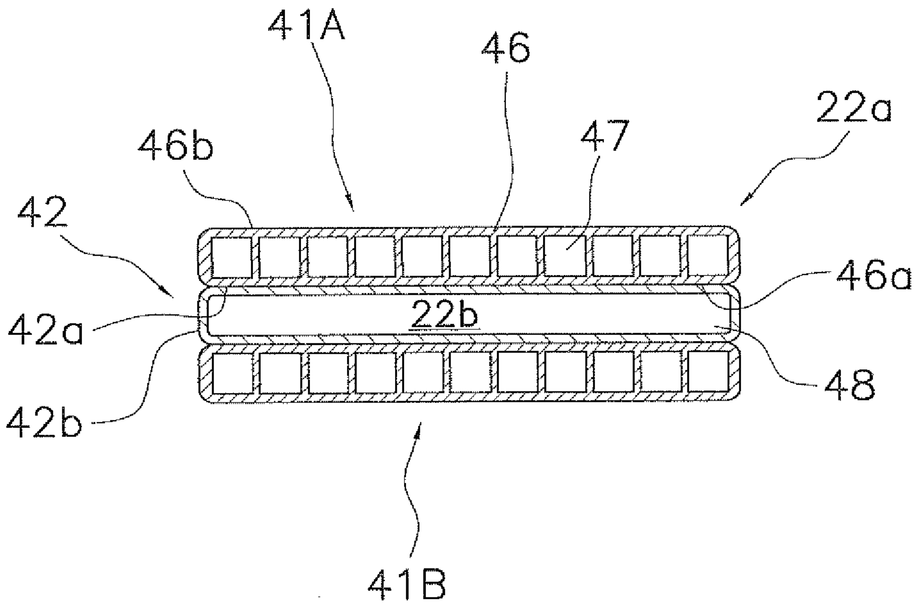

FIG. 6

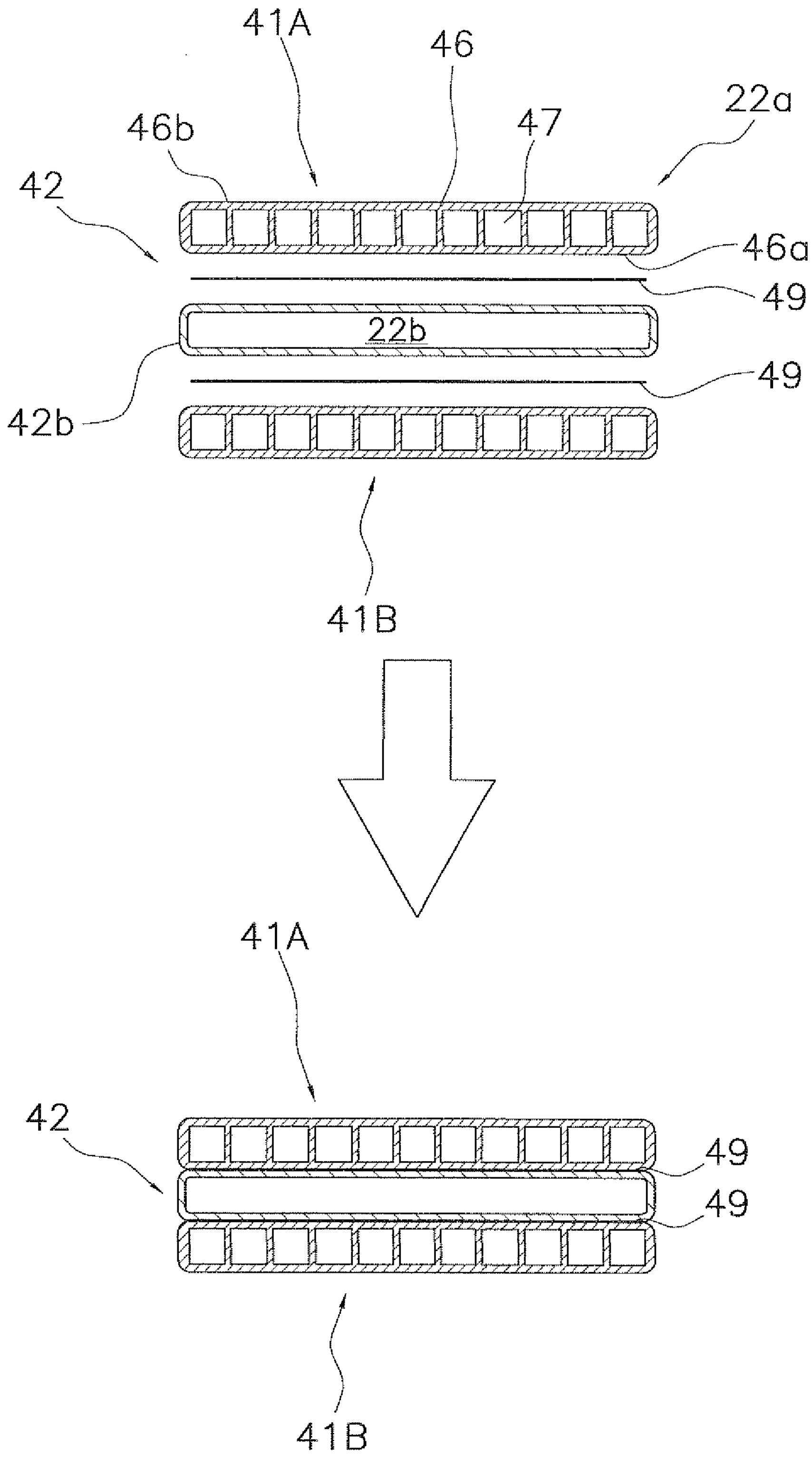

FIG. 7

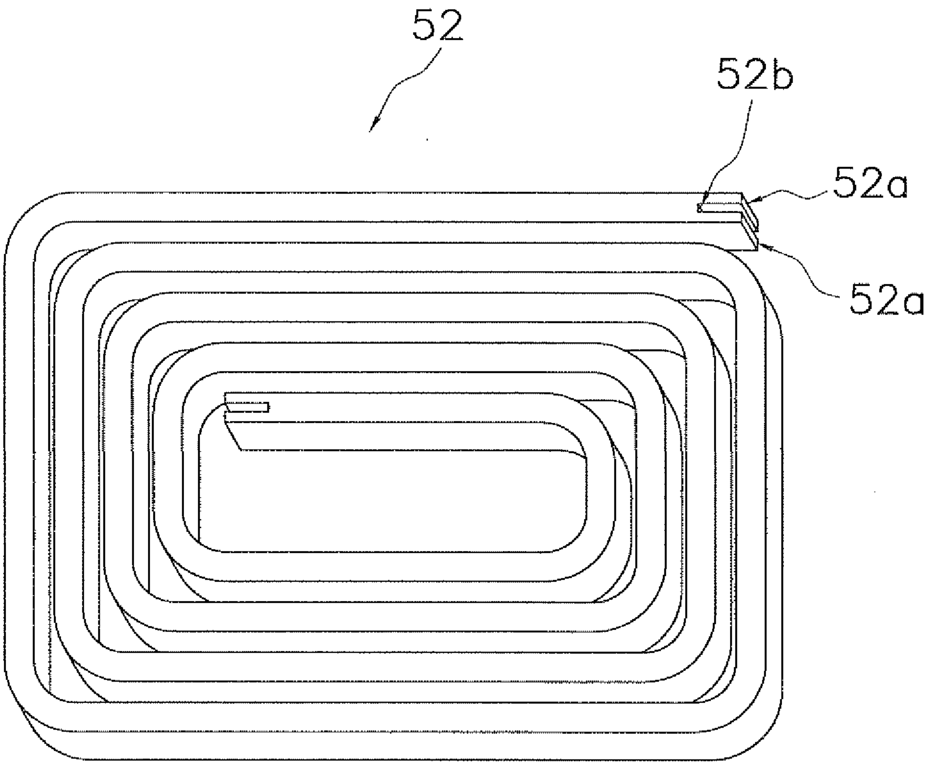

FIG. 8

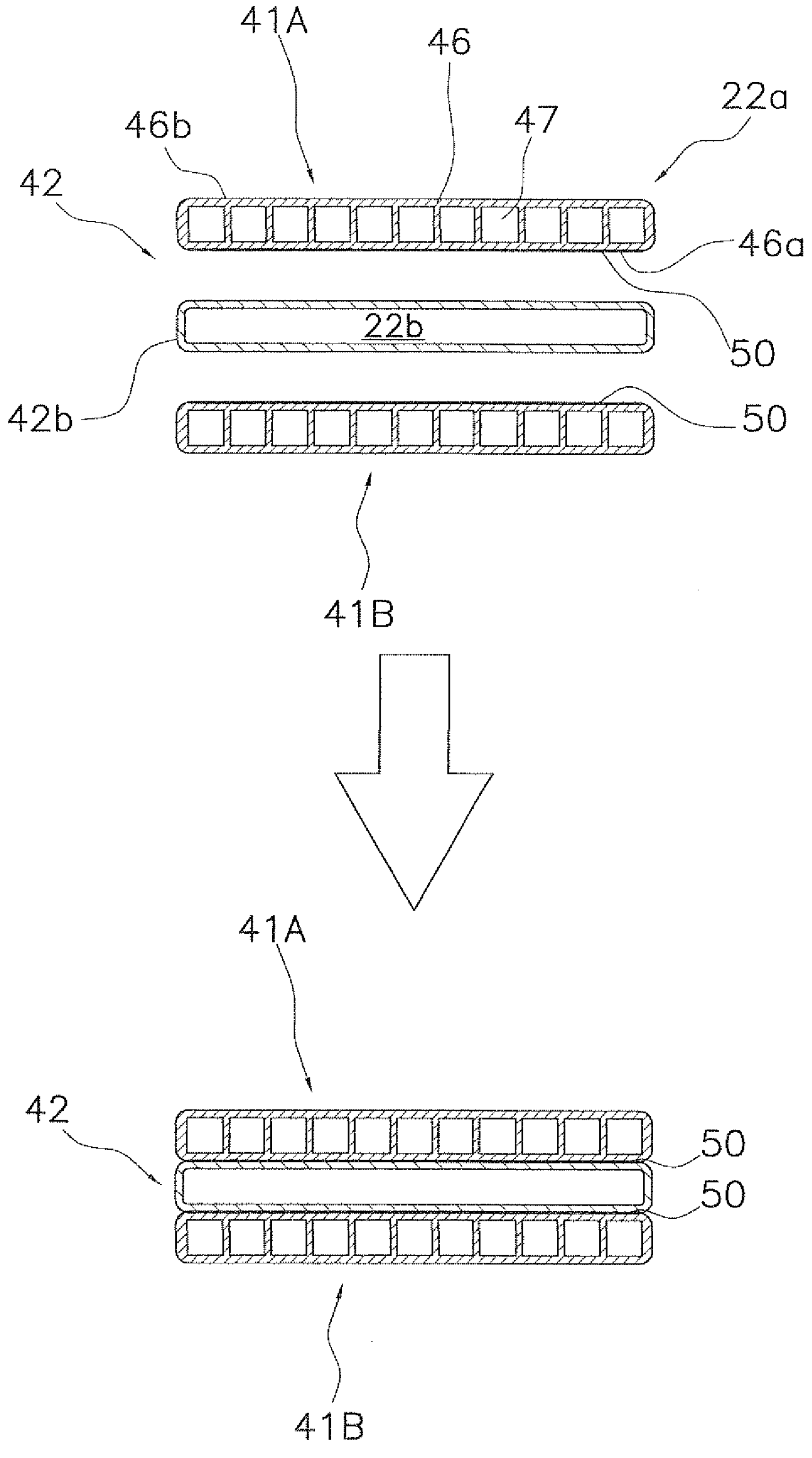

FIG. 9

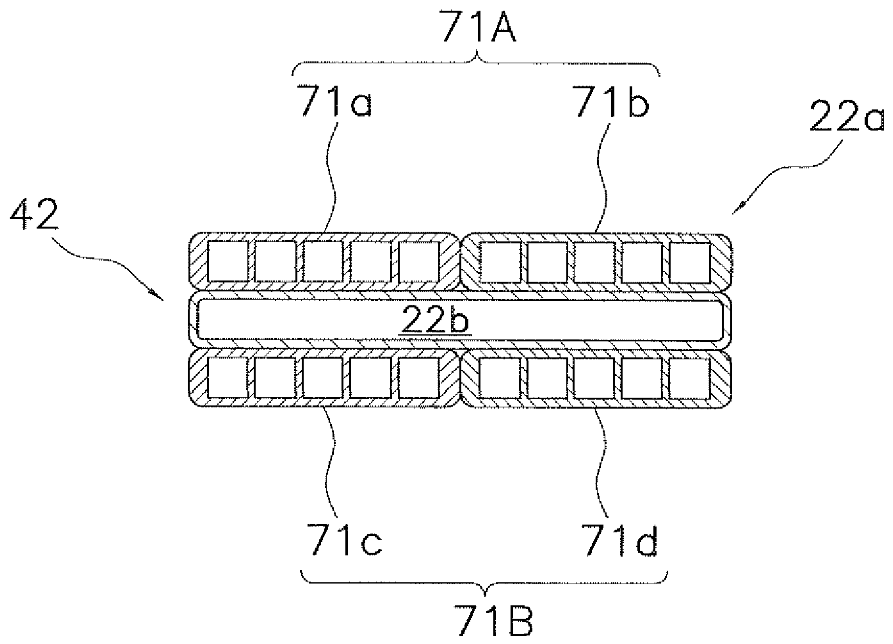

FIG. 10

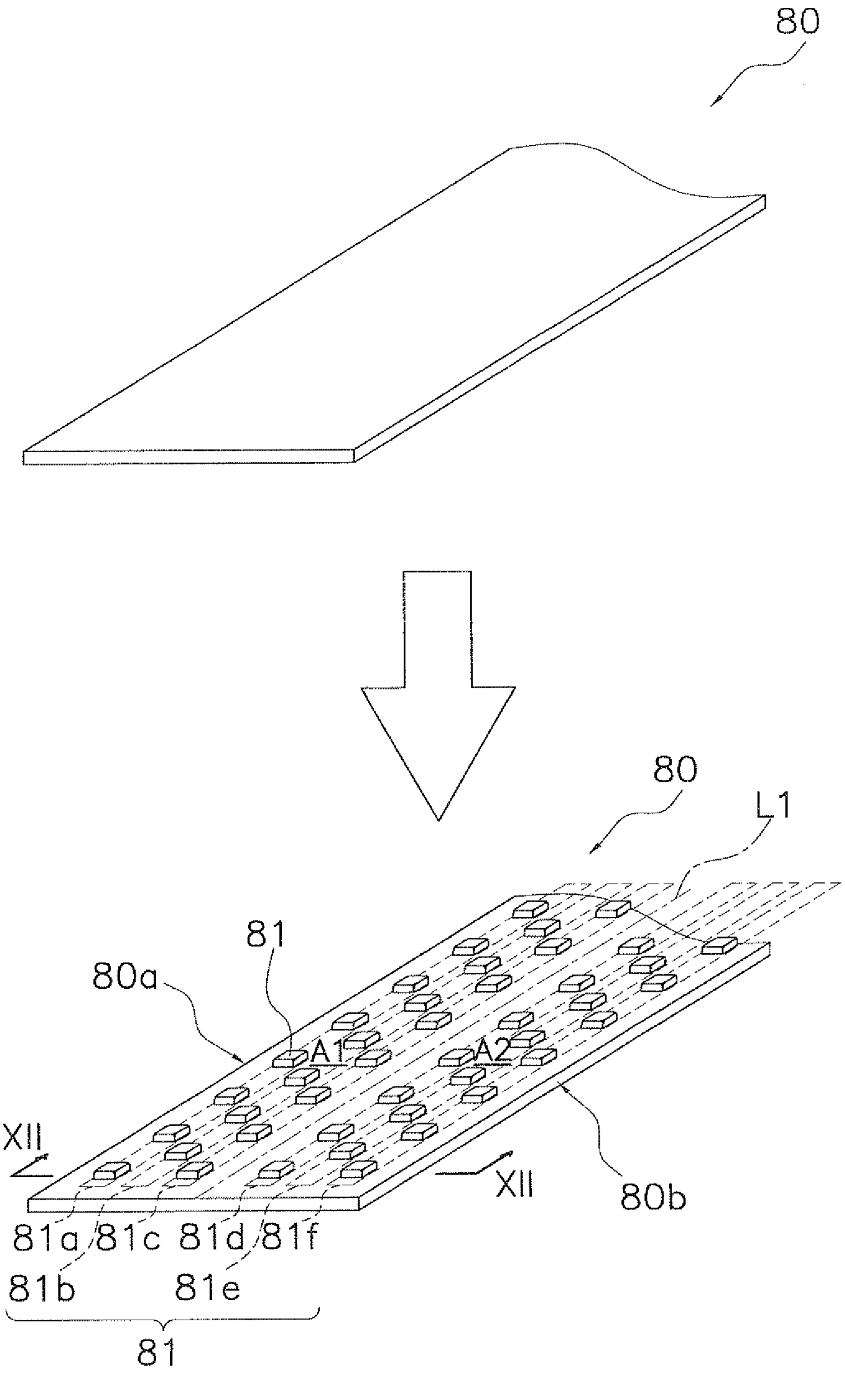

FIG. 11

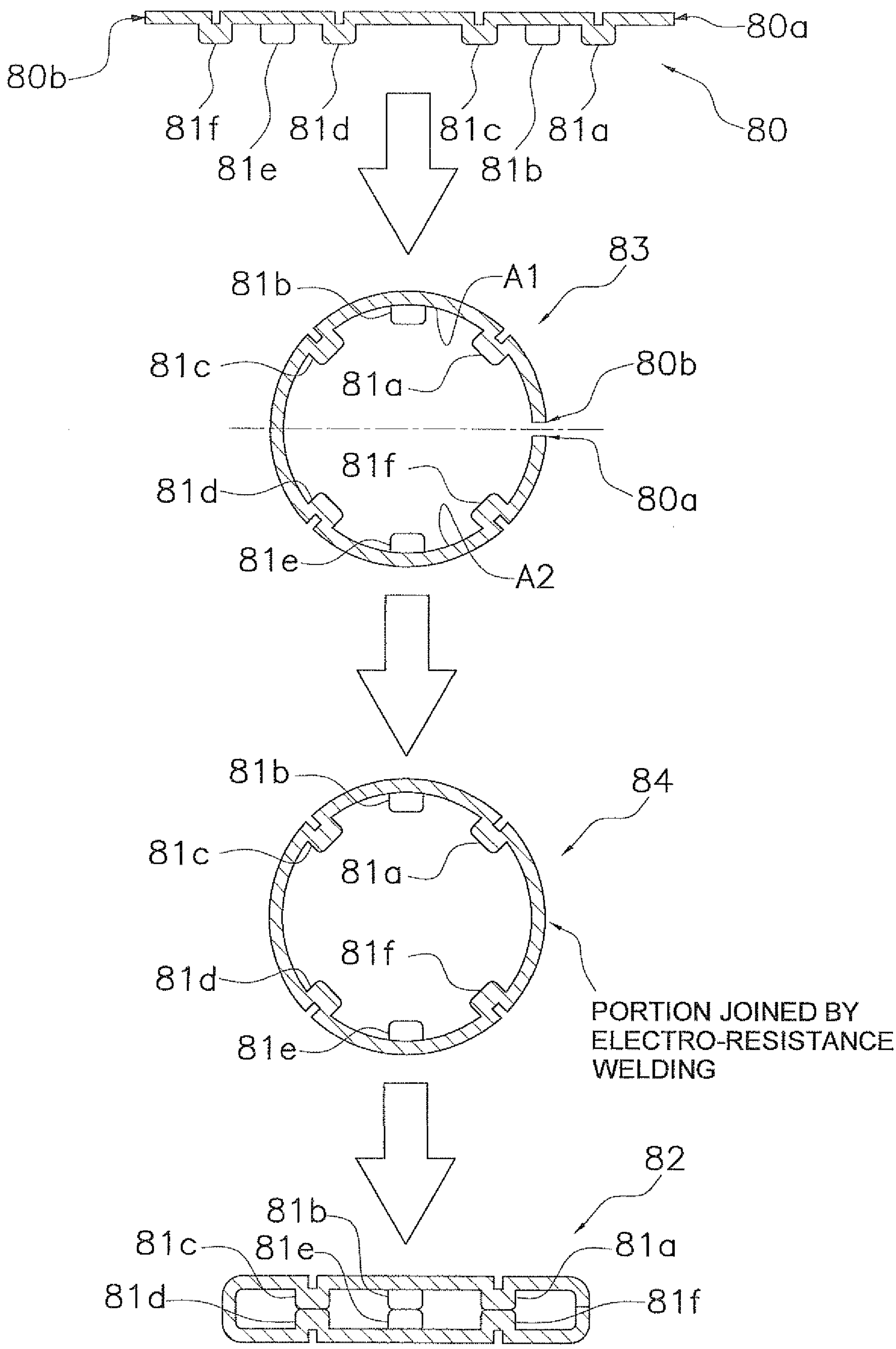
80a
80b
81f
81e
81d
81c
81b
81a
80
83
81b
A1
81c
81a
80b
81f
80a
81d
81e
A2
84
81b
81c
81a
81f
81d
81e
PORTION JOINED BY
ELECTRO-RESISTANCE
WELDING
82
81b
81c
81e
81a
81d
81f

FIG. 12

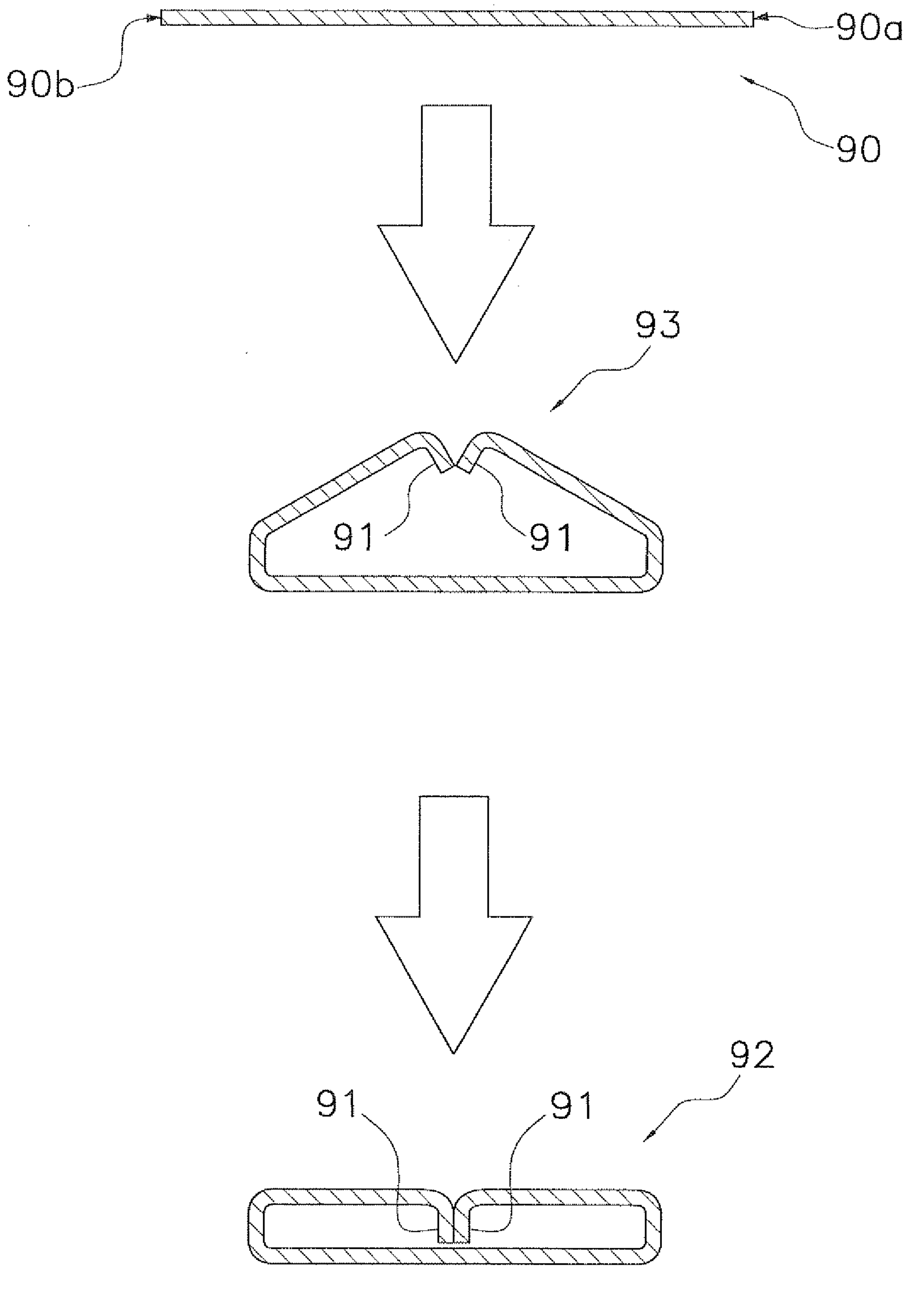

FIG. 13

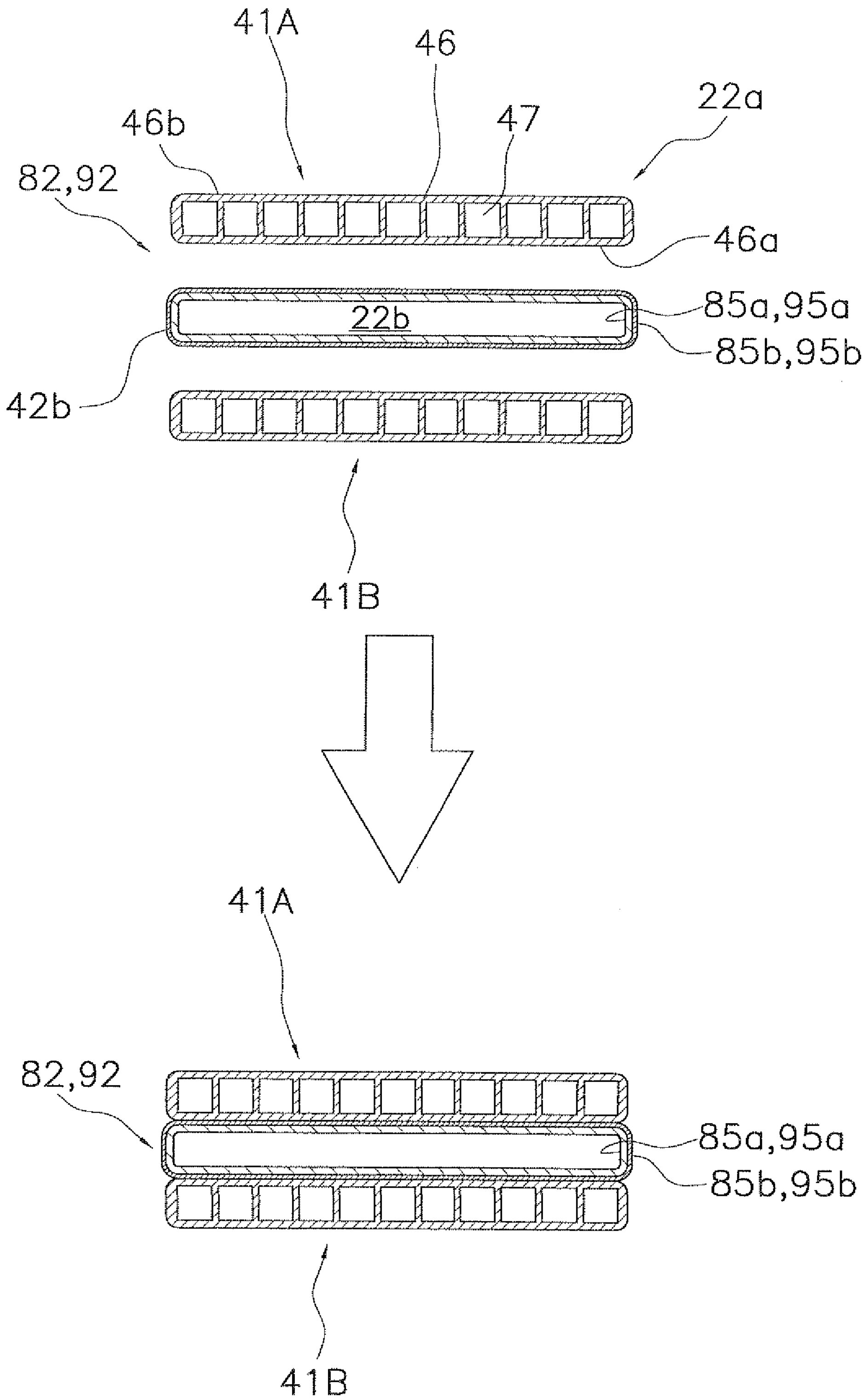
41A
46
22a
46b
47
82,92
46a
22b
85a,95a
85b,95b
42b
41B
41A
82,92
85a,95a
85b,95b
41B

FIG. 14

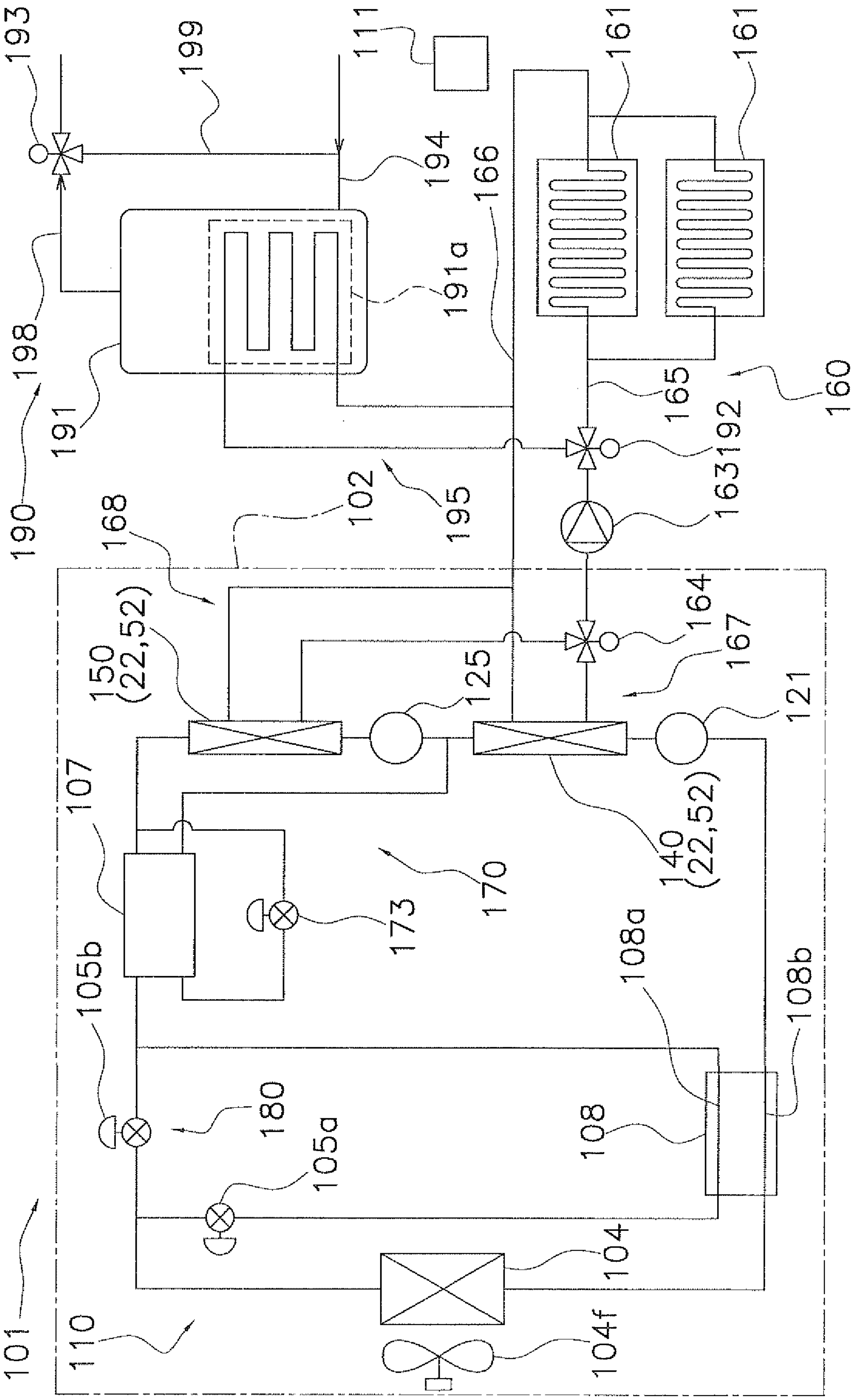
193
199
111
161
161
194
166
191a
198
191
190
165
160
192
163
168
102
195
150
(22,52)
125
164
167
121
107
140
(22,52)
170
173
108a
105b
108b
180
108
105a
104
101
110
104f

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/000265

A. CLASSIFICATION OF SUBJECT MATTER
F28D7/00(2006.01)i, *F25B1/00*(2006.01)i, *F28F1/02*(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)
F28D7/00, F25B1/00, F28F1/02

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.
Y	JP 2004-144430 A (Denso Corp.), 20 May 2004 (20.05.2004), paragraphs [0012] to [0016]; fig. 1, 3 (Family: none)	1-10
Y	JP 2002-98486 A (Zexel Valeo Climate Control Corp.), 05 April 2002 (05.04.2002), paragraphs [0035] to [0040]; fig. 2, 3 & WO 2002/025189 A1	1-10
Y	JP 2005-61667 A (Denso Corp.), 10 March 2005 (10.03.2005), paragraphs [0012] to [0023]; fig. 1 to 4 (Family: none)	1-10

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

* Special categories of cited documents:
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"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
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"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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 March, 2010 (30.03.10)	13 April, 2010 (13.04.10)

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/JP2010/000265

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2007/122685 A1 (Mitsubishi Electric Corp.), 01 November 2007 (01.11.2007), entire text; all drawings & EP 2009380 A1 & EP 2144028 A & EP 2154459 A & WO 2007/122685 A1 & CN 101432590 A	3,4
Y	JP 2004-53128 A (Oka Kogyo Kabushiki Kaisha), 19 February 2004 (19.02.2004), entire text; all drawings (Family: none)	5-7
Y	JP 7-19774 A (Zexel Corp.), 20 January 1995 (20.01.1995), entire text; all drawings (Family: none)	7
Y	JP 2002-107069 A (Sanyo Electric Co., Ltd.), 10 April 2002 (10.04.2002), entire text; all drawings (Family: none)	10

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004218946 A **[0003] [0004] [0099]**