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(54) **WATER HEAT EXCHANGER, MANUFACTURING METHOD OF WATER HEAT EXCHANGER, AND REFRIGERATION CYCLE DEVICE**

(57) To provide a water heat exchanger, a manufacturing method of the water heat exchanger, and a refrigeration cycle apparatus capable of preventing corrosion of a brazing material and deterioration of a refrigerant. The water heat exchanger according to the present embodiment includes a plurality of stacked heat-exchange plates, a joint (9) provided on at least one cover plate (14) of a pair of cover plates sandwiching the plurality of heat exchange plates, a first refrigerant pipe (10) brazed to the joint (9) by a brazing material (11), and a protector (12) provided to prevent contact between the brazing material (11) and the refrigerant circulating to the plurality of heat exchange plates through the first refrigerant pipe (10) and the joint (9).

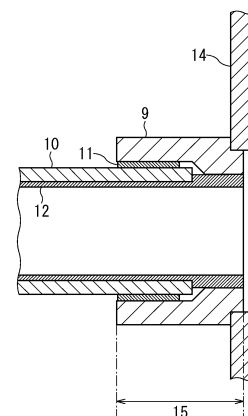


FIG. 2

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Description

TECHNICAL FIELD

[0001] Embodiments of the present invention relate to a water heat exchanger, a manufacturing method of a water heat exchanger, and a refrigeration cycle apparatus.

BACKGROUND

[0002] A temperature control device such as a chiller includes: a utilization side unit that cools or heats space or a subject to be temperature-controlled; and a refrigeration cycle unit. The refrigeration cycle unit also hereinafter referred to as a "refrigeration cycle apparatus". The refrigeration cycle apparatus includes: a compressor; a first heat exchanger; an expander; a second heat exchanger; and a four-way valve. When the refrigeration cycle apparatus is operated for heating, the liquid circulating in the chiller is heated. When the refrigeration cycle apparatus is operated for cooling, the liquid circulating in the chiller is cooled.

[0003] A plate-type water heat exchanger is known as a heat exchanger to be used for the refrigeration cycle apparatus. The plate-type water heat exchanger includes a plurality of stacked thin heat-exchange plates. The plurality of heat-exchange plates include: heat-exchange plates that have a flow path for a liquid circulating in the chiller; and other heat-exchange plates that have a flow path for a refrigerant circulating in the refrigeration cycle apparatus. This water heat exchanger exchanges heat between the liquid circulating in the chiller and the refrigerant flowing through the refrigeration cycle apparatus.

[0004] The plate-type water heat exchanger has a pair of cover plates that sandwich and fix the plurality of stacked heat-exchange plates. The cover plates are provided with joints that extend in the direction away from the heat-exchange plates (i.e., extend in the outward direction or opposite direction). Pipes through which the refrigerant flows are connected to the water heat exchanger via the joints.

[0005] The material of the cover plates and heat-exchange plates is a metal such as stainless steel and aluminum. The material of the joints is the same as the material of the cover plates. The material of the pipes where the refrigerant flowing through the refrigeration cycle apparatus is copper. As described above, an inlet and an outlet of the refrigerant of the water heat exchanger are composed of dissimilar metals such as stainless steel and copper. Such dissimilar metals are joined by brazing, for example.

[0006] It has been considered in recent years to adopt a refrigerant containing iodine carbons such as trifluoroiodomethane (CF₃I, hereinafter, referred to as "CF₃I"), which has less impact on the ozone layer and the global warming, for the refrigeration cycle apparatus.

[0007] However, iodine carbons have the property that

the bond between iodine atoms and carbon atoms is readily broken. Zinc contained in the brazing material reacts with halogen in the presence of water as a catalyst, for example. Contact between a zinc-containing brazing material and a refrigerant containing iodine carbons in the presence of water causes corrosion of the zinc-containing brazing material. The corrosion of the brazing material causes leakage of the refrigerant. In addition, the reaction between zinc and halogen atoms may decompose the refrigerant.

[0008] It is also known that CF₃I decomposed in the presence of zinc as a catalyst generates iodine. When the zinc-containing brazing material is brought into contact with the refrigerant containing CF₃I, the zinc contained in the brazing material reacts with the iodine atom of CF₃I and the refrigerant may be decomposed.

PRIOR ART Document

PATENT DOCUMENT

[0009]

[Patent Document 1] Japanese Translation of PCT International Application Publication No. JP-T-2012-506023

[Patent Document 2] JP 2010-159310 A

SUMMARY

PROBLEMS TO BE SOLVED BY INVENTION

[0010] An object of the present invention is to provide a water heat exchanger, a manufacturing method of a water heat exchanger, and a refrigeration cycle apparatus, each of which can prevent corrosion of a brazing material and deterioration of a refrigerant.

MEANS FOR SOLVING PROBLEM

[0011] To achieve the above object, an aspect of the present invention provides a water heat exchanger including: a plurality of heat-exchange plates that are stacked; a pair of cover plates that sandwich the plurality of heat-exchange plates; a joint that is provided on at least one of the pair of cover plates; a refrigerant pipe that is brazed to the joint by a brazing material; and a protector that contact between the brazing material and a refrigerant flowing through the plurality of heat-exchange plates via the refrigerant pipe and the joint.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

Fig. 1 is a schematic diagram of a refrigeration cycle apparatus according to one embodiment of the present invention.

Fig. 2 is a schematic cross-sectional view of a connection portion of the water heat exchanger according to the embodiment of the present invention.

Fig. 3 is a diagram illustrating one aspect of a manufacturing method of a water heat exchanger according to the embodiment of the present invention.

DETAILED DESCRIPTION

[0013] Embodiments of a water heat exchanger, a manufacturing method of a water heat exchanger, and a refrigeration cycle apparatus according to the present invention will be described by referring to Fig. 1 to Fig. 3. The same reference signs are given to identical or equivalent components in each figure.

[0014] Fig. 1 is a schematic diagram of a refrigeration cycle apparatus 100 according to one embodiment of the present invention. A chiller 200 according to the present embodiment includes the refrigeration cycle apparatus 100 and a utilization unit 300. The chiller 200 according to the present embodiment cools or heats a space or subject that is the temperature-control object of the chiller 200 by exchanging heat between the first refrigerant flowing through the refrigeration cycle apparatus 100 and the second refrigerant flowing through the utilization unit 300.

[0015] As shown in Fig. 1, the refrigeration cycle apparatus 100 includes: a compressor 1; a first heat exchanger 2; a fan 3; an expander 4; a second heat exchanger 5; an accumulator 6; a four-way valve 7; and a first refrigerant pipe 10. The first heat exchanger 2, the expander 4, the second heat exchanger 5, the accumulator 6, the compressor 1, and the four-way valve 7 are sequentially connected by the first refrigerant pipe 10.

[0016] The first refrigerant pipe 10 is made of metal such as copper. The first refrigerant pipe 10 circulates the first refrigerant. The first refrigerant is, for example, a mixed refrigerant containing iodine carbons. The mixed refrigerant containing iodine carbons is, for example, a mixed refrigerant containing CF3I. The refrigerant to be used for the refrigeration cycle apparatus 100 is a mixed refrigerant of difluoromethane (HFC-32, R32, hereinafter referred to as "R32"), pentafluoroethane (HFC125, R125, hereinafter referred to as "R125"), and CF3I. The refrigerant to be used for the refrigeration cycle apparatus 100 is, for example, a mixed refrigerant containing 49.0 weight percent of R32, 11.5 weight percent of R125, and 39.5 weight percent of CF3I. A refrigerant with this composition ratio (components) is provisionally registered as Refrigerant No. R466A in Standard 34 of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

[0017] The compressor 1 compresses the first refrigerant. The compressor 1 may have a configuration in which its operating frequency can be changed by, for example, a known inverter control. Additionally, the compressor 1 may have a configuration in which its operating frequency is fixed (i.e., cannot be changed).

[0018] The first heat exchanger 2 is, for example, a fin-

and-tube heat exchanger. The fan 3 is arranged near the first heat exchanger 2. The first heat exchanger 2 is an air heat exchanger that exchanges heat between the air sent from the fan 3 and the first refrigerant passing through the first heat exchanger 2.

[0019] The expander 4 is, for example, a Pulse Motor Valve (PMV). The expander 4 can adjust the valve opening. The expander 4 includes: a valve body having a through hole; a needle that can advance and retreat with respect to the through hole; and a power source for advancing and retreating the needle, for example. When the through hole is closed by the needle, the expander 4 stops (blocks) the first refrigerant flowing through the refrigeration cycle apparatus 100. At this time, the expander 4 is in the closed state and the opening of the expander 4 is the smallest. When the needle is farthest from the through hole, the flow rate of the first refrigerant in the refrigeration cycle apparatus 100 is maximized and the opening of the expander 4 is the largest in this state.

[0020] The second heat exchanger 5 exchanges heat between the first refrigerant flowing through the first refrigerant pipe 10 and the second refrigerant flowing through the second refrigerant pipe 20, which are the objects of heating or cooling. The second refrigerant is, for example, water. The second refrigerant is sent from the circulation unit (not shown) of the chiller 200 to the second heat exchanger 5 via the second refrigerant pipe 20 by the pump 8. That is, the second heat exchanger 5 is a water heat exchanger that exchanges heat between the first refrigerant flowing through the first refrigerant pipe 10 and the water as the second refrigerant flowing through the second refrigerant pipe 20. Hereinafter, the second heat exchanger 5 is simply referred to as the water heat exchanger 5.

[0021] The water heat exchanger 5 is, for example, a plate-type water heat exchanger. The water heat exchanger 5 includes: a plurality of stacked heat-exchange plates; and a pair of cover plates that sandwich the plurality of stacked heat-exchange plates in the lamination direction. At least one of the cover plates 14 includes a plurality of joints 9 as inlet ports or outlet ports of the refrigerant. Each of the heat-exchange plates includes: a flow path for the first refrigerant flowing through the refrigeration cycle apparatus 100; and a flow path for the second refrigerant flowing through the circulation unit of the chiller 200. The connection portion between the water heat exchanger 5 and the refrigerant pipe (first refrigerant pipe 10) will be described below in detail by referring to Fig. 2.

[0022] The accumulator 6 is arranged between the water heat exchanger 5 and the compressor 1. The accumulator 6 has a casing made of metal such as steel. A liquid phase refrigerant is stored in the lower portion of the casing. A gas phase refrigerant is stored in the upper portion of the casing. The accumulator 6 supplies the gas phase refrigerant to the compressor 1.

[0023] The four-way valve 7 switches between the heating operation and the cooling operation of the refrig-

eration cycle apparatus 100 by switching the flow direction of the first refrigerant.

[0024] When the refrigeration cycle apparatus 100 is operated for heating, the water heat exchanger 5 heats the water flowing through the second refrigerant pipe 20. In the case of the heating operation, the first refrigerant flows in the order of the compressor 1, the water heat exchanger 5, the expander 4, the first heat exchanger 2, and the accumulator 6. The first refrigerant, which has become a high-temperature and high-pressure gas in the compressor 1, is condensed into a liquid by exchanging heat with the water in the water heat exchanger 5. In this case, the water heat exchanger 5 functions as a condenser for condensing the first refrigerant. The first refrigerant condensed by the water heat exchanger 5 partially evaporates when it is depressurized by the expander 4, and changes to a low-temperature low-pressure liquid by the heat of vaporization. Afterward, the first refrigerant having become a low-temperature low-pressure liquid exchanges heat with the air blown from the fan 3 so as to evaporate in the first heat exchanger 2, and changes to a low-temperature low-pressure gas. In this case, the first heat exchanger 2 functions as an evaporator that evaporates the first refrigerant.

[0025] When the refrigeration cycle apparatus 100 is operated for cooling, the water flowing through the second refrigerant pipe 20 is cooled. In the case of the cooling operation, the four-way valve 7 is inverted so as to generate the flow of the refrigerant in the direction opposite to the direction in the case of the heating operation. Thus, the first refrigerant flows in the order of the compressor 1, the first heat exchanger 2, the expander 4, the water heat exchanger 5, and the accumulator 6. In this case, the first refrigerant flowing through the water heat exchanger 5 exchanges heat with the water flowing through the second refrigerant pipe 20 and functions as an evaporator that evaporates the first refrigerant. In addition, the first heat exchanger 2 functions as a condenser that condenses the first refrigerant.

[0026] The foregoing is the description of the refrigeration cycle apparatus 100. Next, a joint part 15 of the water heat exchanger 5 will be described in detail by referring to Fig. 2. The joint part 15 is the inlet port or the outlet port of each refrigerant in the water heat exchanger 5.

[0027] Fig. 2 is a schematic cross-sectional view of the joint part 15 of the water heat exchanger 5 according to the embodiment of the present invention. The water heat exchanger 5 exchanges heat between the first refrigerant and the water that is the second refrigerant. Thus, the water heat exchanger 5 has the inlet ports and the outlet ports corresponding to the respective refrigerants. Each of the inlet ports and the outlet ports are referred to as the joint part 15. Fig. 2 is a cross-sectional view of the joint part 15 between the water heat exchanger 5 and the first refrigerant pipe 10 through which the first refrigerant flows. Illustration of the connector between water heat exchanger 5 and the second refrigerant pipe 20,

through which the second refrigerant flows, is omitted.

[0028] The joint part 15 connects the joint 9 and the first refrigerant pipe 10. For example, when the first refrigerant pipe 10 is internally fitted into the joint 9 as shown in Fig. 2, the joint part 15 includes the portion where the joint 9 and the first refrigerant pipe 10 overlap to the connection portion between the joint 9 and the cover plate 14. In this case, the range of the joint part 15 matches the range of the joint 9. The range of the joint part 15 may include the portion of the first refrigerant pipe 10 that does not overlap with the joint 9. Further, the range of the joint part 15 may be from the end of the first refrigerant pipe 10 on the side of the cover plate 14 to the connection portion between the joint 9 and the cover plate 14.

[0029] The joints 9 are provided on the cover plate 14. The cover plates 14 and the joints 9 are made of stainless steel similarly to the heat-exchange plates. The first refrigerant pipe 10 is made of copper. The joint 9 and the first refrigerant pipe 10 are joined by using a brazing material 11 that connects dissimilar metals. For example, when the first refrigerant pipe 10 is fitted into the joint 9 as shown in Fig 2, the brazing material 11 is sandwiched between the joint 9 and the first refrigerant pipe 10 at the portion where the joint 9 and the first refrigerant pipe 10 are superposed so as to join both.

[0030] A zinc-containing brazing material such as a silver brazing is used for brazing the joint 9 to the first refrigerant pipe 10. Zinc contained in the brazing material reacts with halogen using water as a catalyst, for example. Thus, contact between the zinc-containing brazing material and the refrigerant containing iodine carbons in the presence of water causes corrosion of the zinc-containing brazing material. The corrosion of the brazing material causes leakage of the refrigerant. When zinc reacts with halogen atoms such as iodine constituting the refrigerant in the presence of water as a catalyst, the refrigerant may be decomposed.

[0031] When the zinc-containing brazing material is brought into contact with the refrigerant containing CF₃I, zinc contained in the brazing material may react with the iodine atoms of CF₃I that causes decomposition of the refrigerant.

[0032] For this reason, the water heat exchanger 5 according to the present embodiment includes a protector 12 in the joint part 15. The protector 12 is provided so as to prevent contact between the brazing material 11 and the refrigerant flowing through the plurality of heat-exchange plates stacked via the joint part 15, that is, the joint 9 and the first refrigerant pipe 10. The protector 12 is provided on the flow path of the first refrigerant so as not to obstruct the flow of the first refrigerant.

[0033] The protector 12 is provided so as to cover the portion where the joint 9 and the first refrigerant pipe 10 are overlapped and connected by the brazing material 11, for example. That is, the protector 12 is continuously provided inside the joint 9, inside the overlapping portion between the joint 9 and the first refrigerant pipe 10, and inside the first refrigerant pipe 10. Further, the protector

12 may be provided in the gap formed between the joint 9 and the tip portion of the first refrigerant pipe 10 on the side of the cover plate 14.

[0034] It is preferred that the protector 12 is not provided on the heat-exchange plate side away from the cover plate 14.

[0035] The protector 12 is composed of a polymer compound obtained by polymerizing a vinyl compound containing a vinyl resin, for example. The vinyl resin includes a synthetic resin having a vinyl alcohol group represented by the rational formula $\text{CH}_2\text{CH}(\text{OH})$. The vinyl resin includes a synthetic resin such as polyethylene, polyvinyl chloride, and polystyrene, for example. The vinyl resin may be a polymer obtained by polymerizing one type of monomer such as polyvinyl alcohol (PVOH) and polyvinyl chloride (PVC). Additionally, the vinyl resin may be a polymer obtained by polymerizing a monomer in which two or more types of compounds such as Ethylene Vinylalcohol copolymer (EVOH) are bonded.

[0036] The material forming the protector 12 should not be limited to vinyl resin. For example, the protector 12 may be made of a material such as synthetic rubber, synthetic fiber, and metal. The protector 12 may be made of any material as long as it does not react with the refrigerant and the brazing material, has an excellent gas barrier property, does not deteriorate due to temperature change of the refrigeration cycle apparatus, and is not eluted into the refrigerant.

[0037] Next, a method of installing the protector 12 in the water heat exchanger 5 will be described.

[0038] Fig. 3 is a diagram illustrating one aspect of a manufacturing method of the water heat exchanger 5 having the protector 12 according to the embodiment of the present invention. Fig. 3 shows a method of forming the protector 12 in the water heat exchanger 5 by dipping.

[0039] The protector 12 is formed by a method of immersing the object (i.e., object to be provided with the protector 12) in a solution containing the material forming the protector 12, i.e., so-called dipping method. For example, in the case of using water-soluble PVOH as the material for the protector 12, the protector 12 is formed on the joint part 15 by dipping a part of the water heat exchanger 5 (i.e., the portion having the joint part 15) in the PVOH aqueous solution L.

[0040] Even when the first refrigerant pipe 10 connected to the water heat exchanger 5 is too long that interfere the inflow of the PVOH aqueous solution L, the protector 12 can be reliably formed by applying pressure to the PVOH aqueous solution L to push the PVOH aqueous solution L into the first refrigerant pipe 10 and filling the joint part 15 with the PVOH aqueous solution L. Portions that do not require the protector 12 are appropriately masked. In this manner, the PVOH aqueous solution L can be attached to the desired portion to form the protector 12.

[0041] Although Fig. 3 shows a case of forming the protector 12 by dipping, the method of forming the protector 12 should not be limited to dipping. For example,

the protector 12 may be formed by applying or spraying a solution containing a material of forming the protector 12 onto a desired portion where the protector 12 is meant to be provided.

[0042] Further, the method of forming the protector 12 should not be limited to the method of using a liquid material. For example, the protector 12 may be formed by sticking a sheet-shaped protector 12 at a desired position and adhering it to the pipe wall surface of the joint part 15. Further, the protector 12 may be fixed in a state of being stretched against the wall surface of the joint part 15 by inserting the protector 12 made of shape memory alloy or elastic body into the pipe in a folded state and then unfolding the protector 12 at the desired position.

[0043] As described above, the water heat exchanger 5 and the refrigeration cycle apparatus 100 according to the present embodiment includes the protector 12 at each inlet port and outlet port of the refrigerant of the water heat exchanger 5 for preventing contact between the refrigerant and the brazing material 11. In the manufacturing method of the water heat exchanger 5 according to the present embodiment, the protector 12 is formed at each inlet port and outlet port of the refrigerant of the water heat exchanger 5 for preventing contact between the refrigerant and the brazing material 11. Consequently, the water heat exchanger 5, the manufacturing method of the water heat exchanger 5, and the refrigeration cycle apparatus 100 can prevent corrosion of the brazing material 11 attributable to contact between the refrigerant and the brazing material 11. Hence, the water heat exchanger 5, the manufacturing method of the water heat exchanger 5, and the refrigeration cycle apparatus 100 can prevent leakage of the refrigerant. Further, the water heat exchanger 5, the manufacturing method of the water heat exchanger 5, and the refrigeration cycle apparatus 100 can prevent the zinc contained in the brazing material 11 from reacting with the halogen atoms of the refrigerant so as to prevent decomposition of the refrigerant.

[0044] 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.

REFERENCE SIGNS LIST

[0045]

100	refrigeration cycle apparatus
1	compressor
2	first heat exchanger
3	fan

4	expander	
5	second heat exchanger (water heat exchanger)	
6	accumulator	
7	four-way valve	
8	pump	5
9	joint	
10	first refrigerant pipe	
11	brazing material	
12	protector	
14	cover plate	10
15	connector	
20	second refrigerant pipe	
L	PVOH aqueous solution	

15

Claims

1. A water heat exchanger comprising:

a plurality of heat-exchange plates that are stacked; 20
 a pair of cover plates that sandwich the plurality of heat-exchange plates;
 a joint that is provided on at least one of the pair of cover plates; 25
 a refrigerant pipe that is brazed to the joint by a brazing material; and
 a protector provided in a manner that prevents contact between the brazing material and a refrigerant flowing through the plurality of heat-exchange plates via the refrigerant pipe and the joint. 30

2. The water heat exchanger according to claim 1, wherein the protector is made of vinyl resin. 35

3. A manufacturing method of the water heat exchanger according to claim 1, comprising a step of forming the protector by dipping a joint part in a solution containing the vinyl resin. 40

4. A refrigeration cycle apparatus comprising:

a compressor;
 an expander and; 45
 the water heat exchanger according to claim 1 or claim 2 connected to the compressor and the expander and configured to function as at least one of an evaporator and a condenser. 50

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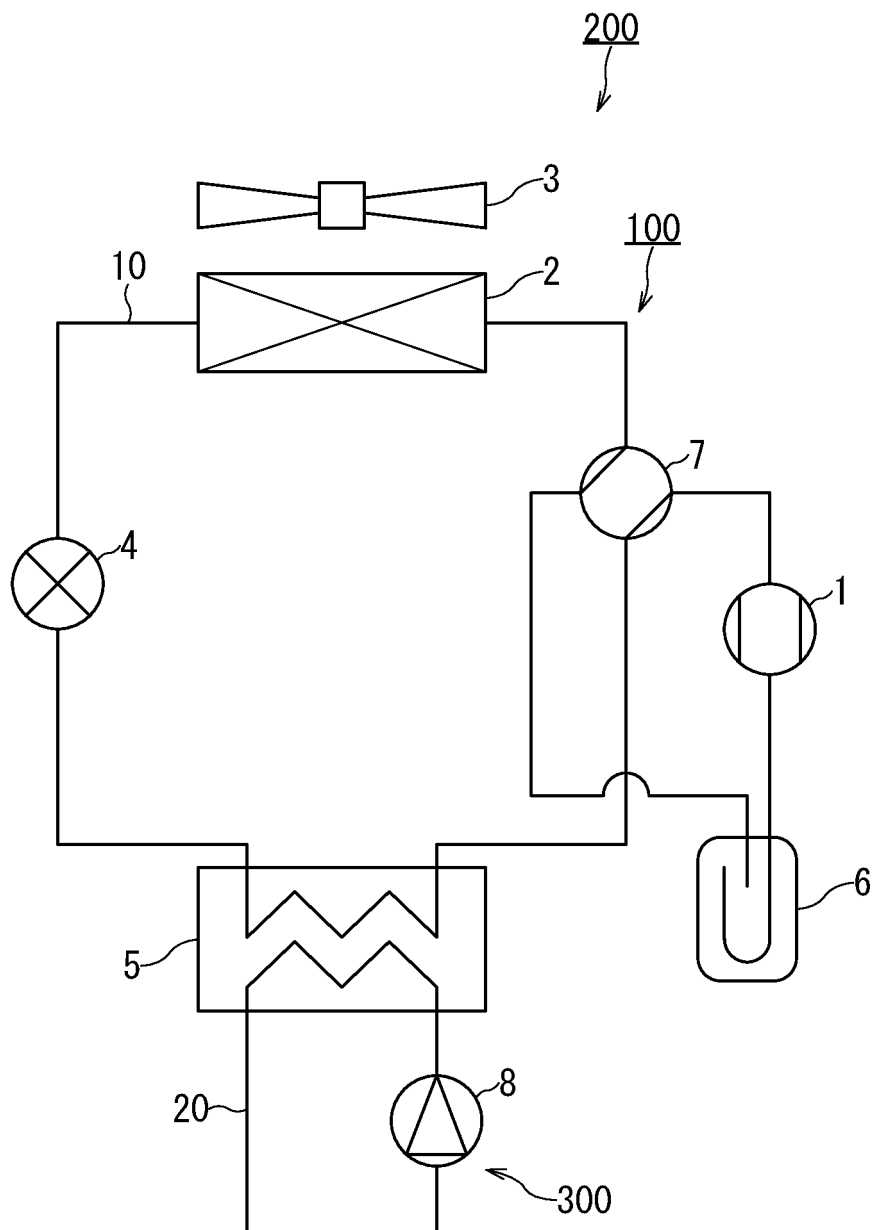


FIG. 1

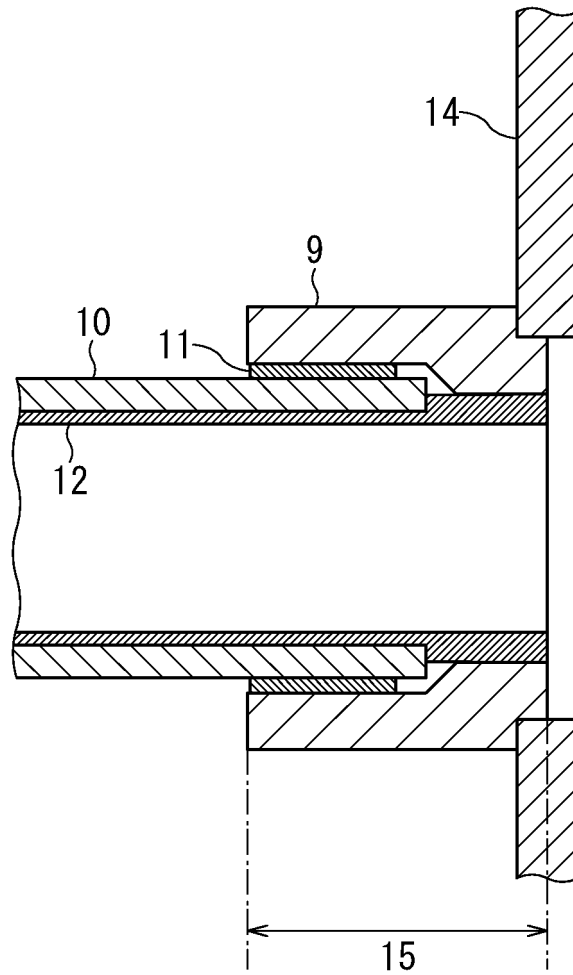


FIG. 2

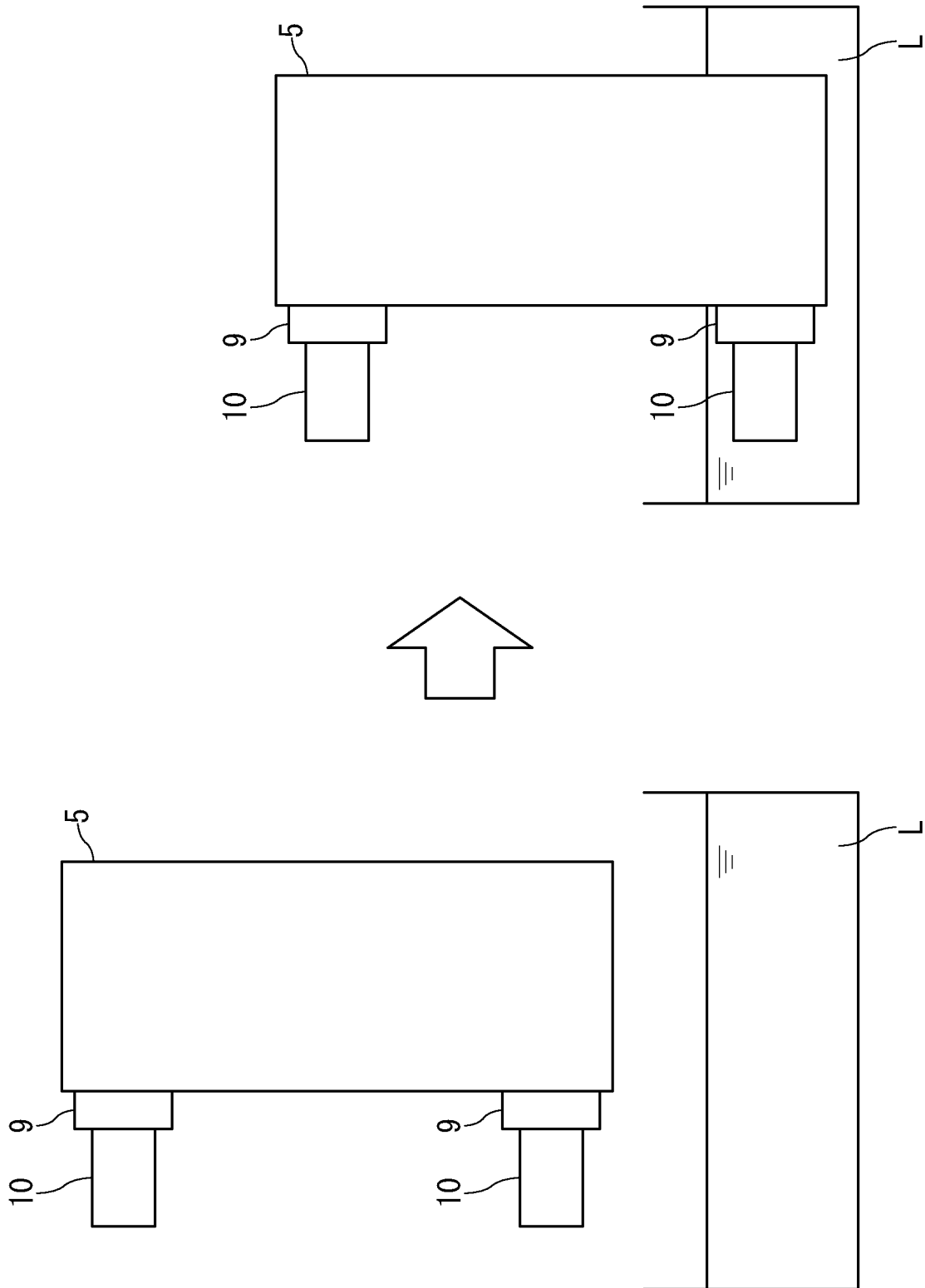


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/028490

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F28F13/18(2006.01)i, F25B39/00(2006.01)i, F28F21/06(2006.01)i, F28F19/00(2006.01)i

FI: F28F13/18Z, F25B39/00G, F25B39/00P, F28F21/06, F28F19/00511Z

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. F28F13/18, F25B39/00, F28F21/06, F28F19/00

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 1971-2020

Registered utility model specifications of Japan 1996-2020

Published registered utility model applications of Japan 1994-2020

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.
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Y	JP 2016-125083 A (DAIKIN INDUSTRIES, LTD.) 11.07.2016 (2016-07-11), paragraph [0030]	1-4
Y	JP 2017-32198 A (MITSUBISHI ELECTRIC CORPORATION) 09.02.2017 (2017-02-09), paragraphs [0011]-[0022], fig. 1, 4	1-4



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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Tokyo 100-8915, Japan

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Telephone No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2020/028490

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paragraphs [0021]-[0037], fig. 2-4
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REFERENCES CITED IN THE DESCRIPTION

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