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(71) Applicant: **Kimura Kohki Co., Ltd.**
Osaka-shi
Osaka 540-0005 (JP)

(72) Inventors:
- **KIMURA, Keiichi**
  Osaka-shi, Osaka 540-0005 (JP)
- **URANO, Katsuhiro**
  Osaka-shi, Osaka 540-0005 (JP)
- **SHIOJI, Masaki**
  Osaka-shi, Osaka 540-0005 (JP)

(74) Representative: **Dantz, Jan Henning et al**
Loesenbeck - Specht - Dantz
Patent- und Rechtsanwälte
Am Zwinger 2
33602 Bielefeld (DE)

(54) **HEAT EXCHANGER**

(57) A heat exchanger includes a fin group and a tube group for a heat exchange medium. The fin group includes plate fins each of which is shaped as a flat polygonal plate having a first acute-angled corner. The plate fins are spaced by gaps through which air for air conditioning passes and arranged such that the air for air conditioning flows in a first direction along one of sides forming the first corner. The tube group includes heat transfer tubes which meander in the first direction. The heat transfer tubes includes fin-mounted portions mounted to and penetrating through the fin group. On the plate fin, between first fin-mounted portions adjacent to one another in the first direction, there are second fin-mounted portions adjacent to the first fin-mounted portions in a direction orthogonal to the first direction.

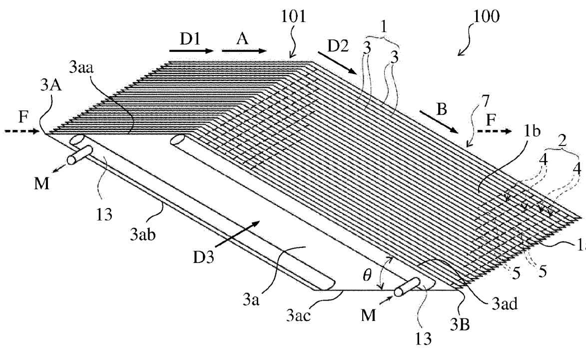

FIG. 1

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Description

FIELD

[0001] The present disclosure relates to a heat exchanger.

BACKGROUND

[0002] Japanese Laid-Open Patent Application Publication No. 2013-100992 discloses a heat exchange coil included in an air conditioner. The heat exchange coil has a structure in which plate fins included in a rectangular plate fin group are spaced by gaps for passage of air for air conditioning and in which a heat transfer tube group for flow of a heat exchange medium is mounted to and penetrates through the plate fins.

SUMMARY

[0003] In the case where a heat exchange coil is tall, an air conditioner including the heat exchange coil cannot be installed in a narrow space above a ceiling. In this case, there is a need for a machinery room for the air conditioner. The air conditioner including the tall heat exchange coil may require a drain pump due to an insufficient downward slope of the drain line. The cost increases for these reasons.

[0004] A heat exchanger according to one aspect of the present disclosure includes: a fin group; and a tube group which is mounted to and penetrates through the fin group and through which a heat exchange medium flows to exchange heat with air for air conditioning. The fin group includes plate fins each of which is shaped as a flat polygonal plate having corners including a first corner whose internal angle is an acute angle, the plate fins being arranged such that respective plate surfaces of the plate fins face one another across gaps through which the air for air conditioning passes and such that the air for air conditioning flows in a first direction along either of first and second sides forming the first corner. The tube group includes heat transfer tubes each of which extends in the first direction and meanders in such a manner as to cross the first direction. Each of the heat transfer tubes includes fin-mounted portions spaced in a direction along the first side and a direction along the second side, the fin-mounted portions being mounted to and penetrating through the fin group at locations in the fin group. The fin-mounted portions mounted to each of the plate fins are arranged such that between first fin-mounted portions adjacent to one another in the first direction, there are second fin-mounted portions adjacent to the first fin-mounted portions in a direction extending along the plate surface of the plate fin and orthogonal to the first direction.

DESCRIPTION OF THE DRAWINGS

[0005] The above and further objects, features and advantages of the present disclosure will be more apparent from the following detailed description of preferred embodiments with reference to the accompanying drawings.

FIG. 1 is a perspective view illustrating an example of the configuration of a heat exchanger according to an embodiment;
FIG. 2 is a schematic view illustrating the heat exchanger of FIG. 1 as viewed in a direction in which the long sides of the heat exchanger extend;
FIG. 3 is a view illustrating the heat exchanger as viewed in a direction in which the central axes of fin-mounted portions extend;
FIG. 4 is an enlarged view of a key part shown in FIG. 3;
FIG. 5 is a perspective view of a key part shown in FIG. 4; and
FIG. 6 is a schematic view illustrating an example of the use of the heat exchanger according to the embodiment.

DESCRIPTION

[0006] First, an aspect of the present disclosure will be described. A heat exchanger according to one aspect of the present disclosure includes: a fin group; and a tube group which is mounted to and penetrates through the fin group and through which a heat exchange medium flows to exchange heat with air for air conditioning, wherein the fin group includes plate fins each of which is shaped as a flat polygonal plate having corners including a first corner whose internal angle is an acute angle, the plate fins being arranged such that respective plate surfaces of the plate fins face one another across gaps through which the air for air conditioning passes and such that the air for air conditioning flows in a first direction along either of first and second sides forming the first corner, the tube group includes heat transfer tubes each of which extends in the first direction and meanders in such a manner as to cross the first direction, each of the heat transfer tubes includes fin-mounted portions spaced in a direction along the first side and a direction along the second side, the fin-mounted portions being mounted to and penetrating through the fin group at locations in the fin group, and the fin-mounted portions mounted to each of the plate fins are arranged such that between first fin-mounted portions adjacent to one another in the first direction, there are second fin-mounted portions adjacent to the first fin-mounted portions in a direction extending along the plate surface of the plate fin and orthogonal to the first direction.

[0007] In the above aspect, the heat exchanger according to the present disclosure allows for a greater width of the flow path through which the air for air conditioning passes and a lower airflow resistance, i.e., a smaller pressure loss, than a heat exchanger described below as a comparative example. The heat exchanger of the comparative example includes rectangular plate fins, has a similar structure to the heat exchanger according to the present disclosure, and has the same level of heat transfer capacity or heat exchange capacity as the heat exchanger according to the present disclosure. In the heat exchanger according to the present disclosure, the heat exchange capacity can be increased by increasing one or both of the flow velocity and flow rate of air, and the increase in heat exchange capacity can be utilized for downsizing.

[0008] The heat exchanger according to the present disclosure, in which one or both of the flow velocity and flow rate of air can be increased, is suitable for use in an indoor space such as a server room which requires strict temperature control. The heat exchanger according to the present disclosure offers an energy-saving effect and allows for space saving.

[0009] The heat exchanger according to the present disclosure can be downsized to have a small height. An air conditioner including the heat exchanger can be a slim air conditioner with a small height. Such an air conditioner can easily be installed in a narrow space above a ceiling. This allows for effective use of a dead space and eliminates the need for a machinery room. Furthermore, in the air conditioner, the drain line can have a sufficient downward slope to eliminate the need for a drain pump. This leads to a reduced cost.

[0010] The heat exchanger according to the present disclosure can have a small height, and at the same time the heat transfer tube effective length and fin heat transfer area of the heat exchanger can be increased to avoid an increase in pressure loss.

[0011] In the heat exchanger according to the one aspect of the present disclosure, the plate fins may be arranged such that the first corner of each of the plate fins is located towards upstream in the first direction.

[0012] In the heat exchanger according to the one aspect, the width of the flow path through which the air for air conditioning passes can be increased from the inlet for flow of the air for air conditioning through the interior of the heat exchanger to reduce the pressure loss.

[0013] In the heat exchanger according to the one aspect of the present disclosure, the plate fins may be quadrilateral, and in each of the plate fins, an internal angle of a second corner opposite to the first corner may be an acute angle.

[0014] In the above aspect, in each of the plate fins, the internal angle of an upstream corner in the first direction and the internal angle of a downstream corner in the first direction are acute angles. The plate fins form a downstream outlet for the air for air conditioning passing between the plate fins, and this outlet extends in a direction oblique to the first direction. Drain water generated during cooling operation can fall vertically under gravity through the gaps between the plate fins, and can be prevented from gathering at the outlet and scattering outward from the outlet under the effect of the flow velocity of the air for air conditioning.

[0015] In the heat exchanger according to the one aspect of the present disclosure, the internal angle of the acute-angled corner may be in a range of 20° to 40°.

[0016] In the above aspect, as the internal angle of the acute-angled corner is 20° or more, the heat exchanger can be prevented from being excessively long in the first direction. This can reduce the size of a space required for placement of the heat exchanger. As the internal angle of the acute-angled corner is 40° or less, the heat exchanger can be prevented from being excessively tall in a direction perpendicular to the first direction. This allows for a reduction in the airflow resistance of the heat exchanger.

[0017] The heat exchanger according to the one aspect of the present disclosure may include at least one protrusion on a portion of each of the plate fins. The portion of each of the plate fins may be located between two of the fin-mounted portions that are adjacent to each other in a second direction crossing the first direction, and the at least one protrusion may guide a flow of the air for air conditioning such that the flow of the air moves along outer peripheries of the two fin-mounted portions so as to surround outer peripheral surfaces of the two fin-mounted portions.

[0018] In the above aspect, the air for air conditioning is guided by the protrusion to meander so as to surround each of the heat transfer tubes. This improves the heat exchange efficiency of the air for air conditioning.

[0019] In the heat exchanger according to the one aspect of the present disclosure, the at least one protrusion may be a bridge lance that is integral with a corresponding one of the plate fins and that is formed by slitting and raising the portion of the corresponding plate fin into the shape of a bridge.

[0020] In the above aspect, the protrusion can be formed by subjecting the plate fin to lancing operation. Thus, for example, even in the case where many protrusions are needed, the protrusions can easily be formed while ensuring the strength with which the protrusions are held on the plate fin. Furthermore, the cost required for formation of the protrusions can be reduced.

[0021] In the heat exchanger according to the one aspect of the present disclosure, there may be a gap between the at least one protrusion and each of the two fin-mounted portions adjacent to each other in the second direction.

[0022] In the above aspect, when passing between the fin-mounted portions adjacent to each other in the second direction, the air for air conditioning is guided by the protrusion to flow through the gaps between the protrusion and the fin-mounted portions. Thus, the air for air conditioning flows along the outer peripheries of the fin-mounted portions so as to surround outer peripheral surfaces of the fin-mounted portions, and this improves the heat exchange efficiency of the air for air conditioning.

[0023] In the heat exchanger according to the one aspect of the present disclosure, the at least one protrusion may be a strip-shaped protrusion extending in the second direction.

[0024] In the above aspect, the protrusion can trap the air for air conditioning passing between the two fin-mounted portions adjacent to each other in the second direction and effectively guide the trapped air toward the two fin-mounted portions.

[0025] In the heat exchanger according to the one aspect of the present disclosure, the at least one protrusion may include protrusions located between the two fin-mounted portions adjacent to each other in the second direction, and the protrusions may be arranged in the first direction.

[0026] In the above aspect, the protrusions located between the two fin-mounted portions adjacent to each other in the second direction are arranged in the upstream-to-downstream direction of the flow of the air for air conditioning. Thus, a downstream one of the protrusions guides bypass air which is a portion of the air for air conditioning that passes beyond an upstream one of the protrusions. The efficiency in guiding the air for air conditioning is improved.

[0027] In the heat exchanger according to the one aspect of the present disclosure, the protrusions may have different lengths, and the farther from a line drawn between the two fin-mounted portions adjacent to each other in the second direction the protrusion is, the longer the protrusion may be.

[0028] In the above aspect, each of the protrusions has a length tailored to the size of the gap between the two fin-mounted portions adjacent to each other in the second direction. Thus, the protrusions can effectively trap and guide the air for air conditioning flowing between the two fin-mounted portions adjacent to each other in the second direction.

[0029] In the heat exchanger according to the one aspect of the present disclosure, each of the protrusions may include opposite first and second ends, the first ends of the protrusions may be located along the outer periphery of one of the two fin-mounted portions adjacent to each other in the second direction, and the second ends of the protrusions may be located along the outer periphery of the other of the two fin-mounted portions adjacent to each other in the second direction.

[0030] In the above aspect, gaps shaped to extend along the outer peripheries of the two fin-mounted portions adjacent to each other in the second direction are formed between the pair of fin-mounted portions and the protrusions. Thus, a flow of the air for air conditioning is effectively created which moves along the outer peripheries of the fin-mounted portions so as to surround outer peripheral surfaces of the two fin-mounted portions.

[0031] In the heat exchanger according to the one aspect of the present disclosure, each of the heat transfer tubes may have a cross-section whose outer peripheral shape is elliptical, and the heat transfer tubes may be arranged such that a major axis of the elliptical shape of the cross-section extends in the first direction.

[0032] In the above aspect, as the outer peripheral shape of the cross-section of each of the heat transfer tubes is elliptical, the pressure loss caused by the heat transfer tubes is low. Thus, the heat exchanger according to the present disclosure is suitable for achieving a large temperature difference by the use of a small amount of water. This leads to a reduction in the pump power for the heat exchanger and a reduction in the equipment cost for the heat exchanger.

[0033] In the heat exchanger according to the one aspect of the present disclosure, on each of the plate fins, the second fin-mounted portions may be offset from the first fin-mounted portions in the direction orthogonal to the first direction and located between the first fin-mounted portions in the first direction.

[0034] In the above aspect, the first and second fin-mounted portions are staggered in the first direction. The air for air conditioning flowing through the heat exchanger meanders by changing its flow direction at the first and second fin-mounted portions. Thus, the air for air conditioning can effectively contact the heat transfer tubes and the plate fins to effect heat exchange. Additionally, the path for the meandering flow of the air for air conditioning can have a large flow path width. This can improve the heat exchange efficiency.

[0035] Hereinafter, exemplary embodiments of the present disclosure will be described with reference to the drawings. The embodiments described below are generic or specific examples. Some elements in the embodiments described below are not included in the appended independent claim that defines the most generic concept, and these elements are described as optional elements. The figures in the accompanying drawings are schematic views, in which the elements are not necessarily precisely depicted. Elements that are substantially the same are denoted by the same reference sings throughout the drawings, and repeated description of such elements may be omitted or simplified. The term "device" as used in the specification and the claims is intended to include not only a single device but also a system made up of a plurality of devices.

[0036] FIGS. 1 to 5 illustrate an example of the configuration of a heat exchanger 100 according to an embodiment. In the present embodiment, the heat exchanger 100 is, but not limited to, what may be called a "coil heat exchanger" which includes a coiled heat transfer tube. As shown in FIG. 1, the heat exchanger 100 includes a heat exchange coil 101 that is a structure including a fin group 1 and a tube group 2.

[0037] Air for air conditioning flows in a first direction F which is an airflow direction. The air is supplied to and passes through the heat exchanger 100. The first direction F is indicated by a bold dashed line in the drawings. The tube group 2 is mounted to and penetrates through the fin group 1. A heat exchange medium M flows inside the tube group 2, in particular inside heat transfer tubes 4 included in the tube group 2. The heat exchange medium M exchanges heat with the air for air conditioning via the heat transfer tubes 4, thereby bringing the air to a temperature suitable for air conditioning.

[0038] The technology of the present disclosure is applicable to a structure in which cool or hot water serves as a heat exchange medium and exchanges heat with air for air conditioning, a structure in which a refrigerant such as a chlorofluorocarbon serves as a heat exchange medium and exchanges heat with air for air conditioning, and a structure in which another kind of heat exchange medium exchanges heat with air for air conditioning. The drawings illustrate an example where the technology of the present disclosure is applied to a structure in which cool or hot water serves as a heat exchange medium and exchanges heat with air for air conditioning.

[0039] The fin group 1 includes a set of plate fins 3. Each of the plate fins 3 is shaped as a flat plate. In the present embodiment, the plate fins 3 as viewed in plan have the same shape and dimensions. The plate fins 3 as viewed in plan may have different shapes and dimensions. The heat exchange coil 101 including the plate fins 3 and the tube group 2 is also called a plate-fin coil, and the heat exchanger 100 is also called a plate-fin coil heat exchanger.

[0040] In the present embodiment, the plate fins 3 as viewed in plan are, but not limited to being, quadrilateral. The internal angle of at least one of the four corners of each of the quadrilateral plate fins 3 is an acute angle. For example, at least the corner that is the most upstream of the four corners of each plate fin 3 in the first direction F may have an acute angle. For example, at least the corner that is the most downstream of the four corners of each plate fin 3 in the first direction F may have an acute angle.

[0041] In the present embodiment, the internal angles of two opposite corners 3A and 3B of each plate fin 3 are acute angles. The corner 3A is the most upstream corner in the first direction F, while the corner 3B is the most downstream corner in the first direction F. Each of the plate fins 3 may be a flat plate having the shape of a parallelogram, and the internal angles of the corners 3A and 3B may be equal. In the example shown, each of the plate fins 3 is a flat plate having the shape of a parallelogram.

[0042] The term "parallelogram" as used in the specification and the claims is intended to include: a quadrilateral in which one pair of opposite angles are equal and the other pair of opposite angles are also equal; a quadrilateral in which one pair of opposite angles are equal and the other pair of opposite angles are not equal but which can be considered to be substantially in the shape of a parallelogram; and a quadrilateral in which one pair of opposite angles are not equal and the other pair of opposite angles are not equal either but which can be considered to be substantially in the shape of a parallelogram.. The term "parallelogram" is intended to include a rhombus. The statement that a plurality of elements have the same shape is intended to include a case where the elements have exactly the same shape and a case where the elements can be considered to have substantially the same shape. The statement that a plurality of elements have the same dimensions is intended to include a case where the elements have exactly the same dimensions and a case where the elements can be considered to have substantially the same dimensions. The statement that one element is "parallel" to another element is intended to include a case where the one element is exactly parallel to the other element and a case where the one element can be considered to be substantially parallel to the other element. The statement that one element is "perpendicular" or "orthogonal" to another element is intended to include a case where the one element is exactly perpendicular or orthogonal to the other element and a case where the one element can be considered to be substantially perpendicular or orthogonal to the other element.

[0043] In each of the plate fins 3, the internal angle θ of the acute-angled corner may be in the range of 20° to 40° and preferably about 30°. For example, in the case where the plate fins 3 have the shape of a parallelogram, the internal angles θ of the acute-angled corners 3A and 3B are in the range of 20° to 40° and preferably about 30°. An "angle of about 30°" is intended to include an angle of exactly 30° and an angle that can be considered to be substantially 30°. For example, an angle in the range of 30° $\pm$ 1% can be considered to be substantially 30°.

[0044] The plate fins 3 are spaced by gaps through which the air for air conditioning passes, and respective plate surfaces 3a of the adjacent plate fins 3 face one another across the gaps. For example, the plate surfaces 3a are the major surfaces of the plate fins 3 shaped as flat plates. The plate fins 3 are arranged in a third direction D3, and the plate surfaces 3a of the plate fins 3 as viewed in the third direction D3 overlap one another. The plate fins 3 are aligned in the third direction D3. As the plate fins 3 as viewed in plan have the same shape and dimensions, the plate surface 3a of each of the plate fins 3 can be hidden by the plate surface 3a of the adjacent plate fin 3. In the present embodiment, the third direction D3 is perpendicular to the plate surfaces 3a.

[0045] For example, the set of plate fins 3 is disposed such that the air for air conditioning flows in the first direction F that is a direction along either a first side direction A along a first side 3aa of the plate surface 3a or a second side direction B along a second side 3ab of the plate surface 3a. The second side 3ab is adjacent to the first side 3aa at the acute-angled corner 3A of the plate surface 3a. The first and second sides 3aa and 3ab form the acute-angled corner 3A. In the example of FIG. 1, the first direction F is a direction along the first side direction A, and the second side direction B is an example of a second direction D2. In the case where the plate fins 3 have the shape of a parallelogram, the first side direction A is a short side direction along a short side of the plate surface 3a, and the second side direction B is a long side direction along a long side of the plate surface 3a.

[0046] The following discusses cases where the structure of the heat exchanger 100 according to the present embodiment is modified while keeping the heat exchange capacity of the heat exchanger at the same level before and after the structural modification. The heat exchanger 100 according to the present embodiment includes the plate fins 3 in each of which the internal angles θ of the acute-angled corners 3A and 3B are in the range of 20° to 40°.

[0047] For example, in the case where the structure of the heat exchanger 100 is modified such that in each of the plate fins 3 the internal angles θ of the acute-angled corners 3A and 3B are less than 20°, the dimension of the heat exchanger in the first direction F needs to be made longer after the structural modification than before the structural modification. Thus, the placement of the heat exchanger could require a wider space after the structural modification than before the structural modification.

[0048] For example, in the case where the structure of the heat exchanger 100 is modified such that in each of the plate fins 3 the internal angles θ of the acute-angled corners 3A and 3B are more than 40°, the heat exchanger needs to be made taller after the structural modification than before the structural modification. Thus, the airflow resistance of the heat exchanger could be higher after the structural modification than before the structural modification.

[0049] An outlet 7 for the air for air conditioning is located on a side surface of the fin group 1. For example, the outlet 7 is defined or formed either on that side surface 1a of the fin group 1 along which third sides 3ac of the plate fins 3 are aligned or on that side surface 1b of the fin group 1 along which fourth sides 3ad of the plate fins 3 are aligned. The third sides 3ac are sides of the plate surfaces 3a that are opposite to the first sides 3aa. The fourth sides 3ad are sides of the plate surface 3a that are opposite to the second sides 3ab. In the present embodiment, the outlet 7 is defined on the side surface 1b. The outlet 7 slopes downward from upstream to downstream in the first direction F. The fin group 1 permits drain water generated during cooling operation to fall vertically under gravity through the gaps between the plate fins 3, and the drain water is prevented from gathering at the outlet 7 under the effect of the flow velocity of the air for air conditioning. This prevents the drain water from scattering.

[0050] As shown in FIG. 2, the tube group 2 includes heat transfer tubes 4 each of which extends in the first direction F and meanders in such a zigzag pattern as to cross the first direction F. The tube group 2 includes inlets and outlets for the heat exchange medium M, and the inlets and outlets are connected to corresponding headers 13. That is, each of the heat transfer tubes 4 includes an inlet and an outlet for the heat exchange medium M, and the inlet and outlet are connected to different headers 13. Each of the heat transfer tubes 4 includes fin-mounted portion 5 mounted to and penetrating through the plate fins 3 of the fin group 1. It is at the fin-mounted portions 5 that each of the heat transfer tubes 4 is mounted to and penetrate through the plate fin 3. Each of the plate fins 3 includes through holes through which the heat transfer tubes 4 pass. The fin-mounted portions 5 of the heat transfer tubes 4 are spaced in the first side direction A and the second side direction B, and each of the heat transfer tubes 4 is mounted to and penetrate through plate fins 3 of the fin group 1 at multiple locations where the fin-mounted portions 5 are located in the fin group 1.

[0051] As shown in FIGS. 3 and 4, each of the heat transfer tubes 4 may have a cross-section whose outer peripheral shape is elliptical. The heat transfer tubes 4 may be arranged on the plate fins 3 such that the major axes LA of the elliptical shapes of the cross-sections extend in the first direction F. In particular, the major axes of the elliptical outer peripheries of the cross-sections of the fin-mounted portions 5 extend in the first direction F. The fin-mounted portions 5 mounted to each of the plate fins 3 are arranged such that between fin-mounted portions 5a and 5b adjacent to one another in the first direction F, there are fin-mounted portions 5c adjacent to the fin-mounted portions 5a and 5b in a direction extending along the plate surface 3 a of the plate fin 3 and orthogonal to the first direction F. The fin-mounted portions 5c located between the fin-mounted portions 5a and 5b are off-set from the fin-mounted portions 5a and 5b in the direction extending along the plate surface 3a of the plate fin 3 and orthogonal to the first direction F. This increases the width L of the flow path through which the air for air conditioning passes.

[0052] In regard to the flow path width L around the fin-mounted portions 5a, 5b, and 5c, there are, for example, a first case where the distance between the fin-mounted portions 5a and 5c in a direction in which the fin-mounted portions 5a and 5c are aligned is the flow path width L and a second case where the distance between the fin-mounted portions 5b and 5c in a direction in which the fin-mounted portions 5b and 5c are aligned is the flow path width L. The flow path width L in the first case is greater than the distance between the fin-mounted portions 5a and 5c in the direction perpendicular to the first direction F. The flow path width L in the second case is greater than the distance between the fin-mounted portions 5b and 5c in the direction perpendicular to the first direction F. The outer peripheral shapes of the cross-sections of the heat transfer tubes 4 and the arrangement of the fin-mounted portions 5 work synergistically to significantly reduce the airflow resistance acting on the air for air conditioning.

[0053] As shown in FIGS. 4 and 5, each of the plate fins 3 includes at least one protrusion 6 located between the fin-mounted portions 5 adjacent to each other in the second direction D2 crossing the first direction F. In the present embodiment, each of the plate fins 3 includes a plurality of such protrusions 6 between the two fin-mounted portions 5 adjacent to each other in the second direction D2. In the present embodiment, the second direction D2 is, but not limited to, a direction along the second side direction B. The at least one protrusion 6 between the two fin-mounted portions 5 is shaped and positioned to guide the flow of the air for air conditioning such that the flow of the air moves along the outer peripheries of the two fin-mounted portions 5 so as to surround outer peripheral surfaces of the two fin-mounted portions 5.

[0054] In the present embodiment, the protrusions 6 are, but not limited to, strip-shaped protrusions extending in a direction crossing the first direction F. For example, the protrusions 6 extend in a direction from one of the two fin-mounted portions 5 toward the other fin-mounted portion 5. The protrusions 6 may extend in the second direction D2. The protrusions 6 are arranged in the first direction F. The protrusions 6 are linear strip-shaped protrusions, but may be non-linear strip-shaped protrusions. The linear protrusions 6 are parallel to one another, but may be non-parallel to one another.

[0055] There are gaps between the plurality of protrusions 6 and the two fin-mounted portions 5 adjacent to the plurality of protrusions 6. The protrusions 6 located between the two fin-mounted portions 5 may have different lengths. For example, the lengths of the protrusions 6 may vary such that the farther from a line drawn between the two fin-mounted portions 5 the protrusion 6 is, the longer the protrusion 6 is. The line may be a line drawn between the centers of the two fin-mounted portions 5. For example, the lengths of the protrusions 6 may vary such that first ends of the protrusions 6 are located along the outer periphery of the cross-section of one of the fin-mounted portions 5 and second ends of the protrusions 6 are located along the outer periphery of the cross-section of the other fin-mounted portion 5.

[0056] The plurality of protrusions 6 as described above allow the flow of the air for air conditioning to meander, thus increasing the total distance over which the air for air conditioning contacts the plate fin 3 and the heat transfer tubes 4 and hence increasing the amount of heat transfer between the air and the plate fin 3 and heat transfer tubes 4. Furthermore, the plurality of protrusions 6 reduce the amount of bypass air which is a portion of the air for air conditioning that passes straight between the two fin-mounted portions 5.

[0057] The protrusions 6 may be integral with or separate from the plate fin 3. In the present embodiment, the protrusions 6 are integral with the plate fin 3. The protrusions 6 may be made of the same material as the plate fin 3 or may be formed from portions of the plate fin 3. In the present embodiment, the protrusions 6 are bridge lances formed by processing the plate fin 3. The "protrusions 6" may hereinafter be referred to as "bridge lances 6". Each of the bridge lances 6 can be formed by lancing operation in which a portion of the plate fin 3 is slit and drawn into the form of a bridge. The bridge lances 6 as viewed in plan may be, but are not limited to being, quadrilateral. The four sides of each of the quadrilateral bridge lances 6 may be parallel to one or more of the four sides 3aa, 3ab, 3ac, and 3ad of the plate surface 3a of the plate fin 3.

[0058] The bridge lances 6 as viewed in plan may have a similar shape to the plate fin 3 and may have the shape of a parallelogram. In this case, each of the four sides of the parallelogram-shaped bridge lances 6 may be parallel to a corresponding one of the four sides of the plate surface 3a.

[0059] For example, each of the parallelogram-shaped bridge lances 6 can be formed by slitting the plate fin 3 at the two long sides of the parallelogram that extend in the second side direction B and then raising the portion between the two slits of the plate fin 3 in a direction perpendicular to the plate surface 3a such that the portion is bent at the two short sides of the parallelogram that extend in the first side direction A. The bridge lance 6 thus formed is in the shape of a bridge having openings facing in the first direction F at side surfaces of the bridge that extend in the second side direction B. Each of the bent end portions of the bridge lance 6 is located along the outer peripheral surface, which has an elliptical cross-section, of a corresponding one of the fin-mounted portions 5.

[0060] FIG. 6 illustrates an example where the heat exchanger 100 according to the above embodiment is used in an air conditioner 8. The air conditioner 8 includes: a heat exchange unit 9 that exchanges heat with air for air conditioning; an air blowing unit 11 including an air blower 10 to supply the air for air conditioning to an indoor space IS through the heat exchange unit 9; and air ducts 12. The heat exchange unit 9 includes the heat exchanger 100. The heat exchange unit 9, the air blowing unit 11, the indoor space IS, an unshown outdoor space, and an unshown indoor space are communicatively connected to one another by the air ducts 12. For example, the air duct 12 communicatively connects the heat exchange unit 9 to the air blowing unit 11. The heat exchange unit 9 exchanges heat with the air for air conditioning supplied by the air blowing unit 11. The air conditioner 8 supplies to the indoor space IS the air for air conditioning having undergone heat exchange in the heat exchange unit 9. For example, the heat exchange unit 9 and the air blowing unit 11 are placed in a space above a ceiling S of a building such as an office building. The air conditioner 8 may have a structure in which the heat exchange unit 9 and the air blowing unit 11 are integral with each other or a structure including the heat exchange unit 9 and the air blowing unit 11 separately.

[0061] Although the foregoing has described an embodiment of the present disclosure, the present disclosure is not limited to the above embodiment. Various changes and modifications can be made without departing from the scope of the present disclosure. The scope of the present disclosure includes, for example, embodiments resulting from various changes made to the above embodiment or constructed by combining elements of different embodiments.

[0062] For example, in the heat exchanger 100 according to the above embodiment, the outlet 7 may be structured to slope downward from downstream to upstream in the first direction F.

[0063] For example, in the heat exchanger 100 according to the above embodiment, the outer peripheral shapes of the cross-sections of the fin-mounted portions 5 of the heat transfer tubes 4 of the tube group 2 can be freely chosen and may be other than an elliptical shape.

[0064] Although in the heat exchanger 100 according to the above embodiment the plate fins 3 as viewed in plan are quadrilateral, the plate fins 3 as viewed in plan are not limited to this shape. The plate fins 3 as viewed in plan may have the shape of a triangle or a polygon with five or more corners.

[0065] Although in the heat exchanger 100 according to the above embodiment the plate fins 3 as viewed in plan have the shape of a quadrilateral with two opposite corners 3A and 3B whose internal angles are acute angles, the plate fins 3 as viewed in plan are not limited to this shape. For example, the internal angle of one of the corners 3A and 3B may be an acute angle, and the internal angles of the other three corners may be 90° or more. In this case, the plate fin 3 as viewed in plan may have the shape of a right trapezoid.

[0066] The numerals such as ordinal numbers and quantities as used herein are all given to describe the technology of the present disclosure in concrete terms and not intended to limit the present disclosure. The connection relationships between the elements are used to describe the technology of the present disclosure in concrete terms, and any connection relationships may be employed to achieve the functionality taught in the present disclosure.

[0067] The scope of the present disclosure is defined by the appended claims rather than by the foregoing description so that the present disclosure may be embodied in various forms without departing from the essential characteristics of the present disclosure. The embodiments and modifications are meant to be illustrative only and not limiting as to the scope of the present disclosure. All changes which come within the meaning and range of equivalency of the claims are to be embraced within the scope of the claims.

REFERENCE SIGNS LIST

[0068]

1	fin group
2	tube group
3	plate fin
3A	first corner
3B	second corner
3a	plate surface
3aa	first side
3ab	second side
4	heat transfer tube
5	fin-mounted portion
6	protrusion, bridge lance
100	heat exchanger
A	first side direction
B	second side direction
D2	second direction
F	airflow direction, first direction
θ	internal angle

Claims

1. A heat exchanger (100) comprising:

   a fin group (1); and
   a tube group (2) which is mounted to and penetrates through the fin group (1) and through which a heat exchange medium flows to exchange heat with air for air conditioning, wherein
   the fin group (1) includes plate fins (3) each of which is shaped as a flat polygonal plate having corners including a first corner (3A) whose internal angle (θ) is an acute angle, the plate fins (3) being arranged such that respective plate surfaces (3a) of the plate fins (3) face one another across gaps through which the air for air conditioning passes and such that the air for air conditioning flows in a first direction (F) along either of first and second sides (3aa) and (3ab) forming the first corner (3A),
   the tube group (2) includes heat transfer tubes (4) each of which extends in the first direction (F) and meanders in such a manner as to cross the first direction (F),
   each of the heat transfer tubes (4) includes fin-mounted portions (5) spaced in a direction (A) along the first side (3aa) and a direction (B) along the second side (3ab), the fin-mounted portions (5) being mounted to and penetrating through the fin group (1) at locations in the fin group (1), and
   the fin-mounted portions (5) mounted to each of the plate fins (3) are arranged such that between first fin-mounted portions (5) adjacent to one another in the first direction (F), there are second fin-mounted portions (5) adjacent to the first fin-mounted portions (5) in a direction extending along the plate surface (3a) of the plate fin (3) and orthogonal to the first direction (F).

2. The heat exchanger (100) according to claim 1, wherein the plate fins (3) are arranged such that the first corner (3A) of each of the plate fins (3) is located towards upstream in the first direction (F).

3. The heat exchanger (100) according to claim 1 or 2, wherein

   the plate fins (3) are quadrilateral, and
   in each of the plate fins (3), an internal angle (θ) of a second corner (3B) opposite to the first cor-

ner (3A) is an acute angle.

4. The heat exchanger (100) according to any one of claims 1 to 3, wherein the internal angle (θ) of the acute-angled corner is in a range of 20° to 40°.

5. The heat exchanger (100) according to any one of claims 1 to 4, further comprising at least one protrusion (6) on a portion of each of the plate fins (3), wherein

the portion of each of the plate fins (3) is located between two of the fin-mounted portions (5) that are adjacent to each other in a second direction crossing the first direction (F), and
the at least one protrusion (6) guides a flow of the air for air conditioning such that the flow of the air moves along outer peripheries of the two fin-mounted portions (5) so as to surround outer peripheral surfaces of the two fin-mounted portions (5).

6. The heat exchanger (100) according to claim 5, wherein
the at least one protrusion (6) is a bridge lance that is integral with a corresponding one of the plate fins (3) and that is formed by slitting and raising the portion of the corresponding plate fin (3) into the shape of a bridge.

7. The heat exchanger (100) according to claim 5 or 6, wherein
there is a gap between the at least one protrusion (6) and each of the two fin-mounted portions (5) adjacent to each other in the second direction.

8. The heat exchanger (100) according to any one of claims 5 to 7, wherein
the at least one protrusion (6) is a strip-shaped protrusion extending in the second direction.

9. The heat exchanger (100) according to any one of claims 5 to 8, wherein

the at least one protrusion (6) includes protrusions (6) located between the two fin-mounted portions (5) adjacent to each other in the second direction, and
the protrusions (6) are arranged in the first direction (F).

10. The heat exchanger (100) according to claim 9, wherein

the protrusions (6) have different lengths, and
the farther from a line drawn between the two fin-mounted portions (5) adjacent to each other in the second direction the protrusion (6) is, the longer the protrusion (6) is.

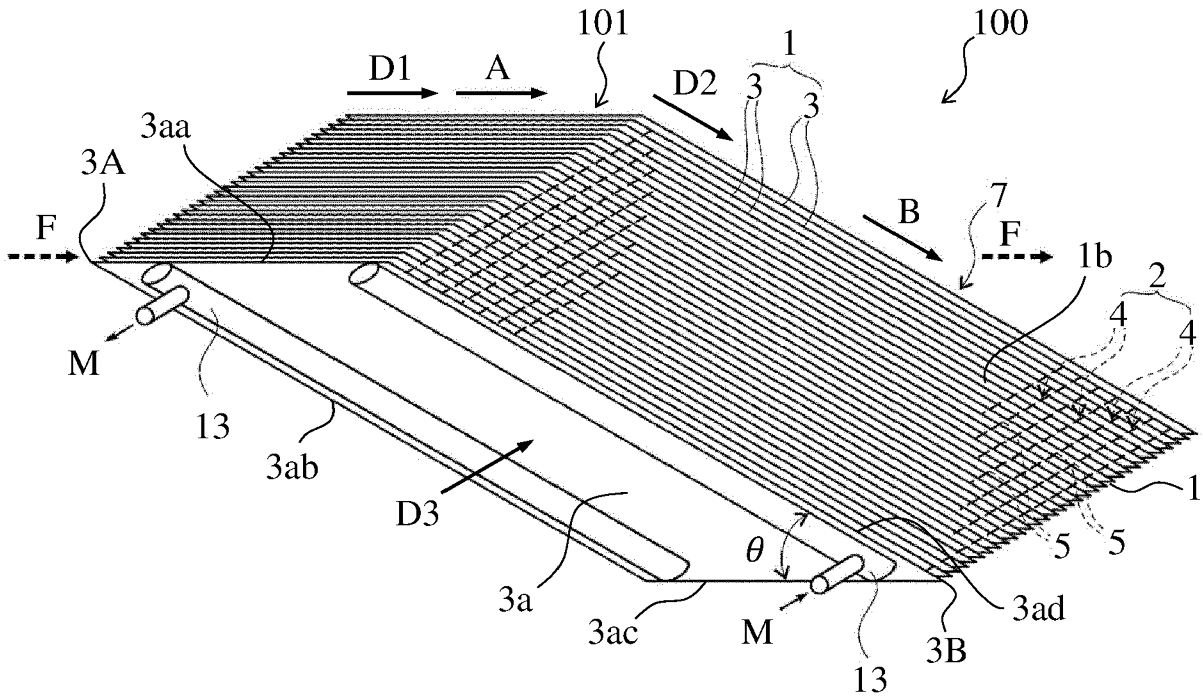
11. The heat exchanger (100) according to claim 9 or 10, wherein

each of the protrusions (6) includes opposite first and second ends,
the first ends of the protrusions (6) are located along the outer periphery of one of the two fin-mounted portions (5) adjacent to each other in the second direction, and
the second ends of the protrusions (6) are located along the outer periphery of the other of the two fin-mounted portions (5) adjacent to each other in the second direction.

12. The heat exchanger (100) according to any one of claims 1 to 11, wherein

each of the heat transfer tubes (4) has a cross-section whose outer peripheral shape is elliptical, and
the heat transfer tubes (4) are arranged such that a major axis of the elliptical shape of the cross-section extends in the first direction (F).

13. The heat exchanger (100) according to any one of claims 1 to 12, wherein
on each of the plate fins (3), the second fin-mounted portions (5) are offset from the first fin-mounted portions (5) in the direction orthogonal to the first direction (F) and are located between the first fin-mounted portions (5) in the first direction (F).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100
1
D1
A
D2
3
3
3aa
3A
F
B
7
F
1b
2
4
4
M
13
3ab
D3
1a
θ
5
5
3a
3ac
M
3ad
3B
13

FIG. 1

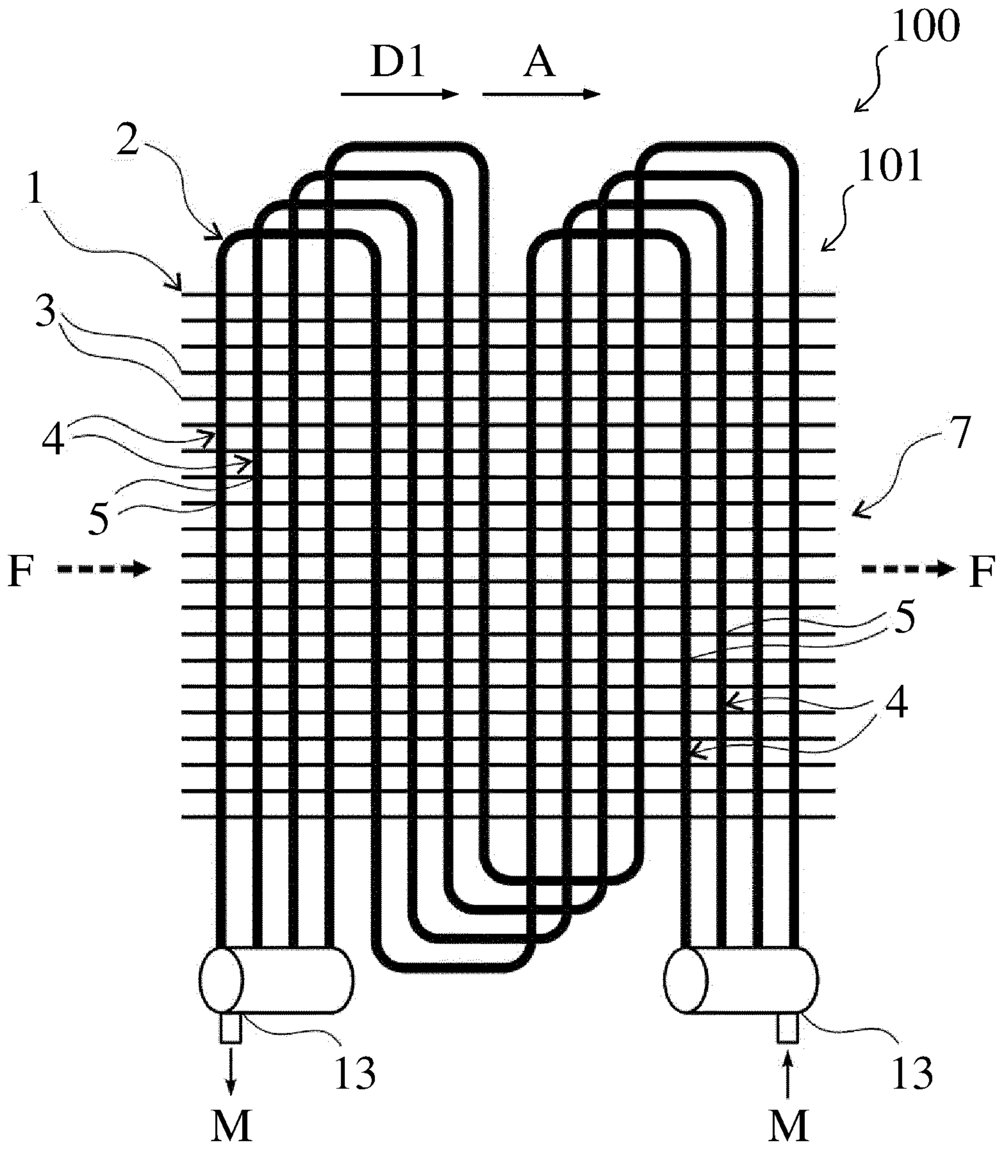
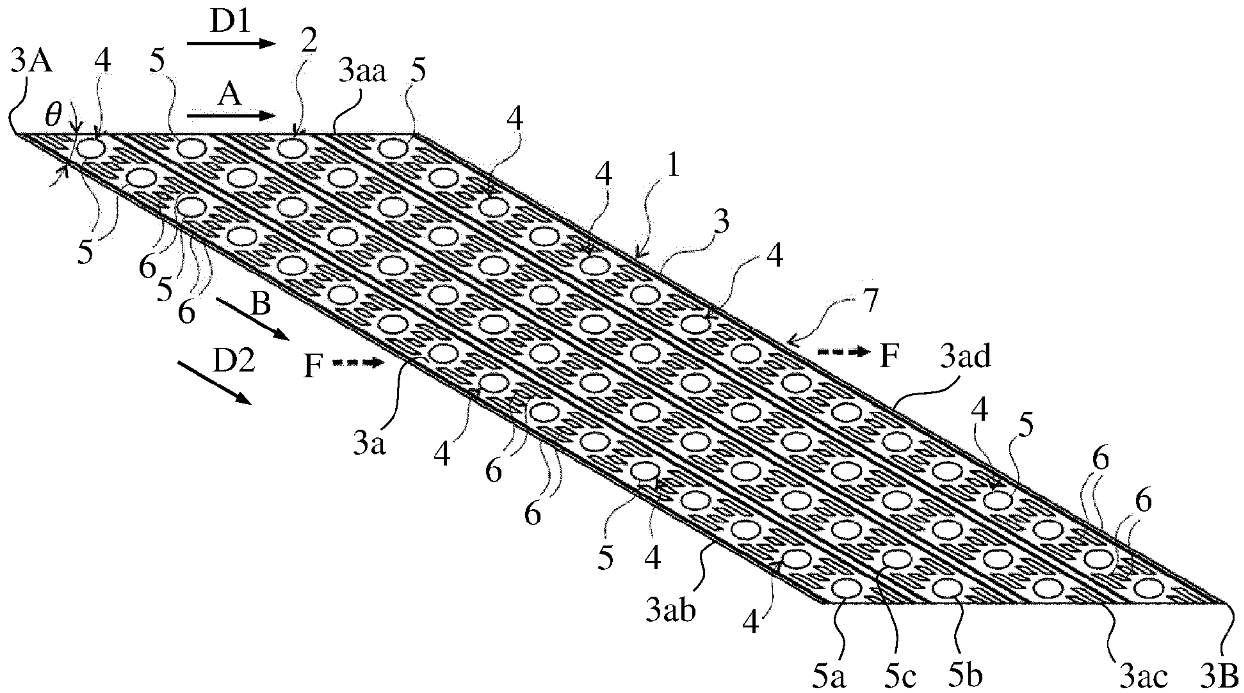


FIG. 2


D1
A
B
D2
F
F
3A
4
5
2
3aa
5
θ
4
4
1
3
4
7
3ad
5
6
5
6
3a
4
6
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4
4
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6
6
3ab
4
5a
5c
5b
3ac
3B

FIG. 3

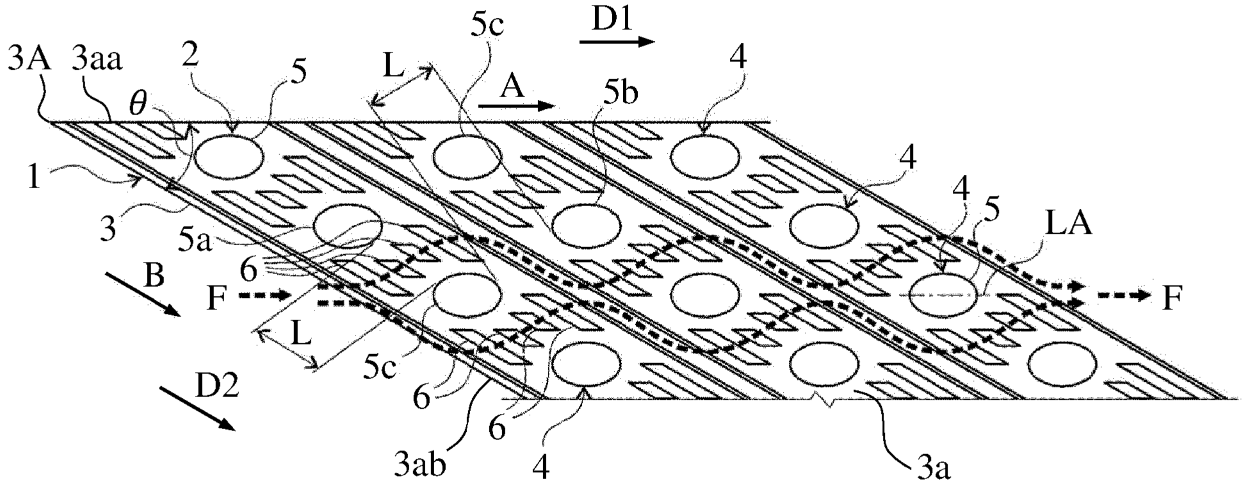

FIG. 4

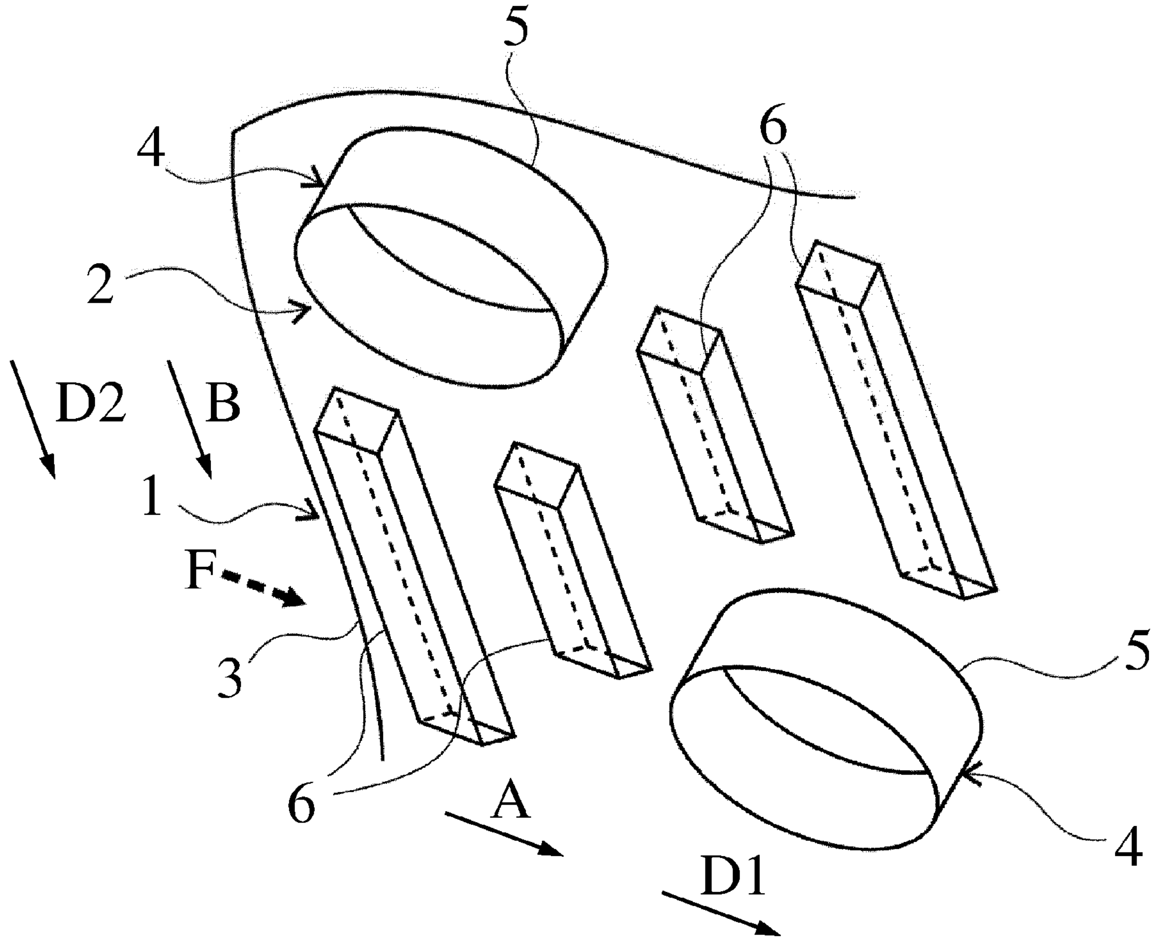

FIG. 5

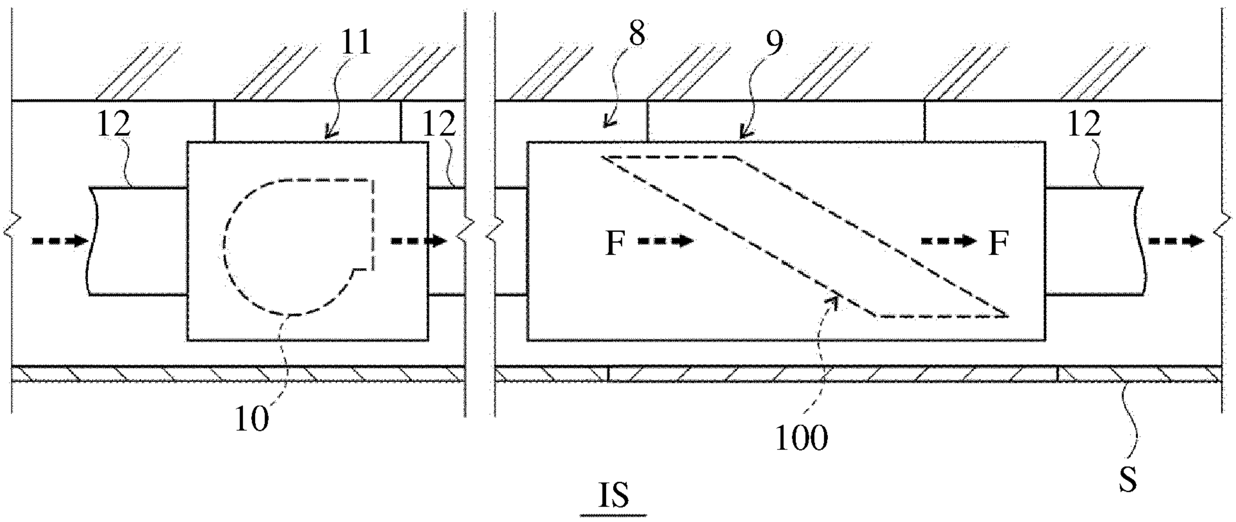

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 15 1760

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP H10 54683 A (HITACHI LTD) 24 February 1998 (1998-02-24) * figures 25-27 * -----	1-13	INV. F28F1/32 F28D1/047
X	JP S60 122670 U (A) 19 August 1985 (1985-08-19) * figure 7 * -----	1	
X	WO 01/67020 A1 (HITACHI LTD [JP]; HITACHI AIR CONDITIONING SYS [JP] ET AL.) 13 September 2001 (2001-09-13) * figure 1 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

F28D
F28F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 May 2023	Martínez Rico, Celia

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12-05-2023

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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