



(11)

**EP 4 083 556 A1**

(12)

**EUROPEAN PATENT APPLICATION**  
published in accordance with Art. 153(4) EPC

(43) Date of publication:  
**02.11.2022 Bulletin 2022/44**

(21) Application number: **19957198.5**

(22) Date of filing: **26.12.2019**

(51) International Patent Classification (IPC):  
**F28D 1/053** <sup>(2006.01)</sup> **F28F 17/00** <sup>(2006.01)</sup>  
**F28G 1/02** <sup>(2006.01)</sup> **F28G 1/16** <sup>(2006.01)</sup>  
**F28G 3/04** <sup>(2006.01)</sup> **F25B 47/02** <sup>(2006.01)</sup>

(52) Cooperative Patent Classification (CPC):  
**F25B 47/02; F28D 1/053; F28F 17/00; F28G 1/02;**  
**F28G 1/16; F28G 3/04**

(86) International application number:  
**PCT/JP2019/051089**

(87) International publication number:  
**WO 2021/130952 (01.07.2021 Gazette 2021/26)**

(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:  
**KH MA MD TN**

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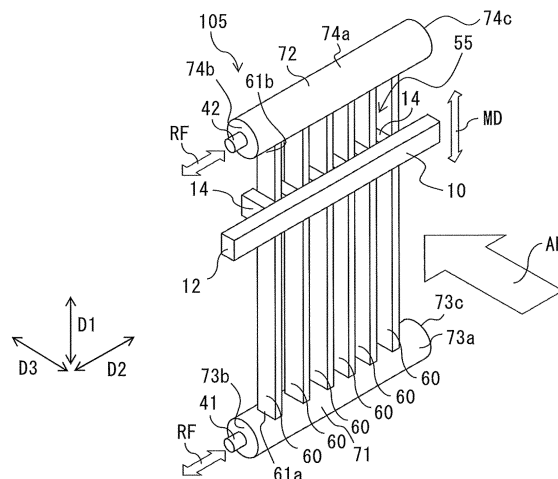
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(54) **HEAT EXCHANGER, OUTDOOR UNIT, AND REFRIGERATION CYCLE DEVICE**

(57) A heat exchanger includes a heat exchange module and a removing device. The heat exchange module includes a plurality of heat transfer tubes each of which allows a first heat exchange fluid to flow there-

through, and which are spaced from each other. The removing device is movable between adjacent ones of the plurality of heat transfer tubes in a first direction that is a flow direction of the first heat exchange fluid.

FIG. 2



## Description

### Technical Field

**[0001]** The present disclosure relates to a heat exchanger, an outdoor unit including the heat exchanger, and a refrigeration cycle apparatus including the heat exchanger or the outdoor unit, and particularly relates to a configuration to remove an adhering substance such as frost that adheres to the heat exchanger.

### Background Art

**[0002]** In general, to a heat exchanger used in an outdoor unit of a refrigerant cycle apparatus, an adhering substance such as frost or dust may adhere. Whether such an adhering substance adheres to the heat exchanger or not depends on the environment of a place where the outdoor unit is installed. In view of the above, as a method of removing frost that adheres to the heat exchanger during an operation of a refrigeration cycle apparatus, for example, during a heating operation of an air-conditioning apparatus, a method of brushing off frost adhering to fins has been proposed (see Patent Literature 1). The heat exchanger disclosed in Patent Literature 1 includes fins each of which includes: linear protruding portions formed close to and parallel to an edge of the fin that is located on the upstream side of the flow of air; and a brush that is in contact with the protruding portions and movable in an up-down direction. The heat exchanger of Patent Literature 1 is considered to enable frost formed on leading edges of the fins to be brushed off using the brush.

### Citation List

#### Patent Literature

**[0003]** Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2018-84354

### Summary of Invention

#### Technical Problem

**[0004]** However, the heat exchanger of Patent Literature 1 is a fin-and-tube heat exchanger including circular tubes, and enables frost adhering to the leading edges of the fins on the upstream side of the flow of air to be brushed off. Thus, the heat exchanger of Patent Literature 1 does not enable frost formed on heat transfer tubes provided in the heat exchanger to be brushed off. In addition, the heat exchanger of Patent Literature 1 does not enable an adhering substance such as dust that adheres to the heat transfer tubes provided in the heat exchanger to be removed. When the adhering substance adheres to the heat exchanger, the heat exchange performance of the heat exchanger may be lowered.

**[0005]** Furthermore, in the heat exchanger in Patent Literature 1, the frost brushed off from the leading edge using the brush may enter the heat exchanger, such as spaces between the heat transfer tubes which are located leeward of the leading edges. Therefore, even though the heat exchanger of Patent Literature 1 includes the brush to remove the frost from the leading edges, the heat exchanger cannot remove the frost that enters the heat exchanger. Consequently, the spaces between the fins may be clogged with the frost.

**[0006]** In the above case, it is necessary for the heat exchanger that a defrosting operation is performed by changing a circulation direction of refrigerant to apply latent heat of condensation of the refrigerant, to thereby defrost the heat exchanger, as in a common air-conditioning apparatus. However, since the air-conditioning apparatus is unable to perform a heating operation during the defrosting operation, the heat exchanger may cause a user discomfort regarding his/her feeling temperature or other factors.

**[0007]** The present disclosure is applied to solve the above problem, and relates to a heat exchanger that can remove an adhering substance such as frost that enters a heat exchanger, an outdoor unit, and a refrigeration cycle apparatus.

#### Solution to Problem

**[0008]** A heat exchanger according to one embodiment of the present disclosure includes: a heat exchange module including a plurality of heat transfer tubes each configured to allow a first heat exchange fluid to flow therethrough, the plurality of heat transfer tubes being spaced from each other; and a removing device movable between adjacent ones of the plurality of heat transfer tubes in a first direction that is a flow direction of the first heat exchange fluid.

**[0009]** An outdoor unit according to another embodiment of the present disclosure includes: the heat exchanger according to the above one embodiment of the present disclosure; a fan configured to produce a flow of a second heat exchange fluid such that the second heat exchange fluid flows between the adjacent ones of the plurality of heat transfer tubes; and a housing housing the heat exchanger and the fan,

**[0010]** A refrigeration cycle apparatus according to still another embodiment of the present disclosure includes the heat exchanger according to the above one embodiment of the present disclosure, or includes the outdoor unit according to the above other embodiment of the present disclosure.

#### Advantageous Effects of Invention

**[0011]** According to the embodiment of the present disclosure, the heat exchanger includes the removing device that is movable between the adjacent ones of the plurality of heat transfer tubes in the first direction that is

the flow direction of the first heat exchange fluid. The removing device is located between the heat transfer tubes in the heat exchanger. The removing device located between the heat transfer tubes is moved along the heat transfer tubes, whereby an adhering substance such as frost that adheres to the heat exchange module is removed. In the heat exchanger, the removing device can thus remove an adhering substance such as frost that enters the heat exchanger.

#### Brief Description of Drawings

#### [0012]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram illustrating a configuration of a refrigeration cycle apparatus including a heat exchanger according to Embodiment 1.

[Fig. 2] Fig. 2 is a perspective view illustrating a configuration of related part of an outdoor heat exchanger according to Embodiment 1.

[Fig. 3] Fig. 3 is a conceptual diagram of the outdoor heat exchanger according to Embodiment 1 as viewed side-on.

[Fig. 4] Fig. 4 is a cross-sectional view of a heat transfer tube that is taken along line A-A in Fig. 3, and illustrates an example of the configuration of the heat transfer tube.

[Fig. 5] Fig. 5 is a top view of the outdoor heat exchanger according to Embodiment 1 as viewed in a fourth direction.

[Fig. 6] Fig. 6 illustrates a first modification of removing portions as illustrated in Fig. 5.

[Fig. 7] Fig. 7 illustrates a second modification of the removing portions as illustrated in Fig. 5.

[Fig. 8] Fig. 8 illustrates a third modification of the removing portions as illustrated in Fig. 5.

[Fig. 9] Fig. 9 illustrates a fourth modification of the removing portions as illustrated in Fig. 5.

[Fig. 10] Fig. 10 is a conceptual diagram illustrating a configuration of an outdoor unit according to Embodiment 2.

[Fig. 11] Fig. 11 is a conceptual diagram illustrating a configuration of an outdoor heat exchanger according to Embodiment 3.

[Fig. 12] Fig. 12 is a block diagram illustrating an example of a configuration related to a control by an outdoor heat exchanger according to Embodiment 4.

[Fig. 13] Fig. 13 is a conceptual diagram illustrating a configuration of an outdoor heat exchanger according to Embodiment 5.

[Fig. 14] Fig. 14 is a conceptual diagram illustrating a configuration of a first modification of the outdoor heat exchanger according to Embodiment 5.

[Fig. 15] Fig. 15 is a conceptual diagram illustrating a configuration of a second modification of the outdoor heat exchanger according to Embodiment 5.

[Fig. 16] Fig. 16 is a conceptual diagram illustrating

a configuration of an outdoor heat exchanger according to Embodiment 6.

[Fig. 17] Fig. 17 is a perspective view illustrating a configuration of related part of an outdoor heat exchanger according to Embodiment 7.

[Fig. 18] Fig. 18 is a conceptual diagram of the outdoor heat exchanger according to Embodiment 7 when viewed from the side.

#### 10 Description of Embodiments

[0013] An outdoor heat exchanger 105 according to Embodiment 1, an outdoor unit 106 according to Embodiment 1, and a refrigeration cycle apparatus 100 according to Embodiment 1 will be described with reference to the drawings, etc. It should be noted that in figures including Fig. 1 that will be referred to below, relative relationships in size and shape between components may differ from those of actual components. In addition, in each of the figures, components that are the same as or equivalent to those in a previous figure or previous figures will be the same reference signs, and the same is true of the entire text of the specification. Furthermore, in order that descriptions be easily understood, terms related to directions (for example, "up", "down", "right", "left", "forward", and "backward") are used as appropriate. However, these terms are merely used for convenience of explanation, and do not limit the positions, the orientations, etc., of devices, apparatuses or components. In the specification, basically, the positional relationships between the components, the directions in which the components extend, and the directions in which components are arranged are those in the case where the heat exchanger 105 is set in a usable state.

#### Embodiment 1

#### [Refrigeration Cycle Apparatus 100]

[0014] Fig. 1 is a refrigerant circuit diagram illustrating a configuration of the refrigeration cycle apparatus 100 including the outdoor heat exchanger 105 according to Embodiment 1. It should be noted that in Fig. 1, dotted arrows indicate the flow direction of refrigerant in a refrigerant circuit 110 during a cooling operation, and solid arrows indicate the flow direction of refrigerant in the refrigerant circuit 110 during the heating operation. First of all, the refrigeration cycle apparatus 100 including the outdoor heat exchanger 105 will be described with reference to Fig. 1.

[0015] Regarding the present embodiment, an air-conditioning apparatus is illustrated as an example of the refrigeration cycle apparatus 100. For example, the refrigeration cycle apparatus 100 is used for refrigeration or air-conditioning in a refrigerator, a freezer, a vending machine, an air-conditioning apparatus, a refrigerating apparatus, or a water heater. It should be noted that the refrigerant circuit 110 as illustrated in Fig. 1 is merely an

example, and descriptions concerning the configurations of circuit elements, etc., in the embodiments are not limiting, and the configurations can be changed as appropriate within the scope of techniques according to the embodiments.

**[0016]** The refrigeration cycle apparatus 100 includes the refrigerant circuit 110 in which a compressor 101, a flow switching device 102, an indoor heat exchanger 103, a pressure reducing device 104, and the outdoor heat exchanger 105 are sequentially connected by refrigerant pipes. The refrigeration cycle apparatus 100 includes the outdoor unit 106 and an indoor unit 107. The outdoor unit 106 includes the compressor 101, the flow switching device 102, the outdoor heat exchanger 105, the pressure reducing device 104, and an outdoor fan 108. The outdoor fan 108 supplies outdoor air to the outdoor heat exchanger 105. The indoor unit 107 includes the indoor heat exchanger 103 and an indoor fan 109. The indoor fan 109 supplies air to the indoor heat exchanger 103. The outdoor unit 106 and the indoor unit 107 are connected to each other by two extension pipes 111 and 112, which are included in the refrigerant pipes.

**[0017]** The compressor 101 is a fluid machine to compress sucked refrigerant and discharge the compressed refrigerant. The flow switching device 102 is, for example, a four-way valve, and switches the flow passage for refrigerant between a flow passage for the cooling operation and a flow passage for the heating operation under a control by a controller (not illustrated). The refrigerant is a first heat exchange fluid. The first heat exchange fluid is, for example, an HFC refrigerant, an HC refrigerant, an HFO refrigerant, or mixed refrigerant mixture that is any combination thereof.

**[0018]** The indoor heat exchanger 103 causes heat exchange to be performed between refrigerant that flows in the indoor heat exchanger 103 and indoor air supplied by the indoor fan 109. The indoor heat exchanger 103 operates as a condenser during the heating operation and as an evaporator during the cooling operation.

**[0019]** The pressure reducing device 104 is, for example, an expansion valve, and decompresses refrigerant. As the pressure reducing device 104, an electronic expansion valve can be used. The opening degree of the electronic expansion valve is adjusted under control by the controller.

**[0020]** The outdoor heat exchanger 105 causes heat exchange to be performed between refrigerant that flows in the outdoor heat exchanger 105 and air supplied by the outdoor fan 108. The outdoor heat exchanger 105 operates as an evaporator during the heating operation and as a condenser during the cooling operation. The air supplied by the outdoor fan 108 is an example of a second heat exchange fluid.

[Operation of Refrigeration Cycle Apparatus 100]

**[0021]** Next, an example of the operation of the refrigeration cycle apparatus 100 will be described with refer-

ence to Fig. 1. During the heating operation of the refrigeration cycle apparatus 100, high-pressure and high-temperature gas refrigerant discharged from the compressor 101 flows into the indoor heat exchanger 103 through the flow switching device 102, and exchanges heat with air supplied by the indoor fan 109 to condense. The refrigerant that has condensed changes into high-pressure liquid refrigerant, and the high-pressure liquid refrigerant flows out of the indoor heat exchanger 103. Then, the high-pressure liquid refrigerant is changed into low-pressure two-phase gas-liquid refrigerant by the pressure reducing device 104. The low-pressure two-phase gas-liquid refrigerant flows into the outdoor heat exchanger 105, and exchanges heat with air supplied by the outdoor fan 108 to evaporate. The refrigerant that has evaporated changes into low-pressure gas refrigerant, and is then sucked into the compressor 101. It should be noted that during the heating operation, frost adheres to the outdoor heat exchanger 105 when the pressure saturation temperature in the outdoor heat exchanger 105 is lower than or equal to the dew-point temperature of outdoor air and is lower than or equal to the freezing point of water.

**[0022]** During the cooling operation of the refrigeration cycle apparatus 100, refrigerant flows in the refrigerant circuit 110 in the opposite direction to the direction in which the refrigerant flows during the heating operation. To be more specific, during the cooling operation of the refrigeration cycle apparatus 100, high-pressure and high-temperature gas refrigerant discharged from the compressor 101 flows into the outdoor heat exchanger 105 through the flow switching device 102, and exchanges heat with air supplied by the outdoor fan 108 to condense. The refrigerant that has condensed changes into high-pressure liquid refrigerant, and the high-pressure liquid refrigerant flows out of the outdoor heat exchanger 105. The high-pressure liquid refrigerant is changed into low-pressure two-phase gas-liquid refrigerant by the pressure reducing device 104. The low-pressure two-phase gas-liquid refrigerant flows into the indoor heat exchanger 103, and exchanges heat with air supplied by the indoor fan 109 to evaporate. The refrigerant that has evaporated changes into low-pressure gas refrigerant, and the low-pressure gas refrigerant is sucked into the compressor 101.

[Outdoor Heat Exchanger 105]

**[0023]** Fig. 2 is a perspective view illustrating the configuration of related part of the outdoor heat exchanger 105 according to Embodiment 1. Fig. 3 is a conceptual diagram of the outdoor heat exchanger 105 according to Embodiment 1 as viewed side-on. It should be noted that in Fig. 2, arrow RF indicates the flow of refrigerant that flows into the outdoor heat exchanger 105 or flows out of the outdoor heat exchanger 105, and arrow AR indicates the flow of the second heat exchange fluid. In addition, in Figs. 2 and 3, arrow MD indicates the flow di-

rection of the first heat exchange fluid. Also, the arrow MD indicates the direction of movement of a removing device 10 that is moved in the extending direction of heat transfer tubes 60. With reference to Figs. 2 and 3, the outdoor heat exchanger 105 according to Embodiment 1 will be described below.

**[0024]** The outdoor heat exchanger 105 includes a heat exchange module 55 and the removing device 10. The heat exchange module 55 causes heat exchange to be performed between the first heat exchange fluid and the second heat exchange fluid. The removing device 10 removes an adhering substance such as frost that adheres to the heat exchange module 55.

#### <Heat Exchange Module 55>

**[0025]** As illustrated in Figs. 2 and 3, the heat exchange module 55 includes a plurality of heat transfer tubes 60 each of which allows the first heat exchange fluid to flow therethrough, and which are spaced from each other. The heat exchange module 55 causes heat exchange to be performed between the first heat exchange fluid such as refrigerant that flows through each of the heat transfer tubes 60 and the second heat exchange fluid such as air that is present around the heat transfer tubes 60.

**[0026]** The heat exchange module 55 includes headers 70 connected to both ends of each of the heat transfer tubes 60 in an extending direction thereof. The headers 70 are a first header 71 and a second header 72. The first header 71 is connected to one end of each of the heat transfer tubes 60 in the extending direction. The second header 72 is connected to the other end of each of the heat transfer tubes 60 in the extending direction. In the heat exchange module 55, the associated heat transfer tube 60 is provided between the first header 71 and the second header 72.

**[0027]** The outdoor heat exchanger 105 further includes a first refrigerant connection pipe 41 and a second refrigerant connection pipe 42. The first refrigerant connection pipe 41 is attached to an end portion of the first header 71 in an axial direction thereof. The second refrigerant connection pipe 42 is attached to an end portion of the second header 72 in an axial direction thereof. The first refrigerant connection pipe 41 and the second refrigerant connection pipe 42 are connected to pipes that are included in the refrigerant circuit 110. The first heat exchange fluid flows between the header 70 and the pipes included in the refrigerant circuit 110 through the first refrigerant connection pipe 41 and the second refrigerant connection pipe 42.

#### (Heat Transfer Tube 60)

**[0028]** Each of the plurality of heat transfer tubes 60 allows the first heat exchange fluid to flow through the heat transfer tube 60. The heat transfer tube 60 extends between the first header 71 and the second header 72. The plurality of heat transfer tubes 60 are spaced from

each other and arranged in the axial direction of the header 70 that is the extending direction thereof. The heat transfer tubes 60 are located to face each other. Between any adjacent two of the heat transfer tubes 60, a space is provided as a flow passage for the second heat exchange fluid.

**[0029]** In the outdoor heat exchanger 105, the direction of arrangement of the heat transfer tubes 60 and the extending direction of the header 70 will be both referred to as a second direction D2. That is, the heat transfer tubes 60 are arranged in the second direction D2. In the outdoor heat exchanger 105, the direction of arrangement of the heat transfer tubes 60, which is the second direction D2, is the horizontal direction. However, the direction of arrangement of the heat transfer tubes 60, which is the second direction D2, is not limited to the horizontal direction, and may be inclined relative to the horizontal direction, or may be the vertical direction.

**[0030]** In the outdoor heat exchanger 105, the extending direction of the heat transfer tubes 60 will be referred to as a first direction D1. The first direction D1 is a flow direction of the first heat exchange fluid. In the outdoor heat exchanger 105, the extending direction of the heat transfer tubes 60, which is the first direction D1, is the vertical direction. However, the extending direction of the heat transfer tubes 60, which is the first direction D1, is not limited to the vertical direction, and may be inclined relative to the vertical direction, or may be the horizontal direction.

**[0031]** Adjacent ones of the heat transfer tubes 60 are not connected to each other by a heat-transfer enhancement member. The heat-transfer enhancement member enhances heat transfer. The heat-transfer enhancement member is, for example, a plate fin or a corrugated fin. Therefore, the outdoor heat exchanger 105 is a so-called "finless heat exchanger." It should be noted that the heat exchange module 55 may have a space or spaces in each of which adjacent ones of the heat transfer tubes 60 are not connected to each other by a heat-transfer enhancement member. That is, in the outdoor heat exchanger 105, the heat exchange module 55 may be formed as a heat exchange module in which some adjacent ones of the heat transfer tubes 60 are connected by a heat-transfer enhancement member or heat-transfer enhancement members, or the heat exchange module 55 may be partially finless.

**[0032]** When the outdoor heat exchanger 105 operates as an evaporator of the refrigeration cycle apparatus 100, refrigerant flows through each of the heat transfer tubes 60 from one end of the heat transfer tube 60 toward the other end thereof in the extending direction. When the outdoor heat exchanger 105 operates as a condenser of the refrigeration cycle apparatus 100, refrigerant flows through each of the heat transfer tubes 60 from the above other end of the heat transfer tube 60 toward the above one end thereof in their extending direction.

**[0033]** Fig. 4 is a cross-sectional view of the heat transfer tube 60 that is taken along the line A-A in Fig. 3, and

illustrates an example of the configuration of the heat transfer tube 60. As illustrated in Fig. 4, the heat transfer tube 60 is a flat tube having an elongated cross section that extends in a single direction, such as an elliptical shape. It should be noted that the heat transfer tube 60 is not limited to a flat tube, and may be, for example, a circular tube. The heat transfer tube 60 is made mainly of aluminum material; however, the main material of the heat transfer tube 60 is not limited to aluminum.

**[0034]** As illustrated in Fig. 4, the heat transfer tube 60 has a first side end portion 60a, a second side end portion 60b, and a pair of flat surfaces 60c and 60d. In the cross section as illustrated in Fig. 4, the first side end portion 60a is formed convex outward between one end portion of the flat surface 60c and one end portion of the flat surface 60d. In the above cross-section, the second side end portion 60b is formed convex outward between the other end portion of the flat surface 60c and the other end portion of the flat surface 60d.

**[0035]** The first side end portion 60a is located on an upstream side in the flow of air that passes through the outdoor heat exchanger 105, that is, the first side end portion 60a is located on a leading-edge side. The second side end portion 60b is located on a downstream side in the flow of air that passes through the outdoor heat exchanger 105, that is, the second side end portion 60b is located on a trailing-edge side. In the following descriptions, a direction along the flat surface 60c and the flat surface 60d and perpendicular to the extending direction of the heat transfer tube 60 may sometimes be referred to as "major-axis direction" of the heat transfer tube 60. In Fig. 4, the major-axis direction of the heat transfer tube 60 will be referred to as a third direction D3, and a minor-axis direction of the heat transfer tube 60 will be referred to as the second direction D2. It should be noted that the third direction D3 crosses a plane parallel to the first direction D1 and the second direction D2. For example, the second heat exchange fluid flows in the third direction D3 perpendicular to the first direction D1 and the second direction D2.

**[0036]** In the heat transfer tube 60, a plurality of refrigerant passages 62 are arranged in the major-axis direction between the first side end portion 60a and the second side end portion 60b. The heat transfer tube 60 is a porous flat tube including the refrigerant passages 62 through which refrigerant flows and which are arranged in the flow direction of air. Each of the refrigerant passages 62 is formed to extend parallel to the extending direction of the heat transfer tube 60. Partition walls 63 are provided between adjacent ones of the refrigerant passages 62. Each of the partition walls 63 continuously extends between both ends of the heat transfer tube 60 in the extending direction thereof. It should be noted that the cross-sectional shape of each of the refrigerant passages 62 and the number of the refrigerant passages 62 are not limited to those indicated in the description concerning the embodiment. For example, the refrigerant passages 62 may be formed into any of various shapes

in cross section, such as a circular shape or a triangular shape. Only one refrigerant passage 62 may be formed, or a plurality of refrigerant passages 62 may be formed.

**[0037]** The heat exchange module 55 may further include fins 65 extending in the third direction D3 that crosses the plane parallel to the first direction D1 and the second direction D2. In each of the heat transfer tubes 60, from both side end portions of the heat transfer tube 60, respective fins 65 extend in the third direction D3. The respective side end portions are the first side end portion 60a and the second side end portion 60b. The fins 65 protrude in the major-axis direction of the heat transfer tubes 60. The fins 65 use heat conduction to assist heat exchange between the first heat exchange fluid and the second heat exchange fluid.

**[0038]** Each of the fins 65 is a plate-like portion that is formed in such a manner as to protrude from one or both of the first side end portion 60a and the second side end portion 60b of the heat transfer tube 60, and extend in the major-axis direction of each of the heat transfer tubes 60. It should be noted that the fin 65 extends in the major-axis direction of the heat transfer tube 60; however, the extending direction of the fin 65 is not limited to the above direction. For example, the fin 65 may be inclined relative to the major-axis direction at a predetermined angle to the direction of arrangement of the heat transfer tubes 60. However, as described above, adjacent ones of the heat transfer tubes 60 are not connected by a heat-transfer enhancement member or heat-transfer enhancement members. Therefore, each of the heat transfer tubes 60 is not connected to associated adjacent ones of the heat transfer tubes 60 by fins 65.

(Header 70)

**[0039]** Re-referring to Figs. 2 and 3, each of the headers 70 will be described. The header 70 is formed to extend in the second direction D2 that is the direction of arrangement of the heat transfer tubes 60. In the outdoor heat exchanger 105, the header 70 operates as a fluid distribution mechanism to distribute to the heat transfer tubes 60, refrigerant that flows into the outdoor heat exchanger 105. In the outdoor heat exchanger 105, the header 70 also operates as a fluid joining mechanism in which refrigerant streams that flow out of the heat transfer tubes 60 join together to form refrigerant that will flow out of the outdoor heat exchanger 105.

**[0040]** The headers 70 are the first header 71 and the second header 72. One of the first header 71 or the second header 72 operates as the fluid distribution mechanism and the other operates as the fluid joining mechanism. As described above, the first header 71 is connected to one end of each of the heat transfer tubes 60 in the extending direction. The second header 72 is connected to the other end of the heat transfer tube 60 in the extending direction. That is, the first header 71 and the second header 72 are attached to respective ends of the heat transfer tube 60 in the extending direction.

**[0041]** The first header 71 has a first cylindrical portion 73a, a first proximal end portion 73b, and a first distal end portion 73c. The first cylindrical portion 73a has a circularly cylindrical shape, and extends in the direction of arrangement of the heat transfer tubes 60. The first proximal end portion 73b closes one end of the first cylindrical portion 73a. The first distal end portion 73c closes the other end of the first cylindrical portion 73a. The first cylindrical portion 73a, the first proximal end portion 73b, and the first distal end portion 73c form an outer shell of the first header 71.

**[0042]** Similarly, the second header 72 has a second cylindrical portion 74a, a second proximal end portion 74b, and a second distal end portion 74c. The second cylindrical portion 74a has a circularly cylindrical shape, and extends in the direction of arrangement of the heat transfer tubes 60. The second proximal end portion 74b closes one end of the second cylindrical portion 74a. The second distal end portion 74c closes the other end of the second cylindrical portion 74a. The second cylindrical portion 74a, the second proximal end portion 74b, and the second distal end portion 74c form an outer shell of the second header 72.

**[0043]** As illustrated in Fig. 2, the first cylindrical portion 73a of the first header 71 and the second cylindrical portion 74a of the second header 72 are both formed into a circularly cylindrical shape as described regarding the embodiment. However, the shapes of the first cylindrical portion 73a and the second cylindrical portion 74a are not limited to the circularly cylindrical shape, and the first cylindrical portion 73a and the second cylindrical portion 74a may be each formed into a cylindrical body having, for example, a polygonal cross section. The first cylindrical portion 73a of the first header 71 and the second cylindrical portion 74a of the second header 72 both extend parallel to the direction of arrangement of the heat transfer tubes 60. The first cylindrical portion 73a of the first header 71 and the second cylindrical portion 74a of the second header 72 are connected to the heat transfer tubes 60 such that the inside of these cylindrical portions communicates with the refrigerant passages 62 of the heat transfer tubes 60. The first heat exchange fluid flows into one of the headers 70, that is, the first header 71 or the second header 72, is then distributed to the heat transfer tubes 60, passes through the other header 70, and returns to the refrigerant circuit 110.

(First Refrigerant Connection Pipe 41 and Second Refrigerant Connection Pipe 42)

**[0044]** The first header 71 includes the first refrigerant connection pipe 41, which communicates with the inside of the first header 71. The first refrigerant connection pipe 41 is connected to the first proximal end portion 73b. The first refrigerant connection pipe 41 protrudes outward in the axial direction of the first header 71, and communicates with the inside of the first cylindrical portion 73a. The first refrigerant connection pipe 41 is a tubular mem-

ber to allow refrigerant to flow therethrough. The first refrigerant connection pipe 41 is formed into, for example, a circularly cylindrical shape. The first refrigerant connection pipe 41 communicates with the inside of the first header 71, and forms an inlet for refrigerant that flows into the first header 71, or forms an outlet for refrigerant that flows out of the first header 71.

**[0045]** The second header 72 includes the second refrigerant connection pipe 42, which communicates with the inside of the second header 72. The second refrigerant connection pipe 42 is connected to the second proximal end portion 74b. The second refrigerant connection pipe 42 protrudes outward in the axial direction of the second header 72, and communicates with the inside of the second cylindrical portion 74a. The second refrigerant connection pipe 42 is a tubular member to allow refrigerant to flow therethrough. The second refrigerant connection pipe 42 is formed into, for example, a circularly cylindrical shape. The second refrigerant connection pipe 42 communicates with the inside of the second header 72, and forms an inlet for refrigerant that flows into the second header 72, or forms an outlet for refrigerant that flows out of the second header 72.

<Removing Device 10>

**[0046]** Fig. 5 is a top view of the outdoor heat exchanger 105 according to Embodiment 1 as viewed in the first direction D1. The removing device 10 is moved in the first direction D1 that is the flow direction of the first heat exchange fluid, between adjacent ones of the heat transfer tubes 60. More specifically, the heat exchange module 55 has a space or spaces in each of which adjacent ones of the heat transfer tubes 60 are not connected to each other by a heat-transfer enhancement member, and the removing device 10 is moved between the adjacent heat transfer tubes 60 in the above space or spaces. The removing device 10 is located between adjacent ones of the heat transfer tubes 60, and is moved in the first direction D1 that is the flow direction of the first heat exchange fluid, thereby removing an adhering substance such as frost that adheres to the heat exchange module 55. It should be noted that the adhering substance is, for example, frost or dust. That is, the removing device 10 is also applicable to removal of dust that adheres to surfaces of the heat transfer tubes 60 in addition to removal of frost. It should be noted that the following descriptions are made by referring mainly to removal of frost by the removing device 10.

**[0047]** The removing device 10 includes a support portion 12 and removing portions 14. The removing device 10 includes the support portion 12 and the removing portions 14, and when the removing device 10 is moved, the support portion 12 and the removing portions 14 are mechanically moved as one body in the first direction D1. It should be noted that in the case where the heat exchange module 55 includes the fins 65, the removing device 10 is located between adjacent ones of the heat transfer

tubes 60 and between adjacent ones of the fins 65.

(Support Portion 12)

**[0048]** The support portion 12 is formed to extend in the second direction D2, which is the direction of arrangement of the heat transfer tubes 60 and the extending direction of the header 70. The support portion 12 is elongated in the second direction D2.

**[0049]** Referring to Fig. 5, the support portion 12 is formed in the shape of a rectangular prism that is elongated in the second direction D2; however, it suffices that the support portion 12 is formed to extend in the second direction D2. The shape of the support portion 12 is not limited to a rectangular prism. For example, the support portion 12 may be formed into a polygonal prism or may also be formed into a circular cylinder.

**[0050]** The support portion 12 is provided movable in the first direction D1. The first direction D1 is the extending direction of the heat transfer tubes 60. The support portion 12 is reciprocated between the first header 71 and the second header 72 in the first direction D1 by, for example, a drive device 90 as illustrated in Figs. 1 and 3 that is a well-known drive device such as a motor and converts electric energy to mechanical energy. As illustrated in Fig. 5, the removing portions 14 are fixed to the support portion 12.

(Removing Portion 14)

**[0051]** The removing portions 14 are located between adjacent ones of the heat transfer tubes 60. To be more specific, the removing portions 14 are located between the adjacent heat transfer tubes 60, and brush off adhering substances such as frost that adhere to surfaces of the heat transfer tubes 60 as the support portion 12 is moved. In the case where the heat exchange module 55 includes the fins 65, when the support portion 12 is moved, the removing portions 14 brush off adhering substances such as frost that adhere to the surfaces of the heat transfer tubes 60 and surfaces of the fins 65.

**[0052]** The removing portions 14 are arranged in the longitudinal direction of the support portion 12. That is, the removing portions 14 are arranged in the second direction D2. The removing portions 14 are arranged in the manner of the teeth of a comb in the removing device 10.

**[0053]** To be more specific, a single group of removing portions 14 is provided in the first direction D1 that is the extending direction of the heat transfer tubes 60, and the removing portions 14 of the group are arranged in line in the longitudinal direction of the support portion 12. However, the arrangement of the removing portions 14 is not limited to the above arrangement. A plurality of groups of removing portions 14 may be arranged in the first direction D1 in which the heat transfer tube 60 extends. That is, a plurality of lines of removing portions 14 arranged in the longitudinal direction of the support portion 12 may be provided in the first direction D1.

**[0054]** The removing portions 14 are provided in such a manner as to protrude from the support portion 12, and extend in the third direction D3. The removing portions 14 are located between adjacent heat transfer tubes 60.

In other words, in the outdoor heat exchanger 105, the heat transfer tubes 60 are located between adjacent ones of the removing portions 14 arranged in the manner of the teeth of a comb. Alternatively, in the outdoor heat exchanger 105, the heat transfer tubes 60 and the fins 65 are located between adjacent ones of the removing portions 14 arranged in the manner of the teeth of a comb.

**[0055]** In the case where each of the heat transfer tubes 60 is a flat tube, each of the removing portions 14 is provided to extend in the major-axis direction of the heat transfer tube 60. The removing unit 14 faces the heat transfer tube 60 in the second direction D2. In the case where the heat exchange module 55 includes the fins 65, the removing unit 14 is formed to face the heat transfer tube 60 and the fins 65.

**[0056]** It is preferable that the removing unit 14 be formed longer in the third direction D3 than the heat exchange module 55. Specifically, it is preferable that the length of the removing unit 14 in the third direction D3 be greater than the length of the heat transfer tube 60 between the both ends thereof in the third direction D3. Furthermore, it is preferable that the length of the removing unit 14 in the third direction D3 is greater than the distance between the end portions of the fins 65, which correspond to the both ends of the heat exchange module 55. That is, it is preferable that the removing unit 14 face the entire portion of the heat transfer tube 60 in the second direction D2. Also, it is preferable that the removing unit 14 face the entire portion of the heat transfer tube 60 and the fins 65 in the second direction D2.

**[0057]** In the case where the support portion 12 is provided downstream of the heat transfer tubes 60 in the flow direction of the second heat exchange fluid, as illustrated in Fig. 5, the removing unit 14 is formed longer than the heat exchange module 55 in the third direction D3. In general, damp air flows on the upstream side of the heat transfer tubes 60, from which the second heat exchange fluid flows. Thus, dew condensation easily occurs and frost is easily formed on the upstream side of the heat transfer tubes 60. Therefore, the removing portions 14 need to brush off frost mainly on the upstream side of the heat transfer tubes 60. For this reason, in the case where the support portion 12 is located downstream of the heat transfer tubes 60, each of the removing portions 14 is formed longer than the heat exchange module 55, whereby the removing portions 14 can brush off adhering substances such as frost that adhere to the upstream side of the heat transfer tubes 60.

**[0058]** Fig. 6 illustrates a first modification of the removing portions 14 as illustrated in Fig. 5. In the case where the support portion 12 is located upstream of the heat transfer tubes 60 in the flow direction of the second heat exchange fluid, as illustrated in Fig. 6, each of the removing portions 14 may be formed shorter than the



heat exchange module 55 in the third direction D3. Also, in this case, it is preferable that the removing unit 14 extend in the third direction D3 to face the heat transfer tube 60 in the major-axis direction and the second direction D2 by a distance that is equal to or greater than half of the length of the heat transfer tube 60. Thus, in the case where the support portion 12 is located upstream of the heat transfer tubes 60 in the flow direction of the second heat exchange fluid, the removing unit 14 may be formed longer than the heat exchange module 55 in the third direction D3, as illustrated in Fig. 5. In other words, in the case where the removing unit 14 is formed longer than the heat exchange module 55 in the third direction D3, the support portion 12 may be provided either downstream or upstream of the heat transfer tubes 60 in the flow direction of the second heat exchange fluid.

**[0059]** Each of the removing portions 14 includes a base portion 14b and a contact portion 14a. The base portion 14b is fixed to the support portion 12 and extends from the support portion 12. The contact portion 14a protrudes from the base portion 14b to contact the heat exchange module 55.

**[0060]** The base portion 14b is provided to protrude from the support portion 12, and is formed in the shape of a column that extends in the third direction D3. In the case where each of the heat transfer tubes 60 is a flat tube, the base portion 14b is provided to extend in the major-axis direction of the heat transfer tube 60. The base portion 14b faces the heat transfer tube 60 in the second direction D2. In the case where the heat exchange module 55 includes the fins 65, the base portion 14b is formed to face the heat transfer tube 60 and the fins 65. The base portion 14b supports the contact portion 14 that protrudes from the base portion 14b.

**[0061]** The contact portion 14a protrudes from the base portion 14b. For example, the contact portion 14a protrudes in the radial direction from the outer circumferential surface of the base portion 14b formed in the shape of a circular column. The contact portion 14a protrudes from the entire outer circumferential surface of the base portion 14b. However, the configuration of the contact portion 14a is not limited to the above configuration. It suffices that the contact portion 14a is formed to protrude from part of the entire outer circumferential surface of the base portion 14b such that the contact portion 14a extends to a position where the heat exchange module 55 is provided.

**[0062]** A distal end of at least part of the contact portion 14a that protrudes from the base portion 14b contacts an associated heat transfer tube or tubes 60 included in the heat exchange module 55. Alternatively, the distal end of the contact portion 14a that protrudes from the base portion 14b at least partially contacts the heat transfer tube 60 and the fins 65 included in the heat exchange module 55.

**[0063]** As illustrated in Figs. 5 and 6, the contact portion 14a is formed of numerous fibrous materials gathered together in the form of a brush. It is preferable that the

contact portion 14a be formed of, for example, resin material, and have elasticity. The material of the contact portion 14a is not limited to resin material, and the contact portion 14a may be made of, for example, metal material. In the case where the contact portion 14a has elasticity, the contact portion 14a can contact the heat transfer tube 60 and the fins 65 along the shape of the heat transfer tube 60 and the fins 65. Thus, the contact portion 14a can easily brush off adhering substances such as frost that adhere to the heat transfer tube 60 and the fins 65. In addition, in the case where the contact portion 14a has elasticity, the contact portion 14a does not easily damage the heat transfer tube 60 or the fins 65.

**[0064]** When the support portion 12 is moved while the contact portion 14a, which is formed in the shape of a brush, is kept in contact with the heat transfer tube 60, adhering substances such as frost are brushed off from the heat transfer tube 60 by the contact portion 14a. Alternatively, when the support portion 12 is moved while the contact portion 14a is kept in contact with the heat transfer tube 60 and the fins 65, the adhering substances such as frost are brushed off from the heat transfer tube 60 and the fins 65 by the contact portion 14a.

**[0065]** Fig. 7 illustrates a second modification of the removing portions 14 as illustrated in Fig. 5. Each of the removing portions 14 in the second modification has a contact portion 14e and a base portion 14f that supports the contact portion 14e. The contact portion 14e formed in the shape of a brush is illustrated as an example in Figs. 5 and 6; however, the shape of the contact portion 14e is not limited to such a shape. For example, as the contact portion 14a, the contact portion 14e may be used which is formed in the shape of a spatula having a given constant width in the third direction D3. In this case also, it is preferable that the contact portion 14e having the above shape be formed to have elasticity.

**[0066]** The contact portion 14e is formed into a thin plate, and contacts a side surface of the heat transfer tube 60. Alternatively, contact portions 14e are each formed into a thin plate, and contact the side surface of the heat transfer tube 60 and side surfaces of fins 65.

**[0067]** The base portion 14f is provided to protrude from the support portion 12, and is formed to extend in the third direction D3. For example, the base portion 14f may have a columnar shape or a plate-like shape. In the case where each of the heat transfer tubes 60 is a flat tube, the base portion 14f is provided in the major-axis direction of the heat transfer tube 60. The base portion 14f faces the heat transfer tube 60 in the second direction D2. In the case where the heat exchange module 55 includes the fins 65, the base portion 14f is formed to face the heat transfer tube 60 and the fins 65. It should be noted that regarding each of the removing portions 14 in Fig. 7, the contact portion 14e and the base portion 14f are illustrated as separated portions; however, the contact portion 14e and the base portion 14f of the removing unit 14 may be formed integrally with each other.

**[0068]** When the support portion 12 is moved while the

contact portion 14e, which is formed in the shape of a spatula, is kept in contact with the heat transfer tube 60, frost adhering to the heat transfer tube 60 is brushed off therefrom by the contact portion 14e. Alternatively, when the support portion 12 is moved while the contact portion 14e is kept in contact with the heat transfer tube 60 and the fins 65, frost adhering to the heat transfer tube 60 and the fins 65 is brushed off therefrom by the contact portion 14e.

**[0069]** Fig. 8 illustrates a third modification of the removing portions 14 as illustrated in Fig. 5. It should be noted that arrows RN in Fig. 8 indicate the rotation of the respective removing portions 14. As illustrated in Fig. 8, the contact portion 14a may be rotated around the axis of the base portion 14b. It should be noted that the rotational direction of the contact portion 14a is not limited. Because of rotation of the contact portion 14a, the contact portion 14a can more easily brush off the adhering substances such as frost from the heat transfer tube 60 and the fins 65. For example, when the base portion 14b is rotated, the contact portion 14a is also rotated along with the base portion 14b. It should be noted that the contact portion 14a may be vibrated via the base portion 14b. Because of vibration of the contact portion 14a, the contact portion 14a can more easily brush off the adhering substances such as frost from the heat transfer tube 60 and the fins 65.

**[0070]** Fig. 9 illustrates a fourth modification of the removing portions 14 as illustrated in Fig. 5. Each of the plurality of removing portions 14 may have a main body portion 14c. The main body portion 14c has one or more ejection holes 14d from which air is ejected, and which are formed at positions where the one or more ejection holes 14d face the heat exchange module 55.

**[0071]** The main body portion 14c is provided to protrude from the support portion 12, and is formed into a cylindrical shape to extend in the third direction D3. In the case where each of the heat transfer tubes 60 is a flat tube, the main body portion 14c is provided to extend in the major-axis direction of the heat transfer tube 60. The main body portion 14c faces the heat transfer tube 60 in the second direction D2. In the case where the heat exchange module 55 includes fins 65, the main body portion 14c is formed to face the heat transfer tube 60 and the fins 65. One or more ejection holes 14d are formed in a circumferential wall of the main body portion 14c that faces the heat transfer tube 60 and the fins 65.

**[0072]** The ejection holes 14d are formed as holes from which air is blown from the inside of the main body portion 14c. The ejection holes 14d are formed in the circumferential wall of the main body portion 14c at positions where the ejection holes 14d face the heat transfer tube 60 included in the heat exchange module 55 or at positions where the ejection holes 14d face the heat transfer tube 60 and the fins 65 that are included in the heat exchange module 55. The ejection holes 14d may be formed in the entire circumferential area of the main body portion 14c or in part of the circumferential area of the main body

portion 14c. Air blown through the ejection holes 14d has a pressure that enables the air to blow off adhering substances such as frost that adhere to the heat transfer tube 60 and the fins 65.

[Example of Operation of Outdoor Heat Exchanger 105]

**[0073]** An operation of the outdoor heat exchanger 105 according to Embodiment 1 will be described by referring to by way of example how the outdoor heat exchanger 105 is operated when the outdoor heat exchanger 105 serves as an evaporator of the refrigeration cycle apparatus 100. When the outdoor heat exchanger 105 serves as an evaporator, two-phase gas-liquid refrigerant obtained through decompression by the pressure reducing device 104 flows into the outdoor heat exchanger 105. In this case, the refrigerant flows from the first header 71 into the outdoor heat exchanger 105 through the first refrigerant connection pipe 41, and is separated into refrigerant streams that flow to passages whose number is equal to the number of the heat transfer tubes 60. Then, while flowing through the refrigerant passages 62 of the heat transfer tubes 60, the refrigerant receives heat and evaporates. Sequentially, the refrigerant passes through the second header 72, flows out from the second refrigerant connection pipe 42, and circulates in the refrigerant circuit 110.

**[0074]** At that time, frost may adhere to the heat exchange module 55 of the outdoor heat exchanger 105. Whether frost adheres to the heat exchange module 55 or not depends on conditions such as the outside air temperature. However, also in the case where an adhering substance such as frost adheres to the heat exchange module 55 of the outdoor heat exchanger 105, when the removing device 10, which has portions located between the heat transfer tubes 60, is moved in the first direction D1 which is the extending direction of the heat transfer tubes 60, the removing device 10 brushes off the adhering substance such as frost that adheres to the heat exchange module 55 of the outdoor heat exchanger 105.

[Advantages of Outdoor Heat Exchanger 105]

**[0075]** The outdoor heat exchanger 105 includes the removing device configured to move in the first direction D1 that is the flow direction of the first heat exchange fluid, between adjacent ones of the heat transfer tubes 60. The removing device 10 is located between the heat transfer tubes 60 included in the outdoor heat exchanger 105, and is moved along the heat transfer tubes 60, thereby removing an adhering substance such as frost that adheres to the heat exchange module 55. Therefore, in the outdoor heat exchanger 105, an adhering substance such as frost that enters the outdoor heat exchanger 105 can be removed by the removing device 10.

**[0076]** As a result, in the outdoor heat exchanger 105, it is not necessary to perform a defrosting operation to remove the frost with latent heat of condensation of re-

frigerant, and it is possible to continuously perform the heating operation. Therefore, the outdoor heat exchanger 105 does not cause the heating operation to be discontinuously performed, and thus can prevent the user from being discomforted by a discontinuous heating operation. Furthermore, in the outdoor unit 106, adhering substances such as frost that are formed around the heat transfer tubes 60 are brushed off during the heating operation. It is therefore possible to prolong time that is taken until the spaces between adjacent heat transfer tubes 60 are clogged with the adhering substance. As a result, the outdoor heat exchanger 105 can extend the duration of the heating operation. In addition, in the outdoor heat exchanger 105, the removing device 10 can remove the adhering substances such as frost from the outdoor heat exchanger 105, and thus reduce deterioration of the heat exchange performance of the outdoor heat exchanger 105 that would be caused by the adhering substances.

**[0077]** In the heat exchange module 55, spaces are each present between associated adjacent two of the heat transfer tubes 60, and are spaces in each of which the adjacent heat transfer tubes 60 are not connected by a heat-transfer enhancement member. Thus, the removing device 10 is moved between the adjacent heat transfer tubes 60 in the above space. The removing device 10 can be used in the outdoor heat exchanger 105 having so-called "finless" space or spaces. The removing device 10 is located between the heat transfer tubes 60 included in the outdoor heat exchanger 105 having the above configuration, and is moved in the heat transfer tubes 60, thereby removing an adhering substance such as frost that adhere to the heat exchange module 55. Therefore, in the outdoor heat exchanger 105, an adhering substance such as frost that enters the outdoor heat exchanger 105 can be removed by the removing device 10.

**[0078]** In the case where the heat exchange module 55 includes the fins 65, the removing device 10 is located between adjacent ones of the heat transfer tubes 60 and between adjacent ones of the fins 65. Because of this configuration, when being moved along the heat transfer tubes 60, the removing device 10 can remove adhering substances such as frost that adhere to the heat transfer tubes 60 and the fins 65.

**[0079]** Each of the heat transfer tubes 60 may be a flat tube including a plurality of refrigerant passages 62 in which refrigerant flows. In recent years, in order to improve the performance of refrigeration cycle apparatuses and reduce the weights thereof, flat tubes have been more widely used as heat transfer tubes for use in a heat exchanger of a refrigerating and air-conditioning apparatus, instead of existing circular tubes. The outdoor heat exchanger 105 can use flat tubes as the heat transfer tubes 60, and can thus contribute to improvement of the performance of the refrigeration cycle apparatus 100 and reduction of the weight thereof. Also, in the refrigeration cycle apparatus 100 as described above, the outdoor heat exchanger 105 can remove, with the removing de-

vice 10, an adhering substance such as frost that adheres to the inside of the heat exchange module 55.

**[0080]** The removing device 10 includes the removing portions 14 that are located between adjacent heat transfer tubes 60 to brush off frost, and the support portion 12 to which the removing portions 14 are fixed and which is movable in the first direction D1. The removing portions 14 are located between the heat transfer tubes 60 included in the outdoor heat exchanger 105, and the support portion 12, which supports the removing portions 14 located between the heat transfer tubes 60, are moved along the heat transfer tubes 60, whereby adhering substances such as frost are brushed off and removed from the heat exchange module 55. Thus, in the outdoor heat exchanger 105, the removing device 10 can remove an adhering substance such as frost that enters the outdoor heat exchanger 105. As a result, in the outdoor heat exchanger 105, it is not necessary to perform the defrosting operation to remove the frost with latent heat of condensation of refrigerant, and it is possible to continuously perform the heating operation. In the outdoor heat exchanger 105, the heat transfer tubes 60 extend in the up-down direction, and an obstruction, which is a heat-transfer enhancement member such as a plate fin, is not present between adjacent heat transfer tubes 60. Therefore, even if the removing portions 14 are made of hard raw material, the removing device 10 can be smoothly moved along the heat transfer tubes 60. The adhering substances such as frost removed from the spaces between the heat transfer tubes 60 are brushed off without being caught by other parts of the outdoor heat exchanger 105.

**[0081]** Each of the removing portions 14 includes the base portion 14b that is fixed to the support portion 12 and the extends from the support portion 12, and the contact portion 14a that protrudes from the base portion 14b to contact the heat exchange module 55. When the support portion 12 is moved along the heat transfer tubes 60, the contact portion 14a is moved while being kept in contact with the heat transfer tube 60 and the fins 65. Thus, when the support portion 12 is moved along the heat transfer tubes 60, adhering substances such as frost that adhere to the heat transfer tubes 60 and the fins 65 are brushed off and removed by the contact portion 14a. Therefore, in the outdoor heat exchanger 105, the removing device 10 can remove adhering substances such as frost that enter the outdoor heat exchanger 105.

**[0082]** Furthermore, the contact portion 14a may be configured to rotate. When the contact portion 14a is rotated, the number of times the contact portion 14a contacts the adhering substances such as frost that adhere to the heat transfer tube 60 and the fins 65 increases, and the pressure applied to the adhering substances by the contact portion 14a increases, whereby the adhering substances can be more easily removed. Thus, in the outdoor heat exchanger 105, the removing device 10 can further remove the adhering substances such as frost that enter the outdoor heat exchanger 105.

**[0083]** The contact portion 14a may be configured to vibrate. When the contact portion 14a is vibrated, adhering substances such as frost that adhere to the heat transfer tube 60 and the fins 65 can be more easily removed. Thus, in the outdoor heat exchanger 105, the removing device 10 can further remove adhering substances such as frost that enter the outdoor heat exchanger 105.

**[0084]** Each of the removing portions 14 has the main body portion 14c that is formed into a cylindrical shape. In the main body portion 14c, one or more ejection holes 14d through which air is ejected are formed at positions where the one or more ejection holes 14d face the heat exchange module 55. The removing portion 14 blows air through the ejection holes 14d to blow off and remove adhering substances such as frost that adhere to the heat transfer tube 60 and the fins 65. The support portion 12 is moved in the extending direction of the heat transfer tubes 60, whereby the removing portions 14 can remove adhering substances such as frost that adhere to the heat transfer tubes 60 and the fins 65 at a position where the support portion 12 faces the heat transfer tubes 60 and the fins 65 when the support portion 12 is moved. Since the removing device 10 does not contact the heat exchange module 55, the removing device 10 does not easily damage the heat exchange module 55.

#### Embodiment 2

**[0085]** Fig. 10 is a conceptual diagram illustrating a configuration of an outdoor unit 106 according to Embodiment 2. It should be noted that components that have the same functions and actions as those in Embodiment 1 will be denoted by the same reference signs, and their descriptions will thus be omitted. The following description regarding the outdoor unit 106 according to Embodiment 2 specifies the location of the support portion 12 of the removing device 10.

**[0086]** The outdoor unit 106 includes the outdoor heat exchanger 105, the outdoor fan 108, and a housing 52. The outdoor fan 108 produces a flow of the second heat exchange fluid that flows between the heat transfer tubes 60. The housing 52 houses the outdoor heat exchanger 105 and the outdoor fan 108. The housing 52 forms an outer shell of the outdoor unit 106. The housing 52 is made of, for example, sheet metal.

**[0087]** The outdoor fan 108 produces a flow of the second heat exchange fluid, causes the second heat exchange fluid to flow into the housing 52, and then discharges the second heat exchange fluid, which has exchanged heat with the first heat exchange fluid that flows in the outdoor heat exchanger 105, from the housing 52.

**[0088]** In the outdoor unit 106, in the flow direction of the second heat exchange fluid, the support portion 12 of the removing device 10 is located between the heat exchange module 55 and the outdoor fan 108.

(Advantages of Outdoor Unit 106 of Embodiment 2)

**[0089]** In the outdoor unit 106, the support portion 12 of the removing device 10 is provided in the housing 52 such that the support portion 12 is located between the heat exchange module 55 and the outdoor fan 108 in the flow direction of the second heat exchange fluid. The support portion 12 is located inward of the outdoor fan 108 in the housing 52, as a result of which the support portion 12 is not moved out of the housing 52. Thus, in the outdoor unit 106, the support portion 12 of the removing device 10 is not directly exposed to wind or rain, and is not brought into contact with another object. Therefore, the support portion 12 is not easily damaged. Furthermore, by virtue of the above configuration of the outdoor unit 106, it is possible to prevent the user from contacting the support portion 12 that is being driven, and also protect the user from the support portion 12.

#### Embodiment 3

**[0090]** Fig. 11 is a conceptual diagram illustrating a configuration of an outdoor heat exchanger 105 according to Embodiment 3. It should be noted that components that have the same functions and actions as those in Embodiment 1 and/or Embodiment 2 will be denoted by the same reference signs, and their descriptions will thus be omitted. The following description concerning the outdoor heat exchanger 105 according to Embodiment 3 specifies the locations of support portions 12 of the removing device 10.

**[0091]** The support portions 12 of the outdoor heat exchanger 105 according to Embodiment 3 are a first support portion 12a and a second support portion 12b. In the third direction D3 that crosses a plane parallel to the first direction D1 and the second direction D2, the first support portion 12a and the second support portion 12b are located opposite to each other with respect to the heat transfer tubes 60. That is, in the outdoor heat exchanger 105 according to Embodiment 3, the heat transfer tubes 60 are sandwiched between the first and second support portions 12a and 12b of the support portion 12.

**[0092]** In the removing device 10, one end of each of the removing portions 14 is fixed to the first support portion 12a and the other end of the removing portion 14 is fixed to the second support portion 12b. In this case, in the outdoor unit 106, in the flow direction of the second heat exchange fluid, the first support portion 12a is located upstream of the heat transfer tubes 60, and the second support portion 12b is located downstream of the heat transfer tubes 60. It should be noted that in the outdoor unit 106, it suffices that in the flow direction of the second heat exchange fluid, the first support portion 12a and the second support portion 12b are located on the opposite sides with respect to the heat transfer tubes 60.

(Advantages of Outdoor Heat Exchanger 105 of Embodiment 3)

**[0093]** In the third direction D3, the first support portion 12a and the second support portion 12b are located opposite to each other with respect to the heat transfer tubes 60. In the outdoor heat exchanger 105 of Embodiment 3 and the outdoor unit 106 including the outdoor heat exchanger 105, the support portion 12 can firmly support the removing portions 14 such that the removing portions 14 are sandwiched between the upstream side and the downstream side of the support portion 12 in the flow direction of the second heat exchange fluid. Thus, the removing portions 14 are not easily damaged.

#### Embodiment 4

**[0094]** Fig. 12 is a block diagram illustrating an example of a configuration related to a control by an outdoor heat exchanger 105 according to Embodiment 4. It should be noted that components that have the same functions and actions as those in any of Embodiments 1 to 3 will be denoted by the same reference signs, and their descriptions will thus be omitted. The following description concerning the outdoor heat exchanger 105 according to Embodiment 4 specifies the operation of the removing device 10.

[Controller 80]

**[0095]** The outdoor heat exchanger 105 in the outdoor unit 106 includes a controller 80. The controller 80 controls the removing device 10 based on a detected temperature measured by a measurement device 30. As illustrated in Fig. 12, the controller 80 includes a memory 84 configured to store a program, a central processing unit (CPU) 82 configured to execute processing according to the program, and a time-measuring device 86. The controller 80 is, for example, a microcomputer. The controller 80 is connected to the measurement device 30 and the drive device 90 by a cable or cables or wirelessly.

**[0096]** The controller 80 receives data indicating the temperature of refrigerant that is measured by the measurement device 30, which is the temperature of refrigerant. The measurement device 30 measures the temperature of refrigerant or an outside air temperature. As illustrated in Fig. 1, the measurement device 30 includes one or both of a first temperature detection device 31 and a second temperature detection device 32. The first temperature detection device 31 measures the temperature of the first heat exchange fluid, and for example, measures the temperature of refrigerant discharged from the outdoor heat exchanger 105. The second temperature detection device 32 measures the temperature of the second heat exchange fluid, and for example, measures the outdoor air temperature at a location where the outdoor heat exchanger 105 is located.

**[0097]** Based on the temperature detected by the

measurement device 30, elapsed time measured by the time-measuring device 86, or other conditions, the controller 80 controls the drive device 90 to move or stop the removing device 10.

[Memory 84]

**[0098]** The memory 84 stores data for use in various processing by the controller 80. The memory 84 includes a volatile storage device (not illustrated) such as a random access memory (RAM) that can temporarily store data, or includes a nonvolatile auxiliary storage device (not illustrated) such as a hard disk, or a flash memory that can store data for a long time. In the memory 84, a set value Ta is stored in advance, and the set value Ta is an arbitrary set temperature to the temperature detected by the first temperature detection device 31. Similarly, in the memory 84, a set value Tb is stored in advance, and the set value Tb is an arbitrary set temperature for the temperature detected by the second temperature detection device 32. Also, in the memory 84, a set time Tm is stored in advance, and the set time Tm is an arbitrary set time for operating the removing device 10 at regular intervals.

[Time-Measuring Device 86]

**[0099]** The time-measuring device 86 includes a timer, etc., and measures time that is applied to time determination by the controller 80.

(Operation of Removing Device 10)

**[0100]** When being in a stopped state that corresponds to default settings of the removing device 10, the removing device 10 is located on a lower side in the first direction D1. Specifically, in the outdoor heat exchanger 105, the first header 71 is located on the lower side in the up-down direction, and the second header 72 is located on an upper side. The heat transfer tubes 60 are provided to extend in the up-down direction. When being in the stopped state, the removing device 10 is located closer to the first header 71 than to the second header 72, and is located at lower end portions 61a of the heat transfer tubes 60 in the extending direction thereof.

**[0101]** It should be noted that the above description concerning the location of the removing device 10 in the stopped state of the removing device 10 is not limiting. When being in the stopped state, the removing device 10 may be located at a position where the removing device 10 does not interfere with the flow of air that flows toward the heat exchange module 55.

**[0102]** The controller 80 drives the drive device 90 to move the removing device 10. The controller 80 may regularly drive the drive device 90 to start movement of the removing device 10. For example, the controller 80 drives the drive device 90 at regular intervals of set time Tm to move the removing device 10.

**[0103]** Based on the temperature detected by the measurement device 30, the controller 80 drives the drive device 90 to move the removing device 10. When the temperature detected by the measurement device 30 is lower than the set temperature, the controller 80 causes the removing device 10 to start moving. For example, when the temperature detected by the first temperature detection device 31 becomes lower than the set value Ta, the controller 80 drives the drive device 90. Alternatively, when the temperature detected by the second temperature detection device 32 becomes lower than the set value Tb, the controller 80 drives the drive device 90. The set value Ta and the set value Tb are each stored as data in the memory 84 in advance as a temperature at which frost starts to adhere to the heat exchange module 55. It should be noted that the controller 80 may drive the drive device 90 in response to an instruction from a user who starts the removing device 10, and may move the removing device 10.

**[0104]** During a removing operation in which the removing device 10 removes an adhering substance, when starting to be moved, the removing device 10 is moved from the lower side to the upper side, and then returned to the low side. That is, in the extending direction of the heat transfer tubes 60, the removing device 10 is moved from the lower end portions 61a of the heat transfer tubes 60 toward the upper end portions 61b thereof, and is then moved downwards from the upper end portions 61b toward the lower end portions 61a. When the removing operation is performed once, a reciprocating movement of the removing device 10 in which the removing device 10 is moved from the lower side toward the upper side and is then returned to the lower side may be performed once, or may be performed a number of times. The movement of the removing device 10 is not limited to the above reciprocating movement. When the removing operation is performed, the removing device 10 may perform a one-way movement in which the removing device 10 is moved from the lower side toward the upper side, not the reciprocating movement.

(Advantages of Outdoor Heat Exchanger 105 of Embodiment 4)

**[0105]** During the removing operation, the removing device 10 is moved upward from the lower end portions 61a of the heat transfer tubes 60, and is then moved downward from the upper end portions 61b thereof. Thus, the outdoor heat exchanger 105 reduces deposition of adhering substances such as frost, which have been brushed off from the heat exchange module 55 by the removing device 10, on the first header 71 located at the lower portions of the heat transfer tubes 60.

**[0106]** For example, in the case where when being in the stopped state, the removing device 10 is located at the upper end portions 61b of the heat transfer tubes 6, and then when the removing device 10 is moved downward from the upper end portions 61b during the remov-

ing operation for the adhering substances, the adhering substances such as frost may deposit on the first header 71 after being brushed off from the heat exchange module 55 by a lower surface side of the removing device 10. If depositing on the first header 71 after being brushed off, the frost changes into solid ice on the first header 71, and the solid ice deteriorates the heat exchange performance. Therefore, in the outdoor heat exchanger 105, it is necessary to perform, for example, the defrosting operation. In a time period in which the defrosting operation is performed, the heating operation cannot be performed. This may cause a user discomfort regarding his/her feeding temperature or other factors.

**[0107]** By contrast, in the case where when being in the stopped state, the removing device 10 is located at the lower end portions 61a of the heat transfer tubes 60, and when performing the removing operation for adhering substances, the removing device 10 is moved upward from the lower end portions 61a of the heat transfer tubes 60, and is then moved downward from the upper end portions 61b thereof, the adhering substances such as frost are brushed off from the heat exchange module 55, but do not fall directly onto the first header 71 located below the removing device 10. This is because the adhering substances adhere to an upper side of the removing device 10 before being brushed off. Therefore, the outdoor heat exchanger 105 reduces deposition of the adhering substances such as frost, which have been brushed off from the heat exchange module 55 by the removing device 10, on the first header 71 located at the lower portion of the heat transfer tubes 60.

**[0108]** The controller 80 regularly causes the removing device 10 to start moving. For example, under environmental conditions in which adhering substances such as frost easily adhere to the heat exchange module 55, the controller 80 regularly causes the removing device 10 to start moving. Therefore, it is not necessary for the user to give an instruction to cause the removing device 10 to start moving, each time the removing operation for adhering substances needs to be performed.

**[0109]** Based on the value measured by the measurement device 30, the controller 80 causes the removing device 10 to start moving. Thus, the controller 80 automatically starts the defrosting operation on the heat exchange module 55 under conditions where frost is easily formed, and the user does not need to give an instruction to start movement of the removing device 10 each time the removing operation needs to be performed.

#### Embodiment 5

**[0110]** Fig. 13 is a conceptual diagram illustrating a configuration of an outdoor heat exchanger 105 according to Embodiment 5. Fig. 14 is a conceptual diagram illustrating a configuration of a first modification of the outdoor heat exchanger 105 according to Embodiment 5. Fig. 15 is a conceptual diagram illustrating a configuration of a second modification of the outdoor heat ex-

changer 105 according to Embodiment 5. Arrow MD1 in Figs. 13 to 15 indicates the direction of movement of the removing device 10, and indicates that the removing device 10 moves upward from the position where the removing device 10 is in the stopped state. It should be noted that components that have the same functions and actions as those in any of Embodiments 1 to 4 will be denoted by the same reference signs, and their descriptions will thus be omitted. The following description concerning the outdoor heat exchanger 105 according to Embodiment 5 further specifies the shape of the removing unit 14 of the removing device 10.

**[0111]** As illustrated in Figs. 13 to 15, the outdoor heat exchanger 105 includes the first header 71 and the second header 72. The first header 71 and the second header 72 are the headers 70 that are connected to respective end portions of the heat transfer tubes 60 in the extending direction thereof. In the direction perpendicular to the plane parallel to the first direction D1 and the second direction D2, the removing portions 14 are formed longer than the width WH of the first header 71, which is located below the removing device 10. That is, a protruding length of each of the removing portions 14 that is a distance by which the removing portion 14 protrudes from the support portion 12 is greater than the width WH that is an outer diameter of the first header 71. The width WH of the first header 71 is an outer diameter of the first cylindrical portion 73a as illustrated in Figs. 2 and 3.

**[0112]** As illustrated in Figs. 13 to 15, in the outdoor heat exchanger 105, at least one end portion of each of the removing portions 14 in the longitudinal direction thereof is located outward of the first cylindrical portion 73a which forms the outer shell of the first header 71. The above end portion of the removing unit 14 include a distal end portion 15a and a connection end portion 15b. The distal end portion 15a is an end portion of the removing unit 14 in the direction in which the removing unit 14 protrudes from the support portion 12. The connection end portion 15b is a distal end portion of the removing unit 14 that is connected to the support portion 12.

**[0113]** In the outdoor heat exchanger 105 as illustrated in Fig. 13, both the distal end portion 15a and the connection end portion 15b of the removing unit 14 are located outward of the first cylindrical portion 73a which forms the outer shell of the first header 71. In the outdoor heat exchanger 105 as illustrated in Fig. 14, the distal end portion 15a of the removing unit 14 is located outward of the first cylindrical portion 73a forming the outer shell of the first header 71. In the outdoor heat exchanger 105 as illustrated in Fig. 15, the connection end portion 15b of the removing unit 14 is located outward of the first cylindrical portion 73a which forms the outer shell of the first header 71.

**[0114]** Each of the removing portions 14 is curved such that in the longitudinal direction in which the removing portion 14 extend from the support portion 12, at least one of the distal end and proximal end of the removing portion 14 extends downward. The removing portions 14

are formed in the shape of an arc that protrudes upward as viewed in a direction parallel to the second direction D2. It is preferable that the removing unit 14 be configured to cause adhering substances such as frost to slip off downward along the curved shape after being removed.

**[0115]** In the outdoor heat exchanger 105 as illustrated in Fig. 13, both the distal end portion 15a and the connection end portion 15b of the removing unit 14 are curved downward. In the outdoor heat exchanger 105 as illustrated in Fig. 14, the distal end portion 15a of the removing unit 14 is curved downward. In the outdoor heat exchanger 105 as illustrated in Fig. 15, the connection end portion 15b of the removing unit 14 is curved downward.

(Advantages of Outdoor Heat Exchanger 105 of Embodiment 5)

**[0116]** The removing portions 14 are formed longer than the width WH of the first header 71 of the header 70, which is located below the removing device 10. At least one longitudinal end portion of each of the removing portions 14 in the longitudinal direction is located outward of the first cylindrical portion 73a which forms the outer shell of the first header 71. Because of the above configuration of the removing portions 14, in the outdoor heat exchanger 105, when the removing device 10 is moved, adhering substances such as frost are brushed off from the heat exchange module 55, but do not fall directly onto the first header 71 located below the removing device 10. This is because the adhering substances are moved on the upper side of the removing device 10 and are then brushed off. Therefore, in the outdoor heat exchanger 105, it is possible to reduce deposition of the adhering substances such as frost, which have been brushed off the heat exchange module 55 by the removing device 10, on the first header 71 located at the lower portion of the heat transfer tubes 60. It is also possible to reduce the probability with which the spaces between lower portions of the heat transfer tubes 60 will be clogged with the deposited adhering substances such as frost.

**[0117]** Each of the removing portions 14 is curved such that in the longitudinal direction in which the removing portion 14 extends from the support portion 12, at least one of the distal end portion and the proximal end portion of the removing portion 14 extends downward. By virtue of the above configuration of the removing portion 14, in the outdoor heat exchanger 105, the adhering substances such as frost easily fall along such a slope as to extend downward as described above; and also, when the removing device 10 is moved, the adhering substances such as frost are brushed off from the heat exchange module 55, but do not fall directly onto the first header 71 located below the removing device 10. This is because the adhering substances are moved on the upper side of the removing device 10 and are then brushed off. Therefore, in the outdoor heat exchanger 105, it is possible to reduce deposition of the adhering substances

such as frost, which have been brushed off from the heat exchange module 55 by the removing device 10, on the first header 71 located at the lower portion of the heat transfer tubes 60. It is also possible to the probability with which the spaces between the heat transfer tubes 60 will be clogged with the deposited adhering substances such as frost.

**[0118]** Each of the removing portions 14 is formed longer than the width WH of the first header 71 of the header 70, which is located below the removing device 10. The removing portion 14 is curved such that in the longitudinal direction in which the removing portion 14 extends from the support portion 12, at least one of the distal end portion and proximal end portion of the removing portion 14 extends downward. In the removing device 10, the removing portion 14 has the above configuration, and when being in the stopped state, the removing device 10 is located at the lower end portion 61a of the heat transfer tubes 60. During the removing operation for the adhering substances, the removing device 10 is moved upward from the lower end portions 61a of the heat transfer tubes 60, and is then moved downward from the upper end portion 61b thereof. In the outdoor heat exchanger 105, since the removing portions 14 have the above configuration, and the removing device 10 is moved in the above manner, the outdoor heat exchanger 105 can further reduce deposition of adhering substances on the first header 71, and reduce the probability with which the spaces between the lower portions of the heat transfer tubes 60 will be clogged with the deposited adhering substances such as frost.

#### Embodiment 6

**[0119]** Fig. 16 is a conceptual diagram illustrating a configuration of an outdoor heat exchanger 105 according to Embodiment 6. It should be noted that components that have the same functions and actions as those in any of Embodiments 1 to 5 will be denoted by the same reference signs, and their descriptions will thus be omitted. The following description regarding the outdoor heat exchanger 105 according to Embodiment 6 further specifies the configuration of the heat transfer tubes 60.

**[0120]** The outdoor heat exchanger 105 according to Embodiment 6 includes a plurality of heat transfer tubes 60 arranged in the third direction D3. The outdoor heat exchanger 105 as illustrated in Fig. 16 has a configuration in which two heat transfer tubes 60 are arranged in the third direction D3. Therefore, the outdoor heat exchanger 105 as illustrated in Fig. 16 has two heat transfer tubes 60 that are arranged in the second direction D2. It should be noted that the configuration of the outdoor heat exchanger 105 according to Embodiment 6 is not limited to the configuration in which two heat transfer tubes 60 are arranged in the third direction D3, and the outdoor heat exchanger 105 may have a configuration in which three or more heat transfer tubes 60 are arranged in the third direction D3.

**[0121]** In the outdoor heat exchanger 105, the heat transfer tubes 60 are located between adjacent ones of the removing portions 14 arranged in the manner of the teeth of a comb. In the outdoor heat exchanger 105 as illustrated in Fig. 16, two heat transfer tubes 60 are located between adjacent ones of the removing portions 14 arranged in the manner of the teeth of a comb.

(Advantages of Outdoor Heat Exchanger 105 of Embodiment 6)

**[0122]** The outdoor heat exchanger 105 according to Embodiment 6 includes the heat transfer tubes 60 arranged in the third direction D3. In the outdoor heat exchanger 105, the heat transfer tubes 60 are located between adjacent removing portions 14. Thus, also in the configuration in which the outdoor heat exchanger 105 according to Embodiment 6 includes the heat transfer tubes 60 arranged in the third direction D3, in the outdoor heat exchanger 105, it is possible to remove adhering substances such as frost that adhere to the heat exchange module 55.

#### Embodiment 7

**[0123]** Fig. 17 is a perspective view illustrating a configuration of related part of an outdoor heat exchanger 105 according to Embodiment 7. Fig. 18 is a conceptual diagram of the outdoor heat exchanger 105 according to Embodiment 7 as viewed side-on. It should be noted that components that have the same functions and actions as those in any of Embodiments 1 to 6 will be denoted by the same reference signs, and their descriptions will thus be omitted.

**[0124]** The outdoor heat exchanger 105 according to Embodiment 7 includes a heater that is a heating element. The removing device 10 in the outdoor heat exchanger 105 includes a heater. In the case where the removing device 10 in the outdoor heat exchanger 105 includes a heater, the support portion 12 may include a support-portion heater 92 as illustrated in Figs. 17 and 18. The support-portion heater 92 is a first heater of the outdoor heat exchanger 105. The removing unit 14 may be configured to generate heat because of heat conduction that occurs when the support-portion heater 92 generates heat.

**[0125]** In the outdoor heat exchanger 105 as illustrated in Figs. 17 and 18, the support-portion heater 92 is formed into an elongated shape, and is provided to extend in the longitudinal direction of the support portion 12. It should be noted that the above description concerning the shape and configuration of the support-portion heater 92 is not limiting. In the outdoor heat exchanger 105 as illustrated in Figs. 17 and 18, the support-portion heater 92 is located on the upper side of the support portion 12, but this is not limiting.

**[0126]** In the where the removing device 10 in the outdoor heat exchanger 105 includes heaters, the removing



portions 14 may include removing-portion heaters 94 as illustrated in Figs. 17 and 18. The removing-portion heaters 94 are second heaters of the outdoor heat exchanger 105.

**[0127]** In the outdoor heat exchanger 105 as illustrated in Figs. 17 and 18, each of the removing-portion heaters 94 is formed into an elongated shape, and is located to extend in the longitudinal direction of the removing unit 14. However, it should be noted that the above description concerning the shape and configuration of the removing-portion heater 94 is not limiting.

**[0128]** In the outdoor heat exchanger 105 as illustrated in Figs. 17 and 18, the removing-portion heaters 94 are provided on the upper side of the removing unit 14. This, however, is not limiting. It is not indispensable that all the removing portions 14 include respective removing-portion heaters 94. In the case where the removing portions 14 include a heater or heaters, at least one of the removing portions 14 includes the removing-portion heater 94.

**[0129]** In the case where the outdoor heat exchanger 105 according to Embodiment 7 includes a heater that is a heating element, the heater may be provided at the first header 71. In the case where the first header 71 includes the heater, the first header 71 may include a header heater 96 that is formed into, for example, an elongated shape and extends in the longitudinal direction of the first header 71. In the case where the first header 71 includes the heater, the first header 71 may include inter-tube heaters 98 that are located, for example, between adjacent heat transfer tubes 60 and extend in the short-side direction of the first header 71. The header heater 96 and the inter-tube heaters 98 will be referred to as a third heater of the outdoor heat exchanger 105.

**[0130]** In the case where the outdoor heat exchanger 105 according to Embodiment 7 includes a heater or heaters that are heating elements, it suffices that the outdoor heat exchanger 105 includes one or more of the support-portion heater 92, one set of removing-portion heaters 94, the header heater 96, and one set of inter-tube heaters 98.

(Advantages of Outdoor Heat Exchanger 105 of Embodiment 7)

**[0131]** The support portion 12 includes the first heater, whereby the outdoor heat exchanger 105 can remove frost, which has not been brushed off and thus still adheres to the heat exchange module 55, by applying heat generated by the first heater. Furthermore, the first heater the support portion 12 includes the first heater configured to generate heat, whereby the outdoor heat exchanger 105 can remove frost that adheres to the support portion 12, and can prevent the frost adhering to the support portion 12 from freezing. The support portion 12 includes the first heater configured to generate heat, whereby the outdoor heat exchanger 105 can remove frost on the first header 71 with the heat generated by the first heater, and can prevent the frost on the first header 71 from

freezing.

**[0132]** The removing portions 14 include the second heater configured to generate heat, whereby the outdoor heat exchanger 105 can remove frost that has not been brushed off and still adheres to the heat exchange module 55, by applying heat generated by the second heater. The removing portions 14 include the second heater configured to generate heat, whereby the outdoor heat exchanger 105 can remove frost that adheres to the removing portions 14, by applying the heat generated by the second heater, and thus can prevent the frost adhering to the removing portions 14 from freezing. The removing portions 14 include the second heater configured to generate heat, whereby when the removing device 10 is located at the lower end portion 61a, the outdoor heat exchanger 105 can remove frost on the first header 71 by applying the heat generated by the second heater. The outdoor heat exchanger 105 can prevent the frost on the first header 71 from freezing.

**[0133]** The first header 71 includes the third heater, whereby the outdoor heat exchanger 105 can remove frost on the first header 71 with heat generated by the third heater, and can thus prevent the frost on the first header 71 from freezing.

[Advantages of Outdoor Unit 106]

**[0134]** The outdoor unit 106 as described above includes the outdoor heat exchanger 105 according to any one of Embodiments 1 to 7. The outdoor unit 106 can thus obtain the same advantages as in any one of Embodiments 1 to 7.

[Advantages of Refrigeration Cycle Apparatus 100]

**[0135]** The refrigeration cycle apparatus 100 as described above includes the outdoor heat exchanger 105 according to any one of Embodiments 1 to 7. The refrigeration cycle apparatus 100 as described above includes the outdoor unit 106 including the outdoor heat exchanger 105 according to any one of Embodiments 1 to 7. The refrigeration cycle apparatus 100 can thus obtain the same advantages as in any one of Embodiments 1 to 7.

**[0136]** Embodiments 1 to 7 as described above can be put to practical use in combination. It should be noted that the configurations described regarding the above embodiments are merely examples, and can thus be combined with another well-known technique or techniques, or partially omitted and modified without departing from the gist of the present disclosure. For example, regarding Embodiment 7, it is described above that the first header 71 includes the third heater; however, the second header 72 may also include the third heater.

Reference Signs List

**[0137]** 10: removing device, 12: support portion, 12a: first support portion, 12b: second support portion, 14: re-

moving portion, 14a: contact portion, 14b: base portion, 14c: main body portion, 14d: ejection hole, 14e: contact portion, 14f: base portion, 15a: distal end portion, 15b: connection end portion, 30: measurement device, 31: first temperature detection device, 32: second temperature detection device, 41: first refrigerant connection pipe, 42: second refrigerant connection pipe, 52: housing, 55: heat exchange module, 60: heat transfer tube, 60a: first side end portion, 60b: second side end portion, 60c: flat surface, 60d: flat surface, 61a: lower end portion, 61b: upper end portion, 62: refrigerant passage, 63: partition wall, 65: fin, 70: header, 71: first header, 72: second header, 73a: first cylindrical portion, 73b: first proximal end portion, 73c: first distal end portion, 74a: second cylindrical portion, 74b: second proximal end portion, 74c: second distal end portion, 80: controller, 82: CPU, 84: memory, 86: time-measuring device, 90: drive device, 92: support-portion heater, 94: removing-portion heater, 96: header heater, 98: inter-tube heater, 100: refrigeration cycle apparatus, 101: compressor, 102: flow switching device, 103: indoor heat exchanger, 104: pressure reducing device, 105: outdoor heat exchanger, 106: outdoor unit, 107: indoor unit, 108: outdoor fan, 109: indoor fan, 110: refrigerant circuit, 111: extension pipe, 112: extension pipe

## Claims

1. A heat exchanger comprising:
  - a heat exchange module including a plurality of heat transfer tubes each configured to allow a first heat exchange fluid to flow therethrough, the plurality of heat transfer tubes being spaced from each other; and
  - a removing device movable between adjacent ones of the plurality of heat transfer tubes in a first direction that is a flow direction of the first heat exchange fluid.
2. The heat exchanger of claim 1, wherein the heat exchange module has a space where the adjacent ones of the plurality of heat transfer tubes are not connected to each other by a heat-transfer enhancement member, and  
the removing device is moved between the adjacent ones of the heat transfer tubes in the space.
3. The heat exchanger of claim 1 or 2, wherein
  - the plurality of heat transfer tubes are provided to extend in an up-down direction, and
  - during an operation of removing an adhering substance, the removing device is moved upward from a lower end portion of each of the plurality of heat transfer tubes, and is then moved downward.
4. The heat exchanger of any one of claims 1 to 3, wherein
  - the heat exchange module further includes fins, and from side-end portions of each of the plurality of heat transfer tubes, associated ones of the fins extend in a third direction crossing a plane parallel to the first direction and a second direction in which the plurality of heat transfer tubes are arranged, and
  - the removing device is moved between the adjacent ones of the heat transfer tubes and between adjacent ones of the fins.
5. The heat exchanger of any one of claims 1 to 4, wherein each of the plurality of heat transfer tubes is a flat tube including a plurality of refrigerant passages in each of which refrigerant flows.
6. The heat exchanger of any one of claims 1 to 5, wherein the removing device includes
  - a removing portion located between the adjacent ones of the plurality of heat transfer tubes, and
  - a support portion to which the removing portion is fixed, the support portion being movable in the first direction.
7. The heat exchanger of claim 6, wherein the support portion includes a first heater configured to generate heat.
8. The heat exchanger of claim 6 or 7, wherein the removing portion includes a second heater configured to generate heat.
9. The heat exchanger of any one of claims 6 to 8, further comprising headers that are connected to respective end portions of each of the plurality of heat transfer tubes in the first direction,
  - wherein
  - in a direction perpendicular to a plane parallel to the first direction and a second direction in which the plurality of heat transfer tubes are arranged, the removing portion are formed longer than a width of a first header that is one of the headers and is located below the removing device, and
  - at least one end portion of the removing portion in a longitudinal direction thereof is located outward of a cylindrical portion of the first header that forms an outer shell of the first header.
10. The heat exchanger of claim 9, wherein the first header includes a third heater configured to generate heat.

11. The heat exchanger of any one of claims 6 to 10, wherein the removing portion is curved such that in a longitudinal direction of the removing portion in which the removing portion extends from the support portion, at least one of a distal end portion and a proximal end of the removing portion extends downward. 5
12. The heat exchanger of any one of claims 6 to 11, wherein the removing portion includes 10
- a base portion fixed to the support portion and extending from the support portion, and
- a contact portion protruding from the base portion to be in contact with the heat exchange module. 15
13. The heat exchanger of claim 12, wherein the contact portion is rotated. 20
14. The heat exchanger of claim 12, wherein the contact portion is vibrated.
15. The heat exchanger of any one of claims 6 to 11, wherein the removing portion includes a main body portion that is formed into a cylindrical shape and includes one or more ejection holes through which air is ejected, the one or more ejection holes being formed in the main body portion at positions where the one or more ejection holes face the heat exchange module. 25 30
16. The heat exchanger of any one of claims 6 to 15, wherein 35
- in a third direction crossing a plane parallel to the first direction and a second direction in which the plurality of heat transfer tubes are arranged, the support portion includes
- a first support portion located on one side of each of the plurality of heat transfer tubes, and 40
- a second support portion located on an other side of the heat transfer tube, and
- in the removing device, one end of the removing portion is fixed to the first support portion, and 45
- an other end of the removing portion is fixed to the second support portion.
17. An outdoor unit comprising: 50
- the heat exchanger of any one of claims 1 to 16;
- a fan configured to produce a flow of a second heat exchange fluid such that the second heat exchange fluid flows between the adjacent ones of the plurality of heat transfer tubes; and 55
- a housing housing the heat exchanger and the fan.
18. An outdoor unit comprising:
- the heat exchanger of any one of claims 6 to 15;
- a fan configured to produce a flow of a second heat exchange fluid such that the second heat exchange fluid flows between the adjacent ones of the plurality of heat transfer tubes; and
- a housing housing the heat exchanger and the fan,
- wherein in a flow direction of the second heat exchange fluid, the support portion is located between the heat exchange module and the fan.
19. The outdoor unit of claim 17 or 18, further comprising a controller configured to control the removing device, wherein the controller causes at regular intervals, the removing device to start moving.
20. The outdoor unit of claim 17 or 18, further comprising:
- a measurement device configured to measure a temperature of refrigerant or an outside air temperature; and
- a controller configured to control the removing device based on the temperature measured by the measurement device,
- wherein the controller causes the removing device to start moving, when the measured temperature is lower than a set temperature.
21. A refrigeration cycle apparatus comprising the heat exchanger of any one of claims 1 to 16.
22. A refrigeration cycle apparatus comprising the outdoor unit of any one of claims 17 to 20.

FIG. 1

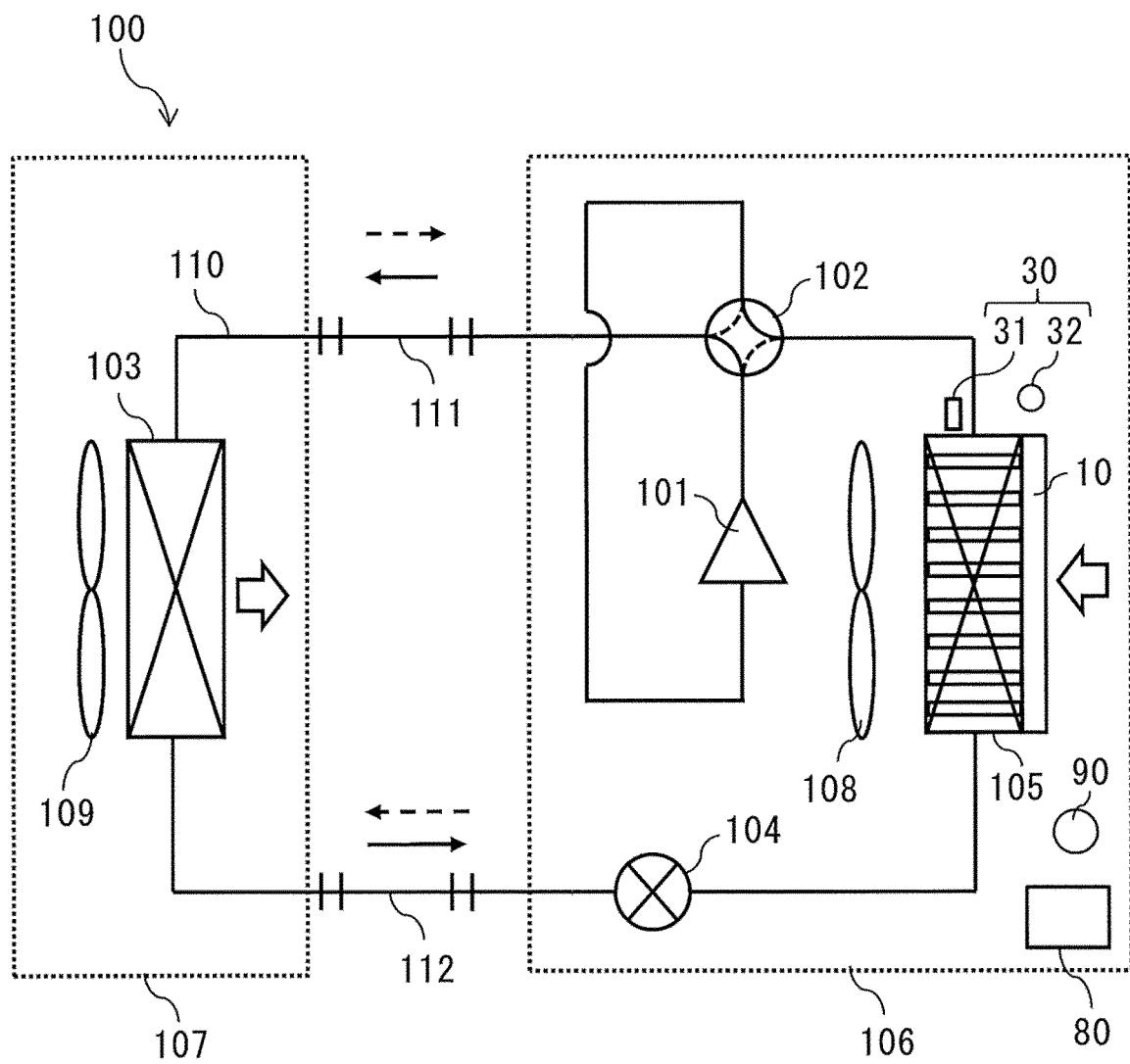


FIG. 2

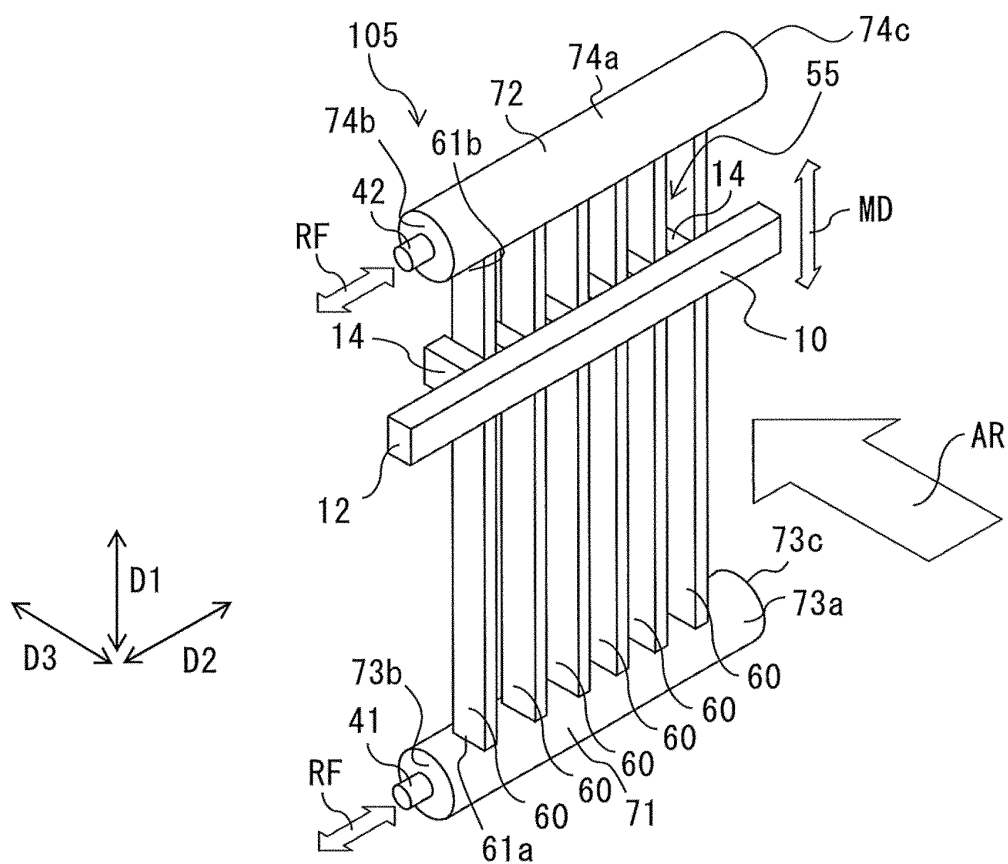


FIG. 3

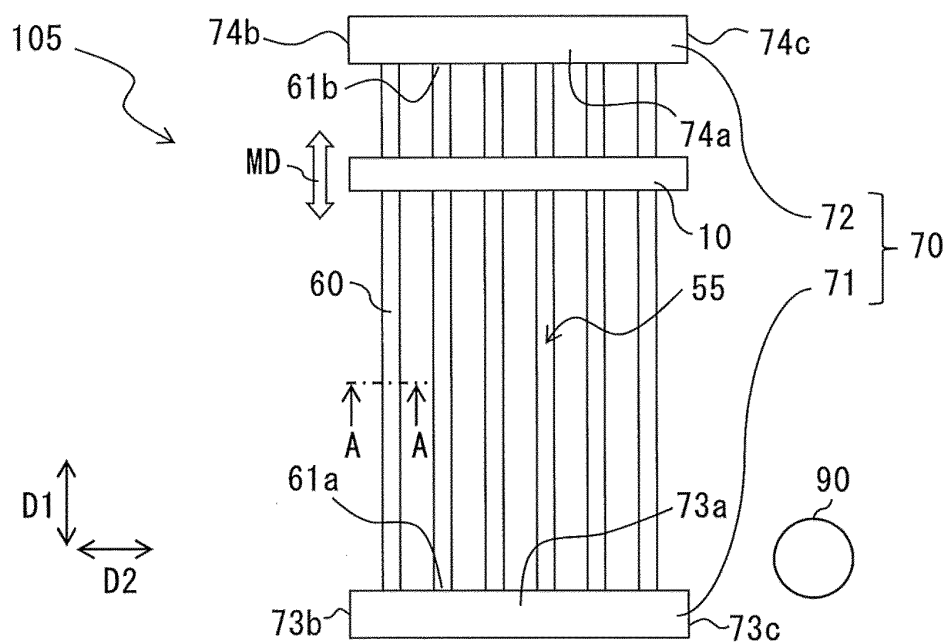


FIG. 4

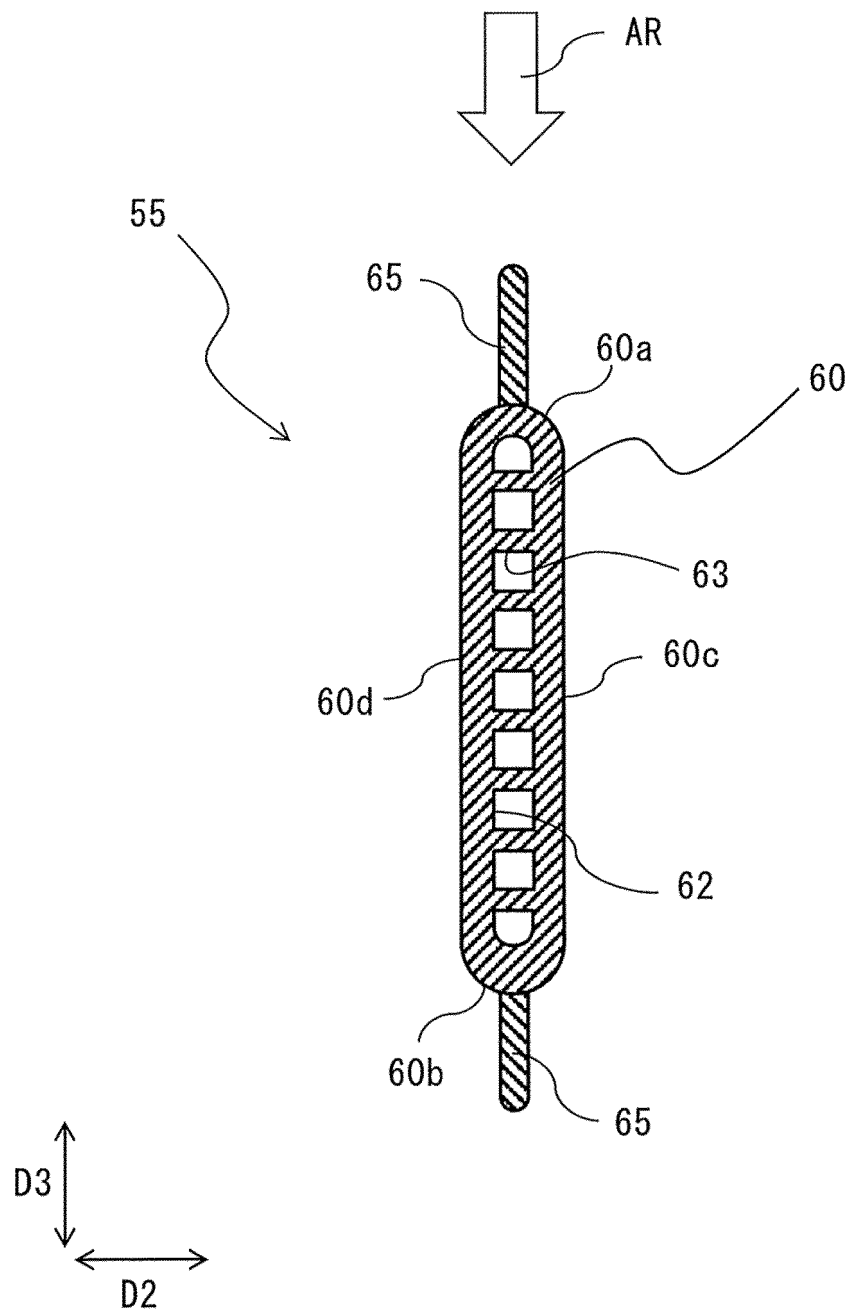


FIG. 5

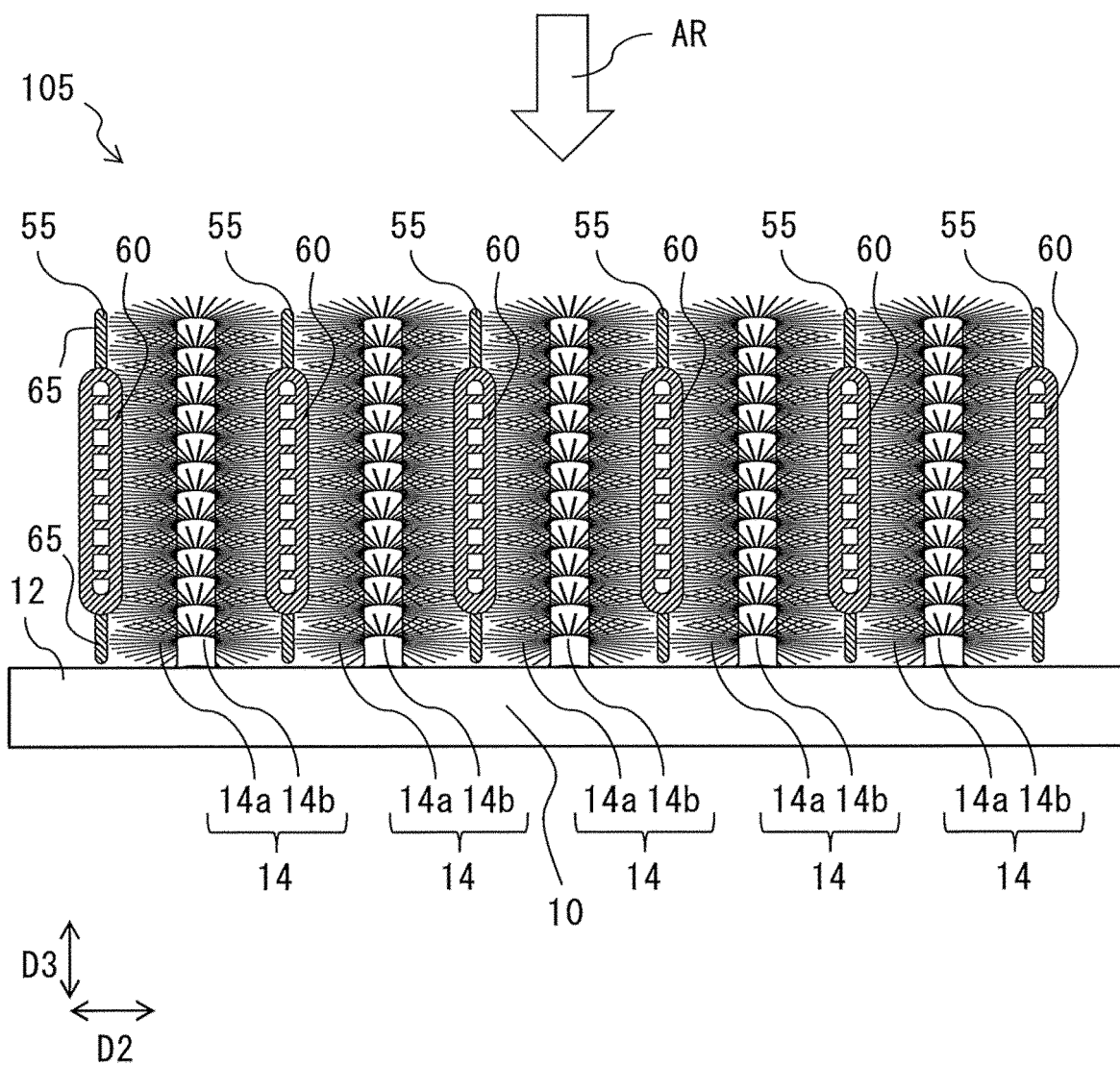


FIG. 6

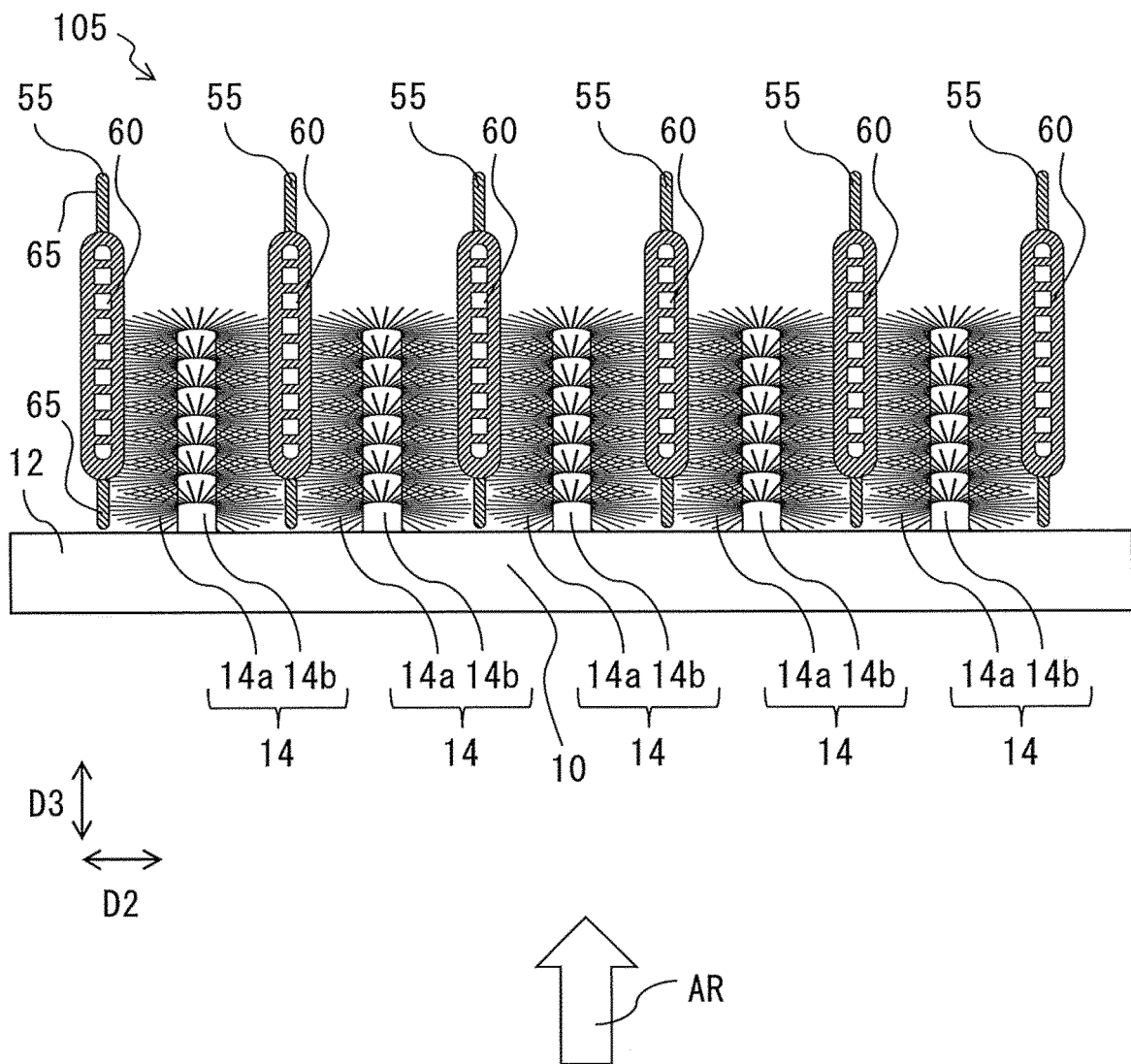




FIG. 7

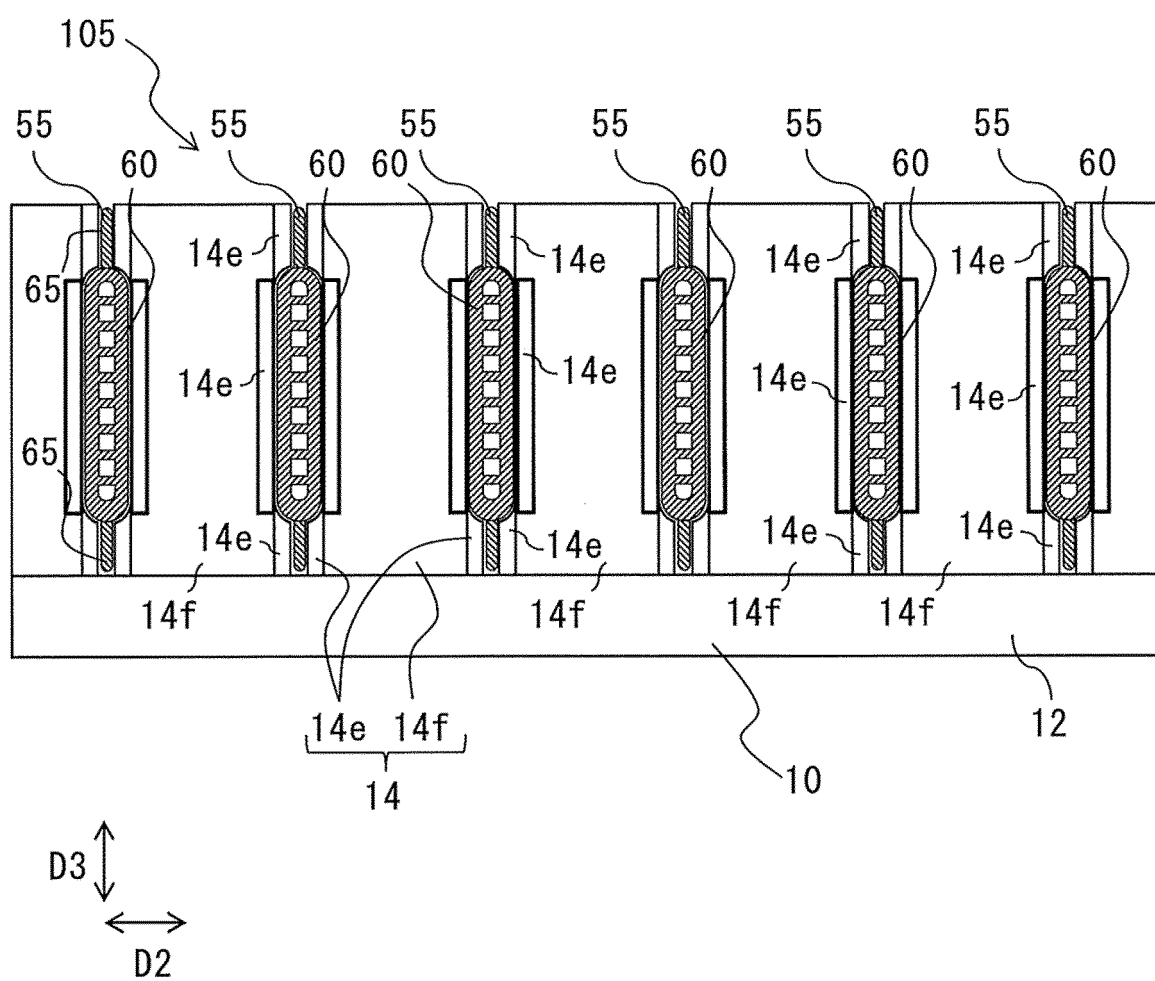


FIG. 8

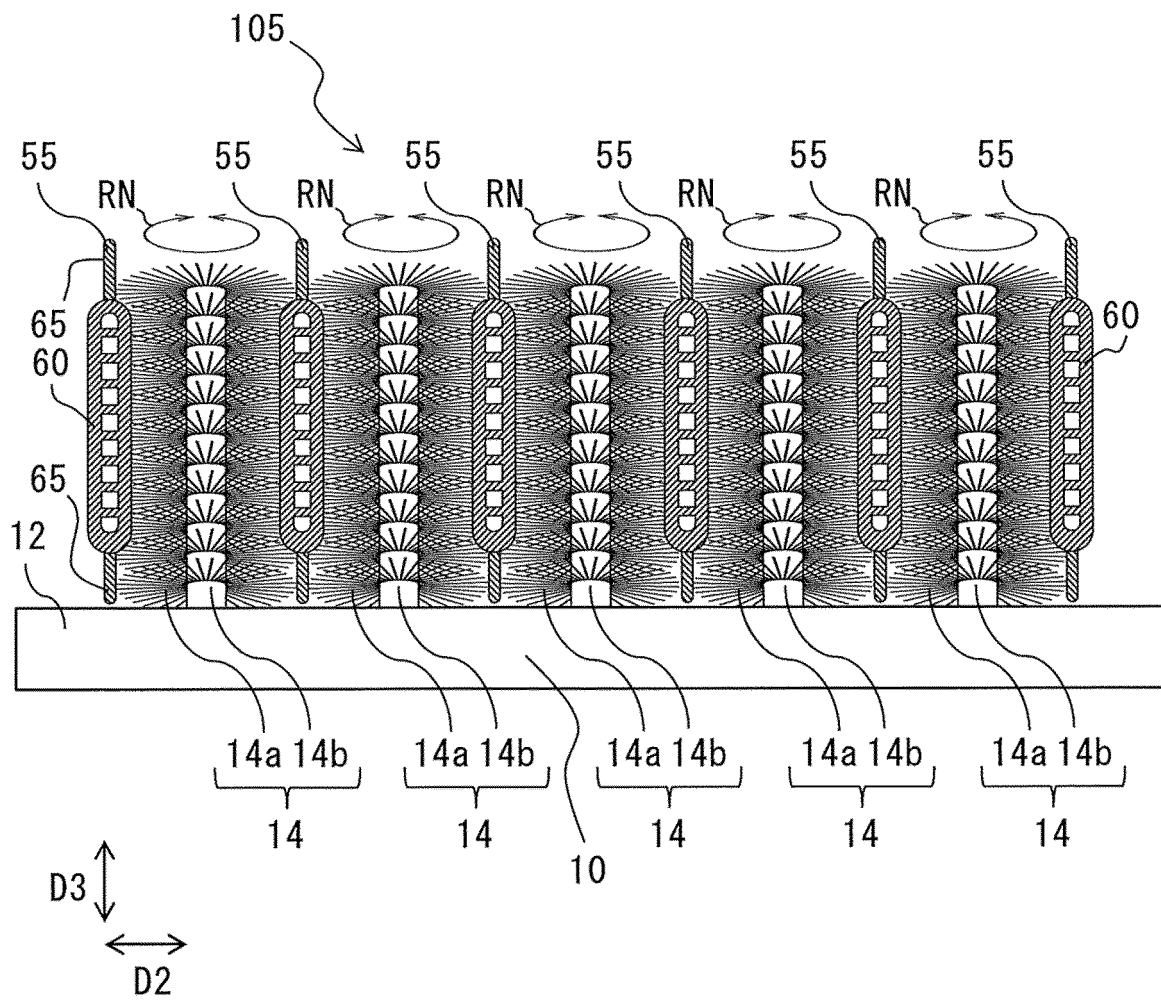


FIG. 9

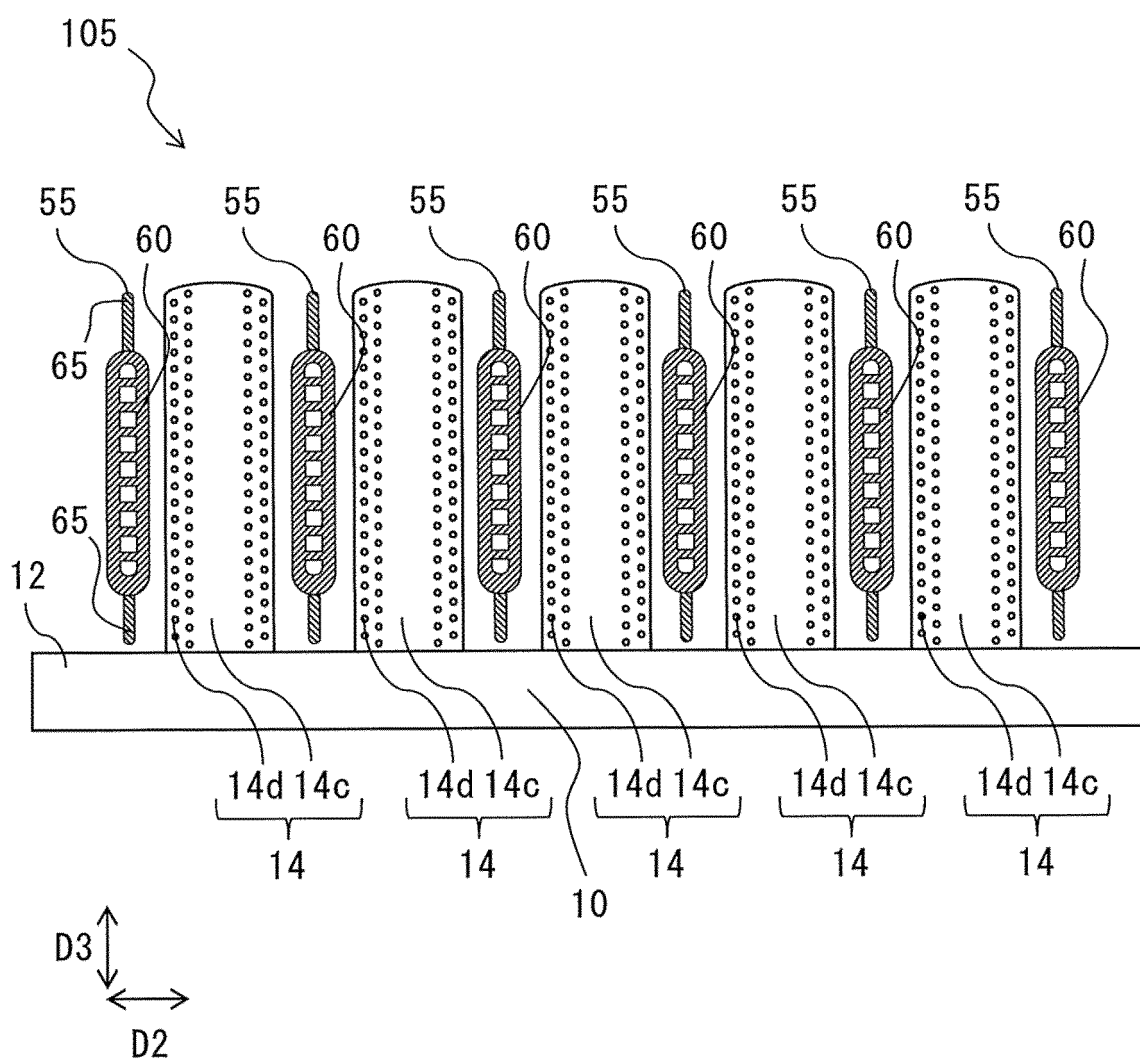


FIG. 10

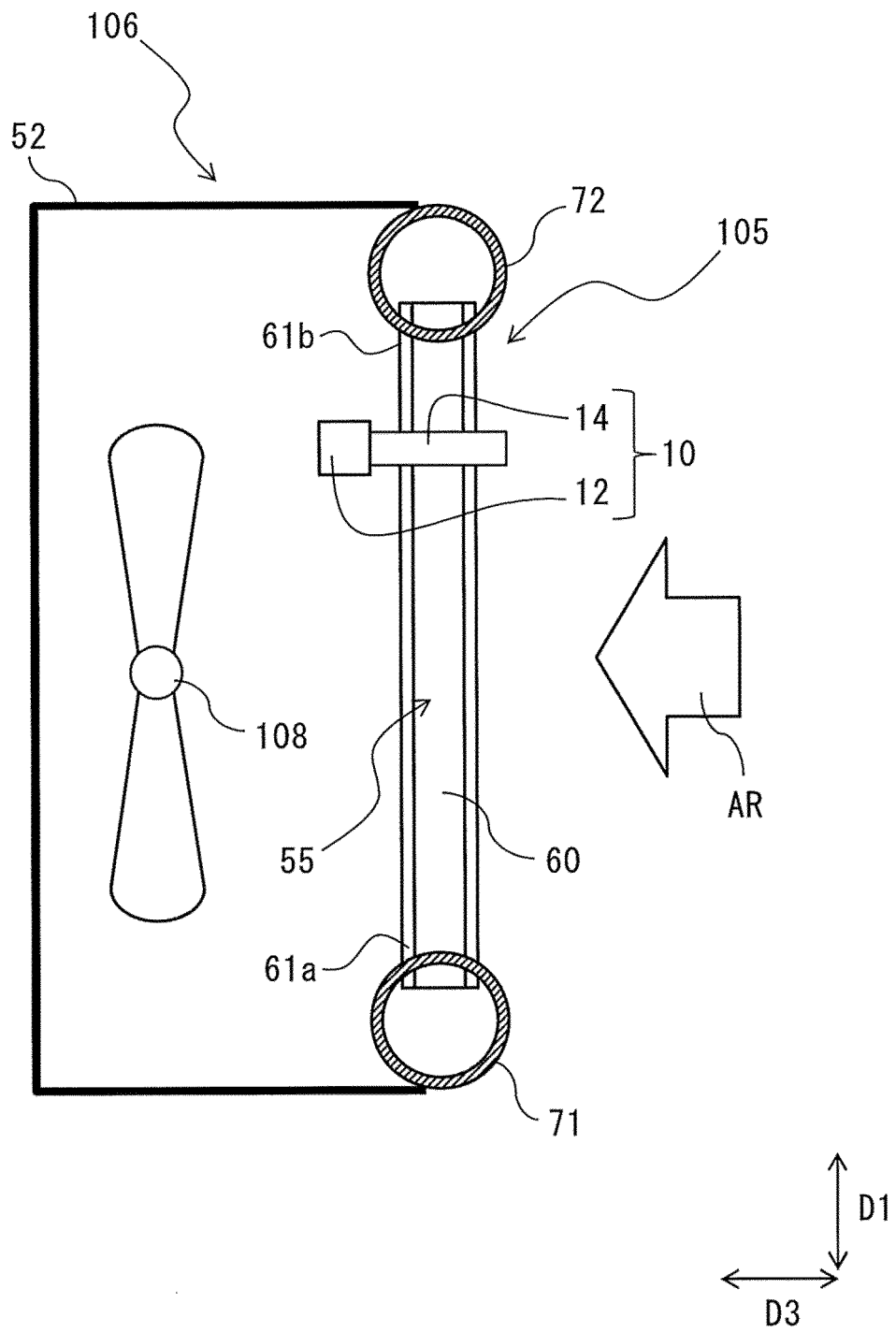


FIG. 11

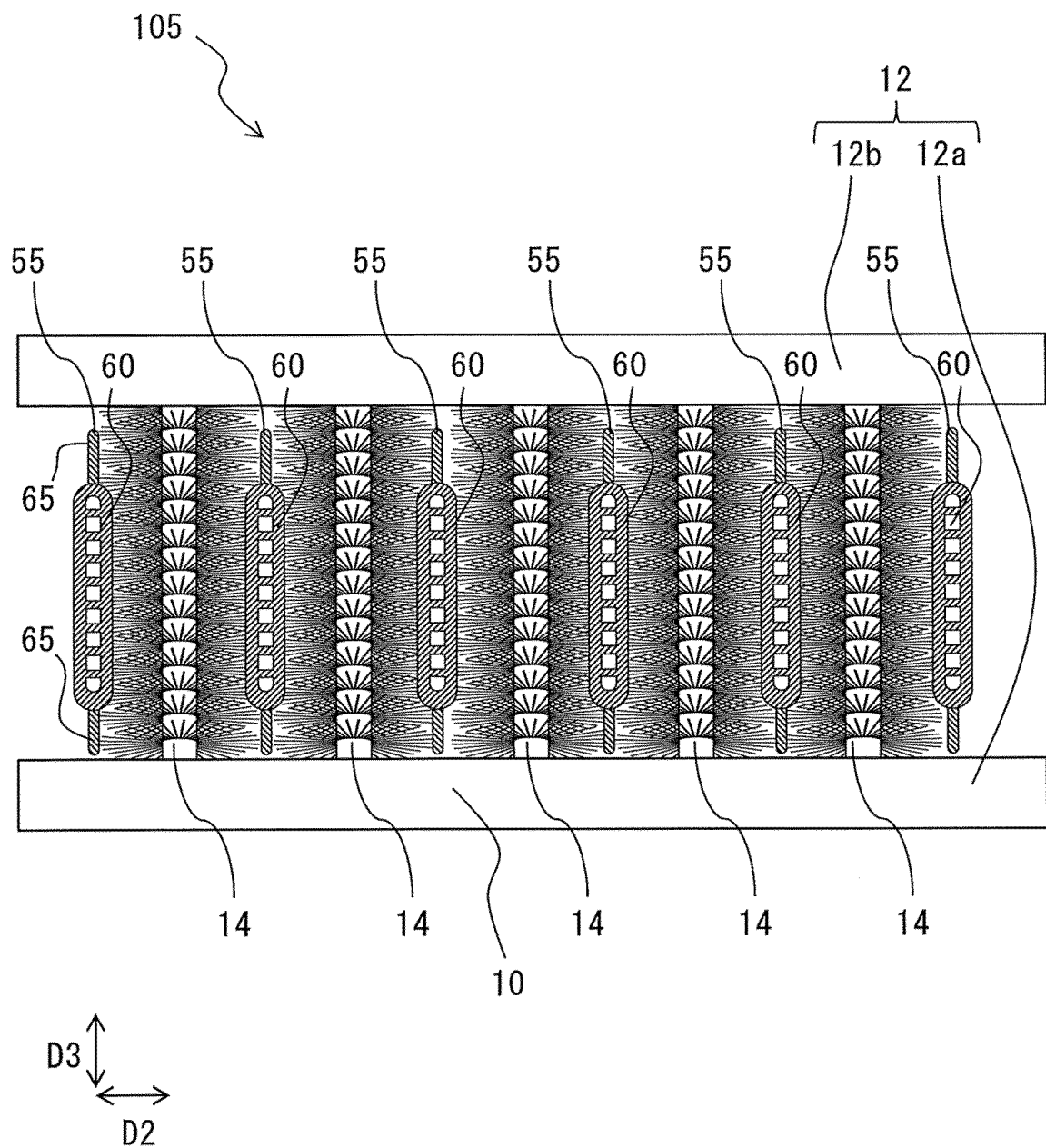


FIG. 12

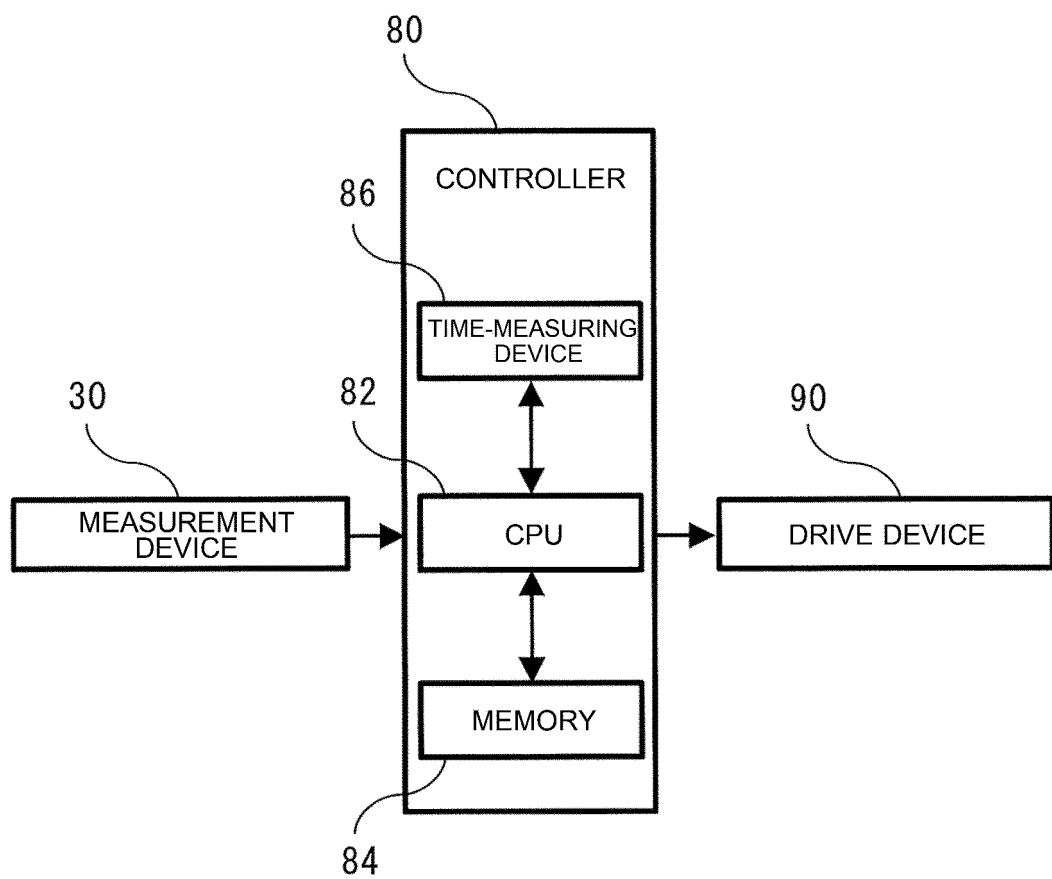


FIG. 13

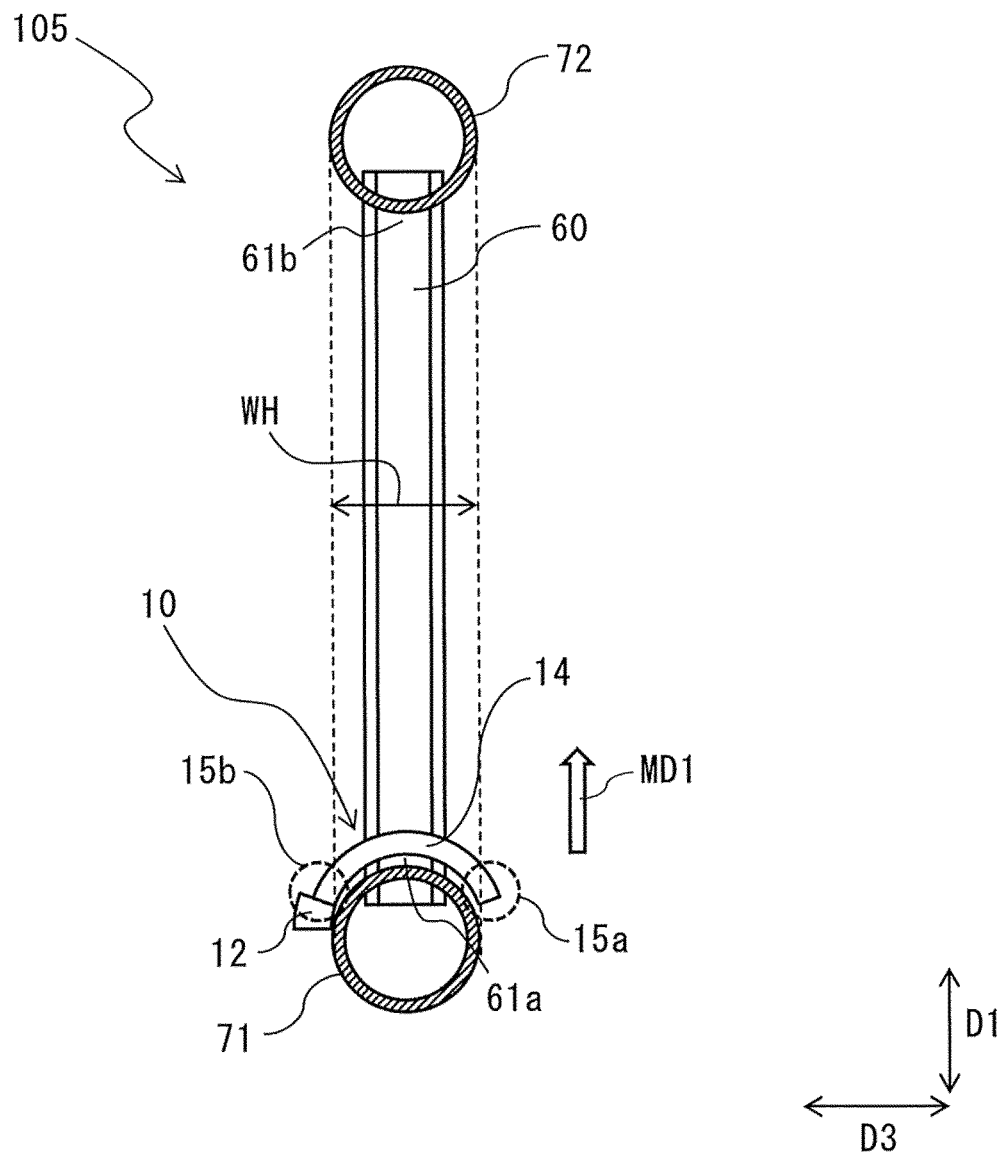


FIG. 14

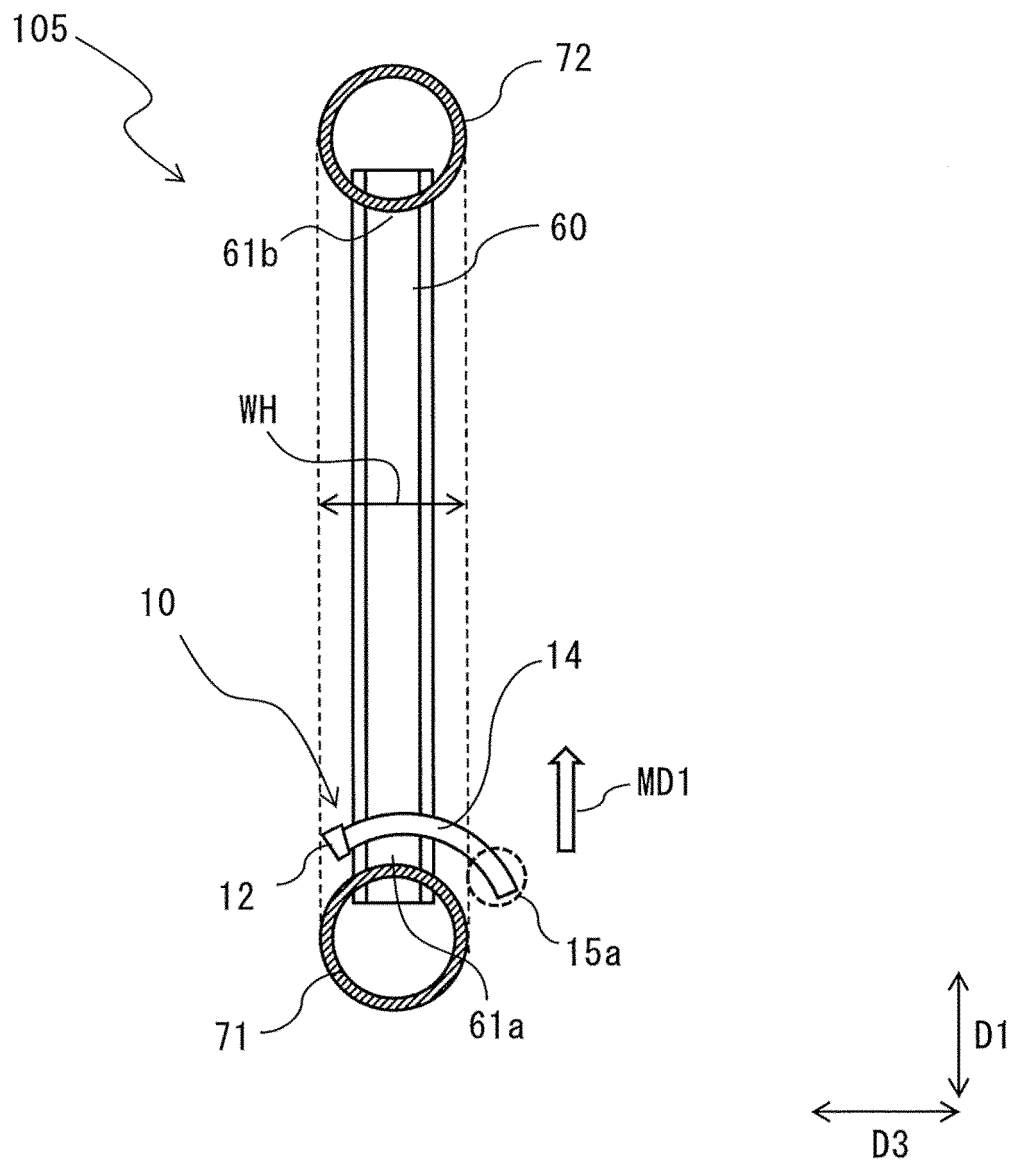




FIG. 15

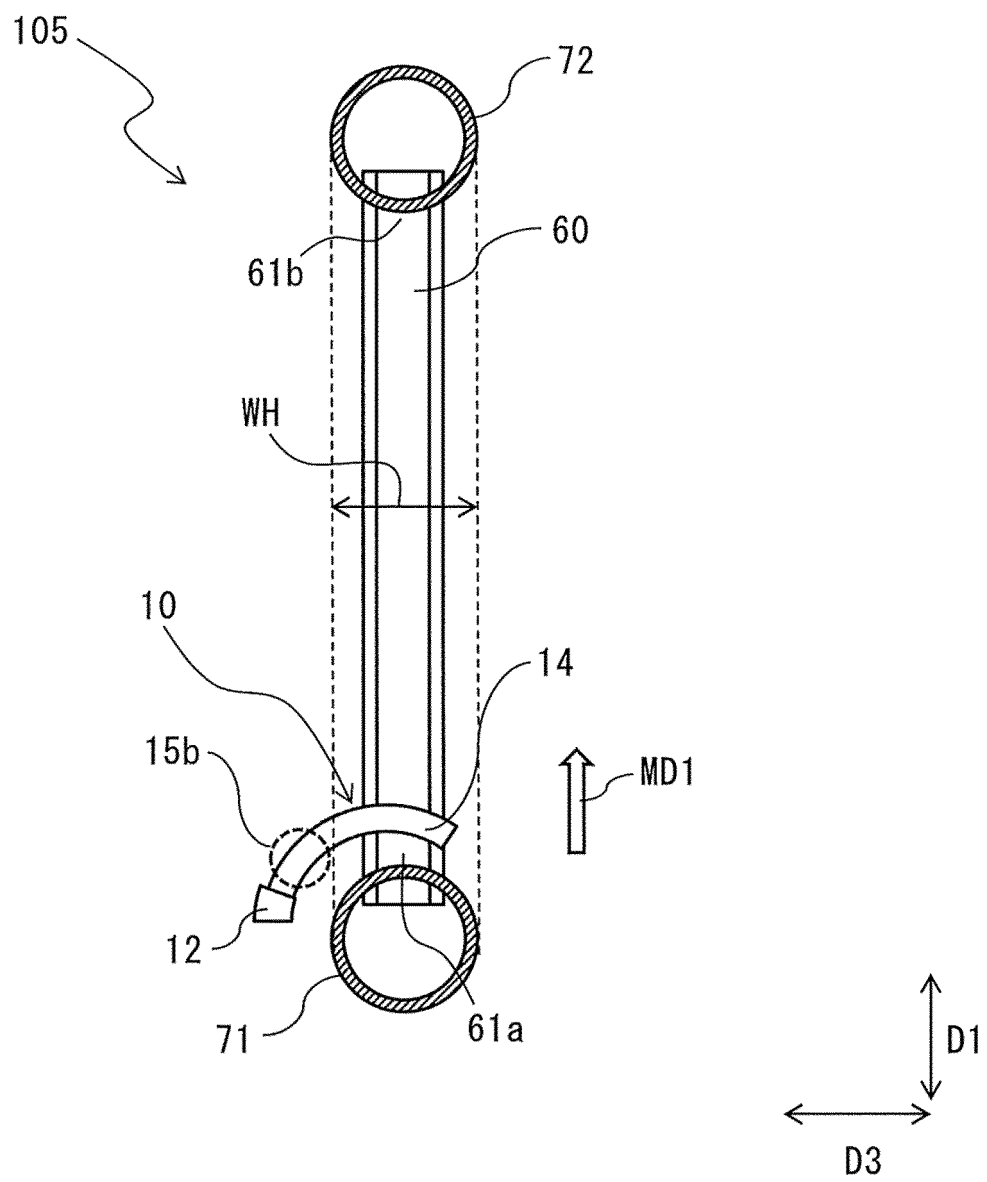


FIG. 16

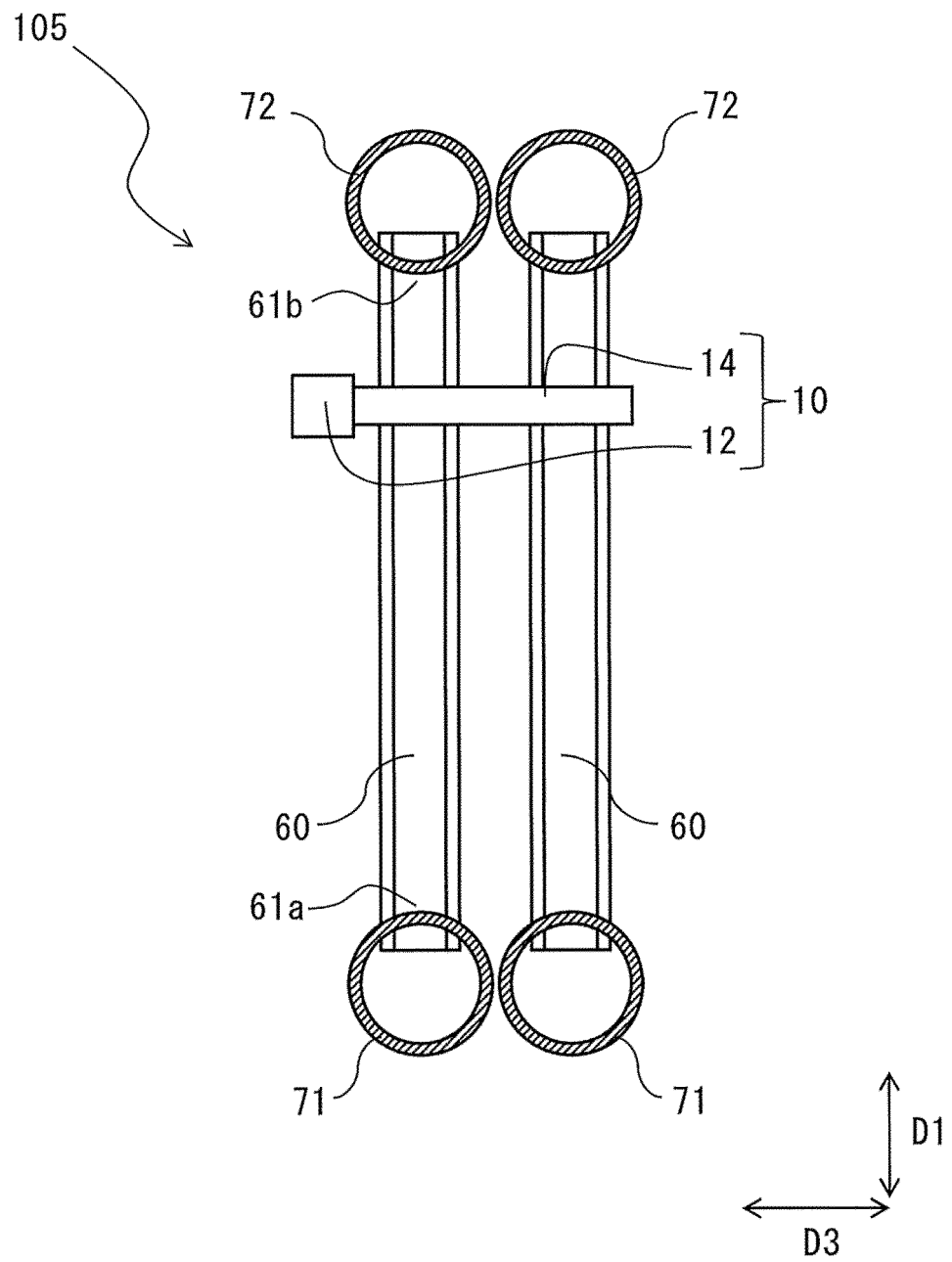


FIG. 17

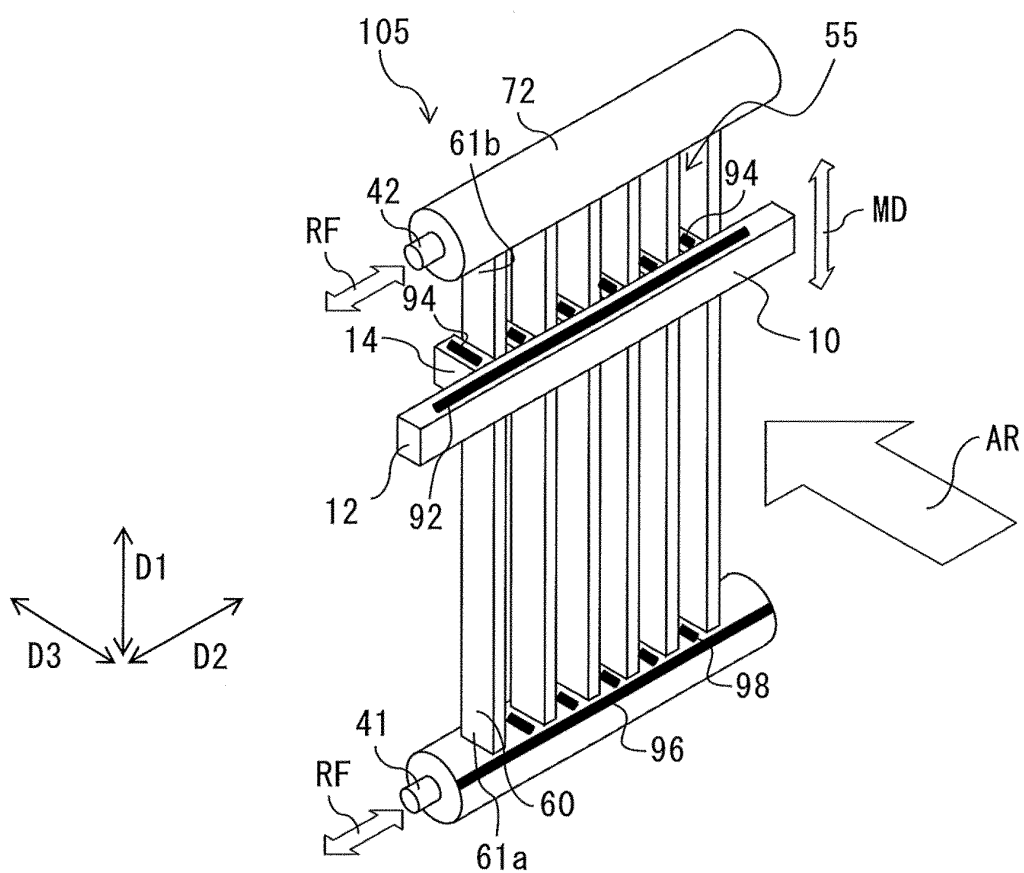
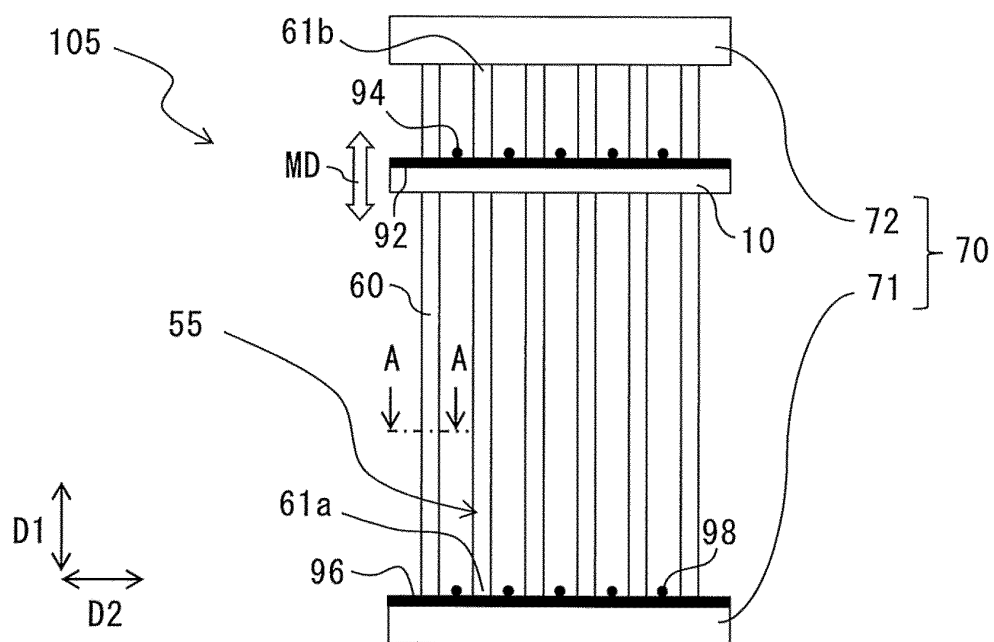


FIG. 18



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/051089

## A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F28D1/053(2006.01)i, F28F17/00(2006.01)i, F28G1/02(2006.01)i, F28G1/16(2006.01)i, F28G3/04(2006.01)i, F25B47/02(2006.01)i  
 FI: F28G1/02, F28G1/16 Z, F28G3/04, F25B47/02 C, F25B47/02 D, F28F17/00 501A, F28D1/053 A

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. F28D1/053, F28F17/00, F28G1/02, F28G1/16, F28G3/04, F25B47/02

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         | [0098], fig. 1-11                                                                                                  | 3-5, 7, 9, 12-16, 18-20 |
| A         |                                                                                                                    | 10-11                   |
| Y         | CN 209295497 U (ZHUHAI ZHONGRUI ENVIRONMENTAL PROTECTION TECH CO LTD.) 23 August 2019, paragraph [0020], fig. 1, 2 | 3-5, 7, 9, 12-16, 18-20 |
| Y         | EP 0774640 A1 (WEHRLE-WERK AG) 21 May 1997, fig. 3-5                                                               | 4-5, 7, 9, 12-16, 18-20 |
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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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18.02.2020Name and mailing address of the ISA/  
Japan Patent Office  
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## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| Y         | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 164161/1986 (Laid-open No. 67792/1988) (SEO KOATSU KOGYO CO., LTD.) 07 May 1988, fig. 1-4 | 9, 12-14, 16, 18-20   |
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| Y         | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 112190/1990 (Laid-open No. 73723/1992) (SAKAE SANGYO KK) 29 June 1992, fig. 3-7           | 9, 15-16, 18-20       |
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Information on patent family members

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| Patent Documents referred to in<br>the Report | Publication Date | Patent Family  | Publication Date |
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**REFERENCES CITED IN THE DESCRIPTION**

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