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(54) **AIR CONDITIONER**

(57) An air conditioner (1) includes an indoor unit (2) and an outdoor unit (3). The indoor unit (2) includes a first heat exchanger (20). The outdoor unit (3) includes a second heat exchanger (30). The first heat exchanger (20) includes a first flat tube (21) and a first fin (22). The first fin (22) is joined to the first flat tube (21). The second heat exchanger (30) includes a second flat tube (31) and a second fin (32). The second fin (32) is joined to the second flat tube (31). A potential difference between the first fin (22) and the first flat tube (21) is smaller than a potential difference between the second fin (32) and the second flat tube (31).

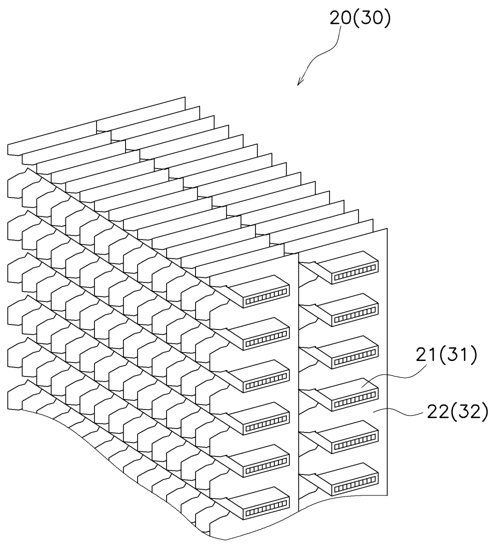


FIG. 2

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## Description

### TECHNICAL FIELD

**[0001]** The present disclosure relates to an air conditioner.

### BACKGROUND ART

**[0002]** Conventionally, a heat exchanger including flat tubes and fins has been known. An example of such a heat exchanger is disclosed in PTL 1 (Japanese Unexamined Patent Application Publication No. 2013-43216).

**[0003]** It is disclosed in PTL 1 that the heat exchanger is formed by brazing heat-exchange tubes and fins that are made of aluminum and an aluminum alloy; the potentials of the fins, the surfaces of the heat-exchange tubes, and the core portions of the heat-exchange tubes after the brazing satisfy the following relationship: (more noble) heat-exchange tube core portions > heat-exchange tube surface > fins (less noble); and the potential differences between the core portions of the heat-exchange tubes and the surfaces of the heat-exchange tubes and between the surfaces of the heat-exchange tubes and the fins after the brazing are each in a range of 40 mV to 60 mV.

### SUMMARY OF INVENTION

<Technical Problem>

**[0004]** However, there is a problem, on which the inventor of the present invention has focused, in that when the heat exchanger in PTL 1 described above is used for an indoor unit, aluminum hydroxide, which is a corrosion product, may be generated and scattered into the room.

<Solution to Problem>

**[0005]** An air conditioner according to a first aspect includes an indoor unit and an outdoor unit. The indoor unit includes a first heat exchanger. The outdoor unit includes a second heat exchanger. The first heat exchanger includes a first flat tube and a first fin. The first fin is joined to the first flat tube. The second heat exchanger includes a second flat tube and a second fin. The second fin is joined to the second flat tube. A potential (electric potential) difference between the first fin and the first flat tube is smaller than a potential difference between the second fin and the second flat tube.

**[0006]** With the air conditioner of the first aspect, since the potential difference between the first fin and the first flat tube of the indoor unit is made smaller than the potential difference between the second fin and the second flat tube of the outdoor unit, corrosion of the first fin and the first flat tube of the indoor unit can be effectively suppressed. As a result, generation of aluminum hydroxide due to corrosion of the first fin and the first flat tube can be reduced. Therefore, it is possible to suppress the scattering of the aluminum hydroxide into a room.

**[0007]** An air conditioner according to a second aspect is the air conditioner according to the first aspect, in which a potential of the first fin is higher than a potential of the second fin.

**[0008]** In the air conditioner of the second aspect, by making the potential of the first fin of the indoor unit higher than the potential of the second fin of the outdoor unit, it is possible to further suppress the scattering of the aluminum hydroxide into the room by suppressing the corrosion of the first fin.

**[0009]** An air conditioner according to a third aspect is the air conditioner of the first aspect or the second aspect, in which a potential of the first fin is higher than a potential of the first flat tube.

**[0010]** In the air conditioner of the third aspect, by making the potential of the first fin higher than the potential of the first flat tube, it is possible to further suppress the scattering of the aluminum hydroxide into the room by suppressing the corrosion of the first fin.

**[0011]** An air conditioner according to a fourth aspect is the air conditioner according to any one of the first aspect to the third aspect, in which the potential difference between the first fin and the first flat tube is not less than 20 mV and not more than 60 mV.

**[0012]** In the air conditioner of the fourth aspect, the potential difference between the first fin and the first flat tube of the indoor unit is made as small as not less than 20 mV and not more than 60 mV. Accordingly, it is possible to further reduce the generation of aluminum hydroxide due to the corrosion of the first fin and the first flat tube.

**[0013]** An air conditioner according to a fifth aspect is the air conditioner according to any one of the first aspect to the fourth aspect, in which a potential of the first fin is not less than -890 mV and not more than -750 mV.

**[0014]** In the air conditioner of the fifth aspect, the first fin of the first heat exchanger of the indoor unit has a high potential of not less than -890 mV and not more than -750 mV. Thus, excessive corrosion of the first fin can be suppressed.

**[0015]** An air conditioner according to a sixth aspect is the air conditioner according to any one of the first aspect to the fifth aspect, in which a potential of the first fin is not less than -890 mV and not more than -800 mV.

**[0016]** In the air conditioner of the sixth aspect, the first fin of the first heat exchanger of the indoor unit has a very high potential of not less than -890 mV and not more than -800 mV. Thus, excessive corrosion of the first fin can be further suppressed.

**[0017]** An air conditioner according to a seventh aspect is the air conditioner according to any one of the first aspect to the sixth aspect, in which a cooling operation and a heating operation are performed.

**[0018]** In the air conditioner of the seventh aspect, when the cooling operation and the heating operation are performed, it is possible to reduce the generation of the aluminum hydroxide due to the corrosion of the first fin and the first flat tube of the indoor unit.

## BRIEF DESCRIPTION OF DRAWINGS

**[0019]**

Fig. 1 is a schematic configuration diagram of an air conditioner according to an embodiment of the present disclosure.
Fig. 2 is a schematic view of an outdoor unit.
Fig. 3 is a cross-sectional view of first and second flat tubes.
Fig. 4 is a cross-sectional view of the first and second fins.
Fig. 5 is a diagram illustrating a method of measuring a potential in an example.
Fig. 6 is a diagram illustrating the method of measuring the potential in the example.
Fig. 7 is a diagram illustrating the method of measuring the potential in the example.

## DESCRIPTION OF EMBODIMENTS

### (1) Overall configuration

**[0020]** An air conditioner 1 according to an embodiment of the present disclosure will be described with reference to Figs. 1 to 4. As illustrated in Fig. 1, the air conditioner 1 is used for indoor cooling and heating for a building or the like by performing a vapor compression refrigeration cycle operation.

**[0021]** The air conditioner 1 mainly includes an indoor unit 2 and an outdoor unit 3, as well as a liquid-refrigerant connection pipe 4 and a gas-refrigerant connection pipe 5 that connect the indoor unit 2 and the outdoor unit 3. A vapor compression refrigerant circuit 10 of the air conditioner 1 is configured by connecting the indoor unit 2 and the outdoor unit 3 through the liquid-refrigerant connection pipe 4 and the gas-refrigerant connection pipe 5.

### (1-1) Indoor unit

**[0022]** The indoor unit 2 is installed in a room. The indoor unit 2 mainly includes a first heat exchanger 20 and a first fan 11.

**[0023]** The first heat exchanger 20 is a heat exchanger that functions as an evaporator of a refrigerant during the cooling operation and functions as a radiator of the refrigerant during the heating operation. The first heat exchanger 20 has the liquid side connected to the liquid-refrigerant connection pipe 4, and has the gas side connected to the gas-refrigerant connection pipe 5.

**[0024]** The first fan 11 sucks indoor air into the indoor unit 2, supplies the indoor air to the first heat exchanger 20, and then discharges the indoor air to the outside of the indoor unit 2.

### (1-2) Outdoor unit

**[0025]** The outdoor unit 3 is installed outdoors. The outdoor unit 3 mainly includes a compressor 12, a flow path switching mechanism 13, a second heat exchanger 30, and an expansion mechanism 14.

**[0026]** The compressor 12 is a mechanism that compresses a low-pressure refrigerant in the refrigeration cycle until the refrigerant reaches a high pressure.

**[0027]** The flow path switching mechanism 13 is a mechanism that switches the direction of the flow of the refrigerant when switching between the cooling operation and the heating operation. During the cooling operation, the flow path switching mechanism 13 connects the discharge side of the compressor 12 to the gas side of the second heat exchanger 30, and connects the gas side of the first heat exchanger 20 to the suction side of the compressor 12 through the gas-refrigerant connection pipe 5 (see the solid line of the flow path switching mechanism 13 in Fig. 1). During the heating operation, the flow path switching mechanism 13 connects the discharge side of the compressor 12 to the gas side of the first heat exchanger 20 through the gas-refrigerant connection pipe 5, and connects the gas side of the second heat exchanger 30 to the suction side of the compressor 12 (see the broken line of the flow path switching mechanism 13 in

Fig. 1).

**[0028]** The second heat exchanger 30 is a heat exchanger that functions as a radiator of the refrigerant during the cooling operation and functions as an evaporator of the refrigerant during the heating operation. The second heat exchanger 30 has the liquid side connected to the expansion mechanism 14, and has the gas side connected to the flow path switching mechanism 13.

**[0029]** The expansion mechanism 14 is a mechanism that decompresses the high-pressure liquid refrigerant that has radiated heat in the second heat exchanger 30 before being sent to the first heat exchanger 20 during the cooling operation, and decompresses the high-pressure liquid refrigerant that has radiated heat in the first heat exchanger 20 before being sent to the second heat exchanger 30 during the heating operation.

**[0030]** The outdoor unit 3 is provided with a second fan 15 for sucking outdoor air into the outdoor unit 3, supplying the outdoor air to the second heat exchanger 30, and then discharging the outdoor air to the outside of the outdoor unit 3.

(2) Detailed configuration

**[0031]** The first heat exchanger 20 and the second heat exchanger 30 will be described with reference to Figs. 2 to 4. The first heat exchanger 20 and the second heat exchanger 30 are micro-channel heat exchangers.

(2-1) First heat exchanger

**[0032]** As illustrated in Fig. 2, the first heat exchanger 20 includes a first flat tube 21 and a first fin 22. Here, a plurality of the first flat tubes 21 and a plurality of the first fins 22 are provided. The first fin 22 is joined to the first flat tube 21.

**[0033]** The first heat exchanger 20 implements heat exchange between the refrigerant flowing inside the first flat tubes 21 and the indoor air flowing outside the first flat tubes 21. With the first heat exchanger 20, the indoor air and the refrigerant exchange heat without being mixed with each other.

**[0034]** The material of the first flat tubes 21 and the first fins 22 is not particularly limited, and includes, for example, aluminum, copper, and the like. The first flat tubes 21 and the first fins 22 of the present embodiment are made of aluminum or an aluminum alloy.

(2-1-1) First flat tube

**[0035]** The plurality of first flat tubes 21 are arranged in the vertical direction. The refrigerant flows inside the first flat tubes 21. As illustrated in Figs. 2 and 3, the first flat tube 21 is a heat transfer tube having a flat shape. Here, the first flat tube 21 is a flat perforated tube. In the first flat tube 21, a plurality of through holes 211 through which the refrigerant to exchange heat with the indoor air in the first heat exchanger 20 passes are formed to be arranged side by side in a predetermined direction. The plurality of through holes 211 penetrate along the longitudinal direction.

**[0036]** As illustrated in Fig. 3, the first flat tube 21 includes a first base material 212 and a first surface layer 213.

**[0037]** The first surface layer 213 is provided on the surface of the first flat tube 21. The first surface layer 213 may be provided entirely on the surface of the first flat tube 21, or may be provided partially on the surface of the first flat tube 21 (not illustrated). In other words, the first surface layer 213 may be formed entirely on the exposed outer surface, or may be formed partially on the exposed outer surface (not illustrated). The first surface layer 213 is formed partially in the thickness direction from the outer surface of the first flat tube 21 toward the inner surface on which the refrigerant flows, and is not formed entirely over the thickness. In other words, in the first flat tube 21, the first surface layer 213 is not formed on at least a part of the inner surface on which the refrigerant flows. In the present embodiment, the first surface layer 213 is not formed entirely on the inner surface of the first flat tube 21.

**[0038]** The first surface layer 213 is less noble in potential than the first base material 212. Therefore, in the first flat tube 21, the first surface layer 213 on the outer surface side is a sacrificial layer that prevents the progress of corrosion of the first base material 212 on the inner surface side.

**[0039]** The first surface layer 213 contains a metal such as zinc in order to lower the potential. The first surface layer 213 of the present embodiment is a zinc diffusion layer in which zinc is thermally sprayed.

(2-1-2) First fin

**[0040]** As illustrated in Fig. 2, the first fins 22 are joined to the plurality of first flat tubes 21. Here, the first flat tubes 21 and the first fins 22 are joined to each other by brazing. The first fins 22 may or may not be in contact with the first flat tubes 21. The first fins 22 increase the heat transfer area between the first flat tubes 21 and the indoor air to facilitate the heat exchange between the refrigerant and the indoor air.

**[0041]** The first fins 22 are stacked in the longitudinal direction in which the first flat tubes 21 extend. Here, the plurality of first fins 22 extend in the vertical direction so as to intersect (orthogonally in Fig. 2) with the first flat tubes 21.

**[0042]** The first fin 22 is a flat plate-shaped member. Further, the first fin 22 has notches for allowing insertion of the plurality of first flat tubes 21. These plurality of notches are arranged in the vertical direction. The first fin 22 may have a collar portion.

**[0043]** As illustrated in Fig. 4, the first fin 22 includes a first body portion 221 and a first surface layer 222.

**[0044]** The first surface layer 222 is provided on the surface of the first body portion 221. Here, the first surface layer 222 is provided on both surfaces extending in the longitudinal direction of the first body portion 221.

**[0045]** The thickness of the first surface layer 222 is smaller than the thickness of the first body portion 221. The thickness of each of the first fins 22 is the maximum value of the distance from the outer surface toward the inside.

**[0046]** The first surface layer 222 is less noble in potential than the first body portion 221. Therefore, in the first fin 22, the first surface layer 222 on the outer surface side is a sacrificial layer that prevents the progress of corrosion of the first body portion 221 on the inner surface side.

**[0047]** The first fin 22 contains a metal such as zinc in order to lower the potential. The first surface layer 222 of the present embodiment is a zinc diffusion layer in which zinc is thermally sprayed. The first fin 22 may further contain magnesium, copper, and the like.

**[0048]** The first fin 22 may be electrically less noble or more noble than the first flat tube 21. Specifically, the first surface layer 222 of the first fin 22 may be electrically less noble or more noble than the first surface layer 213 of the first flat tube 21. In other words, the potential may increase in the order of the first surface layer 213 of the first flat tube 21, the first fin 22, and the first base material 212 of the first flat tube 21, or the potential may increase in the order of the first fin 22, the first surface layer 213 of the first flat tube 21, and the first base material 212 of the first flat tube 21. Still, the first fin 22 is electrically less noble than the first base material 212. In the present embodiment, the potential of the first fin 22 is higher than the potential of the first flat tube 21.

**[0049]** The potential of the first fin 22 of the present embodiment is not less than -890 mV and not more than -750 mV, preferably not less than -890 mV and not more than -800 mV, and more preferably not less than -850 mV and not more than -800 mV. The potential of the first fin 22 is the potential of the outermost surface. Therefore, the potential of the first fin 22 is the potential of the first surface layer 222 when the first fin 22 includes the first surface layer 222, and is the potential of the first body portion 221 when the first fin 22 does not include the first surface layer 222.

**[0050]** Such a potential of the first fin 22 is achieved by adjusting the amount of metal such as zinc contained to lower the potential.

**[0051]** In the present embodiment, the potential difference between the first fin 22 and the first flat tube 21 is not less than 20 mV and not more than 60 mV. This potential difference is the absolute value of the difference between the potential of the first flat tube 21 and the potential of the first fin 22. Specifically, this potential difference is the absolute value of the difference between the potential of the outer surface of the first flat tube 21 and the potential of the outer surface of the first fin 22.

**[0052]** Such a potential difference is achieved by adjusting the amount of metal such as zinc contained in the first fins 22 and the first flat tubes 21 to lower the potential.

**[0053]** Note that the potentials of the first flat tubes 21 and the first fins 22 are values obtained by taking out some of the first flat tubes 21 and the first fins 22 from the first heat exchanger 20, producing test pieces, and measuring the test pieces by a three-electrode method.

(2-1-3) Brazing material

**[0054]** The first heat exchanger 20 further includes a brazing material (not illustrated) connecting the first flat tubes 21 and the first fins 22. The brazing material of the present embodiment contains aluminum.

(2-2) Second heat exchanger

**[0055]** As illustrated in Fig. 2, the second heat exchanger 30 includes a second flat tube 31 and a second fin 32. Here, a plurality of the second flat tubes 31 and a plurality of the second fins 32 are provided. The second fin 32 is joined to the second flat tube 31.

**[0056]** The second heat exchanger 30 implements heat exchange between the refrigerant flowing inside the second flat tubes 31 and the outdoor air flowing outside the second flat tubes 31. With the second heat exchanger 30, the outdoor air and the refrigerant exchange heat without being mixed with each other.

**[0057]** The material of the second flat tubes 31 and the second fins 32 is not particularly limited, and includes, for example, aluminum, copper, and the like. The second flat tubes 31 and the second fins 32 of the present embodiment are made of aluminum or an aluminum alloy.

(2-2-1) Second flat tube

**[0058]** The plurality of second flat tubes 31 are arranged in the vertical direction. The refrigerant flows inside the second flat tubes 31. As illustrated in Figs. 2 and 3, the second flat tube 31 is a heat transfer tube having a flat shape. Here, the second flat tube 31 is a flat perforated tube. In the second flat tube 31, a plurality of through holes 311 through which the refrigerant to exchange heat with the outdoor air in the second heat exchanger 30 passes are formed to be arranged side by side in a predetermined direction. The plurality of through holes 311 penetrate along the longitudinal direction.

**[0059]** As illustrated in Fig. 3, the second flat tube 31 includes a second base material 312 and a second surface layer 313.

**[0060]** The second surface layer 313 is provided on the surface of the second flat tube 31. The second surface layer 313 may be provided entirely on the surface of the second flat tube 31, or may be provided partially on the surface of the second flat tube 31 (not illustrated). In other words, the second surface layer 313 may be formed entirely on the exposed outer surface, or may be formed partially on the exposed outer surface (not illustrated). The second surface layer 313 is formed partially in the thickness direction from the outer surface of the second flat tube 31 toward the inner surface on which the refrigerant flows, and is not formed entirely over the thickness. In other words, in the second flat tube 31, the second surface layer 313 is not formed on at least a part of the inner surface on which the refrigerant flows. In the present embodiment, the second surface layer 313 is not formed entirely on the inner surface of the second flat tube 31.

**[0061]** The second surface layer 313 is less noble in potential than the second base material 312. Therefore, in the second flat tube 31, the second surface layer 313 on the outer surface side is a sacrificial layer that prevents the progress of corrosion of the second base material 312 on the inner surface side.

**[0062]** Note that the potentials of the second base material 312 and the second surface layer 313 are values obtained by taking out some of the second base materials 312 and the second surface layers 313 from the second heat exchanger 30, producing test pieces, and measuring the test pieces by the three-electrode method.

**[0063]** The second surface layer 313 contains a metal such as zinc in order to lower the potential. The second surface layer 313 of the present embodiment is a zinc diffusion layer in which zinc is thermally sprayed.

(2-2-2) Second fin

**[0064]** As illustrated in Fig. 2, the second fins 32 are joined to the plurality of second flat tubes 31. Here, the second flat tubes 31 and the second fins 32 are joined to each other by brazing. The second fins 32 may or may not be in contact with the second flat tubes 31. The second fins 32 increase the heat transfer area between the second flat tubes 31 and the indoor air to promote heat exchange between the refrigerant and the indoor air.

**[0065]** The second fins 32 are stacked in the longitudinal direction in which the second flat tubes 31 extend. Here, the plurality of second fins 32 extend in the vertical direction so as to intersect (orthogonally in Fig. 2) with the second flat tubes 31.

**[0066]** The second fin 32 is a flat plate-shaped member. Further, the second fin 32 has notches for allowing insertion of the plurality of second flat tubes 31. These plurality of notches are arranged in the vertical direction. The second fin 32 may have a collar portion.

**[0067]** As illustrated in Fig. 4, the second fin 32 includes a second body portion 321 and a second surface layer 322.

**[0068]** The second surface layer 322 is provided on the surface of the second body portion 321. Here, the second surface layer 322 is provided on both surfaces extending in the longitudinal direction of the second body portion 321.

**[0069]** The thickness of the second surface layer 322 is smaller than the thickness of the second body portion 321. The thickness of each of the second fins 32 is the maximum value of the distance from the outer surface toward the inside.

**[0070]** The second surface layer 322 is less noble in potential than the second body portion 321. Therefore, in the second fin 32, the second surface layer 322 on the outer surface side is a sacrificial layer that prevents the progress of corrosion of the second body portion 321 on the inner surface side.

**[0071]** The second fin 32 contains a metal such as zinc in order to lower the potential. The second surface layer 322 of the present embodiment is a zinc diffusion layer in which zinc is thermally sprayed. The second fin 32 may further contain magnesium, copper, and the like.

**[0072]** The second fin 32 may be electrically less noble or more noble than the second flat tube 31. Specifically, the second surface layer 322 of the second fin 32 may be electrically less noble or more noble than the second surface layer 313 of the second flat tube 31. In other words, the potential may increase in the order of the second surface layer 313 of the second flat tube 31, the second fin 32, and the second base material 312 of the second flat tube 31, or the potential may increase in the order of the second fin 32, the second surface layer 313 of the second flat tube 31, and the second base material 312 of the second flat tube 31. Still, the second fin 32 is electrically less noble than the second base material 312.

**[0073]** The potential of the second fin 32 is a value obtained by taking out some of the second fins 32 from the second heat exchanger 30, producing test pieces, and measuring the test pieces by the three-electrode method.

(2-2-3) Brazing material

**[0074]** The second heat exchanger 30 further includes a brazing material (not illustrated) connecting the second flat tubes 31 and the second fins 32. The brazing material of the present embodiment contains aluminum.

(2-3) Relationship between first heat exchanger and second heat exchanger

**[0075]** The potential of the first fin 22 is higher than the potential of the second fin 32, and is preferably not less than 110% of the potential of the second fin 32. The potential of the first fin 22 is the potential of the outer surface of the first fin 22. The potential of the second fin 32 is the potential of the outer surface of the second fin 32.

**[0076]** Further, the potential difference between the first fin 22 and the first flat tube 21 is smaller than the potential difference between the second fin 32 and the second flat tube 31, and is preferably not larger than 90% of the potential difference between the second fin 32 and the second flat tube 31. For example, the potential difference between the first fin 22 and the first flat tube 21 is lower than the potential difference between the second fin 32 and the second flat tube 31 by not less than 20 mV and not more than 60 mV, and preferably by not less than 30 mV and not more than 50 mV. Here, the potential difference between the first fin 22 and the first flat tube 21 is the absolute value of the difference between the potential of the first flat tube 21 and the potential of the first fin 22. The potential difference between the second fin 32 and the second flat tube 31 is the absolute value of the difference between the potential of the second fin 32 and the potential of the second flat tube 31. Specifically, the potential difference between the first fin 22 and the first flat tube 21 is the absolute value of the difference between the potential of the outer surface of the first flat tube 21 and the potential of the outer surface of the first fin 22. The potential difference between the second fin 32 and the second flat tube 31 is the absolute value of the difference between the potential of the outer surface of the second flat tube 31 and the potential of the outer surface of the second fin 32.

**[0077]** Such a potential is achieved by adjusting the amount of metal such as zinc contained in the first flat tubes 21, the first fins 22, the second flat tubes 31, and the second fins 32 in order to lower the potential.

(3) Operation

(3-1) Cooling operation

**[0078]** When the air conditioner 1 performs the cooling operation, a low-pressure refrigerant in the refrigeration cycle is sucked into the compressor 12, compressed to a high pressure in the refrigeration cycle, and then discharged. The high-pressure refrigerant discharged from the compressor 12 is sent to the second heat exchanger 30 through the flow path switching mechanism 13. The high-pressure refrigerant sent to the second heat exchanger 30 exchanges heat with the outdoor air supplied by the second fan 15 and radiates heat in the second heat exchanger 30. The high-pressure refrigerant having radiated heat in the second heat exchanger 30 is sent to the expansion mechanism 14 and is decompressed to a low pressure in the refrigeration cycle. The low-pressure refrigerant decompressed in the expansion mechanism 14 is sent to the first heat exchanger 20 through the liquid-refrigerant connection pipe 4. The low-pressure refrigerant sent to the first heat exchanger 20 exchanges heat with the indoor air supplied by the first fan 11 and evaporates in the first heat exchanger 20. As a result, the indoor air is cooled and blown into the room. The low-pressure refrigerant having evaporated in the first heat exchanger 20 is sucked into the compressor 12 again through the gas-refrigerant connection pipe 5 and the flow path switching mechanism 13.

(3-2) Heating operation

**[0079]** When the air conditioner 1 performs the heating operation, a low-pressure refrigerant in the refrigeration cycle is sucked into the compressor 12, compressed to a high pressure in the refrigeration cycle, and then discharged. The high-pressure refrigerant discharged from the compressor 12 is sent to the first heat exchanger 20 through the flow path switching mechanism 13 and the gas-refrigerant connection pipe 5. The high-pressure refrigerant sent to the first heat exchanger 20 exchanges heat with the indoor air supplied by the first fan 11 and radiates heat in the first heat exchanger 20. As a result, the indoor air is heated and blown into the room. The high-pressure refrigerant having radiated heat in the first heat exchanger 20 is sent to the expansion mechanism 14 through the liquid-refrigerant connection pipe 4, and is decompressed to a low pressure in the refrigeration cycle. The low-pressure refrigerant decompressed in the expansion mechanism 14 is sent to the second heat exchanger 30. The low-pressure refrigerant sent to the second heat exchanger 30 exchanges heat with the outdoor air supplied by the second fan 15 and evaporates in the second heat exchanger 30. The low-pressure refrigerant having evaporated in the second heat exchanger 30 is sucked into the compressor 12 again through the flow path switching mechanism 13.

(4) Features

(4-1)

**[0080]** According to a possible technique, in a cross-fin heat exchanger, a resin layer may be formed on a surface of a fin to insulate the fin from a heat transfer tube to suppress corrosion. However, since a fin and a heat transfer tube (flat tube) are brazed in the microchannel heat exchanger, the resin layer cannot be formed on the surface of the fin. Therefore, when there is a potential difference between the fin and the heat transfer tube, the fin or the heat transfer tube corrodes. For example, to prevent corrosion of the heat transfer tube in order to prevent refrigerant leakage, the potential of the fin may be made lower than the potential of the heat transfer tube. In this case, the fin containing aluminum preferentially corrodes to generate aluminum hydroxide. When this microchannel heat exchanger is provided in an indoor unit, there arises the problem that white powdery aluminum hydroxide may scatter into the room. The inventor of the present invention has arrived at the air conditioner 1 of the present disclosure in view of such a problem.

**[0081]** Specifically, the problem of scattering of powder derived from corrosion is not a big problem with the outdoor unit, but is problematic with the indoor unit, and thus is a problem unique to the indoor unit. On the other hand, there is another problem in that the outdoor unit is more likely to corrode due to a higher abundance of chloride ions in the air than the indoor unit. As a result of intensive studies to solve these problems, the inventor of the present invention has drawn idea from the relationship between the potential of the fin and the flat tube of the indoor unit and the potential of the fin and the flat tube of the outdoor unit.

**[0082]** Thus, the air conditioner 1 according to the present embodiment includes the indoor unit 2 and the outdoor unit 3. The indoor unit 2 includes the first heat exchanger 20. The outdoor unit 3 includes the second heat exchanger 30. The first heat exchanger 20 includes the first flat tube 21 and the first fin 22. The first fin 22 is joined to the first flat tube 21. The second heat exchanger 30 includes the second flat tube 31 and the second fin 32. The second fin 32 is joined to the second flat tube 31. The potential difference between the first fin 22 and the first flat tube 21 is smaller than the potential difference between the second fin 32 and the second flat tube 31.

**[0083]** With the air conditioner 1 of the present embodiment, since the potential difference between the first fin 22 and the first flat tube 21 of the indoor unit 2 is made smaller than the potential difference between the second fin 32 and the second flat tube 31 of the outdoor unit 3, it is possible to effectively suppress corrosion of the first fin 22 and the first flat tube 21 of the indoor unit 2 of the microchannel heat exchanger. Thus, it is possible to further reduce the generation of aluminum hydroxide due to the first fin 22 and the first flat tube 21. Therefore, scattering of the white powdery aluminum hydroxide into the room can be suppressed.

**[0084]** Since the potential difference between the second fin 32 and the second flat tube 31 of the outdoor unit 3 can be made larger than the potential difference between the first fin 22 and the first flat tube 21 of the indoor unit 2, corrosion of the second base material 312 of the second flat tube 31 of the outdoor unit 3 can be suppressed.

**[0085]** In addition, since the outdoor unit 3 is more likely to corrode than the indoor unit 2, the potential of the second fin 32 of the outdoor unit 3 is preferably made lower than the potential of the second flat tube 31. In this way, in order to suppress corrosion of the second flat tube 31 and prevent refrigerant leakage, a potential design can be adopted in which the second fin 32 preferentially corrode. Also in this case, while the generation of the aluminum hydroxide in the outdoor unit 3 would not be a big problem, by reducing the potential difference between the first fin 22 and the first flat tube 21 of the indoor unit 2, powder scattering from the indoor unit 2 can be suppressed.

**[0086]** (4-2)

In the air conditioner 1 according to the present embodiment, the potential of the first fin 22 is higher than the potential of the second fin 32.

**[0087]** Here, by making the potential of the first fin 22 of the indoor unit 2 higher than the potential of the second fin 32 of the outdoor unit 3, the corrosion of the first fin 22 is suppressed, and thus the scattering of aluminum hydroxide into the room can be further suppressed.

**[0088]** (4-3)

In the air conditioner 1 according to the present embodiment, the potential of the first fin 22 is higher than the potential of the first flat tube 21.

**[0089]** Here, by making the potential of the first fin 22 higher than the potential of the first flat tube 21, it is possible to further suppress scattering of aluminum hydroxide into the room by suppressing corrosion of the first fin 22.

**[0090]** (4-4)

In the air conditioner 1 according to the present embodiment, the potential difference between the first fin 22 and the first flat tube 21 is not less than 20 mV and not more than 60 mV.

**[0091]** Here, the potential difference between the first fin 22 and the first flat tube 21 of the indoor unit 2 is made as small as not less than 20 mV and not more than 60 mV. Accordingly, it is possible to further reduce the generation of aluminum hydroxide due to corrosion of the first fin 22 and the first flat tube 21.

**[0092]** (4-5)

In the air conditioner 1 according to the present embodiment, the potential of the first fin 22 is not less than -890 mV and not more than -750 mV.

**[0093]** Here, the first fin 22 of the first heat exchanger 20 of the indoor unit 2 is designed to be at a high potential that is not less than -890 mV and not more than -750 mV. Thus, it is possible to reduce generation of aluminum hydroxide due to corrosion of the first fin 22 without excessively corroding the first fin 22.

**[0094]** Further, in the indoor unit 2 of the present embodiment, excessive corrosion of the first fin 22 can be suppressed, and therefore, a corrosive odor can also be suppressed.

**[0095]** (4-6)

In the air conditioner 1 according to the present embodiment, the potential of the first fin 22 is not less than -890 mV and not more than -800 mV.

**[0096]** Here, the first fin 22 of the first heat exchanger 20 of the indoor unit 2 is designed to be at a high potential that is not less than -890 mV and not more than -800 mV. Thus, it is possible to further reduce generation of aluminum hydroxide due to corrosion of the first fin 22 without excessively corroding the first fin 22.

**[0097]** (4-7)

The air conditioner 1 according to the present embodiment performs a cooling operation and a heating operation.

**[0098]** In the present embodiment, excessive corrosion of the first fin 22 and the first flat tube 21 can be suppressed even when operation that causes condensation in the evaporator is performed. Therefore, when the air conditioner 1 performs the cooling operation and the heating operation, it is possible to reduce the generation of aluminum hydroxide due to the corrosion of the first fin 22 and the first flat tube 21 of the indoor unit 2.

(5) Modifications

(5-1) Modification 1

**[0099]** In the above embodiment, the first fin 22 has the first surface layer 222, and the second fin 32 has the second surface layer 322, but the present disclosure is not limited to this. At least one of the first fin 22 and the second fin 32 of the present disclosure may not have a surface layer.

(5-2) Modification 2

**[0100]** In the above-described embodiment, the first flat tube 21 has the first surface layer 213, and the second flat tube 31 has the second surface layer 313, but the present disclosure is not limited to this. At least one of the first flat tube 21 and the second flat tube 31 of the present disclosure may not have a surface layer.

(5-3) Modification 3

**[0101]** In the above-described embodiment, the first surface layer 213 of the first flat tube 21 and the second surface layer 313 of the second flat tube 31 are described to be a diffusion layer in which zinc is thermally sprayed as an example, but the present disclosure is not limited to this. In the present modification, a clad material is used for the base material and the surface layer.

**[0102]** Specifically, the first flat tube 21 is formed using a clad material in which a metal to be the first base material 212 and a metal to be the first surface layer 213 are bonded together. The second flat tube 31 is formed using a clad material in which a metal to be the second base material 312 and a metal to be the second surface layer 313 are bonded together.

(5-4) Modification 4

**[0103]** In the above embodiment, the air conditioner 1 performing the cooling operation and the heating operation is described as an example. However, the air conditioner of the present disclosure is not limited to this. The air conditioner of the present disclosure may further perform a dehumidifying operation, or may be dedicated to cooling.

## EXAMPLES

**[0104]** In the examples, the effect of making the potential difference between the first fin 22 and the first flat tube 21 of the indoor unit 2 smaller than the potential difference between the second fin 32 and the second flat tube 31 of the outdoor unit 3 was investigated.

(EXAMPLE 1)

**[0105]** In Example 1, the air conditioner 1 illustrated in Fig. 1 including microchannel heat exchangers as the first heat exchanger 20 of the indoor unit 2 and the second heat exchanger 30 of the outdoor unit 3 was manufactured.

**[0106]** Specifically, for the first flat tube 21, zinc was thermally sprayed on the surface of the first base material 212 made of aluminum to form the first surface layer 213. For the first fin 22, zinc was thermally sprayed on the surface of the first body portion 221 made of aluminum to form the first surface layer 222. The first flat tube 21 and the first fin 22 were joined together using a brazing material containing aluminum to produce the first heat exchanger 20.

**[0107]** Further, for the second flat tube 31, zinc was thermally sprayed on the surface of the second base material 312 made of aluminum to form the second surface layer 313. For the second fin 32, zinc was thermally sprayed on the surface of the second body portion 321 made of aluminum to form the second surface layer 322. The second flat tube 31 and the second fin 32 were joined together using a brazing material containing aluminum to produce the second heat exchanger 30. In Example 1, the zinc content rate of the first fin 22 was lower than the zinc content rate of the second fin 32.

(Comparative Example 1)

**[0108]** Comparative Example 1 was basically the same as Example 1, except for the first fin of the first heat exchanger of the indoor unit. Specifically, the zinc content rate of a first fin of an indoor unit of Comparative Example 1 was made to be the same as the zinc content rate of a second fin of an outdoor unit.

(Measurement method and results)

**[0109]** The potentials of the first base material and the first surface layer of the first flat tube, the first surface layer of the first fin, the second base material and the second surface layer of the second flat tube, and the second surface layer of the second fin of Example 1 and Comparative Example 1 were measured. The measurement method is as follows.

**[0110]** A portion of the first base material and the first surface layer of the first flat tube, the first surface layer of the first fin, the second base material and the second surface layer of the second flat tube, and the second surface layer of the second fin were taken out from the first heat exchanger and the second heat exchanger to produce test pieces, and the test pieces were measured by the three-electrode method. Specifically, as illustrated in Fig. 5, the length of the test pieces S was set to 40 mm. Then, as illustrated in Fig. 6, epoxy resin R was attached to the test pieces S, and a test surfaces S1 were exposed. The test surfaces S1 were designed to have the entire circumference length of 10 mm. A 2.67% aluminum chloride aqueous solution was used as a test solution. A saturated calomel electrode was used as a reference electrode. Platinum was used for a counter electrode. As illustrated in Fig. 7, the test pieces S were connected to the counter electrode using a lead wire. Then, the potential of the test surfaces S1 was measured by the three-electrode method in a state of being opened to the atmosphere, at a temperature of 40 °C, and with the pH of the test solution adjusted.

**[0111]** Table 1 below lists the results of the measurement of the potentials of Example 1 and Comparative Example 1.

<Table 1>

| | Indoor unit | | | Outdoor unit | | |
|---|---|---|---|---|---|---|
| | First fin | First surface layer | First base material | Second fin | Second surface layer | Second base material |
| Example 1 | -800 mV | -830 mV | -700 mV | -900 mV | -830 mV | -700 mV |
| Comparative example 1 | -900 mV | -830 mV | -700 mV | -900 mV | -830 mV | -700 mV |

**[0112]** As listed in Table 1, in Example 1, the potential (-800 mV) of the first fin was higher than the potential (-900 mv) of the second fin. Further, in Example 1, the potential difference between the first fin and the first flat tube was 30 mV. In Example 1, the potential difference (30 mV) between the first fin and the first flat tube was smaller than the potential difference (70 mV) between the second fin and the second flat tube.

(Evaluation method and results)

**[0113]** For the air conditioner of Example 1 and the air conditioner of Comparative Example 1, whether aluminum hydroxide scattered from the indoor unit after the cooling operation and the heating operation were performed was visually confirmed.

**[0114]** With the air conditioner of Comparative Example 1 in which the potential difference between the first fin 22 and the first flat tube 21 of the indoor unit 2 was the same as the potential difference between the second fin 32 and the second flat tube 31 of the outdoor unit 3, aluminum hydroxide scattered from the indoor unit. On the other hand, with the air conditioner of Example 1 in which the potential difference between the first fin 22 and the first flat tube 21 of the indoor unit 2 was smaller than the potential difference between the second fin 32 and the second flat tube 31 of the outdoor unit 3, aluminum hydroxide did not scatter from the indoor unit.

**[0115]** From the above, it was confirmed that by making the potential of the first fin 22 and the first flat tube 21 of the indoor unit 2 smaller than the potential of the second fin 32 and the second flat tube 31 of the outdoor unit 3, the generation of aluminum hydroxide due to the corrosion of the first fin and the first flat tube is reduced, and thus the scattering of aluminum hydroxide into the room can be suppressed. Furthermore, it was also confirmed that when the potential of the first fin is high, that is, not less than -890 mV and not more than -750 mV, the generation of aluminum hydroxide due to the corrosion of the first fin was reduced, and thus the scattering of aluminum hydroxide into the room can be suppressed.

**[0116]** While embodiments of the present disclosure have been described above, it should be understood that various changes in mode and detail may be made without departing from the spirit and scope of the present disclosure as set forth in the claims.

## REFERENCE SIGNS LIST

**[0117]**

| | |
|---|---|
| 1 | Air conditioner |
| 2 | Indoor unit |
| 3 | Outdoor unit |
| 20 | First heat exchanger |
| 21 | First flat tube |
| 22 | First fin |
| 30 | Second heat exchanger |
| 31 | Second flat tube |
| 32 | Second fin |

## CITATION LIST

### PATENT LITERATURE

**[0118]** PTL 1: Japanese Unexamined Patent Application Publication No. 2013-43216

## Claims

**1.** An air conditioner (1) comprising:

an indoor unit (2) including a first heat exchanger (20); and
an outdoor unit (3) including a second heat exchanger (30), wherein
the first heat exchanger includes
a first flat tube (21), and
a first fin (22) joined to the first flat tube,
the second heat exchanger includes
a second flat tube (31), and
a second fin (32) joined to the second flat tube, and
a potential difference between the first fin and the first flat tube is smaller than a potential difference between the second fin and the second flat tube.

**2.** The air conditioner according to claim 1, wherein a potential of the first fin is higher than a potential of the second fin.

**3.** The air conditioner according to claim 1 or 2, wherein a potential of the first fin is higher than a potential of the first flat tube.

**4.** The air conditioner according to any one of claims 1 to 3, wherein the potential difference between the first fin and the first flat tube is not less than 20 mV and not more than 60 mV.

**5.** The air conditioner according to any one of claims 1 to 4, wherein a potential of the first fin is not less than -890 mV and not more than -750 mV.

**6.** The air conditioner according to any one of claims 1 to 5, wherein a potential of the first fin is not less than -890 mV and not more than -800 mV.

**7.** The air conditioner according to any one of claims 1 to 6, wherein a cooling operation and a heating operation are performed.

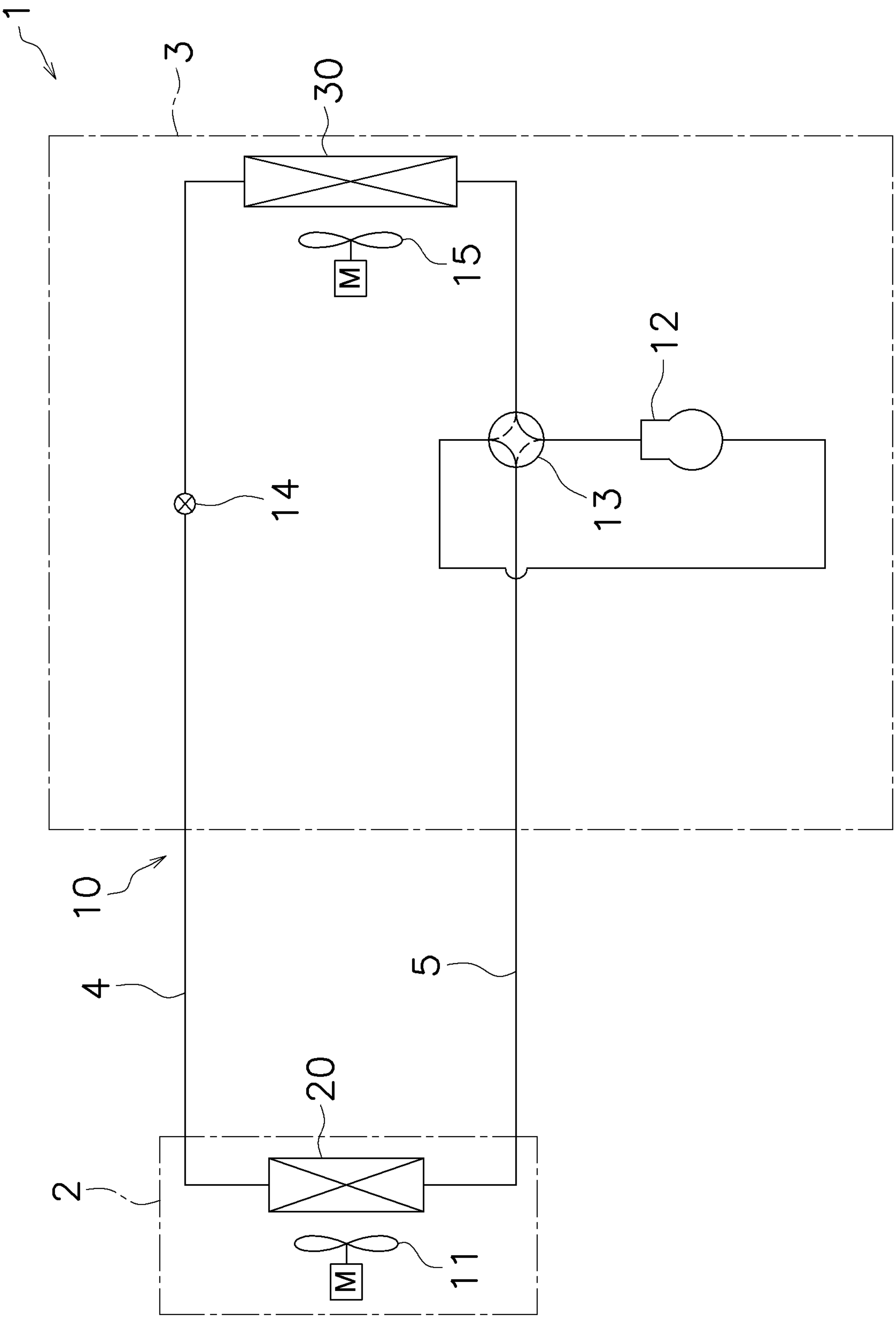


FIG. 1

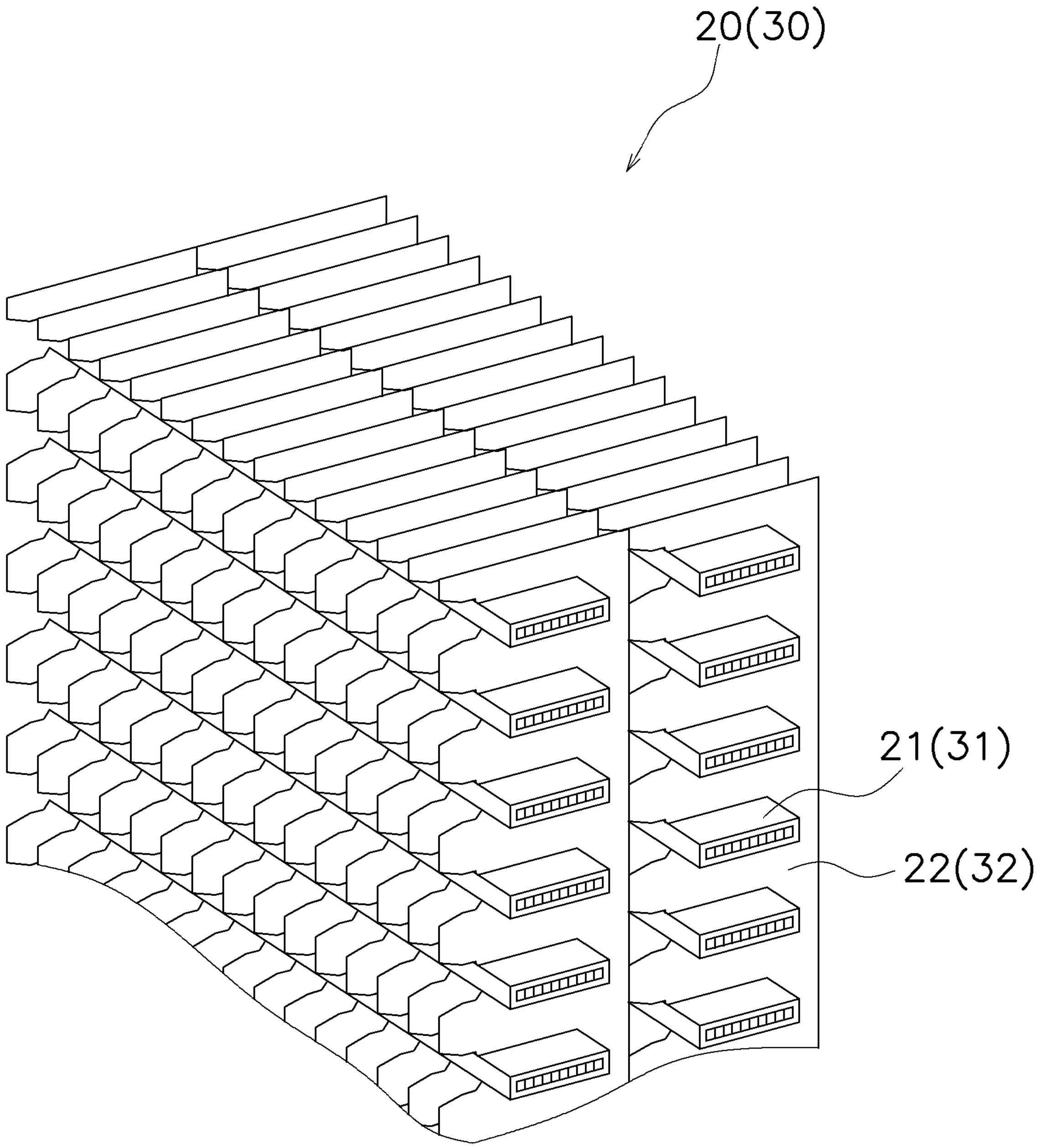


FIG. 2

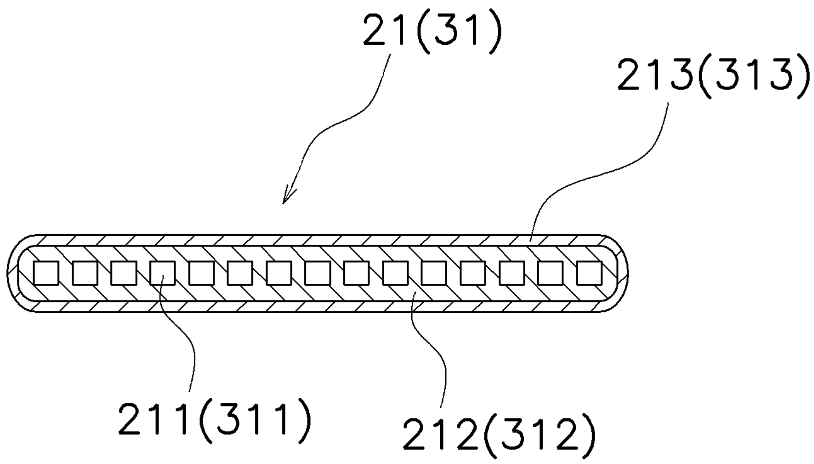


FIG. 3

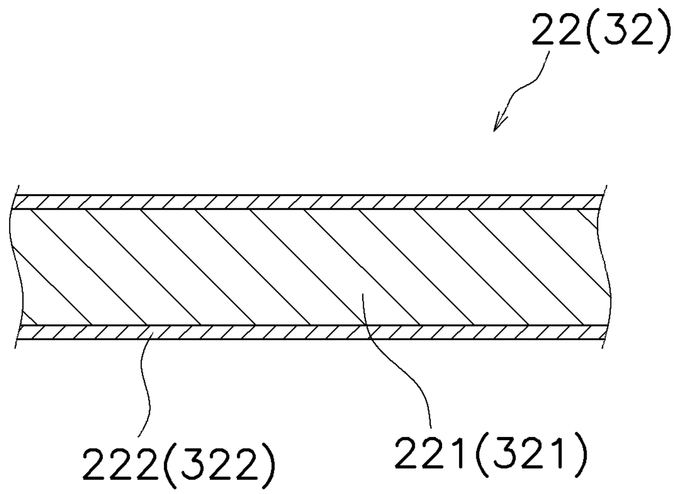


FIG. 4

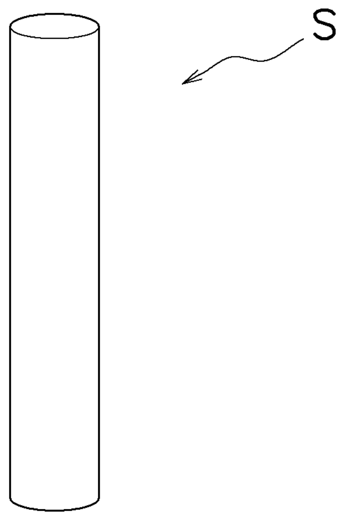


FIG. 5

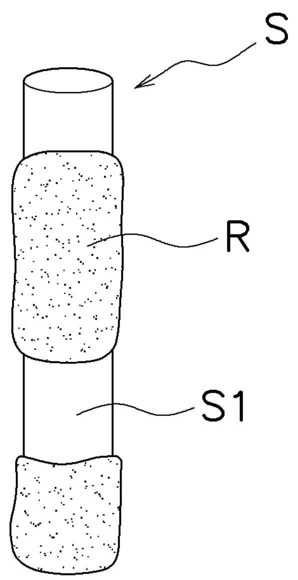


FIG. 6

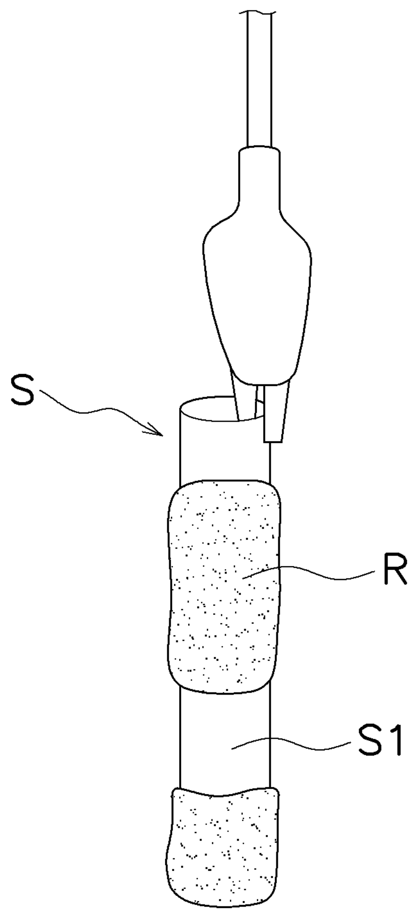


FIG. 7

## INTERNATIONAL SEARCH REPORT

International application No.
**PCT/JP2024/009302**

**A. CLASSIFICATION OF SUBJECT MATTER**

***F28F 19/00***(2006.01)i; ***F24F 1/0059***(2019.01)i; ***F24F 1/14***(2011.01)i; ***F25B 39/00***(2006.01)i; ***F28D 1/053***(2006.01)i
FI: F28F19/00 511Z; F24F1/0059; F24F1/14; F25B39/00 D; 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)

F28F1/00-99/00; F24F1/0059; F24F1/14; F25B39/00-39/04; F28D1/00-21/00

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2024
Registered utility model specifications of Japan 1996-2024
Published registered utility model applications of Japan 1994-2024

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. |
|---|---|---|
| A | JP 2015-117876 A (NIPPON LIGHT METAL COMPANY, LTD.) 25 June 2015 (2015-06-25) in particular, paragraphs [0012]-[0015] | 1-7 |
| A | WO 2022/197118 A1 (SAMSUNG ELECTRONICS CO., LTD.) 22 September 2022 (2022-09-22) in particular, paragraphs [0083]-[0126] | 1-7 |
| A | WO 2019/077744 A1 (MITSUBISHI ELECTRIC CORPORATION) 25 April 2019 (2019-04-25) in particular, paragraphs [0045]-[0050] | 1-7 |
| P, A | JP 2023-151215 A (DAIKIN INDUSTRIES, LTD.) 16 October 2023 (2023-10-16) paragraphs [0023]-[0087] | 1-7 |

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

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| **02 May 2024** | **04 June 2024** |

| Name and mailing address of the ISA/JP | Authorized officer |
|---|---|
| **Japan Patent Office (ISA/JP)**<br>**3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915**<br>**Japan** | Telephone No. |

Form PCT/ISA/210 (second sheet) (July 2022)

**INTERNATIONAL SEARCH REPORT**
**Information on patent family members**

International application No.
**PCT/JP2024/009302**

| Patent document cited in search report | Publication date (day/month/year) | Patent family member(s) | Publication date (day/month/year) |
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Form PCT/ISA/210 (patent family annex) (July 2022)

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