



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.04.2018 Bulletin 2018/15

(51) Int Cl.:
F25B 39/02 (2006.01) **F25B 41/00** (2006.01)
F25B 41/04 (2006.01) **F28F 9/02** (2006.01)
F25B 41/06 (2006.01) **F25B 31/00** (2006.01)
F28D 21/00 (2006.01)

(21) Application number: **17194601.5**

(22) Date of filing: **03.10.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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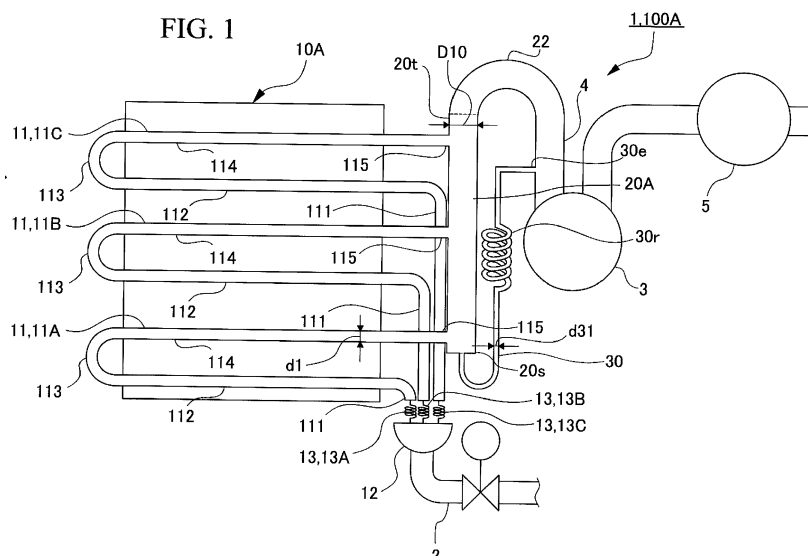
(30) Priority: **05.10.2016 JP 2016197401**

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(54) **EVAPORATOR AND REFRIGERANT CIRCUIT**

(57) The accumulation of lubricating oil within a header (20A, 20D, 20E) is suppressed while suppressing the outflow of a refrigerant in a configuration including a plurality of heat transfer pipes (11, 11A, 11B, 11C). A heat exchanger (10A, 10B, 10C, 10D, 10E) includes a plurality of heat transfer pipes (11, 11A, 11B, 11C) that are provided at intervals in a vertical direction and allow a refrigerant to flow therethrough toward first ends (115); a header (20A, 20D, 20E) that extends in the vertical direction, has the first ends of the plurality of heat transfer pipes (11, 11A, 11B, 11C) connected thereto, and allows the

refrigerant to flow from a lower end (20s) toward an upper end (20t) to which a refrigerant pipe (4, 4E) is connected; and a bypass pipe (30) that allows the lower end (20s) of the header (20A, 20D, 20E) and the refrigerant pipe (4, 4E) to communicate with each other. The length of the bypass pipe (30) is made longer than the length of a flow passage that leads from the lower end (20s) of the header (20A, 20D, 20E) through the upper end (20t) to a site to which the bypass pipe (30) of the refrigerant pipe (4, 4E) is joined.



Description

Summary of Invention

Technical Field

Technical Problem

[0001] The present invention relates to an evaporator and a refrigerant circuit.

Background Art

[0002] In evaporators that constitute refrigeration systems or air-conditioning systems, heat exchange is performed between a refrigerant flowing through a heat transfer pipe and air around the heat transfer pipe. As such evaporators, for example, there is a structure including a plurality of heat transfer pipes disposed at intervals in a vertical direction. In such an evaporator, the refrigerant, which has flowed from an upstream side, branches and flows into a plurality of heat transfer pipes via a header on an evaporator inlet side. A termination end of each heat transfer pipe is connected to a header on an evaporator outlet side that extends in the vertical direction. The refrigerant that has exchanged heat in the heat transfer pipes flows into and joins the header on the evaporator outlet side from the respective heat transfer pipes. The header on the evaporator outlet side is connected to a pipe provided downstream in the flow direction of the refrigerant. The refrigerant is sent to an accumulator or a compressor through this pipe.

[0003] In a refrigerant circuit of a refrigeration system or an air-conditioning system including such an evaporator, the lubricating oil flows with the refrigerant. The lubricating oil circulates through the refrigerant circuit with the refrigerant and lubricates, for example, bearings within the compressor. This lubricating oil may be accumulated with the liquid refrigerant at a bottom part of the header. Thus, a heat exchanger provided with an oil return pipe of which first end is allowed to communicate with a refrigerant return pipe and the other end is disposed within the lubricating oil accumulated within a header tube is described in PTL 1. In such a heat exchanger, a low-pressure space is locally formed around first end (ejector part) of the oil return pipe that opens into the refrigerant return pipe when a gas refrigerant flows. Accordingly, the lubricating oil accumulated at the bottom part of the header tube is pumped up and sent to the compressor with the gas refrigerant.

Citation List

Patent Literature

[0004] [PTL 1] Japanese Unexamined Utility Model Application, First Publication No. S63-144554

[0005] However, in the configuration disclosed in PTL 1, there is a possibility that not only the lubricating oil may flow via the oil return pipe but also much refrigerant may flow via the oil return pipe.

[0006] The invention provides an evaporator and a refrigerant circuit capable of suppressing the accumulation of lubricating oil within a header while suppressing the outflow of a refrigerant in a configuration including a plurality of heat transfer pipes.

Solution to Problem

[0007] An evaporator related to a first aspect of the invention includes a plurality of heat transfer pipes that are provided at intervals in a vertical direction and allow a refrigerant to flow therethrough toward first ends; a header that extends in the vertical direction, has the first ends of the plurality of heat transfer pipes connected thereto, and allows the refrigerant to flow from a lower end toward an upper end to which a refrigerant pipe is connected; and a bypass pipe that allows the lower end of the header and the refrigerant pipe to communicate with each other. A length of the bypass pipe is made longer than a length of a flow passage that leads from the lower end of the header through the upper end to a site to which the bypass pipe of the refrigerant pipe is joined.

[0008] According to such a configuration, the refrigerant can be sent from the lower end through the bypass pipe to the refrigerant pipe without making the lubricating oil at the lower end of the header flow to the upper end. This can suppress the accumulation of the lubricating oil at the lower end of the header. In addition, since the bypass pipe is longer than the length of the flow passage passing through the upper end of the header, the flow rate of the refrigerant that flows through the bypass pipe is suppressed more than the flow rate of the refrigerant that flows through the upper end of the header. Hence, a situation in which the liquid refrigerant within the header flows out excessively via the bypass pipe can be suppressed.

[0009] Additionally, in the evaporator related to a second aspect of the invention based on the first aspect, the bypass pipe may have a flow passage cross-sectional area smaller than a flow passage cross-sectional area at the lower end of the header.

[0010] By adopting such a configuration, the flow rate of the refrigerant that passes through the bypass pipe can be suppressed more than the flow rate of the refrigerant that flows from the lower end of the header to the upper end. Hence, a situation in which the liquid refrigerant within the header flows out excessively via the bypass pipe can be effectively suppressed.

[0011] Additionally, in the evaporator related to a third

aspect of the invention based on the first or second aspect, the bypass pipe may have a spirally wound spiral part.

[0012] By adopting such a configuration, an installation space for the bypass pipe can be suppressed to be small while securing the length of the bypass pipe.

[0013] Additionally, in the evaporator related to a fourth aspect of the invention based on any one of the first to third aspects, the bypass pipe may further include a valve member that controls a flow of the refrigerant within the bypass pipe.

[0014] By adopting such a configuration, the amounts and timings of the lubricating oil and the liquid phase (liquid refrigerant) of the refrigerant, which are sent to the refrigerant pipe via the bypass pipe, can be adjusted.

[0015] Additionally, in the evaporator related to a fifth aspect of the invention based on the fourth aspect, the evaporator may further include a controller that controls opening and closing of the valve member. The controller may control the opening and closing of the valve member on the basis of an elapsed time from starting of a compressor provided downstream of the refrigerant pipe, or the degree of superheat of the refrigerant.

[0016] By adopting such a configuration, for example, when the refrigerant is in an easily liquefied state, such as in a case where the elapsed time from the starting of the compressor is short, or in a case where the degree of superheat of the refrigerant is low, the valve body can be closed to cut off the flow of the bypass pipe such that the liquid refrigerant does not reach the compressor through the bypass pipe.

[0017] Additionally, in the evaporator related to a sixth aspect of the invention based on the fifth aspect, the controller may close the valve member to cut off the flow of the bypass pipe at the starting of the compressor, and may open the valve member to open the flow of the bypass pipe after elapse of a predetermined given time passing since the starting the compressor or in a case where the degree of superheat of the refrigerant becomes equal to or larger than a predetermined reference value.

[0018] By adopting such a configuration, when the refrigerant is in an easily liquefied state immediately after the starting of the compressor, the valve body can be closed to cut off the bypass pipe such that the liquid refrigerant does not reach the compressor through the bypass pipe.

[0019] Additionally, an evaporator related to a seventh aspect of the invention includes a plurality of heat transfer pipes that are provided at intervals in a vertical direction and allow a refrigerant to flow therethrough toward first ends; and a header that extends in the vertical direction, has the first ends of the plurality of heat transfer pipes connected thereto, and allows the refrigerant to flow from an upper end toward a lower end to which a refrigerant pipe is connected.

[0020] In this way, by configuring the header such that the refrigerant flows from the upper end toward the lower

end to which the refrigerant pipe is connected, in the header, the refrigerant flows downward from above that is the same as the gravitational direction. Additionally, in the header, the refrigerants flowing in from the plurality of heat transfer pipes join together at the lower end of the header. Hence, the flow speed of the refrigerant increases at the lower end of the header. Accordingly, the lubricating oil accumulated at the lower end of the header due to gravity smoothly flows from the lower end of the header through the refrigerant pipe with the flow of the refrigerant. As a result, the accumulation of the lubricating oil at the lower end of the header can be suppressed.

[0021] A refrigerant circuit related to an eighth aspect of the invention includes the evaporator of any one of the first to seventh aspects.

Advantageous Effects of Invention

[0022] According to the invention, in the configuration including the plurality of heat transfer pipes, it is possible to suppress the accumulation of the lubricating oil within the header while suppressing that the refrigerant flows in.

Brief Description of Drawings

[0023]

Fig. 1 is schematic view illustrating the configuration of an evaporator and a refrigerant circuit related to a first embodiment of the invention.

Fig. 2 is a schematic view illustrating the configuration of an evaporator and a refrigerant circuit related to a second embodiment of the invention.

Fig. 3 is a schematic view illustrating the configuration of an evaporator and a refrigerant circuit related to a third embodiment of the invention.

Fig. 4 is a view illustrating the flow of opening-and-closing control of a two-way valve by a controller related to a third embodiment of the invention.

Fig. 5 is a schematic view illustrating the configuration of an evaporator and a refrigerant circuit related to a fourth embodiment of the invention.

Fig. 6 is a schematic view illustrating the configuration of an evaporator and a refrigerant circuit related to a fifth embodiment of the invention.

Description of Embodiments

[0024] Hereinafter, embodiments for carrying out an evaporator and a refrigerant circuit according to the invention will be described with reference to the accompanying drawings. However, the invention is not limited only to these embodiments.

(First Embodiment)

[0025] Fig. 1 is schematic view illustrating the configuration of an evaporator and a refrigerant circuit related

to a first embodiment of the invention. As illustrated in Fig. 1, a refrigerant circuit 100A of the present embodiment is provided at an outdoor unit (not illustrated) of an air-conditioning system 1. The air-conditioning system 1 includes the refrigerant circuit 100A. The refrigerant circuit 100A has a heat exchanger (evaporator) 10A, an inlet-side pipe 2, an accumulator 3, an outlet-side pipe (refrigerant pipe) 4, and a compressor 5.

[0026] The heat exchanger 10A functions as an evaporator during a heating operation. In the heat exchanger 10A, the inlet-side pipe 2 used as a flow passage for a refrigerant sent from an indoor unit (not illustrated) is connected to an inlet side that is an upstream side in a flow direction of the refrigerant. In the heat exchanger 10A, the outlet-side pipe (refrigerant pipe) 4 for sending the refrigerant to the compressor 5 is connected to an outlet side that is a downstream side in the flow direction of the refrigerant via the accumulator 3. The heat exchanger 10A includes a plurality of (three in the present embodiment) heat transfer pipes 11, a distributor 12, a plurality of capillary tubes 13, a header 20A, and an oil return pipe (bypass pipe) 30.

[0027] The plurality of heat transfer pipes 11 are connected to the inlet-side pipe 2 via the distributor 12 and the plurality of capillary tubes 13, respectively. In other words, the flow passage for the refrigerant that flows through the inlet-side pipe 2 branches to the plurality of heat transfer pipes 11 via the distributor 12 and the plurality of capillary tubes 13. Accordingly, the refrigerant flows through the plurality of heat transfer pipes 11 to exchange heat. The plurality of heat transfer pipes 11 are provided side by side at intervals in a vertical direction in the heat exchanger 10A. Each heat transfer pipe 11 has a rising section 111, a lower pipe section 112, a bent section 113, and an upper pipe section 114. The heat transfer pipe 11 is a pipe in which the rising section 111, the lower pipe section 112, the bent section 113, and the upper pipe section 114 are integrally formed.

[0028] The rising section 111 extends upward in the vertical direction from the distributor 12 side. An end (an end of the heat transfer pipe 11 on the other side) of the rising section 111 is connected to each capillary tube 13.

[0029] The lower pipe section 112 is continuous with the rising section 111. The lower pipe section 112 horizontally extends in a lateral direction within the heat exchanger 10A.

[0030] The bent section 113 is continuous with the lower pipe section 112. The bent section 113 is bent in a U-shape.

[0031] The upper pipe section 114 is continuous with the bent section 113. The upper pipe section 114 horizontally extends in the lateral direction. The upper pipe section 114 is located to be spaced apart upward in the vertical direction with respect to the lower pipe section 112. A termination end (first end of the heat transfer pipe 11) 115 of the upper pipe section 114 is connected to the header 20A.

[0032] The heat exchanger 10A of the present embodiment

includes a first heat transfer pipe 11A, a second heat transfer pipe 11B, and a third heat transfer pipe 11C in order from below in the vertical direction, as the plurality of heat transfer pipes 11. The first heat transfer pipe 11A, the second heat transfer pipe 11B, and the third heat transfer pipe 11C are disposed to be spaced apart from each other in the vertical direction. The first heat transfer pipe 11A, the second heat transfer pipe 11B, and the third heat transfer pipe 11C are pipes having the same pipe diameter d1.

[0033] The capillary tube 13 is provided between the heat transfer pipe 11 and the distributor 12. The capillary tube 13 has a flow passage cross-sectional area smaller than the heat transfer pipe 11 and is formed in a spiral shape. In the present embodiment, a first capillary tube 13A that connects the first heat transfer pipe 11A and the distributor 12 together, a second capillary tube 13B that connects the second heat transfer pipe 11B and the distributor 12 together, and a third capillary tube 13C that connects the third heat transfer pipe 11C and the distributor 12 together are provided as the plurality of capillary tubes 13.

[0034] The header 20A is disposed laterally of the plurality of heat transfer pipes 11. The header 20A extends upward from below in the vertical direction. The refrigerant flows through the header 20A from a lower end 20s toward an upper end 20t in the vertical direction. The termination ends 115 of the plurality of heat transfer pipes 11 spaced apart from each other in the vertical direction are connected in the header 20A. The upper end 20t of the header 20A is connected to an outlet-side pipe 4. The header 20A of the present embodiment is a pipe having a constant pipe diameter in the vertical direction. The header 20A has a pipe diameter D10 equal to or larger than a pipe diameter d1 of the first heat transfer pipe 11A ($d1 \leq D10$).

[0035] The outlet-side pipe 4 has first end joined to the upper end 20t of the header 20A. The outlet-side pipe 4 has a return part 22 that is curved in a U-shape. The outlet-side pipe 4 is connected to the accumulator 3, which recovers the liquid phase (liquid refrigerant) of the refrigerant, at the other end (second end) that is a side where the outlet-side pipe 4 is not connected to the header 20A.

[0036] The oil return pipe 30 allows the lower end 20s of the header 20A and the outlet-side pipe 4 to communicate with each other. The oil return pipe 30 is connected to the lower end 20s of the header 20A, and a portion that is downstream of the return part 22 of the outlet-side pipe 4 and upstream of a location connected to the accumulator 3. The oil return pipe 30 has a flow passage cross-sectional area smaller than a flow passage cross-sectional area at the lower end 20s of the header 20A. Specifically, the oil return pipe 30 of the present embodiment has a pipe diameter d31 smaller than the pipe diameter d1 of the first heat transfer pipe 11A at the lowermost stage and the pipe diameter D10 of the header 20A. The length of the oil return pipe 30 is made longer

than the length of a flow passage that leads from the lower end 20s of the header 20A through the upper end 20t thereof to a site to which the oil return pipe 30 of the outlet-side pipe 4 is joined. That is, it is more preferable that the oil return pipe 30 has a pipe length that is longer than a flow passage length that leads from the lower end 20s of the header 20A through the upper end 20t thereof to a portion to which a termination end 30e of the oil return pipe 30 of the outlet-side pipe 4 is connected. For this reason, it is preferable that the oil return pipe 30 is formed by a capillary tube having a spirally wound spiral part 30r to secure a length.

[0037] In the air-conditioning system 1 including the heat exchanger 10A of such a configuration, the refrigerant is sent through the inlet-side pipe 2 from the indoor unit side when performing a heating operation. In this case, lubricating oil for lubricating a bearing and the like of the compressor 5 is mixedly present in the refrigerant.

[0038] The refrigerant in which the lubricating oil is mixedly present branches and flows from the inlet-side pipe 2 via the distributor 12 to the first capillary tube 13A, the second capillary tube 13B, and the third capillary tube 13C, respectively. The refrigerant that has flowed into the first capillary tube 13A flows to the first heat transfer pipe 11A in a gas-liquid mixed two-phase state. Similarly, the refrigerant that has flowed into the second capillary tube 13B flows into the second heat transfer pipe 11B, and the refrigerant that has flowed into the third capillary tube 13C flows into the third heat transfer pipe 11C. In each of the first heat transfer pipe 11A, the second heat transfer pipe 11B, and the third heat transfer pipe 11C, the refrigerant exchanges heat with surrounding air and thereby at least a portion thereof is gasified (evaporated). The refrigerant that has exchanged heat by flowing into the first heat transfer pipe 11A, the second heat transfer pipe 11B, and the third heat transfer pipe 11C flows into the header 20A from the respective termination ends 11s, and flows through the header 20A toward the upper end 20t.

[0039] The refrigerant that has flowed into the header 20A from the first heat transfer pipe 11A at the lowermost stage flows toward the upper end 20t. The refrigerant that has flowed into the header 20A from the second heat transfer pipe 11B at a second stage from below joins the refrigerant that has flowed in from the first heat transfer pipe 11A. Moreover, the refrigerant that has flowed into the header 20A from the third heat transfer pipe 11C at an uppermost stage joins the refrigerant that has flowed in from the first heat transfer pipe 11A and the second heat transfer pipe 11B. The refrigerant that has joined within the header 20A in this way is sent from the upper end 20t to the outlet-side pipe 4. Thereafter, the refrigerant is sequentially sent to the accumulator 3 and the compressor 5 through the return part 22.

[0040] Additionally, the lubricating oil accumulated at the lower end 20s of the header 20A due to gravity is bypassed to the middle of the outlet-side pipe 4 downstream of the return part 22 through the oil return pipe

30 without passing through the upper end 20t of the header 20A. Here, in the oil return pipe 30, the lubricating oil flows from the lower end 20s side toward the outlet-side pipe 4 side due to a pressure difference between the header 20A side and the accumulator 3.

[0041] According to the heat exchanger 10A, the refrigerant circuit 100A, and the air-conditioning system 1 as described above, the lubricating oil at the lower end 20s of the header 20A can be sent to the outlet-side pipe 4 through the oil return pipe 30. Hence, the lubricating oil is directly discharged from the lower end 20s via the oil return pipe 30 to the outlet-side pipe 4 without passing through the upper end 20t of the header 20A. This can suppress the accumulation of the lubricating oil at the lower end 20s of the header 20A.

[0042] Additionally, the oil return pipe 30 is formed to be longer than the flow passage length that leads from the lower end 20s of the header 20A through the upper end 20t thereof to the portion to which the termination end 30e of the oil return pipe 30 of the outlet-side pipe 4 is connected. For that reason, the flow rates of the refrigerant and the lubricating oil that flow through the oil return pipe 30 are suppressed more than the flow rates of the refrigerant and the lubricating oil that flow through the upper end 20t of the header. As a result, a situation in which a liquid phase (liquid refrigerant) of a lot of the refrigerant and the lubricating oil flows into the accumulator 3 through the oil return pipe 30 is suppressed. Hence, a situation in which the liquid refrigerant within the header 20A flows out excessively via the oil return pipe 30 can be suppressed. This can suppress the accumulation of the lubricating oil within the header 20A while suppressing the outflow of the refrigerant in the configuration including the plurality of heat transfer pipes 11.

[0043] Additionally, the oil return pipe 30 is formed with the pipe diameter d_{31} smaller than the pipe diameter d_1 of the first heat transfer pipe 11A at the lowermost stage and the pipe diameter D_{10} of the header 20A. That is, the oil return pipe 30 is formed with the flow passage cross-sectional area smaller than the flow passage cross-sectional area at the lower end 20s of the header 20A. For that reason, the flow rates of the liquid refrigerant and the lubricating oil that pass through the oil return pipe 30 can be suppressed to be lower than the flow rates of the liquid refrigerant and the lubricating oil that flow from the lower end 20s of the header 20A toward the upper end 20t. Hence, the situation in which the liquid refrigerant within the header 20A flows out excessively via the oil return pipe 30 can be effectively suppressed.

[0044] Additionally, the oil return pipe 30 has the spirally wound spiral part 30r. For that reason, an installation space for the oil return pipe 30 can be suppressed to be small while securing the length of the oil return pipe 30.

(Second Embodiment)

[0045] Next, an evaporator, an evaporator control

method, and a refrigerant circuit related to a second embodiment of the invention will be described. In addition, in the second embodiment to be described below, the same components as those of the above first embodiment will be designated by the same reference signs in the drawings, and the description thereof will be omitted. The second embodiment is different from the first embodiment in that the bypass pipe has a valve member.

[0046] Fig. 2 is a schematic view illustrating the configuration of the evaporator and the refrigerant circuit related to the second embodiment of the invention. As illustrated in Fig. 2, the oil return pipe 30 is provided with a two-way valve (valve member) 32 that controls the flow of the refrigerant and the lubricating oil within the oil return pipe 30. By opening and closing the two-way valve 32, it is possible to turn on and off the flow of the lubricating oil bypassing a header 20C through the oil return pipe 30. Hence, by appropriately opening and closing the two-way valve 32, it is possible to appropriately switch whether or not the liquid refrigerant and the lubricating oil are made to flow from the lower end 20s of the header 20A through the oil return pipe 30 toward the accumulator 3.

[0047] According to the heat exchanger 10B and the refrigerant circuit 100B as described above, in addition to the same effects as those of the above first embodiment, bypassing to the outlet-side pipe 4 for the lubricating oil and the liquid phase (liquid refrigerant) of the refrigerant can be switched by the two-way valve 32 via the oil return pipe 30. For that reason, the amounts and timings of the lubricating oil and the liquid phase (liquid refrigerant) of the refrigerant, which are sent to the outlet-side pipe 4 via the oil return pipe 30, can be adjusted.

(Third Embodiment)

[0048] Next, an evaporator and a refrigerant circuit related to a third embodiment of the invention will be described. In addition, in the third embodiment to be described below, the same components as those of the above first and second embodiments will be designated by the same reference signs in the drawings, and the description thereof will be omitted. The third embodiment is different from the second embodiment in that a controller is provided.

[0049] Fig. 3 is a schematic view illustrating the configuration of the evaporator and the refrigerant circuit related to the third embodiment of the invention. Fig. 4 is a view illustrating the flow of opening-and-closing control of the two-way valve by the controller related to the third embodiment of the invention.

[0050] As illustrated in Fig. 3, a heat exchanger 10C of the third embodiment further includes a controller 33 that controls the opening and closing of the two-way valve 32.

[0051] The controller 33 controls the opening and closing of the two-way valve 32 on the basis of the elapsed time since the starting of the compressor 5 provided on the downstream side of the outlet-side pipe 4, or the de-

gree of superheat of the refrigerant. As illustrated in Fig. 4, the controller 33 of the present embodiment is brought into a state where the two-way valve is closed at the starting of the compressor 5 (Step S101). Accordingly, the controller 33 cuts off the flow of the liquid refrigerant and the lubricating oil within the oil return pipe 30. The controller 33 causes the two-way valve to be opened after a predetermined given time has elapsed since the start of the compressor 5 (Step S102). Accordingly, the controller 33 opens the flow of the liquid refrigerant and the lubricating oil within the oil return pipe 30.

[0052] In addition, although timing when the two-way valve 32 is opened may be after a given time has been elapsed since the starting of the compressor 5 as in the present embodiment by counting a preset given time by a timer, the invention is not limited to this. It is also possible to provide the header 20A or the like with a thermistor, a pressure sensor, or the like, thereby detecting the degree of superheat of the refrigerant, and determine the timing when the two-way valve 32 is opened in accordance with the detected degree of superheat. In this case, it is preferable to open the two-way valve 32 in a case where the degree of superheat of the refrigerant becomes equal to or higher than a predetermined reference value corresponding to the degree of superheat after the elapse of a given time since the starting.

[0053] According to the heat exchanger 10C and the refrigerant circuit 100C as described above, in addition to the same effects as those of the above second embodiment, the amounts and timings of the lubricating oil and the liquid phase (liquid refrigerant) of the refrigerant, which are sent to the outlet-side pipe 4 via the oil return pipe 30, can be adjusted in accordance with the starting of the compressor 5 by the controller 33. Hence, when the refrigerant immediately after the starting of the compressor 5 tends to be liquefied, the flow within the oil return pipe 30 can be cut off by closing the two-way valve 32. For that reason, much liquid refrigerant can be prevented from reaching the compressor 5 from the accumulator 3 through the oil return pipe 30 in a case where the refrigerant is in the easily liquefied state. Then, the lubricating oil can be sent to the accumulator 3 via the oil return pipe 30 after the degree of superheat of the refrigerant within the header 20A increases and the liquid refrigerant is gasified like after the elapse of a given time since the starting of the compressor 5.

(Fourth Embodiment)

[0054] Next, an evaporator, an evaporator control method, and a refrigerant circuit related to the fourth embodiment of the invention will be described. In addition, in the fourth embodiment to be described below, the same components as those of the above first to third embodiments will be designated by the same reference signs in the drawings, and the description thereof will be omitted. The fourth embodiment is different from the first embodiment in terms of the structure of the header.

[0055] Fig. 5 is a schematic view illustrating the configuration of the evaporator and the refrigerant circuit related to the fourth embodiment of the invention. As illustrated in Fig. 5, in a header 20D of the fourth embodiment, the flow passage cross-sectional area of a portion to which the first heat transfer pipe 11A located at the lowermost stage among the plurality of heat transfer pipes 11 is connected is smaller than the flow passage cross-sectional area at the upper end 20t.

[0056] The header 20D of the present embodiment is formed such that the flow passage cross-sectional area thereof becomes gradually larger as the number of heat transfer pipes 11 to be connected increases from the lower end 20s toward the upper end 20t in the vertical direction. In this embodiment, the header 20D is configured by joining a plurality of (three in the present embodiment) piping members 31 having different pipe diameters (external diameters) and internal diameters upward from below. In the present embodiment, a first piping member 31A, a second piping member 31B, and a third piping member 31C are provided sequentially from the lower end 20s side in the vertical direction. The header 20D of the present embodiment is formed by the first piping member 31A, the second piping member 31B, the third piping member 31C being joined together by joining means, such as brazing or welding.

[0057] The first piping member 31A is located at the lowermost position in the vertical direction. The termination end 115 of the first heat transfer pipe 11A at the lowermost stage is connected to the first piping member 31A. The first piping member 31A is a bottomed tubular pipe of which a lower end in the vertical direction is blocked so as to form the lower end 20s of the header 20D. The first piping member 31A is a pipe having a constant pipe diameter in the vertical direction. The first piping member 31A has a pipe diameter D11 equal to or larger than the pipe diameter d1 of the heat transfer pipe 11A ($d1 \leq D11$). The pipe diameter D11 of the first piping member 31A is larger than the pipe diameter d31 of the oil return pipe 30 ($d31 < D11$).

[0058] The second piping member 31B is disposed above the first piping member 31A in the vertical direction. The termination end 115 of the second heat transfer pipe 11B at a second stage from below is connected to the second piping member 31B. The second piping member 31B is a tubular pipe that is open at both ends. The second piping member 31B is a pipe having a constant pipe diameter in the vertical direction. A lower end of the second piping member 31B in the vertical direction is joined to an upper end of the first piping member 31A in the vertical direction. In the present embodiment, an inner peripheral surface of the lower end of the second piping member 31B in the vertical direction and an outer peripheral surface of the upper end of the first piping member 31A are fitted and joined together so as to slide on each other. The second piping member 31B has a pipe diameter D12 larger than the pipe diameter D11 of the first piping member 31A immediately therebelow ($D11 <$

D12).

[0059] The third piping member 31C is disposed above the second piping member 31B in the vertical direction. The termination end 115 of the third heat transfer pipe 11C at a third stage from below is connected to the third piping member 31C. The third piping member 31C is a tubular pipe that is open at both ends. The third piping member 31C is a pipe having a constant pipe diameter in the vertical direction. A lower end of the third piping member 31C is joined to an upper end of the second piping member 31B in the vertical direction. In the present embodiment, an inner peripheral surface of the lower end of the third piping member 31C in the vertical direction and an outer peripheral surface of the upper end of the second piping member 31B in the vertical direction are fitted and joined together so as to slide on each other. An upper end of the third piping member 31C is joined to an end of the outlet-side pipe 4. The third piping member 31C has a pipe diameter D13 larger than the pipe diameter D12 of the second piping member 31B immediately therebelow ($D12 < D13$). Hence, the pipe diameter of the header 20D becomes gradually larger in the order of the first piping member 31A that forms the lower end 20s, the second piping member 31B, and the third piping member 31C that forms the upper end 20t.

[0060] Here, the joining positions in the vertical direction between the plurality of heat transfer pipes 11 and the plurality of piping members 31 are not limited at all by the present embodiment. However, in the present embodiment, the termination ends 115 of the plurality of heat transfer pipes 11 are joined to the piping members 31 at positions spaced in the vertical direction from joint parts between the piping members 31 adjacent to each other in the vertical direction. That is, it is preferable that joint parts joined to the piping members 31 are formed at the positions apart from each other in the vertical direction with respect to the joint parts between the piping members 31.

[0061] According to the heat exchanger 10D and the refrigerant circuit 100D as described above, the pipe diameter D11 of the first piping member 31A is smaller than the pipe diameter D12 of the second piping member 31B and the pipe diameter D13 of the third piping member 31C on the upper stage side, and the flow passage cross-sectional area thereof is the smallest in the header 20D. That is, the flow passage cross-sectional area of the first piping member 31A to which the first heat transfer pipe 11A at the lowermost stage is connected is made to be the smallest with respect to the upper end 20t of the header 20D. For that reason, in addition to the same effects as those of the above-described first embodiment, the flow speed of the refrigerant at the lower end 20s of the header 20D can be enhanced compared to a case where the flow passage cross-sectional area is not made small. For that reason, since the refrigerant flows in only from the first heat transfer pipe 11A at the lowermost stage, it is suppressed that the flow speed thereof becomes excessively slow within the first piping member 31A having

a low flow rate of the refrigerant flowing therethrough. As a result, the refrigerant and lubricating oil within the first piping member 31A are made to flow toward the upper end 20t side. This can suppress the accumulation of the lubricating oil contained in the refrigerant in the lower end 20s of the header 20D. As a result, the accumulation of the lubricating oil within the header 20D can be suppressed in the heat exchanger 10A including the plurality of heat transfer pipes 11.

[0062] Additionally, by configuring the header 20A such that the flow passage cross-sectional area of the portion to which the first heat transfer pipe 11A is connected become larger than the flow passage cross-sectional area at the upper end 20t, the accumulation of the lubricating oil can be suppressed without forming a guide or a groove for guiding the lubricating oil to the header 20D. Hence, the header 20D in which the accumulation of the lubricating oil is suppressed can be simply manufactured at low costs.

[0063] Additionally, in order to make the flow passage cross-sectional area of the portion to which the first heat transfer pipe 11A at the lowermost stage is connected small with respect to the upper end 20t of the header 20D, for example, a tapered shape can also be formed such that the flow passage cross-sectional area thereof becomes gradually larger from the lower end 20s of the header 20D toward the upper end 20t thereof. In contrast, the flow passage cross-sectional area of the header 20D is increased in stage whenever the number of heat transfer pipes connected by providing the first piping member 31A, the second piping member 31B, and the third piping member 31C increases. For that reason, a change in the flow speed caused with increases in the flow rates of the refrigerant and the lubricating oil that flow through the header 20D can be suppressed. For that reason, the change in the flow speed while from the lower end 20s toward the upper end 20t is suppressed, and disturbance of the flow within the header 20D due to the change in the flow speed is suppressed. Accordingly, a flow speed at which the lubricating oil can be discharged from the inside of the header 20D can be secured from the lower end 20s to the upper end 20t.

[0064] Moreover, the header 20D is configured by joining the first piping member 31A, the second piping member 31B, and the third piping member 31C having internal diameters different from each other side by side in the vertical direction. Accordingly, just by connecting the three piping members 31, the header 20D of which the flow passage cross-sectional area becomes gradually larger from the lower end 20s toward the upper end 20t can be simply manufactured at low costs.

[0065] Additionally, the joint part between the first piping member 31A and the second piping members 31B, the joint part between the second piping members 31B and third piping members 31C, the joint part between the first piping member 31A and the first heat transfer pipe 11A, the joint part between the second piping member 31B and the third piping member 31C, and the joint part

between the second heat transfer pipe 11B and the third heat transfer pipe 11C, are spaced apart from each other in the vertical direction. For that reason, a space for performing the joining work (brazing, welding, or the like) between the plurality of piping members 31 and the joining work (brazing, welding, or the like) between the respective piping members 31 and the respective heat transfer pipe 11 can be secured. Accordingly, the joining work when manufacturing the header can be easily performed.

[0066] Moreover, the pipe diameter D11 of the first piping member 31A is made to be equal to the pipe diameter d1 of the first heat transfer pipe 11A. Accordingly, a decrease in the flow speed when the refrigerant and the lubricating oil flow into the first piping member 31A from the first heat transfer pipe 11A is suppressed. Accordingly, the flow speed at which the lubricating oil can be discharged is more easily secured by the first piping member 31A.

[0067] In addition, the number of piping members 31 provided in the header 20D is not limited to three of the first piping member 31A, the second piping member 31B, and the third piping member 31C as in the present embodiment. The number of piping members 31 may be two or more, for example, four.

[0068] Additionally, the invention is not limited to one heat transfer pipe 11 being connected to one piping member 31. For example, two or more heat transfer pipes 11 may be joined to the first piping member 31A, the second piping member 31B, and the third piping member 31C that constitutes the header 20D.

(Fifth Embodiment)

[0069] Next, an evaporator and a refrigerant circuit related to a fifth embodiment of the invention will be described. In addition, in the fifth embodiment to be described below, the same components as those of the above first to fourth embodiments will be designated by the same reference signs in the drawings, and the description thereof will be omitted.

[0070] Fig. 6 is a schematic view illustrating the configuration of the evaporator and the refrigerant circuit related to the fifth embodiment of the invention. As illustrated in Fig. 6, in a heat exchanger 10E that constitutes the air-conditioning system 1, a header 20E circulates the refrigerant from the upper end 20t toward the lower end 20s in the vertical direction. The termination ends 115 of the plurality of heat transfer pipes 11 spaced apart from each other in the vertical direction are connected to the header 20E. An outlet-side pipe 4E is connected to the lower end 20s of the header 20E. The upper end 20t of the header 20E of the fifth embodiment is blocked. The header 20E is a pipe having a constant pipe diameter in the vertical direction. The header 20E has the pipe diameter D10 equal to or larger than the pipe diameter d1 of the heat transfer pipe 11A ($d1 \leq D10$).

[0071] The outlet-side pipe 4E of the fifth embodiment

has first end joined to the lower end 20s of the header 20E. The outlet-side pipe 4E of the fifth embodiment has a return part 22E that is curved in a U-shape over two stages. The outlet-side pipe 4E is connected to the accumulator 3, which recovers the liquid phase (liquid refrigerant) of the refrigerant, at an end on the side where the outlet-side pipe 4 is not connected to the header 20E.

[0072] In the air-conditioning system 1 including the heat exchanger 10E of such a configuration, when performing a heating operation, in each of the first heat transfer pipe 11A, the second heat transfer pipe 11B, and the third heat transfer pipe 11C, the refrigerant exchanges heat with surrounding air and thereby at least a portion thereof is gasified (evaporated). The refrigerant that has exchanged heat by flowing into the first heat transfer pipe 11A, the second heat transfer pipe 11B, and the third heat transfer pipe 11C flows into the header 20E from the respective termination ends 115, and flows through the header 20E toward the lower end 20s.

[0073] The refrigerant flowing into the header 20E from the third heat transfer pipe 11C at the uppermost stage flows toward the lower end 20s. The refrigerant flowing into the header 20E from the second heat transfer pipe 11B at the second stage from above joins the refrigerant flowing in from the third heat transfer pipe 11C. Moreover, the refrigerant flowing into the header 20E from the first heat transfer pipe 11A at the lowermost stage joins the refrigerant flowing in from the third heat transfer pipe 11C and the second heat transfer pipe 11B. The refrigerant that has joined within the header 20E in this way is sent from the lower end 20s to the outlet-side pipe 4E. Thereafter, the refrigerant is sequentially sent to the accumulator 3 and the compressor 5 through the return part 22E.

[0074] According to the heat exchanger 10E and the refrigerant circuit 100E as described above, the refrigerant flows downward from above within the header 20E, and the return part 22E that constitutes the outlet-side pipe 4E is connected to the lower end 20s of the header 20E. In such a header 20E, the refrigerant flows downward from above that is the same as the gravitational direction. Additionally, in the lower end 20s, the refrigerants that have flowed in from the first heat transfer pipe 11A, the second heat transfer pipe 11B, and the third heat transfer pipe 11C join together and the flow speed of the joined refrigerant is increasing. Accordingly, the lubricating oil accumulated at the lower end 20s of the header 20E due to gravity smoothly flows from the header 20E through the return part 22E toward the accumulator 3 side with the flow of the refrigerant. As a result, the accumulation of the lubricating oil in the lower end 20s of the header 20E can be suppressed.

[0075] Additionally, since such a header 20E may be provided in a reversed manner by turning the header 20A and the header 20D, which are illustrated in the first to fourth embodiments, upside down in the vertical direction, the header 20E can be simply manufactured at low costs.

[0076] Hereinbefore, the embodiments of the present

invention are described with reference to the drawings. However, the configuration of the embodiments, combinations thereof, or the like are examples, and addition, omission, replacement, or other modifications of the configurations can be applied within a scope which does not depart from the scope of the claims. In addition, the present invention is not limited by the above-described embodiments and is limited by only claims.

[0077] For example, the number of heat transfer pipes 11 provided with the heat exchangers 10A to 10E is not limited to three of the first heat transfer pipe 11A, the second heat transfer pipe 11B, and the third heat transfer pipe 11C as in the present embodiment. For example, the number of heat transfer pipes 11 may be only two, or may be four or more.

[0078] Moreover, although the air-conditioning system 1 including the refrigerant circuit is exemplified as an instance, the invention is not limited to this, and the same configuration can also be applied to a refrigeration system including the refrigerant circuit.

Industrial Applicability

[0079] According to the evaporator and the refrigerant circuit, in the configuration including the plurality of heat transfer pipes, it is possible to suppress the accumulation of the lubricating oil within the header while suppressing that the refrigerant flows in.

Reference Signs List

[0080]

- 1: AIR-CONDITIONING SYSTEM
- 2: INLET-SIDE PIPE
- 3: ACCUMULATOR
- 4, 4E: OUTLET-SIDE PIPE (REFRIGERANT PIPE)
- 5: COMPRESSOR
- 10A, 10B, 10C, 10D, 10E: HEAT EXCHANGER (EVAPORATOR)
- 100A, 100B, 100C, 100D, 100E: REFRIGERANT CIRCUIT
- 11: HEAT TRANSFER PIPE
- 11A: FIRST HEAT TRANSFER PIPE
- 11B: SECOND HEAT TRANSFER PIPE
- 11C: THIRD HEAT TRANSFER PIPE
- 111: RISING SECTION
- 112: LOWER PIPE SECTION
- 113: BENT SECTION
- 114: UPPER PIPE SECTION
- 115: TERMINATION END (FIRST END)
- 12: DISTRIBUTOR
- 13: CAPILLARY TUBE
- 13A: FIRST CAPILLARY TUBE
- 13B: SECOND CAPILLARY TUBE
- 13C: THIRD CAPILLARY TUBE
- 20A, 20D, 20E: HEADER
- 20s: LOWER END

20t: UPPER END
 22, 22E: RETURN PART
 30: OIL RETURN PIPE (BYPASS PIPE)
 30E: TERMINATION END
 30R: SPIRAL PART
 31: PIPING MEMBER
 31A: FIRST PIPING MEMBER
 31B: SECOND PIPING MEMBER
 31C: THIRD PIPING MEMBER
 32: TWO-WAY VALVE (VALVE MEMBER)
 33: CONTROLLER

Claims

1. An evaporator (10A, 10B, 10C, 10D, 10E) comprising:

a plurality of heat transfer pipes (11, 11A, 11B, 11C) that are provided at intervals in a vertical direction and allow a refrigerant to flow there-through toward first ends (115);

a header (20A, 20D, 20E), that is configured to extend in the vertical direction, has the first ends (115) of the plurality of heat transfer pipes (11, 11A, 11B, 11C) connected thereto, and is configured to allow the refrigerant to flow from a lower end (20s) toward an upper end (20t) to which a refrigerant pipe (4, 4E) is connected; and

a bypass pipe (30) configured to allow the lower end of the header (20A, 20D, 20E) and the refrigerant pipe (4, 4E) to communicate with each other,

wherein a length of the bypass pipe (30) is made longer than a length of a flow passage configured to lead from the lower end (20s) of the header (20A, 20D, 20E) through the upper end (20t) to a site to which the bypass pipe (30) of the refrigerant pipe (4, 4E) is joined.

2. The evaporator (10A, 10B, 10C, 10D, 10E) according to Claim 1,

wherein the bypass pipe (30) has a flow passage cross-sectional area smaller than a flow passage cross-sectional area at the lower end (20s) of the header (20A, 20D, 20E).

3. The evaporator (10A, 10B, 10C, 10D, 10E) according to Claim 1 or 2,

wherein the bypass pipe (30) has a spirally wound spiral part (30R).

4. The evaporator (10A, 10B, 10C, 10D, 10E) according to any one of Claims 1 to 3,

wherein the bypass pipe (30) further includes a

valve member (32) configured to control a flow of the refrigerant within the bypass pipe (30).

5. The evaporator (10A, 10B, 10C, 10D, 10E) according to Claim 4, further comprising:

a controller (33) configured to control opening and closing of the valve member (32), wherein the controller (33) is configured to control the opening and closing of the valve member (32) on the basis of an elapsed time from starting of a compressor (5) provided downstream of the refrigerant pipe (4, 4E), or the degree of superheat of the refrigerant.

6. The evaporator (10A, 10B, 10C, 10D, 10E) according to Claim 5,

wherein the controller (33) is configured to close the valve member (32) to cut off the flow of the bypass pipe (30) at the starting of the compressor (5), and is configured to open the valve member (32) to open the flow of the bypass pipe (30) after elapse of a predetermined given time passing since the starting the compressor (5) or in a case where the degree of superheat of the refrigerant becomes equal to or larger than a predetermined reference value.

7. An evaporator (10A, 10B, 10C, 10D, 10E) comprising:

a plurality of heat transfer pipes (11, 11A, 11B, 11C) that are provided at intervals in a vertical direction and allow a refrigerant to flow there-through toward first ends; and

a header (20A, 20D, 20E), that is configured to extend in the vertical direction, has the first ends (115) of the plurality of heat transfer pipes (11, 11A, 11B, 11C) connected thereto, and is configured to allow the refrigerant to flow from an upper end (20t) toward a lower end (20s) to which a refrigerant pipe (4, 4E) is connected.

8. A refrigerant circuit (100A, 100B, 100C, 100D, 100E) comprising the evaporator (10A, 10B, 10C, 10D, 10E) according to any one of Claims 1 to 7.

FIG. 1

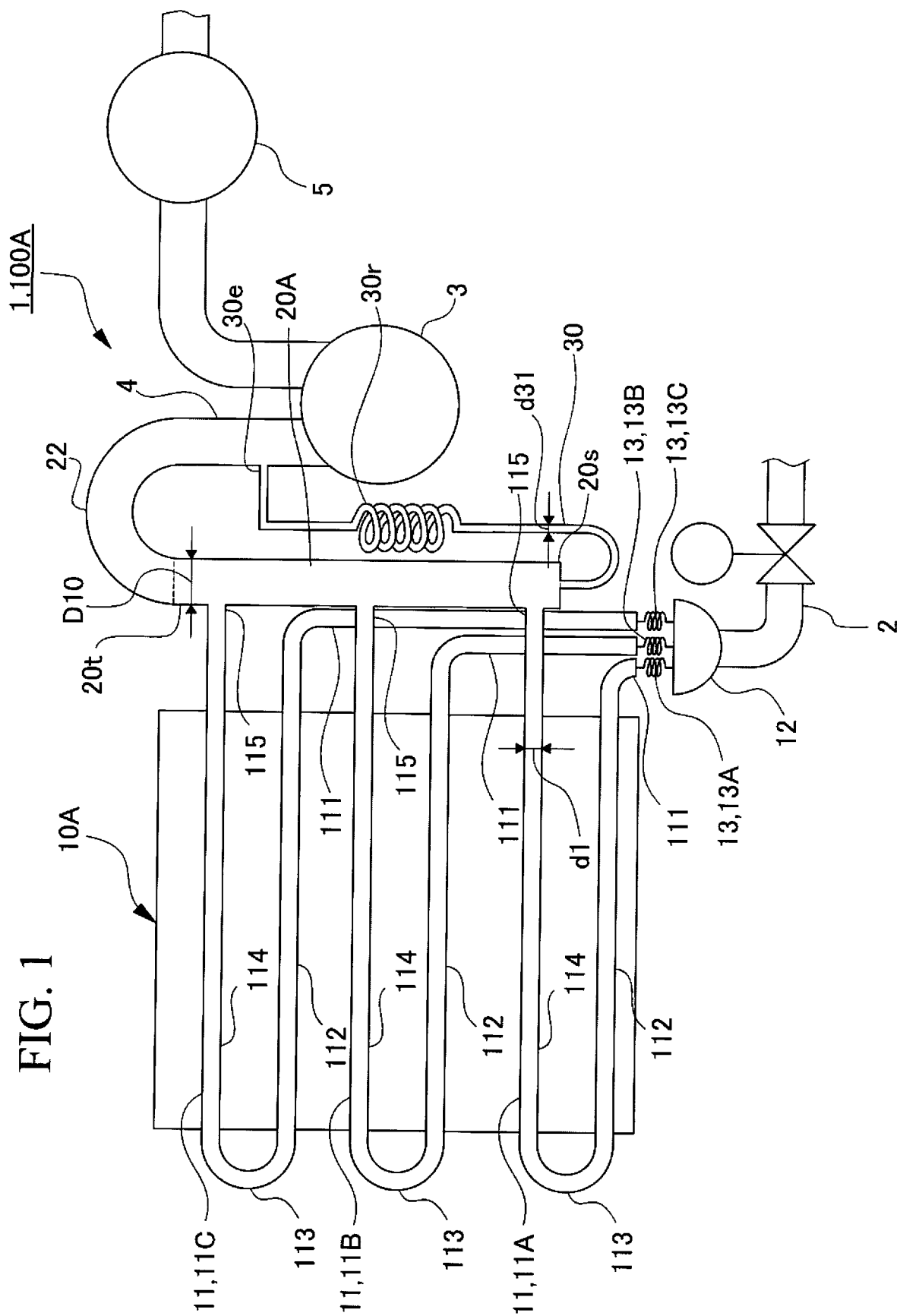


FIG. 2

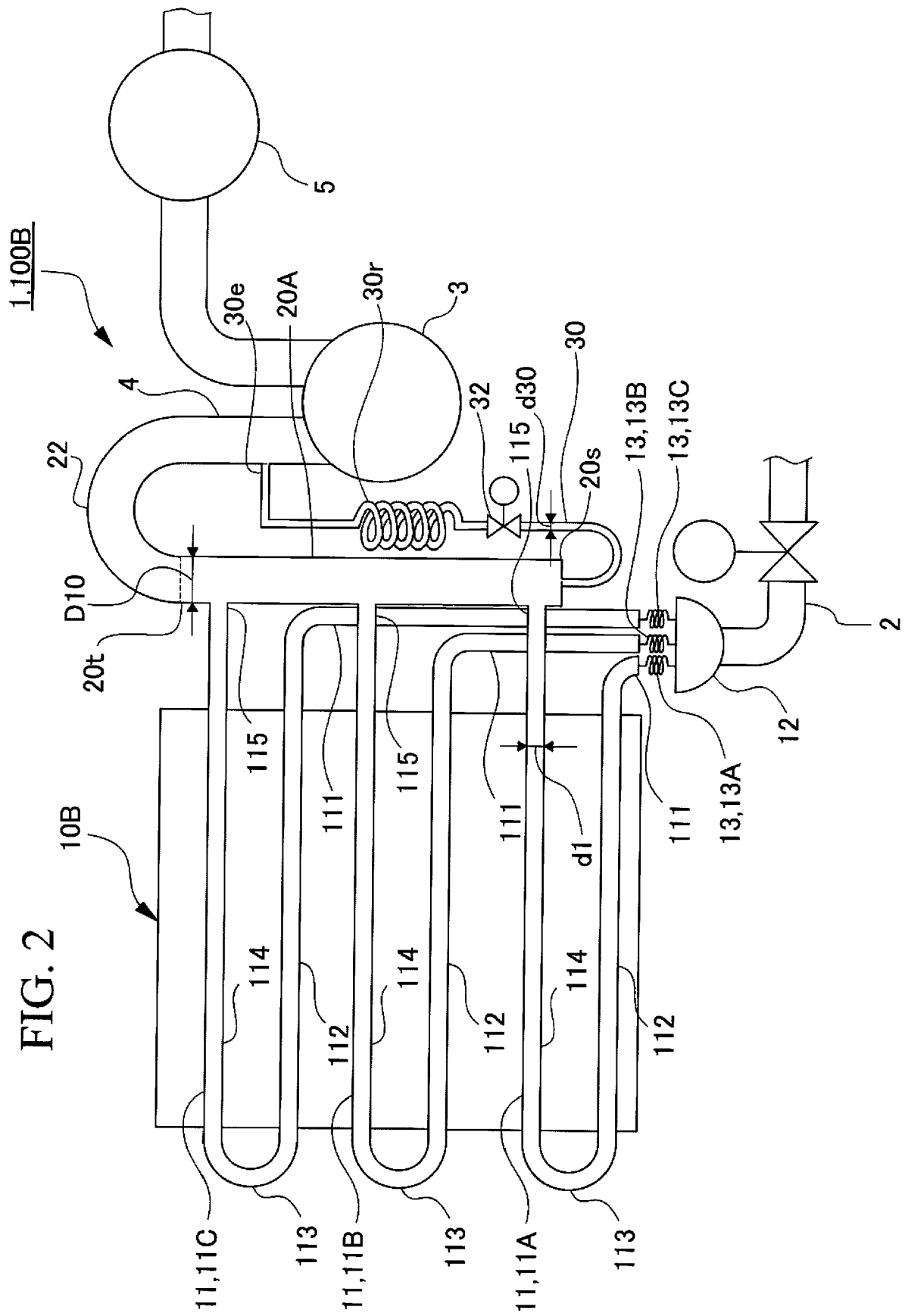


FIG. 3

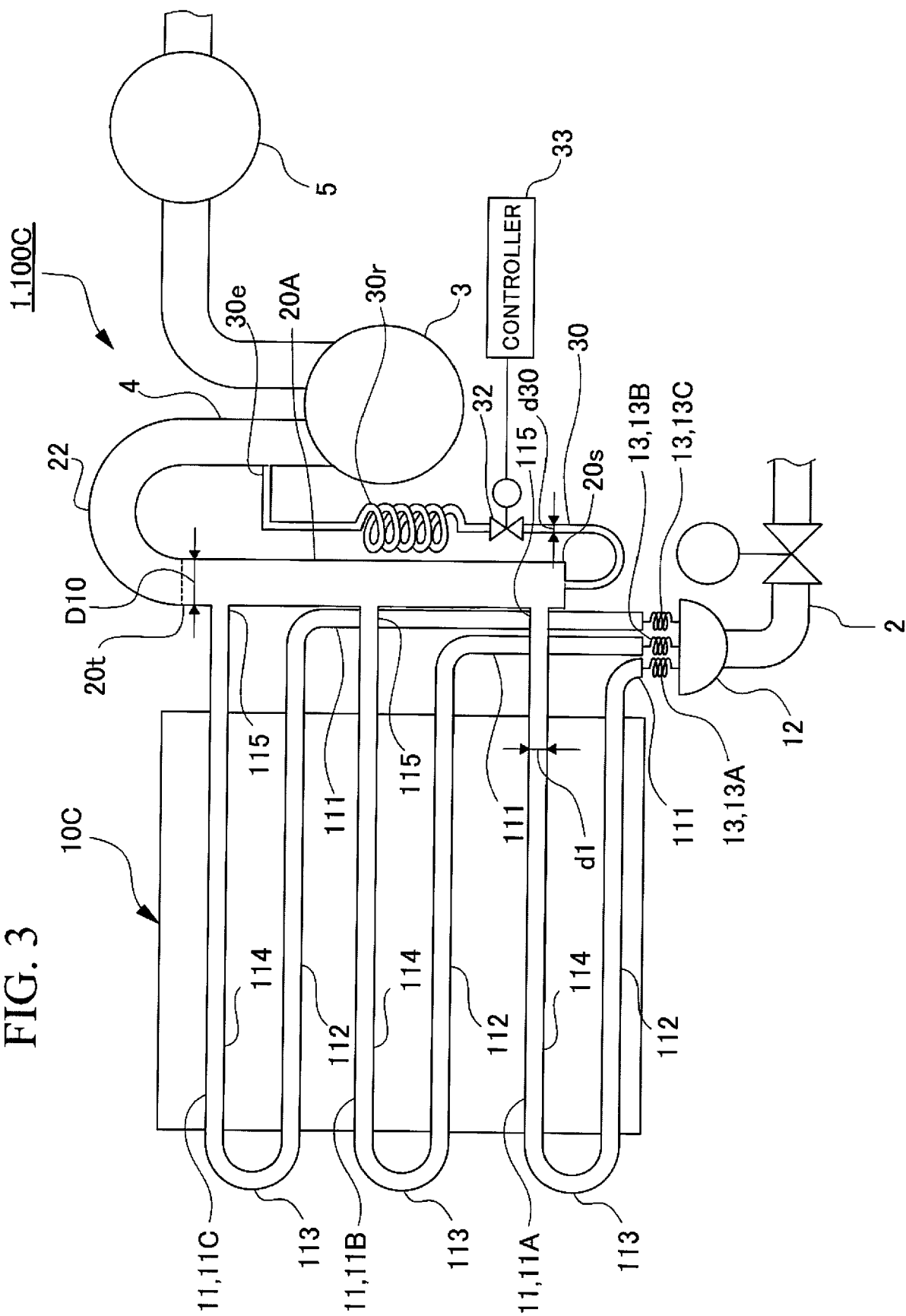


FIG. 4

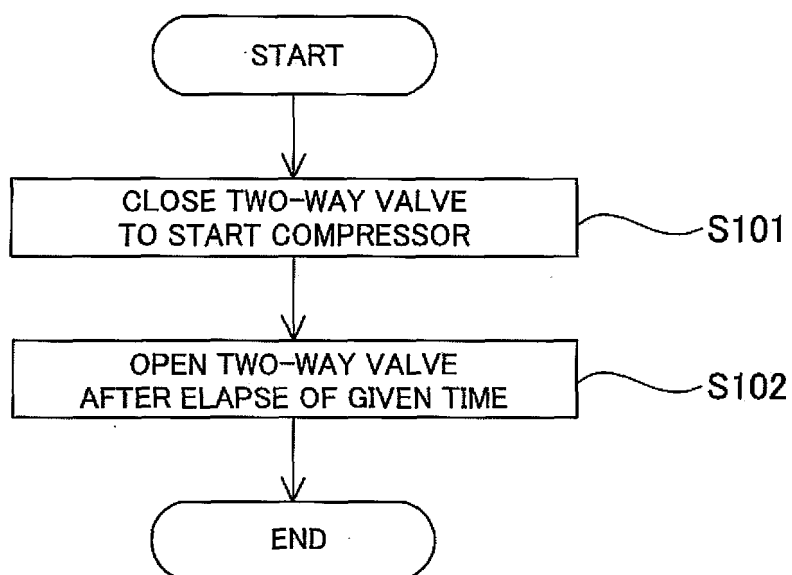


FIG. 5

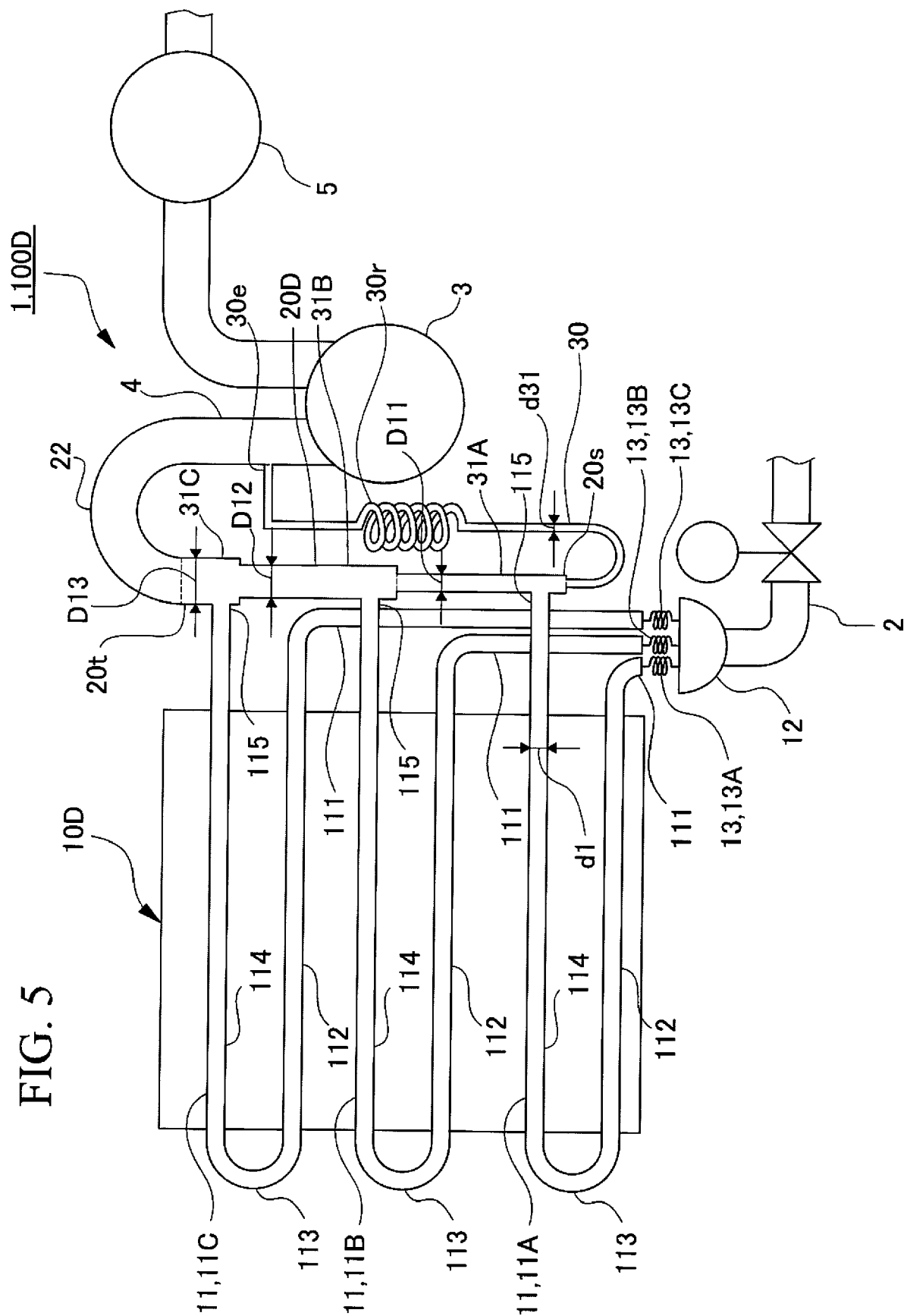
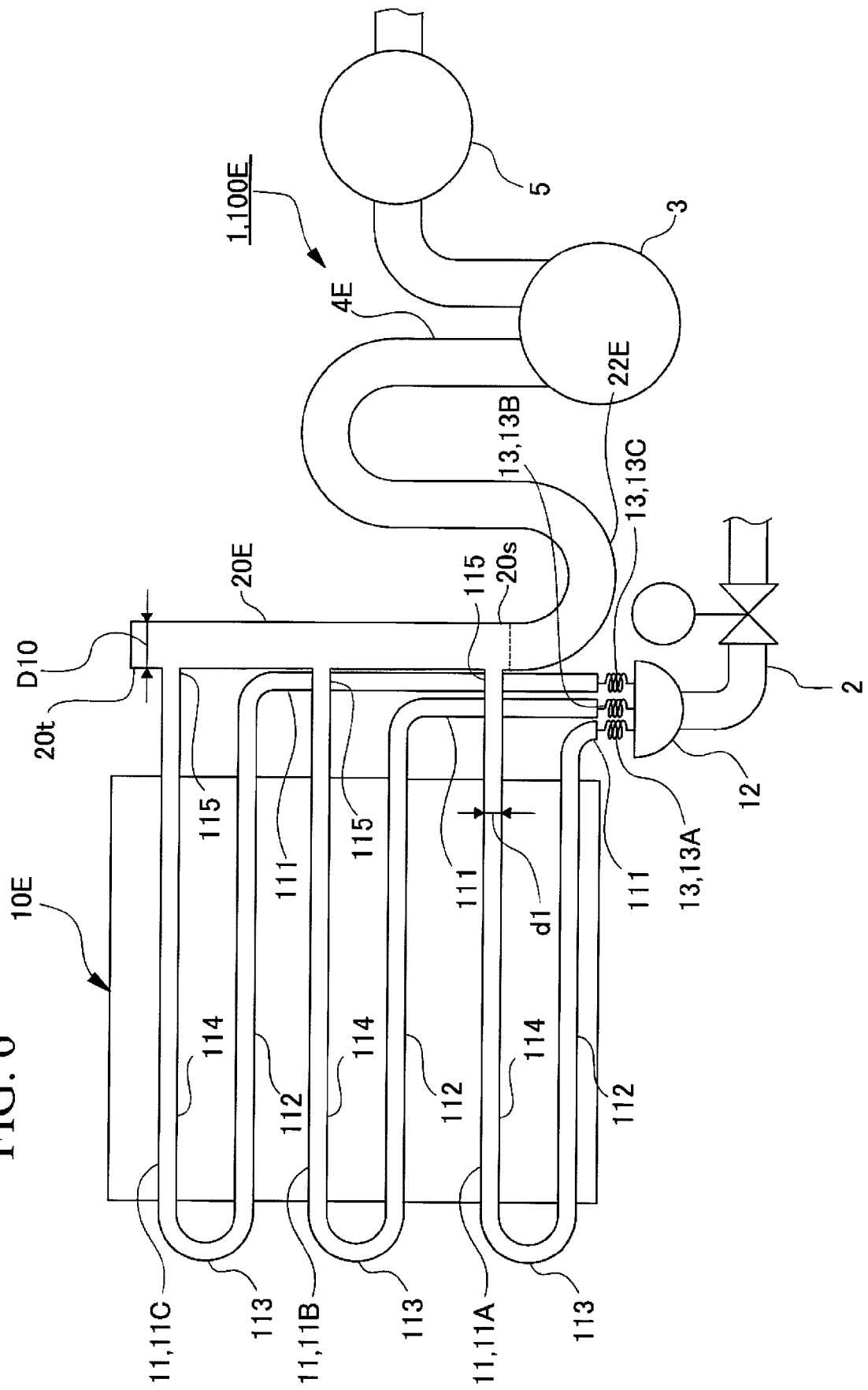


FIG. 6





EUROPEAN SEARCH REPORT

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