



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

(43) Date of publication:
01.10.2014 Bulletin 2014/40

(51) Int Cl.:
F28F 1/32 (2006.01) F25B 39/00 (2006.01)

(21) Application number: **12851069.0**

(86) International application number:
PCT/JP2012/007515

(22) Date of filing: **22.11.2012**

(87) International publication number:
WO 2013/076990 (30.05.2013 Gazette 2013/22)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

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(30) Priority: **25.11.2011 JP 2011257245**

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(54) **HEAT TRANSFER FIN, FIN-TUBE HEAT EXCHANGER, AND HEAT PUMP DEVICE**

(57) A heat transfer fin (3) includes: a base portion (4) having a flat surface (4a); a cylindrical collar portion (5) extending upwardly from the base portion (4); a flared portion (6) flaring radially outwardly from an entire upper end of the collar portion (5); and a receding portion (7) having an inclined surface extending upwardly from a

bottom of the collar portion (5) at an acute angle with respect to a direction toward the upper end of the collar portion (5). The bottom of the collar portion (5) is located at a position not reaching a reference plane when the flat surface (4a) of the base portion (4) is the reference plane.

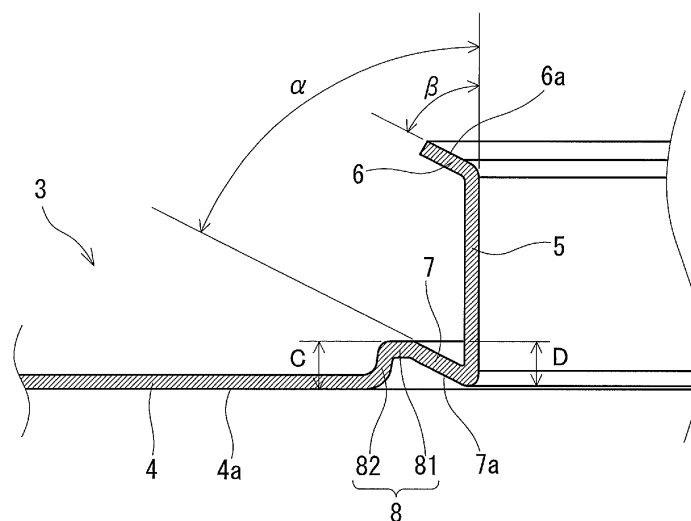


FIG.4

Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a fin-tube heat exchanger and a heat pump device including the fin-tube heat exchanger. The present invention also relates to a heat transfer fin suitable for use in a fin-tube heat exchanger.

BACKGROUND ART

10 **[0002]** Conventionally, fin-tube heat exchangers are used in heat pump devices and the like. For example, Patent Literature 1 discloses a fin-tube heat exchanger 100 as shown in FIG. 8.

15 **[0003]** This heat exchanger 100 includes a stack of heat transfer fins 120 and a heat transfer tube 110 penetrating the stack of heat transfer fins 120. Each of the heat transfer fins 120 has a cylindrical collar portion 123 (having a uniform cross-sectional shape) extending upwardly from a base portion 121. A bottom portion 122 and a flared portion 124 extend radially outwardly in a curved manner from the bottom of the collar portion 123 and the upper end thereof, respectively. The fin pitch (distance between the base portions 121 arranged adjacent to each other) is defined by the collar portion 123 when the flared portion 124 of one of the adjacent heat transfer fins 120 comes into contact with the base portion 121 of the other heat transfer fin 120 in the vicinity of the bottom portion 122.

20 **[0004]** In most cases, the heat transfer tube 110 having an outer diameter smaller than the inner diameter of the collar portion 123 is inserted into the collar portions 123 through the stack of the heat transfer fins 120, and then the heat transfer tube 110 is expanded. Thus, the heat transfer tube 110 is brought into close contact with the collar portions 123. In the heat transfer fin 120 described in Patent Literature 1, a stepped portion 125 for forming a recess of the base portion 121 around the bottom portion 122 is provided in the base portion 121 in order to prevent the heat transfer fins 120 being deformed by contraction of the expanded heat transfer tube 110.

25 **[0005]** In the heat exchanger 100 shown in FIG. 8, since the bottom portion 122 and the flared portion 124 extend in a curved manner, a relatively large gap 130 is formed between the collar portions 123 of the adjacent heat transfer fins 120. In other words, the contact area between the heat transfer tube 110 and the collar portions 123 is limited by the gaps 130 between the collar portions 123.

30 **[0006]** On the other hand, Patent Literature 2 proposes that the gaps 130 be filled with a filler such as a silicone resin so as to improve the performance of heat transfer from the heat transfer tube 110 to the heat transfer fins 120.

CITATION LIST

Patent Literature

35 **[0007]**

Patent Literature 1: JP 09(1997)-119792 A

Patent Literature 2: JP 2010-169344 A

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SUMMARY OF INVENTION

Technical Problem

45 **[0008]** However, if the gap 130 is filled with the filler, when the heat exchanger 100 is discarded, not only metals commonly used for the heat transfer fins 120 and the heat transfer tube 110 but also the filler, a different type of material, must be disposed of. Therefore, it is difficult to separate the materials from one another. As a result, the recycling efficiency is reduced and the environmental impact is increased.

50 **[0009]** The present invention has been made to solve these conventional problems, and it is an object of the present invention to provide a fin-tube heat exchanger in which the area of contact between a heat transfer tube and collar portions of heat transfer fins can be increased without reducing the recycling efficiency, and a heat pump device including this fin-tube heat exchanger. It is another object of the present invention to provide a heat transfer fin suitable for use in a fin-tube heat exchanger.

55 Solution to Problem

[0010] The present disclosure provides a heat transfer fin including: a base portion having a flat surface; a cylindrical collar portion extending upwardly from the base portion; a flared portion flaring radially outwardly from an entire upper

end of the collar portion; and a receding portion having an inclined surface extending upwardly from a bottom of the collar portion at an acute angle with respect to a direction toward the upper end of the collar portion, the bottom of the collar portion being located at a position not reaching a reference plane when the flat surface of the base portion is the reference plane.

Advantageous Effects of Invention

[0011] The present disclosure can provide a heat transfer fin suitable for use in a fin-tube heat exchanger.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

FIG. 1 is a configuration diagram of a fin-tube heat exchanger according to an embodiment of the present invention.

FIG. 2 is a perspective cross-sectional view of the fin-tube heat exchanger shown in FIG. 1.

FIG. 3 is a partial cross-sectional view of the fin-tube heat exchanger shown in FIG. 1.

FIG. 4 is a partial cross-sectional view of one heat transfer fin.

FIG. 5 is a diagram for explaining a method for assembling a fin-tube heat exchanger using heat transfer fins each having a flared portion formed at a smaller inclination angle than that of a receding portion.

FIG. 6 is a partial cross-sectional view of a fin-tube heat exchanger according to a modification.

FIG. 7 is a configuration diagram of a room air conditioner as an example of a heat pump device in which the fin-tube heat exchanger shown in FIG. 1 is used.

FIG. 8 is a partial cross-sectional view of a conventional fin-tube heat exchanger.

DESCRIPTION OF EMBODIMENTS

[0013] A first aspect of the present disclosure provides a heat transfer fin including: a base portion having a flat surface; a cylindrical collar portion extending upwardly from the base portion; a flared portion flaring radially outwardly from an entire upper end of the collar portion; and a receding portion having an inclined surface extending upwardly from a bottom of the collar portion at an acute angle with respect to a direction toward the upper end of the collar portion, the bottom of the collar portion being located at a position not reaching a reference plane when the flat surface of the base portion is the reference plane.

[0014] According to the above configuration, when the heat transfer fins are stacked, the flared portion of one of the heat transfer fins in the stack comes into surface contact with the inclined surface of the receding portion of another heat transfer fin that is stacked on the one heat transfer fin. Therefore, the area of contact between the one heat transfer fin and the another heat transfer fin is increased, and thereby the performance of heat transfer from the collar portion of the one heat transfer fin to the another heat transfer fin can be improved.

[0015] In addition, the flared portion is provided to flare radially outwardly from the entire upper end of the collar portion. Therefore, the area of contact between the collar portion of the one heat transfer fin and the collar portion of the another heat transfer fin can be increased across the entire upper end of the collar portion.

[0016] Furthermore, the bottom of the collar portion does not protrude downward beyond the reference plane when the flat surface of the base portion is the reference plane. That is, the receding portion does not protrude downward beyond the flat surface of the base portion. Therefore, when the heat transfer fin is placed directly on another body, the flat surface of the base portion comes into contact with the body. As a result, it is possible to prevent the receding portion from being deformed by the contact with the body.

[0017] In addition, there is no need to use a filler to fill the gap between the collar portion of the one heat transfer fin and the collar portion of the another heat transfer fin. Therefore, it is easy to separate the materials from one another when the heat exchanger is discarded, and the recycling efficiency can be enhanced.

[0018] A second aspect of the present disclosure provides the heat transfer fin according to the first aspect, wherein an angle of inclination of the flared portion with respect to an axial direction of the collar portion is equal to or smaller than an angle of inclination of the receding portion with respect to the axial direction of the collar portion. According to this configuration, when the heat transfer fins are stacked, the flared portion of one of the heat transfer fins in the stack comes into surface contact with the receding portion of another heat transfer fin that is stacked on the one heat transfer fin. Therefore, the area of contact between the one heat transfer fin and the another heat transfer fin is increased, and thereby the performance of heat transfer from the collar portion of the one heat transfer fin to the another heat transfer fin can be improved.

[0019] A third aspect of the present disclosure provides the heat transfer fin according to the first or second aspect, wherein the flared portion and the inclined surface of the receding portion are parallel to each other. According to this

configuration, the inclination angle of the flared portion with respect to the axial direction of the collar portion is equal to the inclination angle of the receding portion with respect to the axial direction of the collar portion. Therefore, when the heat transfer fins are stacked, the flared portion of one of the heat transfer fins in the stack comes into surface contact with the receding portion of another heat transfer fin that is stacked on the one heat transfer fin. Therefore, the area of contact between the one heat transfer fin and the another heat transfer fin is increased, and thereby the performance of heat transfer from the collar portion of the one heat transfer fin to the another heat transfer fin can be improved.

[0020] A fourth aspect of the present disclosure provides the heat transfer fin according to any one of the first to third aspects, further including a stepped portion raising the receding portion from the base portion, wherein a height C of the stepped portion in an axial direction of the collar portion is greater than a recession distance D of the receding portion in the axial direction of the collar portion. According to this configuration, the receding portion does not protrude downward beyond the flat surface of the base portion. Therefore, when the heat transfer fin is placed directly on another body, the flat surface of the base portion comes into contact with the body. As a result, it is possible to prevent the receding portion from being deformed by the contact with the body. Thereby it is possible to prevent the shape of the heat transfer fins from varying from one to another, and to improve the quality of the heat transfer fins.

[0021] A fifth aspect of the present disclosure provides a fin-tube heat exchanger including: a stack of heat transfer fins; and a heat transfer tube penetrating the stack of heat transfer fins, wherein each of the heat transfer fins includes: a base portion having a flat surface; a cylindrical collar portion extending upwardly from the base portion; a flared portion flaring radially outwardly from an entire upper end of the collar portion; and a receding portion having an inclined surface extending upwardly from a bottom of the collar portion at an acute angle with respect to a direction toward the upper end of the collar portion, the bottom of the collar portion being located at a position not reaching a reference plane when the flat surface of the base portion is the reference plane.

[0022] According to this configuration, when the heat transfer fins are stacked, the flared portion of one of the heat transfer fins in the stack comes into surface contact with the inclined surface of the receding portion of another heat transfer fin that is stacked on the one heat transfer fin. Therefore, the area of contact between the one heat transfer fin and the another heat transfer fin is increased, and thereby the performance of heat transfer from the collar portion of the one heat transfer fin to the another heat transfer fin can be improved.

[0023] In addition, the flared portion is provided to flare radially outwardly from the entire upper end of the collar portion. Therefore, the area of contact between the collar portion of the one heat transfer fin and the collar portion of the another heat transfer fin can be increased across the entire upper end of the collar portion.

[0024] Furthermore, the bottom of the collar portion does not protrude downward beyond the reference plane when the flat surface of the base portion is the reference plane. That is, the receding portion does not protrude downward beyond the flat surface of the base portion. Therefore, when the heat transfer fin is placed directly on another body, the flat surface of the base portion comes into contact with the body. As a result, it is possible to prevent the receding portion from being deformed by the contact with the body.

[0025] In addition, there is no need to use a filler to fill the gap between the collar portion of the one heat transfer fin and the collar portion of the another heat transfer fin. Therefore, it is easy to separate the materials from one another when the heat exchanger is discarded, and the recycling efficiency can be enhanced.

[0026] A sixth aspect of the present disclosure provides the fin-tube heat exchanger according to the fifth aspect, wherein the receding portion of one of the heat transfer fins in the stack enters a space formed by the flared portion of another heat transfer fin that is stacked on the one heat transfer fin and comes into contact with the flared portion. According to this configuration, when the heat transfer fins are stacked, the receding portion of one of the heat transfer fins in the stack enters the space formed by the flared portion of another heat transfer fin that is stacked on the one heat transfer fin and comes into surface contact with that flared portion. Thereby, it is possible to increase the area of contact between the one heat transfer fin and the another heat transfer fin and improve the performance of heat transfer from the collar portion of the one heat transfer fin to the another heat transfer fin.

[0027] In addition, this heat exchanger does not require a filler, unlike the conventional heat exchangers. Therefore, it is easy to separate the materials from one another when the heat exchanger is discarded, and the recycling efficiency does not decrease.

[0028] A seventh aspect of the present disclosure provides the fin-tube heat exchanger according to the fifth or sixth aspect, wherein an angle of inclination of the flared portion with respect to an axial direction of the collar portion is equal to or smaller than an angle of inclination of the receding portion with respect to the axial direction of the collar portion. According to this configuration, when the heat transfer fins are stacked, the flared portion of one of the heat transfer fins in the stack comes into surface contact with the receding portion of another heat transfer fin that is stacked on the one heat transfer fin. Therefore, the area of contact between the one heat transfer fin and the another heat transfer fin is increased, and thereby the performance of heat transfer from the collar portion of the one heat transfer fin to the another heat transfer fin can be improved.

[0029] An eighth aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the fifth to seventh aspects, wherein the flared portion and the inclined surface of the receding portion are parallel to each

other. According to this configuration, the inclination angle of the flared portion with respect to the axial direction of the collar portion is equal to the inclination angle of the receding portion with respect to the axial direction of the collar portion. Therefore, when the heat transfer fins are stacked, the flared portion of one of the heat transfer fins in the stack comes into surface contact with the receding portion of another heat transfer fin that is stacked on the one heat transfer fin. Therefore, the area of contact between the collar portion of the one heat transfer fin and the collar portion of the another heat transfer fin is increased, and thereby the performance of heat transfer from the collar portion of the one heat transfer fin to the another heat transfer fin can be improved.

[0030] A ninth aspect of the present disclosure provides the fin-tube heat exchanger according to any one of the fifth to eighth aspects, further including a stepped portion raising the receding portion from the base portion, wherein a height C of the stepped portion in an axial direction of the collar portion is greater than a recession distance D of the receding portion in the axial direction of the collar portion. According to this configuration, the receding portion does not protrude downward beyond the flat surface of the base portion. Therefore, when the heat transfer fin is placed directly on another body, the flat surface of the base portion comes into contact with the body. As a result, it is possible to prevent the receding portion from being deformed by the contact with the body. Thereby, it is possible to prevent the shape of the heat transfer fins from varying from one to another, and to improve the quality of the heat transfer fins.

[0031] A tenth aspect of the present disclosure provides a heat pump device including: a compressor; a condenser; a throttling device; an evaporator; and a refrigerant circuit in which a refrigerant is circulated to pass through the compressor, the condenser, the throttling device, and the evaporator, wherein at least one of the condenser and the evaporator is the fin-tube heat exchanger according to any one of the fifth to ninth aspects.

(Embodiments)

[0032] Hereinafter, embodiments of the present invention will be described with reference to the drawings. However, the present invention is not limited to the following embodiments.

[0033] FIG. 1 to FIG. 3 show a fin-tube heat exchanger 1 according to an embodiment of the present invention. This heat exchanger 1 includes a stack of heat transfer fins 3, a pair of side plates 20 disposed on both sides of the stack of heat transfer fins 3, and a plurality of U-shaped heat transfer tubes 2 piercing and penetrating the heat transfer fins 3 and the side plates 20.

[0034] Each of the heat transfer fins 3 extends in a specific direction, and the straight portions of the heat transfer tubes 2 are arranged at a constant pitch in the longitudinal direction of the heat transfer fins 3. The straight portions of each heat transfer tube 2 are connected by a bent portion on the side of one side plate 20, and both ends of the heat transfer tube 2 protrude from the other side plate 20, and one end of the heat transfer tube 2 and one end of the adjacent heat transfer tube 2 are connected by a bent pipe 21.

[0035] The heat transfer tube 2 has a cylindrical shape. As the heat transfer tube 2, an internally grooved copper tube can be used, for example.

[0036] Each of the heat transfer fins 3 has a plate shape obtained by, for example, press-forming a thin aluminum plate. Specifically, each of the heat transfer fins 3 includes a base portion 4 spreading around the heat transfer tube 2 and a cylindrical collar portion 5 extending upwardly from the base portion 4 along the heat transfer tube 2. Hereinafter, for the purpose of explanation, the direction in which the collar portion 5 extends is referred to as an upward direction and the direction opposite to the upward direction is referred to as a downward direction.

[0037] The heat exchanger 1 is assembled as follows. The heat transfer fins 3 are stacked so that the collar portions 5 thereof are coaxially aligned with each other. The heat transfer tube 2 having an outer diameter smaller than the inner diameter of the collar portions 5 is inserted through the inner space of the collar portions 5. Then, the heat transfer tube 2 is expanded. Thus, the outer peripheral surface of the heat transfer tube 2 is brought into close contact with the inner peripheral surface of the collar portions 5. This configuration makes it possible to exchange heat between a fluid (for example, R410A refrigerant) flowing in the heat transfer tube 2 and a fluid (for example, air) flowing between the base portions 4 of the heat transfer fins 3.

[0038] Here, the details of heat transfer phenomena are described with reference to the conventional fin-tube heat exchanger 100 shown in FIG. 8. A heat transfer path is indicated by dashed arrows.

[0039] As indicated by a dashed arrow B in FIG. 8, the heat of a fluid flowing in the heat transfer tube 110 is conducted to the outer peripheral surface of the heat transfer tube 110, transferred from the outer peripheral surface of the heat transfer tube 110 to the inner peripheral surface of the collar portion 123, and then is conducted from the collar portion 123 to the base portion 121. At the same time, the heat is transferred from the outer peripheral surface of the collar portion 123 and the upper and lower surfaces of the base portion 121 to a fluid that is to flow between the base portions 121.

[0040] In the case where the heat is transferred from the outer peripheral surface of the heat transfer tube 110 to the inner peripheral surface of the collar portion 123, the thermal contact conductance is generally defined by the following equation 1:

[Equation 1]

$$K = \frac{1.7 \times 10^5}{\frac{\delta_1 + \delta_0}{\lambda_1} + \frac{\delta_2 + \delta_0}{\lambda_2}} \frac{0.6P}{H} + \frac{10^6 \lambda_f}{\delta_1 + \delta_2}$$

where K is the thermal contact conductance (W/m² · K), δ_1 is the surface roughness (μm) of one of two members in contact at the interface, δ_2 is the surface roughness (μm) of the other one of the members in contact at the interface, δ_0 is the equivalent length of the contact (= 23 μm), λ_1 is the thermal conductivity (W/m · K) of the one of the members in contact at the interface, λ_2 is the thermal conductivity (W/m · K) of the other one of the members in contact at the interface, P is the contact pressure (MPa), H is the hardness (Hb) of a softer one of the members in contact at the interface, and λ_f is the thermal conductivity (W/m · K) of an interstitial fluid.

[0041] The thermal contact resistance Rc is calculated from the following equation 2 using the thermal contact conductance K obtained by the above equation 1.

[Equation 2]

$$R_c = 1/(K \times S)$$

where Rc is the thermal contact resistance (K/W) and S is the contact area (m²).

[0042] Therefore, there are the following ways to reduce the thermal contact resistance Rc: one is to increase the thermal contact conductance K; and the other is to increase the contact area S.

[0043] As a way to increase the thermal contact conductance K, there is a method of filling the gaps 130 between the collar portions 123 facing the heat transfer tube 110 with a filler, as described in Patent Literature 2, for example. With the use of the filler instead of the interstitial fluid, which is usually air, this method makes it possible to increase the thermal conductivity λ_f of the interstitial fluid and thus increase the thermal contact conductance K.

[0044] However, if the filler is used, the materials of the heat exchanger 100 include not only the materials of the heat transfer fins 120 and the heat transfer tube 110 but also the filler as a different type of material. Therefore, it is difficult to separate the materials from one another for recycling when the product is discarded. As a result, the recycling efficiency decreases, which leads to a decrease in the recycling rate, an increase in the energy required for recycling, etc., and consequently in an increase in the environmental impact.

[0045] Recently, efforts to reduce the impact on the global environment, for example, the implementation of the Home Appliance Recycling Act, have been made on the initiative of the Japanese government. Since the number of products subject to the Recycling Act tends to be increased, the recycling efficiency is a non-negligible factor.

[0046] In addition to the above-mentioned method, there are many other ways to increase the thermal contact conductance K. For example, there are a method of reducing the surface roughnesses δ_1 and δ_2 of the surfaces in contact, a method of increasing the contact pressure P, a method of increasing the thermal conductivities λ_1 and λ_2 of the heat transfer tube 110 and the heat transfer fin 120, and a method of reducing the hardness H of the softer one of the heat transfer tube 110 and the heat transfer fin 120. The present invention focuses on the method of increasing the contact area S.

[0047] The equation 2 shown above reveals that an increase in the contact area S between the heat transfer tube 110 and the collar portion 123 makes it possible to reduce the thermal contact resistance Rc without changing the thermal contact conductance K. If the thermal contact resistance Rc can be reduced, the performance of heat transfer from the heat transfer tube 110 to the heat transfer fin 120 can be improved. As a result, the heat exchange efficiency of the heat exchanger can be improved.

[0048] Returning to FIG. 2 and FIG. 3, in the present embodiment, a flared portion 6 flaring radially outwardly from the upper end of the collar portion 5 is provided on the collar portion 5, but no bottom portion is provided on the bottom of the collar portion 5. Instead, a receding portion 7 receding toward the bottom of the collar portion 5 is provided around the collar portion 5 so as to form a recess between the collar portion 5 and the receding portion 7. More specifically, as shown in FIG. 4, the base portion 4 has a flat surface 4a. The flat surface 4a is a surface provided on the lower surface (the surface opposite to the surface from which the collar portion 5 extends upwardly) of the base portion 4. The bottom of the collar portion 5 is located at a position not reaching a reference plane when the flat surface 4a of the base portion 4 is the reference plane. That is, the bottom of the collar portion 5 is located above the reference plane. The bottom of the collar portion 5 is located, for example, at a higher position than the reference plane by a distance of at least 25% of the thickness of the base portion 4. The receding portion 7 has an inclined surface extending upwardly from the bottom

of the collar portion 5 at an acute angle with respect to a direction toward the upper end of the collar portion 5. The flared portion 6 flares radially outwardly from the entire upper end of the collar portion 5. In the adjacent heat transfer fins 3, the receding portion 7 of one of the two adjacent heat transfer fins 3 enters the space formed by the flared portion 6 of the other heat transfer fin 3 and comes into contact with that flared portion 6. The fin pitch (distance between the adjacent base portions 4 arranged adjacent to each other) is defined by the collar portion 5 when the receding portion 7 comes into contact with the flared portion 6.

[0049] In this configuration, when the heat transfer fins 3 are stacked, the flared portion 6 of one of the heat transfer fins 3 in the stack comes into surface contact with the inclined surface of the receding portion 7 of another heat transfer fin 3 that is stacked on the one heat transfer fin 3. In addition, when the heat transfer fins 3 are stacked, the receding portion 7 of one of the heat transfer fins 3 in the stack enters the space formed by the flared portion 6 of the another heat transfer fin 3 that is stacked on the one heat transfer fin 3 and comes into surface contact with that flared portion 6. Therefore, the area of contact between the one heat transfer fin 3 and the another heat transfer fin 3 is increased, and thereby the performance of heat transfer from the collar portion 5 of the one heat transfer fin 3 to the another heat transfer fin 3 can be improved. In addition, since the flared portion 6 is provided to flare radially outwardly from the entire upper end of the collar portion 5, the area of contact between the collar portion 5 of the one heat transfer fin 3 and the collar portion 5 of the another heat transfer fin 3 can be increased across the entire upper end of the collar portion 5. Furthermore, the bottom of the collar portion 5 does not protrude downward beyond the reference plane when the flat surface 4a of the base portion 4 is the reference plane. That is, the receding portion 7 does not protrude downward beyond the flat surface 4a of the base portion 4. Therefore, when the heat transfer fin 3 is placed directly on another body, the flat surface 4a of the base portion 4 comes into contact with the body. As a result, it is possible to prevent the receding portion 7 from being deformed by the contact with the body.

[0050] The base portion 4 may be flat as in the present embodiment, or may have a corrugated shape having ridges and grooves. When the base portion 4 has a corrugated shape, it is preferable to provide a flat ring portion around the receding portion 7.

[0051] In the present embodiment, the flared portion 6 and the inclined surface of the receding portion 7 are parallel to each other, and the outside surface 7a of the receding portion 7 is in surface contact with the inside surface 6a of the flared portion 6. In order to achieve this configuration, it is possible to stack the heat transfer fins 3 in which the inclination angle β of the flared portion 6 with respect to the axial direction of the collar portion 5 is equal to the inclination angle α of the receding portion 7 with respect to the axial direction of the collar portion 5, as shown in FIG. 4, when the heat exchanger 1 is assembled. Alternatively, it is also possible to stack the heat transfer fins 3 in which the inclination angle β of the flared portion 6 with respect to the axial direction of the collar portion 5 is smaller than the inclination angle α of the receding portion 7 with respect to the axial direction of the collar portion 5 and then press the stack of the heat transfer fins 3 to compress it in the axial direction of the collar portions 5. As a result, the flared portion 6 is further flared by the receding portion 7 until the flared portion 6 finally becomes parallel to and comes into surface contact with the receding portion 7. In this configuration, when the heat transfer fins 3 are stacked, the flared portion 6 of one of the heat transfer fins 3 in the stack comes into surface contact with the receding portion 7 of another heat transfer fin 3 that is stacked on the one heat transfer fin 3. Therefore, the area of contact between the one heat transfer fin 3 and the another heat transfer fin 3 is increased, and thereby the heat transfer performance from the collar portion 5 of the one heat transfer fin 3 to the another heat transfer fin can be enhanced.

[0052] As described above, since the receding portion 7 enters the space surrounded by the flared portion 6, it is possible to reduce the gap 9 formed between the bottom of the collar portion 5 of one of the heat transfer fins 3 and the upper end of the collar portion 5 of the adjacent heat transfer fin 3 in the stack (first effect). In other words, it is possible to reduce the area in which the heat transfer tube 2 and the collar portions 5 are not in contact with each other and to increase the area of contact between the heat transfer tube and the collar portions.

[0053] For example, in a virtual heat exchanger in which the fin pitch is defined when the receding portion 7 comes into contact with the upper end of the flared portion 6, as shown in a left diagram of FIG. 5, the gaps 9 formed between the collar portions 5 have a certain size. In contrast, in the present embodiment in which the receding portion 7 is in contact with the flared portion 6 in the space surrounded by the flared portion 6, it is possible to minimize the gaps 9 between the collar portions 5. Therefore, the heat exchanger of the present embodiment can have a larger area of contact between the heat transfer tube 2 and the collar portions 5 than that in the virtual heat exchanger (second effect).

[0054] The above two effects make it possible to reduce the thermal contact resistance and improve the performance of heat transfer from the heat transfer tube 2 to the heat transfer fins 3, and thereby to increase the heat exchange efficiency of the heat exchanger 1. In addition, the configuration to achieve these effects requires no other materials than those of the heat transfer tube 2 and the heat transfer fins 3. Therefore, it is easy to separate the materials from one another when the heat exchanger 1 is discarded, and the recycling efficiency does not decrease.

[0055] Furthermore, in the present embodiment, the flared portion 6 and the receding portion 7 are parallel to each other, and the outside surface 7a of the receding portion 7 is in surface contact with the inside surface 6a of the flared portion 6.

[0056] In the conventional heat exchanger 100 shown in FIG. 8, the upper end of the flared portion 124 is in line contact with the base portion 121. The amount of heat transferred through the line contact portion is infinitely small. As indicated by the dashed arrow B in FIG. 8, in the conventional heat exchanger 100, the heat transferred from the heat transfer tube 110 to the collar portion 123 of the heat transfer fin 120 is conducted only to the base portion 121 of that heat transfer fin 120. That is, heat is conducted from the collar portion 123 to the base portion 121 through only one heat conduction path via the bottom portion 122.

[0057] In contrast, in the present embodiment, the outside surface 7a of the receding portion 7 is in surface contact with the inside surface 6a of the flared portion 6. Therefore, as indicated by the dashed arrows A in FIG. 3, the heat transferred from the heat transfer tube 2 to the collar portion 5 of the heat transfer fin is conducted not only to the base portion 4 of that heat transfer fin but also to the base portion 4 of the adjacent heat transfer fin 3. That is, the following two heat conduction paths are secured from the collar portion 5 to the base portion 4: a path via the receding portion 7; and a path from the flared portion 6 to the receding portion 7 of the adjacent heat transfer fin 3. Thereby, the heat can be transferred to the base portion 4 more efficiently than in the conventional heat exchanger 100. Therefore, the performance of heat transfer from the heat transfer tube 2 to the heat transfer fins 3 is further improved, and thus the heat exchange efficiency can be further increased.

[0058] Furthermore, in the present embodiment, as shown in FIG. 4, a stepped portion 8 raising the receding portion 7 with respect to the lower surface of the base portion 4 is provided between the receding portion 7 and the base portion 4. That is, the height C of the stepped portion 8 in the axial direction of the collar portion 5 is greater than the recession distance D of the receding portion 7 in the axial direction of the collar portion 5. The height C of the stepped portion 8 in the axial direction of the collar portion 5 is the height from the flat surface 4a of the base portion 4 to the upper surface of the stepped portion 8 (the upper surface of a flat surface portion 81 described later). The recession distance D of the receding portion 7 is the distance from the upper surface of the stepped portion 8 (the upper surface of the flat surface portion 81) to the lower surface of the receding portion 7 in the axial direction of the collar portion 5. In this configuration, the receding portion 7 does not protrude downward beyond the flat surface 4a of the base portion 4. Therefore, when the heat transfer fin 3 is placed directly on another body, the flat surface 4a of the base portion 4 comes into contact with the body. As a result, it is possible to prevent the receding portion 7 from being deformed by the contact with the body. Thereby, it is possible to prevent the shape of the heat transfer fins 3 from varying from one to another, and to improve the quality of the heat transfer fins 3. In the present embodiment, the stepped portion 8 is formed of a wall portion 82 extending upwardly from the base portion 4 to surround the receding portion 7 and a ring-shaped flat surface portion 81 extending radially inwardly from the upper end of the wall portion 82 to the upper end of the receding portion 7. However, the flat surface portion 81 can be omitted.

[0059] If no stepped portion 8 is provided, the receding portion 7 protrudes downward beyond the lower surface of the base portion 4. Therefore, the receding portion 7 may be deformed by the contact with another body, for example, during the production of the heat transfer fins 3. In contrast, in the present embodiment in which the stepped portion 8 is provided, the receding portion 7 does not protrude downward beyond the lower surface (the flat surface 4a) of the base portion 4. Therefore, it is possible to prevent the receding portion 7 from being deformed by the contact with another body. Thereby, it is possible to prevent the shape of the heat transfer fins 3 from varying from one to another, and to provide high quality heat transfer fins 3.

[0060] Next, a room air conditioner 10 as an example of a heat pump device, in which the above-described heat exchanger 1 is used, is described with reference to FIG. 7.

[0061] In the room air conditioner 10, a refrigerant circuit 10C is configured to pass through both an indoor unit 10A and an outdoor unit 10B. A compressor 11 (for example, a rotary compressor), a four-way valve 12, an outdoor heat exchanger 13, a throttling device 14 (for example, an expansion valve) are disposed in the outdoor unit 10B. An indoor heat exchanger 15 is disposed in the indoor unit 10A. The outdoor unit 10B is provided with an outdoor fan 16 (for example, a propeller fan) for supplying outdoor air to the outdoor heat exchanger 13, and the indoor unit 10A is provided with an indoor fan 17 (for example, a cross flow fan) for supplying indoor air to the indoor heat exchanger 15.

[0062] In the room air conditioner 10, a high-temperature and high-pressure refrigerant compressed by the compressor 11 is directed through the four-way valve 12 to the indoor heat exchanger 15 in heating operation and to the outdoor heat exchanger 13 in cooling operation. In the heating operation, the indoor heat exchanger 15 serves as a condenser, into which the high-temperature refrigerant is introduced through the four-way valve 12. The indoor heat exchanger 15 allows the high-temperature refrigerant introduced therein to transfer its heat to the indoor air supplied by the indoor fan 17 through heat exchange between the refrigerant and the air so as to condense and liquefy the refrigerant. The liquefied refrigerant is adiabatically expanded by the throttling device 14, and the resulting low-temperature and low-pressure refrigerant is supplied to the outdoor heat exchanger 13. The outdoor heat exchanger 13 serves as an evaporator, and allows the vapor-liquid two-phase low-temperature refrigerant to absorb the heat of the outdoor air supplied by the outdoor fan 16 through heat exchange between the refrigerant and the air so as to evaporate and vaporize the refrigerant. The evaporated low-pressure vapor refrigerant is again compressed by the compressor 11. The indoor air is heated by repeating this cycle continuously. Thus, the room is heated. In the cooling operation, the refrigerant is caused to flow in

the reverse direction by switching the four-way valve 12 so as to cool the indoor air. Thus, the room is cooled. That is, in both the heating operation and the cooling operation, the refrigerant circulating in the refrigerant circuit 10C passes through the compressor 11, the condenser, the throttling device 14, and the evaporator in this order.

[0063] When the heat exchanger 1 of the present embodiment is used as at least one of the condenser and the evaporator in the room air conditioner 10 as described above or any other heat pump device, the heat exchange efficiency of the condenser and/or the evaporator can be improved. As a result, the COP (coefficient of performance) of the heat pump device can be improved.

(Modifications)

[0064] The flared portion 6 and the receding portion 7 need not necessarily be tapered as long as the receding portion 7 and the flared portion 6 are in contact with each other in the space surrounded by the flared portion 6. For example, as shown in FIG. 6, the receding portion 7 need not be linear but may recede toward the bottom of the collar portion 5 in a curved manner. Alternatively, the flared portion 6 may be flared radially outwardly in a curved manner, although not shown.

[0065] The heat transfer fins 3 formed in the shape as shown in FIG. 6 is effective in reducing the misalignment of the central axes of the collar portions 5 of the adjacent heat transfer fins 3 in the stack because the receding portion 7 comes into contact with the inside surface 6a of the tapered flared portion 6 when the heat transfer fins 3 are stacked, even if the central axes of the collar portions 5 of the adjacent heat transfer fins 3 are misaligned during the stacking. This effect not only makes it easier to insert the heat transfer tube 2 into the collar portions 5 but also makes it possible to define the radial position of the collar portions 5 of the stacked heat transfer fins 3 relative to the heat transfer tube 2. Therefore, the area of contact between the heat transfer tube 2 and the collar portions 5 does not vary and thus a high-quality fin-tube heat exchanger can be provided. This effect can also be obtained in the case where the heat transfer fin 3 is formed such that the flared portion 6 and the receding portion 7 become parallel to each other.

INDUSTRIAL APPLICABILITY

[0066] The fin-tube heat exchanger of the present invention can be suitably used for heat pump devices such as room air conditioners, water heaters, and space heaters.

Claims

1. A heat transfer fin comprising:

a base portion having a flat surface;
a cylindrical collar portion extending upwardly from the base portion;
a flared portion flaring radially outwardly from an entire upper end of the collar portion; and
a receding portion having an inclined surface extending upwardly from a bottom of the collar portion at an acute angle with respect to a direction toward the upper end of the collar portion, the bottom of the collar portion being located at a position not reaching a reference plane when the flat surface of the base portion is the reference plane.

2. The heat transfer fin according to claim 1, wherein an angle of inclination of the flared portion with respect to an axial direction of the collar portion is equal to or smaller than an angle of inclination of the receding portion with respect to the axial direction of the collar portion.

3. The heat transfer fin according to claim 1, wherein the flared portion and the inclined surface of the receding portion are parallel to each other.

4. The heat transfer fin according to claim 1, further comprising a stepped portion raising the receding portion from the base portion, wherein a height C of the stepped portion in an axial direction of the collar portion is greater than a recession distance D of the receding portion in the axial direction of the collar portion.

5. A fin-tube heat exchanger comprising:

a stack of heat transfer fins; and
a heat transfer tube penetrating the stack of heat transfer fins,

wherein each of the heat transfer fins comprises:

a base portion having a flat surface;
a cylindrical collar portion extending upwardly from the base portion;
a flared portion flaring radially outwardly from an entire upper end of the collar portion; and
a receding portion having an inclined surface extending upwardly from a bottom of the collar portion at an acute angle with respect to a direction toward the upper end of the collar portion, the bottom of the collar portion being located at a position not reaching a reference plane when the flat surface of the base portion is the reference plane.

6. The fin-tube heat exchanger according to claim 5, wherein the receding portion of one of the heat transfer fins in the stack enters a space formed by the flared portion of another heat transfer fin that is stacked on the one heat transfer fin and comes into contact with the flared portion.

7. The fin-tube heat exchanger according to claim 5, wherein an angle of inclination of the flared portion with respect to an axial direction of the collar portion is equal to or smaller than an angle of inclination of the receding portion with respect to the axial direction of the collar portion.

8. The fin-tube heat exchanger according to claim 5, wherein the flared portion and the inclined surface of the receding portion are parallel to each other.

9. The fin-tube heat exchanger according to claim 5, further comprising a stepped portion raising the receding portion from the base portion,
wherein a height C of the stepped portion in an axial direction of the collar portion is greater than a recession distance D of the receding portion in the axial direction of the collar portion.

10. A heat pump device comprising:

a compressor;
a condenser;
a throttling device;
an evaporator; and
a refrigerant circuit in which a refrigerant is circulated to pass through the compressor, the condenser, the throttling device, and the evaporator,
wherein at least one of the condenser and the evaporator is the fin-tube heat exchanger according to claim 5.

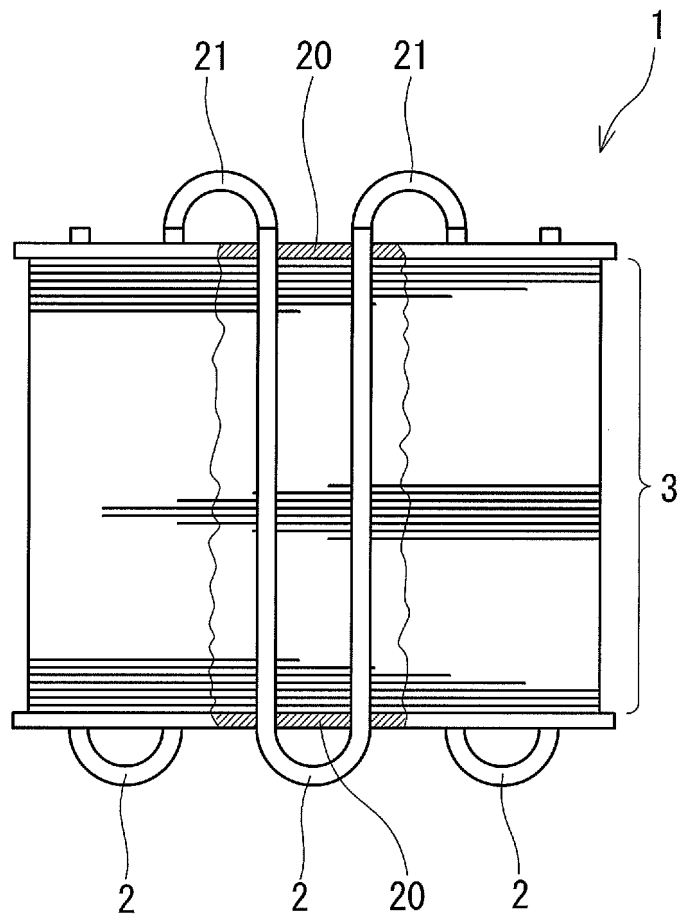


FIG. 1

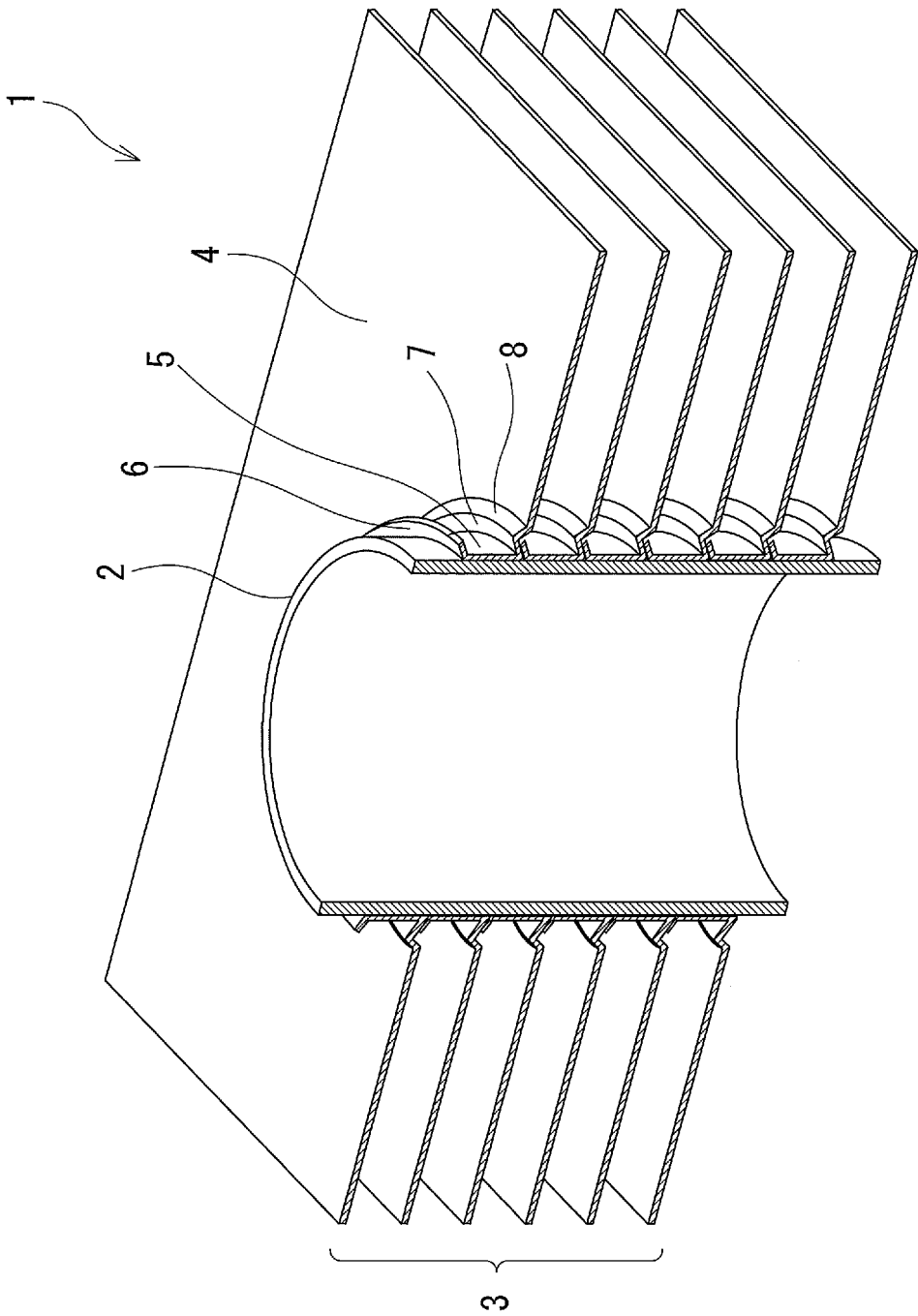


FIG.2

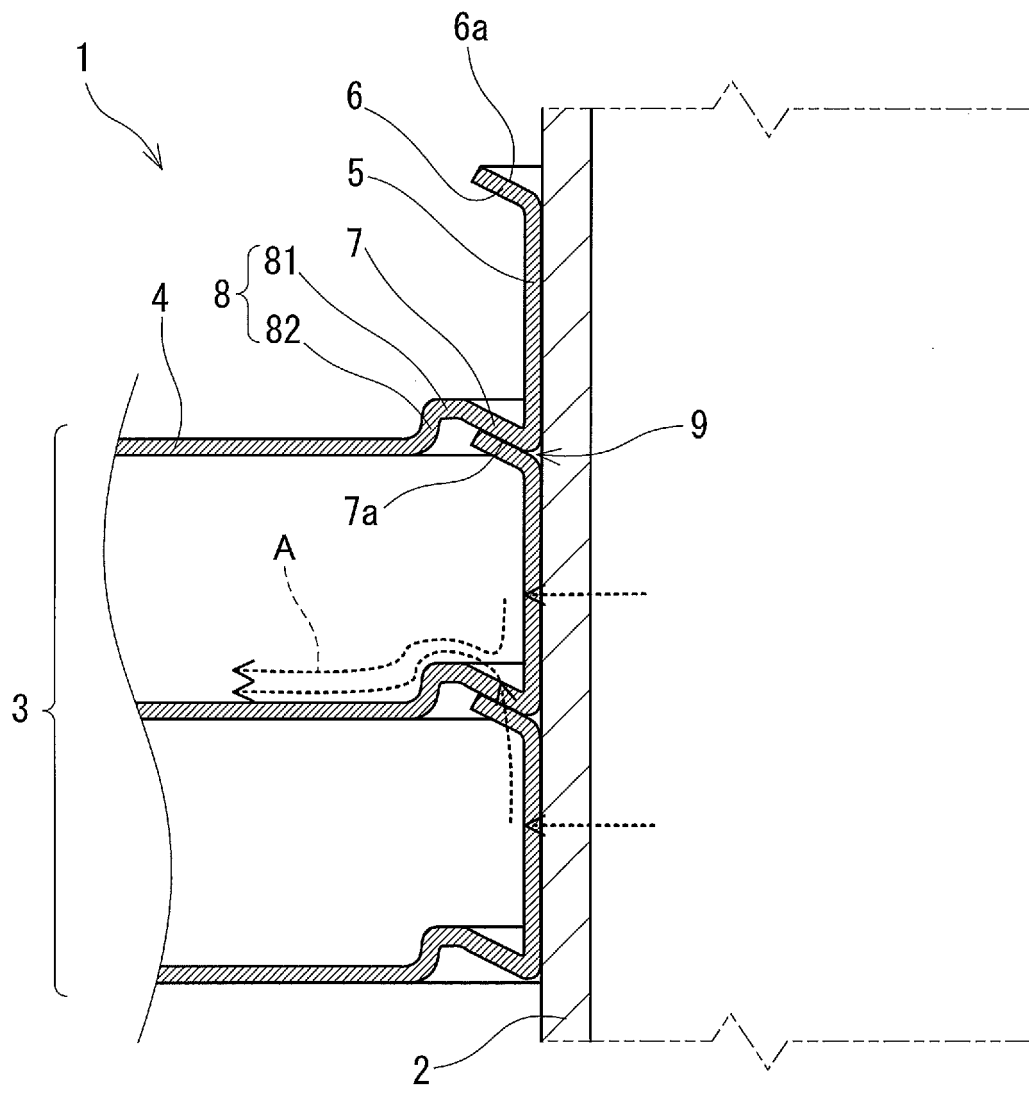


FIG.3

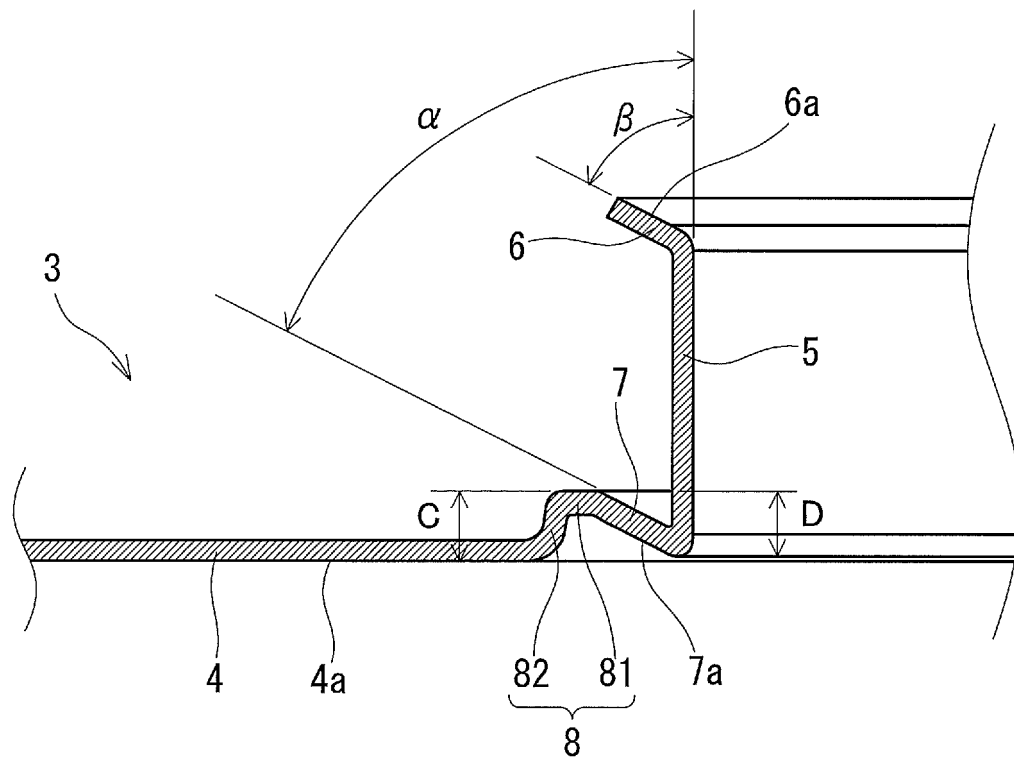


FIG.4

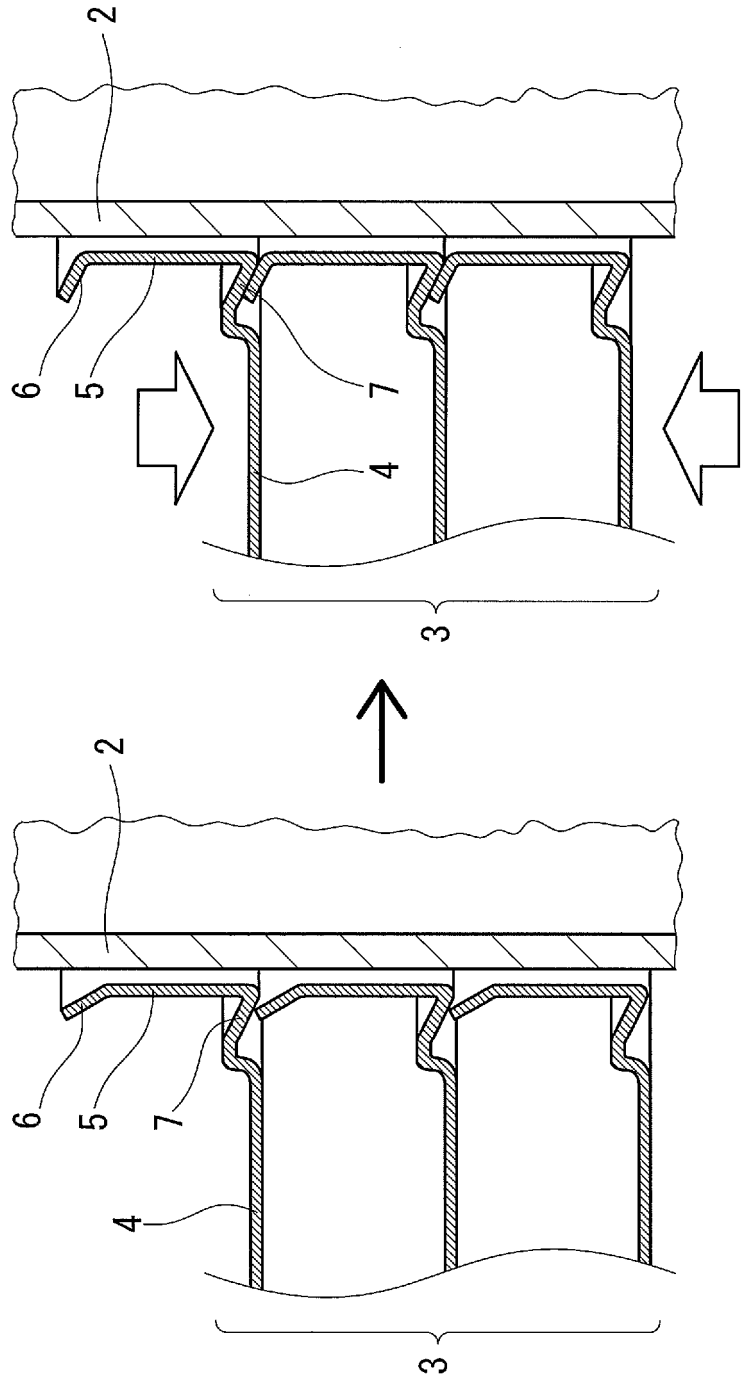


FIG.5

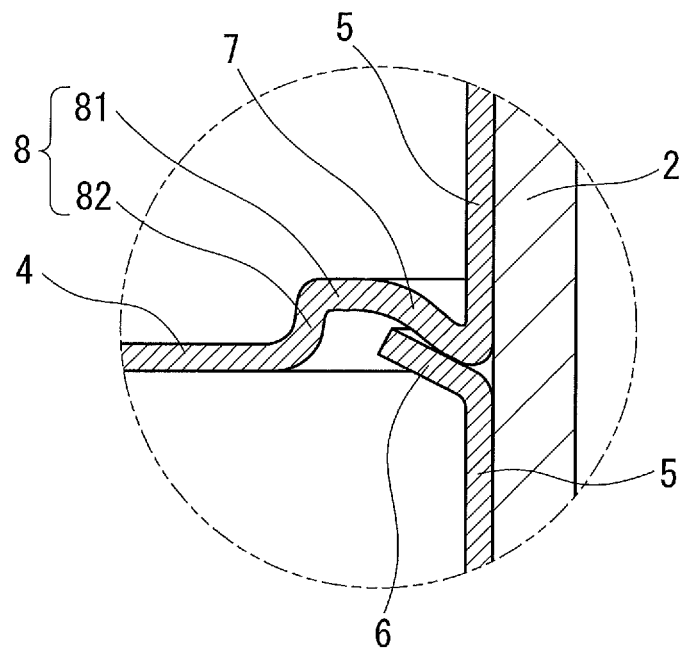


FIG.6

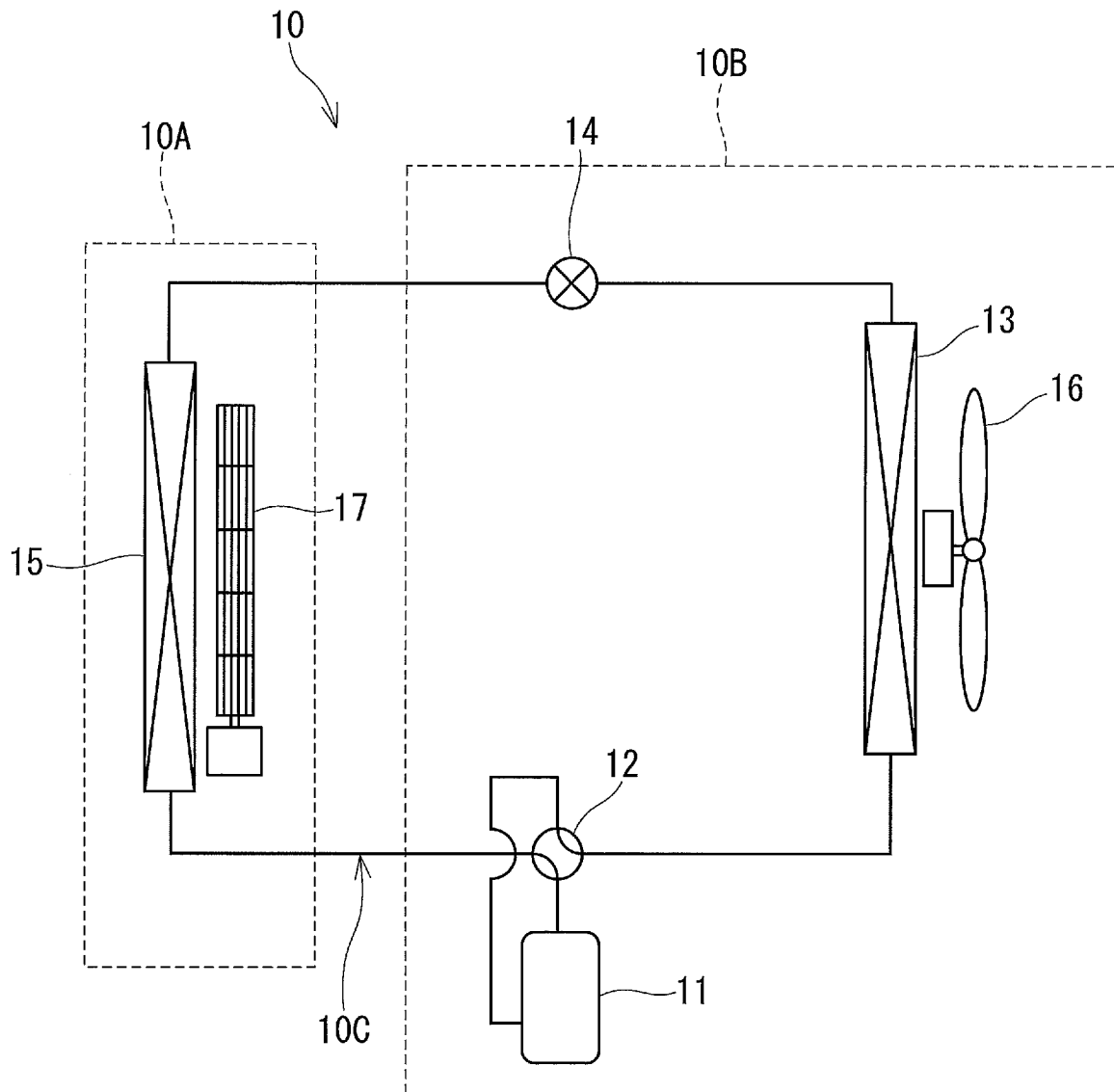


FIG.7

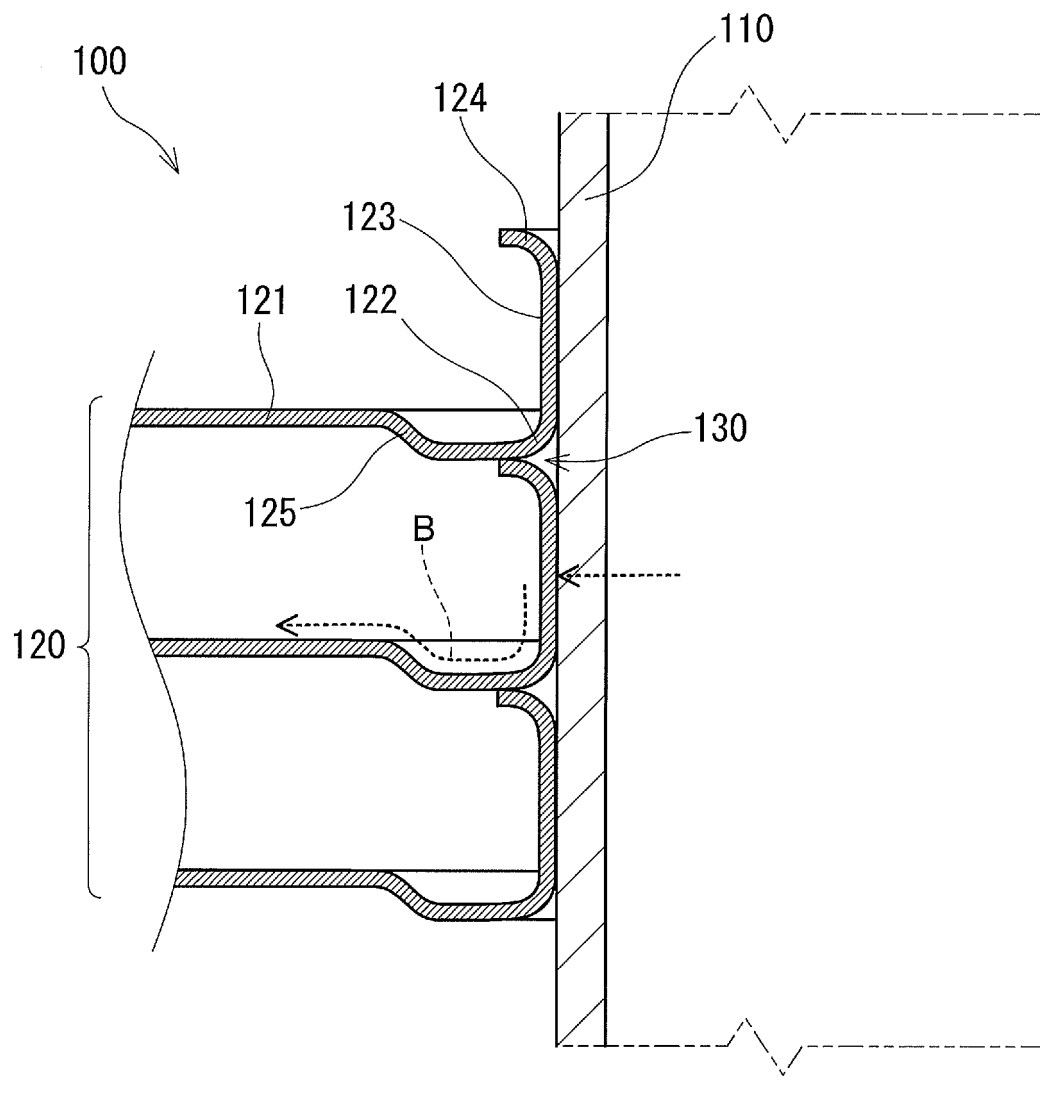


FIG.8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/007515

A. CLASSIFICATION OF SUBJECT MATTER

F28F1/32(2006.01)i, F25B39/00(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, F25B39/00

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	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 52666/1973 (Laid-open No. 3164/1975) (Tokyo Shibaura Electric Co., Ltd.), 14 January 1975 (14.01.1975), entire text; all drawings (particularly, fig. 4) (Family: none)	1-3, 5-8, 10 4, 9
Y A	JP 5-87480 A (Showa Aluminum Corp.), 06 April 1993 (06.04.1993), entire text; all drawings (particularly, fig. 5) (Family: none)	1-3, 5-8, 10 4, 9

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

* Special categories of cited documents:

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Date of the actual completion of the international search
07 January, 2013 (07.01.13)Date of mailing of the international search report
15 January, 2013 (15.01.13)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/007515

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 7-280478 A (Daikin Industries, Ltd.), 27 October 1995 (27.10.1995), entire text; all drawings (particularly, fig. 2, 4, 6, 8, 10, 12, 15) (Family: none)	1, 5
A	JP 11-512811 A (International Confort Products Corp. (USA)), 02 November 1999 (02.11.1999), entire text; all drawings (particularly, fig. 3) & JP 11-511548 A & US 5660230 A & US 6125925 A & WO 1997/012191 A1 & WO 1997/012190 A1 & AU 7373796 A & BR 9610634 A & CA 2235674 A & AU 6850296 A & BR 9610724 A & CA 2238282 A & MX 9802389 A & MX 9802390 A	1, 5
A	JP 2000-190043 A (Hidaka Engineering Co., Ltd.), 11 July 2000 (11.07.2000), entire text; all drawings (particularly, fig. 5, 6) & US 6415506 B1	1, 5
A	JP 2010-169344 A (Fujitsu General Ltd.), 05 August 2010 (05.08.2010), entire text; all drawings (particularly, fig. 2) (Family: none)	1-10
A	JP 2000-51980 A (Hitachi, Ltd.), 22 February 2000 (22.02.2000), entire text; all drawings (particularly, paragraphs [0015] to [0020]; fig. 3 to 8) (Family: none)	1-10

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REFERENCES CITED IN THE DESCRIPTION

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- JP 9119792 A [0007]
- JP 2010169344 A [0007]