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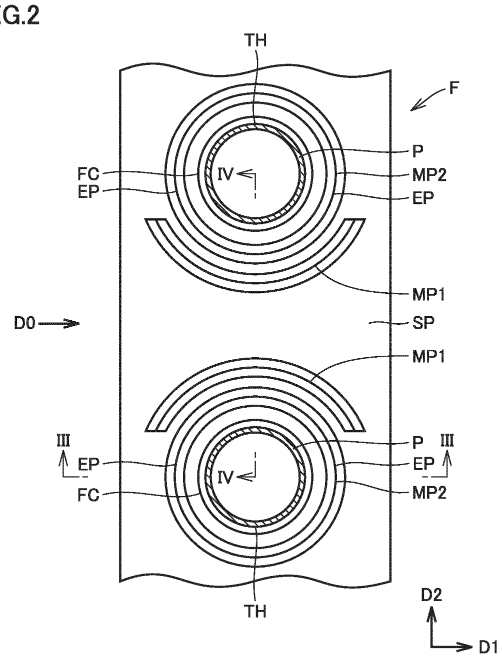
(54) HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE

(57) A heat exchanger (HE) includes: a fin (F) extending in a widthwise direction (D1) along an air flow direction (D0) and extending in a longitudinal direction (D2) crossing the air flow direction (DO); and a heat transfer tube (P) passing through the fin (F). The fin (F) has a through hole (TH). The heat transfer tube (P) is inserted into the through hole (TH). Each fin (F) includes a planar portion (SP), and a first protruding portion (MP1) and a second protruding portion (MP2) protruding from the planar portion (SP). The first protruding portion (MP1) is curved along the longitudinal direction (D2). The second protruding portion (MP2) has an extending portion (EP) extending in the longitudinal direction (D2). The extending portion (EP) is located to overlap a center of the through hole (TH) in the widthwise direction (D1).

FIG.2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger and a refrigeration cycle apparatus.

BACKGROUND ART

[0002] Conventionally, there has been a fin-and-tube-type heat exchanger including a fin and a heat transfer tube passing through the fin. For example, in a heat exchanger described in Japanese Patent Laying-Open No. 2005-77083 (PTL 1), a fin includes a seat portion (planar portion), and peak and valley portions. The seat portion is concentrically formed around an outer circumference of a fin collar to guide air flowing around a heat transfer tube to thereby reduce a wake region. The seat portion is provided with opened front and rear portions. The peak and valley portions are continuously formed between the fin collars to provide airflow variation.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2005-77083

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In the heat exchanger described in the literature above, the peak and valley portions are continuously formed along an air flow direction, and thus, a boundary layer starting from the peak portion is formed. Therefore, the valley portion forms a dead water region. As a result, a local heat transfer coefficient in the valley portion decreases, which leads to a decrease in heat transfer coefficient of the entire fin. In addition, stress concentrates on the planar portion provided with no peak and valley portions, and thus, the fin has insufficient strength.

[0005] The present disclosure has been made in view of the above problem. An object of the present disclosure is to provide a heat exchanger and a refrigeration cycle apparatus that can improve a heat transfer efficiency and improve a strength of a fin.

SOLUTION TO PROBLEM

[0006] A heat exchanger of the present disclosure includes: a fin extending in a widthwise direction along an air flow direction and extending in a longitudinal direction crossing the air flow direction; and a heat transfer tube passing through the fin. The fin has a through hole. The heat transfer tube is inserted into the through hole. The fin includes a planar portion, and a first protruding portion and a second protruding portion protruding from the planar portion. The first protruding portion is curved along the longitudinal direction. The second protruding portion has an extending portion extending in the longitudinal direction. The extending portion is located to overlap a center of the through hole in the widthwise direction.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the heat exchanger of the present disclosure, the first protruding portion and the second protruding portion protrude from the planar portion, and thus, an influence of a dead water region can be suppressed. Therefore, an improvement in heat transfer coefficient of the fin can be achieved. Also, the strength of the fin can be improved by the first protruding portion and the second protruding portion.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a perspective view schematically showing a configuration of a heat exchanger according to a first embodiment.
Fig. 2 is a cross-sectional view of a region A in Fig. 1 taken along line II-II.
Fig. 3 is an end view taken along line III-III in Fig. 2.
Fig. 4 is an end view taken along line IV-IV in Fig. 2.
Fig. 5 is a refrigerant circuit diagram showing a refrigeration cycle apparatus according to the first embodiment.
Fig. 6 is a cross-sectional view schematically showing a configuration of a portion of a heat exchanger according to a second embodiment corresponding to Fig. 2.
Fig. 7 is an end view taken along line VII-VII in Fig. 6.
Fig. 8 is an end view taken along line VIII-VIII in Fig. 6.
Fig. 9 is a cross-sectional view schematically showing a configuration of a portion of a heat exchanger according to a third embodiment corresponding to Fig. 2.
Fig. 10 is an end view taken along line X-X in Fig. 9.
Fig. 11 is an end view taken along line XI-XI in Fig. 9.
Fig. 12 is a cross-sectional view schematically showing a configuration of a portion of a heat exchanger according to a fourth embodiment corresponding to Fig. 2.
Fig. 13 is an end view taken along line XIII-XIII in Fig. 12.
Fig. 14 is an end view taken along line XIV-XIV in Fig. 12.

DESCRIPTION OF EMBODIMENTS

[0009] Embodiments will be described hereinafter with reference to the drawings. In the following description, the same or corresponding portions are denoted by the same reference characters and description thereof will not be repeated.

First Embodiment

[0010] A configuration of a heat exchanger HE according to a first embodiment will be described with reference to Figs. 1 to 4.

[0011] Referring to Figs. 1 and 2, heat exchanger HE includes a fin F and a heat transfer tube P. Fin F extends in a widthwise direction D1 along an air flow direction D0 and extends in a longitudinal direction D2 crossing air flow direction D0. Fin F is formed in a substantially rectangular shape. Heat transfer tube P passes through fin F. Heat transfer tube P is a circular pipe. Fin F has a through hole TH. Through hole TH is formed in a circular shape. Heat transfer tube P is inserted into through hole TH.

[0012] In the present embodiment, heat exchanger HE includes a plurality of fins F. The plurality of fins F are stacked on top of each other at intervals. Heat transfer tube P passes through the plurality of fins F in a direction D3 in which the plurality of fins F are stacked. Each of the plurality of fins F has a plurality of through holes TH. The plurality of through holes TH are aligned in longitudinal direction D2 of fin F. The plurality of through holes TH are spaced apart from each other in longitudinal direction D2 of fin F.

[0013] Widthwise direction D1 of fin F is orthogonal to longitudinal direction D2. Widthwise direction D1 of fin F may be a horizontal direction. Longitudinal direction D2 of fin F may be an up-down direction (vertical direction). Direction D3 in which fins F are stacked is orthogonal to widthwise direction D1 and longitudinal direction D2 of fin F.

[0014] Heat transfer tube P has a plurality of heat transfer portions P1 and a plurality of connection portions P2. Each of the plurality of heat transfer portions P1 passes through the plurality of fins F. Each of the plurality of heat transfer portions P1 is inserted into the plurality of through holes TH in direction D3 in which the plurality of fins F are stacked. The plurality of heat transfer portions P1 are formed linearly. Each of the plurality of heat transfer portions P1 extends in direction D3 in which the plurality of fins F are stacked.

[0015] Each of the plurality of connection portions P2 is a portion that connects corresponding heat transfer portions P1 of the plurality of heat transfer portions P1 outside the plurality of fins F. Each of the plurality of connection portions P2 is formed in a U-shape. Each of the plurality of connection portions P2 connects heat transfer tubes P adjacent to each other in longitudinal direction D2 of fin F. Each of the plurality of connection portions P2 is connected to ends of heat transfer portions P1 in direction D3 in which fins F are stacked. The plurality of heat transfer portions P1 are located at a plurality of stages in longitudinal direction D2 of fin F. In the present embodiment, the plurality of heat transfer portions P1 are located at four stages along longitudinal direction D2 of fin F.

[0016] The plurality of heat transfer portions P1 are connected by the plurality of connection portions P2 as follows. Heat transfer portion P1 in the first stage is connected to heat transfer portion P1 in the second stage by connection portion P2 on the back side in direction D3 in which the plurality of fins F are stacked. Heat transfer portion P1 in the second stage is connected to heat transfer portion P1 in the third stage by connection portion P2 on the front side in direction D3 in which the plurality of fins F are stacked. Heat transfer portion P1 in the third stage is connected to heat transfer portion P1 in the fourth stage by connection portion P2 on the back side in direction D3 in which the plurality of fins F are stacked. In this manner, heat transfer tube P is configured to meander in longitudinal direction D2 of fin F.

[0017] A structure of fin F will be described in detail with reference to Figs. 2 to 4.

[0018] Fin F includes a planar portion SP, a first protruding portion MP1, a second protruding portion MP2, and a fin collar FC. Planar portion SP is formed in a planar shape. Planar portion SP is formed in a flat plate shape.

[0019] First protruding portion MP1 and second protruding portion MP2 protrude from planar portion SP. In the present embodiment, first protruding portion MP1 and second protruding portion MP2 protrude from planar portion SP in the same direction. In the present embodiment, fin F includes a plurality of first protruding portions MP1 and a plurality of second protruding portions MP2.

[0020] First protruding portion MP1 is curved along longitudinal direction D2 of fin F. First protruding portion MP1 is curved to protrude in longitudinal direction D2 of fin F. First protruding portion MP1 has a portion extending along longitudinal direction D2 of fin F. First protruding portion MP1 also has a portion extending along widthwise direction D1 of fin F. First protruding portion MP1 is located to be displaced from the center of through hole TH in widthwise direction D1 of fin F. In the present embodiment, first protruding portion MP1 is formed in a circular arc shape. In the present embodiment, first protruding portions MP1 have the same width.

[0021] The plurality of first protruding portions MP1 are aligned in longitudinal direction D2 of fin F. First protruding portions MP1 are spaced apart from each other in longitudinal direction D2 of fin F. In the present embodiment, two first protruding portions MP1 are located between two through holes TH in longitudinal direction D2 of fin F. Two first protruding portions MP1 are located to face each other in longitudinal direction D2 of fin F. First protruding portions MP1 facing each other are curved to protrude toward each other.

[0022] First protruding portions MP1 are formed in the same shape except for the direction in which first protruding portions MP1 are curved along longitudinal direction D2 of fin F. First protruding portions MP1 have the same radius of curvature. The respective centers of curvature of first protruding portions MP1 are linearly aligned with each other in longitudinal direction D2 of fin F. First protruding portions MP1 have the same width. First protruding portions MP1 have the same length.

[0023] Each of the plurality of first protruding portions MP1 is longer than each of the plurality of second protruding portions MP2 in widthwise direction D1 of fin F. In longitudinal direction D2 of fin F, each of the plurality of first protruding portions MP1 is located between corresponding ones of the plurality of second protruding portions MP2. The respective centers of curvature of the plurality of first protruding portions MP1 are linearly aligned with the respective centers of the plurality of second protruding portions MP2 in longitudinal direction D2 of fin F.

[0024] Second protruding portion MP2 has an extending portion EP extending in longitudinal direction D2 of fin F. Second protruding portion MP2 has a portion extending along longitudinal direction D2 of fin F. Extending portion EP is located to overlap the center of through hole TH in widthwise direction D1 of fin F.

[0025] In the present embodiment, second protruding portion MP2 is located between first protruding portion MP1 and through hole TH. Second protruding portion MP2 surrounds through hole TH. Second protruding portion MP2 is formed in an annular shape. Second protruding portion MP2 protrudes from planar portion SP more than first protruding portion MP1.

[0026] The plurality of second protruding portions MP2 are formed in the same shape. The respective centers of the plurality of second protruding portions MP2 are aligned linearly in longitudinal direction D2 of fin F. The plurality of second protruding portions MP2 have the same width. The plurality of second protruding portions MP2 have the same diameter.

[0027] First protruding portion MP1 and second protruding portion MP2 protrude from planar portion SP less than fin collar FC.

[0028] Fin collar FC is formed in a cylindrical shape. Heat transfer tube P is inserted into fin collar FC. The outer circumferential surface of heat transfer tube P fits onto the inner circumferential surface of fin collar FC. Fin collar FC protrudes from planar portion SP. In the present embodiment, fin collar FC protrudes from planar portion SP in the same direction as that of first protruding portion MP1 and second protruding portion MP2.

[0029] Fin collar FC includes a circumferential wall and a flange. The circumferential wall protrudes from planar portion SP. The flange extends outward from the circumferential wall. The flange is provided at the edge of the circumferential wall opposite to planar portion SP. In the present embodiment, fin F includes a plurality of fin collars FC.

[0030] A configuration of a refrigeration cycle apparatus 100 including heat exchanger HE according to the first embodiment will be described with reference to Fig. 5. Refrigeration cycle apparatus 100 is, for example, an air conditioner or a refrigerator. The first embodiment will describe an air conditioner as an example of refrigeration cycle apparatus 100. Refrigeration cycle apparatus 100 includes a refrigerant circuit RC, refrigerant, a controller CD, and air blowers 6, 7. Refrigeration cycle apparatus 100 includes a refrigerant circulation device RCD. Refrigerant circulation device RCD is configured to circulate refrigerant for performing heat exchange with air in heat exchanger HE. The first embodiment will describe refrigeration cycle apparatus 100 including a compressor 1 incorporated as refrigerant circulation device RCD. Refrigerant circulation device RCD may be a refrigerant pump.

[0031] Refrigerant circuit RC includes compressor 1, a four-way valve 2, an outdoor heat exchanger 3, a pressure reducing valve 4, and an indoor heat exchanger 5. Heat exchanger HE described above may be applied to at least one of outdoor heat exchanger 3 and indoor heat exchanger 5. Compressor 1, four-way valve 2, outdoor heat exchanger 3, pressure reducing valve 4, and indoor heat exchanger 5 are connected by a pipe. Refrigerant circuit RC is configured to circulate the refrigerant. Refrigerant circuit RC is configured to perform a refrigeration cycle in which the refrigerant circulates while changing its phase.

[0032] Compressor 1, four-way valve 2, outdoor heat exchanger 3, pressure reducing valve 4, controller CD, and air blower 6 are housed in an outdoor unit 101. Indoor heat exchanger 5 and air blower 7 are housed in an indoor unit 102.

[0033] Refrigerant circuit RC is configured such that the refrigerant circulates in order of compressor 1, four-way valve 2, outdoor heat exchanger (condenser) 3, pressure reducing valve 4, indoor heat exchanger (evaporator) 5, and four-way valve 2 during a cooling operation. Refrigerant circuit RC is also configured such that the refrigerant circulates in order of compressor 1, four-way valve 2, indoor heat exchanger (condenser) 5, pressure reducing valve 4, outdoor heat exchanger (evaporator) 3, and four-way valve 2 during a heating operation.

[0034] The refrigerant flows through refrigerant circuit RC in order of compressor 1, the condenser, pressure reducing valve 4, and the evaporator.

[0035] Controller CD is configured to control each device of refrigeration cycle apparatus 100 by, for example, performing calculations or providing instructions. Controller CD is electrically connected to compressor 1, four-way valve 2, pressure reducing valve 4, air blowers 6, 7, and the like and is configured to control the operations thereof.

[0036] Compressor 1 is configured to compress the refrigerant for performing heat exchange with the air in heat exchanger HE. Compressor 1 is configured to compress the sucked refrigerant and discharge the compressed refrigerant. Compressor 1 may be configured to have a variable capacity. Compressor 1 may be configured to have a capacity changing through the adjustment of the rotation speed of compressor 1 based on an instruction from controller CD.

[0037] Four-way valve 2 is configured to switch a refrigerant flow such that the refrigerant compressed by compressor 1 flows to outdoor heat exchanger 3 or indoor heat exchanger 5. Four-way valve 2 is configured such that the refrigerant discharged from compressor 1 flows to outdoor heat exchanger (condenser) 3 during the cooling operation. Four-way valve 2 is also configured such that the refrigerant discharged from compressor 1 flows to indoor heat exchanger (evaporator) 5 during the heating operation.

[0038] Outdoor heat exchanger 3 is configured to exchange heat between the refrigerant flowing inside outdoor heat exchanger 3 and the air flowing outside outdoor heat exchanger 3. Outdoor heat exchanger 3 is configured to function as the condenser that condenses the refrigerant during the cooling operation and function as the evaporator that evaporates the refrigerant during the heating operation.

[0039] Pressure reducing valve 4 is configured to reduce pressure by expanding the refrigerant condensed by the condenser. Pressure reducing valve 4 is configured to reduce the pressure of the refrigerant condensed by outdoor heat exchanger (condenser) 3 during the cooling operation and reduce the pressure of the refrigerant condensed by indoor heat exchanger (evaporator) 5 during the heating operation. Pressure reducing valve 4 is, for example, a solenoid valve.

[0040] Indoor heat exchanger 5 is configured to exchange heat between the refrigerant flowing inside indoor heat exchanger 5 and the air flowing outside indoor heat exchanger 5. Indoor heat exchanger 5 is configured to function as the evaporator that evaporates the refrigerant during the cooling operation and function as the condenser that condenses the refrigerant during the heating operation.

[0041] Air blower 6 is configured to blow outdoor air to outdoor heat exchanger 3. In other words, air blower 6 is configured to supply air to outdoor heat exchanger 3. Air blower 6 may be configured to adjust the amount of heat exchange between the refrigerant and the air by adjusting the rotation speed of air blower 6 based on an instruction from controller CD, thereby adjusting an amount of heat exchange between the refrigerant and the air.

[0042] Air blower 7 is configured to blow indoor air to indoor heat exchanger 5. In other words, air blower 7 is configured to supply air to indoor heat exchanger 5. Air blower 7 may be configured to adjust the amount of the air flowing around indoor heat exchanger 5 through the adjustment of the rotation speed of air blower 7 based on an instruction from controller CD, thereby adjusting an amount of heat exchange between the refrigerant and the air.

[0043] Next, an operation of refrigeration cycle apparatus 100 will be described with reference to Fig. 5. In Fig. 5, the solid arrows indicate a refrigerant flow during the cooling operation, and the dashed arrows indicate a refrigerant flow during the heating operation.

[0044] Refrigeration cycle apparatus 100 can selectively perform the cooling operation and the heating operation. During the cooling operation, the refrigerant circulates through refrigerant circuit RC in order of compressor 1, four-way valve 2, outdoor heat exchanger 3, pressure reducing valve 4, indoor heat exchanger 5, and four-way valve 2. During the cooling operation, outdoor heat exchanger 3 functions as the condenser. Heat is exchanged between the refrigerant flowing through outdoor heat exchanger 3 and the air blown by air blower 6. During the cooling operation, indoor heat exchanger 5 functions as the evaporator. Heat is exchanged between the refrigerant flowing through indoor heat exchanger 5 and the air blown by air blower 7.

[0045] During the heating operation, the refrigerant circulates through refrigerant circuit RC in order of compressor 1, four-way valve 2, indoor heat exchanger 5, pressure reducing valve 4, outdoor heat exchanger 3, and four-way valve 2. During the heating operation, indoor heat exchanger 5 functions as the condenser. Heat is exchanged between the refrigerant flowing through indoor heat exchanger 5 and the air blown by air blower 7. During the heating operation, outdoor heat exchanger 3 functions as the evaporator. Heat is exchanged between the refrigerant flowing through outdoor heat exchanger 3 and the air blown by air blower 6.

[0046] Next, functions and effects of the first embodiment will be described.

[0047] In heat exchanger HE according to the first embodiment, first protruding portion MP1 and second protruding portion MP2 protrude from planar portion SP, and thus, an influence of a dead water region can be suppressed. This can improve a heat transfer coefficient of fin F. Also, the strength of fin F can be improved by first protruding portion MP1 and second protruding portion MP2.

[0048] Extending portion EP of second protruding portion MP2 extending in longitudinal direction D2 is located to overlap the center of through hole TH in widthwise direction D1. This can further improve the strength of fin F.

[0049] In heat exchanger HE according to the first embodiment, second protruding portion MP2 is located between first protruding portion MP1 and through hole TH and surrounds through hole TH. This can improve the strength of fin F so as to surround through hole TH by second protruding portion MP2.

Second Embodiment

[0050] Heat exchanger HE and refrigeration cycle apparatus 100 according to a second embodiment have the same configuration, functions and effects as those of heat exchanger HE and refrigeration cycle apparatus 100 according to the first embodiment unless otherwise specified.

[0051] The structure of fin F of heat exchanger HE according to the second embodiment will be described with reference to Figs. 6 to 8.

[0052] Second protruding portion MP2 extends linearly in longitudinal direction D2 of fin F. Second protruding portion MP2 continuously extends from one end to the other end of fin F in longitudinal direction D2. Second protruding portion MP2 protrudes from planar portion SP opposite to first protruding portion MP1. Second protruding portion MP2 protrudes from planar portion SP opposite to fin collar FC.

[0053] In the present embodiment, fin F includes a plurality of second protruding portions MP2. Second protruding portions MP2 extend parallel to each other in longitudinal direction D2 of fin F. Second protruding portions MP2 are located at the opposite ends of fin F in widthwise direction D1. Second protruding portions MP2 are located to sandwich first protruding portions MP1 and heat transfer tubes P. Second protruding portions MP2 have the same width.

[0054] Next, functions and effects of the second embodiment will be described.

[0055] In heat exchanger HE according to the second embodiment, second protruding portion MP2 extends linearly in longitudinal direction D2 of fin F. Thus, the strength of fin F can be improved in longitudinal direction D2 of fin F by second protruding portion MP2.

[0056] In heat exchanger HE according to the second embodiment, second protruding portion MP2 protrudes from planar portion SP opposite to first protruding portion MP1. Thus, first protruding portion MP1 is not affected by the dead water region in the wake of second protruding portion MP2. This can improve the heat transfer coefficient of fin F.

Third Embodiment

[0057] Heat exchanger HE and refrigeration cycle apparatus 100 according to a third embodiment have the same configuration, functions and effects as those of heat exchanger HE and refrigeration cycle apparatus 100 according to the first embodiment unless otherwise specified.

[0058] The structure of fin F of heat exchanger HE according to the third embodiment will be described with reference to Figs. 9 to 11.

[0059] Second protruding portions MP2 extend linearly in longitudinal direction D2 of fin F. Second protruding portions MP2 are spaced apart from each other in longitudinal direction D2 of fin F. Second protruding portions MP2 are separated from each other in longitudinal direction D2 of fin F. Second protruding portion MP2 protrudes from planar portion SP in the same direction as that of first protruding portion MP1. Second protruding portion MP2 protrudes from planar portion SP in the same direction as that of fin collar FC.

[0060] Second protruding portion MP2 is located to be displaced from first protruding portion MP1 in widthwise direction D1 of fin F. Second protruding portion MP2 is located so as not to overlap first protruding portion MP1 in widthwise direction D1 of fin F.

[0061] In the present embodiment, fin F includes a plurality of second protruding portions MP2. Second protruding portions MP2 extend parallel to each other in longitudinal direction D2 of fin F. Second protruding portions MP2 are located at the opposite ends of fin F in widthwise direction D1. Second protruding portions MP2 are located to sandwich first protruding portions MP1 and heat transfer tubes P. Second protruding portions MP2 have the same width.

[0062] Next, functions and effects of the third embodiment will be described.

[0063] In heat exchanger HE according to the third embodiment, second protruding portion MP2 is located to be displaced from first protruding portion MP1 in widthwise direction D1 of fin F. Thus, the strength of fin F can be improved as second protruding portion MP2 is located at a location on which a stress tends to concentrate, where no first protruding portion MP1 is formed.

[0064] Also, first protruding portion MP1 is not affected by the dead water region in the wake of second protruding portion MP2. Thus, the heat transfer coefficient of fin F can be improved.

Fourth Embodiment

[0065] Heat exchanger HE and refrigeration cycle apparatus 100 according to a fourth embodiment have the same configuration, functions and effects as those of heat exchanger HE and refrigeration cycle apparatus 100 according to the first embodiment unless otherwise specified.

[0066] The structure of fin F of heat exchanger HE according to the fourth embodiment will be described with reference to Figs. 12 to 14.

[0067] First protruding portions MP1 are aligned in longitudinal direction D2 of fin F. In the present embodiment, four first protruding portions MP1 are located between two through holes TH in longitudinal direction D2 of fin F.

[0068] Two first protruding portions MP1 located above the lower through hole TH in longitudinal direction D2 of fin F are located adjacent to each other in longitudinal direction D2 of fin F. Two first protruding portions MP1 located below the upper through hole TH in longitudinal direction D2 of fin F are located adjacent to each other in longitudinal direction D2 of fin F.

[0069] Two first protruding portions MP1 located adjacent to each other are curved to the same side along longitudinal direction D2. Also, two first protruding portions MP1 located to face each other in longitudinal direction D2 of fin F are curved to the opposite sides along longitudinal direction D2. Two first protruding portions MP1 located close to the upper through hole TH between two through holes TH are curved to project downward. Two first protruding portions MP1 located close to the lower through hole TH between two through holes TH are curved to protrude upward. The outer first protruding portion MP1 of the two first protruding portions MP1 curved to protrude downward is spaced apart from the outer first protruding portion MP1 of the two first protruding portions MP1 curved to protrude upward.

[0070] The outer first protruding portions MP1 are formed in the same shape except for the direction in which the outer first protruding portions MP1 are curved along longitudinal direction D2 of fin F. The outer first protruding portions MP1 have the same radius of curvature. The respective centers of curvature of the outer first protruding portions MP1 are linearly aligned with each other in longitudinal direction D2 of fin F. The outer first protruding portions MP1 have the same width. The outer first protruding portions MP1 have the same length.

[0071] The inner first protruding portions MP1 are formed in the same shape except for the direction in which the inner first protruding portions MP1 are curved along longitudinal direction D2 of fin F. The inner first protruding portions MP1 have the same radius of curvature. The respective centers of curvature of the inner first protruding portions MP1 are linearly aligned with each other in longitudinal direction D2 of fin F. The inner first protruding portions MP1 have the same width. The inner first protruding portions MP1 have the same length.

[0072] In the present embodiment, the length of the outer first protruding portion MP1 in widthwise direction D 1 of fin F is equal to the length of the inner first protruding portion MP1 in widthwise direction D1 of fin F.

[0073] First protruding portions MP1 are longer than second protruding portions MP2 in widthwise direction D1 of fin F. In longitudinal direction D2 of fin F, each of first protruding portions MP1 is located between second protruding portions MP2. The respective centers of curvature of first protruding portions MP1 are linearly aligned with the respective centers of curvature of second protruding portions MP2 in longitudinal direction D2 of fin F.

[0074] The inner first protruding portion MP1 of two first protruding portions MP1 located above through hole TH in longitudinal direction D2 of fin F is adjacent to second protruding portion MP2. The inner first protruding portion MP1 of two first protruding portions MP1 located below through hole TH in longitudinal direction D2 of fin F is adjacent to second protruding portion MP2.

[0075] Second protruding portion MP2 includes a first portion MP21 and a second portion MP22. First portion MP21 is located between first protruding portion MP1 and through hole TH. First portion MP21 surrounds through hole TH. First portion MP21 is formed in an annular shape. First portion MP21 protrudes from planar portion SP more than first protruding portion MP1. First portion MP21 protrudes from planar portion SP less than second portion MP22.

[0076] Second portions MP22 extend linearly in longitudinal direction D2 of fin F. Second portion MP22 continuously extends from one end to the other end of fin F in longitudinal direction D2. Second portion MP22 protrudes from planar portion SP opposite to first portion MP21. Second portion MP22 extends from planar portion SP opposite to first protruding portion MP1 and fin collar FC.

[0077] In the present embodiment, fin F includes a plurality of second portions MP22. Second portions MP22 extend parallel to each other in longitudinal direction D2 of fin F. Second portions MP22 are located at the opposite ends of fin F in widthwise direction D1. Second portions MP22 are located to sandwich first protruding portions MP1, first portions MP21, and heat transfer tubes P. Second portions MP22 have the same width.

[0078] Fin F includes a first region R1 without through hole TH in widthwise direction D1 of fin F and a second region R2 with through hole TH in widthwise direction D1 of fin F. In first region R1, a first area of first protruding portions MP1 and second protruding portions MP2 extending in widthwise direction D1 of fin F is larger than a second area of first protruding portions MP1 and second protruding portions MP2 extending in longitudinal direction D2 of fin F. In second region R2, the first area is smaller than the second area.

[0079] Next, functions and effects of the fourth embodiment will be described.

[0080] In heat exchanger HE according to the fourth embodiment, the first area of first protruding portions MP1 and second protruding portions MP2 extending in widthwise direction D1 of fin F is larger than the second area of first protruding portions MP1 and second protruding portions MP2 extending in longitudinal direction D2 of fin F in first region R1, and the first area is smaller than the second area in second region R2. Thus, the strength of fin F can be improved in a location where the air flows less easily, while maximizing the improvement in heat transfer performance in a location where the air flows more easily.

[0081] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present disclosure is defined by the scope of the claims, rather than the embodiments described above, and is intended to include any modifications within the scope and meaning equivalent to the scope of the claims.

REFERENCE SIGNS LIST

[0082] 1 compressor; 2 four-way valve; 3 outdoor heat exchanger; 4 pressure reducing valve; 5 indoor heat exchanger; 100 refrigeration cycle apparatus; D0 air flow direction; D1 widthwise direction; D2 longitudinal direction; EP extending portion; F fin; HE heat exchanger; MP1 first protruding portion; MP2 second protruding portion; MP21 first portion; MP22 second portion; P heat transfer tube; R1 first region; R2 second region; SP planar portion; TH through hole.

Claims

1. A heat exchanger comprising:

a fin extending in a widthwise direction along an

air flow direction and extending in a longitudinal direction crossing the air flow direction; and
a heat transfer tube passing through the fin,
the fin having a through hole,
the heat transfer tube being inserted into the through hole,
the fin comprising

a planar portion, and
a first protruding portion and a second protruding portion protruding from the planar portion,

the first protruding portion being curved along the longitudinal direction,
the second protruding portion having an extending portion extending in the longitudinal direction,
the extending portion being located to overlap a center of the through hole in the widthwise direction.

2. The heat exchanger according to claim 1, wherein the second protruding portion is located between the first protruding portion and the through hole and surrounds the through hole.

3. The heat exchanger according to claim 1, wherein the second protruding portion extends linearly in the longitudinal direction.

4. The heat exchanger according to claim 3, wherein the second protruding portion protrudes from the planar portion opposite to the first protruding portion.

5. The heat exchanger according to claim 3 or 4, wherein the second protruding portion is located to be displaced from the first protruding portion in the widthwise direction.

6. The heat exchanger according to any one of claims 1 to 5, wherein

the fin comprises

a first region without the through hole in the widthwise direction, and
a second region with the through hole in the widthwise direction,

in the first region, a first area of the first protruding portion and the second protruding portion extending in the widthwise direction is larger than a second area of the first protruding portion and the second protruding portion extending in the longitudinal direction, and
in the second region, the first area is smaller than the second area.

7. A refrigeration cycle apparatus comprising:

the heat exchanger according to any one of claims 1 to 6; and
a refrigerant circulation device,
the refrigerant circulation device being configured to circulate refrigerant for performing heat exchange with air in the heat exchanger.

FIG.1

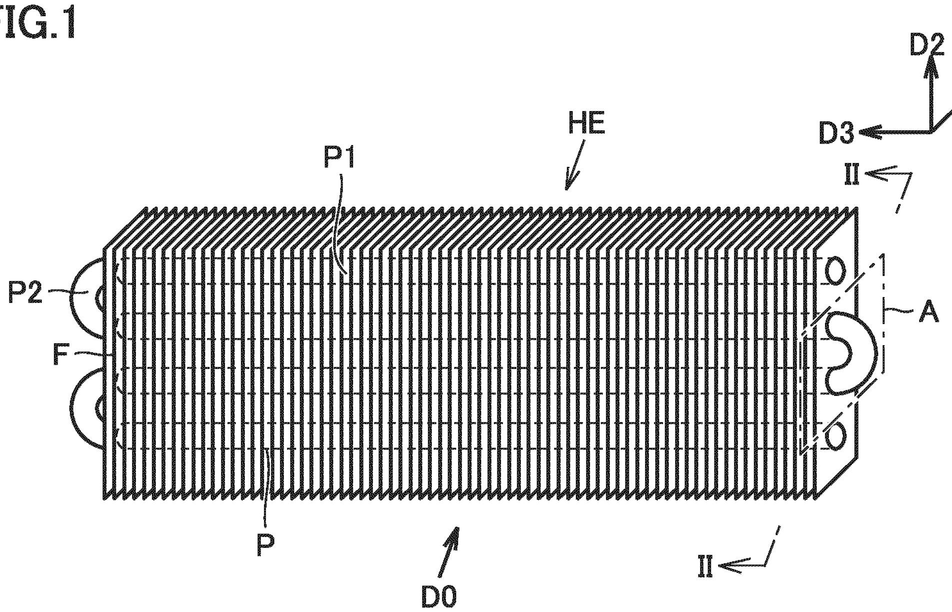


FIG.2

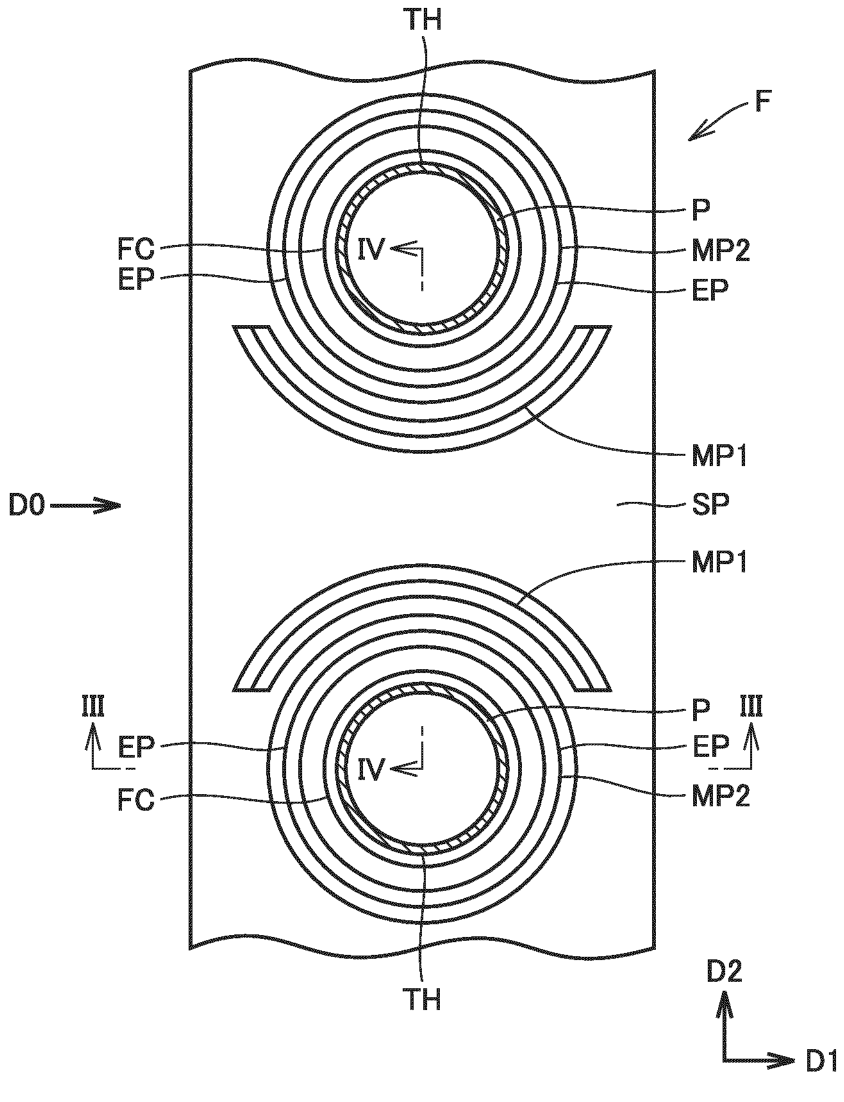


FIG.3

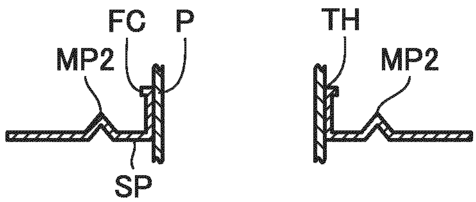


FIG.4

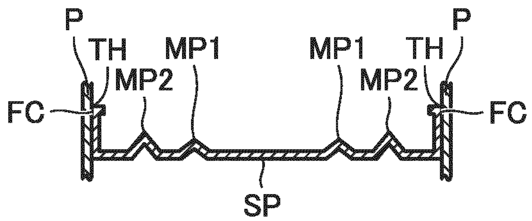


FIG.5

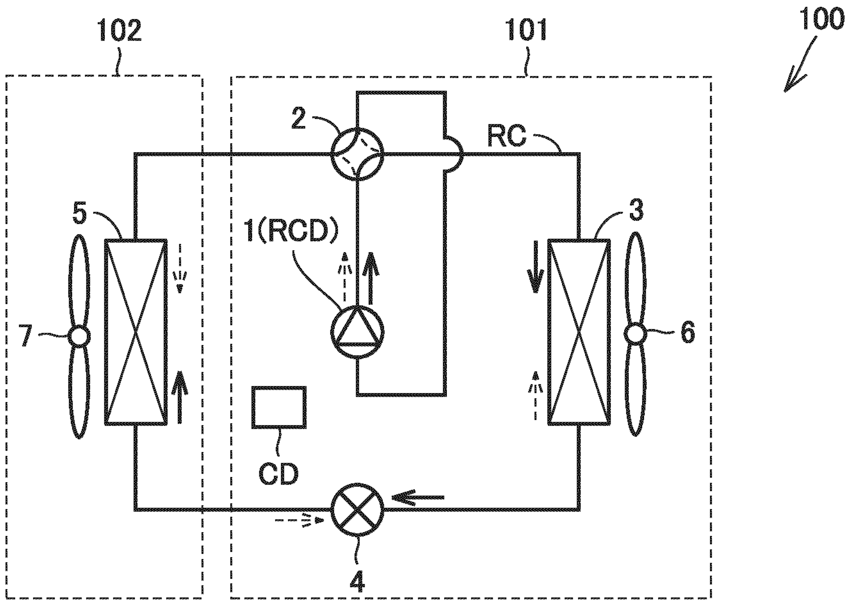
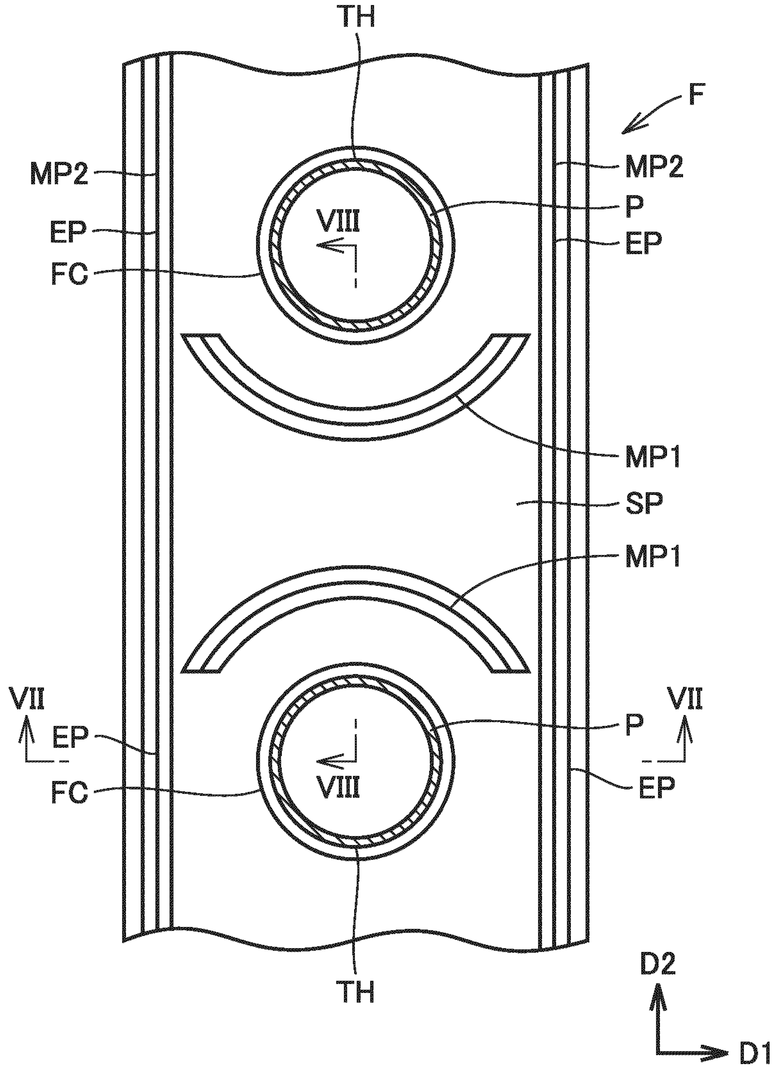


FIG.6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TH
D2
D1

FIG.7

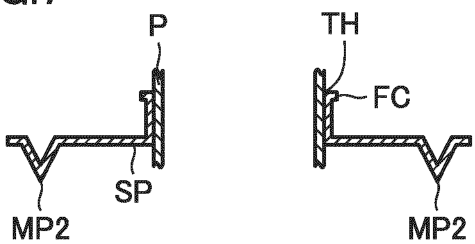

FIG.8

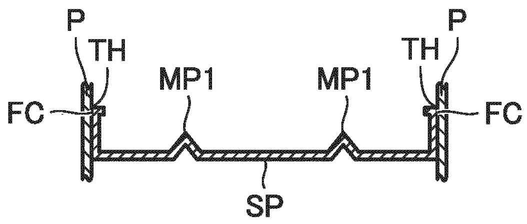

FIG.9

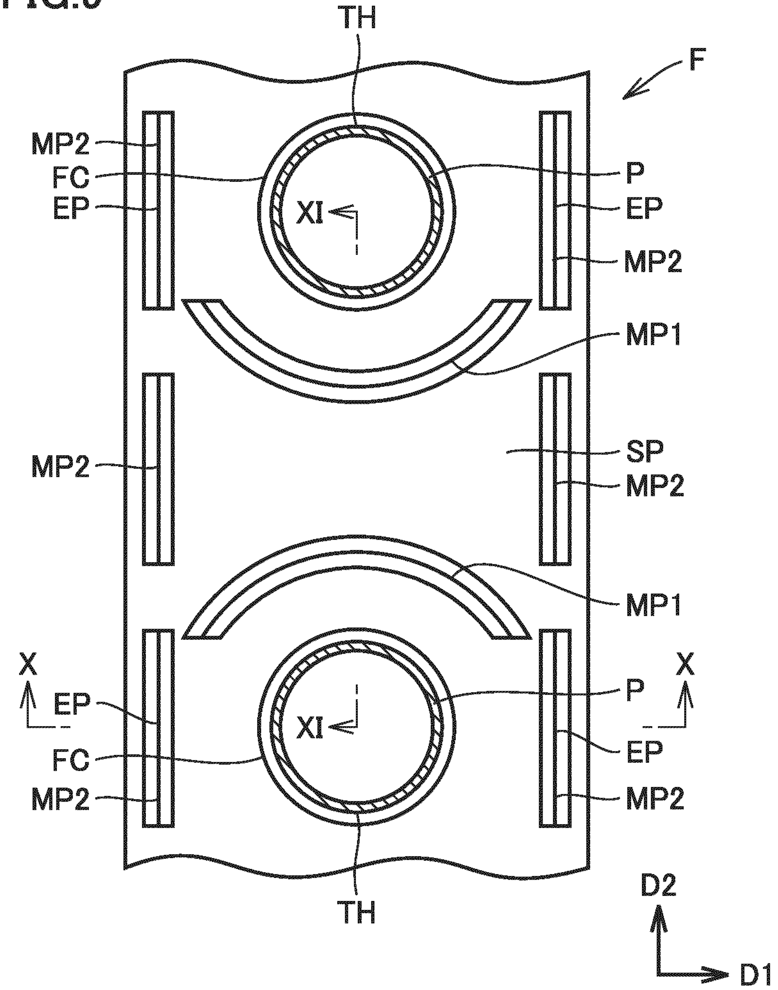
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FIG.10

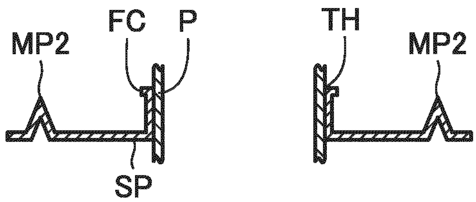


FIG.11

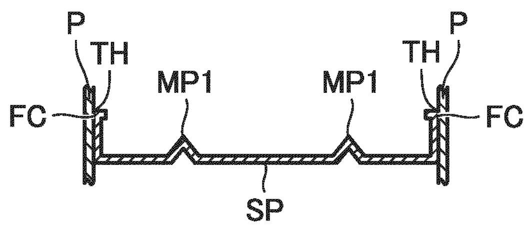
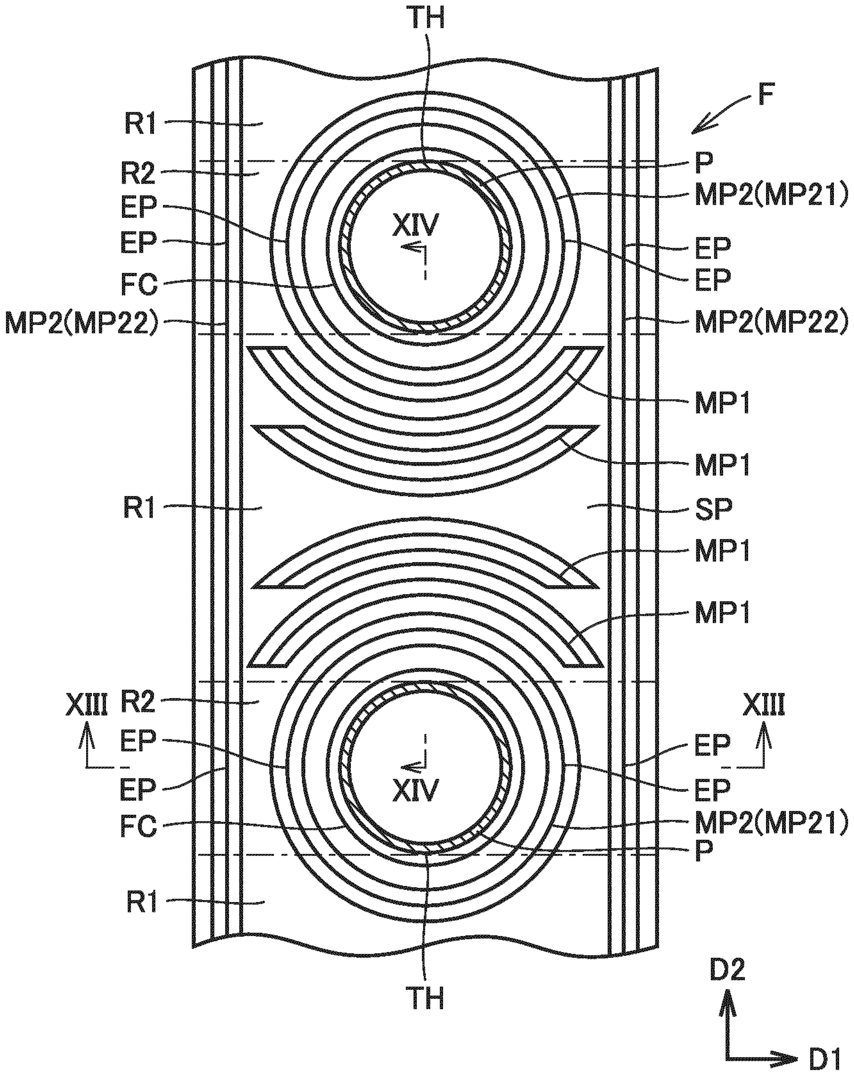


FIG.12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D2
D1

FIG.13

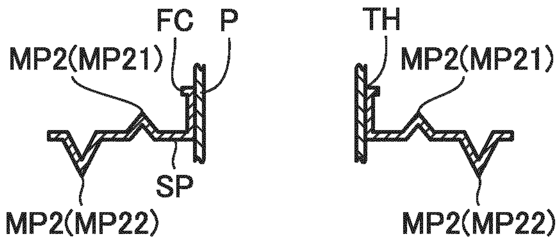
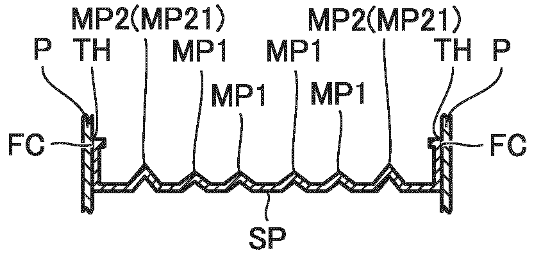


FIG.14



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2020/044333

A. CLASSIFICATION OF SUBJECT MATTER
F28F 1/32(2006.01)i
FI: F28F1/32 L

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)
F28F1/32

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.
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 106111/1980 (Laid-open No. 30591/1982) (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 17 February 1982 (1982-02-17) specification, page 2, line 17 to page 3, line 5, fig. 2	1, 3-4, 7 2, 5-6
Y A	JP 2019-163909 A (TOKYO ELECTRIC POWER COMPANY HOLDINGS, INC.) 26 September 2019 (2019-09-26) paragraphs [0021]-[0023], fig. 1	1, 3-4, 7 2, 5-6

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 December 2020 (11.12.2020)	22 December 2020 (22.12.2020)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/044333

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 106109/1980 (Laid-open No. 30589/1982) (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 17 February 1982 (1982-02-17) specification, page 3, lines 1-14, fig. 1	2, 5-6

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/044333

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 57-30591 U1	17 Feb. 1982	(Family: none)	
JP 2019-163909 A	26 Sep. 2019	(Family: none)	
JP 57-30589 U1	17 Feb. 1982	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005077083 A **[0002] [0003]**