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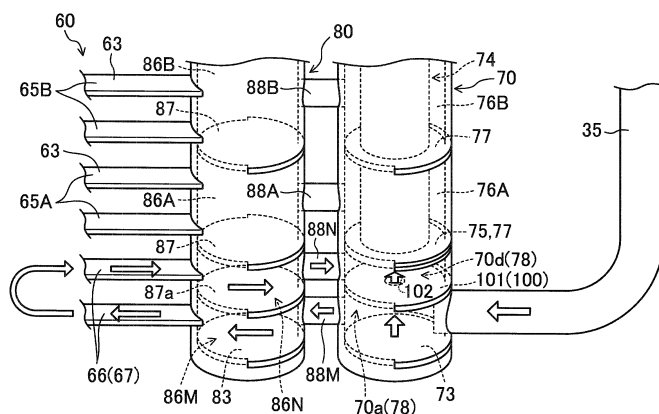
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(54) **HEAT EXCHANGER AND REFRIGERATION DEVICE**

(57) Disclosed is a heat exchanger including multi-bored flat tubes and intended to substantially prevent icing up, while hindering excessively large pressure loss of a refrigerant and an increase in size of the heat exchanger. The heat exchanger is configured such that an anti-icing section (66) has a refrigerant inlet end located below a heat exchanging section (60) and communicat-

ing with a liquid refrigerant pipe (35) of a refrigerant circuit, the heat exchanging section (60) has a refrigerant outlet end communicating with the liquid refrigerant pipe (35) via a throttle mechanism (100), and the anti-icing section (66) has a refrigerant outlet end communicating with a portion downstream of the throttle mechanism (100).

FIG.9



Description

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger of a refrigerant circuit which is capable of performing a defrosting operation. In particular, the present invention relates to a technique to substantially prevent excessive formation of ice which can be caused by a repeat of a cycle of melting of frost due to the defrosting operation and the conversion of water, which remains in a lower portion of the heat exchanger, into ice.

BACKGROUND ART

[0002] As a known example of a refrigeration apparatus which performs a defrosting operation, Patent Document 1 discloses an air-conditioning device including a refrigerant circuit that performs a refrigeration cycle. This air-conditioning device is configured to perform a reverse cycle defrosting operation to remove frost which has formed on an outdoor heat exchanger during a heating operation. In the reverse cycle defrosting operation, the refrigerant is circulated in the direction opposite to that in the heating operation.

[0003] Generally, an outdoor heat exchanger is fixed to a bottom frame of a casing. In a situation where a lower portion of the outdoor heat exchanger is in contact with the bottom frame, frost melts and turns into water during the defrosting operation, and the water remains in the contact portion between the outdoor heat exchanger and the bottom frame. In a situation where the lower portion is not in contact with the bottom frame, the water remains due to surface tension between bottom fins. Therefore, a heating operation following the end of the defrosting operation causes the water to freeze into ice. The defrosting operation is performed next and melts the frost, and the heating operation is then performed again, causing the water to freeze into ice again. If this cycle of the melting of frost and the conversion of water into ice is repeated, the resultant ice gradually grows to an excessive extent (i.e., icing up). This icing up can occur not only when an air-conditioning device defrosts its outdoor heat exchanger during a heating operation, but also when a refrigeration apparatus configured to cool the inside of a refrigerating room or the like performs a defrosting operation for its internal heat exchanger.

[0004] Patent Document 1 discloses a technique to hinder water from remaining in a lower portion of the outdoor heat exchanger by allowing a relatively high-pressure refrigerant before passing through a flow divider (a capillary tube) to flow into a subcooling tube provided at the bottom of the outdoor heat exchanger when the outdoor heat exchanger is used as an evaporator, and by allowing part of gas discharged from a compressor to flow into the subcooling tube when defrosting is carried out.

CITATION LIST

PATENT DOCUMENT

- 5 **[0005]** Patent Document 1: Japanese Unexamined Patent Publication No. 2007-232274

SUMMARY OF THE INVENTION

10 TECHNICAL PROBLEM

[0006] Meanwhile, some heat exchangers include multi-bored flat tubes as heat exchanger tubes and subcooling tubes. It is conceivable that also in such a heat exchanger including the multi-bored flat tubes, the icing up can be hindered through supply of a high-pressure refrigerant to the heat exchanger tube (the subcooling tube) provided at a lower portion when the heat exchanger functions as an evaporator.

15 **[0007]** However, even the configuration, in which a refrigerant before passing through a nozzle orifice of a flow divider and not decompressed is supplied to the subcooling tube when the heat exchanger functions as an evaporator, may not be sufficiently effective in preventing the icing up, in particular when an outdoor air temperature is low. This is because the subcooling tube, of which each flow channel has a small cross-sectional area, causes an excessively large pressure loss. To address this problem, a larger number of multi-bored flat tubes may be used to increase the total cross-sectional area of the flow channels of the subcooling tubes. However, an increase in the number of the multi-bored flat tubes results in an increase in the size of the heat exchanger.

20 **[0008]** In view of the foregoing problems, it is therefore an object of the present invention to substantially prevent the icing up when a heat exchanger including a multi-bored flat tube is used as an evaporator, while hindering an excessively large pressure loss of a refrigerant which is used to prevent the icing up, and an increase in the size of the heat exchanger.

SOLUTION TO THE PROBLEM

25 **[0009]** A first aspect of the present disclosure is implemented as a heat exchanger including a heat exchanging section (60) and an anti-icing section (66) below the heat exchanging section (60), the heat exchanging section (60) and anti-icing section (66) including a heat exchanger tube (63) and a heat exchanger tube (67), respectively, each of the heat exchanger tubes (63, 67) being comprised of a multi-bored flat tube which extends horizontally, is flat in the vertical direction, and includes therein a plurality of refrigerant channels.

30 **[0010]** In this heat exchanger, the anti-icing section (66) has a refrigerant inlet end communicating with a liquid refrigerant pipe (35) of a refrigerant circuit (10), the heat exchanging section (60) has a refrigerant inlet end communicating with the liquid refrigerant pipe (35) via a

throttle mechanism (100), and the anti-icing section (66) has a refrigerant outlet end communicating with a portion downstream of the throttle mechanism (100).

[0011] According to the first aspect, a high-temperature refrigerant in the liquid refrigerant pipe (35) is divided into a refrigerant flow which passes through the throttle mechanism (100) to flow to the heat exchanging section (60), and a refrigerant flow which flows into the anti-icing section (66) without passing through the throttle mechanism (100). The refrigerant flow that has passed through the anti-icing section (66) meets, on the downstream of the throttle mechanism (100), the refrigerant flow that has passed through the throttle mechanism (100). The refrigerant flows, which have met each other, together flow through the heat exchanging section (60). As a result, setting the throttle mechanism at an appropriate degree of opening allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66).

[0012] A second aspect of the present disclosure is an embodiment of the first aspect. In the second aspect, the heat exchanger includes a refrigerant flow divider (70) including a nozzle (79) disposed in a refrigerant passage from the liquid refrigerant pipe (35) to the heat exchanging section (60), and in the refrigerant passage from the liquid refrigerant pipe (35) to the heat exchanging section (60), the throttle mechanism (100) is disposed upstream of the nozzle (79) of the refrigerant flow divider (70).

[0013] According to the second aspect, in the portion upstream of the refrigerant flow divider (70), part of the refrigerant before passing through the throttle mechanism (100) passes through the anti-icing section (66), and then meets the refrigerant flow that has passed through the throttle mechanism (100). The refrigerant flows, which have met each other, together flow to the refrigerant flow divider (70). Just like the first aspect, the high-temperature refrigerant flow continuously passes through the anti-icing section (66).

[0014] A third aspect of the present disclosure is an embodiment of the second aspect. In the third aspect, the throttle mechanism (100) includes a throttle plate (101) which is provided in a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), and which has a throttle orifice (102) formed therein.

[0015] According to the third aspect, the throttle plate (101) that is provided in the portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), and that has the throttle orifice (102) forms the throttle mechanism (100). The throttle mechanism (100) allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66).

[0016] A fourth aspect of the present disclosure is an embodiment of the second aspect. In the fourth aspect, the throttle mechanism (100) includes a capillary tube (105) connected between the liquid refrigerant pipe (35) and a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79).

[0017] According to the fourth aspect, the throttle

mechanism (100), which includes the capillary tube (105) connected between the liquid refrigerant pipe (35) and the portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66).

[0018] A fifth aspect of the present disclosure is an embodiment of the second aspect. In the fifth aspect, the throttle mechanism (100) includes a capillary tube (105) connected between the anti-icing section (66) and a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79).

[0019] According to the fifth aspect, the throttle mechanism (100), which includes the capillary tube (105) connected between the anti-icing section (66) and the portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66).

[0020] A sixth aspect of the present disclosure is an embodiment of the second aspect. In the sixth aspect, the liquid refrigerant pipe (35) penetrates a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), and communicates with the heat exchanger tube (67) of the anti-icing section (66), and the throttle mechanism (100) includes a throttle orifice (106) formed in the liquid refrigerant pipe (35) and located below the nozzle (79) of the refrigerant flow divider (70).

[0021] According to the sixth aspect, the liquid refrigerant pipe (35) penetrates the portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), and communicates with the heat exchanger tube (67) of the anti-icing section (66), and the throttle mechanism (100) includes the throttle orifice (106) formed in the liquid refrigerant pipe (35) and located below the nozzle (79) of the refrigerant flow divider (70). This configuration allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66).

[0022] A seventh aspect of the present disclosure is an embodiment of any one of the first to sixth aspects. In the seventh aspect, the heat exchanger tube (67) of the anti-icing section (66) includes two heat exchanger tubes (67) arranged on top of each other in two layers.

[0023] According to the seventh aspect, the two the two tubes (67) of the anti-icing section arranged on top of each other in two layers below a lowermost one of the heat exchanger tubes (63) of the heat exchanging section (60) can substantially prevent water present in a lower portion of the heat exchanger from freezing.

[0024] An eighth aspect of the present disclosure is implemented as a refrigeration apparatus including a refrigerant circuit (10) including a compressor (21), a first heat exchanger (23), an expansion mechanism (24), and a second heat exchanger (41), all of which are connected together, the refrigeration apparatus being capable of performing an operation in which the first heat exchanger (23) functions as an evaporator.

[0025] In the refrigeration apparatus of the eighth as-

pect, the first heat exchanger (23) is the heat exchanger of any one of the first to seventh aspects. In an operation state in which the first heat exchanger (23) functions as the evaporator, the refrigerant inlet end of the anti-icing section (66) is connected to the liquid refrigerant pipe (35) of the refrigerant circuit (10), and the refrigerant outlet end of the heat exchanging section (60) is connected to the liquid refrigerant pipe (35) via the throttle mechanism (100).

[0026] According to the eighth aspect, in the refrigeration apparatus including the heat exchanger of any one of the first to seventh aspects, it is possible to hinder water from freezing in a lower portion of the heat exchanger when the operation in which the heat exchanger functions as the evaporator is carried out after defrosting of the heat exchanger.

ADVANTAGES OF THE INVENTION

[0027] According to the first aspect of the present disclosure, the anti-icing section (66) has the refrigerant inlet end communicating with the liquid refrigerant pipe (35) of the refrigerant circuit (10), the heat exchanging section (60) has the refrigerant inlet end communicating with the liquid refrigerant pipe (35) via the throttle mechanism (100), and the anti-icing section (66) has the refrigerant outlet end communicating with the portion downstream of the throttle mechanism (100). The high-temperature refrigerant from the liquid refrigerant pipe (35) is divided into a refrigerant flow which passes through the throttle mechanism (100) to flow to the heat exchanging section (60), and a refrigerant flow which flows to the anti-icing section (66) without passing through the throttle mechanism (100). In the portion downstream of the throttle mechanism (100), the refrigerant flow that has passed through the anti-icing section (66) meets the refrigerant flow that has passed through the throttle mechanism (100). The refrigerant flows, which have met each other, together flow to the heat exchanging section (60). Setting the throttle mechanism at an appropriate degree of opening allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66).

[0028] As can be seen, the refrigerant flow that has passed through the anti-icing section (66) and the refrigerant flow that has passed through the throttle mechanism (100) meet each other, and then together flow through the anti-icing section (66) constantly. This makes it possible to maintain the anti-icing section (66) at a high temperature constantly. Part of the circulating refrigerant is allowed to flow through the anti-icing section, instead of allowing all of the circulating refrigerant to flow. This makes it possible to reduce the influence of a pressure loss. Thus, the present disclosure contributes to effective prevention of the icing up even when an outdoor air temperature is low, while substantially avoiding upsizing of the heat exchanger by not allowing the anti-icing section (66) to increase in size.

[0029] According to the second aspect of the present

disclosure, the flow divider (70) includes the nozzle (79) provided in the refrigerant passage from the liquid refrigerant pipe (35) to the heat exchanging section (60), and the throttle mechanism (100) is provided in a portion, of the refrigerant passage from the liquid refrigerant pipe (35) to the heat exchanging section (60), located upstream of the nozzle (79) of the refrigerant flow divider (70). This configuration allows the high-temperature refrigerant flow before passing through the flow divider to pass through the anti-icing section (66) constantly. Thus, just like the first aspect, the second aspect contributes to substantial prevention of the icing up even when an outdoor air temperature is low, while reducing the influence of a pressure loss and maintaining the anti-icing section (66) at a high temperature, resulting in the substantial avoidance of upsizing of the heat exchanger.

[0030] According to the third aspect of the present disclosure, the throttle plate (101) provided with the throttle orifice (102) formed therein is disposed vertically below the nozzle (79) of the refrigerant flow divider (70), thereby achieving a configuration which allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66). Thus, the icing up of the heat exchanger can be substantially prevented with this simple configuration.

[0031] According to the fourth aspect of the present disclosure, the capillary tube (105) is connected between the liquid refrigerant pipe (35) and a portion, of the refrigerant pipe flow divider (70), located vertically below the nozzle (79), thereby achieving a configuration which allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66). Thus, the icing up of the heat exchanger can be substantially prevented with this simple configuration.

[0032] According to the fifth aspect of the present disclosure, the capillary tube (105) is connected between the anti-icing section (66) and a portion, of the refrigerant pipe flow divider (70), located vertically below the nozzle (79), thereby achieving a configuration which allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66). Thus, the icing up of the heat exchanger can be substantially prevented with this simple configuration.

[0033] According to the sixth aspect of the present disclosure, the liquid refrigerant pipe (35) penetrates a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), and communicates with the heat exchanger tube (67) of the anti-icing section (66), and the throttle orifice (106) is formed in a portion, of the liquid refrigerant pipe (35), located below the nozzle (79) of the refrigerant flow divider (70), thereby achieving a configuration which allows the high-temperature refrigerant flow to continuously pass through the anti-icing section (66). Thus, the icing up of the heat exchanger can be substantially prevented with this simple configuration.

[0034] According to the seventh aspect of the present disclosure, the two anti-icing tubes (67) are arranged on top of each other in two layers below the lowermost heat

exchanger tube (63) of the heat exchanging section (60). This configuration hinders cold thermal energy of the heat exchanger tubes (63) from being transferred to the lower end of the heat exchanger, and consequently, substantial prevention of the icing up can be achieved more reliably.

[0035] According to the eighth aspect of the present disclosure, in the refrigeration apparatus including the heat exchanger of any one of the first to seventh aspects, it is possible to hinder the icing up. This contributes to substantial prevention of the degradation of heat exchanging performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

[FIG. 1] FIG. 1 schematically illustrates a configuration for an air-conditioning device including an outdoor heat exchanger according to an embodiment of the present invention.

[FIG. 2] FIG. 2 is a schematic perspective view of an outdoor heat exchanger.

[FIG. 3] FIG. 3 illustrates, on an enlarged scale, a portion of the heat exchanging section of FIG. 2.

[FIG. 4] FIG. 4 corresponds to FIG. 3, and illustrates a configuration in which corrugated fins are adopted as heat transfer fins.

[FIG. 5] FIG. 5 schematically illustrates a configuration for an outdoor heat exchanger.

[FIG. 6] FIG. 6 illustrates, on an enlarged scale, the inlet/outlet header and the refrigerant flow divider of FIG. 2.

[FIG. 7] FIG. 7 is an enlarged cross-sectional view of the inlet/outlet header and the refrigerant flow divider of FIG. 5.

[FIG. 8] FIG. 8 is an enlarged cross-sectional view of lower portions of the inlet/outlet header and the refrigerant flow divider of FIG. 7.

[FIG. 9] FIG. 9 is an enlarged perspective view of lower portions of the inlet/outlet header and the refrigerant flow divider of FIG. 7.

[FIG. 10] FIG. 10 is a perspective view of a rod member.

[FIG. 11] FIG. 11 is a plan view of the rod member.

[FIG. 12] FIG. 12 is an exploded view of the refrigerant flow divider.

[FIG. 13] FIG. 13 is a perspective view illustrating how a rod insertion baffle is inserted into a flow divider case.

[FIG. 14] FIG. 14 is a perspective view illustrating how a nozzle member and a flow divider's vertical end baffle are inserted into the flow divider case.

[FIG. 15] FIG. 15 is a schematic cross-sectional view of a throttle mechanism according to a first variation.

[FIG. 16] FIG. 16 is a schematic cross-sectional view of a throttle mechanism according to a second variation.

[FIG. 17] FIG. 17 is a schematic cross-sectional view

of a refrigerant flow divider and a throttle mechanism according to another variation.

DESCRIPTION OF EMBODIMENTS

[0037] An embodiment of the present invention will now be described in detail with reference to the drawings. This embodiment is an example in which a heat exchanger of the present invention is used as an outdoor heat exchanger for an air-conditioning device.

<Basic Configuration for Air-conditioning Device>

[0038] FIG. 1 schematically illustrates a configuration for an air-conditioning device (1) including a heat exchanger (outdoor heat exchanger (23)) according to the present invention. The air-conditioning device (1) is an example of the refrigeration apparatus of the present invention (i.e., a refrigeration apparatus, in a broad sense, which is configured to refrigerate the inside of a refrigerating room or to condition indoor air).

[0039] The air-conditioning device (1) is capable of heating and cooling indoor air in, for example, a building by performing a vapor compression refrigeration cycle. The air-conditioning device (1) includes, as its main components, an outdoor unit (2) and an indoor unit (4) which are connected together. The outdoor unit (2) and the indoor unit (4) are connected to each other via a liquid refrigerant connection pipe (5) and a gaseous refrigerant connection pipe (6). Thus, the air-conditioning device (1) includes a vapor compression refrigerant circuit (10) comprised of the outdoor unit (2) and the indoor unit (4) connected together via the refrigerant connection pipes (5, 6).

<Indoor Unit>

[0040] The indoor unit (4) is installed inside a room and forms part of the refrigerant circuit (10). The indoor unit (4) includes, as its main component, an indoor heat exchanger (second heat exchanger) (41).

[0041] The indoor heat exchanger (41) functions as a refrigerant evaporator to cool indoor air during a cooling operation, and as a refrigerant radiator to heat indoor air during a heating operation. The indoor heat exchanger (41) has a liquid end connected to the liquid refrigerant connection pipe (5), and a gas end connected to the gaseous refrigerant connection pipe (6).

[0042] The indoor unit (4) includes an indoor fan (42) for sucking indoor air into the indoor unit (4), allowing the sucked air to exchange heat with the refrigerant in the indoor heat exchanger (41), and then supplying the air as supply air into the room. In other words, the indoor unit (4) includes the indoor fan (42) to supply, to the indoor heat exchanger (41), indoor air functioning as a source for heating or cooling the refrigerant that flows through the indoor heat exchanger (41). Here, examples of fans usable as the indoor fan (42) include fans driven by an

indoor fan drive motor (42a), such as centrifugal fan and a multi-blade fan.

<Outdoor Unit>

[0043] The outdoor unit (2) is installed outdoors and forms part of the refrigerant circuit (10). The outdoor unit (2) includes, as its main components, a compressor (21), a four-way switching valve (22), an outdoor heat exchanger (first heat exchanger) (23), an expansion valve (expansion mechanism) (24), a liquid stop valve (25), and a gas stop valve (26).

[0044] The compressor (21) compresses a refrigerant in a low-pressure stage in the refrigeration cycle until the refrigerant moves into a high-pressure stage. The compressor (21) has a hermetic structure including a positive-displacement compressor element (not shown), such as a rotary compression element or a scroll compression element, which is rotationally driven by a compressor motor (21a). The compressor (21) has a suction end connected to a suction pipe (31), and a discharge end connected to a discharge pipe (32). The suction pipe (31) is a refrigerant pipe connecting the suction end of the compressor (21) to the four-way switching valve (22). The discharge pipe (32) is a refrigerant pipe connecting the discharge end of the compressor (21) to the four-way switching valve (22).

[0045] The four-way switching valve (22) is used to change the direction in which a refrigerant flows through the refrigerant circuit (10). For the cooling operation, the four-way switching valve (22) selects a cooling cycle state where the outdoor heat exchanger (23) functions as a radiator for a refrigerant compressed in the compressor (21) and the indoor heat exchanger (41) functions as an evaporator for a refrigerant that has dissipated heat in the outdoor heat exchanger (23). That is, during the cooling operation, the four-way switching valve (22) connects the discharge end of the compressor (21) (in this embodiment, the discharge pipe (32)) to the gas end of the outdoor heat exchanger (23) (in this embodiment, a first gaseous refrigerant pipe (33)) (see one of the solid curves of the four-way switching valve (22) shown in FIG. 1). At this time, the suction end of the compressor (21) (in this embodiment, the suction pipe (31)) is connected to the gaseous refrigerant connection pipe (6) (in this embodiment, a second gaseous refrigerant pipe (34)) (see one of the solid curves of the four-way switching valve (22) shown in FIG. 1).

[0046] When the heating operation is carried out, the four-way switching valve (22) selects a heating cycle state where the outdoor heat exchanger (23) functions as an evaporator for a refrigerant that has dissipated heat in the indoor heat exchanger (41) and the indoor heat exchanger (41) functions as a radiator for a refrigerant compressed in the compressor (21). That is, during the heating operation, the four-way switching valve (22) connects the discharge end of the compressor (21) (in this embodiment, the discharge pipe (32)) to the gaseous re-

frigerant connection pipe (6) (in this embodiment, the second gaseous refrigerant pipe (34)) (see one of the broken curves of the four-way switching valve (22) shown in FIG. 1). At this time, the suction end of the compressor (21) (in this embodiment, the suction pipe (31)) is connected to the gas end of the outdoor heat exchanger (23) (in this embodiment, the first gaseous refrigerant pipe (33)) (see one of the broken curves of the four-way switching valve (22) shown in FIG. 1). The first gaseous refrigerant pipe (33) connects the four-way switching valve (22) to the gas end of the outdoor heat exchanger (23). The second gaseous refrigerant pipe (34) connects the four-way switching valve (22) to the gas stop valve (26).

[0047] The outdoor heat exchanger (23) functions as a radiator for a refrigerant (a refrigerant radiator) which uses outdoor air as a cooling source during the cooling operation, and functions, during the heating operation, as an evaporator for a refrigerant (a refrigerant evaporator) which uses outdoor air as a heating source. The liquid and gas ends of the outdoor heat exchanger (23) are connected to the liquid refrigerant pipe (35) and the first gaseous refrigerant pipe (33), respectively. The liquid refrigerant pipe (35) connects the liquid end of the outdoor heat exchanger (23) to the liquid refrigerant connection pipe (5).

[0048] During the cooling operation, the expansion valve (24) decompresses a refrigerant which has dissipated heat in the outdoor heat exchanger (23) and which is in a high-pressure stage in the refrigeration cycle, until the refrigerant moves into a low-pressure stage in the refrigeration cycle. During the heating operation, the expansion valve (24) decompresses a refrigerant which has dissipated heat in the indoor heat exchanger (41) and which is in the high-pressure stage in the refrigeration cycle, until the refrigerant moves into the low-pressure stage in the refrigeration cycle. The expansion valve (24) is provided on a portion of the liquid refrigerant pipe (35) near a liquid stop valve (25). Here, an electric expansion valve is used as the expansion valve (24).

[0049] The liquid stop valve (25) and the gas stop valve (26) are provided at connecting ports for external devices and piping (specifically, the liquid refrigerant connection pipe (5) and the gaseous refrigerant connection pipe (6)). The liquid stop valve (25) is provided at an end portion of the liquid refrigerant pipe (35). The gas stop valve (26) is provided at an end portion of the second gaseous refrigerant pipe (34).

[0050] The outdoor unit (2) includes an outdoor fan (36) for sucking outdoor air into the outdoor unit (2), causing the sucked air to exchange heat with the refrigerant in the outdoor heat exchanger (23), and then ejecting the air to the outside. In other words, the outdoor unit (2) includes the outdoor fan (36) to supply, to the outdoor heat exchanger (23), outdoor air functioning as a source for heating or cooling the refrigerant that flows through the outdoor heat exchanger (23). Here, examples of fans usable as the outdoor fan (36) include fans driven by an

outdoor fan drive motor (36a), such as a propeller fan.

<Refrigerant Connection Pipe>

[0051] The refrigerant connection pipes (5, 6) are assembled at an installation site such as a building when the air-conditioning device (1) is installed there. The connection pipes (5, 6) for use vary in length and diameter, depending on installation conditions such as the installation site and a combination of the outdoor unit (2) and the indoor unit (4).

[Basic Configuration for Outdoor Heat Exchanger]

[0052] A configuration for the outdoor heat exchanger (23) will be described with reference to FIGS. 1 to 5. Note that in the following description, unless otherwise specified, directions and surfaces are described with reference to a state where the outdoor heat exchanger (23) is placed in the casing (not shown) of the outdoor unit (2). In this embodiment, an anti-icing section (66), which will be described later, is provided below a heat exchanging section (60). However, for the sake of convenience, FIGS. 2 to 4 are simplified by omission of the anti-icing section (66), whereas FIG. 5 shows the anti-icing section (66).

[0053] The outdoor heat exchanger (23) is a heat exchanger panel which has a substantially L-shape in plan view. The outdoor heat exchanger (23) includes, as its main components: the heat exchanging section (60) and the anti-icing section (66) which are configured to exchange heat between outdoor air and a refrigerant; a refrigerant flow divider (70) and inlet/outlet header (80) which are provided adjacent to one end of the heat exchanging section (60) and one end the anti-icing section (66); and an intermediate header (90) provided adjacent to the other end of the heat exchanging section (60) and the other end the anti-icing section (66). The outdoor heat exchanger (23) is an all-aluminum heat exchanger of which the refrigerant flow divider (70), the inlet/outlet header (80), the intermediate header (90), the heat exchanging section (60), and the anti-icing section (66) are all made of aluminum or an aluminum alloy. These components are joined to each other by brazing such as furnace brazing.

[0054] The heat exchanging section (60) includes multiple (in this embodiment, 12) main heat exchanging subsections (61A-61L) which form an upper portion of the outdoor heat exchanger (23), and multiple (in this embodiment, 12) subsidiary heat exchanging subsections (62A-62L) which form a lower portion of the outdoor heat exchanger (23). The main heat exchanging subsections (61A-61L) are arranged such that below the uppermost main heat exchanging subsection (61A), the other main heat exchanging subsections (61B-61L) are sequentially disposed downward in the vertical direction. The subsidiary heat exchanging sections (62A-62L) are arranged such that above the lowermost subsidiary heat exchanging

section (62A), the other subsidiary heat exchanging subsections (62B-62L) are sequentially disposed upward in the vertical direction. As shown in FIG. 5, the anti-icing section (66) having two anti-icing tubes (heat exchanger tubes) (67) arranged on top of each other in two layers is provided below the lowermost subsidiary heat exchanging subsection (62A).

[0055] The heat exchanging section (60) is a heat exchanger of insertion fin type, which includes many (multiple) heat exchanger tubes (63) each comprised of a flat tube, and many heat transfer fins (64) each comprised of an insertion fin. Each heat exchanger tube (63) is a multi-bored flat tube made of aluminum or an aluminum alloy. The multi-bored flat tube has flat surfaces (63a) which face in the vertical direction and function as heat exchanging surfaces, and many narrow internal channels (63b) through which the refrigerant flows. In other words, the heat exchanging section (60) is comprised of a vertical array of the heat exchanger tubes (63) that extend horizontally, are flat in the vertical direction, and include therein the many (multiple) refrigerant channels (63b). The many heat exchanger tubes (63) are arranged in multiple layers and spaced apart from each other in the vertical direction, and each have both ends respectively connected to the inlet/outlet header (80) and the intermediate header (90). The heat transfer fins (64) are made of aluminum or an aluminum alloy, and have many horizontally-extending narrow notches (64a) which receive the many heat exchanger tubes (63), that are arranged between the inlet/outlet header (80) and the intermediate header (90), inserted therein. Each of the notches (64a) of the heat transfer fins (64) has a shape substantially the same as the outline of the cross section of the heat exchanger tube (63). The many heat exchanger tubes (63) are classified into the main heat exchanging subsections (61A-61L) and the subsidiary heat exchanging subsections (62A-62L). Specifically, in this embodiment, part of the many heat exchanger tube (63) are divided into heat exchanger tube groups arranged vertically downward from the top of the outdoor heat exchanger (23). Each of these heat exchanger tube groups consists of a predetermined number of the heat exchanger tubes (63) (approximately three to eight tubes (63)) and forms an associated one of the main heat exchanging subsections (61A-61L). The rest of the many heat exchanger tubes (63) are divided into heat exchanger tube groups arranged vertically upward from the bottom of the outdoor heat exchanger (23). Each of these heat exchanger tube groups consists of a predetermined number of the heat exchanger tubes (63) (approximately one to three tubes (63)) and forms an associated one of the subsidiary heat exchanging subsections (62A-62L). The anti-icing tubes (67) are comprised of the same heat exchanger tubes (63) as the multi-bored flat tubes forming the main heat exchanging subsections (61A-61L) and the subsidiary heat exchanging subsections (62A-62L).

[0056] In the outdoor heat exchanger (23), as will be detailed later, in a situation where the outdoor heat ex-

changer (23) functions as an evaporator, a refrigerant inlet end of the anti-icing section (66) communicates with the liquid refrigerant pipe (35) of the refrigerant circuit (10), and a refrigerant inlet end of the heat exchanging section (60) communicates with the liquid refrigerant pipe (35) via a throttle mechanism (100). A refrigerant outlet end of the anti-icing section (66) communicates with a portion downstream of the throttle mechanism (100).

[0057] Note that the outdoor heat exchanger (23) is not limited to a heat exchanger of insertion fin type in which the insertion fins (see FIG. 3) are adopted as the heat transfer fins (64), but may be a heat exchanger of corrugated fin type in which many corrugated fins (see FIG. 4) are adopted as the heat transfer fins (64).

[Configuration for Intermediate Header]

[0058] A configuration for the intermediate header (90) will be described with reference to FIGS. 1 to 5. Note that in the following description, unless otherwise specified, directions and surfaces are described with reference to a state where the outdoor heat exchanger (23) including the intermediate header (90) is placed in the outdoor unit (2).

[0059] As described previously, the intermediate header (90) is provided adjacent to the respective other ends of the heat exchanging section (60) and the anti-icing section (66), and connected to the respective other ends of the heat exchanger tubes (63) of the heat exchanging section (60) and the anti-icing tubes (67). The intermediate header (90) is comprised of a vertically-extending tubular member made of aluminum or an aluminum alloy, and includes, as its main component, an intermediate header case (91) which is vertically oriented and hollow.

[0060] The internal space of the intermediate header case (91) is partitioned in the vertical direction by multiple (in this embodiment, 11) intermediate header's main-side baffles (92), multiple (in this embodiment, 11) intermediate header's subsidiary-side baffles (93), an intermediate header's boundary baffle (94), and an intermediate header's lower baffle (98). The intermediate header's main-side baffles (92) are sequentially arranged in the vertical direction to partition an upper internal space of the intermediate header case (91) into intermediate header's main-side spaces (95A-95K) which communicate with the respective other ends of the main heat exchanging subsection (61A-61K). The intermediate header's subsidiary-side baffles (93) are sequentially arranged in the vertical direction to partition a lower internal space of the intermediate header case (91) into intermediate header's subsidiary spaces (96A-96K) which communicate with the respective other ends of the subsidiary heat exchanging subsections (62A-62K). The intermediate header's boundary baffle (94) partitions an internal space in the intermediate header case (91), which is sandwiched in the vertical direction between the lowermost intermediate header's main-side baffle (92) and the uppermost intermediate header's subsidiary-side baffle (93), into an in-

termediate header's main-side space (95L) and an intermediate header's subsidiary space (96L). The intermediate header's main-side space (95L) communicates with the other end of the main heat exchanging subsection (61L), and the intermediate header's subsidiary space (96L) communicates with the other end of the subsidiary heat exchanging subsection (62L). The intermediate header's lower baffle (98) defines a lowermost internal space, of the intermediate header case (91), which functions as an intermediate header's lower space (a refrigerant return space) (99) communicating with the respective other ends of the anti-icing tubes (67).

[0061] Multiple (in this embodiment, 11) intermediate header's communication pipes (97A-97K) are connected to the intermediate header case (91). The intermediate header's communication pipes (97A-97K) are refrigerant pipes through which the intermediate header's main-side spaces (95A-95K) communicate with the intermediate header's subsidiary spaces (96A-96K). Thus, the main heat exchanging subsections (61A-61K) communicate with the subsidiary heat exchanging subsections (62A-62K) via the intermediate header (90) and the intermediate header's communication pipes (97A-97K), thereby forming refrigerant paths (65A-65K) of the outdoor heat exchanger (23). The intermediate header's boundary baffle (94) has an intermediate header's baffle communication hole (94a) through which the intermediate header's main-side space (95L) communicates with the intermediate header's subsidiary space (96L). Thus, the main heat exchanging subsection (61L) communicates with the subsidiary heat exchanging subsection (62L) via the intermediate header (90) and the intermediate header's baffle communication hole (94a), thereby forming a refrigerant path (65L) of the outdoor heat exchanger (23). As can be seen, the outdoor heat exchanger (23) has a multi-path configuration including the multiple (in this embodiment, 12) refrigerant paths (65A-65L). The intermediate header's lower space (99) has a closed end face (the left end face in FIG. 5), opposite to the end face connected to the anti-icing tubes (67).

[0062] The intermediate header (90) is not limited to the configuration in which the intermediate header case (91) has the internal spaces simply partitioned by the intermediate header's baffles (92, 93). The intermediate header (90) may have a different configuration which maintains a refrigerant flow therein in a suitable state.

[Configurations for Inlet/outlet Header and Refrigerant Flow Divider]

[0063] Next, configurations for the inlet/outlet header (80) and the refrigerant flow divider (70) will be described with reference to FIGS. 1 to 14. Note that in the following description, unless otherwise specified, directions and surfaces are described with reference to a state where the outdoor heat exchanger (23) including the refrigerant flow divider (70) and the inlet/outlet header (80) is placed in the outdoor unit (2). Further, unless otherwise speci-

fied, directions in which the refrigerant flows in the outdoor heat exchanger (23) including the refrigerant flow divider (70), the inlet/outlet header (80), and the intermediate header (90) is described with reference to a situation where the outdoor heat exchanger (23) functions as a refrigerant evaporator.

<Inlet/outlet Header>

[0064] As described previously, the inlet/outlet header (80) is provided adjacent to the one end of the heat exchanging section (60) and connected to the one end of each of the heat exchanger tubes (63). The inlet/outlet header (80) is comprised of a vertically-extending member made of aluminum or an aluminum alloy, and includes, as its main component, an inlet/outlet header case (81) which is vertically oriented and hollow. The inlet/outlet header case (81) includes, as its main component, an inlet/outlet header tube (82) in the shape of a cylinder having open upper and lower ends, which are respectively closed with two inlet/outlet header's vertical end baffles (83). The internal space of the inlet/outlet header case (81) is partitioned in the vertical direction by an inlet/outlet header's boundary baffle (84) into an upper inlet/outlet space (85) and lower supply spaces (86A-86L). The inlet/outlet space (85) communicates with the one end of each of the main heat exchanging subsections (61A-61L), and functions as an outlet space for causing refrigerant flows that have passed through the refrigerant paths (65A-65L) to meet together. Thus, the upper portion of the inlet/outlet header (80) having the inlet/outlet space (85) functions as a refrigerant outlet section where the refrigerant flows that have come out of the refrigerant paths (65A-65L) to meet together. The inlet/outlet header (80) is connected to the first gaseous refrigerant pipe (33) which communicates with the inlet/outlet space (85). The supply spaces (86A-86L) are multiple (in this embodiment, 12) spaces which are partitioned by multiple (in this embodiment, 11) inlet/outlet header's supply-side baffles (87), and communicate with the one end of each of the subsidiary heat exchanging subsections (62A-62L). The supply spaces (86A-86L) function as spaces through which the refrigerant is delivered to the refrigerant paths (65A-65L). Below the lowermost supply space (86A), a lower supply space (86M) and a lower outflow space (86N) which are connected to the anti-icing tubes (67) are formed with a lower space-partitioning baffle (87a) interposed therebetween.

[0065] Thus, the lower portion of the inlet/outlet header (80) having the multiple supply spaces (86A-86L) functions as a refrigerant supply section (86) for delivering the refrigerant dividedly to the multiple refrigerant paths (65A-65L).

<Refrigerant Flow Divider and Throttle Mechanism>

[0066] As described previously, the refrigerant flow divider (70) is a part through which the refrigerant passes.

Specifically, the refrigerant flow divider (70) divides the refrigerant flowing from the liquid refrigerant pipe (35) into flows and delivers the flows to a downstream side (in this embodiment, to the multiple heat exchanger tubes (63)). The refrigerant flow divider (70) is provided adjacent to the one end of the heat exchanging section (60) and connected to the one end of each of the heat exchanger tubes (63) via the refrigerant supply section (86) of the inlet/outlet header (80). The refrigerant flow divider (70) is comprised of a vertically-extending member made of aluminum or an aluminum alloy, and includes, as its main component, a flow divider case (71) which is vertically oriented and hollow. The flow divider case (71) includes, as its main component, a flow divider header tube (72) having the shape of a cylinder having open upper and lower ends, which are respectively closed with two flow divider's vertical end baffles (73). Each of the flow divider's vertical end baffles (73) is a disc member having a semi-arc edge (73a). The flow divider's vertical end baffles (73) are joined by brazing after having been inserted, through a peripheral surface of the flow divider case (71), into insertion slits (72a) formed at upper and lower end portions of the flow divider header tube (72). Note that the inlet/outlet header case (81), the intermediate header case (91), and the flow divider case (71) are not limited to the cylindrical shape, but may have a shape of a polygonal pipe such as a quadrangular pipe.

[0067] The flow divider case (71) include therein: multiple (in this embodiment, 12) flow divider passages (74A-74L) which are arranged in the circumferential direction; a flow divider space (75) which introduces the refrigerant to the flow divider passages (74A-74L); and multiple (in this embodiment, 12) discharge spaces (76A-76L) which communicate with the flow divider space (75) via the multiple flow divider passages (74A-74L) and are arranged in the vertical direction.

[0068] The multiple (in this embodiment, 12) flow divider passages (74A-74L) are defined in a rod member (74) disposed in the flow divider case (71). The rod member (74) has the shape of a vertically-extending rod and includes therein the multiple flow divider passages (74A-74L) arranged in the circumferential direction. The rod member (74) is an extrusion molding of aluminum or an aluminum alloy. The multiple flow divider passages (74A-74L) are multiple (in this embodiment, 12) holes which are bored directly in the rod member (74) and extend in the longitudinal direction of the rod member (74). The multiple flow divider passages (74A-74L) surround a radial central portion of the rod member (74). The upper end of the rod member (74) in the longitudinal direction is in contact with the lower surface of the flow divider's vertical end baffle (73) disposed at the upper end of the flow divider case (71). Thus, the respective upper ends of the multiple flow divider passages (74A-74L) are closed. However, the upper end of the rod member (74) and the lower surface of the flow divider's vertical end baffle (73) do not have to be in contact with each other, and a slight gap is permissible. On the other hand, the

lower end of the rod member (74) in the longitudinal direction, is located adjacent to a lower portion of the flow divider case (71), but does not reach the upper surface of the flow divider's vertical end baffle (73) disposed at the lower end of the flow divider case (71). Thus, the respective lower ends of the multiple flow divider passages (74A-74L) are not closed and communicate with the flow divider space (75).

[0069] The outer diameter of the rod member (74) is smaller than the inner diameter of the flow divider case (71). A space is provided in the radial direction between the peripheral surface of the rod member (74) and the flow divider case (74). This space serves as the multiple discharge spaces (76A-76L). In this embodiment, multiple (in this embodiment, 11) rod insertion baffles (77) are inserted through the peripheral surface of the flow divider case (71). Each rod insertion baffle (77) has a rod insertion hole (77b) through which the rod member (74) passes. The multiple rod insertion baffles (77) define the multiple discharge spaces (76A-76L). Each of the rod insertion baffles (77) is a disc member having a semi-arc edge (77a). The rod insertion baffles (77) are joined by brazing after having been inserted, through the peripheral surface of the flow divider case (71), into insertion slits (72b) which are formed in a peripheral surface of the flow divider header tube (72) and arranged in the vertical direction. Thus, the rod member (74) is disposed in the flow divider case (71), while vertically passing through the rod insertion holes (77b) of the rod insertion baffles (77). As can be seen, in the flow divider case (71), the radial space between the peripheral surface of the rod member (74) and the flow divider case (71) is partitioned by the multiple rod insertion baffles (77) into the multiple discharge spaces (76A-76L) arranged in the vertical direction.

[0070] The peripheral surface of the rod member (74) is provided with multiple rod surface holes (74a) through which the multiple discharge spaces (76A-76L) communicate with the multiple flow divider spaces (74A-74L). In this embodiment, the multiple flow divider passages (74A-74L) each correspond to an associated one of the multiple discharge spaces (76A-76L) on a one-by-one basis. For example, one of the rod surface holes (74a) which communicates with the discharge space (76A) corresponds only to the flow divider passage (74A), and another one of the rod surface holes (74a) which communicates with the discharge space (76B) corresponds only to the flow divider passage (74B). In this manner, the rod surface holes (74a) are formed such that each flow divider space communicating with the associated discharge space is not allowed to communicate with the other discharge spaces. The multiple rod surface holes (74a) are helically arranged in the longitudinal direction of the rod member (74) (in the vertical direction, in this embodiment).

[0071] In the flow divider case (71), a nozzle member (nozzle) (79) having a nozzle orifice (70c) is provided. The nozzle member (79) partitions a space facing the lower end of the rod member (74) into an introduction

space (78) and the flow divider space (75). The introduction space (78) receives the inflow refrigerant. The flow divider space (75) guides the refrigerant into the multiple flow divider passages (74A-74L).

[0072] The nozzle member (79) is made of aluminum or an aluminum alloy, and is a disc member having a semi-arc edge (79a). The nozzle member (79) has a rod member-side end face (79c) facing the one end (in this embodiment, the lower end) of the rod member (74) in the longitudinal direction. A nozzle recess (79d) which has a larger diameter than the nozzle orifice (70c) is formed on the rod member-side end face (79c). The lower end of the rod member (74) is in contact with the rod member-side end face (79c), and consequently, the lower end of the rod member (74) and the nozzle recess (79d) define a space therebetween, which is the flow divider space (75). The diameter of the nozzle recess (79d) increases in a stepwise manner toward the lower end of the rod member (74). An inlet (74b) is formed at the lower end of the rod member (74). The inlet (74b) is surrounded by the multiple flow divider passages (74A-74L) and faces the nozzle orifice (70c). The inlet (74b) has an area larger than an opening area of the nozzle orifice (70c). The introduction space (78) is located below the nozzle member (79) and receives the refrigerant flowing through a lower peripheral surface of the flow divider case (71) via the liquid refrigerant pipe (35).

[0073] The nozzle member (79), which is a plate member having the nozzle orifice (70c) through which the refrigerant passes, is inserted into the flow divider case (71) through the peripheral surface of the flow divider case (71). The nozzle member (79) is fitted in the flow divider case (71) to be immovable in the lateral direction with respect to the flow divider case (71), in the following manner: the nozzle member (79) is inserted into the flow divider case (71), through an insertion slit (72c) formed in the peripheral surface of the flow divider case (71); and the nozzle member (79) is moved in the vertical direction (downward, in this embodiment) of the flow divider case (71). Specifically, the nozzle member (79) has, on its surface (lower surface, in this embodiment) facing in the vertical direction of the flow divider case (71), a stepped portion (79e) protruding downward of the flow divider case (71). When the nozzle member (79) is moved downward in the flow divider case (71), a side surface (79f) of the stepped portion (79e) comes into contact with the inner surface of the flow divider case (71). As a result, the nozzle member (79) is fitted in the flow divider case (71) to be immovable in the lateral direction with respect to the flow divider case (71). Further, after the nozzle member (79) has been moved downward in the flow divider case (71) (i.e., after the nozzle member (79) has been fitted in the flow divider case (71)), a gap is left in the insertion slit (72c). One of the rod insertion baffles (77) is then inserted into this gap. That is, this rod insertion baffle (77) functions as a filler member to fill the gap that is left in the insertion slit (72c) after the nozzle member (79) has been moved downward in the flow divider case

(71). The nozzle member (79) and the rod insertion baffle (77) are brazed. As a result, the rod insertion baffle (77) inserted into the insertion slit (72c) is disposed on the rod member-side end face (79c) of the nozzle member (79), while the lower end of the rod member (74) passes through the rod insertion hole (77b) of the rod insertion baffle (77).

[0074] As can be seen, in the refrigerant flow divider (70), the nozzle member (79) is provided in the refrigerant passage from the liquid refrigerant pipe (35) to the heat exchanging section (60). Further, in the refrigerant passage from the liquid refrigerant pipe (35) to the heat exchanging section (60), a throttle mechanism (100) is provided upstream of the nozzle member (79) (vertically below the nozzle member (79)). The throttle mechanism (100) includes a throttle plate (101) disposed vertically below the nozzle member (79) in the refrigerant flow divider (70). The throttle plate (101) has a throttle orifice (102). As a matter of course, the throttle plate (101) is disposed above the connecting portion between the flow divider case (71) and the liquid refrigerant pipe (35), and fitted into an insertion slit (72d).

[0075] The refrigerant flow divider (70) functions as a vertically-extending refrigerant introduction/flow divider section which has: a refrigerant introduction section (70a) including the introduction space (78) that introduces the refrigerant flowing through the lower peripheral surface; a refrigerant flow divider section (70b) including the flow divider space (75) that divides the refrigerant into refrigerant flows; and a nozzle inflow section (70d) located between the refrigerant introduction section (70a) and the refrigerant flow divider section (70b). The refrigerant flow divider (70) functioning as the refrigerant introduction/flow divider section is connected to a lower portion, of the inlet/outlet header (80), that functions as the refrigerant supply section (86), via multiple (in this embodiment, 12) connection pipes (88) forming multiple (in this embodiment, 12) connection passages (88A-88L). Specifically, the multiple connection passages (88A-88L) introduce the refrigerant from the multiple discharge spaces (76A-76L) forming the refrigerant flow divider section (70b) to the multiple supply spaces (86A-86L) of the refrigerant supply section (86). Thus, the lower portion of the inlet/outlet header (80) functioning as the refrigerant supply section (86), the refrigerant flow divider (70) functioning as the refrigerant introduction/flow divider section, and the multiple connection pipes (88) forming the multiple connection passages (88A-88L) together function as a refrigerant flow divider/supply section (89) which delivers the refrigerant that has entered therein to the multiple heat exchanger tubes (63) provided downstream and comprised of flat tubes.

[Configuration for Anti-Icing Tube]

[0076] A configuration for the anti-icing section (66) will be described next. As described previously, the outdoor heat exchanger (23) includes the multiple heat exchanger

er tubes (63) that extend horizontally, are arranged in the vertical direction, and are connected to the liquid refrigerant pipe (35) of the refrigerant circuit (10) via the refrigerant flow divider (70). The outdoor heat exchanger (23) is used as an evaporator during the heating operation. The heat exchanger tubes forming the anti-icing section (66), i.e., the two anti-icing tubes (67), are arranged on top of each other in two layers, below the lowermost heat exchanger tube (63) of the heat exchanging section (60).

[0077] As shown in FIGS. 7 to 9, the lower anti-icing tube (67) has one end connected to the refrigerant introduction section (70a) (the introduction space (78)), which is a refrigerant passage where the refrigerant flows before passing through the throttle orifice (102) and the nozzle orifice (70c), via a lower supply space (86M) and a first lower connection pipe (88M) connecting the lower supply space (86M) to the refrigerant introduction section (70a). The upper anti-icing tube (67) has one end connected to the nozzle inflow section (70d) that is a refrigerant passage between the throttle orifice (102) and the nozzle orifice (70c), via a lower outflow space (86N) partitioned by the lower space-partitioning baffle (87a) from the lower supply space (86M) and via a second lower connection pipe (88N) connecting the lower outflow space (86N) to the nozzle inflow section (70d). As described previously, each of the two anti-icing tubes (67) arranged on top of each other in two layers has the other end connected to the intermediate header's lower space (99) of the intermediate header (90) shown in FIG. 5.

[0078] As described previously, just like the heat exchanger tube (63) described above, each anti-icing tube (67) is a multi-bored flat tube that is flat in the vertical direction and includes many (multiple) narrow internal channels (63b) through which the refrigerant flows.

<Defrosting Operation and Prevention of Icing Up>

[0079] If frost forms on the outdoor heat exchanger (23) during the heating operation, the defrosting operation is carried out. The defrosting operation of this embodiment is a reverse cycle defrosting which is carried out by switching the direction of the refrigerant circulation in the refrigerant circuit (10) to the circulation direction for the cooling cycle. In the reverse cycle defrosting, the outdoor heat exchanger (23) functions as a refrigerant radiator, and the heat of the refrigerant is given to the heat exchanger tubes (63) and the frost on the heat exchanger tubes (63), thereby melting and removing the frost in the outdoor heat exchanger (23). The frost turns into water, and part of water remains at a contact portion between the outdoor heat exchanger (23) disposed on a bottom frame (not shown) of the casing of the outdoor unit (2) and the bottom frame.

[0080] When the defrost operation is finished, the heating operation during which the outdoor heat exchanger (23) functions as an evaporator is started again. According to this embodiment, at this time, in FIGS. 7 to 9, the

refrigerant before passing through the nozzle orifice (70c) of the refrigerant flow divider (70) is divided into a refrigerant flow to pass through the throttle mechanism (100) and a refrigerant flow to enter the anti-icing section (66) without passing through the throttle mechanism (100). The refrigerant flow that does not pass through the throttle mechanism (100) passes through the refrigerant introduction section (70a) (the introduction space (78)), the first lower connection pipe (88M), and the lower supply space (86M), and then flows through the lower anti-icing tube (67). The refrigerant flow returning from the intermediate header's lower space (99) of the intermediate header (90) passes through the upper anti-icing tube (67), flows through the lower outflow space (86N) and a second lower connection pipe (88N), and meets the refrigerant flow that has passed through the throttle mechanism (100). The refrigerant flow before passing through the nozzle orifice (70c) of the refrigerant flow divider (70) is not decompressed by the refrigerant flow divider (70), and thus, has a higher temperature than a divided refrigerant flow. In this embodiment, part of this high-temperature refrigerant flow passes through the anti-icing tubes (67) without passing through the throttle mechanism (100), and maintains the temperature of the anti-icing tubes (67). Specifically, setting the throttle mechanism (100) at an appropriate degree of opening allows a constant amount of the refrigerant not passing through the throttle mechanism (100) to flow through the anti-icing tube (67) per unit time. As a result, this high-temperature refrigerant flow hinders the temperature of the anti-icing section (67) from decreasing. As can be seen, the temperature of the anti-icing section (67) is maintained, which makes it difficult for water remaining at the contact portion between the outdoor heat exchanger (23) and the bottom frame of the casing to freeze even when the outdoor air temperature is low.

-Advantages of Embodiment-

[0081] According to this embodiment, the relatively high-pressure refrigerant flow before passing through the nozzle orifice (70c) of the refrigerant flow divider (70), i.e., the relatively high-temperature refrigerant, can be constantly supplied to the anti-icing tubes (67) during the heating operation. Setting the throttle mechanism (100) at an appropriate degree of opening allows the high-temperature refrigerant flow to constantly pass through the anti-icing section (67). As a result, the influence of pressure loss is reduced and the temperature of the anti-icing tubes (67) can be constantly maintained at a high temperature. This makes it possible to prevent the icing up caused by freeze of water resulting from the defrosting operation, even if the outdoor air temperature is low.

[0082] According to the present invention, in the outdoor heat exchanger (23) including the multi-bored flat tubes and capable of substantially preventing icing up, the refrigerant before passing through the nozzle orifice (70c) of the refrigerant flow divider (70), which has a rel-

atively high pressure is caused to constantly flow through the anti-icing tubes (67), thereby enabling the anti-icing tubes (67) to be maintained at a high temperature constantly. This reduces the need for using a large number of multi-bored flat tubes as the anti-icing tubes (67), and as a result, contributes to the substantial avoidance of upsizing of the outdoor heat exchanger (23).

[0083] According to this embodiment, the anti-icing tubes (67) are arranged on top of each other in two layers below the lowermost heat exchanger tube (63) of the heat exchanging section (60). This configuration hinders cold thermal energy of the heat exchanger tubes (63) of the heat exchanger (23) functioning as an evaporator from being transferred to the lower end, and can substantially prevent the icing up more reliably.

[0084] Furthermore, according to this embodiment, use of the same multi-bored flat tubes as both of the heat exchanger tubes (63) of the heat exchanging section (60) and the anti-icing tubes (67) allows the heat exchanger (23) to have a simple structure.

-Variation of Embodiment-

<First Variation>

[0085] The throttle mechanism (100) may have the configuration shown in FIG. 15.

[0086] In the first variation, the throttle mechanism (100) includes a capillary tube (105) connected between the liquid refrigerant pipe (35) and a portion, of the refrigerant flow divider (70), located vertically below the nozzle member (79). The liquid refrigerant pipe (35) has one end directly connected to the lower supply space (86M) of the inlet/outlet header (80).

[0087] This configuration also divides the high-temperature refrigerant flowing from the liquid refrigerant pipe (35) into a refrigerant flow which passes through the capillary tube (105) that functions as the throttle mechanism (100) and a refrigerant flow which does not pass through the capillary tube (105). The refrigerant flow that has flowed through the anti-icing section (66) without passing through the capillary tube (105) meets the refrigerant flow that has passed through the capillary tube (105), and the refrigerant flows enter the refrigerant flow divider (70).

[0088] Therefore, just like the embodiment described above, the high-temperature refrigerant flow maintains the temperature of the anti-icing tubes (67), which hinders water remaining at the contact portion between the outdoor heat exchanger (23) and the bottom frame of the casing from freezing, and enables substantial prevention of icing up, i.e., the phenomenon that water present at a lower portion of the heat exchanger freezes.

[0089] As indicated by the virtual line in FIG. 15, the capillary tube (105) may be connected between the anti-icing section (66) and a portion, of the refrigerant flow divider (70), located vertically below the nozzle member (79). This configuration can provide the same advantages.

<Second Variation>

[0090] The throttle mechanism (100) may have the configuration shown in FIG. 16.

[0091] In the second variation, the liquid refrigerant pipe (35) penetrates a portion, of the refrigerant flow divider (70), located vertically below the nozzle member (79), and communicates with the anti-icing tubes (67), which are heat exchanger tubes forming the anti-icing section (66), via the lower supply space (86M). The throttle mechanism (100) includes a throttle orifice (106) formed in the liquid refrigerant pipe (35) and located below the nozzle member (79) of the refrigerant flow divider (70).

[0092] This configuration also divides the high-temperature refrigerant flowing from the liquid refrigerant pipe (35) into a refrigerant flow which passes through the throttle orifice (106) functioning as the throttle mechanism (100), and a refrigerant flow which does not pass through the throttle orifice (106). The refrigerant flow that has flowed through the anti-icing section (66) without passing through the throttle orifice (106) meets the refrigerant flow that has passed through the throttle orifice (106), and the refrigerant flows enter the refrigerant flow divider (70).

[0093] Therefore, just like the embodiment described above, the high-temperature refrigerant flow maintains the temperature of the anti-icing tubes (67), which hinders water remaining at the contact portion between the outdoor heat exchanger (23) and the bottom frame of the casing from freezing, and enables substantial prevention of icing up, i.e., the phenomenon that water present at a lower portion of the heat exchanger freezes.

<Third Variation>

[0094] For the outdoor heat exchanger (23) of the embodiment described above, the configuration, in which the heat exchanger tubes (63) each comprised of a flat tube are stacked in multiple layers in the vertical direction so as to form a single line in plan view, has been described as an example. However, the present invention is not limited to this configuration. For example, although not shown in the drawings, the heat exchanger tubes (63) may be stacked in multiple layers in the vertical direction so as to form two lines in plan view. Specifically, in this case, the heat exchanger tubes (63) are each folded at its middle portion of the entire length into back and front parts, i.e., back and front lines. Thus, referring to, for example, FIG. 5, in addition to the refrigerant flow divider (70) and the inlet/outlet header (80), the intermediate header (90) is also provided at the ends of the heat exchanger tubes (63) positioned close to the right end of FIG. 5, and the folded portion of each heat exchanger tube (63) is positioned close to the left end of FIG. 5.

[0095] If the heat exchanger tubes (63) of the outdoor heat exchanger (23) are arranged to form the two lines, the anti-icing tubes (67) are also arranged to form two lines, i.e., front and back lines. Also in this configuration

in which the anti-icing tubes (67) are arranged to form the front and back lines, it is suitable to configure the anti-icing section (66) to include two anti-icing tubes (67) arranged on top of each other in two layers.

[Other Embodiments]

[0096] The above embodiment may also be configured as follows.

[0097] For example, the specific configuration for the outdoor heat exchanger (23) and that for the refrigerant flow divider (70) described in the above embodiment are mere examples, and modifications may be made as appropriate. Specifically, the outdoor heat exchanger (23) does not have to have the L-shape in plan view. The number of layers of the heat exchanger tubes forming the heat exchanging section (60) and the anti-icing section (66) may be changed as appropriate.

[0098] Further, the refrigerant flow divider (70) of the embodiment described above does not necessarily have to be provided. Alternatively, the refrigerant flow divider (70) may be provided inside the inlet/outlet header case (81). Furthermore, the flow divider (70) of the embodiment described above may have the configuration shown in FIG. 17.

[0099] The flow divider (70) shown in FIG. 17 includes a flow divider body (110) connected to the liquid refrigerant pipe (35) and to multiple capillary tubes (113). The flow divider body (110) includes a first member (111) connected to the liquid refrigerant pipe (35) and a second member (112) connected to the multiple capillary tubes (113). A nozzle orifice (70c) is formed between the first member (111) and the second member (112). Each of the multiple capillary tubes (113) is connected to a heat exchanger tube. In this configuration, the refrigerant that has passed through the nozzle orifice (70c) is divided into refrigerant flows flowing through the heat exchanger tubes via the capillary tubes (113).

[0100] In the liquid refrigerant pipe (35), a refrigerant passage (70a) where the refrigerant before passing through the nozzle orifice (70c) flows is connected to an anti-icing tube (67) comprised of a multi-bored flat tube. A throttle plate (107) having a throttle orifice (108) and functioning as the throttle mechanism (100) is provided in the liquid refrigerant pipe (35). The lower and upper anti-icing tubes (67) are connected to the liquid refrigerant pipe (35) such that the throttle plate (107) is positioned between the anti-icing tubes (67).

[0101] This configuration also divides the high-temperature refrigerant flowing through the liquid refrigerant pipe into a refrigerant flow which passes through the throttle orifice (108) and a refrigerant flow which does not pass through the throttle orifice (108). The refrigerant flow that has not passed through the throttle orifice (108) flows through the anti-icing tubes (67). The refrigerant flow that has passed through the anti-icing tubes (67) meets the refrigerant flow that passed through the throttle orifice (108). The refrigerant passes through the nozzle orifice

(70c), and is then divided to enter the heat exchanger tubes.

[0102] Thus, the configuration achieves the same advantages as provided by the embodiment and variations described above.

[0103] The heat exchanger of the present invention is applicable not only to the outdoor heat exchanger (23) of an air-conditioning device, but also to an internal heat exchanger of a refrigeration apparatus for refrigerating the inside of a room.

[0104] Note that the foregoing description of the embodiment is a merely preferable example in nature, and is not intended to limit the scope, application, or uses of the present invention.

INDUSTRIAL APPLICABILITY

[0105] As described above, the present invention is useful as a heat exchanger for a refrigerant circuit which is capable of performing a defrosting operation, and as a technique to substantially prevent excessive growth of ice which can be caused by a repeat of a cycle of melting of frost due to the defrosting operation and the conversion of water, which remains in a lower portion of the heat exchanger, into ice.

DESCRIPTION OF REFERENCE CHARACTERS

[0106]

1	Air-Conditioning Device (Refrigeration Apparatus)
10	Refrigerant Circuit
21	Compressor
23	Outdoor Heat Exchanger (First Heat Exchanger)
24	Expansion Mechanism
35	Liquid Refrigerant Pipe
41	Second Heat Exchanger
60	Heat Exchanging Section
63	Heat Exchanger Tube
66	Anti-icing Section
67	Anti-Icing Tube (Heat Exchanger Tube)
70	Refrigerant Flow Divider
79	Nozzle Member (Nozzle)
100	Throttle Mechanism
101	Throttle Plate
102	Throttle Orifice
105	Capillary Tube
106	Throttle Orifice

Claims

1. A heat exchanger, comprising a heat exchanging section (60) and an anti-icing section (66) located below the heat exchanging section (60), the heat exchanging section (60) and the anti-icing

section (66) including a heat exchanger tube (63) and a heat exchanger tube (67), respectively, each of the heat exchanger tubes (63, 67) being comprised of a multi-bored flat tube which extends horizontally, is flat in the vertical direction, and includes therein a plurality of refrigerant channels, **characterized in that**

the anti-icing section (66) has a refrigerant inlet end communicating with a liquid refrigerant pipe (35) of a refrigerant circuit (10), the heat exchanging section (60) has a refrigerant inlet end communicating with the liquid refrigerant pipe (35) via a throttle mechanism (100), and

the anti-icing section (66) has a refrigerant outlet end communicating with a portion downstream of the throttle mechanism (100).

2. The heat exchanger of claim 1, further comprising a refrigerant flow divider (70) including a nozzle (79) disposed in a refrigerant passage from the liquid refrigerant pipe (35) to the heat exchanging section (60), wherein in the refrigerant passage from the liquid refrigerant pipe (35) to the heat exchanging section (60), the throttle mechanism (100) is disposed upstream of the nozzle (79) of the refrigerant flow divider (70).
3. The heat exchanger of claim 2, wherein the throttle mechanism (100) includes a throttle plate (101) which is provided in a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), and which has a throttle orifice (102) formed therein.
4. The heat exchanger of claim 2, wherein the throttle mechanism (100) includes a capillary tube (105) connected between the liquid refrigerant pipe (35) and a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79).
5. The heat exchanger of claim 2, wherein the throttle mechanism (100) includes a capillary tube (105) connected between the anti-icing section (66) and a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79).
6. The heat exchanger of claim 2, wherein the liquid refrigerant pipe (35) penetrates a portion, of the refrigerant flow divider (70), located vertically below the nozzle (79), and communicates with the heat exchanger tube (67) of the anti-icing section (66), and the throttle mechanism (100) includes a throttle orifice (106) formed in the liquid refrigerant pipe (35) and located below the nozzle (79) of the refrigerant flow divider (70).
7. The heat exchanger of any one of claims 1 to 6,

wherein

the heat exchanger tube (67) of the anti-icing section (66) includes two heat exchanger tubes (67) arranged on top of each other in two layers.

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8. A refrigeration apparatus comprising a refrigerant circuit (10) including a compressor (21), a first heat exchanger (23), an expansion mechanism (24), and a second heat exchanger (41), all of which are connected together, the refrigeration apparatus being capable of performing an operation in which the first heat exchanger (23) functions as an evaporator, **characterized in that**

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the first heat exchanger (23) is the heat exchanger of any one of claims 1 to 7, and

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in an operation state in which the first heat exchanger (23) functions as the evaporator, the refrigerant inlet end of the anti-icing section (66) is connected to the liquid refrigerant pipe (35) of the refrigerant circuit (10), and the refrigerant outlet end of the heat exchanging section (60) is connected to the liquid refrigerant pipe (35) via the throttle mechanism (100).

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FIG.1

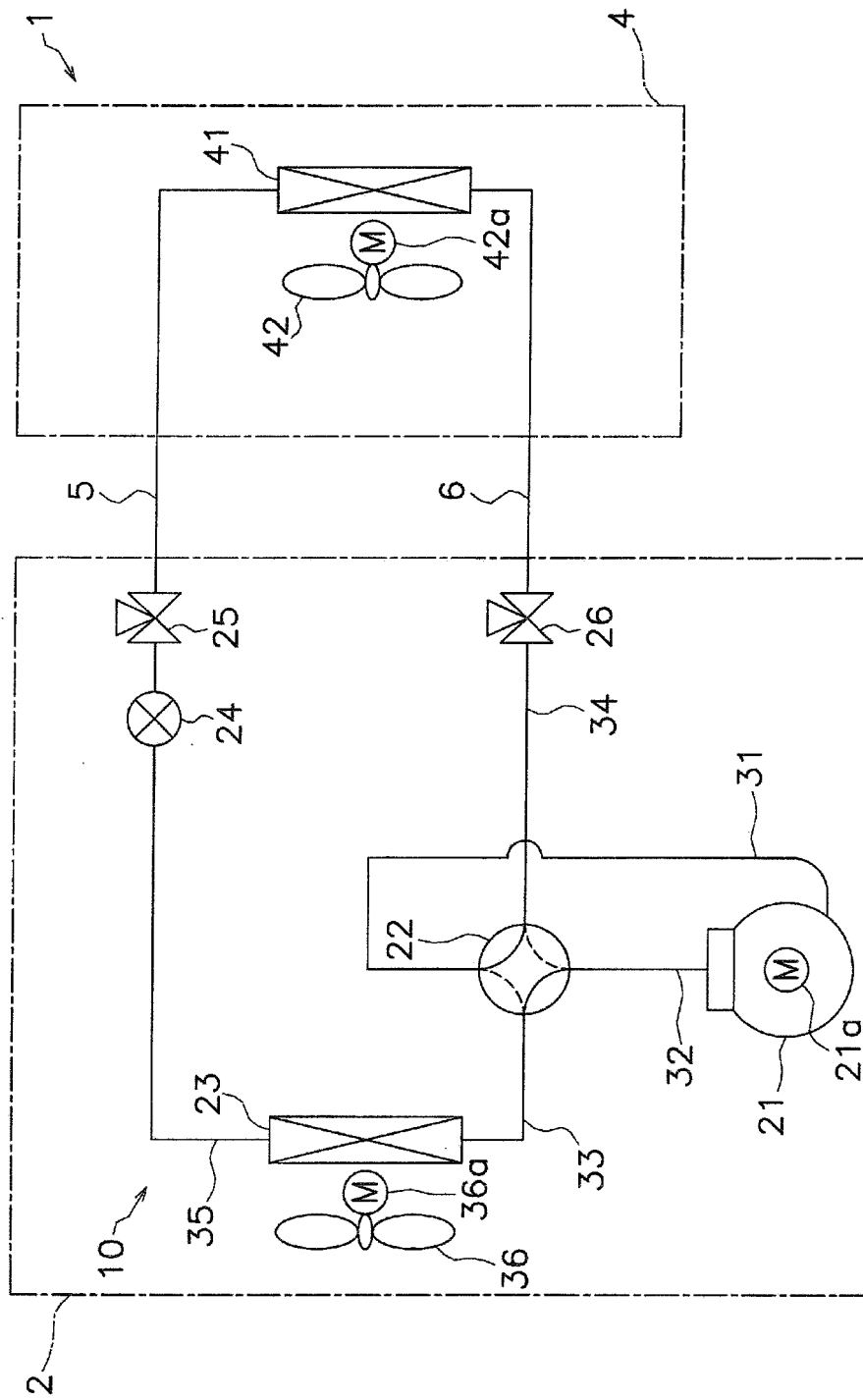


FIG.2

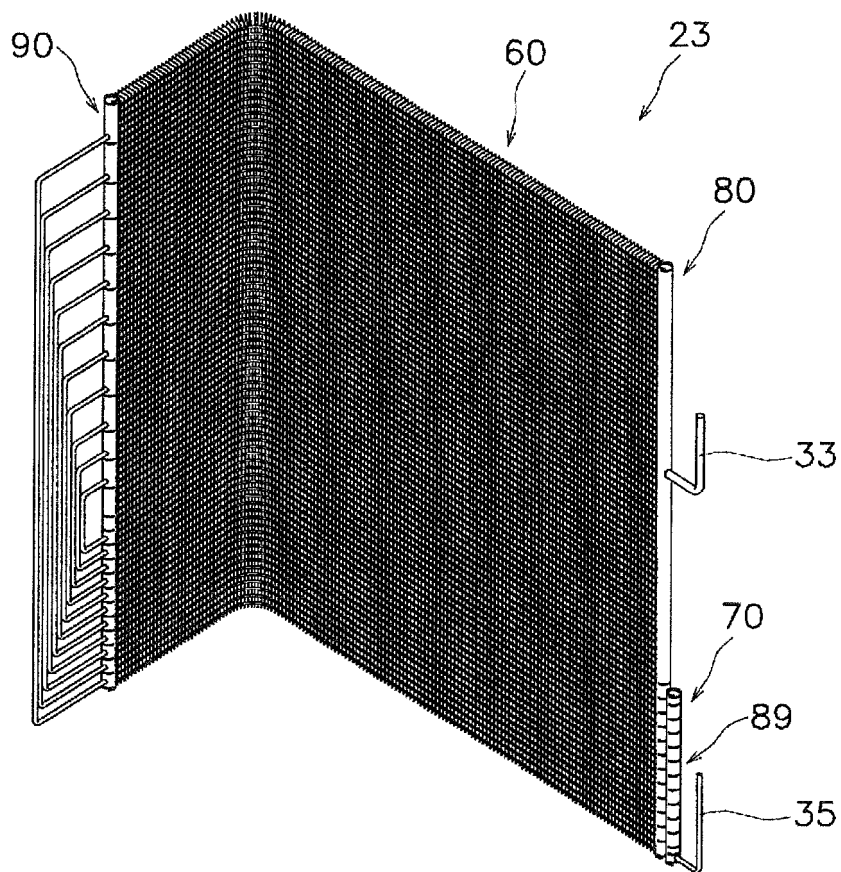


FIG.3

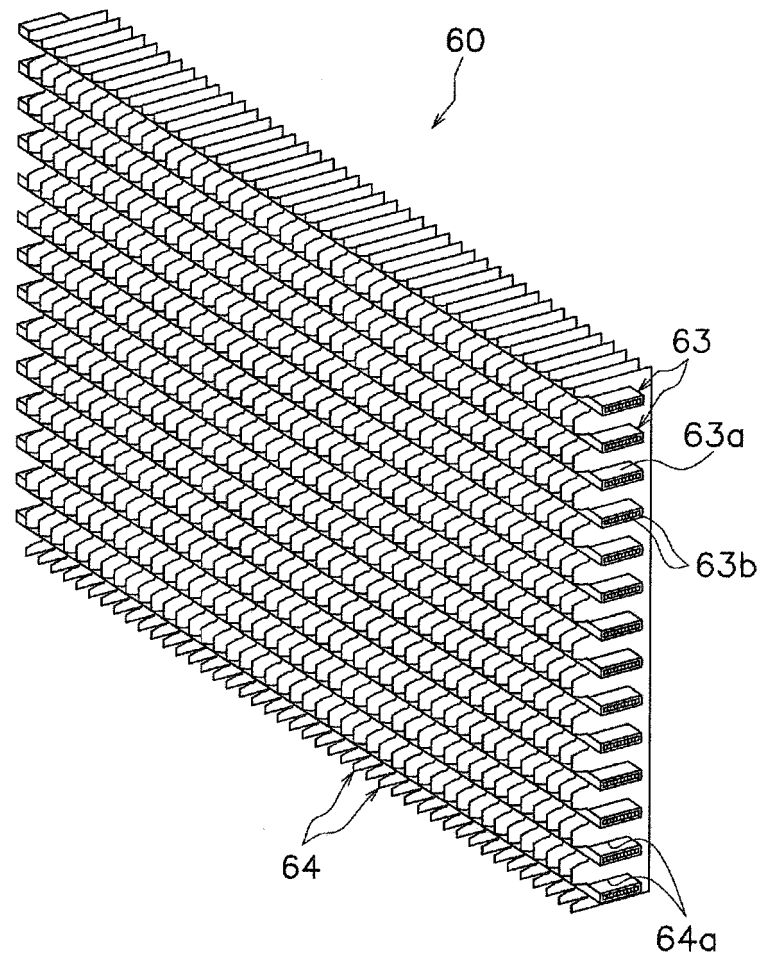


FIG.4

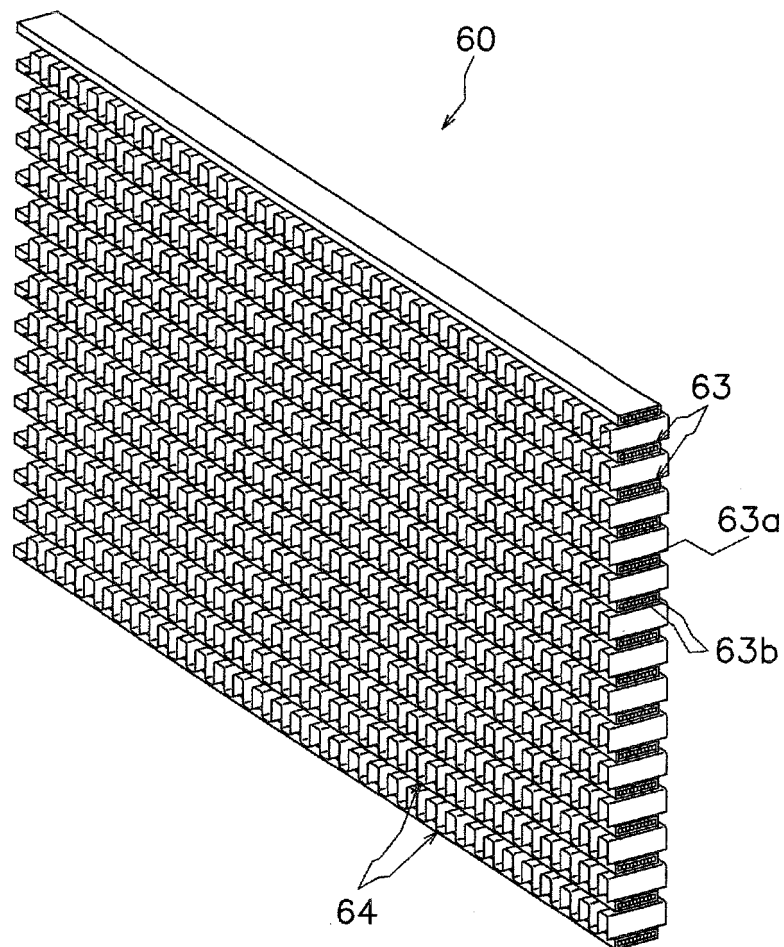


FIG.5

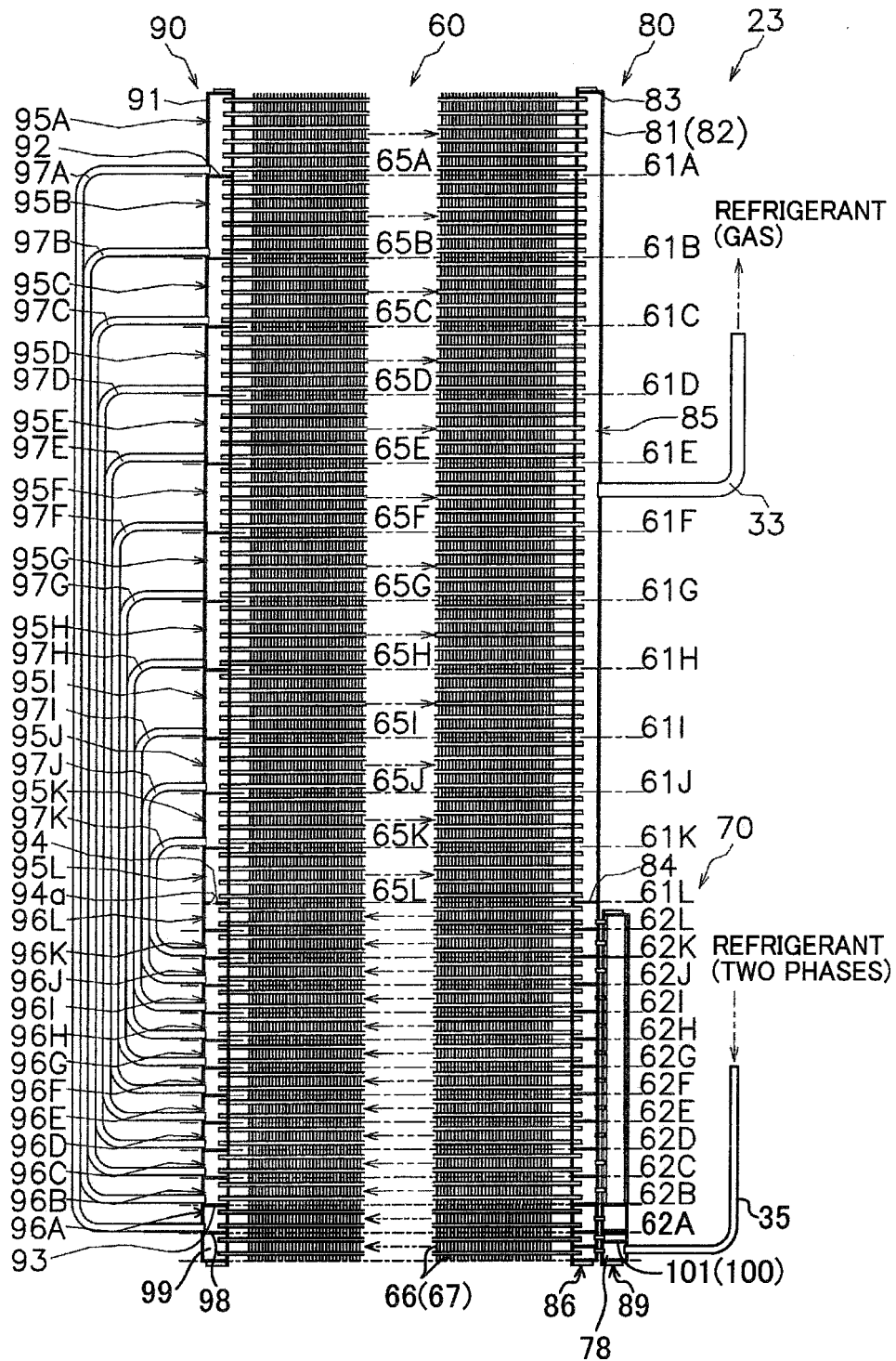


FIG.6

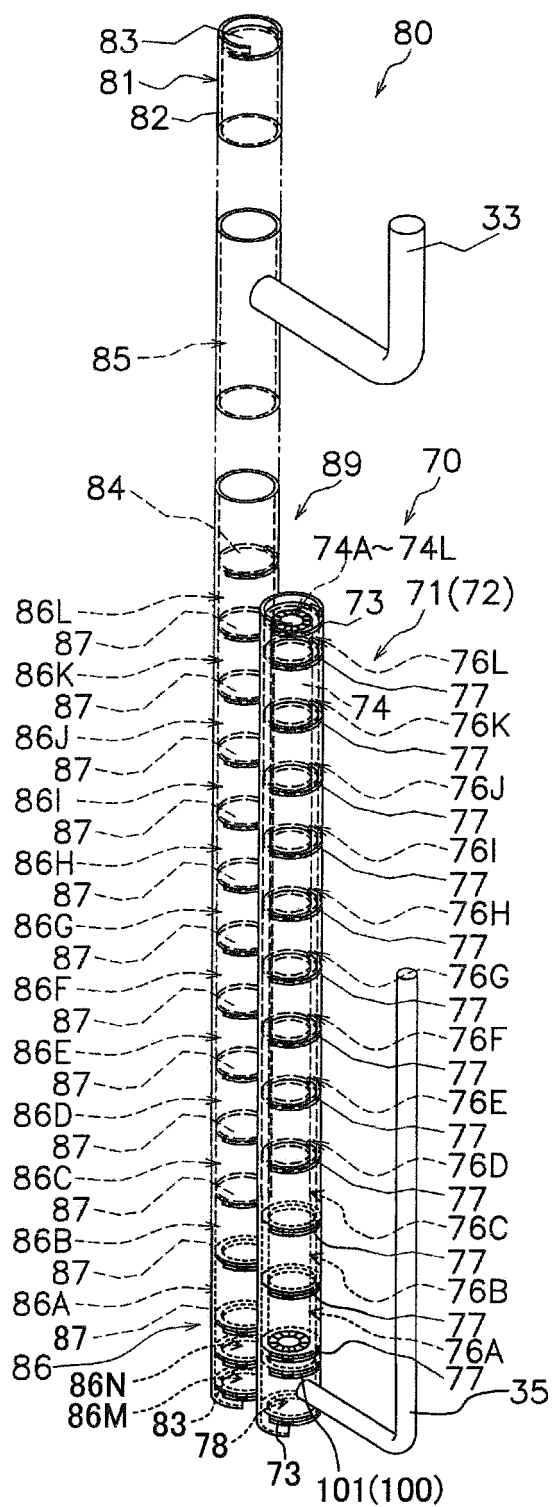


FIG. 7

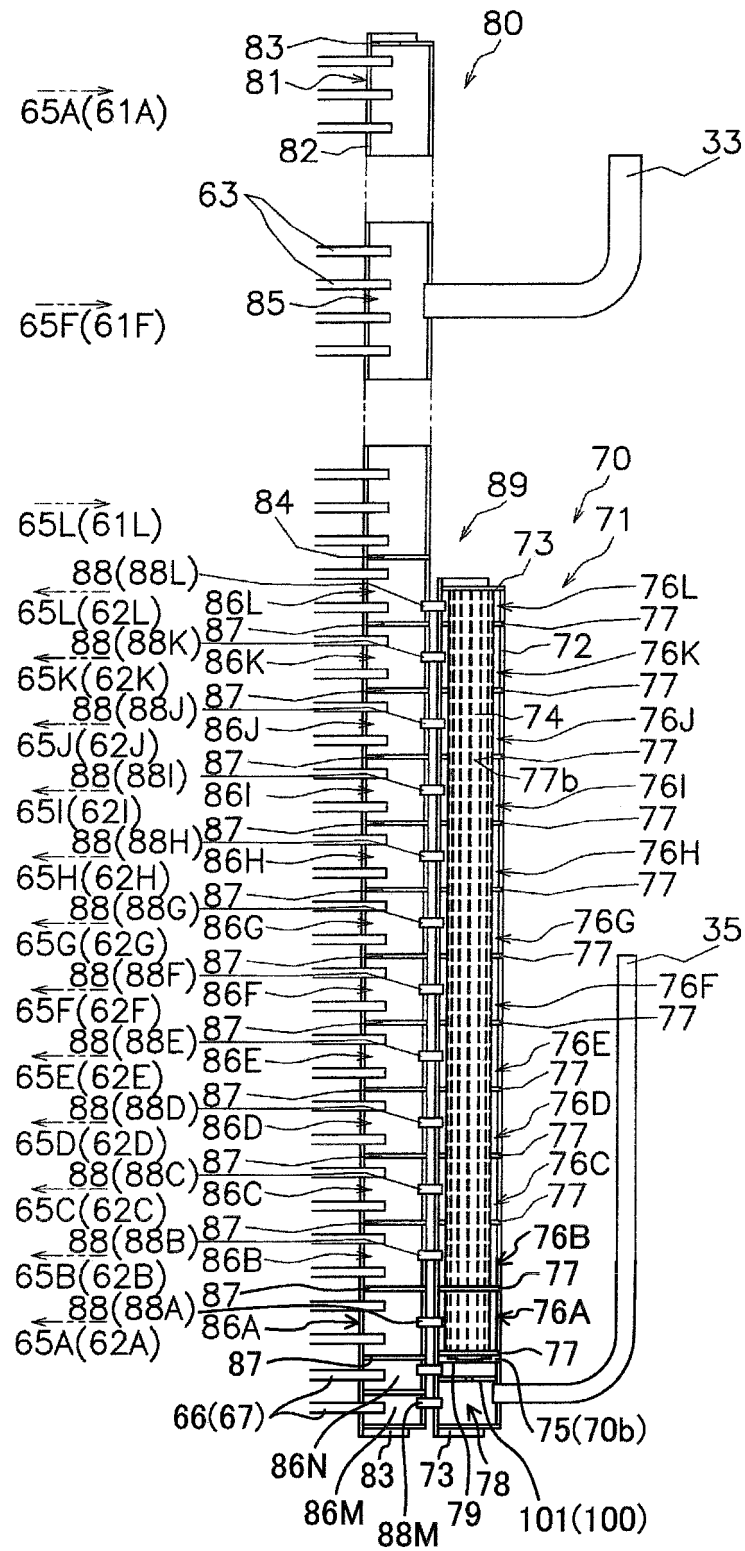


FIG.8

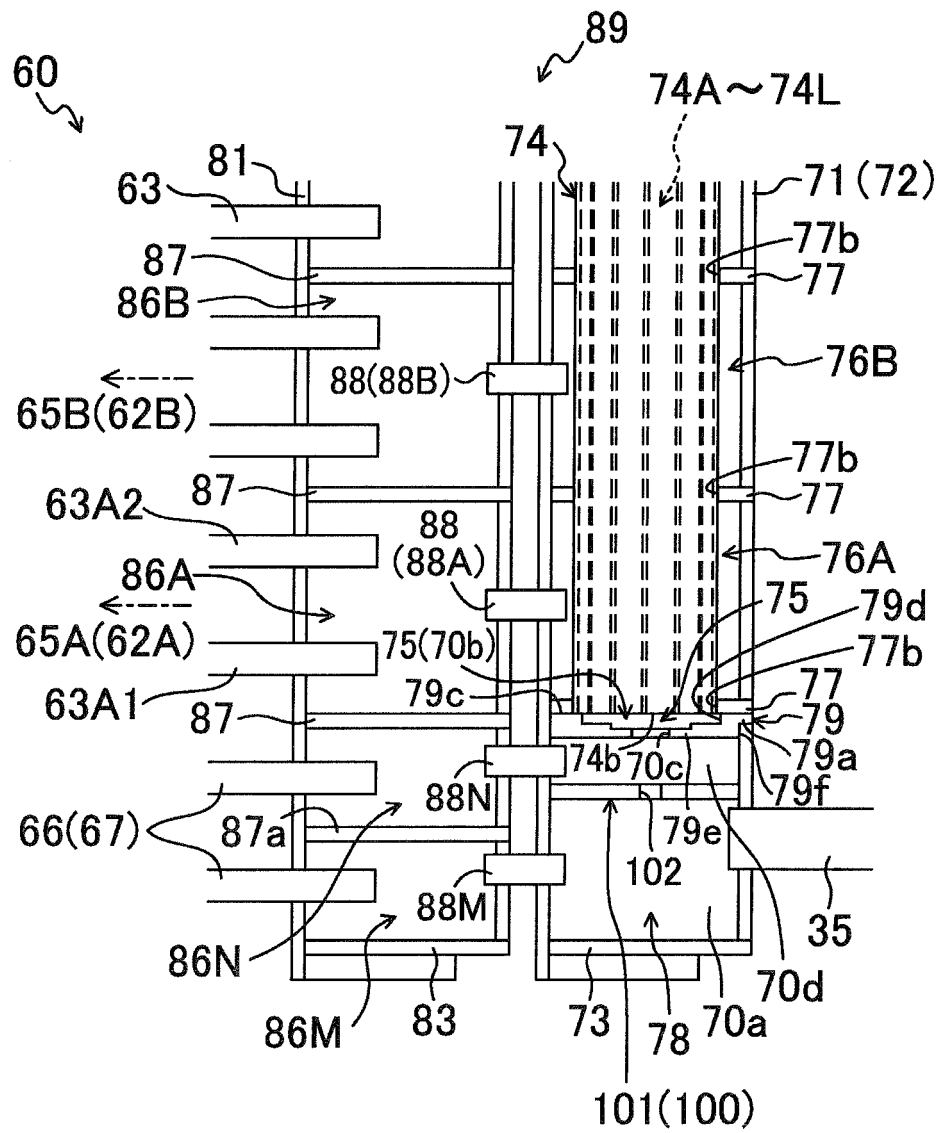


FIG.9

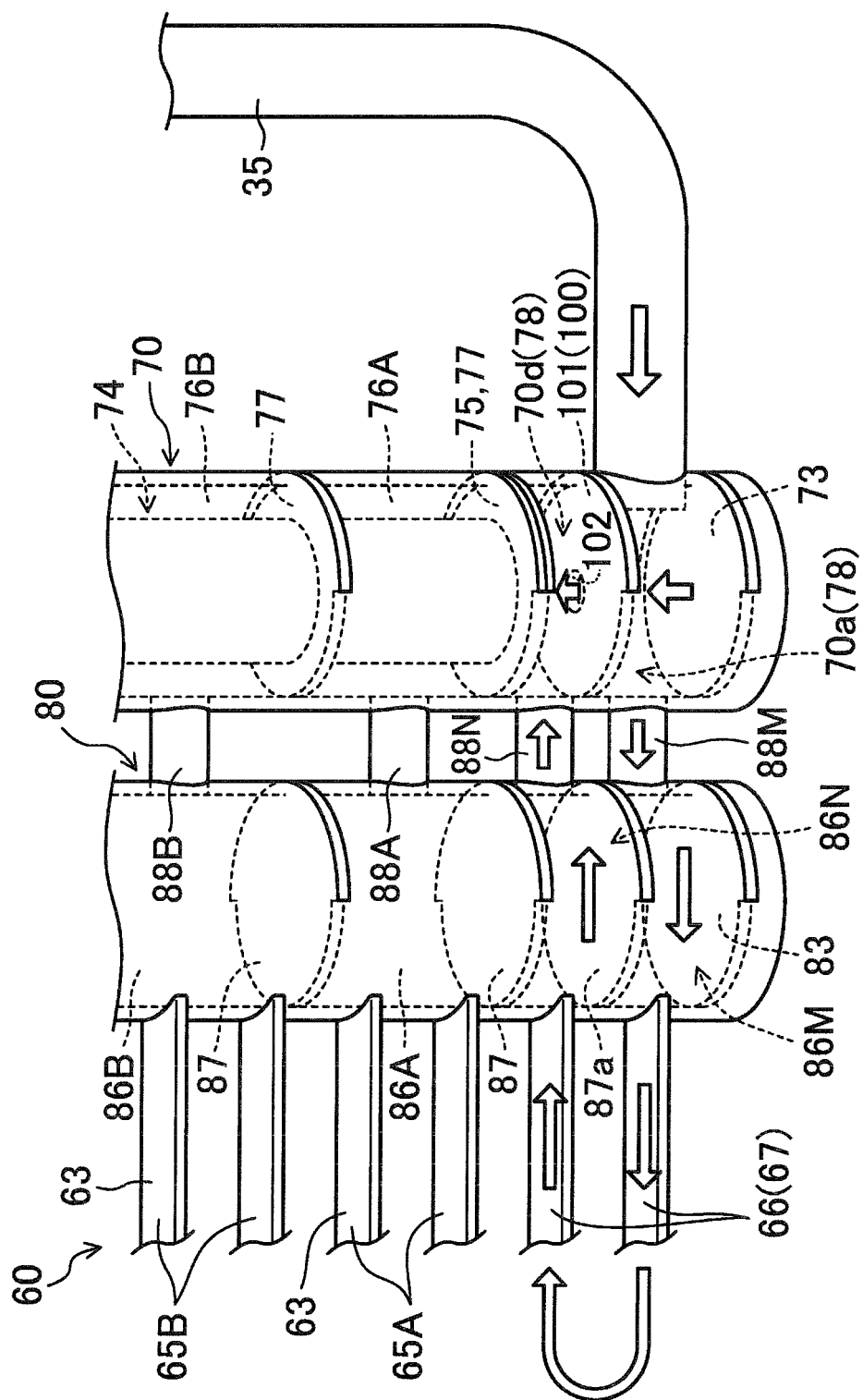


FIG.10

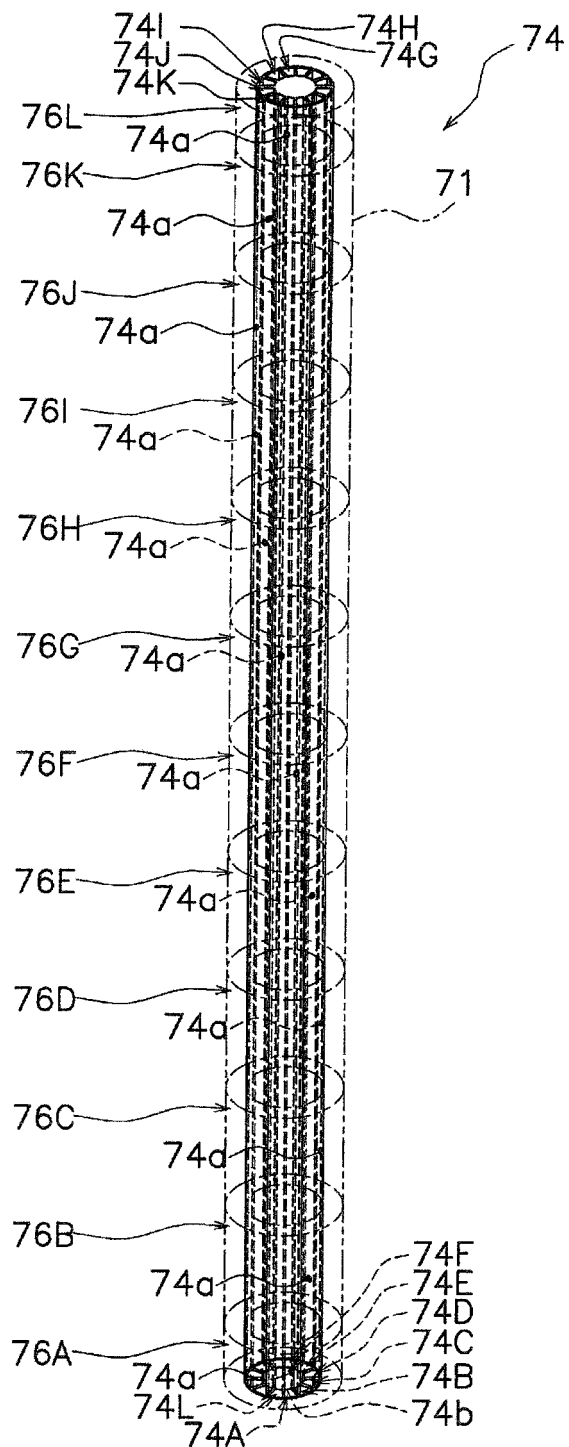


FIG.11

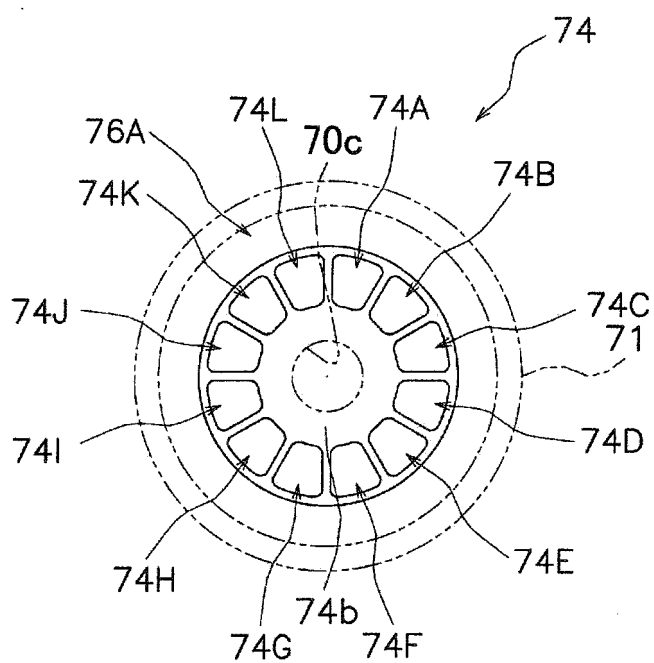


FIG.12

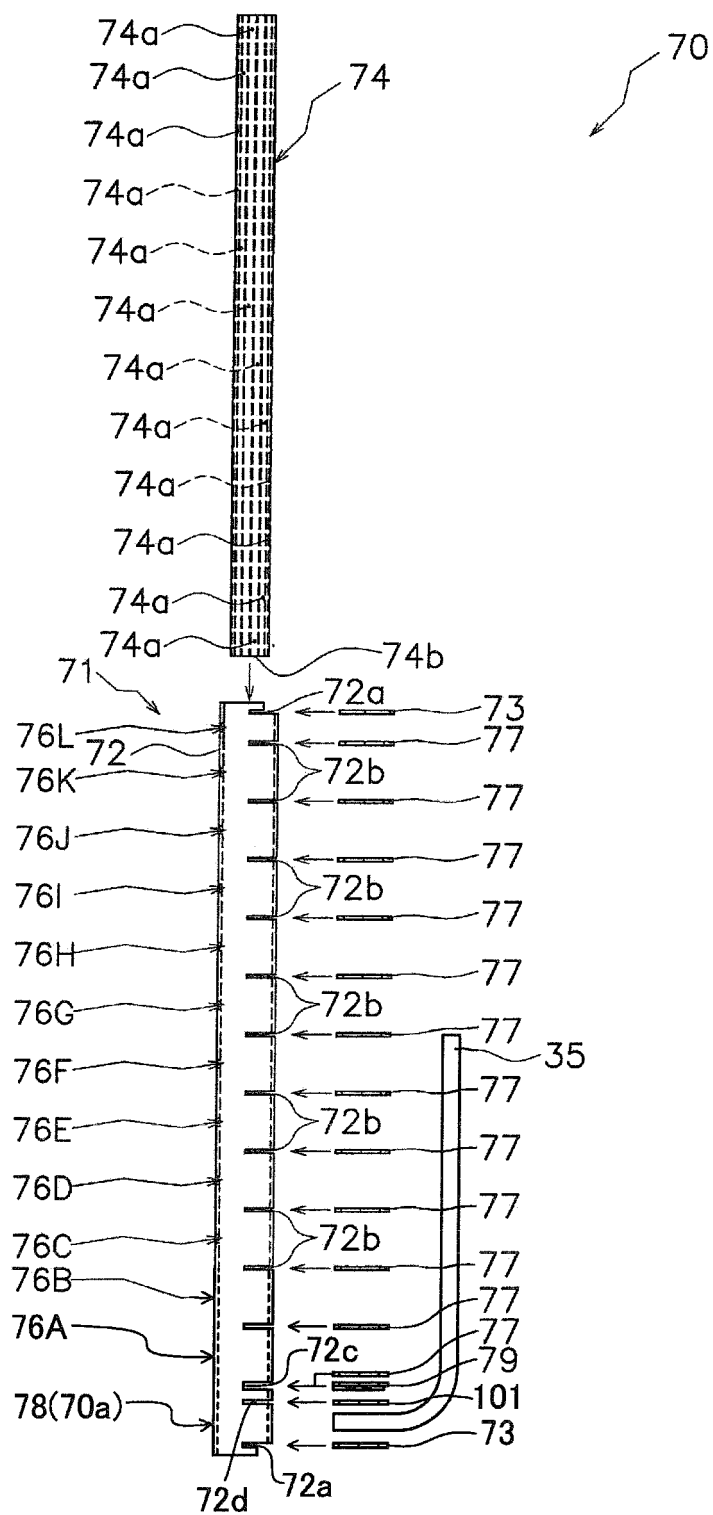


FIG.13

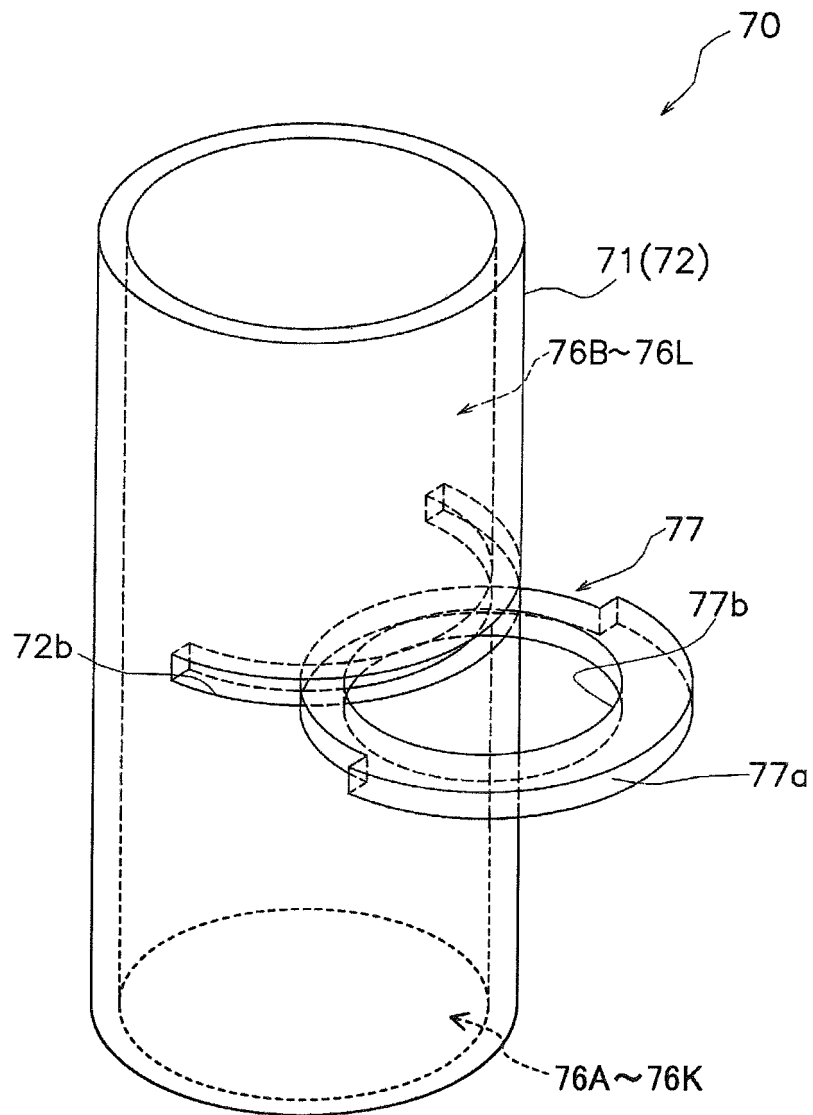


FIG.14

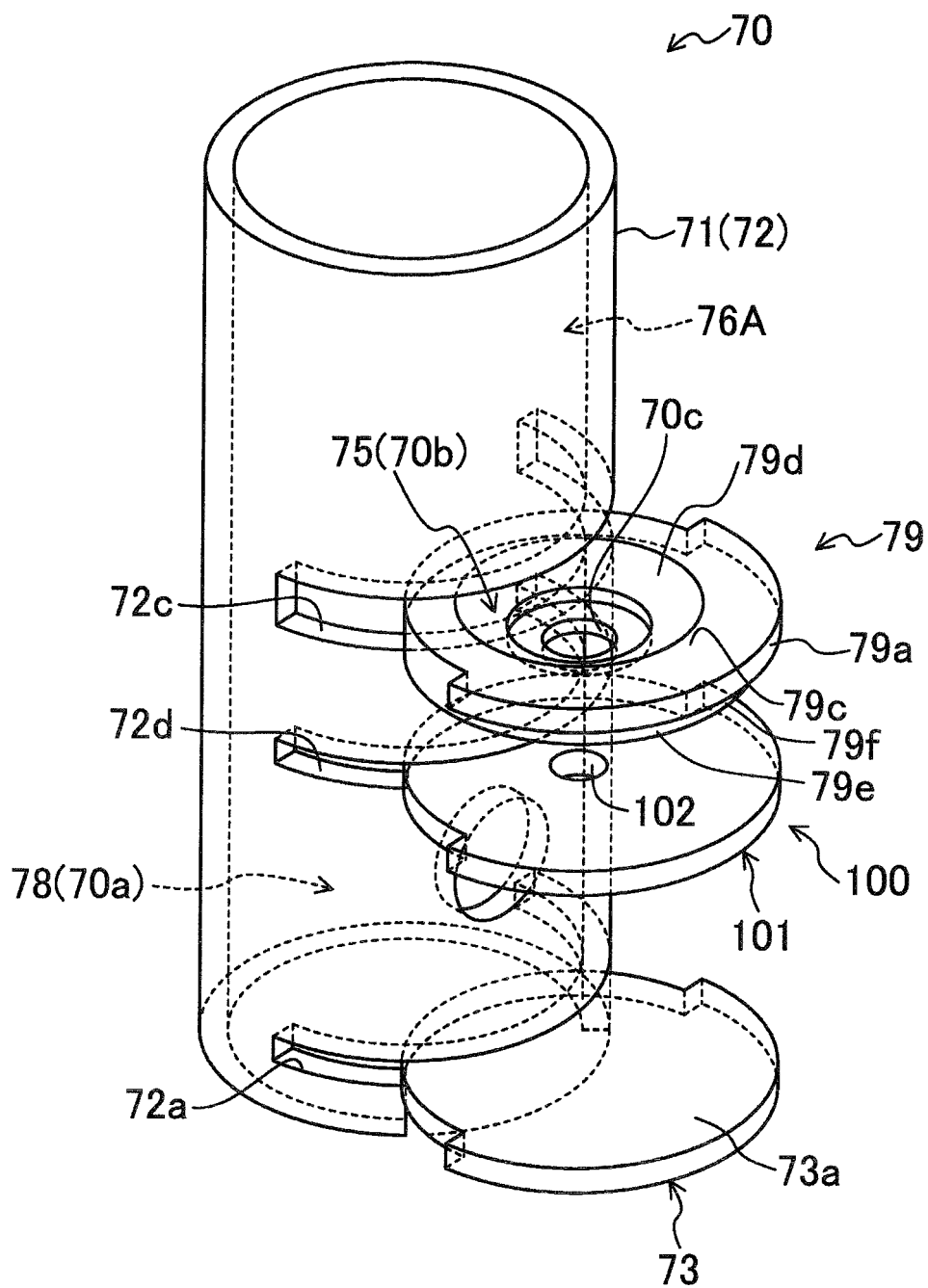


FIG.15

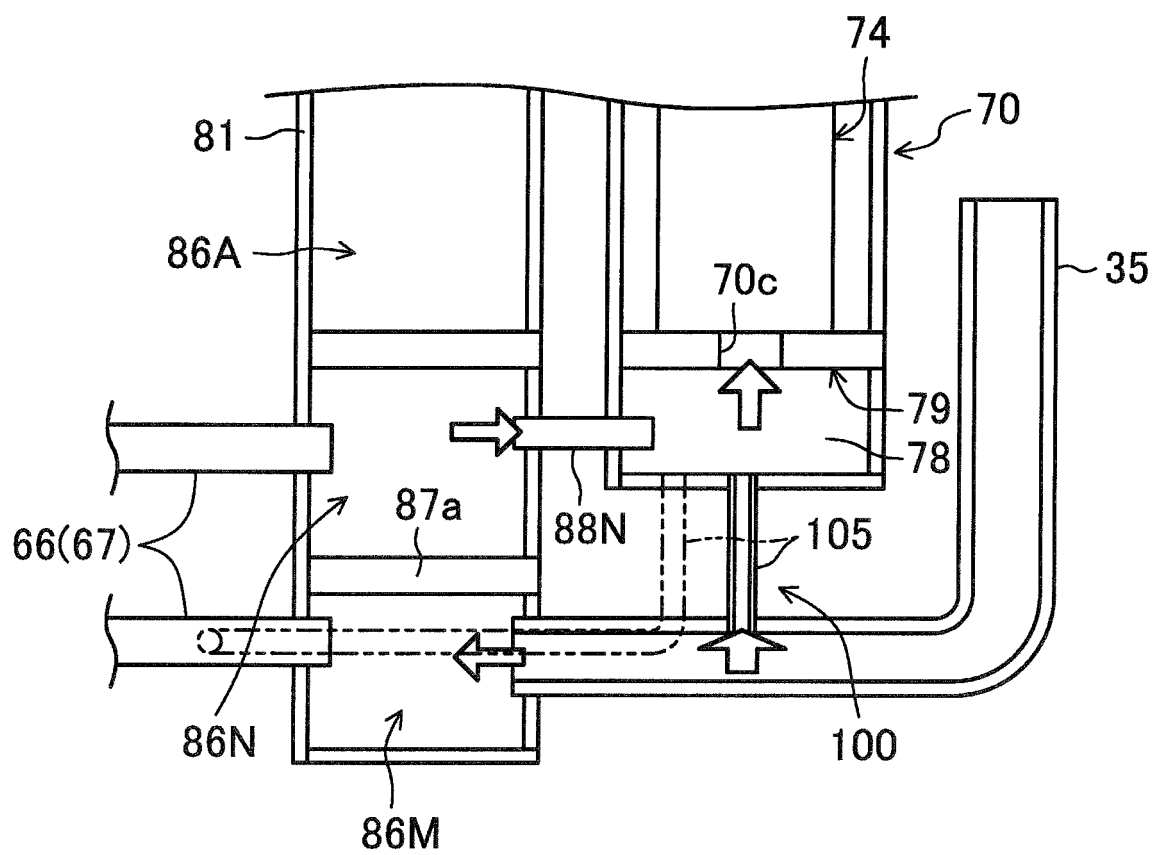


FIG.16

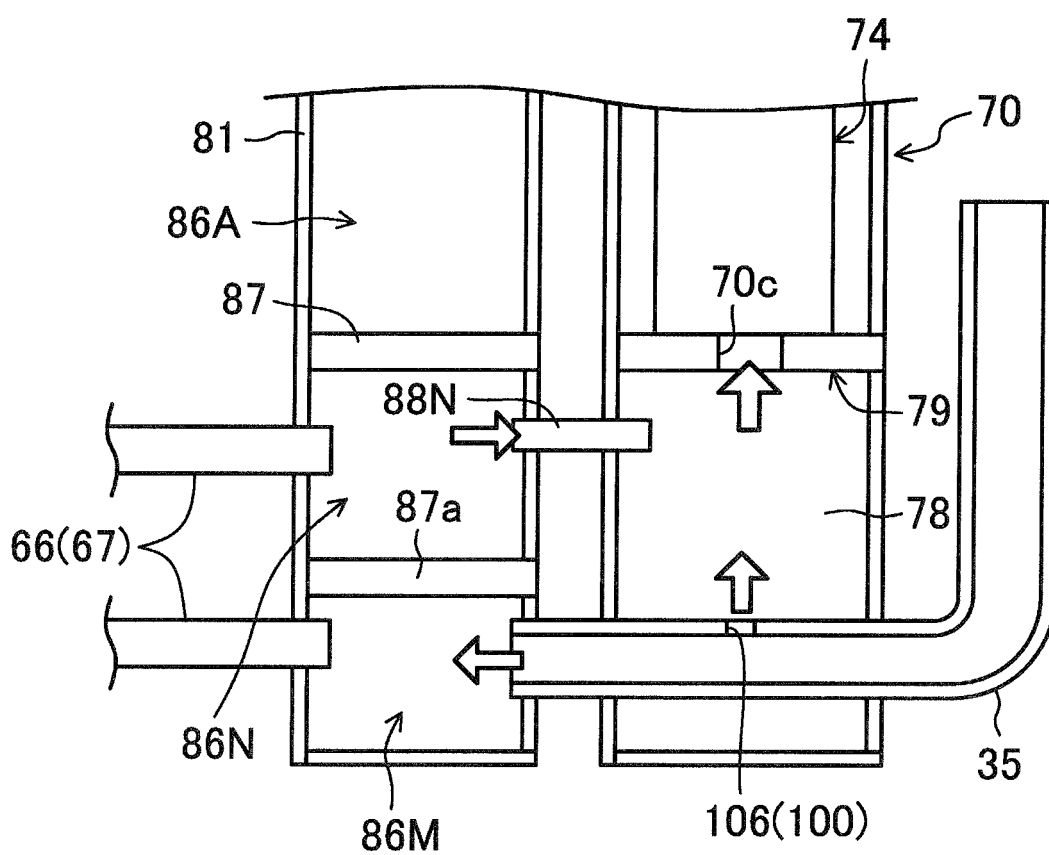
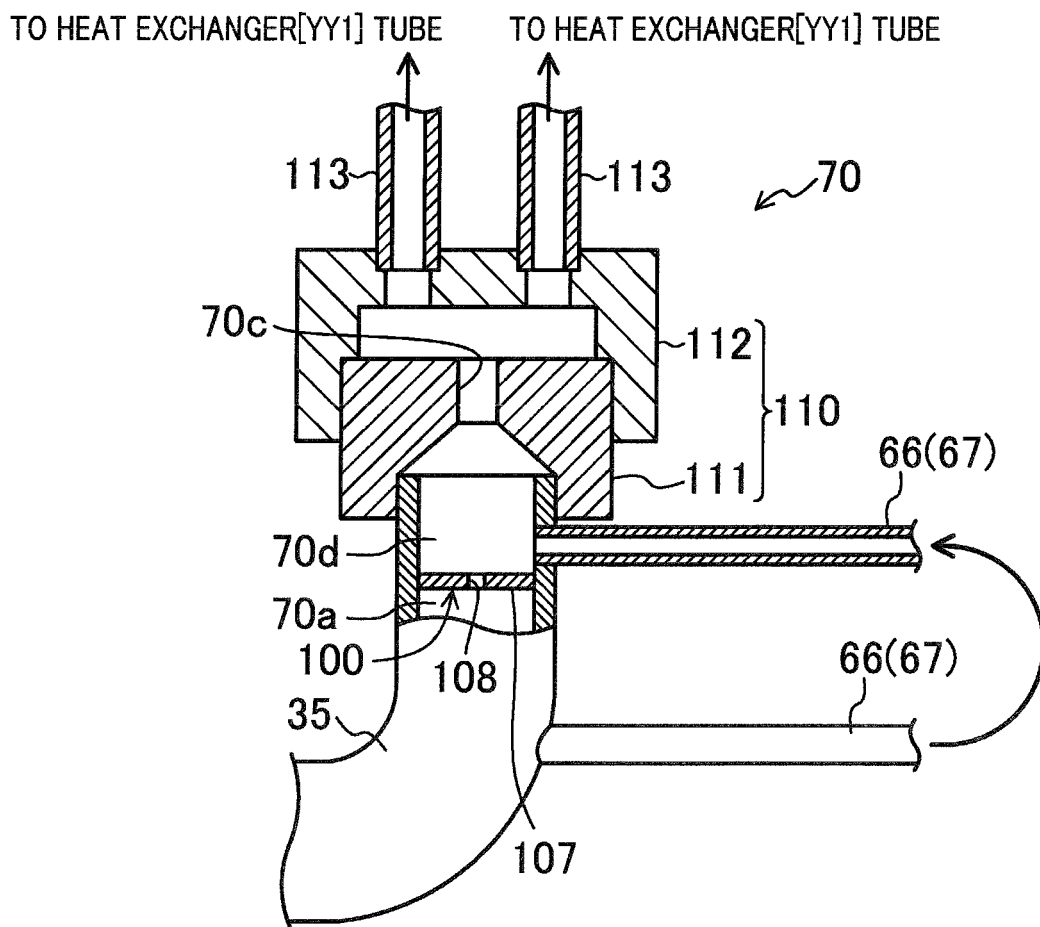


FIG.17



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/003117

A. CLASSIFICATION OF SUBJECT MATTER

F25B47/02(2006.01)i, F25B39/02(2006.01)i, F28D1/053(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)

F25B47/02, F25B39/02, F28D1/053

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	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 10-300271 A (Nippon Light Metal Co., Ltd.),	1
Y	13 November 1998 (13.11.1998),	2, 7-8
A	paragraphs [0010] to [0023]; fig. 1 to 7 (Family: none)	3-6
Y	Microfilm of the specification and drawings	2, 7-8
A	annexed to the request of Japanese Utility Model Application No. 026060/1988 (Laid-open No. 131974/1989) (Fujitsu General Ltd.), 07 September 1989 (07.09.1989), specification, page 1, lines 1 to 17; page 3, line 13 to page 5, line 15; fig. 1 (Family: none)	3-6

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

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
09 September 2016 (09.09.16)Date of mailing of the international search report
20 September 2016 (20.09.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/003117

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 02-219966 A (Matsushita Refrigeration Co.), 03 September 1990 (03.09.1990), page 2, lower right column, line 2 to page 4, upper left column, line 15; fig. 1 to 7 (Family: none)	3-6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007232274 A [0005]