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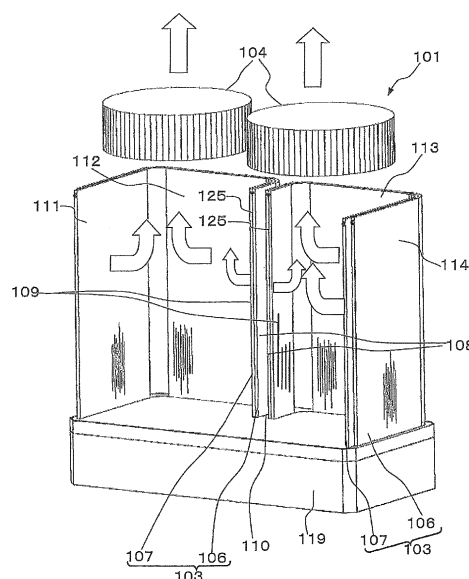
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(54) **OUTDOOR UNIT AND AIR CONDITIONER**

(57) Heat exchanger assemblies 103 included in an outdoor unit 101 each include fins each having notches provided without fin collars or notches provided with fin collars that are shorter than stacking intervals between the fins. At least some of the stacking intervals between the fins 2 in a facing surface are larger than the stacking intervals between the fins 2 in surfaces excluding the facing surface.

FIG. 2



Description

Technical Field

[0001] The present invention relates to an outdoor unit and an air-conditioning apparatus including the outdoor unit.

Background Art

[0002] Known industrial-use air-conditioning apparatuses intended for office buildings, factories, and so forth include those having relatively high power with outdoor units thereof each configured to exhaust air from two positions in an upper portion in external view. A known outdoor unit having such a configuration includes, in its housing, devices such as a heat exchanger assembly, a compressor, pipe components, and so forth, with two propeller fans and two bell mouths that guide the flow of air provided in the upper portion of the housing (see Patent Literature 1, for example). In such an outdoor unit, when outdoor air sucked into the housing by an effect of the propeller fans is made to flow through the heat exchanger assembly, the outdoor air exchanges heat with a refrigerant, and the resulting air is guided by the bell mouths and is exhausted from the upper portion of the housing.

[0003] In general, the heat exchanger assembly included in such an outdoor unit has a two-layer configuration including two heat exchangers. Many of the known heat exchangers employ a plate fin-tube structure obtained as follows: a plurality of strip-like aluminum fins each having circular holes are stacked, a plurality of copper or aluminum heat transfer tubes each having a circular cross-sectional shape are inserted into the fins in a direction substantially vertical to the fins, and the bores of the heat transfer tubes are expanded by using a hydraulic or mechanical tube expander, whereby the closeness between the fins and the heat transfer tubes that is required for providing heat transferability of the heat exchanger is guaranteed (see Patent Literature 2, for example).

[0004] The edges of the circular holes provided in each of the fins are burred and thus form cylindrical collars so that the area of the fin that is in close contact with each of the heat transfer tubes is increased. Furthermore, flat portions of the fin between the circular holes have slits that improve the heat exchangeability with draft air. In a disclosed technique (see Patent Literature 3, for example), the circular holes, the collars, and the slits of the fin are sequentially formed as follows: a progressive die including a plurality of manufacturing step sections is placed on a pressing machine, and the pressing machine is operated consecutively while a strip-like aluminum hoop is fed thereto.

[0005] In a typical method of manufacturing a plate fin-tube heat exchanger, after pressing is performed, a desired number of fins obtained by cutting and each having a desired strip length are sequentially stacked in a collar

section. Subsequently, a plurality of long heat transfer tubes called hair pins and each including a U-shaped portion are inserted into the fins, and the tubes are expanded. Since the stacking of the fins and the insertion of the heat transfer tubes are performed with reference to collars, the fins are consequently stacked and fixed at regular intervals corresponding to the height of the collars (see Patent Literature 4, for example).

[0006] In such a plate fin-tube heat exchanger, a plurality of heat transfer tubes are brazed to U-bends, which are heat transfer tubes for pipe connection each having a circular cross-sectional shape and being bent in a U shape at an end, and to other components such as a distributor, whereby a continuous refrigerant passage that is folded many times while passing through the stack of fins is provided.

[0007] In another disclosed plate fin-tube heat exchanger (see Patent Literature 5, for example), a stack of fins through which heat transfer tubes extend is bent in an L shape a plurality of times (twice, for example). In such a plate fin-tube heat exchanger, the stack of fins is bent a plurality of times. Ultimately, the plate fin-tube heat exchanger is used as a substantially U-shaped heat exchanger in which the fins are stacked and the heat transfer tubes extending therethrough extend in a direction of a contour line (see Patent Literature 5, for example). In the substantially U-shaped heat exchanger having three outer surfaces obtained as a result of bending the stack of fins, all of the fins are at regular intervals corresponding to the height of fin collars and determined in a state prior to bending.

[0008] In addition, in view of recent circumstances concerning enthusiastic discussions about energy problems and so forth, highly competitive energy-saving and cost-reduction strategies are underway. Accordingly, various measures have been sought for further improvements in the shape, the pitch (the stacking intervals between the fins and the intervals between adjacent heat transfer tubes), the materials (the material of the fins and the material of the heat transfer tubes), and other factors of the heat transfer tubes and the fins. Other measures have also been proposed in which the pitch of the fins is changed in accordance with the internal configuration of the outdoor unit (see Patent Literature 6 to 8, for example).

Citation List

Patent Literature

[0009]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2008-138951 (Figs. 1 to 3 and others)

Patent Literature 2: Japanese Examined Patent Application Publication No. 58-13249 (Figs. 1 to 3 and others)

Patent Literature 3: Japanese Examined Patent Application Publication No. 58-9358 (Figs. 1 to 5 and others)

Patent Literature 4: Japanese Examined Patent Application Publication No. 3-80571 (Figs. 1 and 2 and others)

Patent Literature 5: Japanese Patent No. 4417620 (Fig. 20 and others)

Patent Literature 6: Japanese Unexamined Patent Application Publication No. 63-233296 (Figs. 1 and 2 and others)

Patent Literature 7: Japanese Unexamined Patent Application Publication No. 2004-245531 (Figs. 1 and 2 and others)

Patent Literature 8: Japanese Unexamined Patent Application Publication No. 2008-8541 (Fig. 3 and others)

Summary of Invention

Technical Problem

[0010] As described above, in an air-conditioning apparatus employing a heat exchanger that is manufactured by a method including stacking of fins having circular holes, insertion of circular tubes, and expansion of the tubes, the pitch of the fins is a constant value determined by the height of collars formed by burring. Therefore, in such a known air-conditioning apparatus, it is difficult to change the pitch of the fins, for performance improvement, in accordance with the internal configuration of an outdoor unit.

[0011] Particularly, in an air-conditioning apparatus including a plurality of substantially U-shaped heat exchangers that are arranged side by side, the cross-sectional area of openings as air inlets provided between surfaces of substantially U-shaped heat exchangers that are adjacent to each other is smaller than the cross-sectional area of openings as air inlets provided in the other four surfaces (two surfaces of each of two heat exchangers excluding the foregoing surfaces that are adjacent to each other), and the wind speed is therefore lower in the surfaces that are adjacent to each other. To improve cost performance with consideration for such a fact, a measure of changing the stacking intervals between the fins in accordance with the position (the position in the outdoor unit) may be taken. Practically, however, it is difficult to change the pitch of the fins in accordance with the internal configuration of the outdoor unit, as described above.

[0012] In other proposed configurations, the pitch of the fins is changed in some portions by dividing the heat exchanger, by changing the setting for the height of the collars, and by using other techniques. In such a case, different kinds of progressive dies for forming fins need to be prepared, or a die including a mechanism that can alone change the setting for the height of burring needs to be prepared. Moreover, troublesome assembling work

including setting for different groups of fins is required. Therefore, the die may become complicated or large, or the pressing machine may become large. Consequently, the costs of the die, the pressing machine, and the assembling work may become too high to realize any of the above configurations. Moreover, the variations in the height of collars that are determinable by the die are limited to two to three at most because the size of the die is limited. Such a limitation also makes the realization of the above configurations more difficult.

[0013] To avoid the above problems, another measure may be taken in which the height of the collars is made smaller than the stacking intervals between the fins, and the fins are not stacked with reference to the height of the collars. In such a case, however, each heat transfer tube cannot be inserted into a group of fins that are in a stacked state, that is, the fins need to be fitted one by one onto the heat transfer tube while each of the fins is moved toward the distal side of the tube by a long stroke corresponding to the length of the heat transfer tube, leading to significantly troublesome work. This shows that changing the pitch of the fins is impractically difficult.

[0014] The present invention is to solve the above problems and to provide an air-conditioning apparatus in which the stacking pitch of fins is readily changeable.

Solution to Problem

[0015] An outdoor unit according to the present invention includes a housing, at least two plate fin-tube heat exchanger assemblies arranged side by side in the housing and each being bent in an inward direction of the housing such that the heat exchanger assembly has a facing surface that faces a surface of another heat exchanger assembly in the housing, and a fan provided above the housing and causes air taken in from surfaces of the housing to be exhausted from an upper portion of the housing. Each of the heat exchanger assemblies includes fins each having notches provided without fin collars or notches provided with fin collars that are shorter than stacking intervals between the fins. At least some of the stacking intervals between the fins in a portion forming the facing surface are larger than the stacking intervals between the fins in portions forming surfaces excluding the facing surface.

[0016] An air-conditioning apparatus according to the present invention includes the above outdoor unit and an indoor unit connected to the outdoor unit. Advantageous Effects of Invention

[0017] In the outdoor unit according to the present invention, since the fins can be distributed more effectively than in the known art, the heat exchanging efficiency is improved from the viewpoint of cost performance. Thus, energy saving and cost reduction are realized.

[0018] In the air-conditioning apparatus according to the present invention, since the above outdoor unit is employed, the heat exchanging efficiency is improved from the viewpoint of cost performance. Thus, energy saving and cost reduction are realized. Brief Description of Drawings

[0019]

[Fig. 1] Fig. 1 is a schematic external view illustrating an exemplary external configuration of an outdoor unit according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a schematic perspective view illustrating an internal configuration of the outdoor unit according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a schematic perspective view illustrating a configuration of heat exchanger assemblies included in the outdoor unit according to Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a schematic perspective view illustrating a configuration of known heat exchanger assemblies.

[Fig. 5] Fig. 5 includes schematic perspective views each illustrating a part of one of heat exchangers included in each of the heat exchanger assemblies included in the outdoor unit according to Embodiment 1 of the present invention.

[Fig. 6] Fig. 6 is a schematic perspective view illustrating a configuration of heat exchanger assemblies included in an outdoor unit according to Embodiment 2 of the present invention.

[Fig. 7] Fig. 7 is a circuit diagram schematically illustrating a basic configuration of an air-conditioning apparatus according to Embodiment 3 of the present invention.

[Fig. 8] Fig. 8 is a schematic diagram illustrating some steps included in a method of manufacturing a heat exchanger assembly according to Embodiment 4 of the present invention.

[Fig. 9] Fig. 9 is a schematic diagram illustrating some other steps included in the method of manufacturing a heat exchanger assembly according to Embodiment 4 of the present invention.

Description of Embodiments

[0020] Embodiments of the present invention will now be described with reference to the drawings.

Embodiment 1

[0021] Fig. 1 is a schematic external view illustrating an exemplary external configuration of an outdoor unit 101 according to Embodiment 1 of the present invention. Referring to Fig. 1, an outline of the external configuration of the outdoor unit 101 according to Embodiment 1 of the present invention will be described. In the drawings including Fig. 1 to be referred to below, individual elements are not necessarily scaled in accordance with their actual sizes.

[0022] The outdoor unit 101 according to Embodiment 1 forms a part of an industrial-use air-conditioning apparatus used in, for example, an office building or a factory. The outdoor unit 101 has an appearance as illustrated

in Fig. 1 and is configured to exhaust air from two positions in an upper portion thereof. The outdoor unit 101 is connected to a non-illustrated indoor unit, whereby an air-conditioning apparatus is provided. Devices (a compressor, a heat-source-side heat exchanger, an expansion device, and a use-side heat exchanger) included in the outdoor unit 101 and the indoor unit are connected to one another by pipes, whereby a refrigeration cycle is formed, and air conditioning of an air-conditioned space (for example, a room space or the like where the indoor unit is installed) is performed. The air-conditioning apparatus will be described in Embodiment 3.

[0023] The outdoor unit 101 includes at least a housing 102, heat exchanger assemblies 103, bell mouths 104, a cover 105, a non-illustrated compressor, and non-illustrated pipe components. The outdoor unit 101 has two fans (for example, propeller fans or the like corresponding to a fan 55 to be mentioned in Embodiment 3) provided in the upper portion of the housing 102. The outdoor unit 101 takes in air from surfaces of the housing 102 by an effect produced by the fans, allows the air to flow through the heat exchanger assemblies 103, and exhausts the air from the upper portion of the housing 102. In Fig. 1, the bell mouths 104 are simplified as cylindrical members.

[0024] The housing 102 has a substantially rectangular parallelepiped shape and forms an outer shell of the outdoor unit 101. Some of the devices forming the refrigeration cycle are housed by the housing 102. The heat exchanger assemblies 103 allow the air taken in by the fans and a refrigerant to exchange heat therebetween. The number of heat exchanger assemblies 103 is two in correspondence with the number of fans. The bell mouths 104 guide the air that is made to flow by the fans provided in the upper portion of the housing 102. Two bell mouths 104 are provided in correspondence with the number of fans.

[0025] The cover 105 is provided on one of the four surfaces of the housing 102 (for example, a surface on which a control board is provided and maintenance work and other kinds of work are performed by a worker, that is, a surface illustrated on the near surface) and covers that surface of the housing 102. The other three surfaces of the housing 102 that are not covered with the cover 105 allow the heat exchanger assemblies 103 to be exposed to the peripheral environment in most part of the three surfaces excluding portions provided with thin columnar or grating members so that outside air can be taken into the heat exchanger assemblies 103. Although Fig. 1 illustrates an exemplary case where one surface of the housing 102 is covered with one cover 105, the number of covers 105 is not specifically limited. One surface of the housing 102 may alternatively be covered with a plurality of covers 105.

[0026] Fig. 2 is a schematic perspective view illustrating an internal configuration of the outdoor unit 101. Referring to Fig. 2, an outline of the internal configuration of the outdoor unit 101 will be described. Fig. 2 schemat-

ically illustrates the internal configuration of the outdoor unit 101 with members of the housing 102 excluding a bottom plate 119, and the devices provided in the housing 102 being removed so as to illustrate flows of the air produced in the outdoor unit 101. Hence, in Fig. 2, the bell mouths 104 appear to be spaced apart from the housing 102. In addition, white arrows illustrated in Fig. 2 represent the flow of air produced by the effect of the fans, and the size of the white arrows corresponds to the wind speed.

[0027] The heat exchanger assemblies 103 each bent in a substantially U shape in a top view of the outdoor unit 101 are provided below the two bell mouths 104 in such a manner as to surround the two bell mouths 104, respectively. The heat exchanger assemblies 103 each include two layers. The two heat exchanger assemblies 103 are arranged symmetrically with respect to a line connecting the longitudinal centers of the housing 102. Hereinafter, one of the two heat exchangers that is on the outer surface in the outdoor unit 101 is referred to as outer heat exchanger 106, and the other heat exchanger that is on the inner surface in the outdoor unit 101 is referred to as inner heat exchanger 107. Sides of the two respective outer heat exchangers 106 that are adjacent to each other are referred to as outer adjacent surfaces 108. Sides of the two respective inner heat exchangers 107 that are adjacent to each other are referred to as inner adjacent surfaces 109.

[0028] The outer heat exchangers 106 and the inner heat exchangers 107 each include, for example, heat transfer tubes each having a flat cross-sectional shape (hereinafter referred to as flat tubes). The flat tubes are fitted in plate-like fins that are arranged at predetermined intervals. The plate-like fins each have fitting holes provided in the form of notches and in the same number and at the same intervals as the flat tubes in a plate-long-axis direction. Alternatively, the outer heat exchangers 106 and the inner heat exchangers 107 each include, for example, heat transfer tubes each having a circular cross-sectional shape (hereinafter referred to as circular tubes). The circular tubes are fitted in plate-like fins that are arranged at predetermined intervals. The plate-like fins each have circular fitting holes provided in the same number and at the same intervals as the circular tubes in the plate-long-axis direction. The configurations of the outer heat exchanger 106 and the inner heat exchanger 107 will be described in detail separately below, referring to Fig. 5.

[0029] The devices such as the compressor provided in the housing 102 are disposed on the bottom plate 119 of the housing 102 in such a manner as to be surrounded from three surfaces by the heat exchanger assemblies 103. The two heat exchanger assemblies 103 are arranged side by side and symmetrically with respect to a gap 110 of a predetermined space and such that excessive spaces are not provided in the housing 102, with consideration for the ease of assembling of the pipes projecting from end surfaces 125 of the heat exchanger

assemblies 103 (surfaces of the outer adjacent surfaces 108 and the inner adjacent surfaces 109 that face the cover 105) and the space occupied (the space in the housing 102 occupied by the heat exchanger assemblies 103).

[0030] That is, when the housing 102 is seen as a whole as illustrated in Fig. 1, the two heat exchanger assemblies 103 are arranged such that two of the three surfaces of each heat exchanger assembly 103 excluding the adjacent surface (including the outer adjacent surfaces 108 and the inner adjacent surfaces 109) are positioned on corresponding ones of the three surfaces of the housing 102 on which the heat exchanger assemblies 103 are exposed. One of the two surfaces, excluding the adjacent surface, of the heat exchanger assembly 103 on the left side in Fig. 2 that is opposite the adjacent surface is denoted as surface 111, and the other that is opposite the cover 105 is denoted as surface 112. Likewise, one of the two surfaces, excluding the adjacent surface, of the heat exchanger assembly 103 on the right side in Fig. 2 that is opposite the adjacent surface is denoted as surface 114, and the other that is opposite the cover 105 is denoted as surface 113.

[0031] Note that a surface of the housing 102 that is opposite the cover 105 allows the heat exchanger assemblies 103 to be exposed to the peripheral environment so that outside air can be taken into the heat exchanger assemblies 103. Therefore, air is also taken in from the outer adjacent surfaces 108 and the inner adjacent surfaces 109.

[0032] The flow of air produced in the outdoor unit 101 configured as above is roughly illustrated in Fig. 2. Specifically, air having flowed into the housing 102 from three surfaces of the housing 102 by the effect of the fans flows through the heat exchanger assemblies 103 and the bell mouths 104 and is exhausted from the upper portion of the housing 102. In this process, since the surfaces 111 to 114 of the heat exchanger assemblies 103 each have a larger cross-sectional area of openings that face toward the outside of the housing 102 than the adjacent surfaces of the heat exchanger assemblies 103, the draft resistance is smaller on the surfaces 111 to 114, allowing the air to flow therethrough at a higher speed. On the other hand, air is also taken in from the outer adjacent surfaces 108 and the inner adjacent surfaces 109. However, since the cross-sectional area of openings in each of the outer adjacent surfaces 108 and the inner adjacent surfaces 109 that face toward the outside of the housing 102 is small, the draft resistance is large on the outer adjacent surfaces 108 and the inner adjacent surfaces 109, limiting the air to flow therethrough at a lower speed.

[0033] Fig. 3 is a schematic perspective view illustrating the configuration of the heat exchanger assemblies 103. Fig. 4 is a schematic perspective view illustrating a configuration of a known heat exchanger assemblies (hereinafter denoted as heat exchanger assemblies 103'). Referring to Figs. 3 and 4, the configuration of the heat exchanger assemblies 103 will be described in com-

parison with the configuration of the heat exchanger assemblies 103'. Members included in the heat exchanger assemblies 103' are denoted by corresponding reference numerals each suffixed with a prime (') as a matter of convenience for ease of comparison with the corresponding members of the heat exchanger assemblies 103 included in the outdoor unit 101 according to Embodiment 1.

[0034] The heat exchanger assemblies 103 are each ultimately bent in a substantially U shape, as described above, in which the fins are stacked and the heat transfer tubes extending therethrough extend in a direction of a contour line 117. The heat exchanger assemblies 103 each include two layers: the outer heat exchanger 106 and the inner heat exchanger 107. In the two heat exchanger assemblies 103, the outer adjacent surfaces 108 of the two respective outer heat exchangers 106 and the inner adjacent surfaces 109 of the two respective inner heat exchangers 107 face each other.

[0035] The outer heat exchangers 106 and the inner heat exchangers 107 included in the heat exchanger assemblies 103 each include heat transfer tubes (flat tubes or circular tubes). The heat transfer tubes are fitted in plate-like fins that are arranged at predetermined intervals. The plate-like fins each have fitting holes (encompassing notches) provided in the same number and at the same intervals as the heat transfer tubes in the plate-long-axis direction. The fins are formed as follows. After pressing is performed, a desired number of fins obtained by cutting and each having a desired strip length are sequentially stacked in a collar section. Subsequently, a plurality of long heat transfer tubes called hair pins and each including a U-shaped portion 115 are inserted into the fins.

[0036] The fins included in each of the outer heat exchanger 106 and the inner heat exchanger 107 are stacked at predetermined intervals and are fixed. That is, as illustrated in Fig. 3, the intervals between the fins included in each of the outer heat exchanger 106 and the inner heat exchanger 107 are changed in some portions. Subsequently, the plurality of heat transfer tubes (flat tubes or circular tubes) are brazed to U-bends 116 for pipe connection each being bent in a U shape at an end of a corresponding one of the heat exchangers, and to other components such as a distributor, whereby a continuous refrigerant passage that is folded many times while passing through the fins is provided. Subsequently, the stack of fins in which the heat transfer tubes are fitted is bent into an L shape a plurality of times (twice, for example), whereby the outer heat exchanger 106 and the inner heat exchanger 107 each ultimately have a substantially U shape in which the fins are stacked and the heat transfer tubes extending therethrough extend in the direction of the contour line 117.

[0037] Likewise, the heat exchanger assemblies 103' are each bent in a substantially U shape. Furthermore, the heat exchanger assemblies 103' each include two layers: an outer heat exchanger 106' and an inner heat

exchanger 107'. In the two heat exchanger assemblies 103', outer adjacent surfaces 108' of the two respective outer heat exchangers 106' and inner adjacent surfaces 109' of the two respective inner heat exchangers 107' face each other. As can be seen from the above, the heat exchanger assemblies 103 and the heat exchanger assemblies 103' have similar appearances.

[0038] In general, the outer heat exchangers 106' and the inner heat exchangers 107' included in the heat exchanger assemblies 103' each include circular tubes. The circular tubes are fitted in plate-like fins that are arranged at predetermined intervals. The plate-like fins each have circular fitting holes provided in the same number and at the same intervals as the circular tubes in the plate-long-axis direction. As described in Background Art, the edges of the circular holes provided in each of the fins are burred and thus form cylindrical collars so that the area of the fin that is in close contact with each of the heat transfer tubes is increased. Furthermore, flat portions of the fins between the circular holes have slits that improve the heat exchangeability with draft air. The fins are formed as follows. After pressing is performed, a desired number of fins obtained by cutting and each having a desired strip length are sequentially stacked in a collar section. Subsequently, a plurality of long circular tubes called hair pins and each including a U-shaped portion 115' are inserted into the fins.

[0039] As described above, in forming the outer heat exchanger 106' and the inner heat exchanger 107', the stacking of the fins and the fitting of the circular tubes are performed with reference to the collars. Consequently, the fins included in the outer heat exchanger 106' and the inner heat exchanger 107' are stacked and fixed at regular intervals corresponding to the height of the collars. That is, as illustrated in Fig. 4, the intervals between the fins included in each of the outer heat exchanger 106' and the inner heat exchanger 107' are constant. Subsequently, the plurality of circular tubes are brazed to U-bends 116' for pipe connection each being bent in a U shape at an end of a corresponding one of the heat exchangers, and to other components such as a distributor, whereby a continuous refrigerant passage that is folded many times while passing through the fins is provided. Subsequently, the stack of fins in which the circular tubes are fitted is bent into an L shape a plurality of times (twice, for example), whereby the outer heat exchanger 106' and the inner heat exchanger 107' each ultimately have a substantially U shape in which the fins are stacked and the heat transfer tubes extending therethrough extend in the direction of the contour line 117'.

[0040] The pitch of the fins included in the outer heat exchanger 106' and the inner heat exchanger 107' configured as above is determined to be constant by the height of the collars formed by burring. Therefore, as described in Background Art, it is difficult to change the fin pitch in accordance with the internal configuration of the outdoor unit.

[0041] In contrast, unlike the known art, the fin pitch of

the outer heat exchanger 106 and the inner heat exchanger 107 included in each of the heat exchanger assemblies 103 is readily changeable. That is, unlike the known art, the outer heat exchanger 106 and the inner heat exchanger 107 included in each of the heat exchanger assemblies 103 do not include fin collars, and the pitch of the fins is therefore not determined to be constant by the height of the collars formed by burring. In another case, since fin collars that are shorter than the stacking intervals between the fins are provided, the fin pitch is readily changeable. In the outdoor unit 101 according to Embodiment 1, since the fin pitch is readily changeable, the fins can be arranged with consideration for the internal configuration and the cost performance of the outdoor unit 101. Thus, the outdoor unit 101 according to Embodiment 1 can provide improved heat exchanging efficiency and can save energy.

[0042] As illustrated in Fig. 2, since the surfaces 111 to 114 of the heat exchanger assemblies 103 each have a larger cross-sectional area of openings that face toward the outside of the housing 102 than the adjacent surfaces (the outer adjacent surfaces 108 and the inner adjacent surfaces 109) of the heat exchanger assemblies 103, the draft resistance is smaller on the surfaces 111 to 114, allowing the air to flow therethrough at a higher speed. That is, since the adjacent surfaces of the heat exchanger assemblies 103 each have a small cross-sectional area of openings that face toward the outside of the housing 102, the draft resistance is large on the adjacent surfaces, limiting the air to flow therethrough at a low speed. Hence, in the heat exchanger assemblies 103, as illustrated in Fig. 3, the intervals between the fins included in the outer adjacent surfaces 108 and the inner adjacent surfaces 109 are larger than the intervals between the fins included in the surfaces 111 to 114.

[0043] Fig. 5 includes schematic perspective views each illustrating a part of one of the heat exchangers (the outer heat exchanger 106 and the inner heat exchanger 107) included in each of the heat exchanger assemblies 103. Referring to Fig. 5, the configuration of the outer heat exchanger 106 and the inner heat exchanger 107 will be described in detail. Fig. 5(a) illustrates either of the outer heat exchanger 106 and the inner heat exchanger 107 that include flat tubes 1. Fig. 5(b) illustrates either of the outer heat exchanger 106 and the inner heat exchanger 107 that include circular tubes 1 A. The outer heat exchanger 106 and the inner heat exchanger 107 that include the flat tubes 1 are generally referred to as flat-tube heat exchanger 120. The outer heat exchanger 106 and the inner heat exchanger 107 that include the circular tubes 1 A are generally referred to as circular-tube heat exchanger 120A.

[0044] The outer heat exchanger 106 or the inner heat exchanger 107 illustrated in Fig. 5(a) includes flat heat transfer tubes each having a cross-sectional shape defined by a partially curved line. That is, the flat-tube heat exchanger 120 includes a plurality of flat tubes 1 each having a flat cross section whose long sides are defined

by straight lines and whose short sides are defined by curved lines each forming, for example, a semicircle or the like. The plurality of flat tubes 1 are arranged parallel to one another at predetermined intervals (regular intervals, for example) in a direction orthogonal to the direction of the passage of the refrigerant that is made to flow therethrough.

[0045] The flat-tube heat exchanger 120 further includes a plurality of flat-plate-like (rectangular) fins 2. The fins 2 are arranged parallel to one another at predetermined intervals in the direction of the refrigerant passage (a direction orthogonal to the direction in which the flat tubes 1 are arranged side by side). The fins 2 each have a rectangular shape with a length in the long-axis direction of the flat tubes 1 being larger than a length in the width direction of the flat tubes 1 (the vertical direction in the drawing). Therefore, the width direction of the flat tubes 1 is defined as short-side direction, and the long-axis direction of the flat tubes 1 is denoted as long-side direction.

[0046] The flat tubes 1 each have thereinside a plurality of holes 3 extending side by side in the width direction. A refrigerant is made to flow in the holes 3. The refrigerant exchanges heat with, for example, air flowing through the flat-tube heat exchanger 120. The fins 2 each have a plurality of notches 4 arranged in the long-side direction. The notches 4 are provided in correspondence with the flat tubes 1. That is, for example, the notches 4 are provided in the same number and at the same intervals (excluding the ones at both ends) as the flat tubes 1. Furthermore, the notches 4 each have substantially the same width as the flat tubes 1. The notches 4 are provided such that one end of the fin 2 is open. That is, the notches 4 are provided side by side in a comb-like pattern in the long-side direction of the fin 2.

[0047] The fin 2 further has gate-type (bridge-type) cut-raised portions 5 provided by cutting and raising respective portions of the fin 2 between the notches 4. The cut-raised portions 5 promote the heat exchange between air and the refrigerant. Furthermore, the fin 2 has fin collars 6 provided by raising the edges of the notches 4 perpendicularly with respect to the fin 2. The fin collars 6 provided by cutting and raising the fin 2 each have a shorter length than the stacking intervals between the fins 2.

[0048] The plurality of flat tubes 1 are arranged side by side, and the notches 4 of the fins 2 are fitted onto the thus arranged flat tubes 1. Subsequently, the flat tubes 1 and the fin collars 6 are joined to each other with a brazing material or the like, whereby the flat tubes 1 and the fins 2 are fixed to each other. Regarding the flat-tube heat exchanger 120 having such a configuration, many pieces of literature show that capacity performance that is higher than or equal to that of a known heat exchanger including circular tubes and fins is provided because of several points such as an increase in the area of contact surface between the refrigerant and each of the tubes having a reduced thickness. Furthermore, the size of the

flat-tube heat exchanger 120 is selected in accordance with the performance required in the outdoor unit 101, and such a flat-tube heat exchanger 120 is to be included in the outdoor unit 101.

[0049] The outer heat exchanger 106 or the inner heat exchanger 107 illustrated in Fig. 5(b) includes the circular tubes 1 A each having a partially circular cross-sectional shape. The plurality of circular tubes 1 A are arranged in a checkered pattern at predetermined intervals (regular intervals, for example) in a direction orthogonal to the direction of the passage of the refrigerant that is made to flow therethrough. The circular-tube heat exchanger 120A further includes flat-plate-like fins 2A that are similar to the fins 2 of the flat-tube heat exchanger 120. The fins 2A are arranged parallel to one another at predetermined intervals in the direction of refrigerant passage (a direction orthogonal to the direction in which the circular tubes 1 A are arranged side by side).

[0050] A refrigerant is made to flow in the circular tubes 1 A. The refrigerant exchanges heat with, for example, air flowing through the circular-tube heat exchanger 120A. The fins 2A each have a plurality of notches 4A. The notches 4A are provided in correspondence with the circular tubes 1 A. That is, for example, the notches 4A are provided in the same number and at the same intervals (excluding the ones at both ends) as the circular tubes 1 A.

[0051] Furthermore, the fins 2A each have gate-type (bridge-type) cut-raised portions 5A provided by cutting and raising portions of the fin 2A between the notches 4A. The cut-raised portions 5A promote the heat exchange between air and the refrigerant. Furthermore, the fin 2A has fin collars 6A provided by raising the edges of the notches 4A perpendicularly with respect to the fin 2A. As with the fin collars 6, the fin collars 6A provided by cutting and raising the fin 2A each have a shorter length than the stacking intervals between the fins 2A.

[0052] The plurality of circular tubes 1A are arranged at predetermined intervals, and the notches 4A of the fins 2A are fitted onto the thus arranged circular tubes 1 A. Subsequently, the circular tubes 1 A and the fin collars 6A are joined to each other with a brazing material or the like, whereby the circular tubes 1 A and the fins 2A are fixed to each other. The size of the circular-tube heat exchanger 120A is selected in accordance with the performance required in the outdoor unit 101, and such a circular-tube heat exchanger 120A is to be included in the outdoor unit 101.

[0053] As described above, the outdoor unit 101 includes the heat exchanger assemblies 103 each including the flat-tube heat exchangers 120 or the circular-tube heat exchangers 120A, and the fins in the outer adjacent surfaces 108 and the inner adjacent surfaces 109 are stacked at a larger fin pitch than in the other surfaces 111 to 114, whereby the fins can be distributed more effectively than in the known art. In the outdoor unit 101, since the fins can be arranged at a density that is suitable for performance improvement, the heat exchanging effi-

ciency is improved from the viewpoint of cost performance. Thus, energy saving and cost reduction are realized. Furthermore, if there is no problem with performance specifications of the outdoor unit that are the same as those in the known art, the performance improvement described above may be translated into a reduction in the total number of fins, whereby the size and the costs of the outdoor unit 101 can be reduced while substantially the same level of performance is provided.

[0054] While the above description concerns an exemplary case where a plurality of cut-raised portions 5 are provided between the notches 4 of each of the fins 2 so as to produce a more energy saving effect, the cut-raised portions 5 are not necessarily provided. Likewise, while the above description concerns another exemplary case where a plurality of cut-raised portions 5A are provided between the notches 4A of each of the fins 2A so as to produce a more energy saving effect, the cut-raised portions 5A are not necessarily provided.

Embodiment 2

[0055] Fig. 6 is a schematic perspective view illustrating a configuration of heat exchanger assemblies 103A included in an outdoor unit according to Embodiment 2 of the present invention. Referring to Fig. 6, the configuration of the heat exchanger assemblies 103A will now be described. The configuration of the outdoor unit according to Embodiment 2 is basically the same as that of the outdoor unit 101 described in Embodiment 1. The description of Embodiment 2 focuses on differences from Embodiment 1. Elements that are the same as those of Embodiment 1 are denoted by corresponding reference numerals, and description thereof is omitted.

[0056] As with the heat exchanger assemblies 103 described in Embodiment 1, the heat exchanger assemblies 103A are each bent in a substantially U shape such that, ultimately, the fins are stacked and the heat transfer tubes extending therethrough extend in the direction of the contour line 117. The heat exchanger assemblies 103A each include two layers: an outer heat exchanger 106A and an inner heat exchanger 107A. In the two heat exchanger assemblies 103A, outer adjacent surfaces 108A of the two respective outer heat exchangers 106A and inner adjacent surfaces 109A of the two respective inner heat exchangers 107A face each other.

[0057] The outer heat exchangers 106A and the inner heat exchangers 107A included in the heat exchanger assemblies 103A each include heat transfer tubes (flat tubes or circular tubes). The heat transfer tubes are fitted into plate-like fins that are arranged at predetermined intervals. The plate-like fins each have fitting holes (encompassing notches) provided in the same number and at the same intervals as the heat transfer tubes in the plate-long-axis direction. The fins are formed as follows. After pressing is performed, a desired number of fins obtained by cutting and each having a desired strip length are sequentially stacked in a collar section. Subsequent-

ly, a plurality of long heat transfer tubes called hair pins and each including a U-shaped portion 115 are inserted into the fins.

[0058] The fins included in each of the outer heat exchanger 106A and the inner heat exchanger 107A are stacked at predetermined intervals and are fixed. Subsequently, the plurality of heat transfer tubes (flat tubes or circular tubes) are brazed to U-bends 116 for pipe connection each being bent in a U shape at an end of a corresponding one of the heat exchangers, and to other components such as a distributor, whereby a continuous refrigerant passage that is folded many times while passing through the fins is provided. Subsequently, the stack of fins in which the heat transfer tubes are fitted is bent into an L shape a plurality of times (twice, for example), whereby the outer heat exchanger 106A and the inner heat exchanger 107A each ultimately have a substantially U shape in which the fins are stacked and the heat transfer tubes extending therethrough extend in the direction of the contour line 117.

[0059] Unlike the known art, the fin pitch of the outer heat exchanger 106A and the inner heat exchanger 107A included in each of the heat exchanger assemblies 103A is readily changeable. That is, unlike the known art, the pitch of the fins of the outer heat exchanger 106A and the inner heat exchanger 107A included in each of the heat exchanger assemblies 103A is not determined to be constant by the height of collars formed by burring. In another case, fin collars that are shorter than the stacking intervals between the fins are provided. Therefore, the fin pitch is readily changeable. Thus, the outer heat exchanger 106A and the inner heat exchanger 107A are configured with much consideration for the thickness of the fins and the stacking intervals between the fins.

[0060] As described in Embodiment 1, since the surfaces 111 to 114 of the heat exchanger assemblies 103A each have a larger cross-sectional area of openings that face toward the outside of the housing than the adjacent surfaces (the outer adjacent surfaces 108A and the inner adjacent surfaces 109A) of the heat exchanger assemblies 103A, the draft resistance is smaller on the surfaces 111 to 114, allowing the air to flow therethrough at a higher speed. That is, in the heat exchanger assemblies 103A, since the cross-sectional area of openings of the adjacent surfaces that face toward the outside of the housing is small, the draft resistance is large on the adjacent surfaces, limiting the air to flow therethrough at a low speed.

[0061] Hence, in the heat exchanger assemblies 103A, as illustrated in Fig. 6, the intervals between the fins included in the outer adjacent surfaces 108A and the inner adjacent surfaces 109A are larger in some portions than the intervals between the fins included in the surfaces 111 to 114. That is, the stacking intervals between the fins in a surface 36 of each outer adjacent surfaces 108A that is nearer to the end is larger than the stacking intervals between the fins in a surface 38 of the outer adjacent surfaces 108A that is nearer to the curved portion (bent

portion). Thus, the heat exchanging efficiency can be improved in those portions nearer to the end portions of the outer adjacent surfaces 108A and the inner adjacent surfaces 109A in each of which the cross-sectional area of openings that face toward the outside of the housing is small.

[0062] The outdoor unit according to Embodiment 2 includes the heat exchanger assemblies 103A in which the fin pitch is readily changeable as in the heat exchanger assemblies 103 described in Embodiment 1. Hence, the fins can be arranged at a density that is suitable for performance improvement with further consideration for the internal configuration of the outdoor unit, and the fins can be arranged from the viewpoint of cost performance. Thus, in the outdoor unit according to Embodiment 2, the heat exchanging efficiency is further improved, and further energy saving is realized. Moreover, if there is no problem with performance specifications of the outdoor unit that are the same as those in the known art, the performance improvement described above may be translated into a reduction in the total number of fins 2, whereby the size and the costs of the outdoor unit 101 can be reduced while substantially the same level of performance is provided.

Embodiment 3

[0063] Fig. 7 is a circuit diagram schematically illustrating a basic configuration of an air-conditioning apparatus 50 according to Embodiment 3 of the present invention. Referring to Fig. 7, the configuration and operations of the air-conditioning apparatus 50 will now be described. The air-conditioning apparatus 50 includes an outdoor unit and an indoor unit. A refrigerant is made to circulate through devices provided in the outdoor unit and the indoor unit, whereby a cooling operation or a heating operation is realized. While Embodiment 3 concerns a case where the air-conditioning apparatus 50 includes the outdoor unit 101 according to Embodiment 1, the air-conditioning apparatus 50 may alternatively include the outdoor unit according to Embodiment 2.

[0064] The air-conditioning apparatus 50 includes devices such as a compressor 51, a heat-source-side heat exchanger 52, an expansion device 53, and a use-side heat exchanger 54 that are connected to one another by pipes. Among these devices, the compressor 51 and the heat-source-side heat exchanger 52 are included in the outdoor unit 101, and the expansion device 53 and the use-side heat exchanger 54 are included in an indoor unit 60. The expansion device 53 may be included in the outdoor unit 101, not in the indoor unit 60. In addition, a non-illustrated flow switching device such as a four-way valve configured to switch the flow of the refrigerant may be provided on a discharge side of the compressor 51.

[0065] The compressor 51 sucks the refrigerant and compresses the refrigerant, whereby the refrigerant becomes a high-temperature and high-pressure state. The compressor 51 is, for example, an inverter compressor

or the like whose capacity is controllable. The heat-source-side heat exchanger 52 allows the refrigerant and air that is forcibly supplied thereto from a fan 55 to exchange heat therebetween. The heat exchanger assemblies described in Embodiment 1 or Embodiment 2 are employed as the heat-source-side heat exchanger 52. The expansion device 53 expands the refrigerant by reducing the pressure of the refrigerant and includes, for example, an electronic expansion valve or the like whose opening degree is variably controllable. The use-side heat exchanger 54 allows the refrigerant and air that is forcibly supplied thereto from a non-illustrated air-sending device such as a fan to exchange heat therebetween. The fan 55 includes fans provided in the same number as the heat exchanger assemblies included in the heat-source-side heat exchanger 52. The fan 55 supplies air to the heat-source-side heat exchanger 52.

[0066] The heating operation and the cooling operation performed by the air-conditioning apparatus 50 will now be described briefly.

[Heating Operation]

[0067] When the compressor 51 is driven, the compressor 51 raises the pressure of the refrigerant, whereby the refrigerant becomes a high-temperature and high-pressure state and is discharged. The refrigerant discharged from the compressor 51 is supplied to the use-side heat exchanger 54 and is cooled while exchanging heat with air, whereby the refrigerant becomes a low-temperature and high-pressure state. In this step, heating air is supplied from the indoor unit 60, whereby an air-conditioned space is heated. The refrigerant is then discharged from the use-side heat exchanger 54, undergoes pressure reduction by being expanded by the expansion device 53, and becomes a low-temperature and low-pressure state. The refrigerant is then heated in the heat-source-side heat exchanger 52 and flows into the compressor 51 again.

[Cooling Operation]

[0068] When the compressor 51 is driven, the compressor 51 raises the pressure of the refrigerant, whereby the refrigerant becomes a high-temperature and high-pressure state and is discharged. The refrigerant discharged from the compressor 51 is supplied to the heat-source-side heat exchanger 52 and is cooled while exchanging heat with air, whereby the refrigerant becomes a low-temperature and high-pressure state. The refrigerant is then discharged from the heat-source-side heat exchanger 52, undergoes pressure reduction by being expanded by the expansion device 53, and becomes a low-temperature and low-pressure state. The refrigerant is then heated in the use-side heat exchanger 54. In this step, cooling air is supplied from the indoor unit 60, whereby the air-conditioned space is cooled. The refrigerant discharged from the use-side heat exchanger 54

flows into the compressor 51 again.

[0069] As described above, the air-conditioning apparatus 50 includes the outdoor unit 101 including the heat exchanger assemblies 103 each including the flat-tube heat exchangers 120 or the circular-tube heat exchangers 120A. Accordingly, while the total number of fins 2 is not changed, the fins 2 are stacked at a larger fin pitch in each of the outer adjacent surfaces 108 and the inner adjacent surfaces 109 than in each of the other surfaces 111 to 114. Therefore, the fins 2 can be distributed more effectively than in the known art. In the air-conditioning apparatus 50, since the fins can be arranged at a density that is suitable for performance improvement, the heat exchanging efficiency is improved from the viewpoint of cost performance. Thus, energy saving and cost reduction are realized.

Embodiment 4

[0070] Fig. 8 is a schematic diagram illustrating some steps included in a method of manufacturing a heat exchanger assembly according to Embodiment 4 of the present invention. Referring to Fig. 8, a method of manufacturing a flat-tube heat exchanger included in the heat exchanger assembly 103 will now be described. Herein, a case where the flat-tube heat exchanger 120 described in Embodiment 1 is manufactured will be described. In Embodiment 4, elements that are the same as those of any of Embodiments 1 to 3 are denoted by corresponding reference numerals, and description thereof is omitted.

[0071] First, a coil of, for example, aluminum thin plate that is to become fins 2 is prepared. Subsequently, the aluminum thin plate that is fed from the coil is pressed by using a non-illustrated progressive die placed on a high-speed pressing machine. Then, notches 4 are consecutively press-formed in the aluminum thin plate together with circular pilot holes 16 that are formed at both outer-side ends of the aluminum thin plate. In this step, an intermittent hoop feeding operation (arrow 17) is performed by utilizing positioning pins that are fitted into the pilot holes 16. In this manner, the aluminum thin plate is fed as a series of fins 18 in a hoop state as illustrated in Fig. 8.

[0072] The series of fins 18 is cut into individual fins 2 by a cutting operation (arrow 19) performed by a cutter above a plurality of flat tubes 1 that are arranged side by side. Subsequently, each of the fins 2 is held by a non-illustrated transfer mechanism including, for example, a cam and a servo, and is lowered in a moving and rotating operation (arrow 20). In this manner, the fins 2 are fitted onto the flat tubes 1 from an open side of the notches 4. Lastly, the fins 2 are pressed down onto the flat tubes 1 such that each of the fins 2 is at a predetermined interval from the last one in a group of fins 21 that have already been fitted onto the flat tubes 1 and until the rear edges of the notches 4 come into contact with the tops of the flat tubes 1. Thus, fitting and positioning of the fins 2 performed on the flat tubes 1 are complete.

[0073] On the other hand, the flat tubes 1 are placed on a non-illustrated transporting mechanism (a hoop feeding mechanism, for example) including, for example, a servo, a ball screw, a linear guide, and so forth so that the plurality of flat tubes 1 arranged side by side can be moved and positioned altogether in the long-axis direction. Then, the flat tubes 1 are positioned in the long-axis direction of the flat tubes 1 in a pitch feeding operation (arrow 22) performed by the transporting mechanism. The pitch feeding operation is performed such that a predetermined interval from the last fin in the group of fins 21 that have already been fitted onto the flat tubes 1 is provided.

[0074] The cutting operation (arrow 19) and the moving and rotating operation (arrow 20) performed on the fins 2 and the pitch feeding operation (arrow 22) performed on the flat tubes 1 are executed in that order following the hoop feeding operation (arrow 17) performed by the high-speed press and in synchronization with the operations performed by the transfer mechanism and the servo mechanism. Consequently, the fins 2 are stacked at predetermined intervals. Any lags in the synchronization between the high-speed press and the transfer mechanism may be absorbed by, for example, giving some slack in the hoop around transport rollers in such a manner as to provide a buffer for the hoop, and by increasing or decreasing the pressing stroke while detecting the amount of slack.

[0075] Furthermore, the fin pitch is adjustable to a desired value by changing the length of pitch feeding in the pitch feeding operation (arrow 22). The length of pitch feeding is adjusted in accordance with a setting on a controller that controls the transporting mechanism. A large length of pitch feeding is set for a group of fins (a group of fins 23 illustrated in Fig. 8) that is to form the outer adjacent surfaces 108 or the inner adjacent surfaces 109 in which the wind speed is low. A small length of pitch feeding is set for a group of fins (a group of fins 24 illustrated in Fig. 8) that is to form any of the surfaces 111 to 114. In this manner, a required number of fins 2 are stacked. Thus, a fin group assembly 25 including the group of fins 23 that are stacked at large intervals and the fins 24 that are stacked at small intervals is obtained. Note that Fig. 8 illustrates a state where the fin group assembly 25 has been assembled halfway.

[0076] The fin group assembly 25 obtained by completing the stacking of the fins 2 is fixed to the flat tubes 1 by brazing in a furnace with a brazing material that has coated over the flat tubes 1 in advance or by bonding with a bonding agent applied in the gaps. Subsequently, two fin group assemblies 25 are stacked, and the stack of the two fin group assembly 25 is connected to pipe components and is folded into an L shape twice, whereby assembling of the flat-tube heat exchanger 120 having a substantially U shape is complete (see Fig. 9).

[0077] The flat-tube heat exchanger 120 is manufactured by the above manufacturing method. Therefore, unlike the known method in which circular tubes are in-

serted into a group of fins that have been stacked in advance, the stacking intervals are quickly changeable to any of different fin pitches (stacking intervals between the fins) simply by changing a command value of the controller regarding the length of pitch feeding that is set for the transporting mechanism, without using any complicated dies for changing the height of collars and any large pressing machines. That is, the manufacturing method according to Embodiment 4 facilitates the change of the stacking pitch of the fins 2 without increasing the cost of the die for the fins 2, the cost of the pressing machine, and troublesome assembling work.

[0078] Furthermore, unlike the known art in which the collars are short and the fins are not stacked with reference to the collars, the flat-tube heat exchanger 120 is configured such that a desired number of fins 2 can be fitted onto the flat tubes 1 without moving the fins over the entire length of the heat transfer tubes and regardless of the length of the flat tubes 1. Therefore, the flat-tube heat exchanger 120 is hardly affected by the shapes of workpieces. Hence, an operation that is quick enough to follow the speed, at several hundred SPM (strokes per minute), of punching performed by the high-speed pressing machine is realized readily. Furthermore, different fin pitches are realized.

[0079] Fig. 9 is a schematic diagram illustrating some other steps included in the method of manufacturing a heat exchanger assembly according to Embodiment 4 of the present invention. Referring to Fig. 9, a method of manufacturing the heat exchanger assembly 103A described in Embodiment 2 will now be described. Note that Fig. 9 illustrates bending steps that are subsequent to the steps of manufacturing the flat-tube heat exchanger 120 illustrated in Fig. 8.

[0080] A heat exchanger bending device 150 illustrated in Fig. 9 is for bending a set of fin group assemblies 25 and includes at least an L-bending jig 40 and a table 41. The L-bending jig 40 bends the flat tubes 1 included in the set of fin group assemblies 25 substantially perpendicularly (into a substantially L shape). Specifically, the L-bending jig 40 includes a holding portion 40a that holds the set of fin group assemblies 25 and a moving portion 40b that rotates the holding portion 40a substantially perpendicularly. The holding portion 40a that is holding a predetermined position of the set of fin group assemblies 25 is rotated by the moving portion 40b, whereby the flat tubes 1 are bent. In this step, the flat tubes 1 are bent substantially perpendicularly in the width direction.

[0081] The set of fin group assemblies 25 is placed on the table 41 and is slid in a predetermined direction (toward right in Fig. 9) by a non-illustrated driving unit such as rollers. The table 41 includes, for example, a non-illustrated guide rail. When the guide rail is driven by the driving unit, the set of fin group assemblies 25 placed on the table 41 is slid.

[0082] As illustrated in Fig. 8, each fin group assembly 25 obtained by completing the stacking of the fins 2 is

fixed to the flat tubes 1. Two fin group assemblies 25 are stacked and are connected to pipe components (for example, the U-shaped portions 115, the U-bends 116, and so forth). In this state, the set of fin group assemblies 25 is placed on the table 41 of the heat exchanger bending device 150. The set of fin group assemblies 25 placed on the table 41 is slid by the table 41. When the set of fin group assemblies 25 is slid to a predetermined position (the position having the groups of fins 24 that are to form the outer adjacent surfaces 108 and the inner adjacent surfaces 109), the set of fin group assemblies 25 is held by the holding portion 40a of the L-bending jig 40. In this step, the holding portion 40a holds the groups of fins 24 in which the stacking intervals are small.

[0083] The set of fin group assemblies 25 held by the holding portion 40a is bent, while being slid, substantially perpendicularly by the holding portion 40a that is rotated by the moving portion 40b (first L-bending). Thus, the set of fin group assemblies 25 has a first curved portion 44. After the first curved portion 44 is formed, the holding portion 40a releases the set of fin group assemblies 25. The set of fin group assemblies 25 is further slid in the forward direction by the table 41. When the set of fin group assemblies 25 is slid to a predetermined position (the position having the groups of fins 24 that are to form the surface 112 or the surface 113), the set of fin group assemblies 25 is held by the holding portion 40a of the L-bending jig 40 again. In this step also, the holding portion 40a holds the groups of fins 24 in which the stacking intervals are small.

[0084] The set of fin group assemblies 25 held by the holding portion 40a is bent, while being slid, substantially perpendicularly by the holding portion 40a that is rotated by the moving portion 40b (second L-bending). Thus, the set of fin group assemblies 25 has a second curved portion 45. After the second curved portion 45 is formed, the holding portion 40a releases the set of fin group assemblies 25. In this manner, the heat exchanger assembly 103A having a substantially U shape is obtained.

[0085] As described above, since the heat exchanger bending device 150 holds the groups of fins 24 in which the stacking intervals are small by using the holding portion 40a, the stress applied to the end surfaces of the fins 2 when the flat tubes 1 are bent is reduced. Therefore, in the heat exchanger bending device 150, the occurrence of tilting or buckling of the fins 2 in the bending step is suppressed efficiently. Hence, even if the fins 2 are relatively thin or the stacking intervals between the fins 2 are relatively large, the fins 2 can be arranged at large stacking intervals while a certain level of manufacturing quality is maintained. Accordingly, in the method of manufacturing a heat exchanger assembly according to Embodiment 4, the heat exchanging efficiency is improved from the viewpoint of cost performance, and a heat exchanger assembly in which energy saving, cost reduction, and size reduction are realized is provided.

[0086] While Embodiment 4 concerns an exemplary method of manufacturing the heat exchanger assembly

103A described in Embodiment 2, Embodiment 4 may be applied to a method of manufacturing the heat exchanger assembly 103 described in Embodiment 1, needless to mention. In that case, however, the position to be held by the holding portion 40a needs to be determined carefully.

[0087] While each of Embodiments concerns an exemplary case where portions of the flat tubes 1 extending in the adjacent surfaces (the outer adjacent surfaces 108 and the inner adjacent surfaces 109) are shorter than the other portions of the flat tubes 1 extending in the surfaces excluding the adjacent surfaces, the present invention is not limited thereto. Needless to mention, similar effects are expected to be produced even if the former portions of the flat tubes 1 have the same length as or are longer than the portions of the flat tubes 1 extending in the surfaces excluding the adjacent surfaces.

[0088] While each of Embodiments concerns an exemplary case where the outdoor unit includes two substantially U-shaped heat exchangers that are arranged side by side, similar effects are expected to be produced even if the outdoor unit includes three or more heat exchangers, needless to mention, as long as the heat exchangers each have a surface that is adjacent to a surface of another heat exchanger. Furthermore, while no special description is given regarding the number of rows of heat exchangers that are stacked vertically in each of Embodiments, the heat exchanger may include one row as described in each of Embodiments, or the heat exchanger may include two or more rows. Furthermore, while each of Embodiments concerns an exemplary case where the heat exchanger includes two layers, the present invention is not limited thereto. Similar effects are expected to be produced even with a heat exchanger including one layer or with a heat exchanger including three or more layers.

Reference Signs List

[0089] 1 flat tube 1A circular tube 2 fin 2A fin 3 hole 4 notch 4A notch 5 cut-raised portion 5A cut-raised portion 6 fin collar 6A fin collar 16 pilot hole 17 arrow 18 series of fins 19 arrow 20 arrow 21 group of fins 22 arrow 23 group of fins 24 group of fins 25 fin group assembly 36 surface nearer to end 38 surface nearer to curved portion 40 L-bending jig 40a holding portion 40b moving portion 41 table 44 first curved portion 45 second curved portion 50 air-conditioning apparatus 51 compressor 52 heat-source-side heat exchanger 53 expansion device 54 use-side heat exchanger 55 fan 60 indoor unit 101 outdoor unit 102 housing 103 heat exchanger assembly 103A heat exchanger assembly 104 bell mouth 105 cover 106 outer heat exchanger 106A outer heat exchanger 107 inner heat exchanger 107A inner heat exchanger 108 outer adjacent surface 108A outer adjacent surface 109 inner adjacent surface 109A inner adjacent surface 110 gap 111 surface 112 surface 113 surface 114 surface 115 U-shaped portion 116 U-bend 117 contour line 119

bottom plate 120 flat-tube heat exchanger 120A circular-tube heat exchanger 125 end surface 150 heat exchanger bending device

Claims

1. An outdoor unit comprising:

a housing;
at least two plate fin-tube heat exchanger assemblies arranged side by side in the housing and each being bent in an inward direction of the housing such that the heat exchanger assembly has a facing surface that faces a surface of another heat exchanger assembly in the housing; and
a fan provided above the housing and causes air taken in from surfaces of the housing to be exhausted from an upper portion of the housing, wherein each of the heat exchanger assemblies includes

fins each having notches provided without fin collars or notches provided with fin collars that are shorter than stacking intervals between the fins, and

wherein at least some of the stacking intervals between the fins in a portion forming the facing surface are larger than the stacking intervals between the fins in portions forming surfaces excluding the facing surface.

2. The outdoor unit of claim 1, wherein, in a case where the heat exchanger assemblies are each bent substantially perpendicularly at least once,

the stacking intervals between the fins in a portion of the facing surface that is nearer to an end are larger than the stacking intervals between the fins in another portion of the facing surface that is nearer to a bent portion.

3. The outdoor unit of claim 2, wherein each of the heat exchanger assemblies is bent along surfaces of the housing excluding one surface.

4. The outdoor unit of any one of claims 1 to 3, wherein each of the heat exchanger assemblies includes flat tubes each having a flat cross-sectional shape are fitted in the notches provided in the fins, the flat cross-sectional shape being a shape in which long side thereof is linear while short side thereof is curved in a semicircular manner.

5. The outdoor unit of claim 4, wherein the fins each include a plurality of bridge-type cut-raised portions provided between the notches.

6. The outdoor unit of claim 4 or 5, wherein the fins are fixed to the flat tubes, which are fitted in the notches, by brazing or bonding.

7. An air-conditioning apparatus comprising:

the outdoor unit of any one of claims 1 to 6; and
an indoor unit connected to the outdoor unit.

FIG. 1

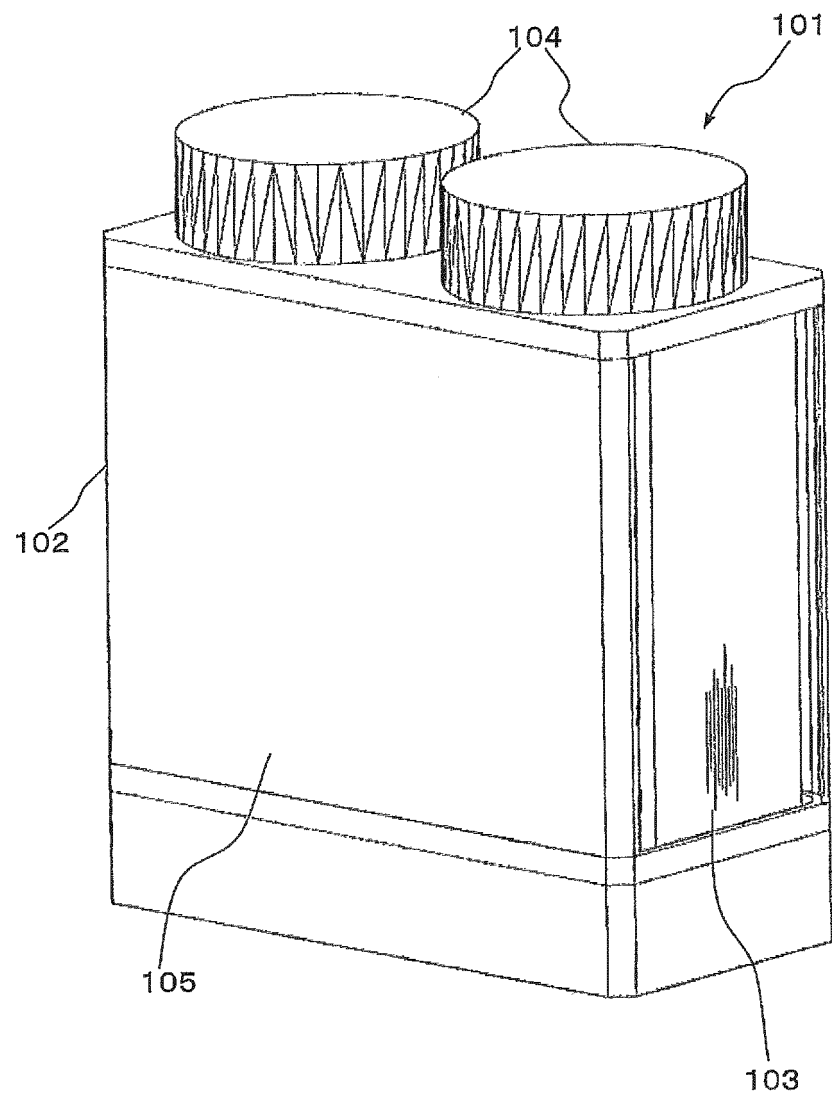


FIG. 2

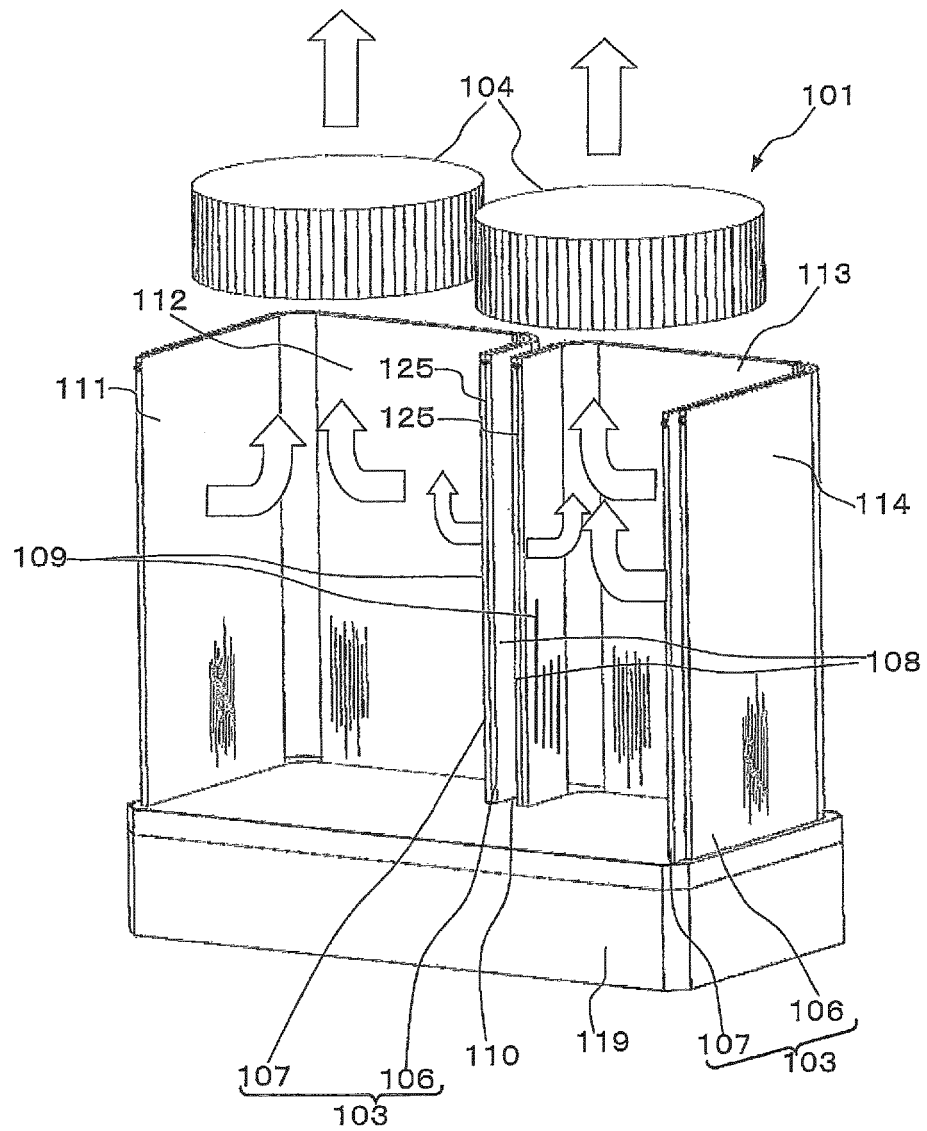


FIG. 3

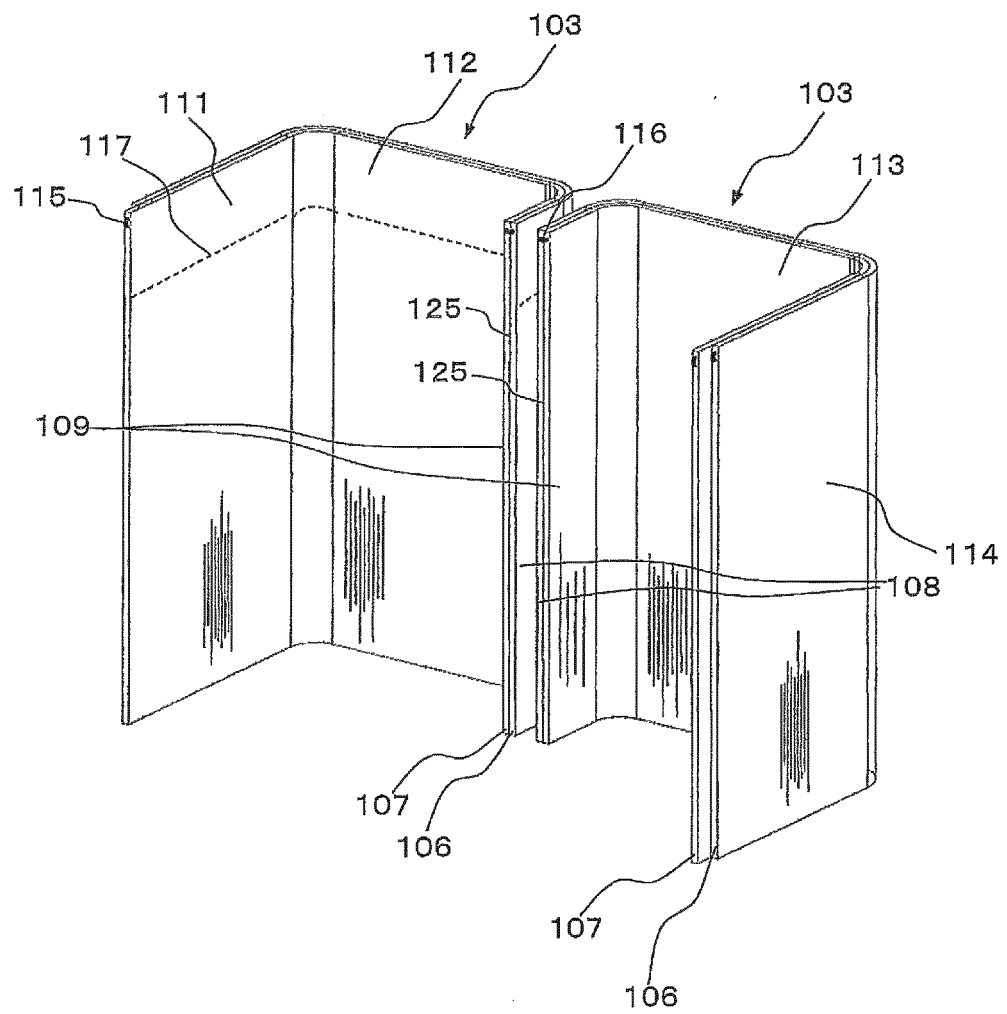


FIG. 4

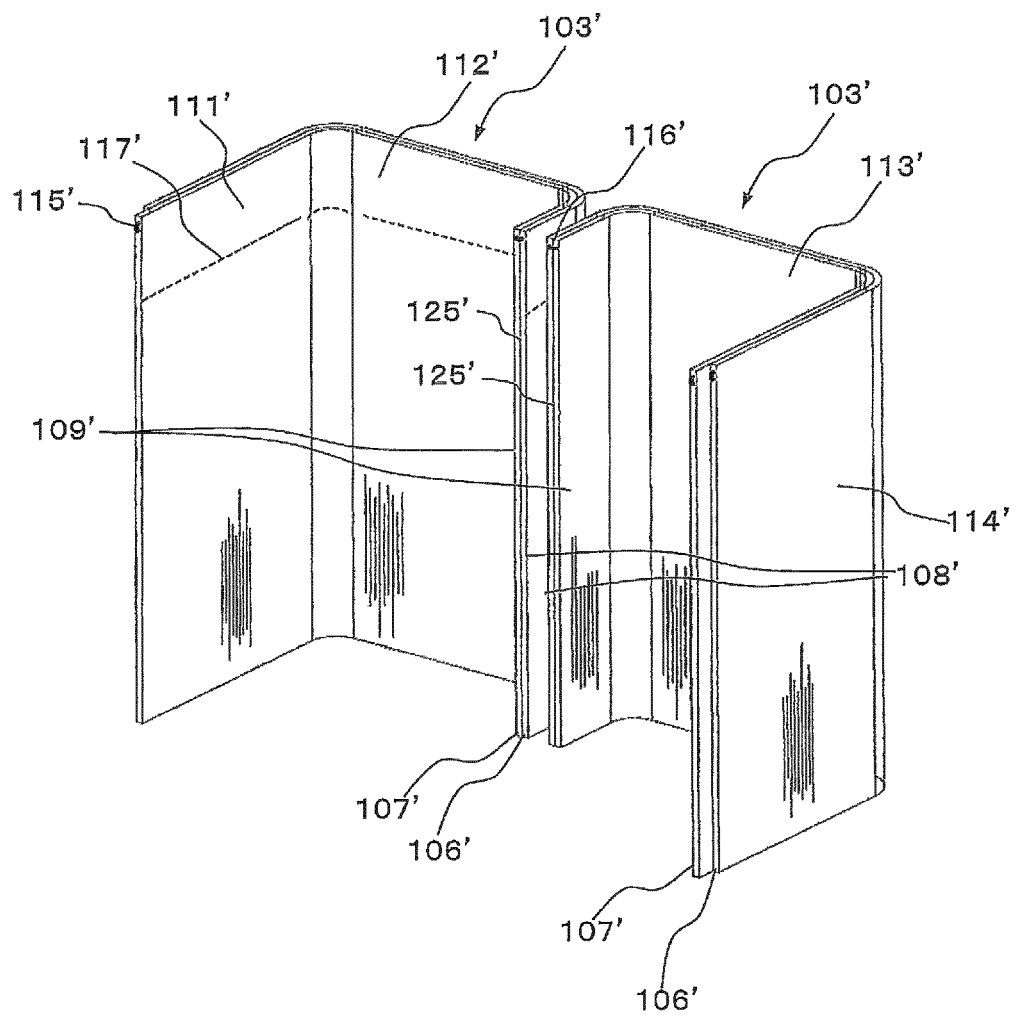


FIG. 5

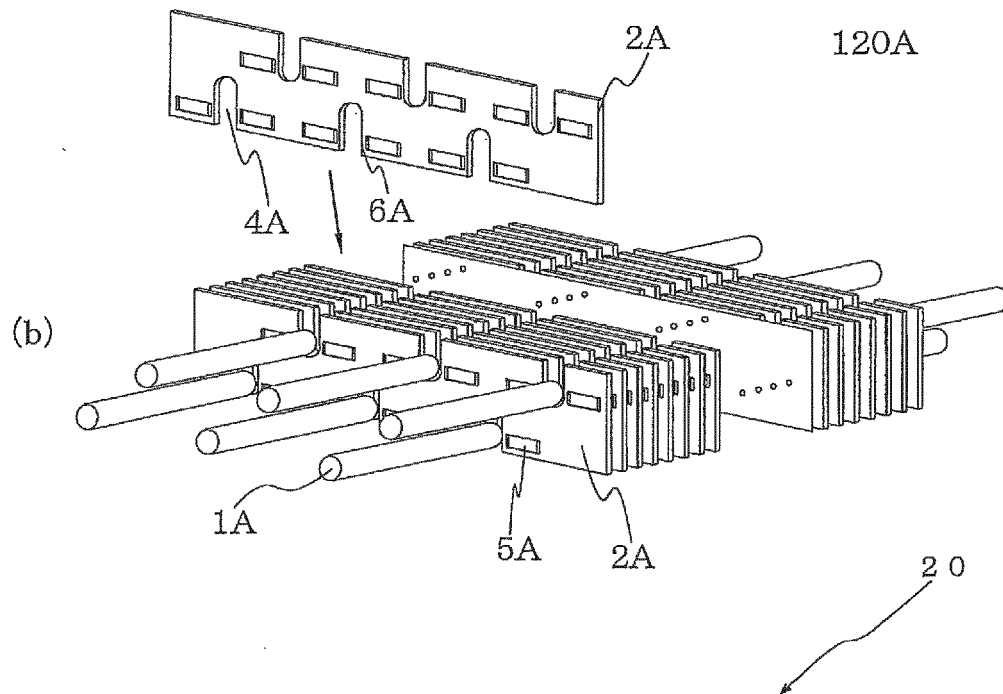
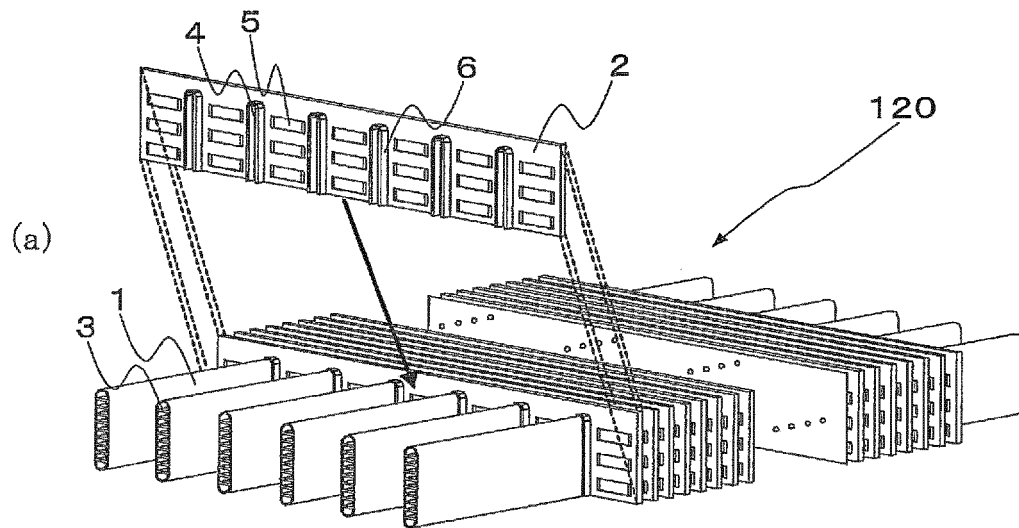


FIG. 6

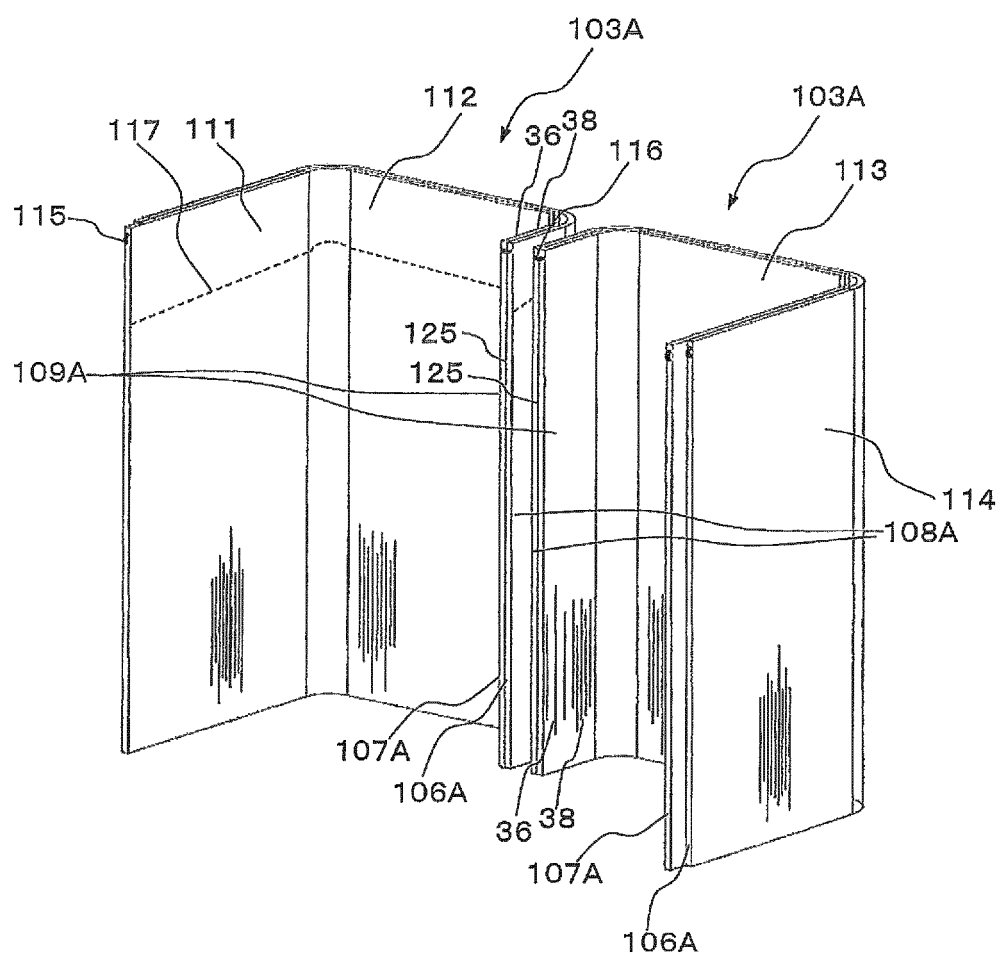


FIG. 7

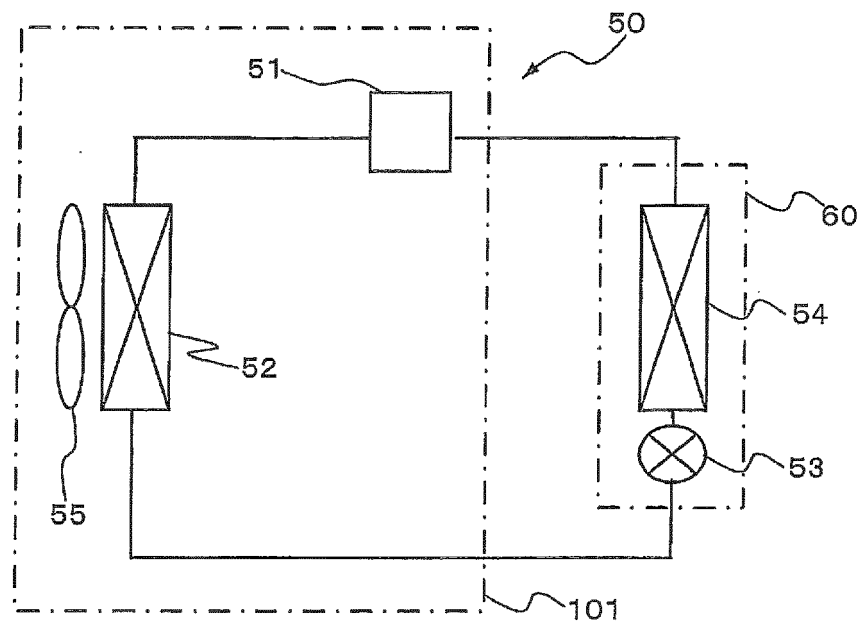


FIG. 8

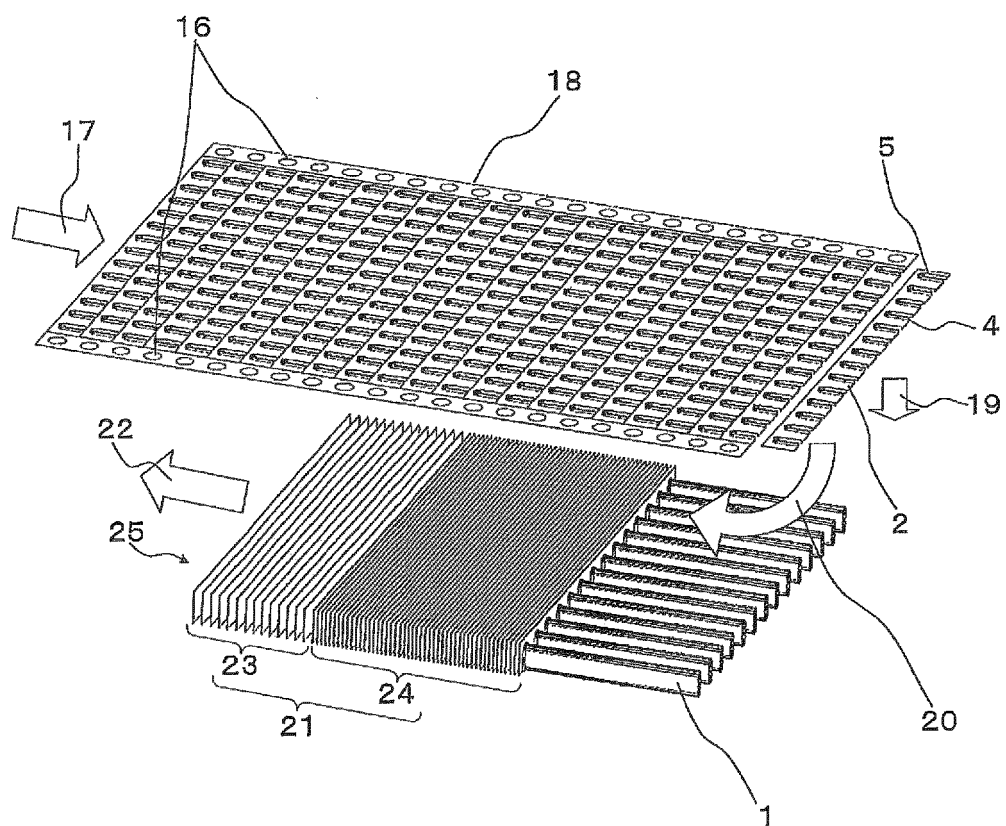
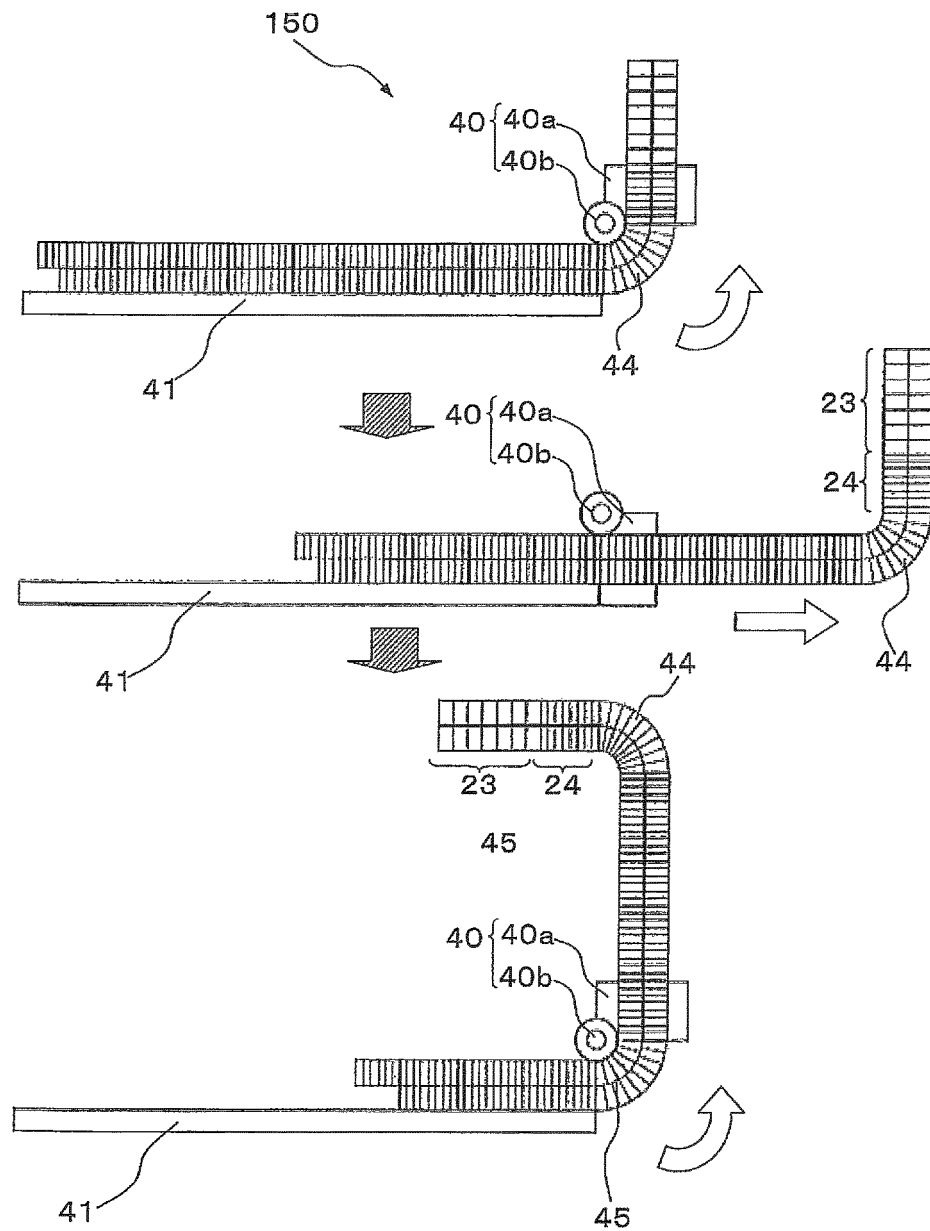


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER

F24F1/16(2011.01)i, F24F1/50(2011.01)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)

F24F1/16, F24F1/50

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-112303 A (Mitsubishi Electric Corp.), 09 June 2011 (09.06.2011), paragraphs [0014], [0015]; fig. 1 to 3 (Family: none)	1-7
Y	JP 2010-121895 A (Sanyo Electric Co., Ltd.), 03 June 2010 (03.06.2010), paragraph [0024]; fig. 4, 5 (Family: none)	1-7
Y	JP 63-233296 A (Matsushita Electric Industrial Co., Ltd.), 28 September 1988 (28.09.1988), claims; fig. 2, 3 (Family: none)	1-7



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

21 February, 2012 (21.02.12)

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Name and mailing address of the ISA/
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Authorized officer

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International application No.

PCT/JP2011/007260

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2010-286187 A (Mitsubishi Electric Corp.), 24 December 2010 (24.12.2010), paragraphs [0011] to [0013]; fig. 1 (Family: none)	1-7
A	JP 10-259931 A (Hitachi, Ltd.), 29 September 1998 (29.09.1998), paragraph [0035] (Family: none)	1-7

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REFERENCES CITED IN THE DESCRIPTION

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