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(54) **BENDING WORK METHOD FOR HEAT EXCHANGER**

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## Description

### FIELD

**[0001]** The present invention relates to a heat exchanger bending method and particularly a heat exchanger bending method that performs bending by pressing a flat panel-like heat exchanger, in which heat transfer fins and heat transfer tubes are arranged with parts of the heat transfer fins projecting in a direction orthogonal to a lengthwise direction of the heat transfer tubes, against a bending die in such a way as to wrap the heat exchanger around the bending die.

### BACKGROUND ART

**[0002]** Conventionally, there has been the heat exchanger bending method described in patent citation 1 (Japanese Utility Model Application No. 58-47318). This heat exchanger bending method performs bending by pressing a flat panel-like heat exchanger, which comprises fins (heat transfer fins) and pipes (heat transfer tubes), against a curved surface of a forming ram (bending die) in such a way as to wrap the heat exchanger around the curved surface of the forming ram. By performing this kind of bending, the heat exchanger can be placed compactly inside a machine such as an outdoor unit of an air conditioning apparatus.

**[0003]** JP 10-166 091 A discloses a method to attain bending at a plurality of points and bending to an angle of 180° quickly and simultaneously regarding bending of peripheral finned tube. By the return motion of the cylinder, the early bending guide is shifted, and a main link and an auxiliary link are turned centering a link pin. By the gears fixed to the link pin, the main link comes to have the same bend angle as the auxiliary link oppositely, so all the main links are bent at equal angle alternately; at the same time by running the driving motor the chain is moved inward and the outermost slide bearing is moved inward, by which the main links are folded progressively and quick and simultaneous multiple bending of peripheral finned tube is attained. After that, by pushing up the swinging shaft by pusher and by thrusting the guide with the pusher, a form of bending at 180 degrees is attained.

**[0004]** JP 2002 224 756 A, on which the preamble of clam 1 is based, discloses a method for bending a fin and heating tube of a heat exchanger without deformation, wherein a heat exchanger for an outdoor unit of an air conditioner whose front surface area is increased to improve its performance is required to be accommodated by being bent within a space determined for miniaturization of a product. A clamping accuracy of the heat exchanger is improved and a fin slide plate a is provided on a bending mold contacting the inside of the fin, even in the case of a heat exchanger whose bending and raising dimensions are short. When two types of heat exchangers are bended at the same time, the fin slide plate is disposed between the upper and lower fins, thereby enabling the bending without deformation of the fin.

**[0005]** EP 2 394 753 A1, which is a late published document forming a state of the art according to Art. 54(3) EPC, discloses an apparatus for bending a heat exchange battery comprising a shaper, which is adapted to pivot about an axis of rotation, first gripper means for gripping a first end of the heat exchange battery, second gripper means for gripping a second end of the heat exchange battery, wherein the second gripper means are movable from and to the shaper in a sliding direction perpendicular to the axis of rotation, first drive means for rotating the shaper and second drive means for moving the second gripper means in the sliding direction. The shaping surface has at least two curved shaping portions which have different bend radiuses and which are joined by a flat shaping portion.

### SUMMARY OF INVENTION

**[0006]** However, in the heat exchanger bending method of patent citation 1, there is the problem that parts of the heat transfer fins projecting in a direction orthogonal to the lengthwise direction of the heat transfer tubes buckle. For this reason, in a case where the heat exchanger that has been bent is used as a heat exchanger that performs heat exchange between refrigerant that flows inside the heat transfer tubes and an air flow that travels across the heat transfer tubes, there is the concern that this buckling will end up increasing the flow resistance of the air flow.

**[0007]** It is an object of the present invention to suppress projecting sections of heat transfer fins from buckling in a heat exchanger bending method that performs bending by pressing a flat panel-like heat exchanger, in which heat transfer fins and heat transfer tubes are arranged with parts of the heat transfer fins projecting in a direction orthogonal to a lengthwise direction of the heat transfer tubes, against a bending die in such a way as to wrap the heat exchanger around the bending die.

**[0008]** A heat exchanger bending method according to the present invention is defined by claim 1. Dependent claims relate to preferred embodiments.

**[0009]** The heat exchanger bending method performs bending by pressing a flat panel-like heat exchanger, in which heat transfer fins and heat transfer tubes are arranged with parts of the heat transfer fins projecting in a direction orthogonal to a lengthwise direction of the heat transfer tubes, against a bending die in such a way as to wrap the heat exchanger around the bending die. This heat exchanger bending method employs, as the bending die, a bending die having a curved surface whose bend radius changes in such a way as to become smaller from a starting point to an end point of the bending of the heat exchanger. The curved surface has a first curved surface, which is positioned near the starting point and has a bend radius that is large, and a main curved surface, which is positioned near the end point and has a bend radius that is smaller than that of the first curved surface. Additionally, this heat exchanger bending method performs a first step at the time of the start of the bending of the heat exchanger and performs a main step after the first step. The first step is a step of bending the heat exchanger by pressing projecting sections of the heat transfer fins against the first curved surface in such a way as to wrap the projecting sections of the heat transfer fins around the first curved surface. The main step is a step of bending the heat exchanger by pressing the projecting sections of the heat transfer fins against the main curved surface in such a way as to wrap the projecting sections of the heat transfer fins around the main curved surface.

**[0010]** In a bending method that presses the heat exchanger against the bending die in such a way as to wrap the heat exchanger around the bending die, a load acts on the heat transfer fins from the bending die. For this reason, in a bending method that presses the heat exchanger against the bending die in such a way as to wrap the heat exchanger around the bending die, the problem arises that the projecting sections of the heat transfer fins buckle. In particular, when a bending die having a single bend radius is employed as the bending die like conventionally, the load acting on the heat transfer fins from the bending die becomes extremely large at the time of the start of the bending of the heat exchanger, and as a result, the problem tends to arise that the projecting sections of the heat transfer fins buckle.

**[0011]** Thus, focusing on the fact that, as described above, there is a tendency for the load acting on the heat transfer fins from the bending die to become large at the time of the start of the bending of the heat exchanger, this bending method employs, as the bending die, a bending die having a curved surface whose bend radius changes in such a way as to become smaller from the starting point to the end point of the bending of the heat exchanger. Additionally, at the time of the start of the bending of the heat exchanger, the bending method performs bending with the first curved surface having the bend radius that is large, and thereafter the bending method performs bending with the main curved surface having the bend radius that is small.

**[0012]** For this reason, in this bending method, the load acting on the heat transfer fins from the bending die can be reduced at the time of the start of the bending of the heat exchanger, and because of this, the projecting sections of heat transfer fins can be suppressed from buckling.

**[0013]** Further, the first curved surface is formed within the range of a wrap angle of up to 10 degrees from the starting point.

**[0014]** In this bending method, by setting the range of the wrap angle of the first curved surface to be equal to or less than 10 degrees, the size of the section of the heat exchanger on which the bending has been performed can be suppressed from becoming too large.

**[0015]** Alternatively or in addition to the above, the curved surface further has, between the first curved surface and the main curved surface, a second curved surface having a bend radius that is smaller than that of the first curved surface and larger than that of the main curved surface. Additionally, between the first step and the main step, this heat exchanger bending method performs a second step of bending the heat exchanger by pressing the projecting sections of the heat transfer fins against the second curved surface in such a way as to wrap the projecting sections of the heat transfer fins around the second curved surface.

**[0016]** When the curved surface is configured by only the first curved surface and the main curved surface and the main step is performed immediately after the first step, there is the concern that the load acting on the projecting sections of the heat transfer fins from the bending die will suddenly change as a result of the bend radius of the curved surface becoming smaller.

**[0017]** Thus, in this bending method, the second curved surface, which has the bend radius that is smaller than that of the first curved surface and larger than that of the main curved surface, is disposed between the first curved surface and the main curved surface, and the second step is performed between the first step and the main step.

**[0018]** For this reason, in this bending method, the load acting on the projecting sections of the heat transfer fins from the bending die can be kept from suddenly changing, and because of this, the projecting sections of the heat transfer fins can be reliably suppressed from buckling.

**[0019]** Further, the first curved surface and the second curved surface are formed within the range of a wrap angle of up to 20 degrees from the starting point.

**[0020]** In this bending method, by setting the range of the wrap angle of the first curved surface and the second curved surface to be equal to or less than 20 degrees, the size of the section of the heat exchanger on which the bending has been performed can be suppressed from becoming too large.

**[0021]** According to some preferred embodiments, the heat exchanger performs heat exchange between refrigerant that flows inside the heat transfer tubes and an air flow that travels across the heat transfer tubes. The projecting sections of the heat transfer fins are positioned on a downstream side of the air flow in the heat exchanger.

**[0022]** In a case where a heat exchanger on which bending has been performed is used as a heat exchanger that performs heat exchange between refrigerant and an air flow, there is a tendency for the flow resistance of the air flow in the section of the heat exchanger on which the bending has been performed to become larger in comparison to the section on which the bending has not been performed. For this reason, in order to suppress the heat transfer fins from buckling, it is preferred that the projecting sections of the heat transfer fins not be disposed in the section of the heat exchanger on which the bending is to be performed. However, in the case of bending the heat exchanger that performs heat exchange between the refrigerant and the air flow, there are many cases in which the heat exchanger is bent in such a way that the surface of the heat exchanger on the upstream side of the air flow becomes convex. Further, due to reasons such as promoting the drainage of water adhering to the heat exchanger, oftentimes the projecting sections of the heat transfer fins are disposed on the downstream side of the air flow in the heat exchanger.

**[0023]** With respect to this, in this heat exchanger bending method, the projecting sections of the heat transfer fins can be suppressed from buckling even in a heat exchanger that performs heat exchange between refrigerant that flows inside the heat transfer tubes and an air flow that travels across the heat transfer tubes.

**[0024]** According to some preferred embodiments, the heat transfer tubes are flat tubes having a wide width in the direction orthogonal to the lengthwise direction.

**[0025]** According to some preferred embodiments, the heat transfer tubes are multi-hole flat tubes in which plural flow path holes lined up side by side in the width direction are formed.

**[0026]** In a heat exchanger that employs flat tubes or multi-hole flat tubes as the heat transfer tubes, there is a tendency for the load acting on the projecting sections of the heat transfer fins from the bending die to become larger at the time of the bending in comparison to a heat exchanger that employs round tubes as the heat transfer tubes. For this reason, the problem tends to arise that the projecting sections of the heat transfer fins buckle.

**[0027]** With respect to this, in this heat exchanger bending method, the projecting sections of the heat transfer fins can be suppressed from buckling even in a heat exchanger that employs flat tubes or multi-hole flat tubes as the heat transfer tubes.

**[0028]** According to some preferred embodiments, the heat transfer fins are brazed to the heat transfer tubes.

**[0029]** In a heat exchanger in which the heat transfer fins are brazed to the heat transfer tubes, the strength of the heat transfer fins tends to become lower and the projecting sections of the heat transfer fins tend to buckle due to the effect of the heat at the time of the brazing and a reduction in thickness caused by the brazing material on the surfaces of the heat transfer fins flowing to different places.

**[0030]** With respect to this, in this heat exchanger bending method, the projecting sections of the heat transfer fins can be suppressed from buckling even in a heat exchanger in which the heat transfer fins are brazed to the heat transfer tubes.

## BRIEF DESCRIPTION OF DRAWINGS

**[0031]**

FIG. 1 is a perspective view showing the general internal structure of an outdoor unit having an outdoor heat exchanger in which a heat exchanger bending method and a heat exchanger pertaining to an embodiment of the present invention are employed.

FIG. 2 is an enlarged perspective view of portion D of FIG. 1.

FIG. 3 is a view showing the bending of the outdoor heat exchanger (a preparatory state).

FIG. 4 is a cross-sectional view of a bending die.

FIG. 5 is a view showing the bending of the outdoor heat exchanger (a bending state).

FIG. 6 is a view showing a section of the outdoor heat exchanger on which the bending has been performed (the bending die is indicated by a long dashed double-short dashed line).

FIG. 7 is a cross-sectional view of the bending die in modification 1.

FIG. 8 is a view showing a section of the outdoor heat exchanger in modification 1 on which the bending has been performed (the bending die is indicated by a long dashed double-short dashed line).

FIG. 9 is a cross-sectional view of the bending die in modification 2.

FIG. 10 is a cross-sectional view of the bending die in modification 3.

## DESCRIPTION OF EMBODIMENT

**[0032]** A heat exchanger bending method and a heat exchanger pertaining to the present invention will be described on the basis of the drawings.

-General Configuration of Outdoor-

**[0033]** FIG. 1 is a perspective view showing the general internal structure of an outdoor unit 1 having an outdoor heat exchanger 7 in which a heat exchanger bending method and a heat exchanger pertaining to an embodiment of the present invention are employed. The outdoor unit 1 configures an air conditioning apparatus that performs air conditioning by a vapor compression refrigeration cycle. The outdoor unit 1 is connected to an indoor unit (not shown in the drawings) via refrigerant connection tubes 2 and 3. In the description below, the near side of the page of FIG. 1 will be called the "front surface", the far side of the page of FIG. 1 will be called the "back surface", the left side of the page of FIG. 1 will be called the "left side surface", the right side of the page of FIG. 1 will be called the "right side surface", the upper side of the page of FIG. 1 will be called the "top surface", and the lower side of the page of FIG. 1 will be called the "bottom surface".

**[0034]** The outdoor unit 1 mainly has a substantially cuboid box-like unit casing 4, a compressor 6, the outdoor heat exchanger 7, and an outdoor fan 8. In addition to these, various instruments, valves, and refrigerant tubes and the like are housed in the outdoor unit 1, but description thereof will be omitted here.

[0035] The unit casing 4 mainly has a bottom panel 41, a top panel 42 (indicated by a long dashed double-short dashed line), a front panel 43 (indicated by a long dashed double-short dashed line), a side panel 44 (indicated by a long dashed double-short dashed line), and a partition panel 45.

[0036] The bottom panel 41 is a horizontally long, substantially rectangular panel-like member that configures the bottom surface section of the unit casing 4. The peripheral edge portion of the bottom panel 41 is folded upward. Two fixing legs 5 that become fixed to an onsite installation surface are disposed on the outer surface of the bottom panel 41. The fixing legs 5 extend from the front side to the rear side of the unit casing 4.

[0037] The top panel 42 is a horizontally long, substantially rectangular panel-like member that configures the top surface section of the unit casing 4.

[0038] The front panel 43 is a panel-like member that mainly configures the front surface section and the front portion of the right side surface of the unit casing 4. The lower portion of the front panel 43 is fixed to the bottom panel 41 with screws or the like. An air outlet 43a is formed in the front panel 43. The air outlet 43a is an opening for blowing out outdoor air that has been taken into the unit casing 4 through air inlets (not shown in the drawings) formed in the back surface and the left side surface of the unit casing 4 (see arrows A to C, which show the flow of the air).

[0039] The side panel 44 is panel-like member that mainly configures the rear portion of the right side surface and the right back surface section of the unit casing 4. The lower portion of the side panel 44 is fixed to the bottom panel 42 with screws or the like.

[0040] The partition panel 45 is a panel-like member that is placed on the bottom panel 41. The partition panel 45 extends vertically. The partition panel 45 is placed in such a way as to partition the interior space of the unit casing 4 into two spaces on the left and right (that is, a blower compartment S1 and a machine compartment S2). The lower portion of the partition panel 45 is fixed to the bottom panel 41 with screws or the like.

[0041] In this way, the interior space of the unit casing 4 is divided by the partition panel 45 into the blower compartment S1 and the machine compartment S2. The blower compartment S1 is a space enclosed by the bottom panel 41, the top panel 42, the front panel 43, and the partition panel 45. The machine compartment S2 is a space enclosed by the bottom panel 41, the top panel 42, the front panel 43, the side panel 44, and the partition panel 45. Additionally, mainly the outdoor heat exchanger 7 and the outdoor fan 8 are placed in the blower compartment S1. Mainly a compressor 6 is placed in the machine compartment S2.

[0042] The compressor 6 is a compressor for compressing low-pressure refrigerant in the refrigeration cycle into high-pressure refrigerant. The compressor 6 is a substantially upright cylinder-like hermetic compressor. The compressor 6 is placed in the substantial center of the machine compartment S2 as seen in a plan view.

[0043] The outdoor heat exchanger 7 is a heat exchanger that functions as a refrigerant radiator using the outdoor air as a heat source during cooling and functions as a refrigerant evaporator using the outdoor air as a heat source during heating. The outdoor heat exchanger 7 is a fin-and-tube heat exchanger configured by plural heat transfer tubes 11 and plural heat transfer fins 21. The outdoor heat exchanger 7 is bent in such a way as to form a substantial L shape as seen in a plan view. The outdoor heat exchanger 7 is placed in the blower compartment S2 in such a way as to follow the left side surface and the back surface of the unit casing 4 and in such a way as to surround the left side surface side and the back surface side of the outdoor fan 8. The detailed configuration of the outdoor heat exchanger 7 and a method of manufacturing the outdoor heat exchanger 7 will be described later.

[0044] The outdoor fan 8 is a blower fan that functions to take air into the blower compartment S1 through the air inlets (not shown in the drawings) formed in the left side surface and back surface of the unit casing 4, cause the air to pass through the outdoor heat exchanger 7, and blow out the air from the air outlet 43a formed in the front surface of the unit casing 4. Here, the outdoor fan 8 is a propeller fan and is placed on the downstream side of the outdoor heat exchanger 7 in the blower compartment S1.

-Detailed Configuration of Outdoor Heat Exchanger-

[0045] Next, the detailed configuration of the outdoor heat exchanger 7 will be described using FIG. 1 and FIG. 2. Here, FIG. 2 is an enlarged perspective view of portion D of FIG. 1.

[0046] The outdoor heat exchanger 7 mainly has the heat transfer tubes 11 and the heat transfer fins 21. In addition to these, header tubes and so forth are also disposed in the outdoor heat exchanger 7, but description thereof will be omitted here.

[0047] The heat transfer tubes 11 comprise flat tubes that have planar portions 12 having a wide width in a direction orthogonal to a lengthwise direction of the heat transfer tubes 11. A plurality of the heat transfer tubes 11 are arranged, with the planar portions 12 facing the up-and-down direction, in such a way that flow spaces through which the outdoor air flows in the width direction of the planar portions 12 (the direction of arrows A and B in FIG. 1 and the direction of arrow E in FIG. 2) are intervened between the heat transfer tubes 11 in the up-and-down direction.

[0048] Plural flow path holes 13 lined up side by side in the width direction in such a way as to penetrate the planar portions 12 in the lengthwise direction are formed in the planar portions 12. Additionally, the refrigerant flows through each of the flow path holes 13. The heat transfer tubes 11 comprise a metal material such as aluminum and are manufactured by extrusion or the like. In this way, here, multi-hole flat tubes in which the plural flow path holes 13 are formed are employed as the heat transfer tubes 11, and the heat transfer coefficient on the refrigerant side improves.

**[0049]** The heat transfer fins 21 are corrugated fins configured as a result of a panel-like material whose width direction dimension is larger than the width direction dimension of the planar portions 12 of the heat transfer tubes 11 being folded in a corrugated shape along the lengthwise direction of the heat transfer tubes 11. Here, assuming that W1 is the width direction dimension of the planar portions 12 and W2 is the width direction dimension of the heat transfer fins 21, the relationship between the widths is such that the width direction dimension W1 of the planar portions 12 is smaller than the width direction dimension W2 of the heat transfer fins 21. The heat transfer fins 21 comprise a metal material such as aluminum. Additionally, the heat transfer fins 21 have fin body portions 22 and fin edge portions 23.

**[0050]** The fin body portions 22 are sections placed in the flow spaces between the planar portions 12 in the up-and-down direction, and upper ends 24 and lower ends 25 are formed on the fin body portions 22 by folding the panel-like material into a corrugated shape along the lengthwise direction of the heat transfer tubes 11. The upper ends 24 are joined by brazing to the undersurfaces of the planar portions 12. The lower ends 25 are joined by brazing to the upper surfaces of the planar portions 12. Further, plural body-side cut-and-raised portions 26 are formed in the fin body portions 22 by cutting and raising the up-and-down direction center sections of the fin body portions 22 in order to improve the heat exchange efficiency. Here, the body-side cut-and-raised portions 26 are cut and raised in louver shapes. Additionally, the body-side cut-and-raised portions 26 are formed in such a way that their directions of inclination with respect to the outdoor air flow are opposite between the sections on the upstream side and the sections on the downstream side of the outdoor air flow.

**[0051]** The fin edge portions 23 are sections where parts of the heat transfer fins 21 project in a direction orthogonal to the lengthwise direction of the heat transfer tubes 11. More specifically, the fin edge portions 23 are sections where parts of the heat transfer fins 21 project from each of the flow spaces outward in the width direction of the heat transfer tubes 11 (here, outward on both width direction sides). Upper ends 27 and lower ends 28 are formed on the fin edge portions 23. The upper ends 27 and the lower ends 28 are sections that are cut and raised in the up-and-down direction when folding the panel-like material in a corrugated shape along the lengthwise direction of the heat transfer tubes 11 to form the upper ends 24 and the lower ends 25 by disposing incisions in the neighborhoods of fold lines for forming the upper ends 24 and the lower ends 25. Here, the upper ends 27 and the lower ends 28 are formed on only the fin edge portions 23-among the fin edge portions 23 formed on both width direction sides of the heat transfer tubes 11-positioned on the downstream side of the outdoor air flow (the outdoor fan 8 side in FIG. 1 and the arrow E side in FIG. 2). For this reason, the fin edge portions 23 adjacent to each other in the up-and-down direction contact or are in proximity to each other via the upper ends 27 and the lower ends 28. Here, the upper ends 27 and the lower ends 28 are cut and raised in substantially rectangular shapes because the incisions are disposed parallel to the width direction of the heat transfer tubes 11, but the upper ends 27 and the lower ends 28 may also be cut and raised in substantially triangular shapes or substantially trapezoidal shapes by disposing the incisions obliquely to the width direction of the heat transfer tubes 11. Further, plural edge-side cut-and-raised portions 29a and 29b are formed in the fin edge portions 23 by cutting and raising the up-and-down direction center sections of the fin edge portions 23 in order to improve the heat exchange efficiency. The edge-side cut-and-raised portions 29a positioned on the upstream side of the outdoor air flow are formed in such a way as to have the same up-and-down direction width as that of the body-side cut-and-raised portions 26. The edge-side cut-and-raised portions 29b positioned on the downstream side of the outdoor air flow are formed in such a way that their up-and-down direction width is shorter than that of the body-side cut-and-raised portions 26. Here, the edge-side cut-and-raised portions 29a and 29b are cut and raised in louver shapes. Additionally, the edge-side cut-and-raised portions 29a and 29b are formed in such a way that their directions of inclination with respect to the outdoor air flow are opposite between the sections on the upstream side and the sections on the downstream side of the outdoor air flow. In this way, here, a lowering of the strength of the fin edge portions 23 is suppressed because the up-and-down direction width of the edge-side cut-and-raised portions 29b is made shorter than that of the body-side cut-and-raised portions 26.

**[0052]** Additionally, when the outdoor heat exchanger 7 having the configuration described above is caused to function as a refrigerant radiator during cooling, the refrigerant that flows inside the heat transfer tubes 11 and the outdoor air serving as a cooling source that flows through the flow spaces in such a way as to travel across the heat transfer tubes 11 perform heat exchange via the heat transfer fins 21 and the heat transfer tubes 11. Thus, radiation of the heat of the refrigerant is performed. Further, when the outdoor heat exchanger 7 is caused to function as a refrigerant evaporator, the refrigerant that flows through the heat transfer tubes 11 and the outdoor air serving as a heating source that flows through the flow spaces in such a way as to travel across the heat transfer tubes 11 perform heat exchange via the heat transfer fins 21 and the heat transfer tubes 11. Thus, evaporation of the refrigerant is performed. At this time, dew condensation water forms on the surfaces of the heat transfer fins 21, but because the projecting fin edge portions 23 are formed on the downstream side of the outdoor air flow in the outdoor heat exchanger 7, the dew condensation water can be allowed to flow downward via the fin edge portions 23. In particular, here, as described above, the fin edge portions 23 have the upper ends 27 and the lower ends 28, and the fin edge portions 23 adjacent to each other in the up-and-down direction contact or are in proximity to each other, so the water drainage performance further improves.

-Method of Manufacturing Outdoor Heat Exchanger-

**[0053]** Next, a method of manufacturing the outdoor heat exchanger 7 will be described using FIG. 1 to FIG. 6. Here, FIG. 3 is a view showing the bending of the outdoor heat exchanger 7 (a preparatory state). FIG. 4 is a cross-sectional view of a bending die 55. FIG. 5 is a view showing the bending of the outdoor heat exchanger 7 (a bending state). FIG. 6 is a view showing a section of the outdoor heat exchanger 7 on which the bending has been performed (the bending die 55 is indicated by a long dashed double-short dashed line).

**[0054]** First, the flat panel-like outdoor heat exchanger 7 on which bending has not been performed is prepared. Here, as described above, the flat panel-like outdoor heat exchanger 7 is a heat exchanger in which a plurality of the straight tube-like heat transfer tubes 11 are arranged with the planar portions 12 opposing each other and the flow spaces being intervened between the planar portions 12 and in which the heat transfer fins 21 folded in corrugated shapes are arranged in each of the flow spaces, with the heat transfer tubes 11 and the heat transfer fins 21 being layered on top of each other. Here, the heat transfer fins 21 are brazed to both surfaces of the planar portions 12. More specifically, a brazing material is disposed on both surfaces of the planar portions 12, and brazing of the heat transfer tubes 11 and the heat transfer fins 21 to each other is performed by heating them in a brazing furnace or the like with the plural heat transfer tubes 11 on which the brazing material has been disposed and the heat transfer fins 21 being layered on top of each other. Because of this, as described above, the flat panel-like outdoor heat exchanger 7 in which the fin edge portions 23 project outward on both width direction sides of the planar portions 12 is obtained. In this flat panel-like outdoor heat exchanger 7, as shown in FIG. 6, in regard to one direction in the width direction of the planar portions 12 (the direction facing the downstream side of the outdoor air flow), among the fin edge portions 23, the fin edge portions 23 on which the upper ends 27 and the lower ends 28 are formed project. Further, in regard to the other direction in the width direction of the planar portions 12 (the direction facing the upstream side of the outdoor air flow), the fin edge portions 23 on which the upper ends 27 and the lower ends 28 are not formed project toward the upstream side of the outdoor air flow.

**[0055]** Next, a bending apparatus 51 is used to bend the flat panel-like outdoor heat exchanger 7. The bending apparatus 51 is an apparatus that performs bending by pressing the flat panel-like outdoor heat exchanger 7 against the bending die 55 in such a way as to wrap the outdoor heat exchanger 7 around the bending die 55. The bending apparatus 51 described below is an example for implementing the bending method pertaining to the present invention, but another bending apparatus may also be used provided that it uses the bending die 55 that is the characteristic of the bending method pertaining to the present invention.

**[0056]** The bending apparatus 51 mainly has a base plate 52, two clamps 53 and 54, and the bending die 55. The base plate 52 is a member on which the flat panel-like outdoor heat exchanger 7 is placed with at least one lengthwise direction end of the flat panel-like outdoor heat exchanger 7 sticking out. The first clamp 53 is a member that supports, from below (see arrow F in FIG. 3), the one lengthwise direction end of the outdoor heat exchanger 7 sticking out from the base plate 52. The second clamp 54 is a member that supports the section of the outdoor heat exchanger 7 on the opposite side of the first clamp 53 across the bending die 55 by clamping that section between the second clamp 54 and the base plate 52 from above (see arrow G in FIG. 3). The bending die 55 mainly has a bending member 56 and a mandrel 57. The bending member 56 is a member that supports the one lengthwise direction end of the outdoor heat exchanger 57 sticking out from the base plate 52 by clamping the one lengthwise direction end between the bending member 56 and the first clamp 53 from above. The mandrel 57 is a member having a curved surface 58 on its outer surface that contacts the outdoor heat exchanger 7. The mandrel 57 is driven to rotate in the direction of arrow H by a motor not shown in the drawings. Additionally, the bending member 56 is fixed to the mandrel 57. For this reason, the bending member 56 moves in accompaniment with the rotation of the mandrel 57 and presses the outdoor heat exchanger 7 against the curved surface 58 of the bending die 55 in such a way as to wrap the outdoor heat exchanger 7 around the curved surface 58 of the bending die 55. Because of this, the one lengthwise direction end of the outdoor heat exchanger 7 sticking out from the base plate 52 becomes bent. Here, in order to bend the flat panel-like outdoor heat exchanger 7 in such a way as to form a substantial L shape, the mandrel 57 rotates 90 degrees from a starting point (point XS in FIG. 4 and FIG. 6) of the bending of the outdoor heat exchanger 7 to an end point (point XE in FIG. 4 and FIG. 6). Further, parts of the heat transfer fins 21 (here, the fin edge portions 23 of the heat transfer fins 21) of the outdoor heat exchanger 7 project in a direction orthogonal to the lengthwise direction of the heat transfer tubes 11, so the fin edge portions 23 that are the projecting sections of the heat transfer fins 21 contact the curved surface 58 of the mandrel 57.

**[0057]** In a bending method such as described above that presses the outdoor heat exchanger 7 against the bending die 55 in such a way as to wrap the outdoor heat exchanger 7 around the bending die 55, a load acts on the heat transfer fins 21 from the bending die 55. For this reason, in a bending method that presses the outdoor heat exchanger 7 against the bending die 55 in such a way as to wrap the outdoor heat exchanger 7 around the bending die 55, the problem arises that the fin edge portions 23 that are the projecting sections of the heat transfer fins 21 buckle. In particular, when a bending die having a single bend radius is employed as the bending die 55 like conventionally, the load acting on the heat transfer fins 21 from the bending die 55 becomes extremely large at the time of the start of the bending of the outdoor heat exchanger 7 (the vicinity of point XS in FIG. 4 and FIG. 6), and as a result, the problem tends to arise that the fin edge portions 23 buckle.

**[0058]** Thus, focusing on the fact that there is a tendency for the load acting on the heat transfer fins 21 from the bending die 55 to become large at the time of the start of the bending of the outdoor heat exchanger 7, the bending method of the present invention employs, as the curved surface 58 of the bending die 55, a curved surface whose bend radius changes in such a way as to become smaller from the starting point XS to the end point XE of the bending of the outdoor heat exchanger 7. Specifically, the curved surface 58 has a first curved surface 61 and a main curved surface 62. The first curved surface 61 is positioned near the starting point XS (specifically in the range of a wrap angle θ1 from the starting point XS to a point XI) and has a bend radius R1 that is large. The main curved surface 62 is positioned near the end point XE (specifically in the range of a wrap angle θM from the point X1 to the end point XE) and has a bend radius RM that is smaller than that of the first curved surface 61. For this reason, in the bending of the outdoor heat exchanger 7, because of the rotation of the mandrel 57, at the time of the start of the bending, a first step of bending the outdoor heat exchanger 7 by pressing the fin edge portions 23 that are the projecting sections of the heat transfer fins 21 against the first curved surface 61 in such a way as to wrap the fin edge portions 23 around the first curved surface 61 is performed. Additionally, after this first step, a main step of bending the outdoor heat exchanger 7 by pressing the fin edge portions 23 that are the projecting sections of the heat transfer fins 21 against the main curved surface 62 in such a way as to wrap the fin edge portions 23 around the main curved surface 62 is performed. In this way, the curved surface 58 of the bending die 55 (specifically the first curved surface 61 and the main curved surface 62) is transferred to the flat panel-like outdoor heat exchanger 7.

**[0059]** Because of this, in this bending method, the load acting on the heat transfer fins 21 from the bending die 55 can be reduced at the time of the start of the bending of the outdoor heat exchanger 7, and the fin edge portions 23 that are the projecting sections of the heat transfer fins 21 can be suppressed from buckling.

**[0060]** Further, here, the wrap angle θ1 of the first curved surface 61 is set to be equal to or less than 10 degrees, so the size of the section of the outdoor heat exchanger 7 on which the bending has been performed can be suppressed from becoming too large.

**[0061]** Further, here, as described above, the outdoor heat exchanger 7 on which the bending has been performed is used as a heat exchanger that performs heat exchange between refrigerant and an air flow. For this reason, there is a tendency for the flow resistance of the outdoor air flow in the section of the outdoor heat exchanger 7 on which the bending has been performed to become larger in comparison to the section on which the bending has not been performed. For this reason, in order to suppress the heat transfer fins 21 from buckling, it is preferred that the projecting sections of the heat transfer fins 21 (here, the fin edge portions 23) not be disposed in the section of the outdoor heat exchanger 7 on which the bending is to be performed. However, in the case of bending the outdoor heat exchanger 7 that performs heat exchange between the refrigerant and the outdoor air flow, there are many cases in which, as shown in FIG. 1, the outdoor heat exchanger 7 is bent in such a way that the surface of the outdoor heat exchanger 7 on the upstream side of the outdoor air flow becomes convex. Further, due to reasons such as promoting the drainage of water adhering to the outdoor heat exchanger 7, oftentimes the fin edge portions 23 that are the projecting sections of the heat transfer fins 21 are disposed on the downstream side of the outdoor air flow in the outdoor heat exchanger 7. Moreover, here, in order to promote allowing the dew condensation water forming on the surfaces of the heat transfer fins 21 to flow downward, the upper ends 27 and the lower ends 28 formed by cutting and raising are disposed on the fin edge portions 23 projecting on the downstream side of the outdoor air flow in the outdoor heat exchanger 7. For this reason, the upper ends 27 and the lower ends 28 of the fin edge portions 23 contact the curved surface 58 of the mandrel 57. These upper ends 27 and lower ends 28 are sections formed by cutting and raising, so their strength becomes extremely weak.

**[0062]** With respect to this, in this bending method, as described above, the load acting on the heat transfer fins 21 from the bending die 55 can be reduced at the time of the start of the bending of the outdoor heat exchanger 7. For this reason, the fin edge portions 23 that are the projecting sections of the heat transfer fins 21 can be suppressed from buckling despite the fact that the heat exchanger is a heat exchanger that performs heat exchange between the refrigerant that flows inside the heat transfer tubes 11 and the outdoor air flow that travels across the heat transfer tubes 11.

**[0063]** Further, here, as described above, the bending method employs, as the heat transfer tubes 11, flat tubes having a wide width in the direction orthogonal to the lengthwise direction. Moreover, the flat tubes employed for the heat transfer tubes 11 are multi-hole flat tubes in which the plural flow path holes 13 lined up side by side in the width direction are formed. For this reason, there is a tendency for the load acting on the projecting sections of the heat transfer fins from the bending die to become larger at the time of the bending in comparison to the case of employing round tubes as the heat transfer tubes. For this reason, the problem tends to arise that the projecting sections of the heat transfer fins (here, the fin edge portions 23) buckle.

**[0064]** With respect to this, in this bending method, as described above, the load acting on the heat transfer fins 21 from the bending die 55 at the time of the start of the bending of the outdoor heat exchanger 7 can be reduced. For this reason, the fin edge portions 23 can be suppressed from buckling despite the fact that the heat exchanger is a heat exchanger that employs flat tubes or multi-hole flat tubes as the heat transfer tubes 11.

**[0065]** Moreover, here, as described above, the heat transfer fins 21 are brazed to the heat transfer tubes 11. For this reason, the strength of the heat transfer fins 21 tends to become lower and the projecting sections of the heat transfer fins 21 (here, the fin edge portions 23) tend to buckle due to the effect of the heat at the time of the brazing and a reduction in thickness caused by the brazing material on the surfaces of the heat transfer fins flowing to different places.

**[0066]** With respect to this, in this bending method, as described above, the load acting on the heat transfer fins 21 from the bending die 55 at the time of the start of the bending of the outdoor heat exchanger 7 can be reduced. For this reason, the fin edge portions 23 can be suppressed from buckling despite the fact that the heat exchanger is a heat exchanger in which the heat transfer fins 21 are brazed to the heat transfer tubes 11.

-Modification 1 of Method of Manufacturing Outdoor Heat Exchanger-

**[0067]** The outdoor heat exchanger 7 bending method described above employs, as the curved surface 58 of the bending die 55, a curved surface having only the first curved surface 61 and the main curved surface 62 and performs the main step immediately after the first step. However, in this bending method, there is the concern that the load acting on the projecting sections of the heat transfer fins 21 (here, the fin edge portions 23) from the bending die 55 will suddenly change as a result of the bend radius of the curved surface 58 becoming smaller.

**[0068]** Thus, in the bending method of the present modification, as shown in FIG. 7 and FIG. 8, as the curved surface 58 of the bending die 55, a second curved surface 63 having a bend radius R2 that is smaller than that of the first curved surface 61 and larger than that of the main curved surface 62 is disposed between the first curved surface 61 and the main curved surface 62. Specifically, the first curved surface 61 is positioned near the starting point XS (specifically in the range of the wrap angle $\theta 1$ from the starting point XS to the point XI) and has the bend radius R1 that is large. The second curved surface 63 is positioned in the range of a wrap angle $\theta 2$ from the point XI, which is the end point of the first curved surface 61, to a point X2 and has the bend radius R2 that is smaller than that of the first curved surface 61 and larger than that of the main curved surface 62. The main curved surface 62 is positioned near the end point XE (specifically in the range of the wrap angle $\theta M$ from the point X2 to the end point XE) and has the bend radius RM that is smaller than that of the second curved surface 63. Additionally, between the first step and the main step, the bending method performs a second step of bending the outdoor heat exchanger 7 by pressing the projecting sections of the heat transfer fins 21 (here, the fin edge portions 23) against the second curved surface 63 in such a way as to wrap the projecting sections of the heat transfer fins 21 around the second curved surface 63. Here, FIG. 7 is a cross-sectional view of the bending die 55 in the present modification. FIG. 8 is a view showing a section of the outdoor heat exchanger 7 in the present modification on which the bending has been performed (the bending die 55 is indicated by a long dashed double-short dashed line).

**[0069]** Because of this, in the bending method of the present modification, the load acting on the projecting sections of the heat transfer fins 21 (here, the fin edge portions 23) from the bending die 55 can be kept from suddenly changing, and the fin edge portions 23 can be reliably suppressed from buckling.

**[0070]** Moreover, here, the wrap angle (that is, $\theta 1 + \theta 2$) of the first curved surface 61 and the second curved surface 63 is set to be equal to or less than 20 degrees, so the size of the section of the outdoor heat exchanger 7 on which the bending has been performed can be suppressed from becoming too large.

-Modification 2 of Method of Manufacturing Outdoor Heat Exchanger-

**[0071]** The outdoor heat exchanger 7 bending method of modification 1 described above employs, as the curved surface 58 of the bending die 55, a curved surface having the first curved surface 61, the second curved surface 63, and the main curved surface 62 and performs the main step after the first step and the second step. However, in order to further reduce the change in the load acting on the projecting sections of the heat transfer fins 21 (here, the fin edge portions 23) from the bending die 55, the bending method may also employ a curved surface whose bend radius changes in such a way to become even smaller in multiple stages.

**[0072]** In this case, in order to satisfy FIG. 9 and the following general expression, it suffices to make the bend radius of the curved surface 58 of the bending die 55 smaller in multiple stages.

**[0073]** That is, assuming that a line segment OnXn is equal to a bend radius Rn (here, On is the center of the bend radius Rn) and the mandrel 57 rotates $\theta n$ degrees in the state of the bend radius Rn such that the bending (here, the mandrel 57 rotates 90 degrees in total) proceeds, then $\Sigma\theta = \theta 1 + \theta 2 + \cdots + \theta n - 1 = 90$ degrees.

**[0074]** Here, the bend radius Rn is equal to or less than the length of the line segment On - 1Xn, so R1 ≥ R2 ≥ ··· ≥ Rn.

**[0075]** It will be understood that the curved surface 58 described above, which has the first curved surface 61 and the main curved surface 62, and also the curved surface 58 of modification 1, which has the first curved surface 61, the second curved surface 63, and the main curved surface 62, fit the general expression described above if indexes "S", "M", and "E" are replaced with "1", "n", and "n" and n = 2 or n = 3. Further, if n is increased to infinity, the curved surface 58 (that is, the line joining the starting point XS and the end point XE) forms a generally involute curved surface.

**[0076]** Because of this, in the bending method of the present modification, in essence, a second step of performing bending with the second curved surface whose bend radius becomes smaller in multiple stages is performed between the first step of performing bending with the first curved surface and the main step of performing bending with the main curved surface. Additionally, the change in the load acting on the projecting sections of the heat transfer fins 21 (here, the fin edge portions 23) from the bending die 55 can be reduced even more than in the bending method of modification 1 described above.

-Modification 3 of Method of Manufacturing Outdoor Heat Exchanger-

**[0077]** The outdoor heat exchanger 7 bending method described above employs, as the bending die 55, a bending die in which the curved surface 58 is smoothly continuous from the starting point to the end point of the bending. For example, the bending die 55 in modification 1 employs a bending die in which the first curved surface 61, the second curved surface 63, and the main curved surface 62 are smoothly continuous. However, it is not invariably necessary for the first curved surface 61, the second curved surface 63, and the main curved surface 62 to be smoothly continuous, and the first curved surface 61, the second curved surface 63, and the main curved surface 62 may also be continuous via some steps.

**[0078]** For example, as shown in FIG. 10, in the bending die 55 of modification 1, a step 64 may also exist between the second curved surface 63 and the main curved surface 62. Here, a mandrel having only the main curved surface 62 is employed as the mandrel 57, and a bending member disposed with an attachment 65 having the first curved surface 61 and the second curved surface 63 formed on its surface is employed as the bending member 56. For this reason, the thick part of the end portion of the attachment 65 on the mandrel 57 side appears as the step 64. That is, the step 64 is formed in such a way that the end portion of the second curved surface 63 on the main curved surface 62 side projects more toward the outer peripheral side than the end portion of the main curved surface 62 on the second curved surface 63 side. The step 64 is a small step of about several mm.

**[0079]** In the present modification also, the same action and effects as those of the outdoor heat exchanger 7 processing bending method described above can be obtained.

**[0080]** For example, let it be assumed that in the configuration of the bending die 55 having the step 64 such as in the present modification, the bend radii R1, R2, and RM of the first curved surface 61, the second curved surface 63, and the main curved surface 62 are 200 mm, 77 mm, and 70 mm, respectively. Further, let it be assumed that the wrap angle θ1 of the first curved surface 61 is 5 degrees, the wrap angle θ2 of the second curved surface 63 is 13 degrees, and the wrap angle θM of the main curved surface 62 is 72 degrees. When this bending die 55 is used to bend the outdoor heat exchanger 7, the load acting on the heat transfer fins 21 from the bending die 55 at the time of the start of the bending of the outdoor heat exchanger 7 can be reduced, and because of this, the projecting sections of the heat transfer fins 21 can be suppressed from buckling.

-Other Embodiments-

**[0081]** An embodiment of the present invention and modifications thereof have been described above on the basis of the drawings, but the specific configurations are not limited to those in the embodiment described above and the modifications thereof and can be changed without departing from the scope of the appended claims.

(A) In the embodiment described above and the modifications thereof, the invention is applied to the outdoor heat exchanger 7 that uses multi-hole flat tubes as the heat transfer tubes 11 and uses corrugated fins as the heat transfer fins 21, but the present invention is not limited to this.

**[0082]** For example, the present invention may also be applied to a heat exchanger that uses flat tubes as the heat transfer tubes. Further, the present invention may also be applied to a heat exchanger that uses round tubes as the heat transfer tubes. Further, the present invention may also be applied to a heat exchanger that uses, as the heat transfer fins, plate fins disposed a predetermined interval apart from each other in the lengthwise direction of the heat transfer tubes.

**[0083]** However, in a heat exchanger that uses round tubes as the heat transfer tubes and uses plate fins as the heat transfer fins, the fixing of the heat transfer tubes and the heat transfer fins to each other is performed by performing tube expansion after the heat transfer tubes have been inserted through the heat transfer fins. For this reason, the effects of heat and the reduction in thickness like in the case of fixing the heat transfer tubes and the heat transfer fins to each other by brazing do not arise, so a lowering of the strength of the sections of the heat transfer fins projecting in a direction orthogonal to the lengthwise direction of the heat transfer tubes is suppressed. Further, because the heat transfer tubes are round tubes, the load received from the bending die becomes smaller in comparison to the case of using flat tubes.

**[0084]** For this reason, the bending method of the present invention is extremely effective with respect to a heat exchanger that uses flat tubes (multi-hole flat tubes) as the heat transfer tubes and uses brazing to fix the heat transfer tubes and the heat transfer fins to each other like in the embodiment described above and the modifications thereof.

**[0085]** (B) In the embodiment described above and the modifications thereof, the present invention is applied when bending the outdoor heat exchanger 7 in such a way as to form a substantial L shape, but the present invention is not limited to this.

**[0086]** For example, the present invention may also be applied when bending the outdoor heat exchanger 7 in such a way as to form a substantial U shape.

**[0087]** (C) In the embodiment described above and the modifications thereof, the present invention is applied to the outdoor heat exchanger 7 that configures an outdoor unit, but the present invention is not limited to this.

**[0088]** For example, the present invention may also be applied to an indoor heat exchanger that configures an indoor unit and heat exchangers and the like in other forms of air conditioning apparatus.

## INDUSTRIAL APPLICABILITY

**[0089]** The present invention is widely applicable to a heat exchanger bending method that performs bending by pressing a flat panel-like heat exchanger, in which heat transfer fins and heat transfer tubes are placed with parts of the heat transfer fins projecting in a direction orthogonal to a lengthwise direction of the heat transfer tubes, against a bending die in such a way as to wrap the heat exchanger around the bending die.

## REFERENCE SIGNS LIST

**[0090]**

| | |
|---|---|
| 7 | Outdoor Heat Exchanger |
| 11 | Heat Transfer Tubes |
| 21 | Heat Transfer Fins |
| 55 | Bending Die |
| 58 | Curved Surface |
| 61 | First Curved Surface |
| 62 | Main Curved Surface |
| 63 | Second Curved Surface |

## CITATION LIST

<Patent Literature>

**[0091]** Patent Citation 1: Japanese Utility Model Application No. 58-47318

## Claims

1. A heat exchanger bending method that performs bending by pressing a flat panel-like heat exchanger (7), in which heat transfer fins (21) and heat transfer tubes (11) are arranged with parts of the heat transfer fins projecting in a direction orthogonal to a lengthwise direction of the heat transfer tubes, against a bending die (55) in such a way as to wrap the heat exchanger around the bending die,
**characterized in that**:

    the heat exchanger bending method employs, as the bending die, a bending die having a curved surface (58) whose bend radius changes in such a way as to become smaller from a starting point to an end point of the bending of the heat exchanger,
    the curved surface has a first curved surface (61), which is positioned near the starting point and has a bend radius that is large, and a main curved surface (62), which is positioned near the end point and has a bend radius that is smaller than that of the first curved surface,
    at the time of the start of the bending of the heat exchanger, the heat exchanger bending method performs a first step of bending the heat exchanger by pressing projecting sections of the heat transfer fins against the first curved surface in such a way as to wrap the projecting sections of the heat transfer fins around the first curved surface, and
    after the first step, the heat exchanger bending method performs a main step of bending the heat exchanger by pressing the projecting sections of the heat transfer fins against the main curved surface in such a way as to wrap the projecting sections of the heat transfer fins around the main curved surface,
    wherein the first curved surface (61) is formed within the range of a wrap angle of up to 10 degrees from the starting point,
    and/or wherein the curved surface (58) further has, between the first curved surface (61) and the main curved surface (62), a second curved surface (63) having a bend radius that is smaller than that of the first curved surface and larger than that of the main curved surface, and
    between the first step and the main step, the heat exchanger bending method performs a second step of bending the heat exchanger (7) by pressing the projecting sections of the heat transfer fins (21) against the second curved surface in such a way as to wrap the projecting sections of the heat transfer fins around the second

curved surface,
wherein the first curved surface (61) and the second curved surface (63) are formed within the range of a wrap angle of up to 20 degrees from the starting point.

**2.** The heat exchanger bending method according to claim 1, wherein the heat exchanger (7) performs heat exchange between refrigerant that flows inside the heat transfer tubes (11) and an air flow that travels across the heat transfer tubes, and
the projecting sections of the heat transfer fins (21) are positioned on a downstream side of the air flow in the heat exchanger.

**3.** The heat exchanger bending method according to claim 1 or 2, wherein the heat transfer tubes (11) are flat tubes having a wide width in the direction orthogonal to the lengthwise direction.

**4.** The heat exchanger bending method according to claim 3, wherein the heat transfer tubes (11) are multi-hole flat tubes in which plural flow path holes lined up side by side in the width direction are formed.

**5.** The heat exchanger bending method according to any one of claims 1 to 4, wherein the heat transfer fins (21) are brazed to the heat transfer tubes (11).

**Patentansprüche**

**1.** Biegeverfahren für einen Wärmetauscher, das Biegen durch Pressen eines flachen plattenartigen Wärmetauschers (7), in dem Wärmeübertragungslamellen (21) und Wärmeübertragungsrohre (11) angeordnet sind, wobei Teile der Wärmeübertragungslamellen in einer Richtung orthogonal zu einer Längsrichtung der Wärmeübertragungsrohre vorstehen, gegen einen Biegestempel (55) derart durchführt, dass der Wärmetauscher um den Biegestempel geschlungen wird,
**dadurch gekennzeichnet, dass**:

das Biegeverfahren für einen Wärmetauscher als den Biegestempel einen Biegestempel mit einer gekrümmten Oberfläche (58) verwendet, dessen Biegungsradius sich derart ändert, dass er von einem Anfangspunkt zu einem Endpunkt der Biegung des Wärmetauschers kleiner wird, die gekrümmte Oberfläche eine erste gekrümmte Oberfläche (61), die nahe dem Anfangspunkt positioniert ist und einen Biegungsradius aufweist, der groß ist, und eine gekrümmte Hauptoberfläche (62), die nahe dem Endpunkt positioniert ist und einen Biegungsradius aufweist, der kleiner als jener der ersten gekrümmten Oberfläche ist, aufweist,
zum Zeitpunkt des Beginns der Biegung des Wärmetauschers das Biegeverfahren für einen Wärmetauscher einen ersten Schritt zum Biegen des Wärmetauschers durch Pressen vorstehender Abschnitte der Wärmeübertragungslamellen gegen die erste gekrümmte Oberfläche derart durchführt, dass die vorstehenden Abschnitte der Wärmeübertragungslamellen um die erste gekrümmte Oberfläche geschlungen werden, und
nach dem ersten Schritt das Biegeverfahren für einen Wärmetauscher einen Hauptschritt zum Biegen des Wärmetauschers durch Pressen der vorstehenden Abschnitte der Wärmeübertragungslamellen gegen die gekrümmte Hauptoberfläche derart durchführt, dass die vorstehenden Abschnitte der Wärmeübertragungslamellen um die gekrümmte Hauptoberfläche geschlungen werden,
wobei

die erste gekrümmte Oberfläche (61) innerhalb eines Bereichs eines Umschlingungswinkel von bis zu 10 Grad vom Anfangspunkt gebildet wird,
und/oder wobei die gekrümmte Oberfläche (58) weiter zwischen der ersten gekrümmten Oberfläche (61) und der gekrümmten Hauptoberfläche (62) eine zweite gekrümmte Oberfläche (63) mit einem Biegungsradius aufweist, der kleiner als jener der ersten gekrümmten Oberfläche und größer als jener der gekrümmten Hauptoberfläche ist, und
zwischen dem ersten Schritt und dem Hauptschritt das Biegeverfahren für einen Wärmetauscher einen zweiten Schritt zum Biegen des Wärmetauschers (7) durch Pressen der vorstehenden Abschnitte der Wärmeübertragungslamellen (21) gegen die zweite gekrümmte Oberfläche derart durchführt, dass die vorstehenden Abschnitte der Wärmeübertragungslamellen um die zweite gekrümmte Oberfläche geschlungen werden,
wobei die erste gekrümmte Oberfläche (61) und die zweite gekrümmte Oberfläche (63) innerhalb des Bereichs eines Umschlingungswinkels von bis zu 20 Grad vom Anfangspunkt gebildet wird.

**2.** Biegeverfahren für einen Wärmetauscher nach Anspruch 1, wobei der Wärmetauscher (7) Wärmeaustausch zwischen Kältemittel, das im Inneren der Wärmeübertragungsrohre (11) fließt, und einem Luftstrom, der sich über die Wärmeübertragungsrohre bewegt, ausführt und
die vorstehenden Abschnitte der Wärmeübertra-

gungslamellen (21) an einer stromabwärts liegenden Seite des Luftstroms in dem Wärmetauscher positioniert sind.

**3.** Biegeverfahren für einen Wärmetauscher nach Anspruch 1 oder 2, wobei die Wärmeübertragungsrohre (11) flache Rohre mit einer weiten Breite in der Richtung orthogonal zu der Längsrichtung sind.

**4.** Biegeverfahren für einen Wärmetauscher nach Anspruch 3, wobei die Wärmeübertragungsrohre (11) mehrlöchrige flache Rohre sind, in welchen mehrere Strömungspfadlöcher, die Seite an Seite in der Breitenrichtung aufgereiht sind, gebildet sind.

**5.** Biegeverfahren für einen Wärmetauscher nach einem der Ansprüche 1 bis 4, wobei die Wärmeübertragungslamellen (21) an die Wärmeübertragungsrohre (11) hartgelötet sind.

**Revendications**

**1.** Procédé de pliage d'échangeur de chaleur qui exécute un pliage en pressant un échangeur de chaleur en forme de plaque (7), dans lequel des ailettes de transfert de chaleur (21) et les tubes de transfert de chaleur (11) sont disposés avec des parties des ailettes de transfert de chaleur faisant saillie dans une direction orthogonale à une direction longitudinale des tubes de transfert de chaleur, contre une matrice de pliage (55) de manière à enrouler l'échangeur de chaleur autour de la matrice de pliage,
**caractérisé en ce que** :

le procédé de pliage d'échangeur de chaleur utilise, comme matrice de pliage, une matrice de pliage présentant une surface courbe (58) dont le rayon de courbure varie de manière à décroître d'un point de départ vers un point de fin du pliage de l'échangeur de chaleur,
la surface courbe présente une première surface courbe (61), qui est positionnée près du point de départ et qui présente un rayon de courbure qui est grand, et une surface courbe principale (62), qui est positionnée près du point de fin et qui présente un rayon de courbure inférieur à celui de la première surface courbe,
au moment du départ du pliage de l'échangeur de chaleur, le procédé de pliage d'échangeur de chaleur exécute une première étape de pliage de l'échangeur de chaleur en pressant des sections faisant saillie des ailettes de transfert de chaleur contre la première surface courbe de manière à envelopper les sections faisant saillie des ailettes de transfert de chaleur autour de la première surface courbe, et
après la première étape, le procédé de pliage d'échangeur de chaleur exécute une étape principale de pliage d'échangeur de chaleur en pressant les sections faisant saillie des ailettes de transfert de chaleur contre la surface courbe principale de manière à enrouler les sections faisant saillie des ailettes de transfert de chaleur autour la surface courbe principale,
dans lequel

la première surface courbe (61) est formée dans la plage d'un angle d'enroulement allant jusqu'à 10 degrés à partir du point de départ,
et/ou dans lequel la surface courbe (58) présente en outre, entre la première surface courbe (61) et la surface courbe principale (62), une seconde surface courbe (63) présentant un rayon de courbure inférieur à celui de la première surface courbe et supérieur à celui de la surface courbe principale, et
entre la première étape et l'étape principale, le procédé de pliage d'échangeur de chaleur exécute une deuxième étape de pliage d'échangeur de chaleur (7) en pressant les sections faisant saillie des ailettes de transfert de chaleur (21) contre la seconde surface courbe de manière à enrouler les sections faisant saillie des ailettes de transfert de chaleur autour de la seconde surface courbe,
dans lequel la première surface courbe (61) et la seconde surface courbe (63) sont formées dans la plage d'un angle d'enroulement allant jusqu'à 20 degrés à partir du point de départ.

**2.** Procédé de pliage d'échangeur de chaleur selon la revendication 1, dans lequel l'échangeur de chaleur (7) exécute un échange de chaleur entre du frigorigène qui circule à l'intérieur des tubes de transfert de chaleur (11) et un flux d'air qui se déplace à travers les tubes de transfert de chaleur, et
les sections faisant saillie des ailettes de transfert de chaleur (21) sont positionnées en aval du flux d'air dans l'échangeur de chaleur.

**3.** Procédé de pliage d'échangeur de chaleur selon la revendication 1 ou 2, dans lequel les tubes de transfert de chaleur (11) sont des tubes plats présentant une largeur large dans la direction orthogonale à la direction longitudinale.

**4.** Procédé de pliage d'échangeur de chaleur selon la revendication 3, dans lequel les tubes de transfert de chaleur (11) sont des tubes plats multi-trous dans lesquels sont formés plusieurs trous de trajet d'écoulement alignés côte à côte dans la direction de largeur.

**5.** Procédé de pliage d'échangeur de chaleur selon l'une quelconque des revendications 1 à 4, dans lequel les ailettes de transfert de chaleur (21) sont brasées aux tubes de transfert de chaleur (11).

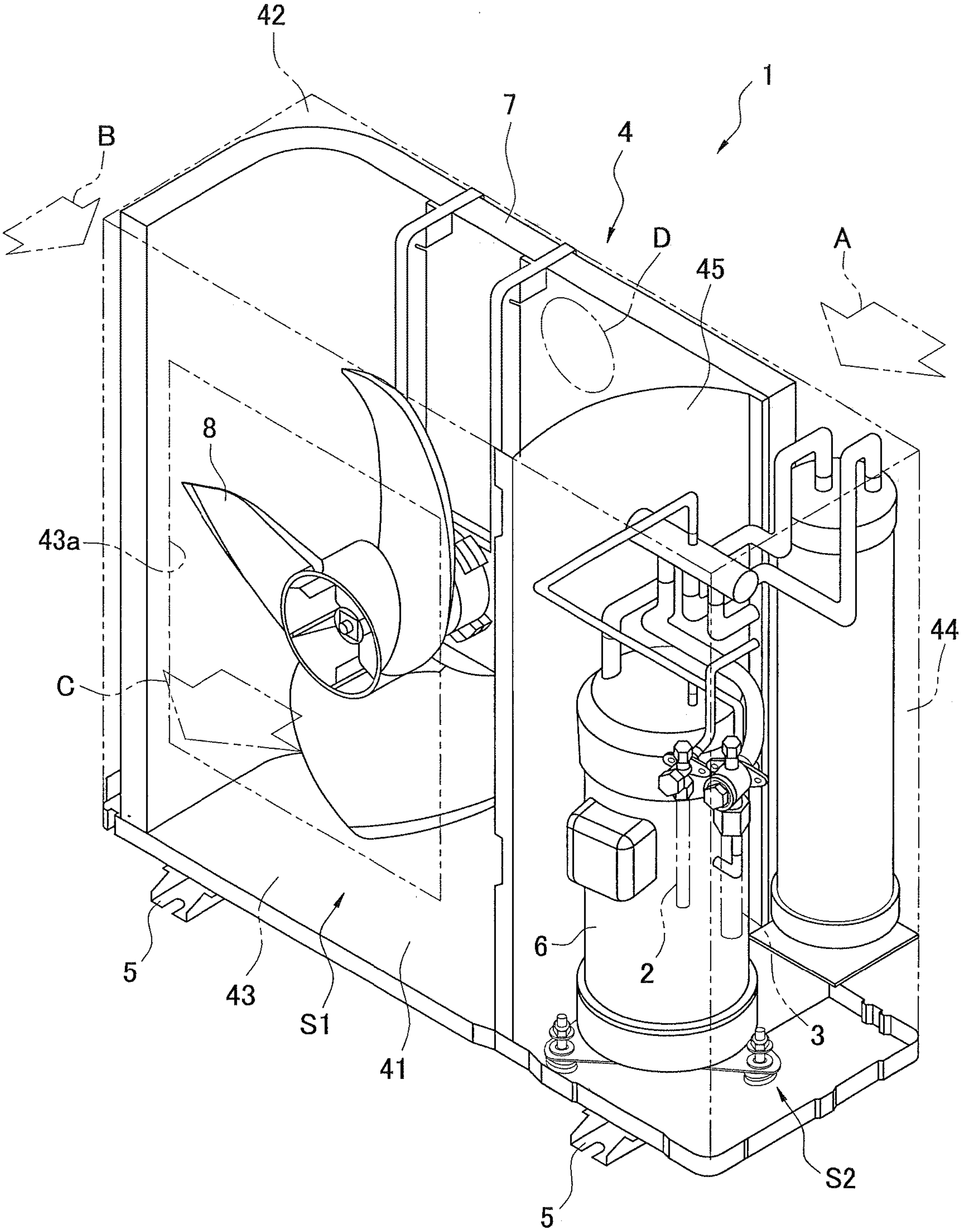



FIG. 1

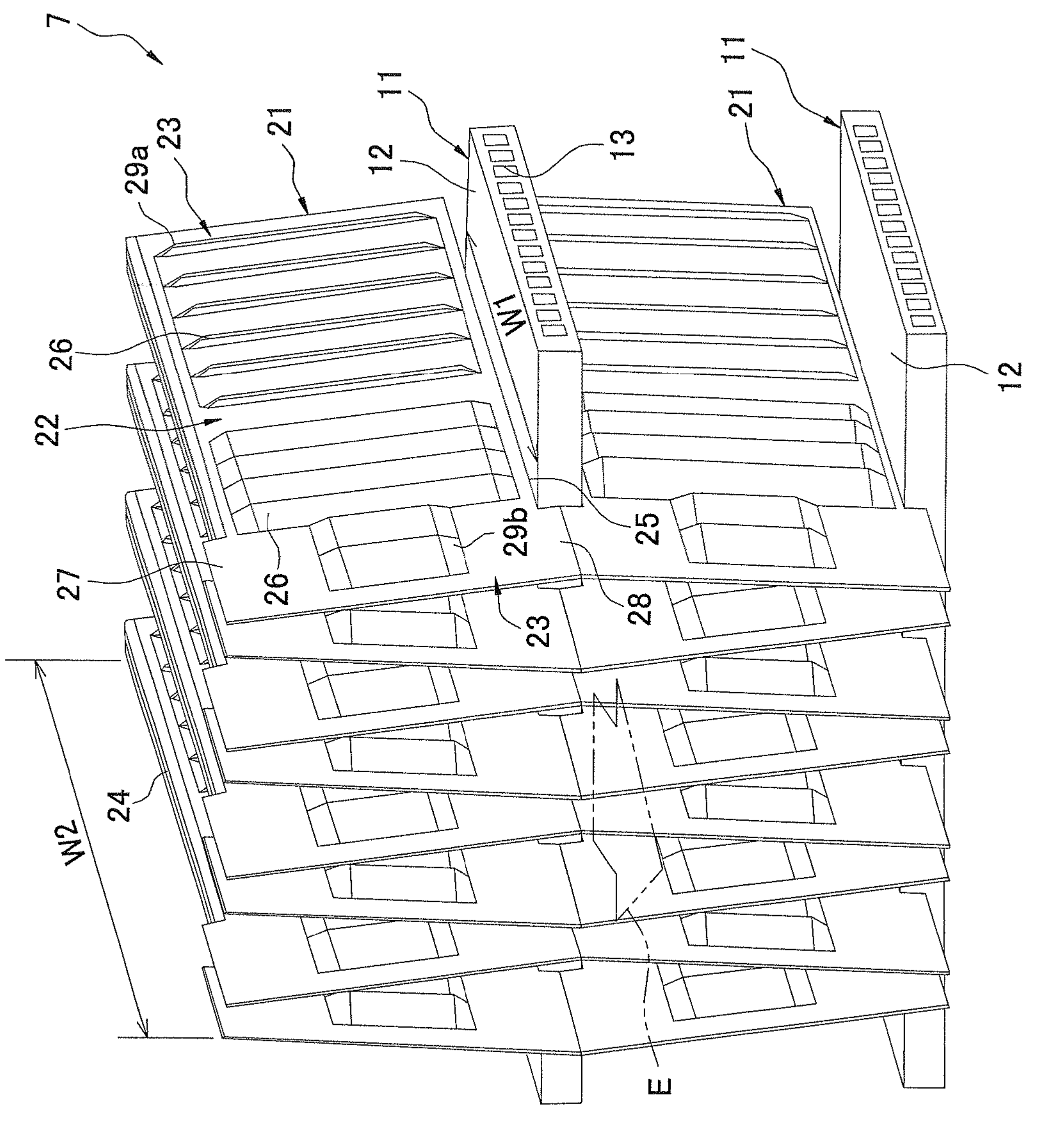



FIG. 2

FIG. 3

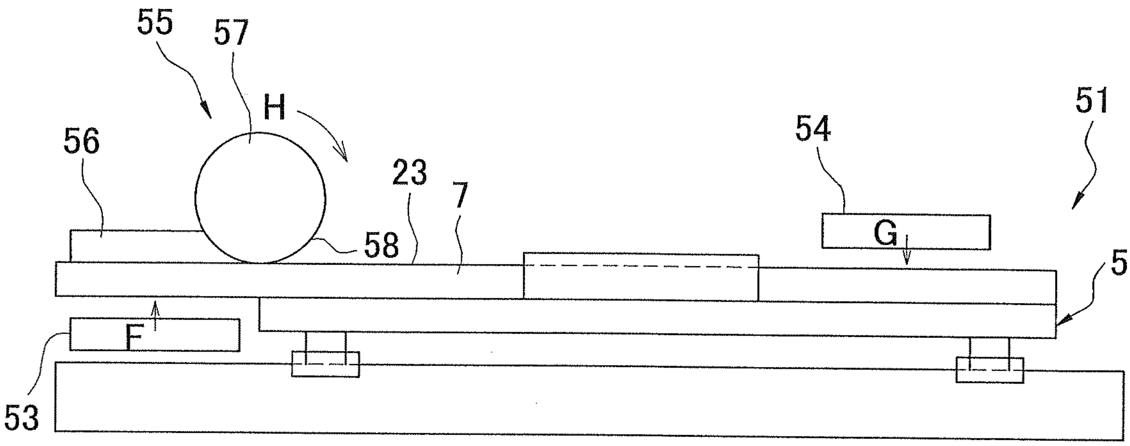

55
57
H
56
23
7
54
51
G
58
52
F
53

FIG. 4

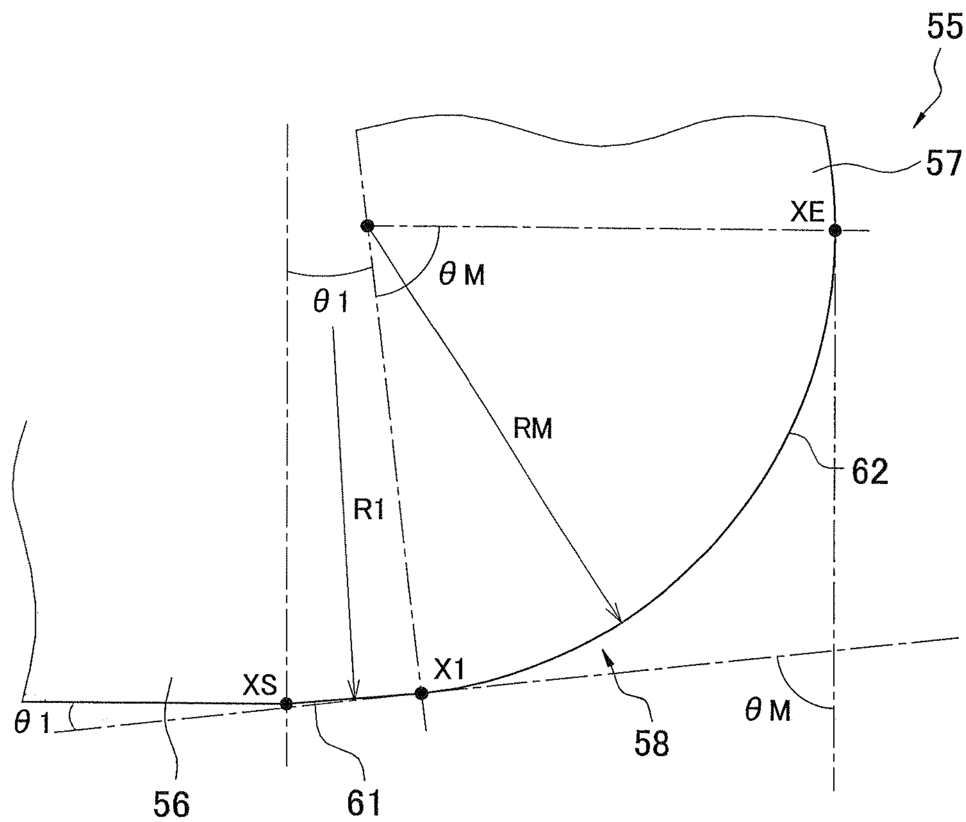

55
57
XE
θM
θ1
RM
R1
62
X1
XS
θ1
θM
58
56
61

FIG. 5

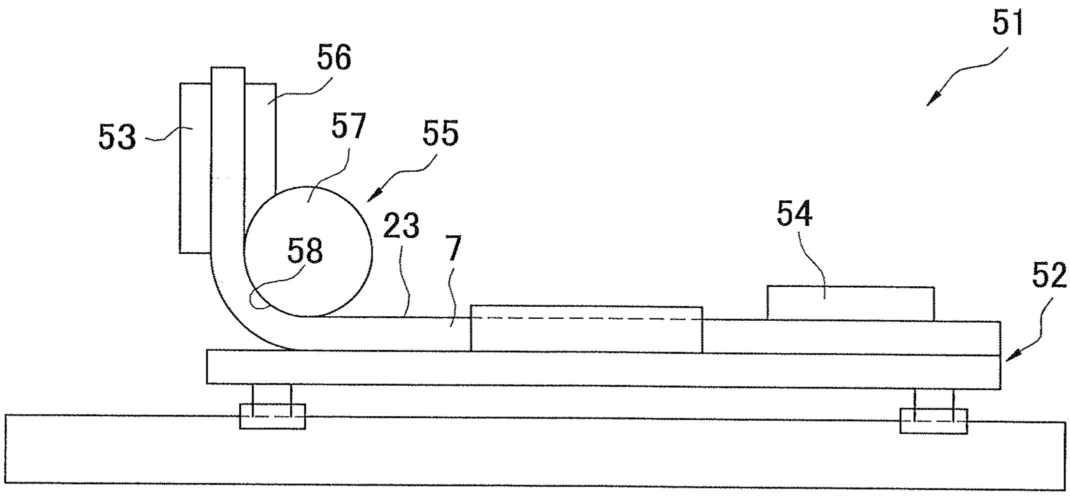
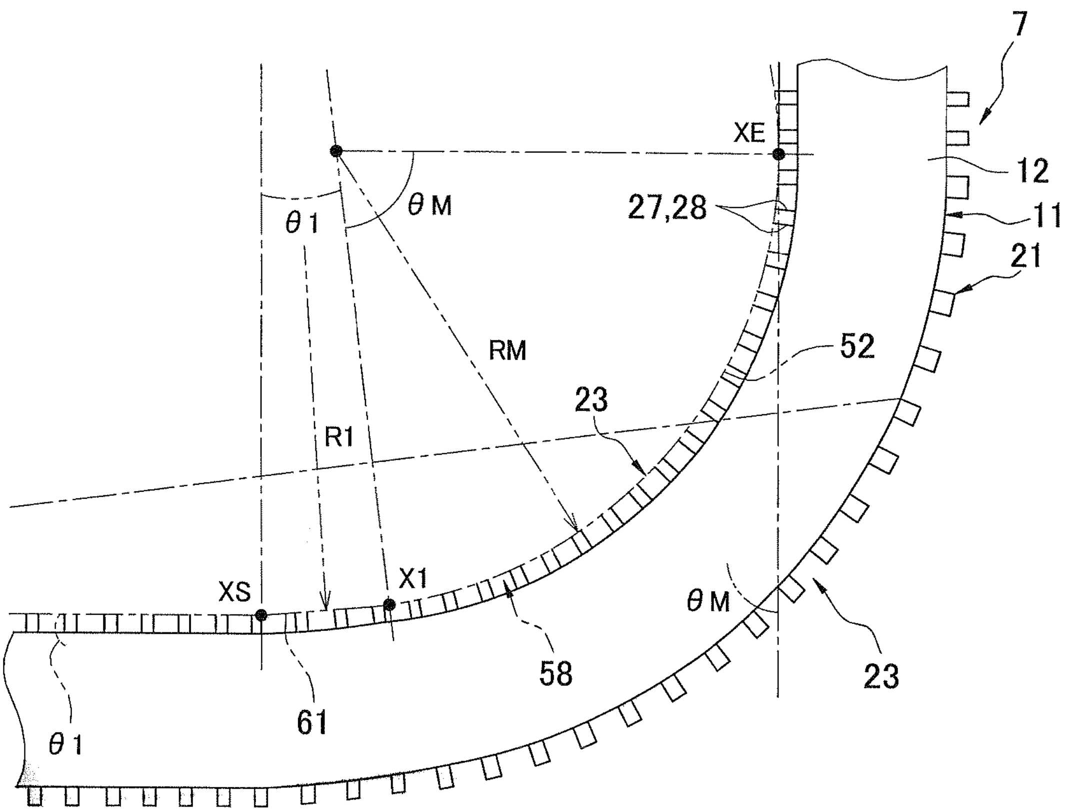
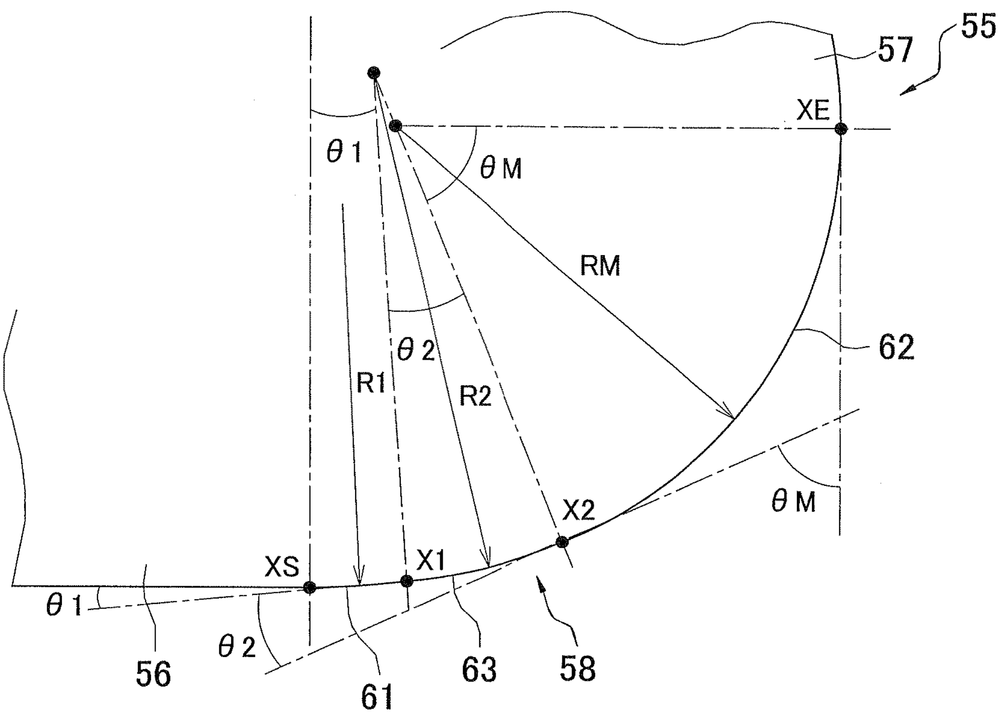

51
56
53
57
55
23
54
58
7
52

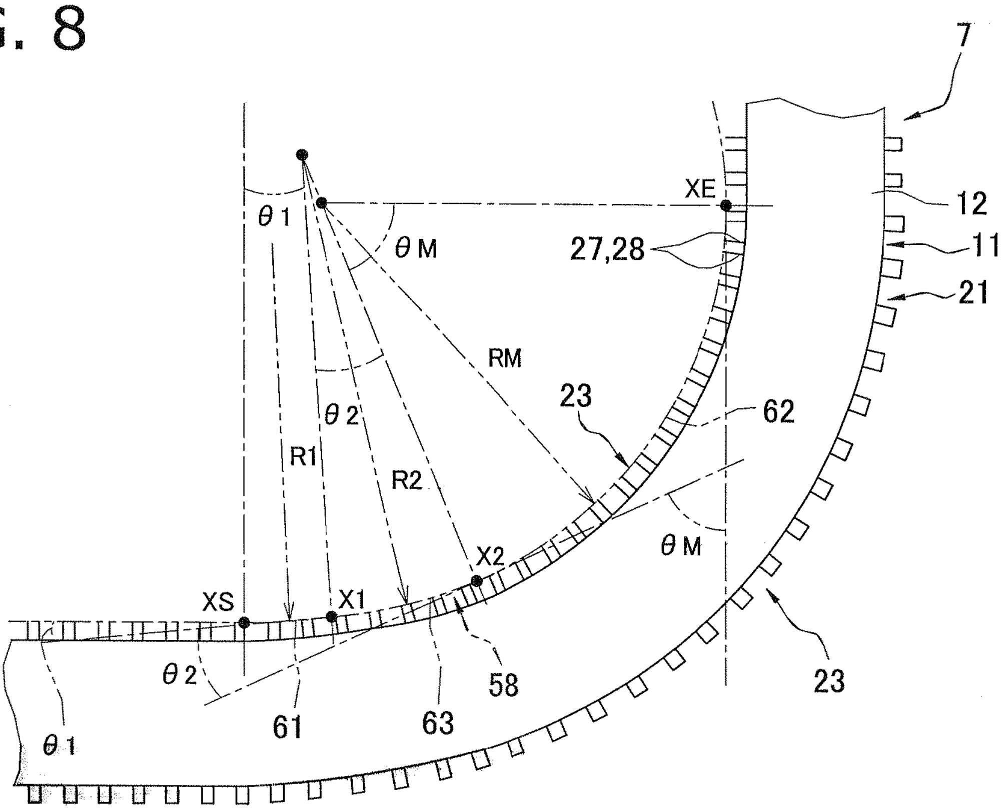
FIG. 6


7
XE
12
θM
27,28
11
θ1
21
RM
52
23
R1
XS
X1
θM
58
23
61
θ1

# FIG. 7


55
57
XE
θ1
θM
RM
62
θ2
R1
R2
θM
X2
XS
X1
θ1
θ2
56
61
63
58

# FIG. 8


7
XE
12
θ1
θM
27,28
11
21
RM
23
62
θ2
R1
R2
θM
X2
XS
X1
θ2
58
23
61
63
θ1

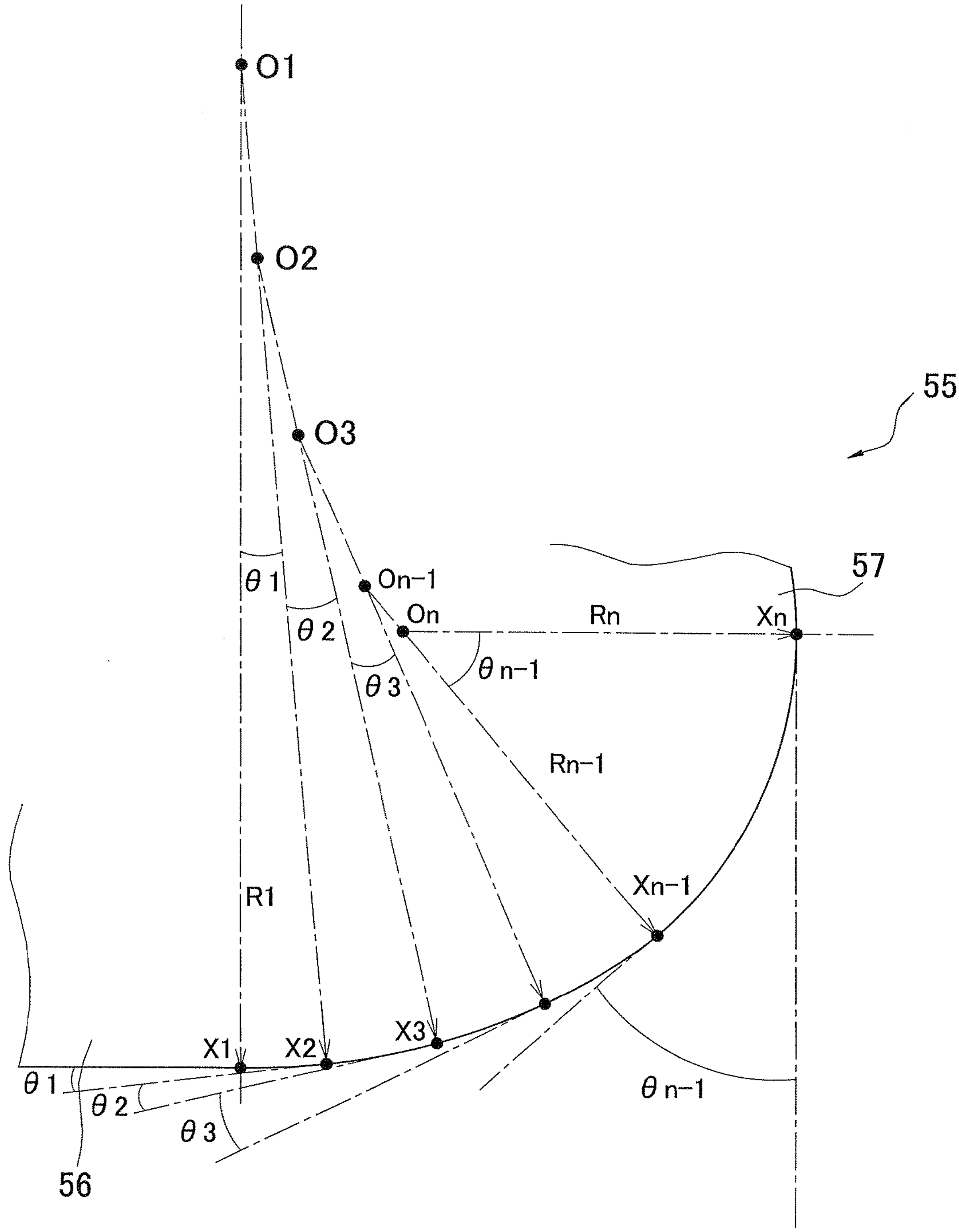

O1
O2
O3
55
57
On-1
On
Rn
Xn
θ1
θ2
θn-1
θ3
Rn-1
R1
Xn-1
X1
X2
X3
θ1
θ2
θ3
θn-1
56

FIG. 9

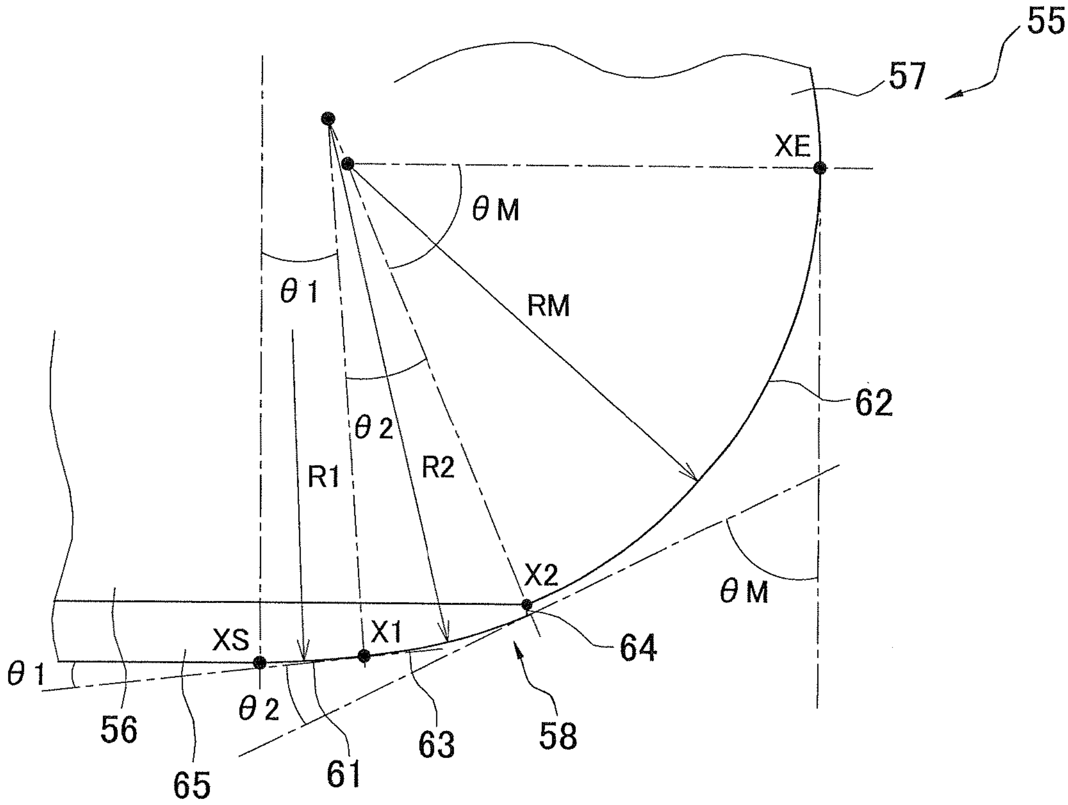



FIG. 10

## REFERENCES CITED IN THE DESCRIPTION

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