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(54) **MULTI-TYPE AIR CONDITIONING SYSTEM AND INDOOR UNIT**

(57) A multi-type air-conditioning system includes an outdoor unit including an outdoor heat exchanger, a plurality of indoor units each including an expansion valve into which the refrigerant passing through the outdoor heat exchanger flows and an indoor heat exchanger configured to cause heat exchange to be carried out between the refrigerant decompressed by the expansion valve and air, and refrigerant piping which connects the plural-

ity of indoor units in parallel to the outdoor unit, and through which the refrigerant flows. Part of the refrigerant piping positioned inside each of the indoor units includes a plurality of capillaries at a position on the upstream side of the expansion valve in the flow direction of the refrigerant, and the capillaries are connected in parallel to the refrigerant piping.

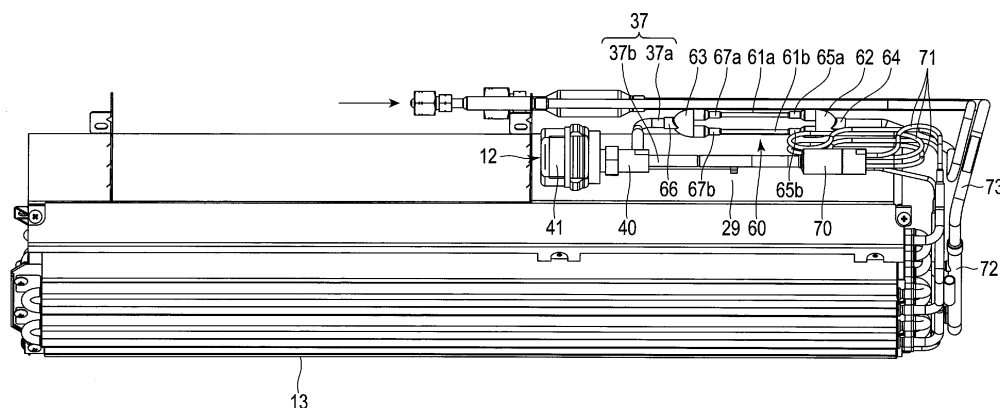


FIG. 4

Description

Summary of Invention

Technical Field

Technical Problem

[0001] Embodiments described herein relate generally to a multi-type air-conditioning system and indoor unit.

Background Art

[0002] For example, in a multi-type air-conditioning system in which a plurality of indoor units are connected to one outdoor unit, the amount of the refrigerant to be supplied to each indoor unit changes from moment to moment depending on the room temperature, the usage state or the like of the indoor units. Accordingly, depending on the state of the refrigerant flowing into the plurality of indoor units, there is a possibility of the refrigerant to be supplied from the outdoor unit to the indoor units being changed from the liquid-phase flow state to the gas-liquid two-phase flow state.

[0003] It is known that when a refrigerant of the gas-liquid two-phase flow flows into an expansion valve of the indoor unit, a harsh refrigerant flow sound is generated. That is, the refrigerant flow sound is dependent on the flow regime of the gas-liquid two-phase flow and, when a slug flow or froth flow caused when non-uniform bubbles intermittently exist in the flow of the refrigerant comes into the expansion valve while being accompanied by pressure pulsation, a large unusual sound is intermittently generated from the expansion valve.

[0004] In order to reduce the refrigerant flow sound generated from the expansion valve, in the conventional indoor unit, making the bore diameter of the expansion valve less than the inner diameter of the refrigerant piping or once branching the flow of the refrigerant into a plurality of flows, and providing a branch confluence part at which the branched flows are thereafter made to join together again at a position of the refrigerant piping located on the upstream side of the expansion valve is tentatively executed.

[0005] According to this configuration, it is possible to make the flow of the refrigerant to be guided to the expansion valve shift from the slug flow or froth flow to a more stable and continuous flow and reduce the refrigerant flow sound attributable to the gas-liquid two-phase flow.

Citation List

Patent Literatures

[0006]

Patent Literature 1: JP H09-292166 A

Patent Literature 2: JP H09-318198 A

[0007] However, as in the case where, for example, the rotational speed of the compressor configured to send forth the refrigerant to the indoor units lowers or where the operation is shifted to a defrosting operation while a heating operation is carried out, when a gas-liquid two-phase state of the refrigerant is caused by an abrupt pressure change inside the refrigerant piping, it is undeniable that it becomes difficult to suppress the refrigerant flow sound by only making the bore diameter of the expansion valve smaller as a countermeasure.

[0008] Furthermore, for example, as in the case where the multi-type air-conditioning system is started or as in the case where the operation is shifted to the defrosting operation while the heating operation is carried out, when the flow rate (velocity) of the refrigerant flowing through the refrigerant piping is not sufficient, it can be predicted that it may become difficult to sufficiently mix the gas and liquid at the bifurcation confluence part located on the upstream side of the expansion valve.

[0009] An embodiment described herein aims to obtain a multi-type air-conditioning system capable of reducing a refrigerant flow sound caused when a refrigerant flows into an expansion valve in a gas-liquid two-phase flow state, and including indoor units capable of silent operations.

Means for Solving the Problem

[0010] According to an embodiment, a multi-type air-conditioning system includes an outdoor unit including an outdoor heat exchanger, a plurality of indoor units each including an expansion valve into which the refrigerant passing through the outdoor heat exchanger flows and an indoor heat exchanger configured to cause heat exchange to be carried out between the refrigerant decompressed by the expansion valve and air, and refrigerant piping which connects the plurality of indoor units in parallel to the outdoor unit, and through which the refrigerant flows.

[0011] Part of the refrigerant piping positioned inside each of the indoor units includes a plurality of capillaries at a position on the upstream side of the expansion valve in the flow direction of the refrigerant, and the capillaries are connected in parallel to the refrigerant piping.

Brief Description of Drawings

[0012]

FIG. 1 is a circuit diagram showing a refrigerating cycle of a multi-type air-conditioning system according to an embodiment.

FIG. 2 is a perspective view of a wall-mounted indoor unit to be used for the multi-type air-conditioning sys-

tem.

FIG. 3 is a cross-sectional view of the wall-mounted indoor unit.

FIG. 4 is a plan view of the indoor unit showing positional relationships among an indoor heat exchanger, expansion valve, and capillary section.

FIG. 5 is a cross-sectional view of the expansion valve to be used for the multi-type air-conditioning system.

FIG. 6 is a plan view showing the capillary section of FIG. 4 in an enlarging manner.

[0013] Mode for Carrying Out the Invention Hereinafter, an embodiment of the present invention will be described below with reference to the accompanying drawings.

[0014] FIG. 1 is a circuit diagram showing a refrigerating cycle of a multi-type air-conditioning system 1 to be used for, for example, a medium low story building or store building. The multi-type air-conditioning system 1 according to this embodiment is provided with one outdoor unit 2, three indoor units 3, and refrigerant piping 4 through which a refrigerant circulating among the outdoor unit 2 and indoor units 3 flows.

[0015] More specifically, the outdoor unit 2 includes a hermetic type compressor 5, four-way valve 6, outdoor heat exchanger 7, first expansion valve 8, and accumulator 9. As shown in FIG. 1, a discharge port of the hermetic type compressor 5 is connected to a first port 6a of the four-way valve 6. A second port 6b of the four-way valve 6 is connected to the outdoor heat exchanger 7. The outdoor heat exchanger 7 is connected to the first expansion valve 8. Furthermore, a third port 6c of the four-way valve 6 is connected to the accumulator 9. The accumulator 9 is connected to an admission port of the hermetic type compressor 5 through a suction cup 10.

[0016] The three indoor units 3 are connected in parallel between a fourth port 6d of the four-way valve 6 and first expansion valve 8. Each indoor unit 3 includes a second expansion valve 12 and indoor heat exchanger 13. The second expansion valve 12 is interposed between the first expansion valve 8 and indoor heat exchanger 13 and is connected to the first expansion valve 8 and indoor heat exchanger 13. The indoor heat exchanger 13 is connected to the fourth port 6d of the four-way valve 6.

[0017] When the multi-type air-conditioning system 1 is to carry out a cooling operation, the four-way valve 6 is switched in such a manner that the first port 6a communicates with second port 6b and third port 6c communicates with fourth port 6d. When the cooling operation is started, a high-temperature/high-pressure gas-phase refrigerant compressed by the hermetic type compressor 5 is discharged into the refrigerant piping 4. The high-temperature/high-pressure gas-phase refrigerant is guided to the outdoor heat exchanger 7 functioning as a condenser through the four-way valve 6.

[0018] The gas-phase refrigerant which has been guided

to the outdoor heat exchanger 7 is condensed by heat exchange with the outdoor air sent from a blast fan 11 and is changed into a high-pressure liquid-phase refrigerant. The high-pressure liquid-phase refrigerant is decompressed in the process of passing through the first expansion valve 8 and is thereafter distributed to the three indoor units 3.

[0019] That is, the refrigerant passing through the first expansion valve 8 is decompressed again in the process of passing through the second expansion valves 12 of the indoor units 3 and is changed into a low-pressure gas-liquid two-phase flow refrigerant. The gas-liquid two-phase refrigerant is guided to the indoor heat exchangers 13 functioning as evaporators. The gas-liquid two-phase refrigerant which has been guided to the indoor heat exchangers 13 carries out heat exchange with the indoor air sent from blast fans 14 in the process of passing through the indoor heat exchangers 13.

[0020] As result, the gas-liquid two-phase refrigerant carries out heat removal from the indoor air to thereby evaporate and changes into a low-temperature/low-pressure gas-phase refrigerant. The air passing through the indoor heat exchangers 13 is cooled by the latent heat of vaporization of the liquid-phase refrigerant, is made the cool air, and is sent into the rooms to be cooled.

[0021] The low-temperature/low-pressure gas-phase refrigerant passing through the indoor heat exchangers 13 is sucked into the hermetic type compressor 5 from the four-way valve 6 through the accumulator 9 and suction cup 10. The gas-phase refrigerant which has been sucked into the hermetic type compressor 5 is again compressed into a high-temperature/high-pressure gas-phase refrigerant and is discharged into the refrigerant piping 4.

[0022] On the other hand, when the multi-type air-conditioning system 1 is to carry out a heating operation, the four-way valve 6 is switched in such a manner that the first port 6a communicates with the fourth port 6d and second port 6b communicates with third port 6c. When the heating operation is started, the high-temperature/high-pressure gas-phase refrigerant compressed by the hermetic type compressor 5 is distributed to the indoor heat exchangers 13 of the three indoor units 3 and carries out heat exchange with the indoor air sent from the blast fans 14 in the process of passing through the indoor heat exchangers 13 functioning as condensers.

[0023] As a result, the gas-phase refrigerant passing through the indoor heat exchangers 13 condenses by carrying out heat exchange with the indoor air and changes into a high-pressure liquid-phase refrigerant. The air passing through the indoor heat exchangers 13 is heated by the heat exchange with the gas-phase refrigerant, is made the warm air, and is sent into the rooms to be heated.

[0024] The high-pressure liquid-phase refrigerant passing through the indoor heat exchangers 13 is decompressed in the process of passing through the second expansion valves 12 and first expansion valve 8 and

is changed into a low-pressure gas-liquid two-phase flow refrigerant. The gas-liquid two-phase refrigerant is guided to the outdoor heat exchanger 7 functioning as an evaporator, evaporates here by heat exchange with the outdoor air sent from the blast fan 11, and changes into a low-temperature/low-pressure gas-phase refrigerant. The low-temperature/low-pressure gas-phase refrigerant passing through the outdoor heat exchanger 7 is, as in the case of the cooling operation, sucked into the hermetic type compressor 5 from the four-way valve 6 through the accumulator 9 and suction cup 10.

[0025] When frost forms on the outdoor heat exchanger 7 during the heating operation, the operation is shifted to the defrosting operation of removing the frost. In the defrosting operation, the four-way valve 6 is switched from the state of the heating operation to the state of the cooling operation and the blast fan 11 is stopped. Thereby, the high-temperature gas-phase refrigerant compressed by the hermetic type compressor 5 is guided to the outdoor heat exchanger 7 and melts the frost adhering to the outdoor heat exchanger 7.

[0026] As shown in FIG. 2 and FIG. 3, the indoor unit 3 of this embodiment is a wall-mounted type unit installed on the upper part of the wall surface W of a room R to be air-conditioned and includes a housing 20 fixed to the wall surface W. The housing 20 is a box-shaped element including a front panel 21, rear panel 22, and side panels 23 on the right and left sides. The housing 20 is protruded from the wall surface W toward the inside of the room R to be air-conditioned and extends in the lateral directions along the wall surface W.

[0027] Furthermore, the housing 20 includes a suction opening 24 and blowout opening 25. The suction opening 24 is opened at the top surface of the housing 20. The blowout opening 25 is opened at the lower surface of the housing 20. In the blowout opening 25, a horizontal louver 26 configured to change the blowout direction of the air-conditioned air to the vertical directions of the housing 20 and a plurality of vertical louvers 27 (only one of them is shown) configured to change the blowout direction of the air-conditioned air to the lateral directions of the housing 20 are arranged.

[0028] As shown in FIG. 3, the inside of the housing 20 is divided into a heat-exchanging chamber 28 and piping-accommodating chamber 29. The heat-exchanging chamber 28 occupies a large part of the interior of the housing 20 and the suction opening 24 and blowout opening 25 are made to communicate with the heat-exchanging chamber 28. The piping-accommodating chamber 29 is surrounded by a cover 30 to thereby be separated from the heat-exchanging chamber 28. The piping-accommodating chamber 29 is shifted to one side of the housing 20 in the width direction of the housing 20 and is positioned at the upper rear part of the heat-exchanging chamber 28.

[0029] The aforementioned indoor heat exchanger 13, blast fan 14, and a filter 33 are accommodated in the heat-exchanging chamber 28. The indoor heat exchanger

13 is a plate-like element made to vertically rise behind the front panel 21 and is provided with a plurality of cooling fins 34 and a plurality of heat exchanger tubes 35 through which the refrigerant flows.

[0030] The cooling fins 34 extend in the height direction of the housing 20 and are arranged in a line at intervals in the width direction of the housing 20. The heat exchanger tubes 35 are arranged at intervals in both the height direction and depth direction of the housing 20 and define a plurality of refrigerant paths independent of each other. Furthermore, the heat exchanger tubes 35 are thermally connected to the cooling fins 34.

[0031] The blast fan 14 is horizontally arranged in the width direction of the housing 20 behind the indoor heat exchanger 13. Accordingly, in this embodiment, the indoor heat exchanger 13 is interposed between the blast fan 14 and suction opening 24 of the housing 20, and blowout opening 25 including the horizontal louver 26 and vertical louvers 27 is positioned directly below the blast fan 14.

[0032] The filter 33 is detachably supported on the heat-exchanging chamber 28 in such a manner as to be opposed to the front panel 21 of the housing 20 and suction opening 24 thereof. When the blast fan 14 starts an operation, the air inside the room R to be air-conditioned is sucked into the heat-exchanging chamber 28 from the suction opening 24. The air which has been sucked into the heat-exchanging chamber 28 is filtered by the filter 33 and is thereafter guided to the indoor heat exchanger 13. The air passing through the indoor heat exchanger 13 is changed in the blowout direction thereof by the vertical louvers 27 and horizontal louver 26 and is thereafter discharged from the blowout opening 25 into the inside of the room R to be air-conditioned.

[0033] As shown in FIG. 3 and FIG. 4, the aforementioned second expansion valve 12 and liquid-side piping 37 are accommodated in the piping-accommodating chamber 29 of the housing 20. The liquid-side piping 37 constitutes a part of the refrigerant piping 4, the part connecting between the first expansion valve 8 and indoor heat exchanger 13 of each indoor unit 3.

[0034] As shown in FIG. 4 and FIG. 5, the second expansion valve 12 is connected to an intermediate part of the liquid-side piping 37. The second expansion valve 12 divides the liquid-side piping 37 into an entrance pipe section 37a and exit pipe section 37b. The entrance pipe section 37a and exit pipe section 37b horizontally extend in the width direction of the housing 20 inside the piping-accommodating chamber 29 and are arranged horizontally in parallel to each other with a gap held between them in the height direction of the housing 20. A downstream end of the entrance pipe section 37a is upwardly bent at right angles.

[0035] The second expansion valve 12 is provided with a valve main body 40 and drive section 41. Inside the valve main body 40, a refrigerant path 42 is formed. The refrigerant path 42 includes a refrigerant introductory section 42a and refrigerant lead-out section 42b. A down-

stream end of the entrance pipe section 37a of the liquid-side piping 37 is connected to the refrigerant introductory section 42a. An upstream end of the exit pipe section 37b of the liquid-side piping 37 is connected to the refrigerant lead-out section 42b.

[0036] Furthermore, the refrigerant introductory section 42a and refrigerant lead-out section 42b are made to intersect each other inside the valve main body 40. At a part at which the refrigerant introductory section 42a and refrigerant lead-out section intersect each other, a valve seat 43 is formed.

[0037] The valve main body 40 of this embodiment includes a needle supporting section 44 protruded toward the opposite side of the refrigerant lead-out section 42b. A needle insertion hole 45 is formed inside the needle supporting section 44. The needle insertion hole 45 is positioned coaxially with the refrigerant lead-out section 42b.

[0038] A needle 47 functioning as a valve body is inserted into the needle insertion hole 45 in such a manner as to be slidable in the axial direction. The needle 47 is supported by the needle supporting section 44 in such a manner as to be movable between the fully-closed position and opened position.

[0039] At the fully-closed position, a head section 47a having a tapered shape and positioned at one end of the needle 47 in the axial direction thereof is seated in the valve seat 43 and shuts off the communication between the refrigerant introductory section 42a and refrigerant lead-out section 42b. At the opened position, the head section 47a of the needle 47 separates from the valve seat 43 and the cross-sectional area of the flow path between the head section 47a and valve seat 43 is increased/decreased. Thereby, the flow rate of the refrigerant flowing from the refrigerant introductory section 42a toward the refrigerant lead-out section 42b is controlled.

[0040] The drive section 41 of the second expansion valve 12 is an element configured to move the needle 47 in the axial direction, and is provided with a motor 48 and electromagnet 49 as main constituents. The motor 48 includes a cylindrical rotor section 51 screwed onto the outer circumferential surface of the needle supporting section 44, cylindrical spacer 52 fitted onto the outer circumferential surface of the rotor section 51, and electromagnet 53 fixed to the outer circumferential surface of the spacer 52. The tip of the rotor section 51 is coupled to the end 47b of the needle 47 on the opposite side of the head section 47a through an engaging piece 54.

[0041] Furthermore, the motor 48 is covered with a case 55 together with the needle supporting section 44. The electromagnet 49 surrounds the electromagnet 53 from outside the case 55.

[0042] The rotor section 51 of the motor 48 rotates according to the amount of power fed to the electromagnet 49. The rotor section 51 is screwed onto the needle supporting section 44, and hence the rotor section 51 rotates to thereby move in the axial direction of the needle supporting section 44. The movement of the rotor section 51

is transmitted to the needle 47, whereby the needle 47 linearly moves between the fully-closed position and opened position. Thereby, flow rate control of the refrigerant flowing from the refrigerant introductory section 42a toward the refrigerant lead-out section 42b is carried out.

[0043] As shown in FIG. 4 and FIG. 6, a capillary section 60 is provided in the middle of the entrance pipe section 37a of the liquid-side piping 37. The capillary section 60 is positioned on the upstream side of the second expansion valve 12 in the flow direction of the refrigerant at the time of the cooling operation.

[0044] The capillary section 60 is provided with two capillaries 61a and 61b, bifurcation pipe section 62, and confluence pipe section 63. Each of the capillaries 61a and 61b is constituted of a straight pipe previously having a predetermined length L and inner diameter d2. In this embodiment, the length L of each of the capillaries 61a and 61b is set to 80 mm, and inner diameter d2 of each of the capillaries 61a and 61b is set to 2 mm.

[0045] The bifurcation pipe section 62 includes one first connection port 64 to which the liquid-side piping 37 is connected and a pair of second connection ports 65a and 65b bifurcated from the first connection port 64. The confluence pipe section 63 includes one third connection port 66 to which the entrance pipe section 37a is connected and a pair of fourth connection ports 67a and 67b bifurcated from the third connection port 66.

[0046] The one capillary 61a is stretched between the second connection port 65a of the bifurcation pipe section 62 and fourth connection port 67a of the confluence pipe section 63. The other capillary 61b is stretched between the second connection port 65b of the bifurcation pipe section 62 and fourth connection port 67b of the confluence pipe section 63. Accordingly, the capillaries 61a and 61b are arranged in parallel to the entrance pipe section 37a of the liquid-side piping 37 in such a manner that the capillaries 61a and 61b are parallel to each other with a gap held between them in, for example, the height direction of the housing 20.

[0047] In this embodiment, the inner diameter d2 of each of the capillaries 61a and 61b is set to a value equal to or greater than the inner diameter d1 of the refrigerant introductory section 42a of the second expansion valve 12, and is set to a value less than the inner diameter d3 of the entrance pipe section 37a of the liquid-side piping 37. Furthermore, it is desirable that the inner diameters d1, d2, and d3 should satisfy the following relationship when the number of the capillaries 61a and 61b is assumed to be n.

$$d1 < d2 \times n < d3$$

[0048] As shown in FIG. 4, the exit pipe section 37b of the liquid-side piping 37 is connected to a plurality of branch pipes 71 through a distributor 70. The branch pipes 71 correspond to the number of the plurality of re-

refrigerant flow paths included in the indoor heat exchanger 13, and the branch pipes 71 are connected to entrances of the refrigerant flow paths.

[0049] Furthermore, exits of the plurality of refrigerant flow paths of the indoor heat exchanger 13 are made to join together to form one single flow path at the header 72 and the one flow path is connected to the gas-side piping 73 through the header 72. The gas-side piping 73 constitutes a part of the aforementioned refrigerant piping 4, the part connecting between the indoor heat exchanger 13 of each indoor unit 3 and fourth port 6d of the four-way valve 6.

[0050] In the state where the multi-type air-conditioning system 1 is cooling-operated, assuming that the refrigerant passing through the first expansion valve 8 is of a flow regime such as a slug flow caused when non-uniform bubbles intermittently exist in the flow of the refrigerant, when the refrigerant passes through the gap of the second expansion valve 12 between the head section 47a of the needle 47 and valve seat 43, an unpleasant refrigerant flow sound is generated.

[0051] In the indoor unit 3 of this embodiment, the capillary section 60 including the two capillaries 61a and 61b is provided on the upstream side of the second expansion valve 12 in the flow direction of the refrigerant. Accordingly, when the refrigerant of a gas-liquid two-phase flow containing therein non-uniform bubbles reaches the capillary section 60, the refrigerant is bifurcated into two flows at the bifurcation pipe section 62 and thereafter flows into the capillaries 61a and 61b.

[0052] The inner diameter d2 of each of the capillaries 61a and 61b is less than the inner diameter d3 of the entrance pipe section 37a of the liquid-side piping 37, and hence the flow velocity of the refrigerant bifurcated into the two flows is enhanced by the throttling effect achieved by the capillaries 61a and 61b.

[0053] Thereby, the flow of the refrigerant passing through the capillaries 61a and 61b is changed from the slug flow into a flow regime of a stable spray flow. That is, with an increase in the flow velocity, the flow of the refrigerant becomes continuous, and the intermittent flow of the refrigerant causing an occurrence factor of the refrigerant flow sound is dissolved.

[0054] Furthermore, the bifurcated flows of the refrigerant which have shifted to the continuous spray flows in the process of passing through the capillaries 61a and 61b join together at the confluence pipe section 63. Thereby, mixing of the gas and liquid contained in the refrigerant is promoted, and it is possible to form a uniform flow of the refrigerant in which the bubbles contained in the refrigerant flowing from the confluence pipe section 63 toward the second expansion valve 12 are fractionated.

[0055] As a result, at the point of time at which the refrigerant reaches a position in the vicinity of the gap of the second expansion valve 12 between the head section 47a of the needle 47 and valve seat 43, the refrigerant shifts to such a flow regime that minute bubbles uniformly

and continuously exist in the liquid in the state where the bubbles are intermingled with the refrigerant, and it is possible to limit the pressure change at the time when the refrigerant passes through the aforementioned gap to a small change.

[0056] Accordingly, as in the case where for example, the multi-type air-conditioning system 1 is started or the operation is shifted from the heating operation to the defrosting operation, even when the flow velocity of the refrigerant of the gas-liquid two-phase flow flowing through the liquid-side piping 37 is not sufficient, it is possible to efficiently reduce the refrigerant flow sound generated from the second expansion valve 12 of the indoor unit 3, and a silent operation is enabled.

[0057] Moreover, in this embodiment, when the bore diameter of the second expansion valve 12 is d1, inner diameter of each of the capillaries 61a and 61b is d2, inner diameter of the entrance pipe section 37a of the liquid-side piping 37 is d3, and the number of the capillaries 61a and 61b is n, the following relationship is satisfied.

$$d1 < d2 \times n < d3$$

[0058] Thereby, it is possible to sufficiently secure the total sum of the path cross-sectional areas of the capillaries 61a and 61b with respect to the bore diameter d1 of the second expansion valve 12, and prevent the unnecessary pressure loss at the time when the refrigerant passes through the capillaries 61a and 61b from occurring.

[0059] In addition, the inner diameter d2 of each of the capillaries 61a and 61b is less than the inner diameter d3 of the entrance pipe section 37a of the liquid-side piping 37, and hence it is possible to make the capillaries 61a and 61b sufficiently exert the refrigerant throttling effect. Accordingly, the flow velocity of the refrigerant passing through the capillaries 61a and 61b is enhanced, this being convenient for further uniformizing the flow of the refrigerant to be guided to the second expansion valve 12.

[0060] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

[0061] For example, the outdoor unit of the multi-type air-conditioning system is not limited to one unit, two or three outdoor units may be provided and, there is no particular restriction on the number of the outdoor units or

indoor units.

[0062] Furthermore, in the embodiment described above, although the number of the capillaries is two, there is no restriction also on the number of the capillaries. In addition to the above, the inner diameters of the capillaries need not be equal to each other and, the inner diameters of a plurality of capillaries may be made different from each other if the inner diameters are less than that of the entrance pipe section of the liquid-side piping.

[0063] In addition, arrangement of the capillaries is not limited to the horizontal arrangement and, for example, the capillaries may be made to stand upright inside the housing if sufficient space can be secured inside the housing.

Reference Signs List

[0064] 1...multi-type air-conditioning system, 2...outdoor unit, 3...indoor unit, 4...refrigerant piping, 5...compressor (hermetic type compressor), 7...outdoor heat exchanger, 12...expansion valve (second expansion valve), 13...indoor heat exchanger, 61a, 61b...capillary

Claims

1. A multi-type air-conditioning system comprising:

an outdoor unit including an outdoor heat exchanger configured to cause heat exchange to be carried out between a refrigerant compressed by a compressor and air;

a plurality of indoor units each including an expansion valve into which the refrigerant passing through the outdoor heat exchanger flows and an indoor heat exchanger configured to cause heat exchange to be carried out between the refrigerant decompressed by the expansion valve and air, and each being exposed to the inside of a room to be air-conditioned; and refrigerant piping which connects the plurality of indoor units in parallel to the outdoor unit, and through which the refrigerant circulating among the outdoor unit and the indoor units flows, wherein

part of the refrigerant piping positioned inside each of the indoor units includes a plurality of capillaries at a position on the upstream side of the expansion valve in the flow direction of the refrigerant, and the capillaries are connected in parallel to the refrigerant piping.

2. The multi-type air-conditioning system of Claim 1, wherein

each of the capillaries is a straight pipe possessing a predetermined total length and configured to enhance the flow velocity of the refrigerant flowing therethrough toward the expansion valve.

3. The multi-type air-conditioning system of Claim 1 or Claim 2, further comprising a bifurcation pipe section connecting between an upstream end of each of the capillaries and the refrigerant piping, and a confluence pipe section connecting between a downstream end of each of the capillaries and the refrigerant piping.

4. The multi-type air-conditioning system of Claim 2, wherein the indoor unit is a wall-mounted type unit which is exposed to the inside of a room to be air-conditioned, and in which the plurality of capillaries are horizontally arranged with a gap held between them.

5. The multi-type air-conditioning system of Claim 3, wherein when a bore diameter of the expansion valve is d_1 , an inner diameter of the capillary is d_2 , an inner diameter of the refrigerant piping connected to the bifurcation pipe section is d_3 , and the number of the capillaries is n , the following relationship is satisfied.

$$d_1 < d_2 \times n < d_3$$

6. The multi-type air-conditioning system of Claim 1, wherein

at the time of a cooling operation and at the time of a defrosting operation, a flow of the refrigerant passing through the outdoor heat exchanger is bifurcated into the plurality of capillaries and the refrigerant passing through the plurality of capillaries is guided to the expansion valve in a state where the bifurcated flows of the refrigerant join together.

7. An indoor unit comprising:

an expansion valve;
refrigerant piping configured to guide a refrigerant which has been subjected to heat exchange in an outdoor unit to the expansion valve; and
an indoor heat exchanger configured to carry out heat exchange with the refrigerant decompressed by the expansion valve, wherein a plurality of capillaries connected in parallel to the refrigerant piping are provided at a position of the refrigerant piping on the upstream side of the expansion valve in the flow direction of the refrigerant.

8. The indoor unit of Claim 7, wherein each of the capillaries is a straight pipe possessing a predetermined total length and configured to enhance the flow velocity of the refrigerant flowing therethrough toward the expansion valve.

9. The indoor unit of Claim 7 or Claim 8, further comprising a bifurcation pipe section connecting between an upstream end of each of the capillaries and the refrigerant piping, and a confluence pipe section connecting between a downstream end of each of the capillaries and the refrigerant piping. 5

10. The indoor unit of Claim 9, wherein when a bore diameter of the expansion valve is d1, an inner diameter of the capillary is d2, an inner diameter of the refrigerant piping connected to the bifurcation pipe section is d3, and the number of the capillaries is n, the following relationship is satisfied. 10

$$d1 < d2 \times n < d3 \quad 15$$

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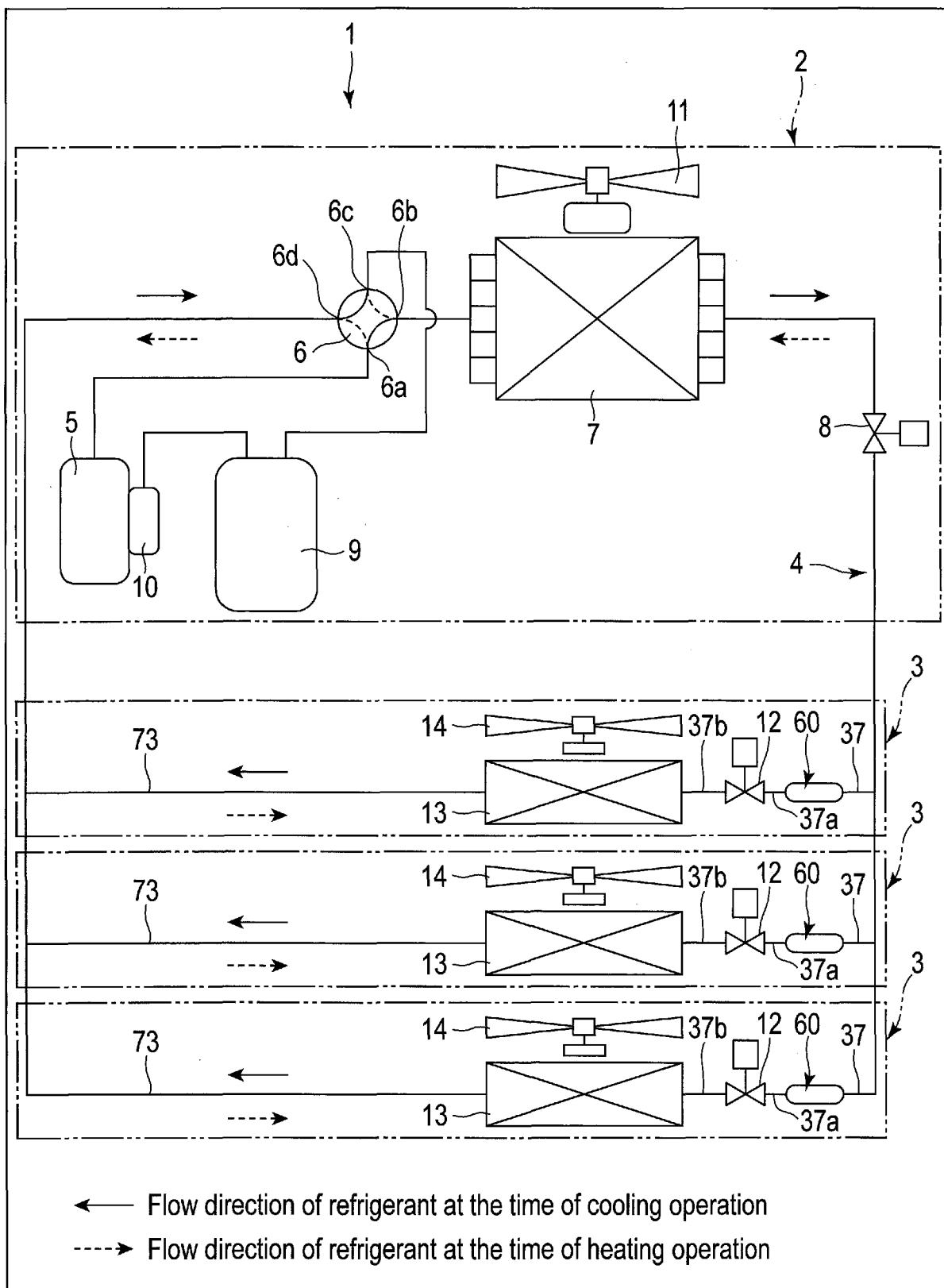


FIG. 1

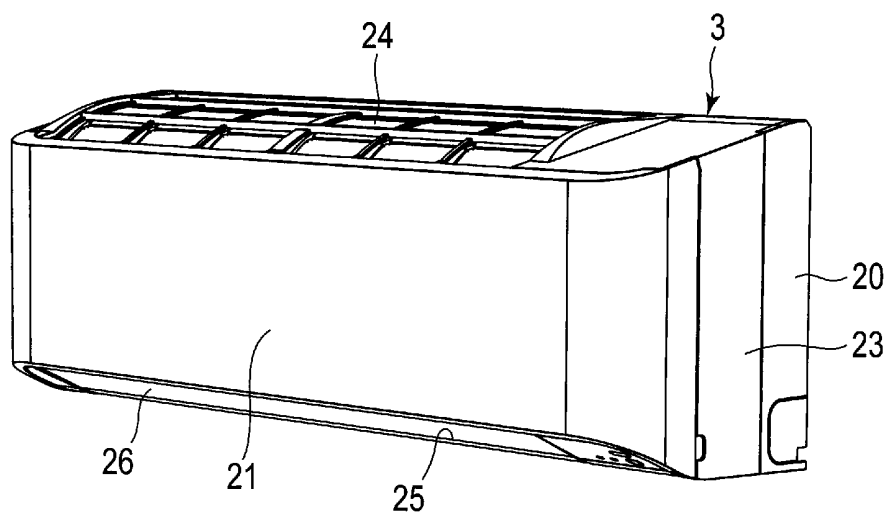


FIG. 2

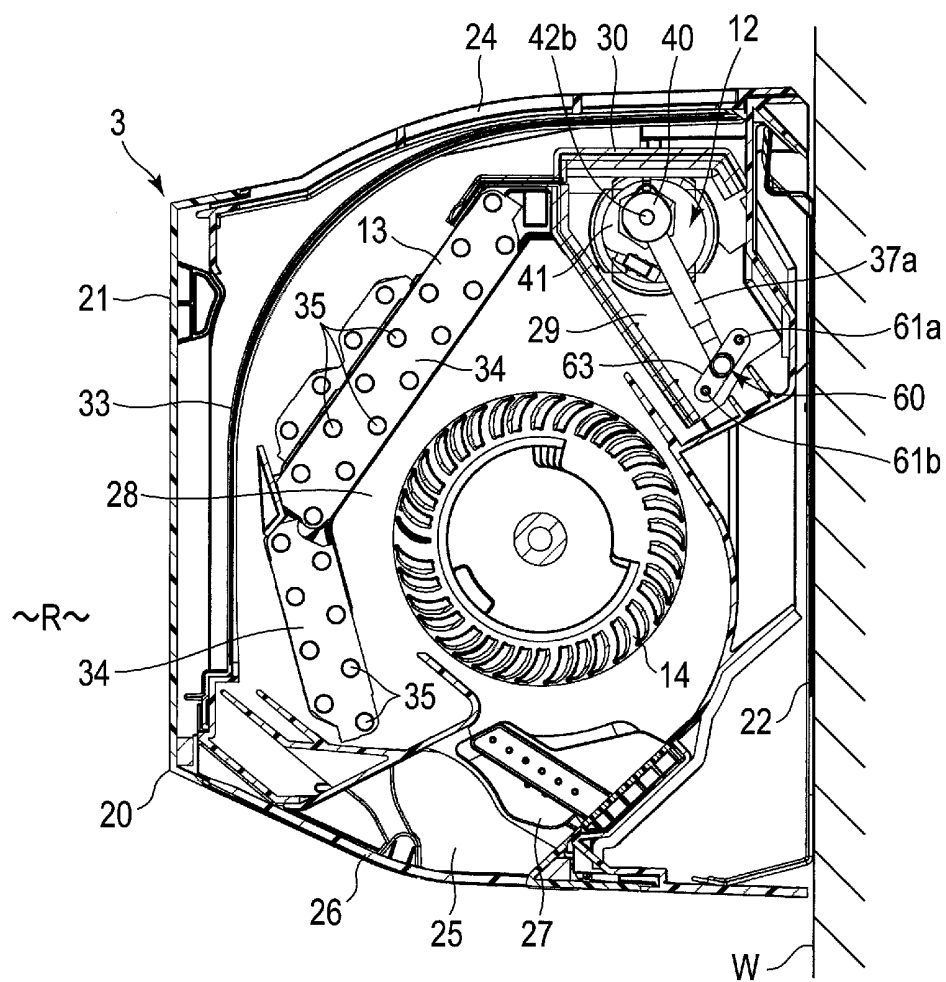


FIG. 3

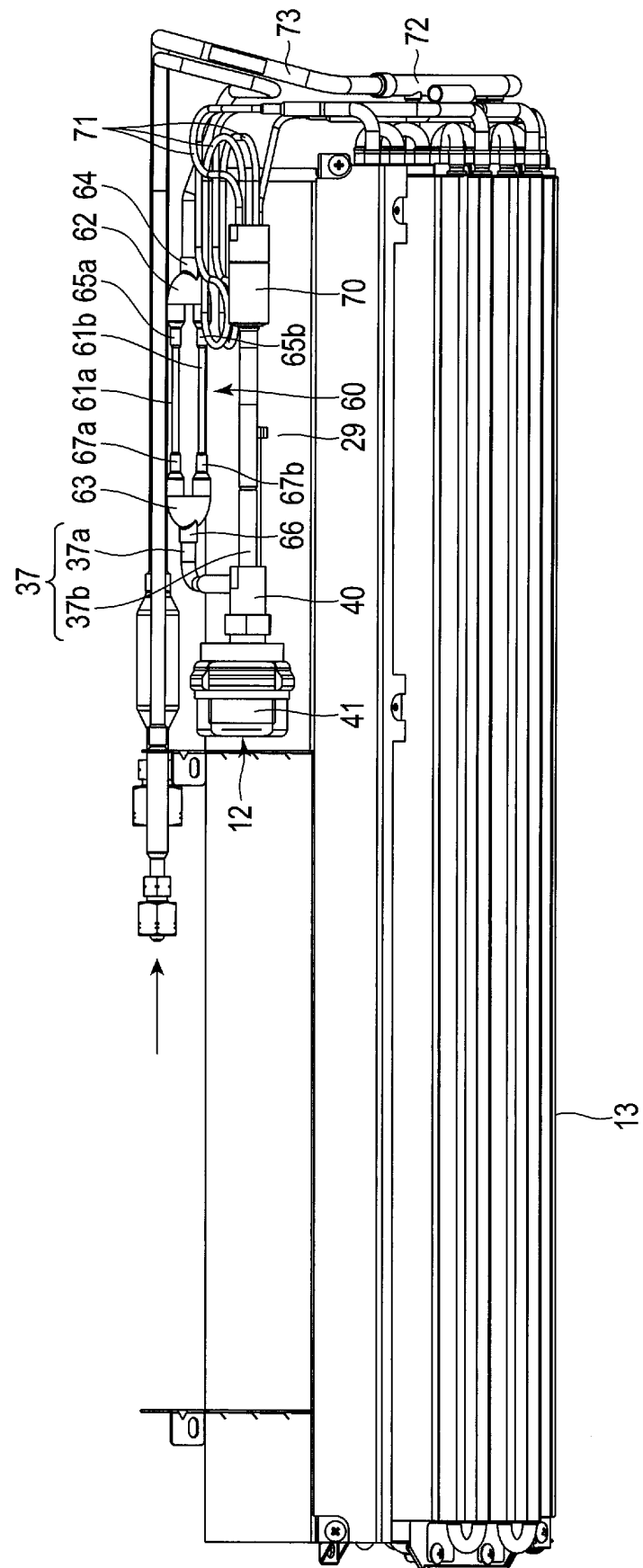


FIG. 4

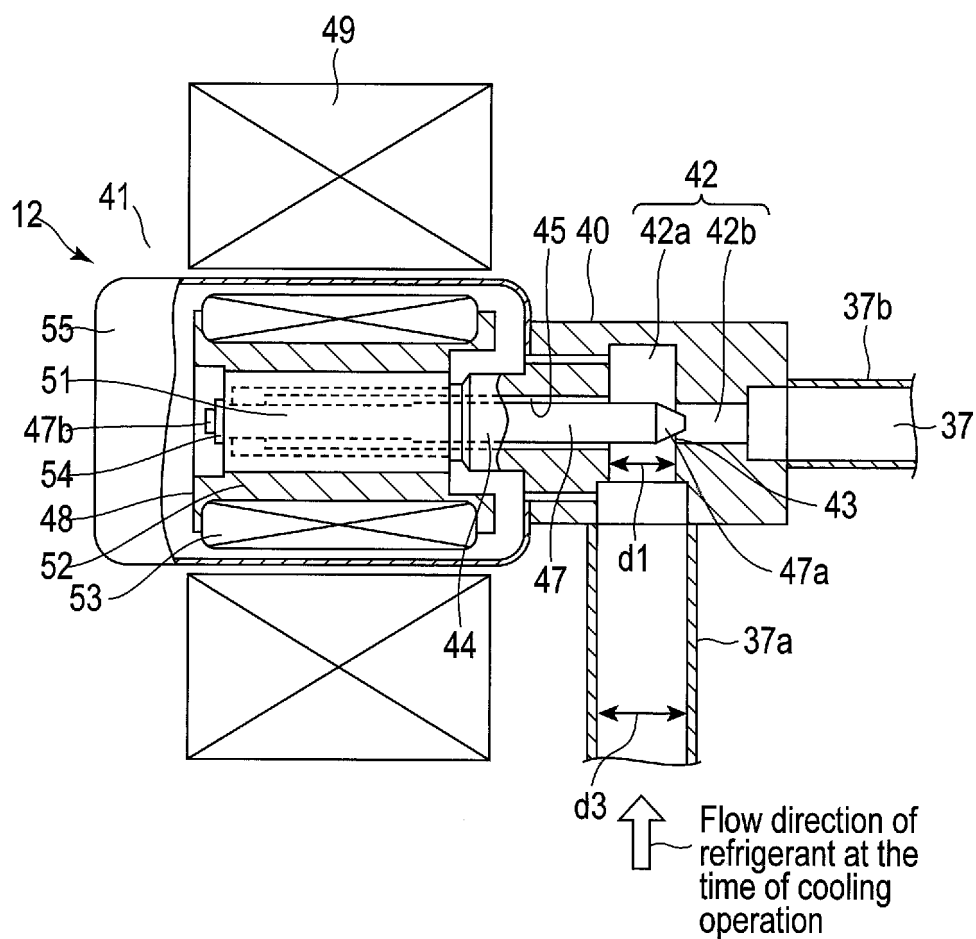


FIG. 5

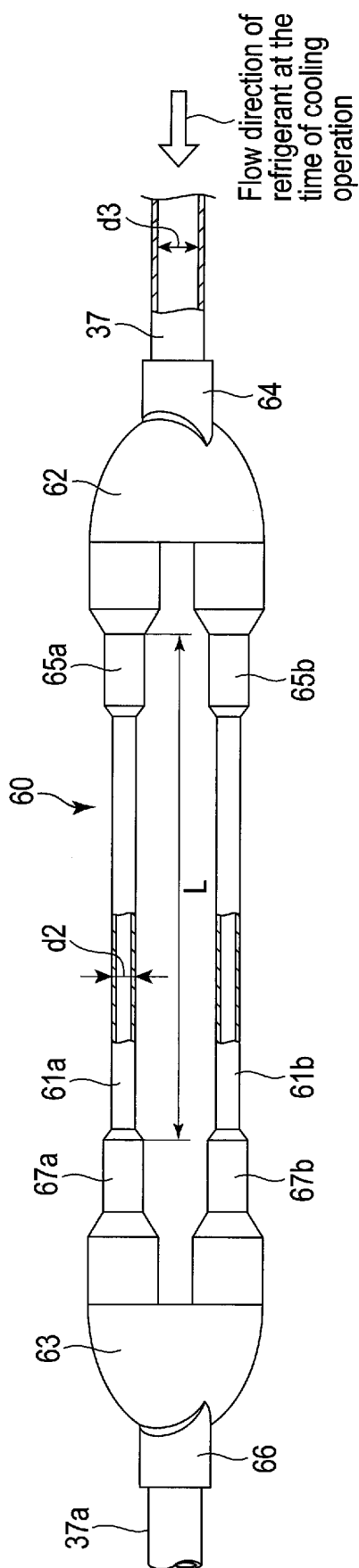


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/031203

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F25B41/00 (2006.01) i, F24F1/00 (2011.01) i, F24F13/32 (2006.01) i,
F25B13/00 (2006.01) i, F25B41/06 (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)

Int.Cl. F25B41/00, F24F1/00, F24F13/32, F25B13/00, F25B41/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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 2001-304721 A (MITSUBISHI ELECTRIC CORPORATION) 31 October 2001, paragraphs [0012]-[0019], [0028], fig. 1, 2, 4 (Family: none)	1-10
Y	JP 07-146032 A (MATSUSHITA SEIKO CO., LTD.) 06 June 1995, claim 2, paragraphs [0001], [0002], [0005], [0023]-[0026], [0037], fig. 2, 7 (Family: none)	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

02.11.2018

Date of mailing of the international search report

13.11.2018

Name and mailing address of the ISA/

Japan Patent Office

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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/031203

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 018049/1993 (Laid-open No. 078769/1994) (MITSUBISHI HEAVY INDUSTRIES, LTD.) 04 November 1994, paragraphs [0001]-[0018], fig. 1, 2 (Family: none)	1-10
Y	JP 2004-257596 A (TOSHIBA KYARIA KK) 16 September 2004, paragraphs [0013], [0014], fig. 3, 4 (Family: none)	2, 4, 8
Y	JP 2004-354026 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 16 December 2004, paragraphs [0022], [0023], fig. 2 (Family: none)	2, 4, 8
Y	JP 2014-228224 A (HITACHI APPLIANCES INC.) 08 December 2014, paragraph [0012], fig. 2 (Family: none)	4
Y	JP 2001-311573 A (MITSUBISHI ELECTRIC CORPORATION) 09 November 2001, paragraphs [0047]-[0049], fig. 6-10 (Family: none)	4
Y	JP 2009-228975 A (HITACHI APPLIANCES INC.) 08 October 2009, paragraph [0015] (Family: none)	6
A	JP 11-325655 A (MATSUSHITA SEIKO CO., LTD.) 26 November 1999, entire text, all drawings & US 6148631 A & HK 1022513 A & CN 1236083 A	1-10
A	WO 2011/099052 A1 (E·T·L CORPORATION) 18 August 2011, entire text, all drawings (Family: none)	1-10
A	US 2010/0089079 A1 (BSH BOSCH UND SIEMENS HAUSGERATE GMBH) 15 April 2010, entire text, all drawings & WO 2008/077697 A2 & EP 2426434 A1 & DE 102006061091 A1 & CN 101568773 A	1-10

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REFERENCES CITED IN THE DESCRIPTION

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