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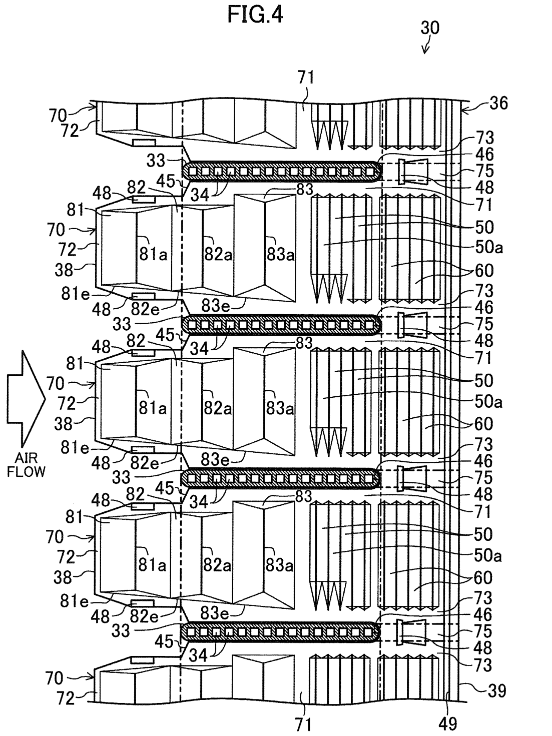
(54) HEAT EXCHANGER AND AIR CONDITIONER

(57) A heat exchanger (30) includes flat tubes (33) and fins (36). The plate-like fins (36) are spaced from one another by a predetermined distance in the direction in which the flat tubes (33) extend. The flat tubes (33) are inserted in pipe insertion portions (46) of the fins (36). In the fins (36), parts of the fins (36) between vertically adjacent ones of the flat tubes (33) are heat transfer parts (70). Each of the heat transfer parts (70) includes protrusions (81-83) and louvers (50, 60). The protrusions (81-83) are located at a windward region of the heat transfer part (70) and formed by making the heat transfer part (70) protrude in an inverted V shape. The louvers (50, 60) are located in a leeward region of the heat transfer part (70) and bend out from the heat transfer part (70).

FIG.4



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to heat exchangers including flat tubes and fins and configured to perform heat exchange between air and fluid flowing in the flat tubes.

BACKGROUND ART

[0002] Heat exchangers including flat tubes and fins have been known in the art. For example, in a heat exchanger described in Patent Document 1, laterally extending flat tubes are arranged to be spaced from one another in the vertical direction (i.e., the upward and downward directions) by a predetermined distance, and plate-like fins are arranged to be spaced from one another by a predetermined distance in the direction in which the flat tubes extend. In each of heat exchangers described in Patent Documents 2 and 3, laterally extending flat tubes are arranged to be spaced from one another in the vertical direction by a predetermined distance, and a corrugated fin is provided between each adjacent ones of the flat tubes. In these heat exchangers, air flowing while being in contact with the fins exchanges heat with fluid flowing in the flat tubes.

[0003] In general, fins in heat exchangers of this type are provided with louvers for promoting heat transfer. For example, as illustrated in FIG. 4 of Patent Document 3, in fins of a conventional heat exchanger, louvers having the same bent-out heights are arranged in the air passage direction.

CITATION LIST

PATENT DOCUMENT

[0004]

[Patent Document 1] Japanese Patent Publication No. 2003-262485
[Patent Document 2] Japanese Patent Publication No. 2010-002138
[Patent Document 3] Japanese Patent Publication No. H11-294984

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005] Refrigerant circuits of air conditioners include outdoor heat exchangers for performing heat exchange between refrigerant and outdoor air. During heating operation of an air conditioner, an outdoor heat exchanger serves as an evaporator. When the evaporating temperature of refrigerant in the outdoor heat exchanger decreases below 0°C, moisture in the air becomes frost (i.e., ice) and is attached to the outdoor heat exchanger. Thus, in heating operation under low outdoor temperatures, defrosting operation for melting frost on the outdoor heat exchanger is performed after every predetermined period, for example. During the defrosting operation, high-temperature refrigerant discharged from a compressor is supplied to the outdoor heat exchanger, and heats frost attached to the outdoor heat exchanger to cause the frost to melt. During the defrosting operation, since the refrigerant discharged from the compressor is supplied not to an indoor heat exchanger but to the outdoor heat exchanger, a flow of heated air into the room is interrupted.

[0006] On the other hand, a heat exchanger including flat tubes and fins can be used as an outdoor heat exchanger of an air conditioner. In a conventional heat exchanger of this type, however, louvers are provided on fins from a portion near a front edge to a portion near a rear edge thereof in general. Accordingly, in an outdoor heat exchanger constituted by a heat exchanger of this type, frost is correctively attached to a windward region of fins, and the attached frost hinders an air flow. Consequently, although frost is hardly attached to a leeward region of the fins, the flow rate of air passing through the heat exchanger decreases, and defrosting operation comes to be needed. Thus, in the case of using a heat exchanger of this type as an outdoor heat exchanger of an air conditioner, defrosting operation is likely to interrupt a flow of heated air into the room, thereby causing the possibility of a substantial decrease in heating capacity of the air conditioner.

[0007] It is therefore an object of the present disclosure to prolong the period until the capability of a heat exchanger including flat tubes and fins decreases to a minimum because of frost attached to the fins.

SOLUTION TO THE PROBLEM

[0008] A first aspect of the present disclosure is directed to a heat exchanger including: flat tubes (33) vertically arranged with side surfaces thereof facing one another, each of the flat tubes (33) including a fluid passage (34) therein; and fins (35, 36) each dividing a space between adjacent ones of the flat tubes (33) into a plurality of air passages (40) through which air flows Each of the fins (35, 36) includes heat transfer parts (70) each having a plate shape extending from an adjacent one of the flat tubes (33) to the other adjacent flat tube (33), and the heat transfer parts (70) form side walls of the air passages (40). Each of the heat transfer parts (70) of the fins (35, 36) includes louvers (50, 60) that bend out from the heat transfer part (70), and protrusions (81-83) located at a windward side of the louvers (50, 60), formed by making the heat transfer part (70) protrude, and extending in a direction intersecting with an air passage direction.

[0009] In the first aspect, the heat exchanger (30) includes the flat tubes (33) and the fins (35, 36). The heat transfer parts (70) of the fins (35, 36) are located between the vertically arranged flat tubes (33). In the heat exchanger (30), air passes through the air passages (40) between the vertically arranged flat tubes (33), and exchanges heat with fluid flowing through the fluid passages (34) in the flat tubes (33).

[0010] In the first aspect, each of the heat transfer parts (70) of the fins (35, 36) includes the protrusions (81-83) and the louvers (50, 60). The protrusions (81-83) are located at a windward side of the louvers (50, 60) in each of the heat transfer parts (70). The presence of the protrusions (81-83) and the louvers (50, 60) in the heat transfer parts (70) disturbs an air flow in the air passages (40), thereby promoting heat transfer between the air and the fins.

[0011] In general, an air flow is disturbed more greatly by the louvers (50, 60) bending out from the heat transfer parts (70) than by the protrusions (81-83) protruding from the heat transfer parts (70). Thus, in most cases, heat transfer is more greatly promoted by the louvers (50, 60) than by the protrusions (81-83).

[0012] When the temperature of fluid flowing in the flat tubes (33) is less than 0°C, moisture in the air becomes frost and is attached to the surfaces of the heat transfer parts (70). On the other hand, in each of the heat transfer parts (70) of the fins (35, 36) of the first aspect, the protrusions (81-83) showing a relatively low degree of heat transfer promotion are provided at the windward side of the louvers (50, 60) showing a relatively high degree of heat transfer promotion. Thus, as compared to a case where the louvers (50, 60) are provided in the entire heat transfer parts (70), the amount of frost attached to a windward region of the heat transfer parts (70) decreases, and the amount of frost attached to a leeward region of the heat transfer parts (70) increases. As a result, the heat transfer parts (70) of this aspect shows a small difference between the amount of frost attached to the windward region and the amount of frost attached to the leeward region.

[0013] In a second aspect of the present disclosure, in the heat exchanger (30) of the first aspect, at least a louver (50) that is included in the louvers (50, 60) provided on each of the heat transfer parts (70) of the fins (35, 36) and is located near the protrusions (81-83) has a leeward bent-out end (53) projecting in a direction in which the protrusions (81-83) protrude.

[0014] In each of the heat transfer parts (70) of the fins (35, 36) of the second aspect, the louver (50) located near the protrusions (81-83) has the leeward bent-out end (53) projecting in the direction in which the protrusions (81-83) protrude. Specifically, the louver (50) near the protrusions (81-83) is tilted in the direction opposite to the direction in which parts of the protrusions (81-83) in a leeward region are tilted. Air that has flown across the protrusions (81-83) strikes the louver (50) near the protrusions (81-83), and the direction of this air flow is changed. Accordingly, the flow of air that has flown across the protrusions (81-83) is further disturbed when striking the louver (50) near the protrusions (81-83).

[0015] In a third aspect of the present disclosure, in the heat exchanger (30) of the first or second aspect, a bent-out end (53, 63) of each of the louvers (50, 60) includes a main edge (54, 64), an upper edge (55, 65) extending from an upper end of the main edge (54, 64) to an upper end of the louver (50, 60) and tilted relative to the main edge (54, 64), and a lower edge (56, 66) extending from a lower end of the main edge (54, 64) to a lower end of the louver (50, 60) and tilted relative to the main edge (54, 64), and at least one of the louvers (50, 60) provided on each of the heat transfer parts (70) of the fins (35, 36) is an asymmetric louver in which a tilt angle of the lower edge (56) relative to the main edge (54) is smaller than a tilt angle of the upper edge (55) relative to the main edge (54).

[0016] In the third aspect, the bent-out end (53, 63) of each of the louvers (50, 60) includes the main edge (54, 64), the upper edge (55, 65), and the lower edge (56, 66). At least one of the louvers (50, 60) provided on each of the heat transfer parts (70) of the fins (35, 36) is the asymmetric louver (50a). In the asymmetric louver (50a), the tilt angle of the lower edge (56) relative to the main edge (54) is smaller than the tilt angle of the upper edge (55) relative to the main edge (54). Thus, between the bent-out ends (53) of the asymmetric louvers (50a) that are adjacent to each other in the air passage direction, a gap between the lower edges (56) is more slender than a gap between the upper edges (55).

[0017] On the surfaces of the fins (35, 36) of the heat exchanger (30) of the third aspect, drain water is generated by condensation of moisture in the air and melting of frost attached to the fins (35, 36). The drain water generated on the surfaces of the fins (35, 36) also enters a gap between the bent-out ends (53) of the asymmetric louvers (50a) that are adjacent to each other in the air passage direction. The drain water between the asymmetric louvers (50a) is drawn into a gap between the slender lower edges (56) by a capillary phenomenon.

[0018] In a fourth aspect of the present disclosure, in the heat exchanger (30) of the third aspect, in each of the heat transfer parts (70) of the fins (35, 36), at least one of the louvers (50) located in a region adjacent to the flat tubes (33) is the asymmetric louver.

[0019] In the fourth aspect, in each of the heat transfer parts (70) of the fins (35, 36), the louvers (50) are provided in a region adjacent to the flat tubes (33), and part or all of the windward louvers (50) are asymmetric louvers.

[0020] In a fifth aspect of the present disclosure, in the heat exchanger (30) of any one of the first through fourth aspects, each of the heat transfer parts (70) of the fins (35, 36) includes a leeward end portion (73) located at a leeward side of the flat tubes (33), and at least one louver (60) of the louvers (50, 60) is located on the leeward end portion (73) of each of the heat transfer parts (70) of the fins (35, 36).

[0021] In the fifth aspect, each of the heat transfer parts (70) of the fins (35, 36) includes the leeward end portion (73). The leeward end portion (73) of each of the heat transfer parts (70) projects toward the leeward from the flat tubes (33). In each of the heat transfer parts (70) of this aspect, the leeward louvers (60) are provided in the leeward end portion (73). In each of the heat transfer parts (70) of this aspect, it is sufficient to provide the louvers (50, 60) in at least the leeward end portion (73). That is, in each of the heat transfer parts (70) of this aspect, the louvers (50, 60) may be provided in a region including the leeward end portion (73) and a portion at the windward side of the leeward end portion (73).

[0022] In a sixth aspect of the present disclosure, in the heat exchanger (30) of any one of the first through fifth aspects, the protrusions (81-83) are arranged side by side in an air passage direction in each of the heat transfer parts (70) of the fins (35, 36).

[0023] In the sixth aspect, the protrusions (81-83) are provided in each of the heat transfer parts (70) of the fins (35, 36). In each of the heat transfer parts (70), the protrusions (81-83) are arranged side by side in the air passage direction. An air flow in the air passages (40) is disturbed every when the air flows across the protrusions (81-83).

[0024] In a seventh aspect of the present disclosure, in the heat exchanger (30) of the sixth aspect, among the protrusions (81-83) of each of the heat transfer parts (70) of the fins (35, 36), the protrusion (81) closest to a windward side of the heat transfer part (70) has a largest width in the air passage direction.

[0025] As the width, in the air passage direction, of the protrusions (81-83) increases, the change in the direction of air flowing along the protrusions (81-83) decreases, resulting in reduction of the degree of heat transfer promotion by the protrusions (81-83). On the other hand, the difference in temperature between air flowing in the air passages (40) and the heat transfer parts (70) is the largest at the inlets of the air passages (40), and gradually decreases toward the leeward.

[0026] In the seventh aspect, in each of the heat transfer parts (70) of the fins (35, 36), the width, in the air passage direction, of the first protrusions (81) closest to the windward side is larger than those of the other protrusions (82, 83). That is, in each of the heat transfer parts (70) of the fins (35, 36), the first protrusions (81) showing a relatively low degree of heat transfer promotion and having the largest width is provided in a windward region where the temperature difference between air flowing in the air passages (40) and the heat transfer parts (70) is relatively large. As a result, in each of the heat transfer parts (70) of the fins (35, 36), the amount of frost attached to a windward region where the widest protrusion (81) is located can be reduced.

[0027] In an eighth aspect of the present disclosure, in the heat exchanger (30) of the sixth or seventh aspect, among the protrusions (81-83) of each of the heat transfer parts (70) of the fins (35, 36), the protrusion (81) closest to a windward side of the heat transfer part (70) has a smallest height in a direction in which the protrusions (81-83) protrude.

[0028] As the height, in the protrusion direction, of the protrusions (81-83) decreases, the change in the direction of air flowing along the protrusions (81-83) decreases, resulting in reduction of the degree of heat transfer promotion by the protrusions (81-83). On the other hand, the difference in temperature between air flowing in the air passages (40) and the heat transfer parts (70) is the largest at the inlets of the air passages (40), and gradually decreases toward the leeward.

[0029] In the eighth aspect, in each of the heat transfer parts (70) of the fins (35, 36), the height, in the protrusion direction, of the first protrusions (81) closest to the windward side is smaller than those of the other protrusions (82, 83). That is, in each of the heat transfer parts (70) of the fins (35, 36), the first protrusions (81) showing a relatively low degree of heat transfer promotion and having the smallest height is provided in a windward region where the temperature difference between air flowing in the air passages (40) and the heat transfer parts (70) is relatively large. As a result, in each of the heat transfer parts (70) of the fins (35, 36), the amount of frost attached to the windward region where the protrusion (81) having the smallest height is located can be reduced.

[0030] In a ninth aspect of the present disclosure, in the heat exchanger (30) of any one of the sixth through eighth aspects, in each of the heat transfer parts (70) of the fins (35, 36), the protrusions (81-83) are located in a region from a windward edge (38) of the heat transfer part (70) to a portion at a leeward side of a middle, in the air passage direction, of the heat transfer part (70).

[0031] In the ninth aspect, the protrusions (81-83) are provided in a half or more, in the air passage direction, of each of the heat transfer parts (70) of the fins (35, 36).

[0032] In a tenth aspect of the present disclosure, in the heat exchanger (30) of any one of the sixth through ninth aspects, each of the heat transfer parts (70) of the fins (35, 36) includes a windward end portion (72) located windward of the flat tubes (33), and in each of the heat transfer parts (70) of the fins (35, 36), the protrusions (81-83) are located in a region including the windward end portion (72) and a portion at a leeward side of the windward end portion (72).

[0033] In the tenth aspect, each of the heat transfer parts (70) of the fins (35, 36) includes the windward end portion (72). In each of the heat transfer parts (70), the protrusions (81-83) are provided in a region including both of the windward end portion (72) and a portion adjacent to the leeward side of the windward end portion (72).

[0034] In an eleventh aspect of the present disclosure, in the heat exchanger (30) of any one of the sixth through tenth aspects, in each of the heat transfer parts (70) of the fins (35, 36), the protrusions (81-83) are tilted such that vertical positions of lower ends of the protrusions (81-83) become lower toward a leeward side of the heat transfer part (70).

[0035] In the eleventh aspect, the lower ends of the protrusions (81-83) provided on each of the heat transfer parts (70) of the fins (35, 36) are tilted. The vertical positions of the lower ends of the protrusions (81-83) become lower toward the leeward side of the heat transfer part (70). Thus, in each of the heat transfer parts (70) of the fins (35, 36), the distance from one of the flat tubes (33) adjacent to, and located below, the heat transfer parts (70) to the lower end of the protrusion (81-83) gradually decreases toward the leeward.

[0036] In defrosting operation for melting frost attached to the fins (35, 36), drain water generated by melting the frost flows down from the protrusions (81-83) along the surface of each of the heat transfer parts (70). The drain water that has flown down from the protrusions (81-83) is accumulated on the flat tube (33) adjacent to, and located below, the heat transfer part (70). On the other hand, in the eleventh aspect, the distance from the flat tube (33) below the heat transfer part (70) to the lower end of the protrusions (81-83) gradually decreases toward the leeward. Thus, the drain water that has flown down from the protrusions (81-83) and is accumulated on the flat tube (33) is drawn by a capillary phenomenon from the flat tube (33) to a leeward region where the distances from the flat tube (33) to the lower ends of the protrusions (81-83) are small.

[0037] In a twelfth aspect of the present disclosure, in the heat exchanger (30) of any one of the first through eleventh aspects, the fins (36) each have a plate shape with notches (45) into which the flat tubes (33) are inserted, are arranged to be spaced from one another by a predetermined distance in a direction in which the flat tubes (33) extend, and sandwich the flat tubes (33) at edges of the notches (45), and parts of the fins (36) between vertically adjacent ones of the notches (45) are the heat transfer parts (70).

[0038] In the twelfth aspect, the plate-like fins (36) are arranged to be spaced from one another by a predetermined distance in the direction in which the flat tubes (33) extend. Each of the fins (36) has the notches (45) into which the flat tubes (33) are inserted. In the fins (36), the peripheries of the notches (45) sandwich the flat tubes (33). Spaces between vertically adjacent ones of the notches (45) of the fins (36) are the heat transfer parts (70).

[0039] In a thirteenth aspect of the present disclosure, in the heat exchanger (30) of any one of the first through the eleventh aspects, each of the fins (35) is a corrugated fin that bends up and down and is located between adjacent ones of the flat tubes (33), includes the heat transfer parts (37) arranged in a direction in which the flat tubes (33) extend, and also includes intermediate plate parts (41) continuous to upper or lower ends of adjacent ones of the heat transfer parts (37) and joined to the flat tubes (33).

[0040] In the thirteenth aspect, the fins (35) that are corrugated fins are located between adjacent ones of the flat tubes (33). Each of the fins (35) includes the heat transfer parts (70) arranged in the direction in which the flat tubes (33) extend. In the fins (35), adjacent ones of the heat transfer parts (70) are continuous to an associated one of the intermediate plate parts (41), and the intermediate plate parts (41) are joined to flat side surfaces of the flat tubes (33).

[0041] A fourteenth aspect of the present disclosure is directed to an air conditioner (10) including a refrigerant circuit (20) including the heat exchanger (30) of any one of the first through thirteenth aspects, and the refrigerant circuit (20) circulates refrigerant therein, thereby performing a refrigeration cycle.

[0042] In the fourteenth aspect, the heat exchanger (30) of any one of the first through thirteenth aspects is connected to the refrigerant circuit (20). In the heat exchanger (30), refrigerant circulating in the refrigerant circuit (20) flows through the fluid passages (34) of the flat tubes (33), and exchanges heat with air flowing in the air passages (40).

ADVANTAGES OF THE INVENTION

[0043] In each of the heat transfer parts (70) of the fins (35, 36) of the present disclosure, the protrusions (81-83) showing a relatively low degree of heat transfer promotion are provided at the windward side of the louvers (50, 60). Thus, the difference between the amount of frost attached to a windward region of the heat transfer parts (70) and the amount of frost attached to a leeward region of the heat transfer parts (70) is reduced. Accordingly, as compared to a conventional heat exchanger in which frost is collectively attached to a windward region of fins, the heat exchanger (30) of the present disclosure can increase the amount of frost attached to the fins at the time when the capability of heat exchange decreases to a minimum. As a result, the present disclosure can prolong the period until the capability of the heat exchanger (30) decreases to a minimum because of frost attached to the fins, thereby decreasing frequency of defrosting operation.

[0044] In each of the heat transfer parts (70) of the second aspect, at least a louver (50) that is located near the protrusions (81-83) has the leeward bent-out end (53) projecting in the direction in which the protrusions (81-83) protrude. Thus, air that has flown across the protrusions (81-83) is further disturbed when striking the louver (50) near the protrusions (81-83). As a result, the heat exchanger (30) of this aspect ensures promotion of heat transfer between the fins (35, 36) and the air in a portion of the heat transfer parts (70) on which the louvers (50, 60) are provided.

[0045] In the third aspect, at least one of the louvers (50, 60) provided on each of the heat transfer parts (70) of the fins (35, 36) is the asymmetric louver (50a). In the asymmetric louver (50a), the tilt angle of the lower edge (56) relative to the main edge (54) is smaller than the tilt angle of the upper edge (55) relative to the main edge (54). Thus, drain water generated on the surfaces of the fins (35, 36) and present between the bent-out ends (53) of the louvers (50a) that are adjacent to each other in the air passage direction can be drawn into gaps between the slender lower edges (56) by a capillarity phenomenon. Thus, the heat exchanger (30) of this aspect can allow drain water between the bent-out ends (53) of the louvers (50a) that are adjacent to each other in the air passage direction to flow downward by not only gravity but also a capillary phenomenon, thereby reducing the amount of drain water remaining on the surfaces of the heat transfer parts (70).

[0046] In the fifth aspect, the louvers (50, 60) are provided on the leeward end portion (73) of each of the heat transfer parts (70) of the fins (35, 36). The temperature difference between the leeward end portion (73) and air flowing in the air passages (40) is smaller than that between a portion sandwiched between the vertically adjacent flat tubes (33) and air flowing in the air passages (40). On the other hand, in the heat exchanger (30) of this aspect, the leeward louvers (60) are provided in the leeward end portion (73) of each of the heat transfer parts (70) to promote heat transfer between the leeward end portion (73) and the air. As a result, the heat exchanger (30) of this aspect can effectively utilize the leeward end portions (73) of the heat transfer parts (70) for heat exchange with the air, thereby enhancing performance of the heat exchanger (30).

[0047] In the sixth aspect, the protrusions (81-83) are provided in each of the heat transfer parts (70) of the fins (35, 36). Thus, an air flow in the air passages (40) is disturbed even when air flows across the protrusions (81-83). As a result, the heat exchanger (30) of this aspect can promote heat transfer between portions of the heat transfer parts (70) where the protrusions (81-83) are provided and the air.

[0048] In the seventh aspect, in each of the heat transfer parts (70) of the fins (35, 36), the width, in the air passage direction, of the protrusion (81) closest to a windward side of the heat transfer part (70) is larger than those of the other protrusions (82, 83). In the eighth aspect, in each of the heat transfer parts (70) of the fins (35, 36), the height, in the protrusion direction, of the protrusion (81) closest to a windward side of the heat transfer part (70) is smaller than those of the other protrusions (82, 83).

[0049] That is, in the seventh and eighth aspects, in each of the heat transfer parts (70) of the fins (35, 36), the protrusion (81) showing a lower degree of heat transfer promotion than the other protrusions (82, 83) is provided in a windward region where the temperature difference between air flowing in the air passages (40) and the heat transfer parts (70) is relatively large. Thus, the heat exchangers (30) of these aspects can reduce the amount of frost attached to a windward region of each of the heat transfer parts (70) of the fins (35, 36), thereby ensuring reduction of the difference between the amount of frost attached to a windward region of the heat transfer parts (70) and the amount of frost attached to a leeward region of the heat transfer parts (70).

[0050] In the eleventh aspect, in each of the heat transfer parts (70) of the fins (35, 36), the vertical positions of the lower ends of the protrusions (81-83) become lower toward a leeward side of the heat transfer part (70). Thus, drain water that has been generated on the surfaces of the heat transfer parts (70) and flown down from the protrusions (81-83) is drawn by a capillary phenomenon from the flat tubes (33) to a leeward region where the distances from the flat tube (33) to the lower ends of the protrusions (81-83) are small. As a result, the heat exchanger (30) of this aspect can promote movement of drain water generated on the surfaces of the heat transfer parts (70) toward the leeward, thereby reducing the amount of drain water remaining on the heat exchanger (30).

BRIEF DESCRIPTION OF THE DRAWINGS

[0051]

FIG. 1 is a refrigerant circuit diagram schematically illustrating an air conditioner including a heat exchanger according to a first embodiment.

FIG. 2 is a perspective view schematically illustrating the heat exchanger of the first embodiment.

FIG. 3 is a partial cross-sectional view illustrating the heat exchanger of the first embodiment when viewed from the front.

FIG. 4 is a cross-sectional view partially illustrating the heat exchanger taken along the line A-A in FIG. 3.

FIGS. 5A and 5B are views illustrating a main portion of a fin of the heat exchanger of the first embodiment, FIG. 5A is a front view of the fin, and FIG. 5B is a cross-sectional view taken along the line B-B in FIG. 5A.

FIGS. 6A-6C illustrate the fin of the heat exchanger of the first embodiment, FIG. 6A is a cross-sectional view taken along the line C-C in FIGS. 5A and 5B, FIG. 6B is a cross-sectional view taken along the line D-D in FIGS. 5A and 5B, and FIG. 6C is a cross-sectional view taken along the line E-E in FIGS. 5A and 5B.

FIG. 7 is a cross-sectional view illustrating heat transfer parts of fins of the heat exchanger of the first embodiment, and corresponds to FIG. 5B.

FIG. 8 is a cross-sectional view illustrating the fin taken along the line F-F in FIGS. 5A and 5B.

FIG. 9 is a perspective view schematically illustrating a heat exchanger according to a second embodiment.

FIG. 10 is a partial cross-sectional view illustrating the heat exchanger of the second embodiment when viewed from the front.

FIG. 11 is a cross-sectional view partially illustrating the heat exchanger taken along the line G-G in FIG. 10.

FIG. 12 is a perspective view schematically illustrating a fin provided in the heat exchanger of the second embodiment.

FIG. 13 is a cross-sectional view illustrating a heat exchanger according to a third embodiment and corresponds to FIG. 4.

FIGS. 14A and 14B illustrate a main portion of a fin of the heat exchanger of the third embodiment, FIG. 14A is a front view of the fin, and FIG. 14B is a cross-sectional view taken along the line H-H in FIG. 14A.

FIG. 15 is a front view illustrating a fin obtained by applying a first variation as other embodiments to the fin of the first embodiment and corresponds to FIG. 4.

FIG. 16 is a front view illustrating a fin obtained by applying a second variation as other embodiments to the fin of the first embodiment and corresponds to FIG. 4.

FIGS. 17A and 17B are cross-sectional views illustrating fins of other embodiments and corresponds to FIG. 5B, FIG. 17A illustrates a fin obtained by applying a third variation to the fin of the first embodiment, and FIG. 17B illustrates a fin obtained by applying a fourth variation to the fin of the first embodiment.

DESCRIPTION OF EMBODIMENTS

[0052] Embodiments of the present disclosure will be described with reference to the drawings.

<<First Embodiment>>

[0053] A first embodiment of the present disclosure will now be described. A heat exchanger (30) according to the first embodiment constitutes an outdoor heat exchanger (23) of an air conditioner (10), which will be described later.

-Air Conditioner-

[0054] Referring now to FIG. 1, the air conditioner (10) including the heat exchanger (30) of this embodiment will be described.

<Configuration of Air Conditioner>

[0055] The air conditioner (10) includes an outdoor unit (11) and an indoor unit (12). The outdoor unit (11) and the indoor unit (12) are connected to each other through a liquid communication pipe (13) and a gas communication pipe (14). In the air conditioner (10), the outdoor unit (11), the indoor unit (12), the liquid communication pipe (13), and the gas communication pipe (14) constitute a refrigerant circuit (20).

[0056] The refrigerant circuit (20) includes a compressor (21), a four-way valve (22), an outdoor heat exchanger (23), an expansion valve (24), and an indoor heat exchanger (25). The compressor (21), the four-way valve (22), the outdoor heat exchanger (23), and the expansion valve (24) are housed in the outdoor unit (11). The outdoor unit (11) includes outdoor fans (15) for supplying outdoor air to the outdoor heat exchanger (23). On the other hand, the indoor heat exchanger (25) is housed in the indoor unit (12). The indoor unit (12) includes indoor fans (16) for supplying indoor air to the indoor heat exchanger (25).

[0057] The refrigerant circuit (20) is a closed circuit charged with refrigerant. In the refrigerant circuit (20), a discharge side of the compressor (21) is connected to a first port of the four-way valve (22) and a suction side of the compressor (21) is connected to a second port of the four-way valve (22). In the refrigerant circuit (20), the outdoor heat exchanger (23), the expansion valve (24), and the indoor heat exchanger (25) are arranged in this order from a third port to a fourth port of the four-way valve (22).

[0058] The compressor (21) is a scroll or rotary hermetic compressor. The four-way valve (22) switches between a first position (indicated by broken lines in FIG. 1) at which the first port communicates with the third port and the second port communicates with the fourth port and a second position (indicated by continuous lines in FIG. 1) at which the first port communicates with the fourth port and the second port communicates with the third port. The expansion valve (24) is a so-called electronic expansion valve.

[0059] The outdoor heat exchanger (23) performs heat exchange between outdoor air and refrigerant. The outdoor heat exchanger (23) is constituted by the heat exchanger (30) of this embodiment. On the other hand, the indoor heat exchanger (25) performs heat exchange between indoor air and refrigerant. The indoor heat exchanger (25) is a so-called cross-fin type fin-and-tube heat exchanger including a circular heat transfer tube.

<Cooling Operation>

[0060] The air conditioner (10) performs cooling operation. In the cooling operation, the four-way valve (22) is set at the first position. In addition, in the cooling operation, the outdoor fans (15) and the indoor fans (16) operate.

[0061] The refrigerant circuit (20) performs a refrigeration cycle. Specifically, refrigerant discharged from the compressor (21) flows into the outdoor heat exchanger (23) through the four-way valve (22), and dissipates heat into the outdoor air to be condensed. Refrigerant that has flown out of the outdoor heat exchanger (23) expands when passing through the expansion valve (24), then flows into the indoor heat exchanger (25), and absorbs heat from the indoor air to evaporate. Refrigerant that has flown out of the indoor heat exchanger (25) passes through the four-way valve (22) and then is sucked into the compressor (21) to be compressed therein. The indoor unit (12) supplies air cooled in the indoor heat exchanger (25) into the room.

<Heating Operation>

[0062] The air conditioner (10) performs heating operation. In the heating operation, the four-way valve (22) is set at the second position. In addition, in the heating operation, the outdoor fans (15) and the indoor fans (16) operate.

[0063] The refrigerant circuit (20) performs a refrigeration cycle. Specifically, refrigerant discharged from the compressor (21) flows into the indoor heat exchanger (25) through the four-way valve (22), and dissipates heat into the indoor air to be condensed. Refrigerant that has flown out of the indoor heat exchanger (25) expands when passing through the expansion valve (24), then flows into the outdoor heat exchanger (23), and absorbs heat from the outdoor air to evaporate. Refrigerant that has flown out of the outdoor heat exchanger (23) passes through the four-way valve (22) and then is sucked into the compressor (21) to be compressed therein. The indoor unit (12) supplies air heated in the indoor heat exchanger (25) into the room.

<Defrost Operation>

[0064] As described above, in the heating operation, the outdoor heat exchanger (23) serves as an evaporator. Under operating conditions where the temperature of the outdoor air is low, the evaporating temperature of refrigerant in the outdoor heat exchanger (23) is lower than 0°C in some cases. In these cases, moisture in the outdoor air becomes frost and is attached to the outdoor heat exchanger (23). To prevent this, the air conditioner (10) performs defrosting operation every when the time duration of the heating operation reaches a predetermined value (e.g., several ten minutes), for example.

[0065] To start defrosting operation, the four-way valve (22) switches from the second position to the first position, and the outdoor fans (15) and the indoor fans (16) stop. In the refrigerant circuit (20) during the defrosting operation, high-temperature refrigerant discharged from the compressor (21) is supplied to the outdoor heat exchanger (23). In the outdoor heat exchanger (23), frost attached to the surface of the outdoor heat exchanger (23) is heated by the refrigerant, and melts. The refrigerant that has dissipated heat in the outdoor heat exchanger (23) passes through the expansion valve (24) and the indoor heat exchanger (25) in this order, and then is sucked into the compressor (21) to be compressed. After the defrosting operation is finished, heating operation is started again. That is, the four-way valve (22) switches from the first position to the second position, and the outdoor fans (15) and the indoor fans (16) operate again.

-Heat Exchanger of First Embodiment-

[0066] The heat exchanger (30) of this embodiment constituting the outdoor heat exchanger (23) of the air conditioner (10) will be described with reference to FIGS. 2-8 as necessary.

<Overall Configuration of Heat Exchanger>

[0067] As illustrated in FIGS. 2 and 3, the heat exchanger (30) of this embodiment includes a first header concentrated pipe (31), a second header concentrated pipe (32), a large number of flat tubes (33), and a large number of fins (36). The first header concentrated pipe (31), the second header concentrated pipe (32), the flat tubes (33), and the fins (36) are made of an aluminium alloy, and are joined to one another by brazing.

[0068] Each of the first header concentrated pipe (31) and the second header concentrated pipe (32) has a slender hollow cylindrical shape whose both ends are closed. As illustrated in FIG. 3, the first header concentrated pipe (31) stands at the left end of the heat exchanger (30), and the second header concentrated pipe (32) stands at the right end of the heat exchanger (30). That is, the first and second header concentrated pipes (31) and (32) are oriented such that the axes thereof extend in the vertical direction.

[0069] As also illustrated in FIG. 4, each of the flat tubes (33) is a heat transfer tube that is in the shape of a flat ellipse or a rounded rectangle in cross section. In the heat exchanger (30), the direction in which the flat tubes (33) extend is the transverse direction, and the flat side surfaces of the flat tubes (33) face one another. The flat tubes (33) are spaced from one another in the vertical direction by a predetermined distance. Each of the flat tubes (33) has its one end inserted in the first header concentrated pipe (31) and the other end inserted in the second header concentrated pipe (32).

[0070] The fins (36) are plate-like fins and spaced from one another by a predetermined distance in the direction in which the flat tubes (33) extend. That is, the fins (36) are substantially orthogonal to the direction in which the flat tubes (33) extend. Although specifically described later, in each of the fins (36), a portion between vertically adjacent ones of the flat tubes (33) constitutes a heat transfer part (70).

[0071] As illustrated in FIG. 3, in the heat exchanger (30), a space between vertically adjacent ones of the flat tubes (33) is divided into a plurality of air passages (40) by the heat transfer parts (70) of the fin (36). The heat exchanger (30) performs heat exchange between refrigerant flowing in the fluid passages (34) of the flat tubes (33) and air flowing in the air passages (40).

[0072] As described above, the heat exchanger (30) includes: the vertically arranged flat tubes (33) whose flat side surfaces face one another; and the fins (36) each including the plate-like heat transfer parts (70) extending from one of its adjacent flat tubes (33) to the other. The heat transfer parts (70) are located between adjacent ones of the flat tubes (33), and arranged side by side in the direction in which the flat tubes (33) extend. In the heat exchanger (30), air flowing between adjacent ones of the heat transfer parts (70) exchanges heat with fluid flowing in the flat tubes (33).

<Fin Configuration>

[0073] As illustrated in FIG. 4, each of the fins (36) is an elongate plate-like fin formed by pressing a metal plate. The thickness of each of the fins (36) is approximately 0.1 mm.

[0074] Each of the fins (36) has a large number of slender notches (45) extending from a front edge (38) of the fin (36) in the width direction (i.e., in the air passage direction) of the fin (36). In each of the fins (36), the large number of notches (45) are spaced from one another by a predetermined distance in the longitudinal direction (i.e., the vertical direction) of the fin (36). The notches (45) are notches into which the flat tubes (33) are inserted. Leeward portions of the notches (45) constitute pipe insertion portions (46). The vertical width of the pipe insertion portions (46) is substantially equal to the thickness of the flat tubes (33), and the length of the pipe insertion portions (46) is substantially equal to the width of the flat tubes (33).

[0075] The flat tubes (33) are inserted into the pipe insertion portions (46) of the fins (36), and joined to the peripheries of the pipe insertion portions (46) by brazing. That is, each of the flat tubes (33) is sandwiched between the periphery of an associated one of the pipe insertion portions (46), which are part of the notches (45).

[0076] In the fins (36), portions between vertically adjacent ones of the notches (45) are heat transfer parts (70). That is, each of the fins (36) includes the heat transfer parts (70) vertically adjacent ones of which sandwich an associated one of the flat tubes (33). In the heat exchanger (30) of this embodiment, the heat transfer parts (70) of each of the fins (36) are disposed between the vertically arranged flat tubes (33).

[0077] Each of the heat transfer parts (70) of the fins (36) includes an intermediate portion (71), a windward end portion (72), and a leeward end portion (73). In each of the heat transfer parts (70), a portion overlapping its vertically adjacent ones of the flat tubes (33) (i.e., a portion located immediately above or under its vertically adjacent ones of the flat tubes (33)) is the intermediate portion (71). In each of the heat transfer parts (70), a portion that is located windward of the intermediate portion (71) (i.e., a portion projecting windward from the flat tubes (33)) is the windward end portion (72), and a portion that is located leeward of the intermediate portion (71) (i.e., a portion projecting leeward from the flat tubes (33)) is the leeward end portion (73).

[0078] In the fins (36), the leeward end portions (73) of vertically adjacent ones of the heat transfer parts (70) are coupled to each other through a coupling plate portion (75). Each of the fins (36) also includes a water-conveyance rib (49). The water-conveyance rib (49) is a slender groove vertically extending along a rear edge (39) of the fin (36). The water-conveyance rib (49) extends from the upper end to the lower end of the fin (36).

[0079] As illustrated in FIGS. 5A and 5B, each of the heat transfer parts (70) of the fins (36) includes protrusions (81-83) and louvers (50, 60). In each of the heat transfer parts (70), the protrusions (81-83) are located in a windward region, and the louvers (50, 60) are located in a leeward region. That is, in each of the heat transfer parts (70), the louvers (50, 60) are located only in the leeward region, and the protrusions (81-83) are located windward of the louvers (50, 60). The numbers of the protrusions (81-83) and the louvers (50, 60) are merely examples.

[0080] In each of the heat transfer parts (70) of the fins (36), the three protrusions (81-83) are provided in a region from the windward end portion (72) to a windward region of the intermediate portion (71). The three protrusions (81-83) are arranged side by side in the air passage direction (i.e., the direction from the front edge (38) to the rear edge (39) of the fin (36)). Each of the protrusions (81-83) has an inverted V shape formed by making the heat transfer part (70) protrude toward the air passage (40). The protrusions (81-83) will be described in detail later.

[0081] In each of the heat transfer parts (70) of the fins (36), the vertically extending louvers (50, 60) are provided in each of a leeward region of the intermediate portion (71) and the leeward end portion (73). In each of the heat transfer parts (70), the louvers (50, 60) are arranged side by side in the air passage direction. The louvers (50, 60) will be described in detail later.

[0082] Each of the fins (36) includes tabs (48) for keeping the distance from its adjacent fin (36). As illustrated in FIG. 5B, the tabs (48) are rectangular flaps formed by bending out the fin (36). As illustrated in FIG. 7, the tabs (48) keep the distance between the fins (36) with the tips of the tabs (48) being in contact with their adjacent ones of the fins (36). As illustrated in FIG. 5A, in each of the heat transfer parts (70), one of the tabs (48) is located at the upper edge of the heat the windward end portion (72), and another tab (48) is located at the lower edge of the windward end portion (72). Another tab (48) is also located on each of the coupling plate portions (75).

<Arrangement and Shape of Protruding Portion>

[0083] The arrangement and shapes of the protrusions (81-83) of the fins (36) will now be described in detail. The "right" and "left" herein are based on the direction when the fins (36) are seen from the windward side (i.e., from the front side of the heat exchanger (30)).

[0084] As illustrated in FIGS. 5A and 5B, each of the heat transfer parts (70) of the fins (36) includes a first protrusion (81), a second protrusion (82), and a third protrusion (83). The protrusions (81-83) are formed by plastically deforming the heat transfer parts (70) of the fins (36) by, for example, pressing, and protrude to the right from the heat transfer parts (70) (see FIG. 6A). The protrusion direction from the heat transfer parts (70) is merely an example. That is, the protrusions (81-83) may protrude to the left from the heat transfer parts (70).

[0085] Each of the protrusions (81-83) extends in the direction intersecting with the air passage direction in the air passage (40). Specifically, each of the protrusions (81-83) has an inverted V shape in which a ridge (81 a, 82a, 8 3 a) is substantially in parallel with the front edge (38) of the fin (36). That is, the ridges (81a, 82a, 83a) of the protrusions (81-83) intersect with the air passage direction. In each of the protrusions (81-83), each of a tilted portion from the front end (i.e., the windward end) to the ridge (81a, 82a, 83a) and a tilted portion from the rear end (i.e., the leeward end) to the ridge (81a, 82a, 83a) is a slope (81b, 82b, 83b). In addition, in each of the protrusions (81-83), each of a portion from the upper end (81 d, 82d, 83d) to the upper end of the slope (81b, 82b, 83b) and a portion from the lower end (81e, 82e, 83e) to the lower end of the slope (81b, 82b, 83b) is a side surface (81 c, 82c, 83c).

[0086] In each of the heat transfer parts (70) of the fins (36), the first protrusion (81), the second protrusion (82), and the third protrusion (83) are arranged in this order in the air passage direction (i.e., the direction from the front edge (38) to the rear edge (39) of the fin (36)). In each of the heat transfer parts (70), the three protrusions (81-83) are provided in a region including the windward end portion (72) and a windward region of the intermediate portion (71). Specifically, the front end of the first protrusion (81) is close to the front edge (38) of the fin (36). The rear end of the first protrusion (81) is continuous to the front end of the second protrusion (82), and the rear end of the second protrusion (82) is continuous to the front end of the third protrusion (83). The rear end of the third protrusion (83) is located leeward of the center, in the air passage direction, of the heat transfer part (70) is. That is, the length L1 from the front edge (38) of the fin (36) to the rear end of the third protrusion (83) is larger than a half of the length L from the front edge (38) to the rear edge (39) of the fin (36) (i.e., $L1 > L/2$).

[0087] As illustrated in FIG. 5A, the width W1, in the air passage direction, of the first protrusion (81) is larger than each of the width W2, in the air passage direction, of the second protrusion (82) and the width W3, in the air passage direction, of the third protrusion (83). The width W2 of the second protrusion (82) is equal to the width W3 of the third protrusion (83). That is, the widths of the protrusions (81-83) have the relationship of $W1 > W2 = W3$. On the other hand, as illustrated in FIG. 5B, the height H1, in the protrusion direction, of the first protrusion (81) is smaller than the height H2, in the protrusion direction, of the second protrusion (82), and the height H2, in the protrusion direction, of the second protrusion (82) is smaller than the height H3, in the protrusion direction, of the third protrusion (83) (i.e., $H1 < H2 < H3$).

[0088] The upper end (81d) of the first protrusion (81) is tilted upward toward the leeward. On the other hand, the upper end (82d) of the second protrusion (82) and the upper end (83d) of the third protrusion (83) are substantially orthogonal to the front edge (38) of the fin (36). In each of the heat transfer parts (70), the distance from the upper end of the heat transfer part (70) to the upper end (83d) of the third protrusion (83) is smaller than the distance from the upper end of the heat transfer part (70) to the upper end (82d) of the second protrusion (82).

[0089] Each of the lower ends (81e, 82e, 83e) of the protrusions (81-83) is tilted downward toward the leeward. The lower ends (81e, 82e, 83e) of the three protrusions (81-83) are arranged on a line tilted downward toward the leeward. Thus, in each of the heat transfer parts (70), the distance D2 from the lower end of the heat transfer part (70) to the leeward end of the lower end (83e) of the third protrusion (83) is smaller than the distance D1 from the lower end of the heat transfer part (70) to the windward end of the lower end (81e) of the first protrusion (81). In each of the heat transfer parts (70), the distance from the lower end of the heat transfer part (70) to the lower end (81e, 82e, 83e) of the protrusion (81-83) decreases toward the leeward.

<Arrangement and Shape of Louvers>

[0090] The arrangement and shape of the louvers (50, 60) formed on the fins (36) will now be described in detail. The "right" and "left" herein are based on the direction when the fins (36) are seen from the windward side (i.e., from the front side of the heat exchanger (30)).

[0091] As illustrated in FIGS. 5A and 5B, in each of the heat transfer parts (70) of the fins (36), the louvers (50, 60) are arranged side by side in the air passage direction. In the heat transfer part (70), a group of louvers provided in the intermediate portion (71) are windward louvers (50), and a group of louvers provided in the leeward end portion (73) are leeward louvers (60).

[0092] The louvers (50, 60) are obtained by forming slits in the heat transfer part (70) and plastically deforming portions between adjacent ones of the slits. The longitudinal direction of the louvers (50, 60) is substantially in parallel with (i.e., in the vertical direction) of the front edge (38) of the heat transfer part (70). That is, the longitudinal direction of the louvers (50, 60) intersects with the air passage direction. The louvers (50, 60) have the same length.

[0093] In each of the heat transfer parts (70), the distance from the lower end of the heat transfer part (70) to the lower end of each of the louvers (50, 60) is substantially equal to the distance D from the lower end of the heat transfer part (70) to the leeward end of the lower end (83e) of the third protrusion (83). In each of the heat transfer parts (70), the distance from the upper end of the heat transfer part (70) to the upper ends of the louvers (50, 60) is substantially equal to the distance from the upper end of the heat transfer part (70) to the upper end (83d) of the third protrusion (83).

[0094] As illustrated in FIG. 5B, the louvers (50, 60) are tilted relative to their peripheral flat portions. The windward louvers (50) and the leeward louvers (60) are tilted in opposite directions. In the windward louvers (50), bent-out ends (53) at the windward side protrude to the left, and bent-out ends (53) at the leeward side protrude to the right. That is, in each of the windward louvers (50), the bent-out end (53) at the leeward side protrudes in the same direction as the direction in which the third protrusion (83) protrudes. On the other hand, in each of the leeward louvers (60), the bent-out end (63) at the windward side protrudes to the right, and the bent-out end (63) at the leeward side protrudes to the left.

[0095] As illustrated in FIGS. 6B and 6C, the bent-out ends (53, 63) of the windward louvers (50) and the leeward louvers (60) include main edges (54, 64), upper edges (55, 65), and lower edges (56, 66). The main edges (54, 64) extend substantially in parallel with the direction in which the front edge (38) of the heat transfer part (70) extends. The upper edges (55, 65) extend from the upper ends of the main edges (54, 64) to the upper ends of the louvers (50, 60), and are tilted relative to the main edges (54, 64). The lower edges (56, 66) extend from the lower ends of the main edges (54, 64) to the lower ends of the louvers (50, 60), and are tilted relative to the main edges (54, 64).

[0096] As illustrated in FIG. 6B, in each of the windward louvers (50), the upper edge (55) is tilted at a tilt angle $\theta 1$ relative to the main edge (54), and the lower edge (56) is tilted at a tilt angle $\theta 2$ relative to the main edge (54). As illustrated in FIG. 5A, in some of the windward louvers (50a) located in a windward region, the tilt angle $\theta 2$ of the lower edge (56) is smaller than the tilt angle $\theta 1$ of the upper edge (55) (i.e., $02 < \theta 1$). Thus, in each of the windward louvers (50a), the lower edge (56) is longer than the upper edge (55). The windward louvers (50a) are asymmetric louvers in each of which the shape of the bent-out end (53) is asymmetric in the vertical direction. On the other hand, in some of the windward louvers (50b) located in a leeward region, the tilt angle $\theta 2$ of the lower edge (56) is equal to the tilt angle $\theta 1$ of the upper edge (55). The windward louvers (50b) are symmetric louvers in each of which the shape of the bent-out end (53) is symmetric in the vertical direction.

[0097] As illustrated in FIG. 6C, in each of the leeward louvers (60), the upper edge (65) is tilted at a tilt angle $\theta 3$ relative to the main edge (64), and the lower edge (66) is tilted at a tilt angle $\theta 4$ relative to the main edge (64). As illustrated in FIG. 5A, in each of the leeward louvers (60a), the tilt angle $\theta 4$ of the lower edge (66) is equal to the tilt angle $\theta 3$ of the upper edge (65). The leeward louvers (60) are symmetric louvers in each of which the shape of the bent-out end (63) is symmetric in the vertical direction.

-Air Flow in Heat Exchanger-

[0098] An air flow in the heat exchanger (30) will be described with reference to FIG. 7.

[0099] In the heat exchanger (30), air passages (40) are formed between the heat transfer parts (70) that are adjacent one another in the direction in which the flat tubes (33) extend, and air flows through the air passages (40). On the other hand, each of the heat transfer parts (70) of the fins (36) includes the protrusions (81-83) protruding in one direction (which is right when viewed from the front edges (38) of the fins (36) in this embodiment). Thus, part of the air passages (40) facing the protrusions (81-83) of the heat transfer part (70) bends up and down along the protrusions (81-83).

[0100] Air that has flown into the air passages (40) from the front edges (38) of the fins (36) flows in a bending portion of the air passages (40) along the protrusions (81-83). Accordingly, the air flow in the air passages (40) is disturbed with its direction changed when striking the protrusions (81-83). As a result, as compared to a case where the heat transfer parts (70) are flat without unevenness, heat transfer between air flowing in the air passages (40) and the heat transfer parts (70) is promoted.

[0101] In the air passages (40), air that has flown while bending up and down along the protrusions (81-83) strikes the windward louvers (50). At this time, air that has flown across the ridges (83a) of the third protrusions (83) flows along the leeward slopes (83b), and then strikes the windward louvers (50). In each of the windward louvers (50), the bent-out end (53) at the leeward side projects in the direction in which the third protrusion (83) protrudes. Thus, when air that has flown along the leeward slope (83b) of the third protrusion (83) strikes the windward louver (50), the direction of the air flow is changed by the windward louver (50). Thus, the air flow in the air passages (40) is disturbed, thereby promoting heat transfer between the air and the heat transfer parts (70).

[0102] As described above, the louvers (50, 60) bend out from the heat transfer parts (70). Thus, in the heat exchanger (30), air is replaced between adjacent ones of the air passages (40) sandwiching the heat transfer parts (70), and an air flow in the air passages (40) is greatly disturbed. As a result, as compared to a case where the heat transfer parts (70) are flat plates without unevenness and a case where the heat transfer parts (70) include only protrusions, heat transfer between air flowing in the air passages (40) and the heat transfer parts (70) is promoted.

-Conditions of Frost and Drain Water on Fin-

[0103] As described above, the heat exchanger (30) of this embodiment constitutes the outdoor heat exchanger (23) of the air conditioner (10). The air conditioner (10) performs heating operation. In an operating state where the evaporating temperature of refrigerant in the outdoor heat exchanger (23) is less than 0°C, moisture in the outdoor air becomes frost to be attached to the outdoor heat exchanger (23). Thus, the air conditioner (10) performs defrosting operation in order to melt the frost attached to the outdoor heat exchanger (23). During the defrosting operation, drain water is generated due to melting of the frost.

<Attachment of Frost to Fin>

[0104] A process in which frost is attached to the heat exchanger (30) constituting the outdoor heat exchanger (23) will be described. Air that has flown into the air passages (40) of the heat exchanger (30) exchanges heat with refrigerant flowing in the fluid passages (34) of the flat tubes (33) through the heat transfer parts (70) of the fins (36). When the surface temperature of the heat transfer parts (70) is less than 0°C, moisture in the air is frozen to become frost and is attached to the surfaces of the heat transfer parts (70).

[0105] In general, an air flow is disturbed more greatly by the louvers (50, 60) bending out from the heat transfer parts (70) than by the protrusions (81-83) protruding without bending out from the heat transfer parts (70). Thus, in most cases, heat transfer is more greatly promoted by the louvers (50, 60) than by the protrusions (81-83).

[0106] On the other hand, in each of the heat transfer parts (70) of the fins (36), the louvers (50, 60) showing a relatively high degree of heat transfer promotion are provided in a leeward region, and the protrusions (81-83) showing a relatively low degree of heat transfer promotion are provided at the windward side of the louvers (50, 60). Thus, as compared to a case where louvers are provided in the entire region of the heat transfer part (70), the amount of frost attached to a windward region of the heat transfer parts (70) is reduced, and the amount of frost attached to a leeward region of the heat transfer parts (70) is increased. Accordingly, in each of the heat transfer parts (70) of the fins (36), the difference in the amount of attached frost is small between the windward region and the leeward region.

[0107] When the surface temperature of the heat transfer parts (70) is less than 0°C, moisture in air flowing in the air passages (40) gradually becomes frost and is attached to the heat transfer parts (70). Thus, the absolute humidity of air flowing in the air passages (40) gradually decreases toward the leeward. The absolute humidity of air that has reached the louvers (50, 60) showing a relatively high degree of heat transfer promotion is relatively low. Thus, in each of the heat transfer parts (70) of the fins (36), an excessive amount of frost is not attached to a region of the heat transfer parts (70) on which the louvers (50, 60) are provided.

[0108] As described above, the air passages (40) formed by the heat transfer parts (70) including the protrusions (81-83) bend up and down along the protrusions (81-83). In a configuration in which the heights, in the protrusion direction, of the protrusions are the same, the change in the direction of an air flow along the protrusions decreases as the width, in the air passage direction, of a protrusion increases. In a configuration in which the widths, in the air passage direction, of the protrusions are the same, the change in the direction of an air flow along the protrusions decreases as the height, in the protrusion direction, of the protrusions decreases. When the change in the direction of an air flow along the protrusions decreases, the degree of heat transfer promotion by the protrusions decreases. On the other hand, the difference in temperature between air flowing in the air passages (40) and the heat transfer parts (70) is the largest at the inlets of the air passages (40), and gradually decreases toward the leeward.

[0109] In each of the heat transfer parts (70) of this embodiment, the width W1 of the first protrusion (81) is larger than the width W2 of the second protrusion (82) and the width W3 of the third protrusion (83). In each of the heat transfer parts (70), the height H1 of the first protrusion (81) is smaller than the height H2 of the second protrusion (82) and the height H3 of the third protrusion (83). That is, in each of the heat transfer parts (70) of the fins (36), the first upper flat part (81) showing a relatively low degree of heat transfer promotion is provided in a windward region where the temperature difference between air flowing in the air passages (40) and the heat transfer parts (70) is relatively large. This configuration ensures reduction of the amount of frost attached to a windward region of the heat transfer parts (70) of the fins (36).

[0110] In this manner, in the heat exchanger (30) of this embodiment, frost is attached not only to a windward region of the fins (36) but also to a leeward region of the fins (36). Thus, the amount of frost attached to the heat exchanger (30) at the time when defrosting operation is needed is larger in the heat exchanger (30) of this embodiment than in a conventional heat exchanger in which louvers are provided in the entire part of heat transfer parts. Accordingly, as compared to an air conditioner including an outdoor heat exchanger constituted by the conventional heat exchanger, the air conditioner (10) including the outdoor heat exchanger (23) constituted by the heat exchanger (30) of this embodiment can prolong the time interval from the end of defrosting operation to the start of next defrosting operation, resulting in an increase in time duration of heating operation.

<Conditions of Frost and Drain Water in Defrost Operation>

[0111] Conditions of frost and drain water in the heat exchanger (30) in defrosting operation of the air conditioner (10) will be described. In the defrosting operation, frost attached to the heat exchanger (30) melts and becomes drain water, and the drain water generated is discharged from the heat exchanger (30).

[0112] In each of the heat transfer parts (70) of the fins (36), when frost attached to the heat transfer parts (70) melts, drain water is generated and flows down. At this time, frost attached to the windward end portions (72) of the heat transfer parts (70) becomes drain water, and the drain water flows down from the windward end portions (72). On the other hand, frost attached to the intermediate portions (71) of the heat transfer parts (70) becomes drain water, and the drain water remains on the flat side surfaces of the flat tubes (33).

[0113] In each of the heat transfer parts (70) of the fins (36), each of the lower ends (81e, 82e, 83e) of the protrusions (81-83) is tilted, and the distance from the lower end of the heat transfer part (70) to the lower end (81e, 82e, 83e) of the protrusion (81-83) gradually decreases toward the leeward. Thus, in each of the heat transfer parts (70), the distance from one of the flat tubes (33) located below this heat transfer part (70) to the lower end (81e, 82e, 83e) of the protrusion (81-83) gradually decreases toward the leeward. Accordingly, drain water that has flown down from the protrusions (81-83) and accumulated on the flat tubes (33) is drawn by a capillary phenomenon from the flat tubes (33) to a leeward region where the distances from the flat tubes (33) to the lower ends (81e, 82e, 83e) of the protrusions (81-83) are small. That is, although the outdoor fans (15) are halted during defrosting operation and the upper surfaces of the flat tubes (33) are substantially horizontal, drain water moves leeward.

[0114] In this manner, the heat exchanger (30) of this embodiment ensures discharge of drain water generated during defrosting operation to the leeward. Thus, the amount of drain water remaining on the surfaces of the heat transfer parts (70) decreases at the end of the defrosting operation. If drain water remained on the surfaces of the heat transfer parts (70), drain water remaining would be frozen after restart of heating operation, resulting in reduction in the time until defrosting operation is needed again. Thus, as compared to the air conditioner including the outdoor heat exchanger constituted by the conventional heat exchanger, the air conditioner (10) including the outdoor heat exchanger (23) constituted by the heat exchanger (30) of this embodiment can prolong the period from the end of defrosting operation to the start of next defrosting operation (i.e., time duration of heating operation).

[0115] As described above, in the heat exchanger (30) of this embodiment, some of the windward louvers (50a) are asymmetric louvers. That is, the tilt angle θ2 of the lower edges (56) of the windward louvers (50a) is smaller than the tilt angle θ1 of the upper edges (55) thereof (see FIG. 6B). Thus, as illustrated in FIG. 8, between the windward louvers (50a) that are adjacent to each other in the air passage direction, a gap between the lower edges (56) is more slender than a gap between the upper edges (55).

[0116] In general, liquid in a relatively narrow gap has a relatively large capillary force. The capillary force of liquid increases as the gap becomes narrower. As illustrated in FIG. 8, in a state where drain water is present between the bent-out ends (53) of the windward louvers (50a) that are adjacent to each other in the air passage direction, the gap between the lower edges (56) that are in contact with the lower end of the drain water is narrower than the gap between the main edges (54) that are in contact with the upper end of the drain water. Accordingly, downward capillary force of the drain water is larger than upward capillary force thereof, thereby causing the drain water to be drawn toward the lower edges (56) (i.e., downward).

[0117] As described above, the lower edges (56) of the windward louvers (50a) that are asymmetric louvers are relatively long. Thus, between the windward louvers (50a) that are adjacent to each other in the air passage direction, a narrow gap between the bent-out ends (53) is enlarged. Consequently, a region where downward capillary force of the drain water is larger than upward capillary force thereof is enlarged, resulting an increase in the possibility of downward movement of the drain water due to a capillary phenomenon.

[0118] In this manner, drain water between the bent-out ends (53) of the windward louvers (50a) that are adjacent to each other in the air passage direction is drawn into a slender narrow gap between the lower edges (56) due to a capillary phenomenon. That is, the drain water flows down due to not only gravity but also a capillary phenomenon. Accordingly, drain water generated near the windward louvers (50a) during defrosting operation is quickly discharged downward, and is less likely to be held between the bent-out ends (53) of the windward louvers (50a) that are adjacent to each other in the air passage direction.

[0119] In each of the heat transfer parts (70) of the fins (36), the amount of frost attached to the windward louvers (50) provided on the intermediate portion (71) close to the flat tubes (33) is larger than that attached to the leeward louvers (60) provided on the leeward end portion (73) located away from the flat tubes (33). Among the windward louvers (50), the amount of frost attached to the windward louvers (50a) at the windward side is larger than that attached to the windward louvers (50b) at the leeward side. Thus, the amount of drain water generated during defrosting operation increases as the location of the windward louvers (50) approaches the windward side.

[0120] On the other hand, in each of the heat transfer parts (70) of the fins (36) of this embodiment, at least one of the windward louvers (50a) at the windward side is an asymmetric louver. That is, in each of the heat transfer parts (70), some of the windward louvers (50a) at the windward side where a large amount of drain water is generated during defrosting operation are asymmetric louvers on which a small amount of drain water is held. Thus, the configuration in which some of the windward louvers (50a) are asymmetric louvers can also reduce the amount of drain water remaining on the surfaces of the heat transfer parts (70) at the end of the defrosting operation.

-Advantages of First Embodiment-

[0121] As described above, in the heat exchanger (30) of this embodiment, in heating operation of the air conditioner (10), frost can be attached not only to a windward region but also to a leeward region in the heat transfer parts (70) of the fins (36). Thus, the outdoor heat exchanger (23) of the air conditioner (10) constituted by the heat exchanger (30) of this embodiment can prolong time duration of heating operation.

[0122] Further, the heat exchanger (30) of this embodiment can reduce the amount of drain water remaining on the surfaces of the heat transfer parts (70) at the end of defrosting operation. Drain water remaining on the surfaces of the heat transfer parts (70) is frozen after restart of heating operation. Accordingly, reduction of drain water remaining on the surfaces of the heat transfer parts (70) can prolong the period until next defrosting operation is needed. Thus, the outdoor heat exchanger (23) of the air conditioner (10) constituted by the heat exchanger (30) of this embodiment can prolong time duration of heating operation.

[0123] In this manner, the outdoor heat exchanger (23) of the air conditioner (10) constituted by the heat exchanger (30) of this embodiment can prolong time duration of heating operation, and reduce the time necessary for defrosting operation. Thus, the outdoor heat exchanger (23) of the air conditioner (10) constituted by the heat exchanger (30) of this embodiment can enhance the mean value, in terms of time, of heating capacity of the air conditioner (10) (i.e., substantial heating capacity of the air conditioner (10)).

<<Second Embodiment>>

[0124] A second embodiment of the present disclosure will be described. In the same manner as the heat exchanger (30) of the first embodiment, a heat exchanger (30) according to the second embodiment constitutes an outdoor heat exchanger (23) of an air conditioner (10). The heat exchanger (30) of this embodiment will now be described with reference to FIGS. 9-12.

<Overall Configuration of Heat Exchanger>

[0125] As illustrated in FIGS. 9 and 10, the heat exchanger (30) of this embodiment includes a first header concentrated pipe (31), a second header concentrated pipe (32), a large number of flat tubes (33), and a large number of fins (35). The first header concentrated pipe (31), the second header concentrated pipe (32), the flat tubes (33), and the fins (35) are made of an aluminium alloy, and are joined to one another by brazing.

[0126] The configurations and layouts of the first header concentrated pipe (31), the second header concentrated pipe (32), and flat tubes (33) are the same as those of the heat exchanger (30) of the first embodiment. Specifically, each of the first header concentrated pipe (31) and the second header concentrated pipe (32) has a slender cylindrical shape. One of the first header concentrated pipe (31) or the second header concentrated pipe (32) is located at the left end of the heat exchanger (30), and the other is located at the right end of the heat exchanger (30). The flat tubes (33) are heat transfer tubes having flat shapes in cross section, and are arranged in the vertical direction with their flat side surfaces face one another. Each of the flat tubes (33) includes a plurality of fluid passages (34). Each of the vertically arranged flat tubes (33) is inserted in the first header concentrated pipe (31) at one end, and in the second header concentrated pipe (32) at the other end.

[0127] Each of the fins (35) is a corrugated fin that bends up and down, and is located between vertically adjacent ones of the flat tubes (33). Each of the fins (35) includes a plurality of heat transfer parts (70) and a plurality of intermediate plate parts (41), which will be described in detail later. In each of the fins (35), the intermediate plate parts (41) are brazed to adjacent ones of the flat tubes (33).

[0128] As illustrated in FIG. 10, in the heat exchanger (30), a space between vertically adjacent ones of the flat tubes (33) is divided into a plurality of air passages (40) by the heat transfer parts (70) of the fins (35). The heat exchanger (30) performs heat exchange between refrigerant flowing in the fluid passages (34) of the flat tubes (33) and air flowing in the air passages (40).

[0129] As described above, the heat exchanger (30) includes: the vertically arranged flat tubes (33) whose flat side surfaces face one another; and the fins (35) including the plate-like heat transfer parts (70) each extending from one of its adjacent flat tubes (33) to the other. The heat transfer parts (70) are located between adjacent ones of the flat tubes (33), and arranged in the direction in which the flat tubes (33) extend. In the heat exchanger (30), air flowing between adjacent ones of the heat transfer parts (70) exchanges heat with fluid flowing in the flat tubes (33).

<Fin Configuration>

[0130] As illustrated in FIG. 12, each of the fins (35) is a corrugated fin formed by bending a metal plate with a uniform width, and bends up and down. In the fin (35), the heat transfer parts (70) and the intermediate plate parts (41) are alternately arranged in the direction in which the flat tubes (33) extend. That is, the fin (35) includes the heat transfer parts (70) that are located between adjacent ones of the flat tubes (33) and arranged side by side in the direction in which the flat tubes (33) extend. The fin (35) also includes projecting plate parts (42). In FIG. 12, protrusions (81-83) and louvers (50, 60), which will be described later, are not shown.

[0131] The heat transfer parts (70) are plate-like parts each extending from one of its vertically adjacent ones of the flat tubes (33) to the other. The windward ends of the heat transfer parts (70) hereinafter referred to as front edges (38), and the leeward ends of the heat transfer parts (70) hereinafter referred to as rear edges (39). The intermediate plate parts (41) are plate-like parts along the flat side surfaces of the flat tubes (33), The intermediate plate parts (41) of laterally (i.e., in the transverse direction) adjacent ones of the heat transfer parts (70) are continuous at the upper and lower ends thereof. The heat transfer parts (70) are approximately at a right angle relative to the intermediate plate parts (41).

[0132] As illustrated in FIG. 11, each of the heat transfer parts (70) of the fins (35) includes an intermediate portion (71), a windward end portion (72), and a leeward end portion (73). In each of the heat transfer parts (70), a portion overlapping its vertically adjacent ones of the flat tubes (33) (i.e., a portion located immediately above or under its vertically adjacent ones of the flat tubes (33)) is the intermediate portion (71). In each of the heat transfer parts (70), a portion that is located windward of the intermediate portion (71) (i.e., a portion projecting windward from the flat tubes (33)) is the windward end portion (72), and a portion that is located leeward of the intermediate portion (71) (i.e., a portion projecting leeward from the flat tubes (33)) is the leeward end portion (73).

[0133] Each of the heat transfer parts (70) includes two projecting plate parts (42). Each of the projecting plate parts (42) has a trapezoid shape continuous to the leeward end portion (73). In each of the heat transfer parts (70), one of the projecting plate parts (42) projects upward from the upper end of the leeward end portion (73), and the other projecting plate part (42) projects downward from the lower end of the leeward end portion (73). In the heat exchanger (30), the projecting plate parts (42) of vertically adjacent ones of the fins (35) sandwiching an associated one of the flat tubes (33) are in contact with each other.

[0134] As illustrated in FIG. 11, each of the heat transfer parts (70) of the fins (35) includes a plurality of protrusions (81-83) and a plurality of louvers (50, 60). In the same manner as in the fins (36) of the first embodiment, in each of the heat transfer parts (70), the protrusions (81-83) are located in a windward region, and the louvers (50, 60) are located in a leeward region. That is, in each of the heat transfer parts (70), the louvers (50, 60) are located only in the leeward region, and the protrusions (81-83) are located windward of the louvers (50, 60).

<Arrangement and Shape of Protruding Portion>

[0135] The arrangement and shapes of the protrusions (81-83) of the fins (35) will now be described in detail. The "right" and "left" herein are based on the direction when the fins (35) are seen from the windward side (i.e., from the front side of the heat exchanger (30)).

[0136] As illustrated in FIG. 11, the arrangement of the protrusions (81-83) and the shape of each of the protrusions (81-83) in each of the heat transfer parts (70) of the fins (35) are similar to those in the fins (36) of the first embodiment. The number and protrusion direction of the protrusions (81-83), which will be described later, are merely examples, as in the first embodiment.

[0137] Specifically, each of the protrusions (81-83) has an inverted V shape formed by making the heat transfer part (70) protrude toward the air passage (40), and has its ridge (81 a, 82a, 83a) substantially in parallel with the front edge (38) of the fin (35). The protrusions (81-83) protrude to the right from the heat transfer part (70).

[0138] In each of the heat transfer parts (70), the three protrusions (81-83) are arranged side by side in the air passage direction (i.e., in the direction from the front edge (38) to the rear edge (39) of the fin (35)). In each of the heat transfer parts (70), the three protrusions (81-83) are provided in a region including the windward end portion (72) and a windward region of the intermediate portion (71).

[0139] In each of the heat transfer parts (70), the width, in the air passage direction, of the first protrusion (81) is the largest among the three protrusions (81-83). The second protrusion (82) and the third protrusion (83) have the same width in the air passage direction. In each of the heat transfer parts (70), the height, in the protrusion direction, of the first protrusion (81) is the smallest among the three protrusions (81-83). The height, in the protrusion direction, of the second protrusion (82) is smaller than that of the third protrusion (83).

[0140] Each of the lower ends (81e, 82e, 83e) of the protrusions (81-83) is tilted downward toward the leeward. In each of the heat transfer parts (70), the distance from the lower end of the heat transfer part (70) to the lower end (81e, 82e, 83e) of the protrusion (81-83) decreases toward the leeward.

<Arrangement and Shape of Louvers>

[0141] The arrangement and shape of the louvers (50, 60) formed on the fins (35) will now be described in detail. The "right" and "left" herein are based on the direction when the fins (35) are seen from the windward side (i.e., from the front side of the heat exchanger (30)).

[0142] As illustrated in FIG. 11, the arrangement of the louvers (50, 60) and the shape of each of the louvers (50, 60) on the heat transfer parts (70) of the fins (35) are similar to those of the fins (36) of the first embodiment. The numbers of the louvers (50, 60) shown in FIG. 11 are merely examples, as in the first embodiment.

[0143] Specifically, in each of the heat transfer parts (70) of the fins (35), the louvers (50, 60) are arranged side by side in the air passage direction in a region from a leeward region of the intermediate portion (71) to the leeward end portion (73). A group of louvers located in a windward region are windward louvers (50), and a group of louvers located in a leeward region are leeward louvers (60). The louvers (50, 60) have the same length.

[0144] In each of the heat transfer parts (70) of the fins (35), some of the windward louvers (50a) located at the windward side are asymmetric louvers. In each of the heat transfer parts (70), some of the windward louvers (50b) at the leeward and all the leeward louvers (60) are symmetric louvers.

[0145] In each of the heat transfer parts (70) of the fins (35), the windward louvers (50) and the leeward louvers (60) are tilted in opposite directions. In the windward louvers (50), bent-out ends (53) at the windward side protrude to the left, and bent-out ends (53) at the leeward side protrude to the right. That is, in each of the windward louvers (50), the bent-out end (53) at the leeward side protrudes in the same direction as the direction in which the third protrusion (83) protrudes. On the other hand, in each of the leeward louvers (60), the bent-out end (63) at the windward side protrudes to the right, and the bent-out end (63) at the leeward protrudes to the left.

-Advantages of Second Embodiment-

[0146] Advantages of the heat exchanger (30) of this embodiment are substantially the same as those of the heat exchanger (30) of the first embodiment.

[0147] Specifically, in the same manner as in the heat exchanger (30) of the first embodiment, in the heat exchanger (30) of the second embodiment, the protrusions (81-83) are located in a windward region and the louvers (50, 60) are located in a leeward region in each of the heat transfer parts (70) of the fins (35). In the heat exchanger (30) of this embodiment, in the same manner as in the heat exchanger (30) of the first embodiment, the first upper flat part (81) closest to the windward side has the largest width and the smallest height in the protrusion direction. Accordingly, each of the heat transfer parts (70) of the fins (35) shows a small difference between the amount of frost attached to the windward region and the amount of frost attached to the leeward region. As a result, time duration of heating operation of the air conditioner (10) can be prolonged, thereby enhancing substantial heating capacity of the air conditioner (10).

[0148] In the heat exchanger (30) of this embodiment, in the same manner as in the heat exchanger (30) of the first embodiment, the lower ends (81 e, 82e, 83 e) of the protrusions (81-83) are tilted, and the windward louvers (50a) located in a windward region are asymmetric louvers. This configuration can reduce the amount of drain water remaining on the surfaces of the heat transfer parts (70) at the end of defrosting operation, resulting in prolonged time interval before next defrosting operation (i.e., time duration of heating operation).

«Third Embodiment»

[0149] A third embodiment of the present disclosure will be described. A heat exchanger (30) according to the third embodiment is obtained by changing the configuration of the fins (36) in the heat exchanger (30) of the first embodiment. Now, part of the configuration of fins (36) of the heat exchanger (30) of this embodiment different from those of the heat exchanger (30) of the first embodiment will be described.

[0150] As illustrated in FIGS. 13, 14A, and 14B, in the same manner as the fins (36) of the first embodiment, the fins (36) of the third embodiment include first protrusions (81), second protrusions (82), third protrusions (83), and windward louvers (50). The fins (36) of this embodiment include leeward protrusions (85), instead of the leeward louvers (60). The fins (36) of this embodiment additionally include auxiliary protrusions (86), upper horizontal ribs (91), and lower horizontal ribs (92). In the fins (36) of this embodiment, the arrangement of tabs (48) differs from that in the fins (36) of the first embodiment.

[0151] The shapes and arrangement of the first protrusions (81), the second protrusions (82), and the third protrusions (83) of the fins (36) of this embodiment differ from those in the first embodiment. The first protrusions (81), the second protrusions (82), and the third protrusions (83) are arranged in this order from a front edge (38) to a rear edge (39) of each of the fins (36), in the same manner as in the first embodiment.

[0152] In each heat transfer part (70) of the fins (36) of this embodiment, the first protrusion (81) extends from a windward end portion (72) to an intermediate portion (71), and the second protrusion (82) and the third protrusion (83) are located in the intermediate portion (71). Upper ends (81d-83d) and lower ends (81e-83e) of the protrusions (81-83) substantially orthogonally intersect with the front edge (38) of each of the fins (36). The length of the first protrusion (81) is smaller than that of the second protrusion (82). The length of the second protrusion (82) is equal to that of the third protrusion (83). The widths of the protrusions (81-83) increase in the order of the third protrusion (83), the first protrusion (81), and the second protrusion (82) (i.e., W3 < W1 < W2). The protrusions (81-83) have the same height in the protrusion direction (i.e., H1 = H2 = H3).

[0153] In the same manner as in the first embodiment, in each of the fins (36) of this embodiment, a plurality of windward louvers (50) are provided at the leeward side of the third protrusion (83). In the same manner as in the first embodiment, some windward louvers (50a) located in a windward region are asymmetric louvers, and the other windward louvers (50b) located in a leeward region are symmetric louvers. In each of the fins (36) of this embodiment, in the same manner as in the first embodiment, bent-out ends (53) at the leeward side of the windward louvers (50) protrude in the same direction as the protrusion direction of the third protrusions (83) (see FIG. 14B).

[0154] As illustrated in FIG. 14A, the length L1 from the upper ends of the second protrusion (82) and the third protrusion (83) to the upper end of the intermediate portion (71), the length L2 from the lower ends of the second protrusion (82) and the third protrusion (83) to the lower end of the intermediate portion (71), the length L3 from the upper ends of the louvers (50a, 50b) to the upper end of the intermediate portion (71), and the length L4 from the lower ends of the louvers (50a, 50b) to the lower end of the intermediate portion (71) are the same.

[0155] In the same manner as in the first embodiment, in each of the fins (36) of this embodiment, tabs (48) are provided in a windward end portion (72) of each of heat transfer parts (70). In each of the heat transfer parts (70) of the fins (36) of this embodiment, one tab (48) is located windward of the first protrusion (81) in the windward end portion (72). This tab (48) is located near the middle, in the vertical direction, of the windward end portion (72). In addition, this tab (48) is tilted relative to the front edge (38) of the fin (36).

[0156] An upper horizontal rib (91) and a lower horizontal rib (92) are provided in each of the heat transfer parts (70) of the fins (36). The upper horizontal rib (91) is located above the first protrusion (81), and the lower horizontal rib (92) is located below the first protrusion (81). The horizontal ribs (91, 92) have straight slender ridge shapes extending from the front edge (38) of the fin (36) to the second protrusion (82). In the same manner as the protrusions (81, 82, 83, 84), the horizontal ribs (91, 92) are formed by making the heat transfer part (70) protrude toward air passages (40). The horizontal ribs (91, 92) protrude in the same direction as the direction in which the protrusions (81-83) protrude.

[0157] Each of the heat transfer parts (70) of the fins (36) includes one auxiliary protrusion (86). In each of the heat transfer parts (70), the auxiliary protrusion (86) is located at the leeward side of the louvers (50). In each of the heat transfer parts (70), the auxiliary protrusion (86) extends from the intermediate portion (71) to the leeward end portion (73).

[0158] The auxiliary protrusion (86) has an inverted V shape formed by making the fin (36) protrude. The auxiliary protrusion (86) extends in the direction intersecting with the air passage direction in the air passages (40). In the fin (36) of this embodiment, the auxiliary protrusion (86) protrudes to the right when viewed from the front edge (38) of the fin (36). A ridge (85a) of the auxiliary protrusion (86) is substantially in parallel with the front edge (38) of the fin (36). That is, the ridge (85a) of the auxiliary protrusion (86) intersects with the air flow direction in the air passages (40). The lower end of the auxiliary protrusion (86) is tilted downward toward the leeward.

[0159] As illustrated in FIG. 14B, the height H5, in the protrusion direction, of the auxiliary protrusion (86) is smaller than the height H3, in the protrusion direction, of the third protrusion (83) (i.e., $H5 < H3$). As illustrated in FIG. 14A, the width W5, in the air passage direction, of the auxiliary protrusion (86) is smaller than the width W3, in the air passage direction, of the third protrusion (83) (i.e., $W5 < W3$).

[0160] One leeward protrusion (85) is located at the leeward side of each of notches (45). The leeward protrusion (85) is provided in a region including a coupling plate portion (75), a leeward end portion (73) located above the coupling plate portion (75), and a leeward end portion (73) located below the coupling plate portion (75).

[0161] The leeward protrusion (85) has an inverted V shape formed by making the fin (36) protrude. The leeward protrusion (85) extends in the direction intersecting with the air passage direction in the air passages (40). In the fin (36) of this embodiment, the leeward protrusion (85) protrudes to the right when viewed form the front edge (38) of the fin (36). A ridge (84a) of the leeward protrusion (85) is substantially in parallel with the front edge (38) of the fin (36). That is, the ridge (84a) of the leeward protrusion (85) intersects with the air flow direction in the air passages (40).

[0162] As illustrated in FIG. 14B, the height H4, in the protrusion direction, of the leeward protrusion (85) is equal to the height H2, in the protrusion direction, of the second protrusion (82) (i.e., $H4 = H2$). As illustrated in FIG. 14A, the width W4, in the air passage direction, of the leeward protrusion (85) is equal to the width W2, in the air passage direction, of the second protrusion (82) (i.e., $W4 = W2$).

[0163] In the fins (36) of this embodiment, one tab (48) is provided between adjacent ones of the leeward protrusions (85). That is, in the fins (36), one tab (48) is provided in the leeward end portion (73) of each of the heat transfer parts (70).

-Advantages of Third Embodiment-

[0164] Advantages of the heat exchanger (30) of the third embodiment are substantially the same as those of the heat exchanger (30) of the first embodiment.

[0165] Specifically, in the same manner as in the heat exchanger (30) of the first embodiment, in the heat exchanger (30) of the third embodiment, the protrusions (81-83) are located in a windward region and the louvers (50) are located in a leeward region in each of the heat transfer parts (70) of the fins (36). Thus, each of the heat transfer parts (70) of the fins (36) shows a small difference between the amount of frost attached to the windward region and the amount of frost attached to the leeward region. As a result, time duration of heating operation of the air conditioner (10) can be prolonged, thereby enhancing substantial heating capacity of the air conditioner (10).

<<Other Embodiments>>

[0166] Variations of the heat exchangers (30) of the first and second embodiments will be described.

-First Variation-

[0167] In the heat exchangers (30) of the above embodiments, all the windward louvers (50) provided in each of eth heat transfer parts (70) of the fins (35, 36) may be asymmetric louvers.

[0168] FIG. 15 illustrates an application of this variation to the fins (36) of the heat exchanger (30) of the first embodiment. In each of the heat transfer parts (70) of the fins (36) illustrated in FIG. 15, all the windward louvers (50) are asymmetric louvers, and all the leeward louvers (60) are symmetric louvers.

-Second Variation-

[0169] Each of the heat transfer parts (70) of the fins (35, 36) of the heat exchangers (30) of the above embodiments may have a configuration in which a plurality of protrusions (81, 82, 83, 84) are provided in the windward end portion (72) and the entire intermediate portion (71), and the leeward louvers (60) are provided only in the leeward end portion (73).

[0170] FIG. 16 illustrates an application of this variation to the fins (36) of the heat exchanger (30) of the first embodiment. In each of the heat transfer parts (70) of the fins (36) illustrated in FIG. 16, four protrusions (81, 82, 83, 84) are provided side by side in the air passage direction in the windward end portion (72) and the entire intermediate portion (71). The fourth protrusion (84) closest to the leeward side is adjacent to the third protrusion (83). All the leeward louvers (60) located in the leeward end portion (73) are symmetric louvers.

-Third Variation-

[0171] In each of the heat transfer parts (70) of the fins (35, 36) provided in the heat exchangers (30) of the above embodiments, a region where the louvers (50, 60) are provided may protrude toward the air passages (40).

[0172] FIG. 17A illustrates an application of this variation to the fins (36) of the heat exchanger (30) of the first embodiment. In each of the heat transfer parts (70) of the fins (36) illustrated in FIG. 17A, a region where the louvers (50, 60) are provided protrudes in the same direction as the protrusion direction of the protrusions (81-83). Specifically, a region of each of the heat transfer parts (70) where the windward louvers (50) are provided is tilted in the same direction as the slopes (81b, 82b, 83b) at the windward side of the protrusions (81-83). A region n of each of the heat transfer parts (70) where the leeward louvers (60) are provided is tilted in the same direction as the slopes (81b, 82b, 83b) at the leeward side of the protrusions (81-83).

-Fourth Variation-

[0173] In each of the heat transfer parts (70) of the fins (35, 36) in the heat exchangers (30) of the above embodiments, the louvers (50, 60) may be tilted in opposite directions.

[0174] FIG. 17B illustrates an application of this variation to the fins (36) of the heat exchanger (30) of the first embodiment. In each of the heat transfer parts (70) of the fins (36) illustrated in FIG. 17B, the bent-out ends (63) at the windward side of the windward louvers (50) protrude to the right, and the bent-out ends (63) at the leeward side thereof protrude to the left. That is, the bent-out ends (53) at the windward side of the windward louvers (50) project in the same direction as the protrusion direction of the third protrusion (83). On the other hand, the bent-out ends (53) at the windward side of the leeward louvers (60) protrude to the left, and the bent-out ends (53) at the leeward side thereof protrude to the right. Here, the "right" and "left" are based on the direction when the fins (36) are seen from the windward side (i.e., from the front side of the heat exchanger (30)).

[0175] The foregoing embodiments are merely preferred examples in nature, and are not intended to limit the scope, applications, and use of the invention.

INDUSTRIAL APPLICABILITY

[0176] As described above, the present disclosure is useful for a heat exchanger including vertically arranged flat tubes and fins.

DESCRIPTION OF REFERENCE CHARACTERS

[0177]

10	air conditioner
20	refrigerant circuit
30	heat exchanger
33	flat tube
34	fluid passage (passage)
35	fin
36	fin
38	front edge
40	air passage
41	intermediate plate part
45	notch
50	windward louver (louver)
50a	windward louver (asymmetric louver)
53	bent-out end
54	main edge
55	upper edge
56	lower edge
60	leeward louver (louver)
63	bent-out end
64	main edge
65	upper edge
66	lower edge
70	heat transfer part
72	windward end portion
73	leeward end portion
81	first protrusion
82	second protrusion
83	third protrusion
84	fourth protrusion

Claims

1. A heat exchanger, comprising:

flat tubes (33) vertically arranged with side surfaces thereof facing one another, each of the flat tubes (33) including a fluid passage (34) therein; and
fins (35, 36) each dividing a space between adjacent ones of the flat tubes (33) into a plurality of air passages (40) through which air flows, wherein

each of the fins (35, 36) includes heat transfer parts (70) each having a plate shape extending from an adjacent one of the flat tubes (33) to the other adjacent flat tube (33), the heat transfer parts (70) forming side walls of the air passages (40),
each of the heat transfer parts (70) of the fins (35, 36) includes
louvers (50, 60) that bend out from the heat transfer part (70), and
protrusions (81-83) located at a windward side of the louvers (50, 60), formed by making the heat transfer part (70) protrude, and extending in a direction intersecting with an air passage direction.

2. The heat exchanger of claim 1, wherein
at least a louver (50) that is included in the louvers (50, 60) provided on each of the heat transfer parts (70) of the fins (35, 36) and is located near the protrusions (81-83) has a leeward bent-out end (53) projecting in a direction in which the protrusions (81-83) protrude.

3. The heat exchanger of claim 1 or 2, wherein
a bent-out end (53, 63) of each of the louvers (50, 60) includes a main edge (54, 64), an upper edge (55, 65) extending from an upper end of the main edge (54, 64) to an upper end of the louver (50, 60) and tilted relative to the main edge (54, 64), and a lower edge (56, 66) extending from a lower end of the main edge (54, 64) to a lower end of the louver (50, 60) and tilted relative to the main edge (54, 64), and
at least one of the louvers (50, 60) provided on each of the heat transfer parts (70) of the fins (35, 36) is an asymmetric louver in which a tilt angle of the lower edge (56) relative to the main edge (54) is smaller than a tilt angle of the upper edge (55) relative to the main edge (54).

4. The heat exchanger of claim 3, wherein
in each of the heat transfer parts (70) of the fins (35, 36), at least one of the louvers (50) located in a region adjacent to the flat tubes (33) is the asymmetric louver.

5. The heat exchanger of claim 1, wherein
each of the heat transfer parts (70) of the fins (35, 36) includes a leeward end portion (73) located at a leeward side of the flat tubes (33), and
at least one louver (60) of the louvers (50, 60) is located on the leeward end portion (73) of each of the heat transfer parts (70) of the fins (35, 36).

6. The heat exchanger of claim 1, wherein
the protrusions (81-83) are arranged side by side in an air passage direction in each of the heat transfer parts (70) of the fins (35, 36).

7. The heat exchanger of claim 6, wherein
among the protrusions (81-83) of each of the heat transfer parts (70) of the fins (35, 36), the protrusion (81) closest to a windward side of the heat transfer part (70) has a largest width in the air passage direction.

8. The heat exchanger of claim 6 or 7, wherein
among the protrusions (81-83) of each of the heat transfer parts (70) of the fins (35, 36), the protrusion (81) closest to a windward side of the heat transfer part (70) has a smallest height in a direction in which the protrusions (81-83) protrude.

9. The heat exchanger of claim 6, wherein
in each of the heat transfer parts (70) of the fins (35, 36), the protrusions (81-83) are located in a region from a windward edge (38) of the heat transfer part (70) to a portion at a leeward side of a middle, in the air passage direction, of the heat transfer part (70).

10. The heat exchanger of claim 6, wherein
each of the heat transfer parts (70) of the fins (35, 36) includes a windward end portion (72) located windward of the flat tubes (33), and
in each of the heat transfer parts (70) of the fins (35, 36), the protrusions (81-83) are located in a region including the windward end portion (72) and a portion adjacent to a leeward side of the windward end portion (72).

11. The heat exchanger of claim 6, wherein
in each of the heat transfer parts (70) of the fins (35, 36), vertical positions of lower ends of the protrusions (81-83) become lower toward a leeward side of the heat transfer part (70).

12. The heat exchanger of claim 1, wherein
the fins (36) each have a plate shape with notches (45) into which the flat tubes (33) are inserted, are arranged to be spaced from one another by a predetermined distance in a direction in which the flat tubes (33) extend, and sandwich the flat tubes (33) at edges of the notches (45), and
parts of the fins (36) between vertically adjacent ones of the notches (45) are the heat transfer parts (70).

13. The heat exchanger of claim 1, wherein
each of the fins (35) is a corrugated fin that bends up and down and is located between adjacent ones of the flat tubes (33), includes the heat transfer parts (70) arranged in a direction in which the flat tubes (33) extend, and also includes intermediate plate parts (41) continuous to upper or lower ends of adjacent ones of the heat transfer parts (70) and joined to the flat tubes (33).

14. An air conditioner, comprising:

a refrigerant circuit (20) including the heat exchanger (30) of claim 1, wherein
the refrigerant circuit (20) circulates refrigerant therein, thereby performing a refrigeration cycle.

FIG.1

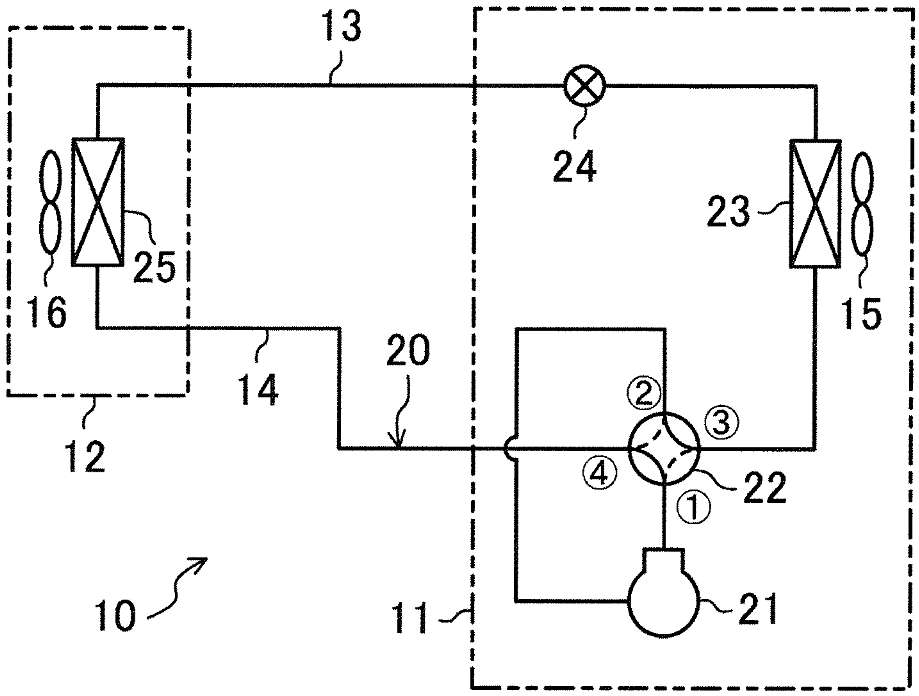


FIG.2

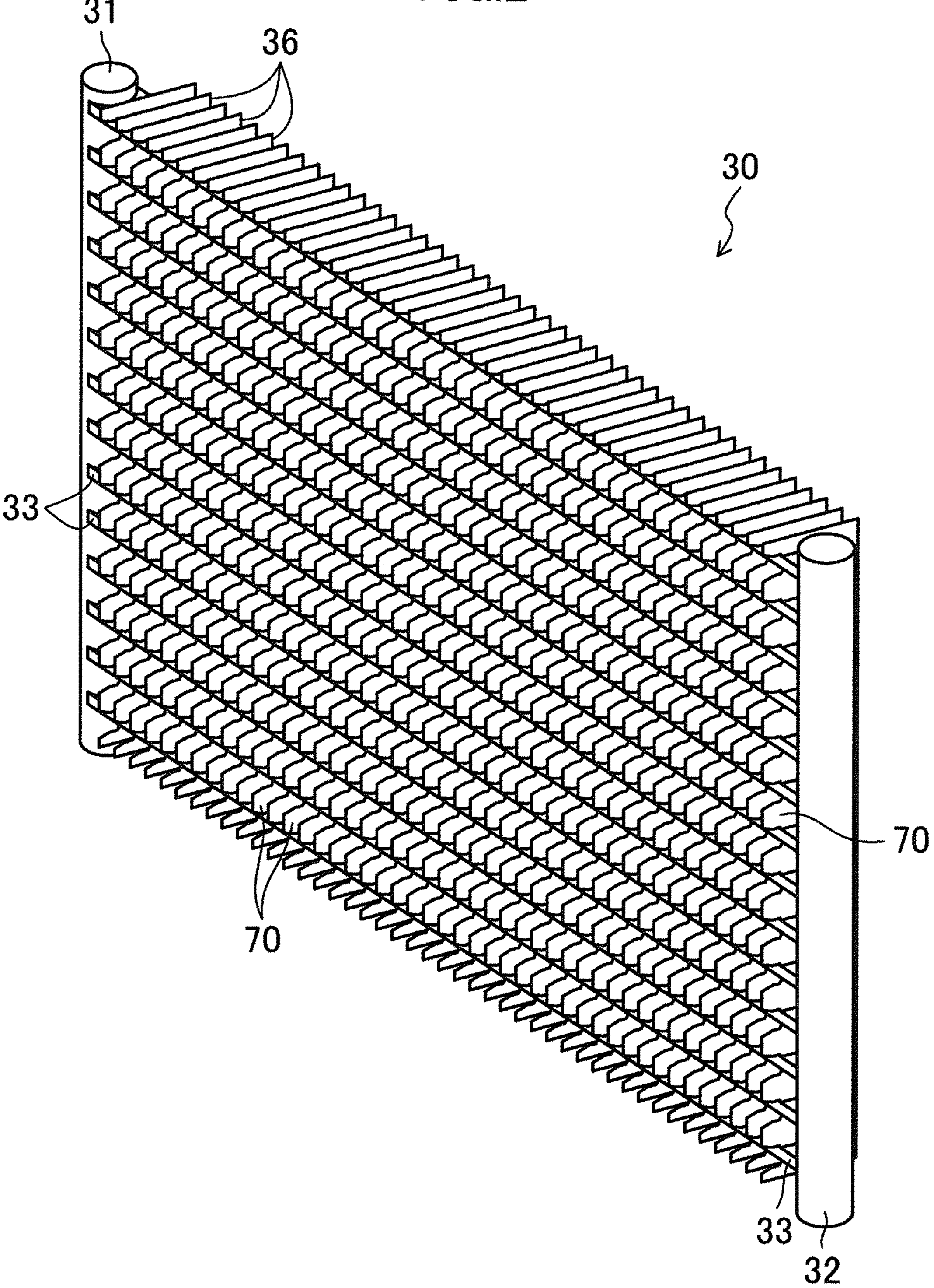


FIG.3

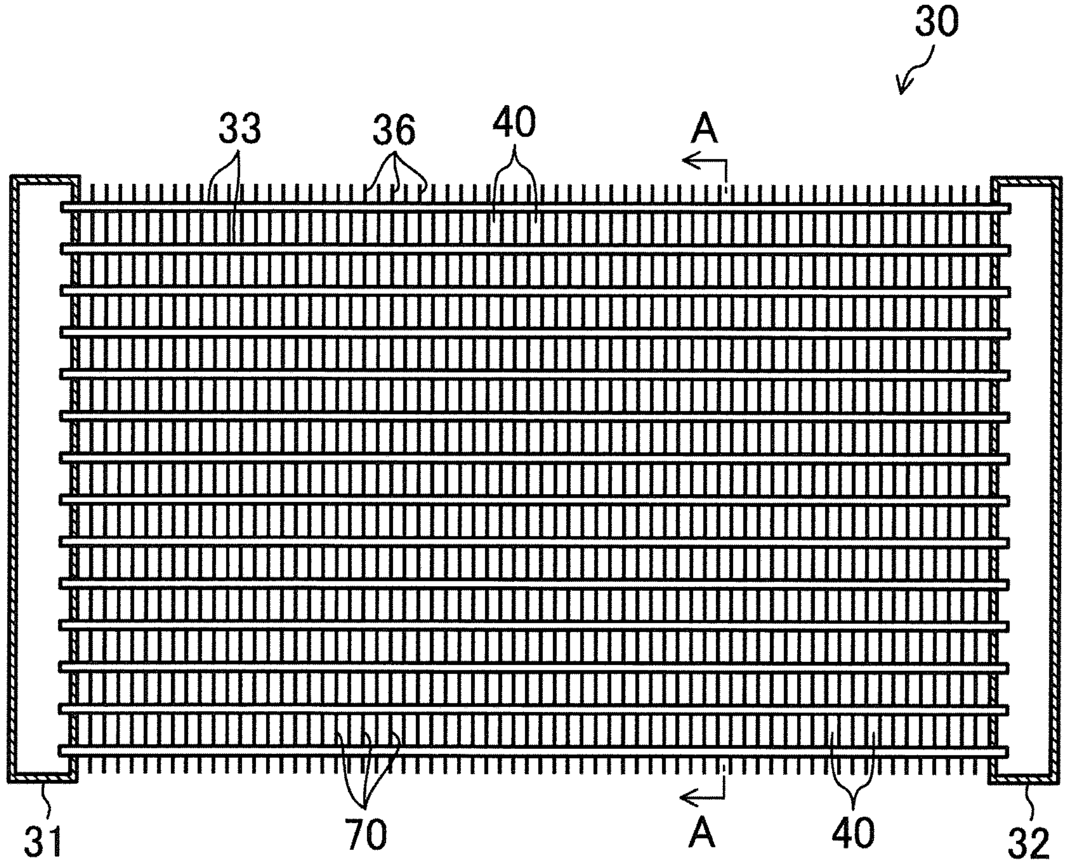
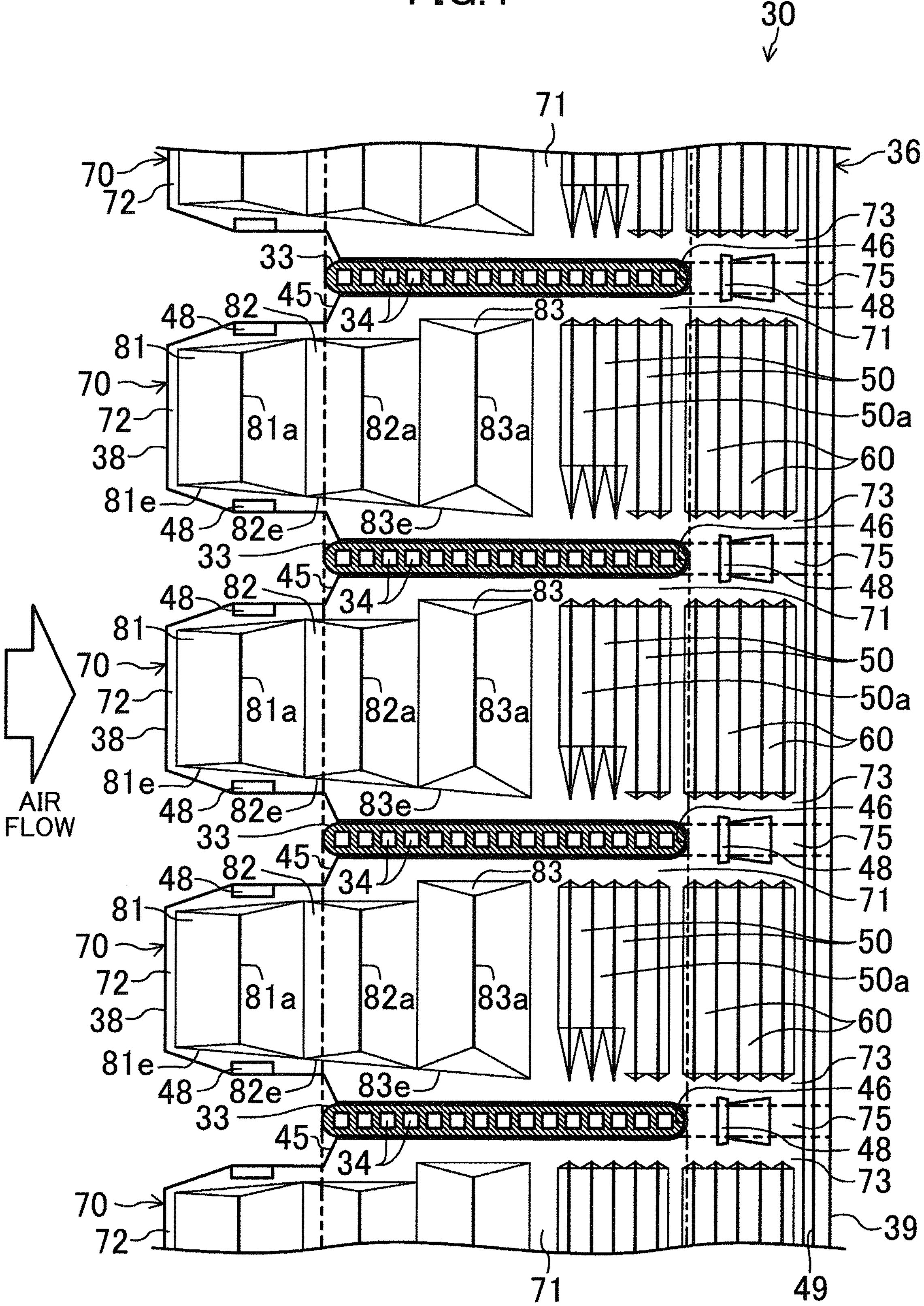


FIG.4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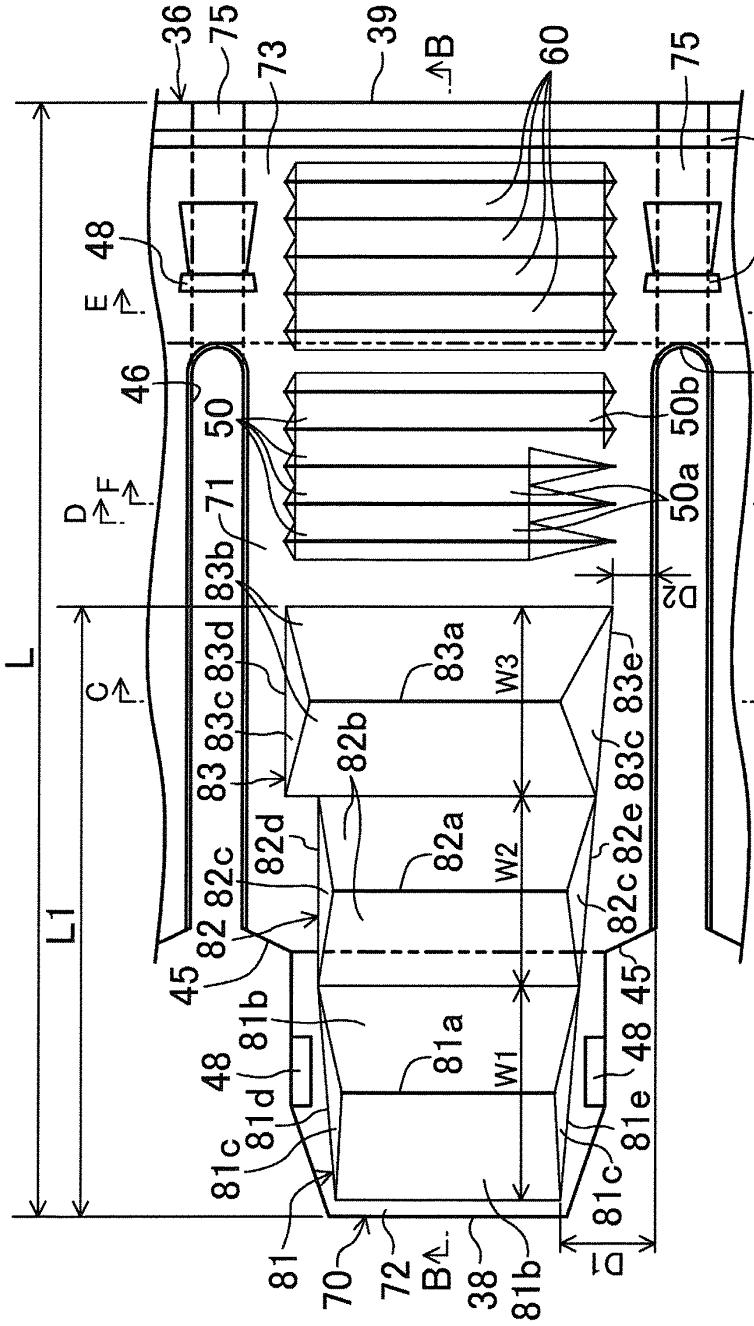
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W3
83c
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82b
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82a
W2
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L1
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81b
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81c
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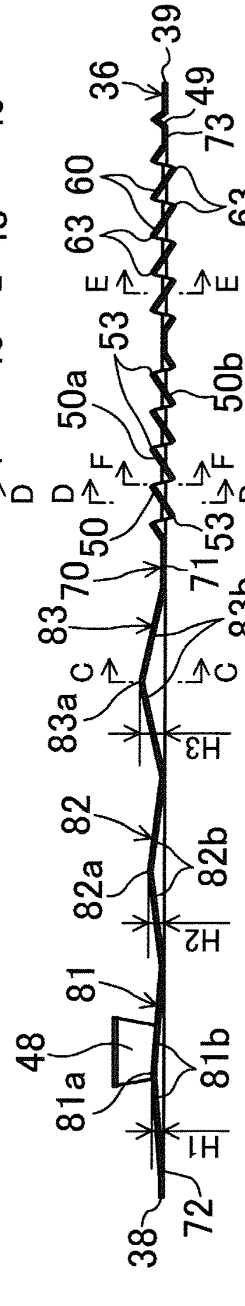
FIG.5A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H3
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H2
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81b
H1
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72

FIG.5B

FIG.6A

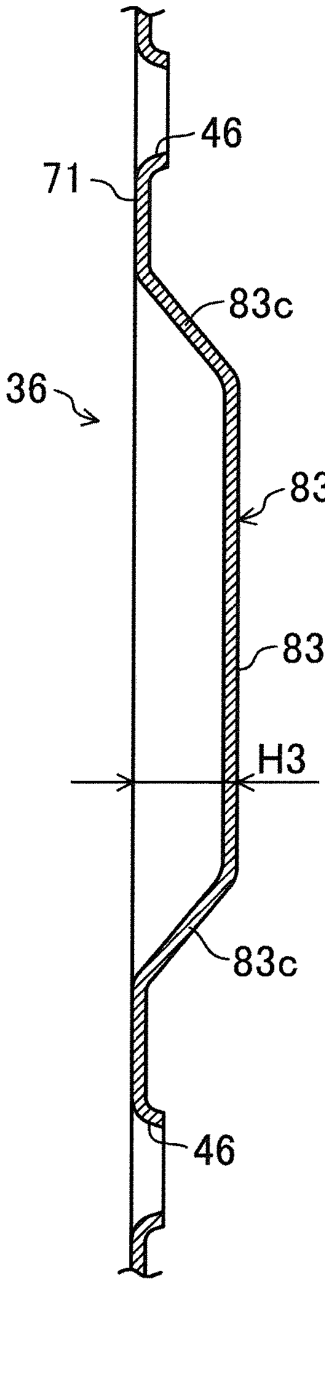


FIG.6B

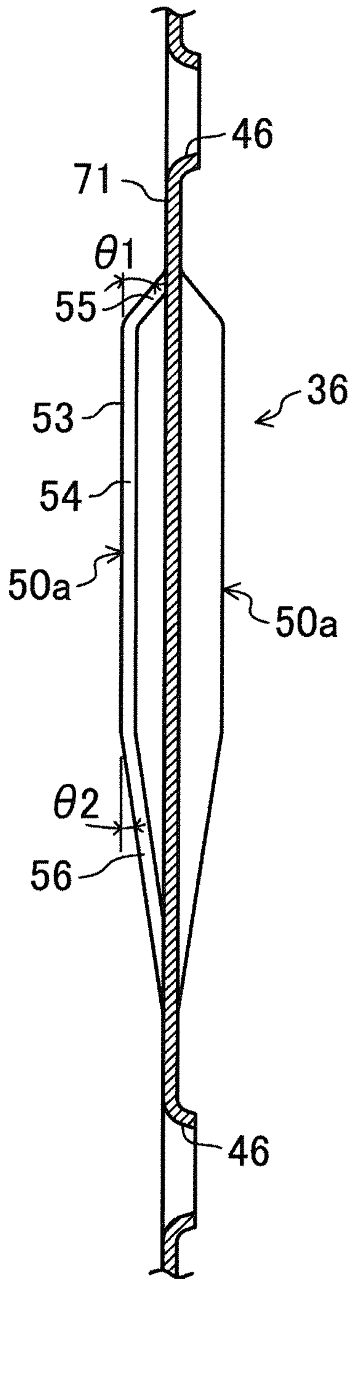


FIG.6C

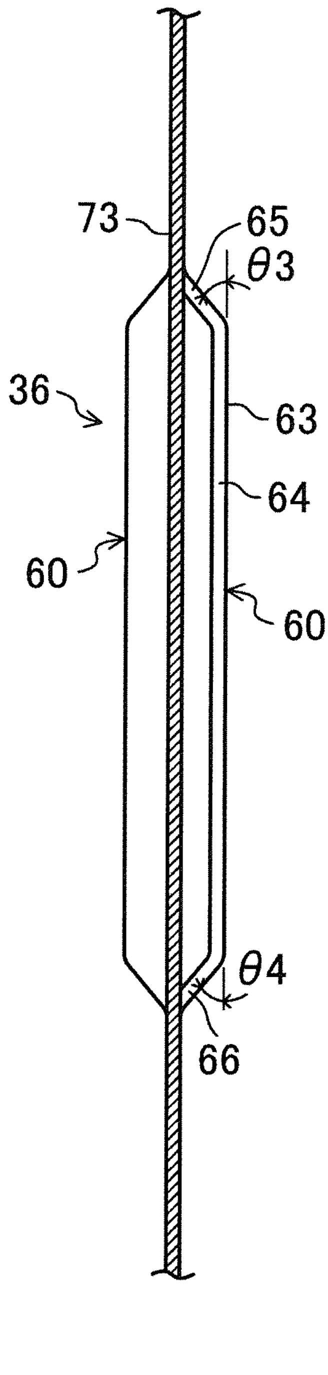
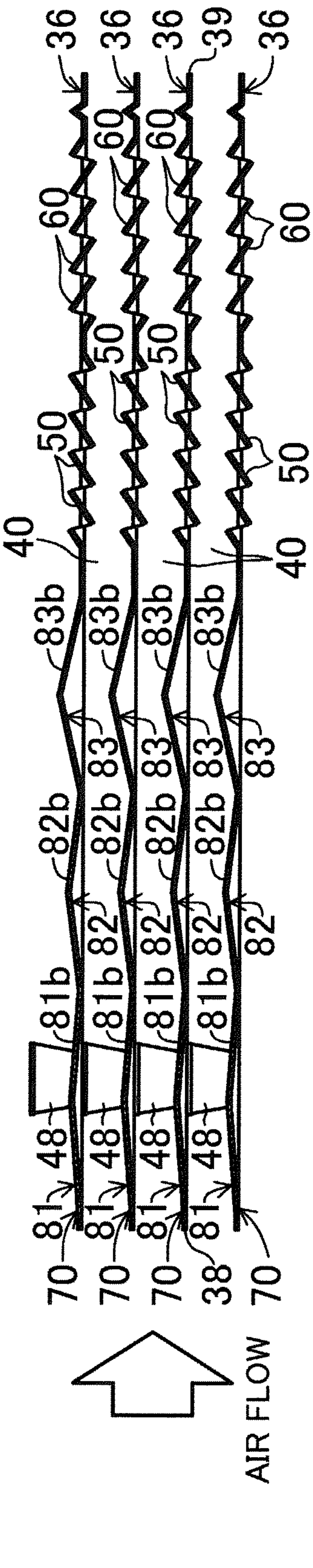


FIG.7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AIR FLOW

FIG.8

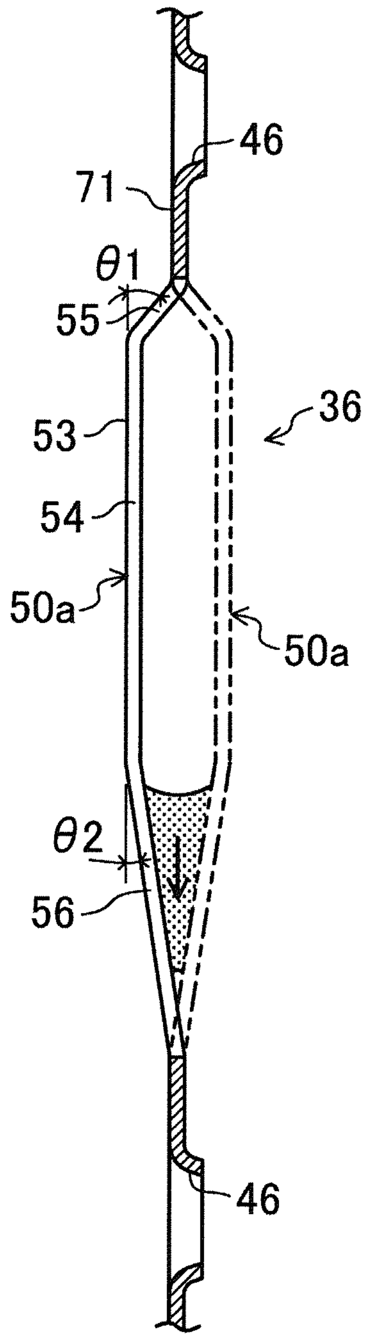


FIG.9

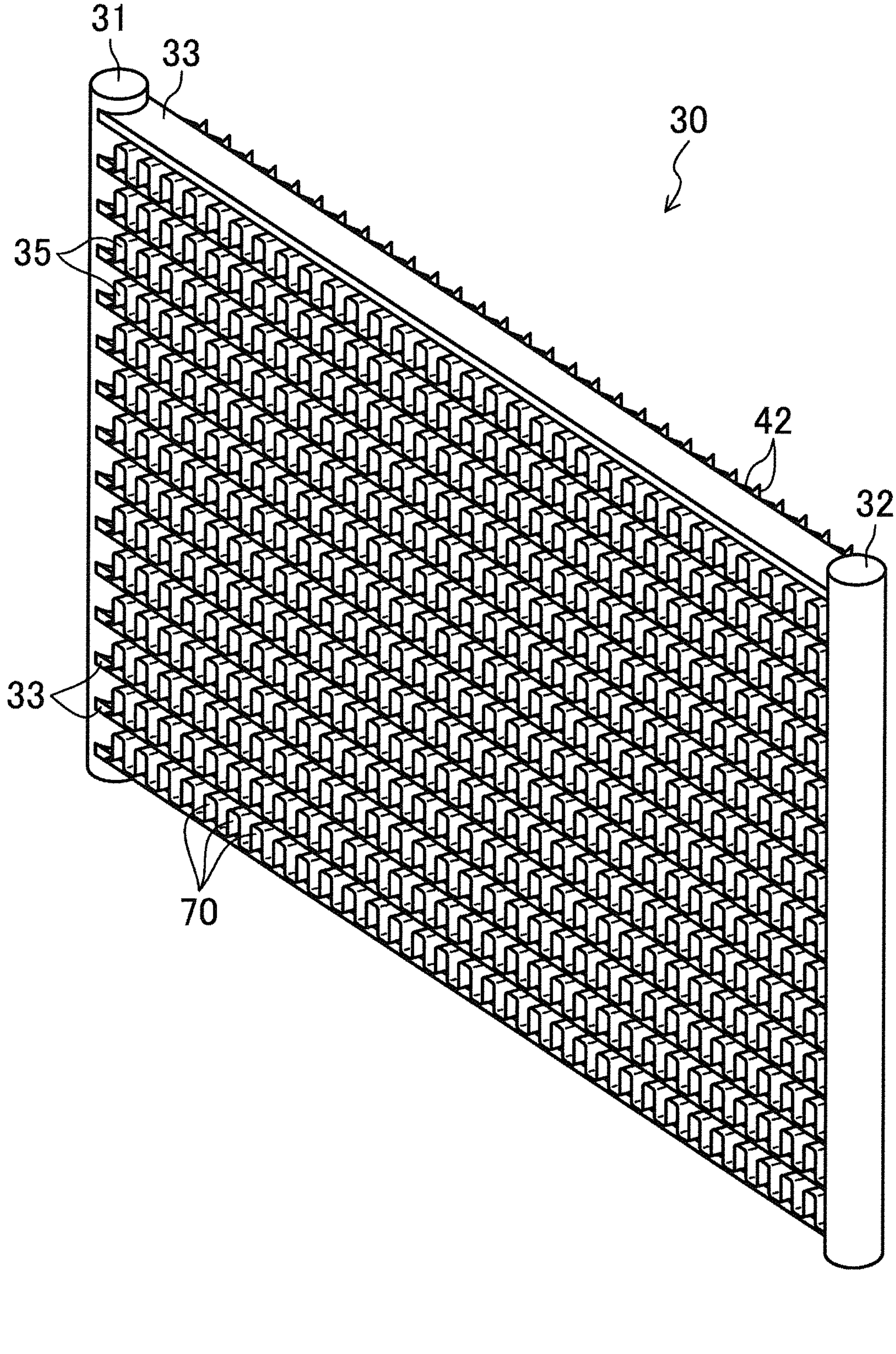


FIG.10

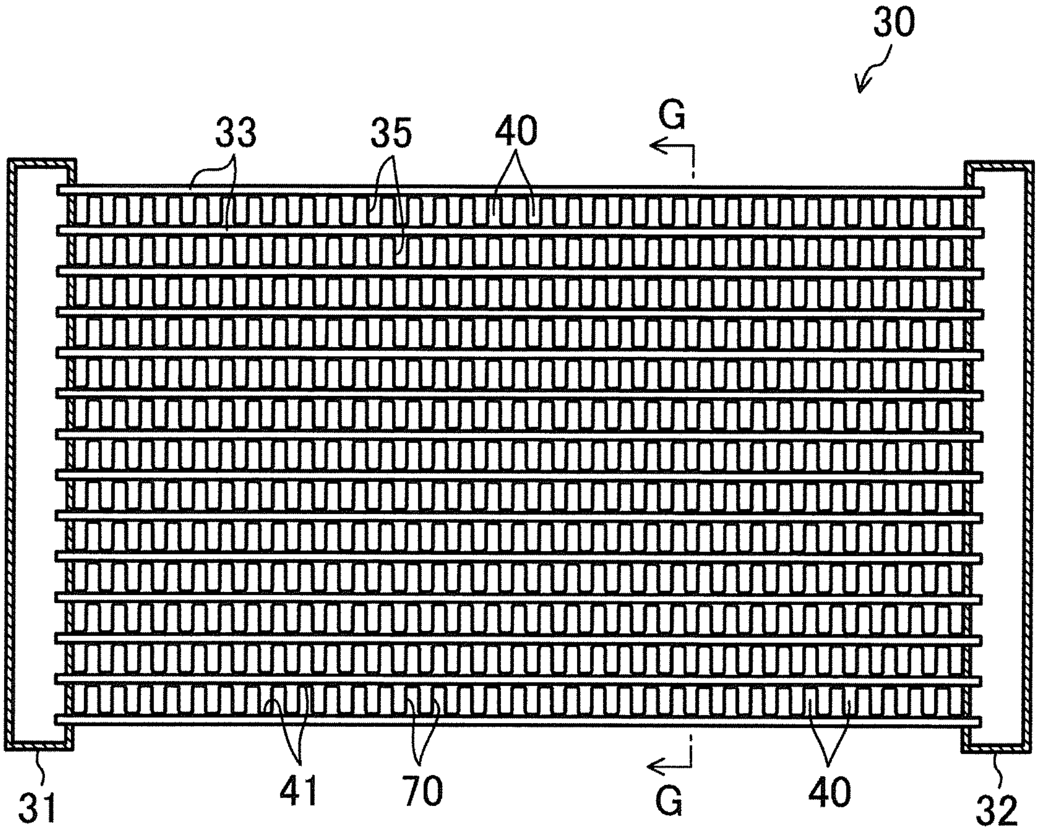
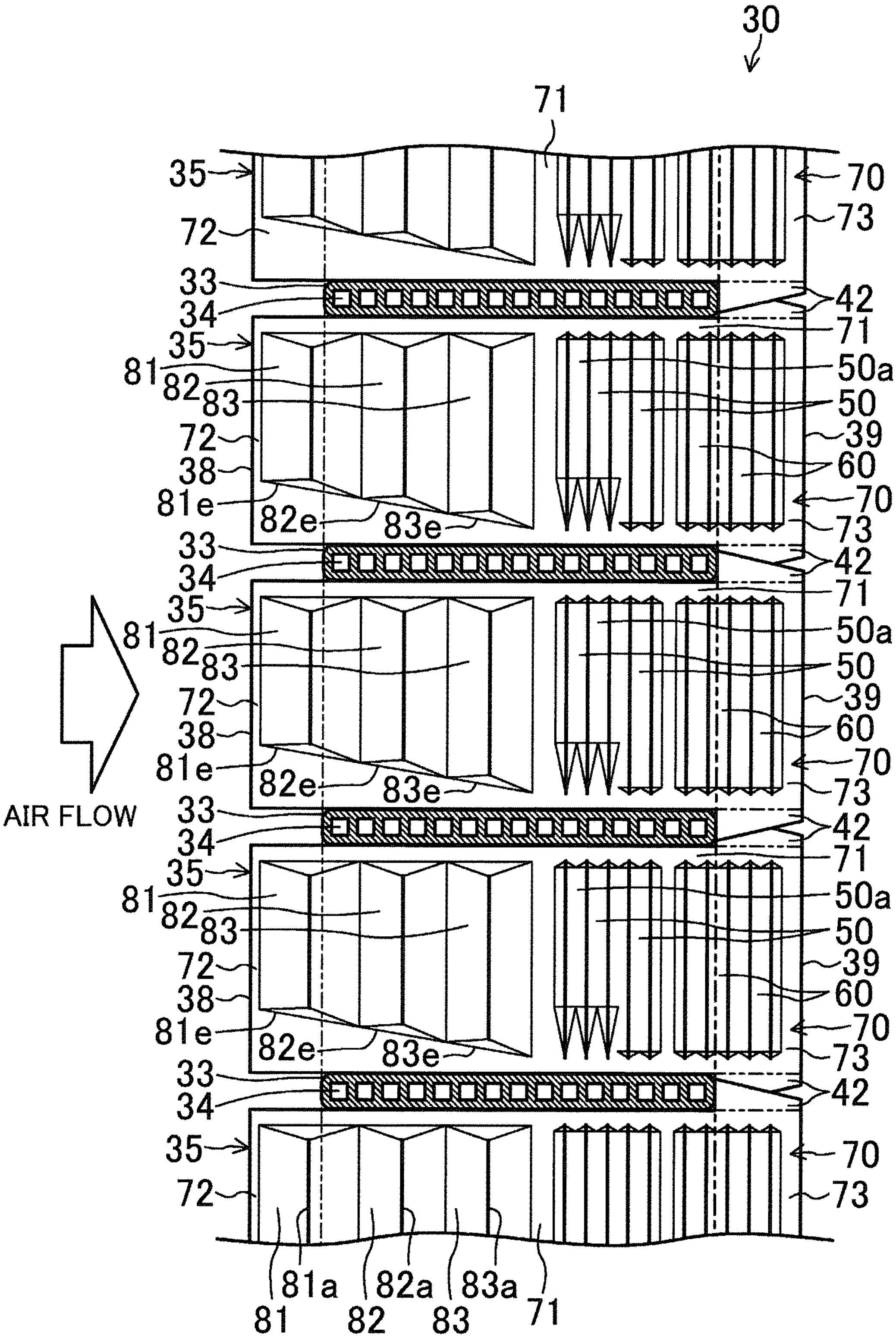


FIG.11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AIR FLOW
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FIG.12

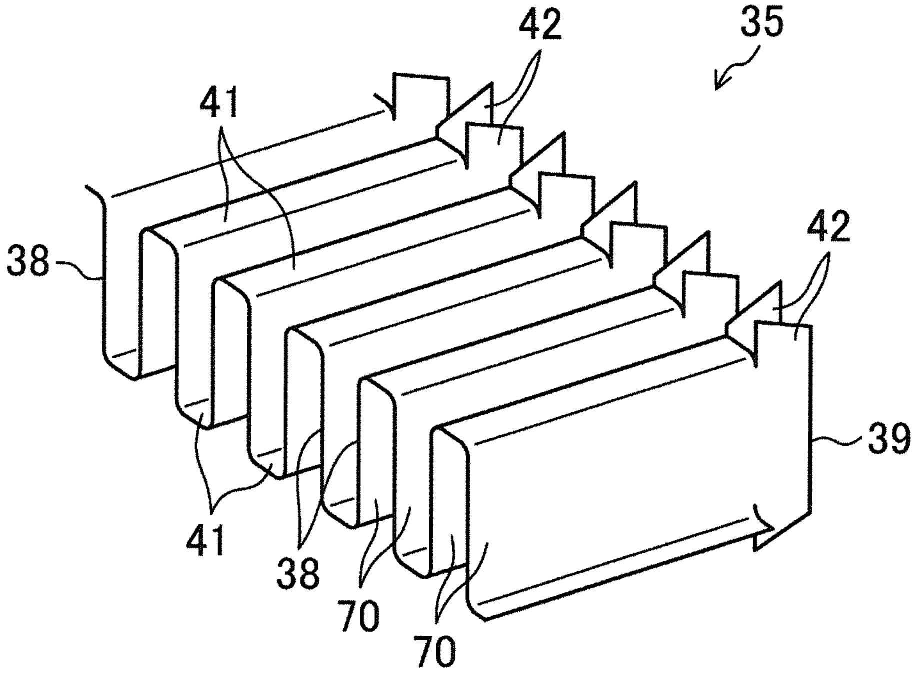

FIG.13

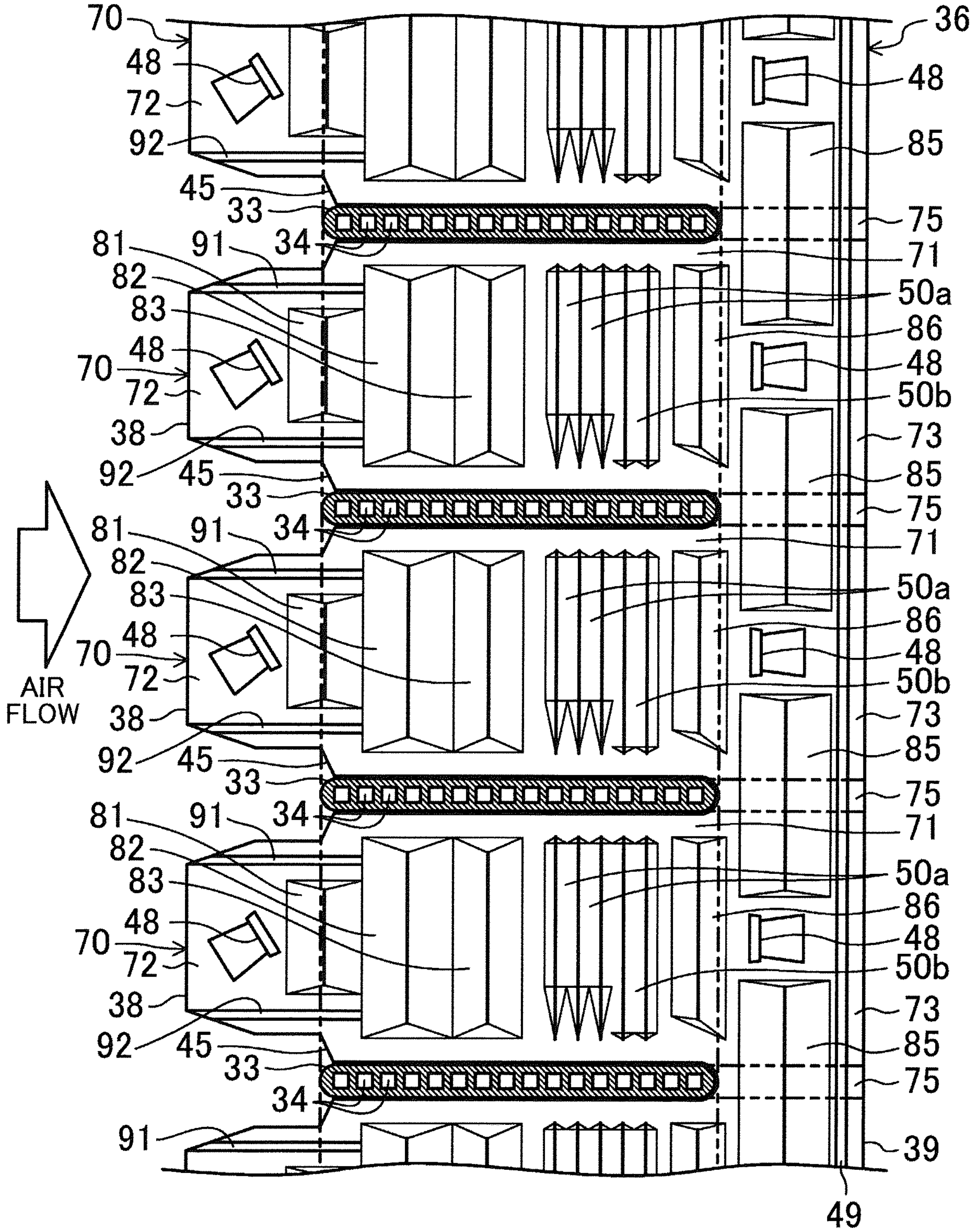
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FIG.14A

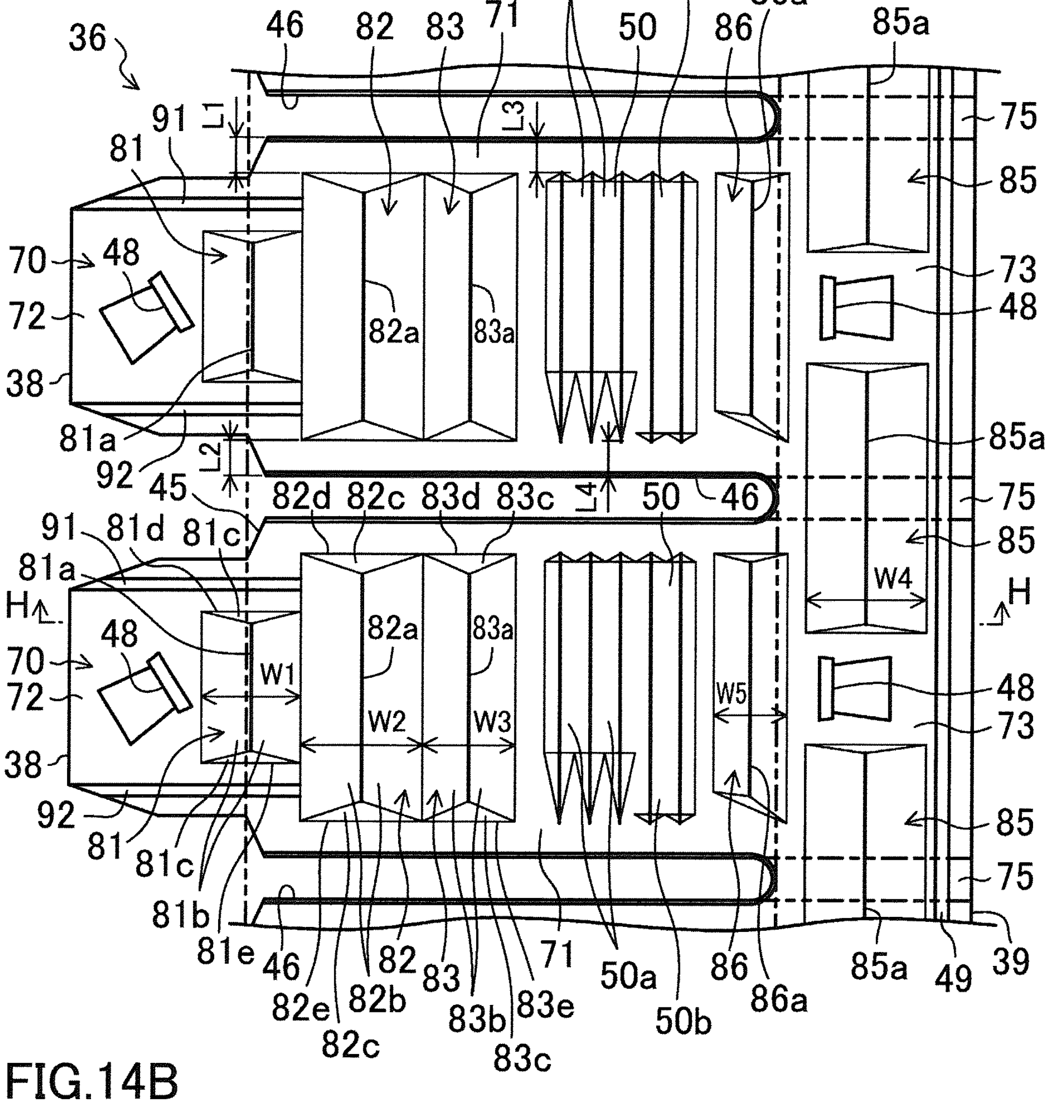

FIG.14B

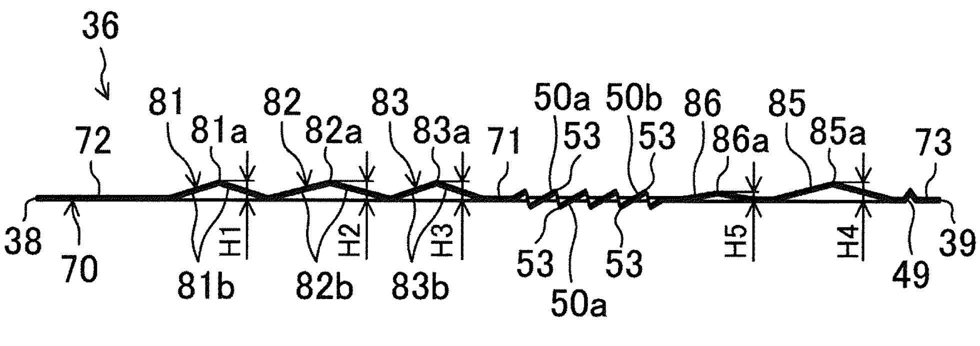

FIG.15

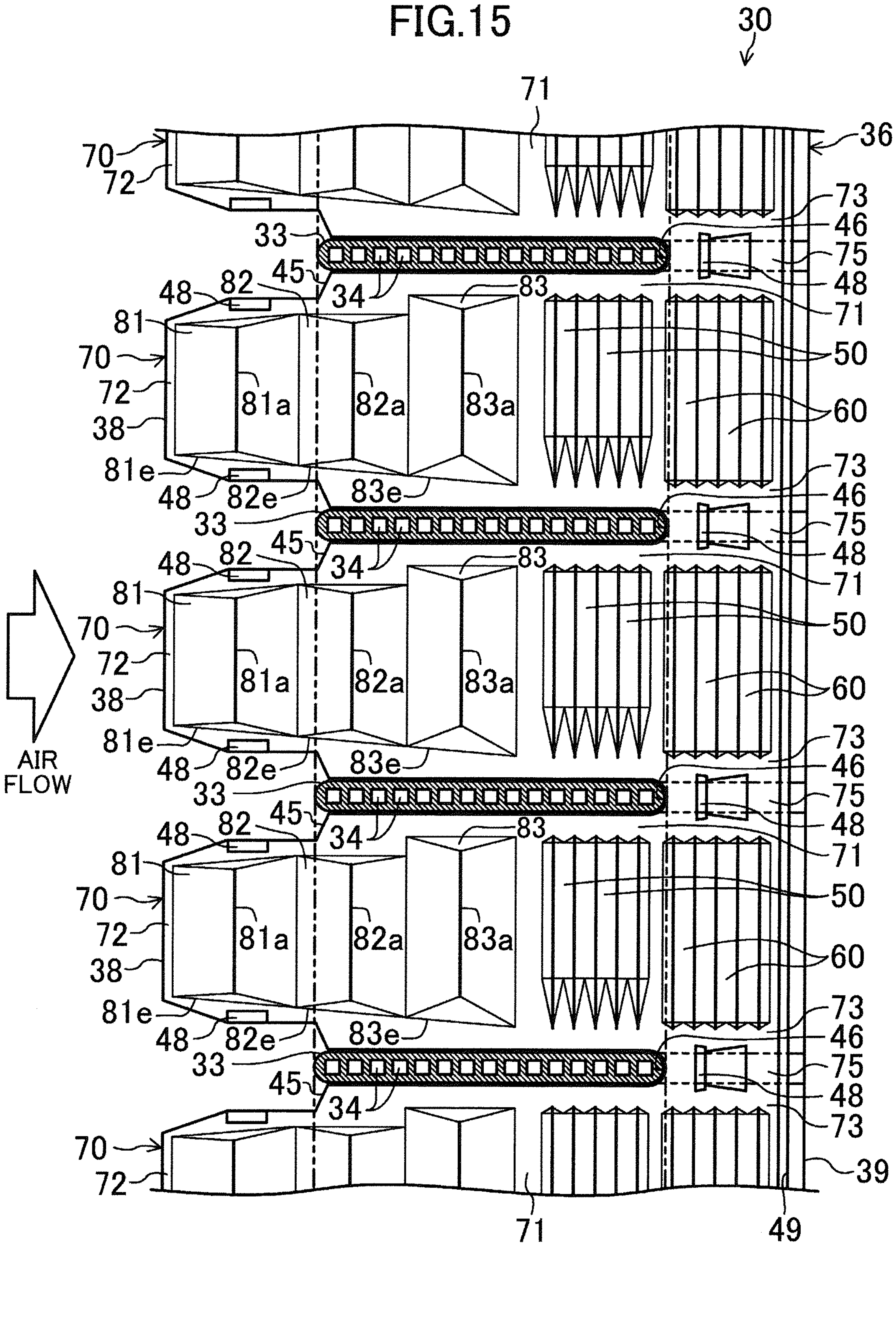
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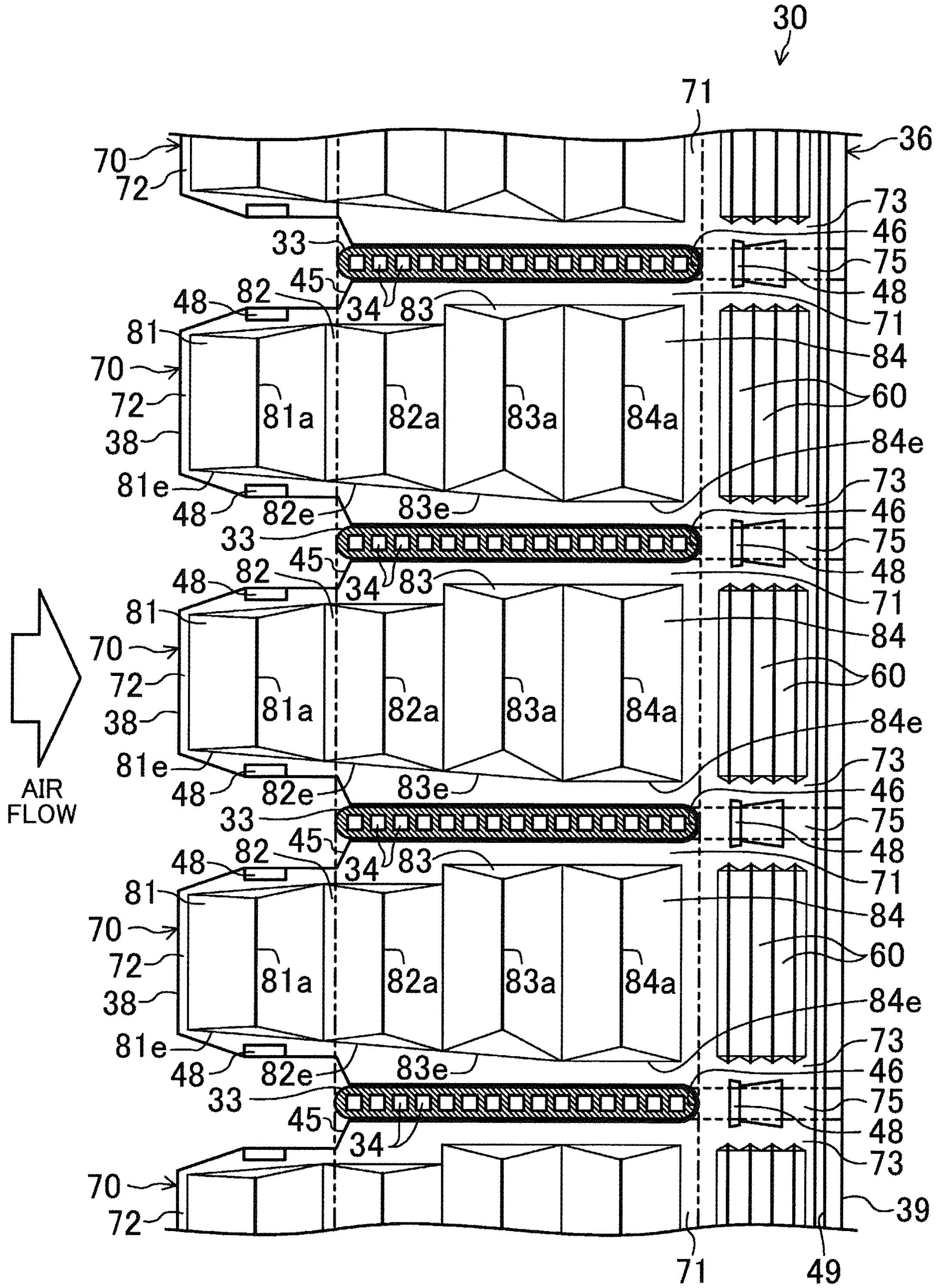
FIG.16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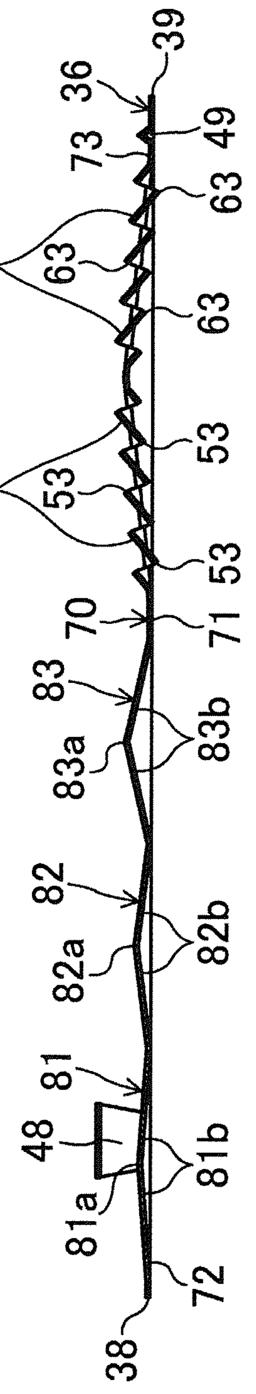

FIG.17A

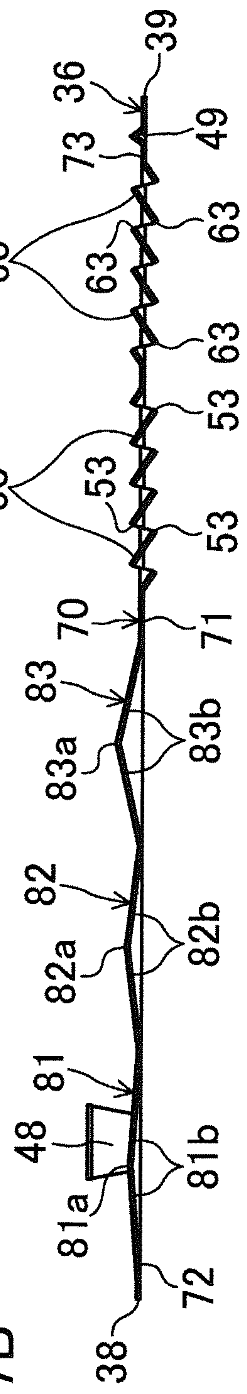

FIG.17B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/000401

A. CLASSIFICATION OF SUBJECT MATTER
F28F1/32(2006.01)i

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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	JP 2-71096 A (Matsushita Refrigeration Co.), 09 March 1990 (09.03.1990), entire text; all drawings (particularly, page 2, upper left column, line 17 to upper right column, line 8; page 2, lower left column, lines 5 to 18; fig. 2 to 5) (Family: none)	1-14
Y	JP 2000-234883 A (Showa Aluminum Corp.), 29 August 2000 (29.08.2000), entire text; all drawings (Family: none)	1-14

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
16 February, 2012 (16.02.12)	28 February, 2012 (28.02.12)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/000401

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-201467 A (Matsushita Electric Industrial Co., Ltd.), 28 July 2005 (28.07.2005), entire text; all drawings (particularly, paragraph [0018]; fig. 1, 2) (Family: none)	1-14
Y	JP 2001-41670 A (Hitachi, Ltd.), 02 February 2001 (02.02.2001), entire text; all drawings (particularly, paragraph [0019]; fig. 5) (Family: none)	3,4
Y	JP 61-159094 A (Matsushita Electric Industrial Co., Ltd.), 18 July 1986 (18.07.1986), entire text; all drawings (particularly, page 2, upper right column, line 13 to page 3, upper left column, line 3; fig. 1) (Family: none)	7
Y	JP 61-153498 A (Matsushita Electric Industrial Co., Ltd.), 12 July 1986 (12.07.1986), entire text; all drawings (particularly, page 2, upper right column, line 12 to lower right column, line 19; fig. 1) (Family: none)	8
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REFERENCES CITED IN THE DESCRIPTION

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