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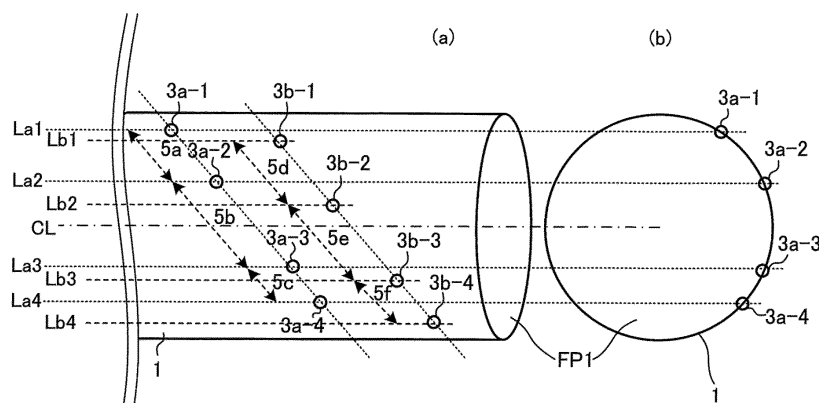
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(54) **HEAT EXCHANGER, REFRIGERATION CYCLE DEVICE, AND METHOD FOR MANUFACTURING HEAT EXCHANGER**

(57) A heat exchanger according to an embodiment of the present disclosure includes: a first tube through which a first heat medium flows; and a second tube through which a second heat medium flows, the second tube being wound around the first tube, the first tube having a plurality of protrusions protruding inside of the first

tube, the plurality of protrusions being provided in a plurality of streaks being provided in a spiral manner in a direction to which the first heat medium flows in the first tube, one streak of the plurality of streaks including the plurality of protrusions each being arranged at unequal spacing intervals.

FIG. 5



Description

Technical Field

5 **[0001]** The present disclosure relates to a heat exchanger including a first tube and a second tube wound around the first tube, a refrigeration cycle apparatus including the heat exchanger, and a method of manufacturing the heat exchanger.

Background Art

10 **[0002]** Conventionally, there has been a heat exchanger including a first tube in which a path through which a first heat medium flows is formed, and a second tube in which a path through which a second heat medium flows is formed, the second tube being wound around the outer periphery of the first tube. In such a heat exchanger, heat is exchanged between the first heat medium flowing in the first tube and the second heat medium flowing in the second tube. The first tube may be called a core tube. The second tube may be called an external tube. One example of the first heat medium is water or antifreeze. One example of the second heat medium is refrigerant.

15 **[0003]** As such a heat exchanger, as described in Patent Literature 1, there has been proposed "a heat exchanger including a core tube having a plurality of protrusions on the inside of the core tube, formed by pressing the outside of the core tube, and a winding tube wound around the outside of the core tube".

20 **[0004]** The heat exchanger of Patent Literature 1 includes the core tube having the plurality of protrusions on the inside of the core tube, formed by pressing the outside of the core tube. By making the core tube in such a manner, in the heat exchanger of Patent Literature 1, a flow of the first heat medium flowing in the core tube is agitated by the protrusions, thereby improving a heat exchange performance between water as the first heat medium flowing in the core tube and refrigerant as the second heat medium flowing in the winding tube.

25 Citation List

Patent Literature

30 **[0005]** Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2006-317114

Summary of Invention

Technical Problem

35 **[0006]** In the heat exchanger of Patent Literature 1, when forming the plurality of protrusions on the inside of the core tube by pressing the outside of the core tube, as a method of forming the plurality of protrusions, a gearwheel-like jig is used, and teeth parts of the gearwheel-like jig are pressed against the outside of the core tube to form the inside protrusions in a spiral manner. In the following description, the gearwheel-like jig is simply referred to as the jig. Moreover, for a further improvement of the heat exchange performance by adding the protrusions, it is possible to provide a large number of inside protrusions in a spiral direction with the use of a plurality of jigs. The plurality of protrusions are provided by independently operating each of the plurality of jigs.

40 **[0007]** In the case where the protrusions are formed by the plurality of jigs, the positional relationship between the protrusions to be added by the respective gearwheels is determined by the phase difference between the respective gearwheels. Depending on the phase difference between the respective jigs, the protrusions to be added by one jig and the protrusions to be added by other jig may be aligned with each other in a tube axis direction. A flow of the first heat medium is agitated by the protrusions provided on an upstream side of the flow of the first heat medium, thereby improving the heat exchange performance. On the other hand, at the protrusions provided on a downstream side of the flow of the first heat medium, the flow rate is reduced, the agitation effect is decreased, and the effect of improving the heat exchange performance by the protrusions is decreased.

45 **[0008]** Considering the above problem in the background, it is a purpose of the matters recited in the present disclosure to provide a heat exchanger configured to improve the heat exchange performance by avoiding a decrease in the agitation effect of the plurality of protrusions, a refrigeration cycle apparatus including the heat exchanger, and a method of manufacturing the heat exchanger.

55 Solution to Problem

[0009] A heat exchanger of an embodiment of the present disclosure includes: a first tube through which a first heat

medium flows; and a second tube through which a second heat medium flows, the second tube being wound around the first tube, the first tube having a plurality of protrusions protruding inside of the first tube, the plurality of protrusions being provided in a plurality of streaks being provided in a spiral manner in a direction to which the first heat medium of the first path flows in the first tube, one streak of the plurality of streaks including the plurality of protrusions each being arranged at unequal spacing intervals.

Advantageous Effects of Invention

[0010] According to the heat exchanger of the embodiment of the present disclosure, in a projection in which the first tube is projected in the tube axis direction, adjacent protrusions do not overlap, and therefore the flow rate is not reduced even at the protrusions provided on the downstream side of the flow of the first heat medium, and the heat exchange performance is improved.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a schematic configuration diagram schematically illustrating an example of a circuit configuration of a refrigeration cycle apparatus including a heat exchanger according to Embodiment 1 of the present disclosure.

[Fig. 2] Fig. 2 is a perspective diagram schematically illustrating a configuration of the heat exchanger according to Embodiment 1 of the present disclosure.

[Fig. 3] Fig. 3 is an explanatory diagram for explaining an example of providing protrusions on a first tube of the heat exchanger according to Embodiment 1 of the present disclosure.

[Fig. 4] Fig. 4 is an explanatory diagram for explaining a conventional example of providing protrusions on the first tube as a comparative example.

[Fig. 5] Fig. 5 is an explanatory diagram for explaining the first tube having the protrusions provided by the method of Fig. 3.

[Fig. 6] Fig. 6 is an explanatory diagram for explaining the first tube having the protrusions provided by the method of Fig. 4.

[Fig. 7] Fig. 7 is an explanatory diagram for explaining other example of providing protrusions on the first tube according to Embodiment 1 of the present disclosure.

[Fig. 8] Fig. 8 is an explanatory diagram for explaining the spacing interval of the protrusions of the first tube of the heat exchanger according to Embodiment 1 of the present disclosure.

[Fig. 9] Fig. 9 is an explanatory diagram for explaining the spacing interval of the protrusions of the first tube of the heat exchanger according to Embodiment 1 of the present disclosure.

[Fig. 10] Fig. 10 is an explanatory diagram for explaining a shape of the first tube of the heat exchanger according to Embodiment 2 of the present disclosure.

[Fig. 11] Fig. 11 is an explanatory diagram for explaining a shape of the first tube of the heat exchanger according to Embodiment 3 of the present disclosure.

Description of Embodiments

[0012] Embodiments of the present disclosure will be described hereinafter with reference to the drawings as appropriate. In the following drawings including Fig. 1, the relationship in size among component parts may be different from the actual relationship. In the following drawings including Fig. 1, the component parts labelled with the same reference signs are the same component parts or equivalent, and the same can be said for the entire description. Moreover, the forms of the components stated in the full description are merely examples, and not what limits the scope of matters in present disclosure.

Embodiment 1

[0013] Fig. 1 is a schematic configuration diagram schematically illustrating an example of a circuit configuration of a refrigeration cycle apparatus 200 including a heat exchanger 100 according to Embodiment 1 of the present disclosure. The refrigeration cycle apparatus 200 will be described with reference to Fig. 1.

[0014] In Embodiment 1, the description is given on an assumption that a first heat medium is water, and a second heat medium is refrigerant.

[Overall Configuration of Refrigeration Cycle Apparatus 200]

[0015] The refrigeration cycle apparatus 200 has a refrigerant circuit A1, and a heat medium circuit A2. The refrigerant circuit A1 and the heat medium circuit A2 are thermally connected through the heat exchanger 100. The heat medium circuit A2 is also connected to a water supply circuit A3 through a hot water storage tank 207. The water supply circuit A3 is connected to a hot water supply utility unit U, and configured to supply hot water to the hot water supply utility unit U. Examples of the hot water supply utility unit U include at least one of various loads that require hot water, such as a faucet and a bath of a household. The water supply circuit A3 is connected to a water pipe or other pipe, and is configured to be able to supply water.

[0016] Refrigerant circulates in the refrigerant circuit A1 through a refrigerant tube 20A. Carbon dioxide can be used as the refrigerant. The refrigerant circuit A1 is configured to include a compressor 201 for compressing the refrigerant, the heat exchanger 100 functioning as a condenser, an expansion device 202, and a heat exchanger 203 functioning as an evaporator.

[0017] The compressor 201 compresses the refrigerant. The refrigerant compressed by the compressor 201 is discharged from the compressor 201 and sent to the heat exchanger 100. The compressor 201 can be made of, for example, a rotary compressor, a scroll compressor, a screw compressor, or a reciprocating compressor.

[0018] The heat exchanger 100 functions as a condenser, exchanges heat between high-temperature, high-pressure refrigerant flowing in the refrigerant circuit A1 and water flowing in the heat medium circuit A2, heats the water, and condenses the refrigerant. The heat exchanger 100 is a water-refrigerant heat exchanger that exchanges heat between water and refrigerant. The heat exchanger will be described in detail later.

[0019] The heat exchanger 100 is an equivalent of a heat exchanger of the present disclosure.

[0020] The expansion device 202 expands the refrigerant flowing out of the heat exchanger 100 and reduces the pressure. The expansion device 202 may be made of, for example, an electric expansion valve capable of adjusting the flow rate of the refrigerant. As the expansion device 202, not only the electric expansion valve, but also a mechanical expansion valve using a diaphragm for a pressure receiving part, a capillary tube or the like is applicable.

[0021] The heat exchanger 203 functions as an evaporator, exchanges heat between low-temperature, low-pressure refrigerant discharged from the expansion device 202 and air supplied by a fan 203A attached to the heat exchanger 203, and evaporates low-temperature, low-pressure liquid refrigerant or two-phase refrigerant. The heat exchanger 203 can be made of, for example, a fin-and-tube type heat exchanger, a micro channel heat exchanger, or a heat pipe type heat exchanger.

[0022] The water circulates in the heat medium circuit A2 through a heat medium tube 10A. The heat medium circuit A2 is configured to include the heat exchanger 100 and a pump 205 for conveying the water.

[0023] Moreover, the refrigeration cycle apparatus 200 includes a controller 60 for generally controlling the entire refrigeration cycle apparatus 200. The controller 60 controls a driving frequency of the compressor 201. Further, the controller 60 controls the opening degree of the expansion device 202, according to the operation state. Furthermore, the controller 60 controls driving of the fan 203A and the pump 205. That is, based on an operation instruction, the controller 60 uses information sent from each of temperature sensors (not shown) and each of pressure sensors (not shown), and controls actuators of the compressor 201, the expansion device 202, the fan 203A, the pump 205, etc.

[0024] Each of functional units included in the controller 60 is made of dedicated hardware, or a micro processing unit (MPU) for executing a program stored in a memory.

[Configuration of Heat Exchanger 100]

[0025] Fig. 2 is a perspective diagram schematically illustrating the configuration of the heat exchanger 100.

[0026] The heat exchanger 100 has a first tube 1 in which a first path FP1 through which water as the first heat medium flows, and a second tube 2 in which a second path FP2 through which refrigerant as the second heat medium flows is formed. The second tube 2 is wound in one turn or a plurality of turns around the outer periphery of the first tube 1 and in contact with the first tube 1. The first tube 1 makes a part of the heat medium tube 10A. The second tube 2 makes a part of the refrigerant tube 20A.

[0027] In the first tube 1, a water inlet 1a and a water outlet 1b communicating with the first path FP1 are provided. In the second tube 2, a refrigerant inlet 2a and a refrigerant outlet 2b communicating with the second path FP2 are provided.

[0028] The heat exchanger 100 can be connected to the refrigerant circuit A1 and the heat medium circuit A2 such that the direction of the water flowing through the first tube 1 and the direction of the refrigerant flowing through the second tube 2 are opposite. Hence, the heat exchange efficiency between the heat medium and the refrigerant is improved.

[Operation of Refrigeration Cycle Apparatus 200]

[0029] Here, returning to Fig. 1, an operation of the refrigeration cycle apparatus 200 will be described.

[0030] The refrigeration cycle apparatus 200 can perform a hot water supply operation, based on an instruction from the load side.

[0031] The operations of the actuators are controlled by the controller 60.

[0032] The low-temperature, low-pressure refrigerant is compressed by the compressor 201 to be high-temperature, high-pressure gas refrigerant, and is discharged from the compressor 201. The high-temperature, high-pressure gas refrigerant discharged from the compressor 201 flows into the heat exchanger 100. The refrigerant that has flowed into the heat exchanger 100 circulates in the second tube 2, and exchanges heat with the water flowing in the first tube 1. At this time, the refrigerant is condensed to be low-temperature, high-pressure liquid refrigerant, and flows out of the heat exchanger 100. In the case where carbon dioxide is used as the refrigerant, the refrigerant undergoes a temperature change while in a supercritical state.

[0033] On the other hand, the water that has flowed into the first tube 1 is heated by the refrigerant flowing in the second tube 2, and is supplied to the load side.

[0034] The low-temperature, high-pressure liquid refrigerant flowing out of the heat exchanger 100 is made low-temperature, low-pressure liquid refrigerant or two-phase refrigerant by the expansion device 202, and flows into the heat exchanger 203. The refrigerant that has flowed into the heat exchanger 203 exchanges heat with the air supplied by the fan 203A attached to the heat exchanger 203, becomes low-temperature, low-pressure gas refrigerant, and flows out of the heat exchanger 203. The refrigerant that has flowed out of the heat exchanger 203 is sucked into the compressor 201 again.

[0035] In Fig. 1, the case where the refrigerant flows in a fixed direction in the refrigerant circuit A1 is shown as an example, but a path switching device may be provided on the discharge side of the compressor 201 to make it possible to reverse the flow of the refrigerant. In the case where the path switching device is provided, the heat exchanger 100 also functions as an evaporator, and the heat exchanger 203 also functions as a condenser. As the path switching device, it is possible to use, for example, a combination of two-way valves, a combination of three-way valves, or a four-way valve.

[0036] As the refrigerant to be used in the refrigeration cycle apparatus 200, carbon dioxide is desirable, but the refrigerant is not necessarily limited to carbon dioxide. Other than carbon dioxide, it is possible to use natural refrigerant such as hydrocarbons or helium, alternative refrigerant containing no chlorine, such as HFC410A, HFC407C or HFC404A, or fluorocarbon refrigerant used in existing products, such as R22 or R134a.

[Detailed Configuration of Heat Exchanger 100]

[0037] Fig. 3 is an explanatory diagram for explaining an example of providing protrusions on the first tube. Fig. 4 is an explanatory diagram for explaining a conventional example of providing protrusions on the first tube as a comparative example. The first tube will be described in detail based on Fig. 3 in comparison to the first tube of Fig. 4. In the conventional example of Fig. 4, "X" is added to the end of reference signs for distinguishing from the first tube 1. A case where two streaks of protrusions are formed on the first tube using two jigs is described for convenience. In Figs. 3 and 4, Fig. 3(a) and Fig. 4(a) each schematically illustrate a state of the first tube seen from a side, and Fig. 3(b) and Fig. 4(b) each schematically illustrate a projection in which the first tube is projected in the tube axis direction. Further, in Figs. 3 and 4, the tube axis is shown as a tube axis CL.

[0038] As shown in Fig. 3, when forming two streaks of protrusions 3 on the first tube 1, a plurality of gearwheel-like jigs are used. One of the gearwheel-like jigs is called a jig 6a, and another is called a jig 6b. The protrusions 3 to be formed by the jig 6a are called protrusions 3a, and the protrusions 3 to be formed by the jig 6b are called protrusions 3b. In the state shown in Fig. 3, it is assumed that the protrusions 3a formed by the jig 6a are placed on the upstream side of the flow of the first heat medium, and the protrusions 3b formed by the jig 6b are provided on the downstream side of the flow of the first heat medium.

[0039] The jig 6a has a gearwheel 9A. In the gearwheel 9A, a plurality of protruding parts 9a for forming the protrusions 3a are provided at mutually different spacing intervals. When an outside of the first tube 1 is pressed by the jig 6a, an inside of the first tube 1 protrudes due to the protruding parts 9a of the gearwheel 9A, and a plurality of protrusions 3a are formed as a streak in a spiral direction. The spacing intervals between the plurality of protrusions 3a formed by the jig 6a are shown as a pitch 5a, a pitch 5b, and a pitch 5c.

[0040] Similarly, the jig 6b has a gearwheel 9B. In the gearwheel 9B, a plurality of protruding parts 9b for forming the protrusions 3b are provided at mutually different spacing intervals. When the outside of the first tube 1 is pressed by the jig 6b, the inside of the first tube 1 protrudes due to the protruding parts 9b of the gearwheel 9B, and a plurality of protrusions 3b are formed as another streak in a spiral direction. The spacing intervals between the plurality of protrusions 3b formed by the jig 6b are shown as a pitch 5d, a pitch 5e, and a pitch 5f.

[0041] As shown in Fig. 3, the pitch 5a, the pitch 5b and the pitch 5c of the protrusions 3a are of different lengths. That is, the plurality of protrusions 3a are provided at unequal spacing intervals.

[0042] Similarly, the pitch 5d, the pitch 5e and the pitch 5f of the protrusions 3b are of different lengths. That is, the plurality of protrusions 3b are provided at unequal spacing intervals.

[0043] Here, the unequal spacing intervals mean that two or more lengths are present as the spacing intervals between the protrusions 3 formed by each of the jig 6a and the jig 6b.

[0044] The positional relationship between the protrusion 3a and the protrusion 3b is determined by the phase difference between the gearwheel 9A of the jig 6a and the gearwheel 9B of the jig 6b. That is, in the jig 6a, the plurality of protruding parts 9a are provided at unequal spacing intervals, and therefore the plurality of protrusions 3a to be formed also have unequal spacing intervals. Similarly, in the jig 6b, the plurality of protruding parts 9b are provided at unequal spacing intervals, and therefore the plurality of protrusions 3b to be formed also have unequal spacing intervals. Hence, the flow of the first heat medium is agitated by both the protrusions 3a and the protrusions 3b, thereby improving the heat exchange performance.

[0045] On the other hand, in the conventional example of Fig. 4, when forming two streaks of protrusions 3X on a first tube 1X, a jig 6aX and a jig 6bX are used, but the spacing interval between protruding parts 9aX of a gearwheel 9AX of the jig 6aX and the spacing interval between protruding parts 9bX of a gearwheel 9BX of the jig 6bX are constant. Moreover, as shown in Fig. 4, the spacing intervals between protrusions 3aX and protrusions 3bX adjacent to each other in a tube axis direction are equal. Thus, as shown in Fig. 4, a pitch 5aX, a pitch 5bX and a pitch 5cX of the protrusions 3aX are of the same length. That is, the plurality of protrusions 3aX are provided at equal spacing intervals. Similarly, a pitch 5dX, a pitch 5eX and a pitch 5fX of the protrusions 3bX are of the same length. That is, the plurality of protrusions 3bX are provided at equal spacing intervals.

[0046] That is, in the jig 6aX, the plurality of protruding parts 9aX are provided at equal spacing intervals, and therefore the plurality of protrusions 3aX to be formed also have equal spacing intervals. Similarly, in the jig 6bX, the plurality of protruding parts 9bX are provided at equal spacing intervals, and therefore the plurality of protrusions 3bX to be formed also have equal spacing intervals. Hence, the protrusions 3aX and the protrusions 3bX are all arranged in alignment in the tube axis direction. In this case, the effect of improving the heat exchange performance by the protrusions 3bX provided on the downstream side is decreased. This is because, at the protrusions 3aX, the flow of the first heat medium is agitated and the heat exchange performance is improved, but, at the protrusions 3bX, the flow rate is reduced and the effect of agitating the flow of the first heat medium is decreased.

[Method of Manufacturing First Tube 1]

[0047] A method of manufacturing the first tube 1 will be described based on Fig. 3 in comparison to the conventional example of Fig. 4. Here, a case where two streaks of protrusions are formed on the first tube using two jigs is also described for convenience.

[0048] As a method of forming the plurality of protrusions 3 on the inside of the first tube 1, as shown in Fig. 3, the jig 6a having the gearwheel 9A and the jig 6B having the gearwheel 9B are used. In the gearwheel 9A, the plurality of protruding parts 9a are provided. In the gearwheel 9B, the plurality of protruding parts 9b are provided. The protruding parts 9a are pressed against an outer wall of the first tube 1 to form one streak of protrusions 3a in a spiral manner on the inside of the first tube 1. Similarly, the protruding parts 9b are pressed against the outer wall of the first tube 1 to form one streak of protrusions 3b in a spiral manner on the inside of the first tube 1. That is, two streaks of the plurality of protrusions 3 are provided in a spiral manner on the first tube 1.

[0049] The jig 6a and the jig 6b are rotated independently of each other, and the protruding parts 9a and the protruding parts 9b provided intermittently are successively pressed against the outside of the first tube 1. Consequently, the two streaks of protrusions 3 are formed in a spiral manner on the first tube 1. Since the spacing intervals between each of the protruding parts 9a and the spacing intervals between each of the protruding parts 9b are unequal spacing intervals, the protrusions 3a to be formed by the protruding parts 9a and the protrusions 3b to be formed by the protruding parts 9b also have unequal spacing intervals.

[0050] Whereas, in the conventional example shown in Fig. 4, although the two streaks of protrusions 3X are formed in a spiral manner on the first tube 1X by rotating each of the jig 6aX and the jig 6bX, the spacing intervals between each of the protruding parts 9aX and the spacing intervals between each of the protruding parts 9bX are regular spacing intervals, that is, equal spacing intervals. Therefore, the protrusions 3aX to be formed by the protruding parts 9aX and the protrusions 3bX to be formed by the protruding parts 9bX also have regular spacing intervals, that is, equal spacing intervals.

[0051] Fig. 5 is an explanatory diagram for explaining the first tube 1 having the protrusions 3 formed by the method of Fig. 3. Fig. 6 is an explanatory diagram for explaining the first tube 1X having the protrusions 3X formed by the method of Fig. 4. The first tube will be described in detail based on Fig. 5 in comparison to the first tube of Fig. 6. In Figs. 5 and 6, Fig. 5(a) and Fig. 6(a) each schematically illustrate a state of the first tube seen from a side, and Fig. 5(b) and Fig.

6(b) each schematically illustrate a projection in which the first tube is projected in the tube axis direction. In Figs. 5 and 6, the tube axis is shown as the tube axis CL.

[0052] As shown in Fig. 5, the protrusions 3a are provided at unequal spacing intervals on the first tube 1. That is, the pitch 5a, the pitch 5b and the pitch 5c of the protrusions 3a are of different lengths.

[0053] Similarly, the protrusions 3b are provided at unequal spacing intervals on the first tube 1. That is, the pitch 5d, the pitch 5e and the pitch 5f of the protrusions 3a are of different lengths.

[0054] Therefore, even when the spacing intervals between the protrusion 3a and the protrusion 3b are equal, the protrusion 3a and the protrusion 3b adjacent to each other in the tube axis direction are not aligned with each other in the tube axis direction.

[0055] As shown in Fig. 5, the topmost protrusion 3a-1 on the topmost level in the drawing paper is provided on a straight line La1, the protrusion 3a-2 on the second level from the top in the drawing paper is provided on a straight line La2, the protrusion 3a-3 on the third level from the top in the drawing paper is provided on a straight line La3, and the protrusion 3a-4 on the lowermost level in the drawing paper is provided on a straight line La4.

[0056] Each of the straight lines La1 to La4 is a straight line parallel to the tube axis CL. In the following description, the straight lines La1 to La4 may be collectively referred to as straight lines La. The fact that the protrusion 3a is provided on the straight line La parallel to the tube axis CL means that a portion including the top of the protrusion 3a overlaps the straight line La.

[0057] Similarly, the protrusion 3b-1 on the topmost level in the drawing paper is provided on a straight line Lb1, the protrusion 3b-2 on the second level from the top in the drawing paper is provided on the straight line La2, a protrusion 3b-3 on the third level from the top in the drawing paper is provided on a straight line Lb3, and the protrusion 3b-4 on the lowermost level in the drawing paper is provided on a straight line Lb4.

[0058] Each of the straight lines Lb1-Lb4 is a straight line parallel to the tube axis CL. In the following description, the straight lines Lb1 to Lb4 may be collectively referred to as straight lines Lb. The fact that the protrusion 3b is provided on the straight line Lb parallel to the tube axis CL means that a portion including the top of the protrusion 3b overlaps the straight line Lb.

[0059] That is, the protrusion 3a-1 and the protrusion 3b-1 are provided on different straight lines parallel to the tube axis CL, and are not aligned with each other in the tube axis direction, and similarly the protrusion 3a-2 and the protrusion 3b-2 are provided on different straight lines parallel to the tube axis CL, and are not aligned with each other in the tube axis direction. Similarly, the protrusion 3a-3 and the protrusion 3b-3 are provided on different straight lines parallel to the tube axis CL, and are not aligned with each other in the tube axis direction. Similarly, the protrusion 3a-4 and the protrusion 3b-4 are provided on different straight lines parallel to the tube axis CL, and are not aligned with each other in the tube axis direction.

[0060] Therefore, even at the protrusions 3b provided on the downstream side of the flow of the first heat medium, the flow rate is not decreased, and the effect of agitating the flow of the first heat medium is not decreased. Hence, the flow of the first heat medium is agitated with both the protrusions 3a and the protrusions 3b, and the effect of improving the heat exchange performance is not decreased.

[0061] On the other hand, in the conventional example of Fig. 6, the protrusions 3aX are provided at regular spacing intervals on the first tube 1X. That is, the pitch 5aX, the pitch 5bX and the pitch 5cX of the protrusions 3aX are of the same length.

[0062] Similarly, the protrusions 3bX are provided at regular spacing intervals on the first tube 1X. That is, the pitch 5dX, the pitch 5eX and the pitch 5fX of the protrusions 3aX are of the same length.

[0063] Therefore, when the spacing intervals between the protrusions 3aX and the protrusions 3bX are equal, the protrusion 3aX and the protrusion 3bX adjacent to each other in the tube axis direction are aligned with each other in the tube axis direction at some phase difference.

[0064] As shown in Fig. 6, the protrusion 3a-5X on the lowermost level in the drawing paper is provided on a straight line La5.

[0065] Like the straight lines La1 to La4, the straight line La5 is a straight line parallel to the tube axis CL. The fact that the protrusion 3aX is provided on the straight line La parallel to the tube axis CL means that a portion including the top of the protrusion 3aX overlaps the straight line La. The protrusion 3a-4X is provided on the fourth level from the top in the drawing paper in Fig. 6.

[0066] Similarly, the protrusion 3b-5X on the lowermost level in the drawing paper is provided on the straight line Lb4.

[0067] Like the straight lines Lb1 to Lb4, the straight line Lb5 is a straight line parallel to the tube axis CL. The fact that the protrusion 3bX is provided on the straight line Lb parallel to the tube axis CL means that a portion including the top of the protrusion 3bX overlaps the straight line Lb. The protrusion 3b-4X is provided on the fourth level from the top in the drawing paper in Fig. 6.

[0068] Here, as shown in Fig. 6, in the state seen from a side, the straight line La1 and the straight line Lb1 overlap in the tube axis direction, and are the same straight line. Similarly, the straight line La2 and the straight line Lb2 overlap in the tube axis direction, and are the same straight line. Similarly, the straight line La3 and the straight line Lb3 overlap

in the tube axis direction, and are the same straight line. Similarly, the straight line La4 and the straight line Lb4 overlap in the tube axis direction, and are the same straight line. Similarly, the straight line La5 and the straight line Lb5 overlap in the tube axis direction, and are the same straight line.

[0069] That is, the protrusion 3a-1X and the protrusion 3b-1X are provided on the same straight line parallel to the tube axis CL, and are aligned with each other in the tube axis direction. Similarly, the protrusion 3a-2X and the protrusion 3b-2X are provided on the same straight line parallel to the tube axis CL, and are aligned with each other in the tube axis direction. Similarly, the protrusion 3a-3X and the protrusion 3b-3X are provided on the same straight line parallel to the tube axis CL, and are aligned with each other in the tube axis direction. Similarly, the protrusion 3a-4X and the protrusion 3b-4X are provided on the same straight line parallel to the tube axis CL, and are aligned with each other in the tube axis direction. Similarly, the protrusion 3a-5X and the protrusion 3b-5X are provided on the same straight line parallel to the tube axis CL, and are aligned with each other in the tube axis direction.

[0070] Therefore, as shown by an arrow F in Fig. 6, at the protrusions 3aX provided on the upstream side of the flow of the first heat medium, the flow of the first heat medium is agitated, but, at the protrusions 3bX provided on the downstream side of the flow of the first heat medium, the flow rate is reduced, and the effect of agitating the flow of the first heat medium is decreased. That is, the effect of improving the heat exchange performance with the protrusions 3bX provided on the downstream side of the first heat medium is decreased.

[Modified Example of First Tube 1]

[0071] Fig. 7 is an explanatory diagram for explaining other example of forming the protrusions of the first tube. Based on Fig. 7, the effect achieved by the heat exchanger 100 including the first tube 1 will be described. In Fig. 7, Fig. 7(a) schematically illustrates a state of the first tube seen from a side, and Fig. 7(b) schematically illustrates a projection in which the first tube is projected in the tube axis direction. Here, a case where two streaks of protrusions are formed on the first tube using two jigs is described for convenience.

[0072] Like Fig. 3, in the case of forming the plurality of protrusions 3 in a spiral manner, Fig. 7 schematically shows a case where the protrusions 3 were provided at unequal spacing intervals so that the spacing interval between the protrusions 3a and the spacing interval between the protrusions 3b to be added by the identical jig 6a and jig 6b, respectively, had two or more different lengths. Although the jig 6a and the jig 6b had the same configuration, the spacing interval between the protruding parts 9a and the spacing interval between the protruding parts 9b have different lengths.

[0073] As shown in Fig. 7, when the spacing interval between the protruding parts 9a and the spacing interval between the protruding parts 9b are unequal spacing intervals, the protrusions 3a and the protrusions 3b are also provided at unequal spacing intervals on the first tube 1. Further, although the spacing interval between the protruding parts 9a and the spacing interval between the protruding parts 9b are made different, some protrusion 3a and protrusion 3b adjacent to each other in the tube axis direction may be aligned with each other in the tube axis direction. This case is reviewed. In Fig. 7, the case where the protrusion 3a-1 on the topmost level in the drawing paper and the protrusion 3b-1 on the topmost position in the drawing paper are aligned with each other in the tube axis direction is shown as an example.

[0074] Also in Fig. 7, the spacing interval between the protruding parts 9a and the spacing interval between the protruding parts 9b are unequal spacing intervals, and the spacing interval between the protruding parts 9a and the spacing interval between the protruding parts 9b are different between that in the jig 6a and that in the jig 6b, and therefore the protrusions 3 other than the topmost protrusion 3a-1 and the topmost protrusion 3b-1 are not aligned with each other in the tube axis direction. Hence, even when some of the protrusions 3 are aligned with each other in the tube axis direction, deterioration of the heat exchange performance can be reduced and the heat exchange performance can be improved compared to the first tube of the conventional example.

[Detailed Configuration of Jig 6a and Jig 6b]

[0075] Fig. 8 and Fig. 9 are explanatory diagrams for explaining the spacing interval between the protrusions 3 of the first tube 1. Based on Fig. 8 and Fig. 9, a description will be given for the maximum angle and the minimum angle of the spacing intervals between the protrusions 3a and the spacing intervals between the protrusions 3b formed by the jigs of the same configuration, namely the jig 6a and the jig 6b, to realize unequal spacing intervals between the protrusions 3. In Figs. 8 and 9, Fig. 8(a) and Fig. 9(a) each schematically illustrate a state of the first tube seen from a side, and Fig. 8(b) and Fig. 9(b) each schematically illustrate a projection in which the first tube is projected in the tube axis direction. An angle θ between the protrusions 3a is defined by two straight lines connecting the center of the first tube 1 and the center of each of target protrusions 3a.

[0076] First, the minimum value of the angle of the spacing interval between the protrusions 3a to be added to the first tube 1 by the jig 6a, that is, the minimum angle θ_1 [rad] will be described based on Fig. 8.

[0077] In Fig. 8, a case where five protrusions 3a are provided from the topmost level in the drawing paper to the lowermost level in the drawing paper is shown as an example, and the protrusions 3a are shown as the protrusion 3a-

1, the protrusion 3a-2, the protrusion 3a-3, the protrusion 3a-4, and the protrusion 3a-5 from the topmost level in the drawing paper. It is assumed that the protrusion 3a-1, the protrusion 3a-2, the protrusion 3a-3, the protrusion 3a-4, and the protrusion 3a-5 are provided in the same shape and the same size.

[0078] Here, as shown in Fig. 8(b), the width of each of the protrusions 3a, that is, the diameter of the protrusion 3a is defined as a width W. Moreover, as shown in Fig. 8(b), the length equivalent to the width W of the protrusion 3a is defined as a length 3b1. Further, the inner diameter of the first tube 1 is defined as an inner diameter Dwi.

[0079] Consider a case where, between the protrusion 3a-1 to be added by the jig 6a and the protrusion 3a-2 to be added subsequently by the jig 6a, the protrusion 3b is added by the jig 6b. In Fig. 8(b), when the protrusions 3a to be added by the jig 6a and the protrusions 3b to be added by the jig 6b are arranged not to overlap each other, the minimum angle θ_1 between the protrusion 3a-1 and the protrusion 3a-2 is given by Expression (1).

[Expression 1]

$$\theta_1 = \frac{W \times 2}{Dwi \times \pi} \times 2 \times \pi = \frac{4 \times W}{Dwi} \quad \dots (1)$$

[0080] Next, the maximum value of the angle of the spacing interval between the protrusions 3a to be added to the first tube 1 by the jig 6a, that is, the maximum angle θ_2 [rad] will be described based on Fig. 9. The description will be given on an assumption that n pieces of protrusions 3 per circumferential length are formed on the first tube 1.

[0081] In Fig. 9, a case where four protrusions 3a are provided from the topmost level in the drawing paper to the lowermost level in the drawing paper is shown as an example, and the protrusions 3a are shown as the protrusion 3a-1, the protrusion 3a-2, the protrusion 3a-3, and the protrusion 3a-4 from the topmost level in the drawing paper. It is assumed that the protrusions 3a-1, the protrusion 3a-2, the protrusion 3a-3, and the protrusion 3a-4 are provided in the same shape and the same size.

[0082] The distance from the protrusion 3a-1 to the protrusion 3a-2 is determined by the above-mentioned minimum angle θ_1 . The angle from the protrusion 3a-2 to the protrusion 3a-3 is made $\theta_1 \times 3/2$, that is, 1.5 times of θ_1 so that the protrusions 3a are provided at unequal spacing intervals without overlapping from the protrusion 3a-1 to the protrusion 3a-2. Similarly, the angle from the protrusion 3a-3 to the protrusion 3a-4 is made $\theta_1 \times 4/2$. Therefore, the angle from the protrusion 3a-1 to the protrusion 3a-4 is $\theta_1 \times 9/2$.

[0083] Thus, an angle corresponding to the maximum angle θ_2' [rad] of the maximum spacing interval when the number of the protrusions 3a are four can be given by Expression (2).

[Expression 2]

$$\theta_2' = 2 \times \pi - \frac{9 \times \theta_1}{2} \quad \dots (2)$$

[0084] In Expression (2), when the number of the protrusions 3 to be provided is n ($n > 2$), the maximum angle θ_2 can be given by Expression (3).

[Expression 3]

$$\theta_2 = 2 \times \pi - \frac{2 \times W \times \sum_{i=2}^n i}{Dwi} \quad \dots (3)$$

[0085] From the above, the angle between the protrusions 3 to be added by the jig 6a is within the range of Expression (4).

[Expression 4]

$$\frac{4 \times W}{Dwi} \leq \theta \leq \left(2 \times \pi - 2 \times \frac{W \times \sum_{i=2}^n i}{Dwi} \right) \dots (4)$$

[0086] Here, the relationship between the adjacent protrusions 3a and 3b is described by taking, as an example, the case where the protrusions 3 are formed by two jigs, namely the jig 6a and the jig 6b. That is, the above description applies to the relationship between the protrusions to be provided adjacent to each other by the respective jigs when the protrusions are formed using the plurality of jigs. However, although the case where the protrusions 3 are formed by the two jigs is described as an example, the number of the jigs is not particularly limited. Even when two or more jigs are used, a range of the angle between each of the protrusions 3 can be given by Expression (4). Thus, when the spacing intervals of the protrusions 3 to be added by the same jig are made unequal spacing intervals, the effect of improving the heat exchange performance can be obtained.

[Effects Achieved by Heat Exchanger 100, Refrigeration Cycle Apparatus 200 and Method of Manufacturing Heat Exchanger]

[0087] As described above, in the heat exchanger 100, one protrusion 3a and the protrusion 3b adjacent to the protrusion 3a are provided on different straight lines parallel to the tube axis direction, and the adjacent protrusions 3 do not overlap each other in the projection in which the first tube 1 is projected in the tube axis direction. Therefore, according to the heat exchanger 100, the phenomenon described in Fig. 6 is less likely to occur, and the heat exchange performance is improved.

[0088] According to the heat exchanger 100, since the protrusions 3 provided in one streak are arranged at unequal spacing intervals, it is possible to arrange the adjacent protrusions 3 not to overlap each other in the projection in which the first tube 1 is projected in the tube axis direction.

[0089] According to the heat exchanger 100, since the angle θ between the protrusions 3 is arranged to be within the range of Expression (4) described above, it is possible to arrange the adjacent protrusions 3 not to overlap each other in the projection in which the first tube 1 is projected in the tube axis direction.

[0090] According to the refrigeration cycle apparatus 200, since the above-described heat exchanger is provided as a condenser, an improvement in the heat exchange performance of the condenser can be expected.

[0091] In the method of manufacturing the heat exchanger 100, the protrusions 3a are formed at unequal spacing intervals by arranging each of the plurality of protruding parts 9a of the jig 6a at unequal spacing intervals, and the protrusions 3b are formed at unequal spacing intervals by arranging each of the plurality of protruding parts 9b of the jig 6b at unequal spacing intervals. Thus, according to the method of manufacturing the heat exchanger 100, it is possible to manufacture the heat exchanger 100 without using a special jig and going through a special process.

Embodiment 2

[0092] Fig. 10 is an explanatory diagram for explaining a shape of a first tube 1A of a heat exchanger of Embodiment 2 of the present disclosure. Based on Fig. 10, the shape of the first tube 1A of the heat exchanger of Embodiment 2 will be described.

[0093] In Embodiment 2, differences from Embodiment 1 will be mainly described, and the same parts as those in Embodiment 1 will be labelled with the same reference signs and description thereof will be omitted. In Fig. 10, Fig. 10(a) schematically illustrates a state of the first tube seen from a side, and Fig. 10(b) schematically illustrates a projection in which the first tube is projected in the tube axis direction.

[0094] In Embodiment 1, the case where the first tube 1 is a circular tube having no unevenness on the outer circumferential surface is described as an example, whereas, in Embodiment 2, a case where the first tube 1A is a corrugated tube having a single streak of spiral groove 35 provided on the outer circumferential surface is described as an example. When providing the protrusions 3 on the first tube 1A, as shown in Fig. 10, the protrusions 3 are provided at portions other than the spiral groove 35. The second tube is wound around the spiral groove 35 of the first tube 1A.

[0095] Thus, by making the first tube 1A by the corrugated tube, it is possible to further promote a turbulent flow of the refrigerant inside the first tube 1A. Hence, the heat exchange performance can be further improved compared to the case where the protrusions are added to the first tube 1 as described in Embodiment 1.

Embodiment 3

[0096] Fig. 11 is an explanatory diagram for explaining a shape of a first tube 1B of a heat exchanger of Embodiment 3 of the present disclosure. Based on Fig. 11, the shape of the first tube 1B of the heat exchanger according to Embodiment 3 will be described.

[0097] In Embodiment 3, differences from Embodiment 1 will be mainly described, and the same parts as those in Embodiment 1 will be labelled with the same reference signs, and description thereof will be omitted. In Fig. 11, Fig. 11(a) schematically illustrates a state of the first tube seen from a side, and Fig. 11(b) schematically illustrates a projection in which the first tube is projected in the tube axis direction.

[0098] In Embodiment 1, the case where the first tube 1 is a circular tube having no unevenness on the outer circumferential surface is described as an example, whereas, in Embodiment 3, a case where the first tube 1B is a torsion tube having a peak portion 30a and a valley portion 30b is described as an example. The peak portion 30a is a portion that protrudes in a radially expanding direction in which the diameter of the first tube 1B expands, and is formed in a spiral manner in a direction to which the first heat medium flows in the first path FP1. The valley portion 30b is a portion in which an outer diameter of the first tube is smaller than in a portion where the peak portion 30a is formed, and around which the second tube is to be wound, and is formed in a spiral manner along the peak portion 30a. When providing the protrusions 3 on the first tube 1B, as shown in Fig. 11, the protrusions 3 are provided in the valley portion 30b. That is, the protrusions 3 are provided in the spiral direction that is the direction in which the valley portion 30b is formed. The second tube is wound around the first tube 1B by being fitted in the valley portion 30b.

[0099] Thus, by making the first tube 1B by the torsion tube, it is possible to further promote a turbulent flow of the refrigerant inside the first tube 1B. Moreover, the contact area between the first tube 1B and the second tube can be increased. Hence, the heat exchange performance can be further improved compared to the case where the protrusions are added to the first tube 1 as described in Embodiment 1.

[0100] Although the present disclosure is described by separate embodiments, specific configurations are not limited to the described embodiments, and can be modified within a range not departing from the gist of the invention.

Reference Signs List

[0101]

1 first tube, 1A first tube, 1B first tube, 1X first tube, 1a inlet, 1b outlet, 2 second tube, 2a inlet, 2b outlet, 3 protrusion, 3X protrusion, 3a protrusion, 3a-1 protrusion, 3a-1X protrusion, 3a-2 protrusion, 3a-2X protrusion, 3a-3 protrusion, 3a-3X protrusion, 3a-4 protrusion, 3a-4X protrusion, 3a-5 protrusion, 3a-5X protrusion, 3aX protrusion, 3b protrusion, 3b-1 protrusion, 3b-1X protrusion, 3b-2 protrusion, 3b-2X protrusion, 3b-3 protrusion, 3b-3X protrusion, 3b-4 protrusion, 3b-4X protrusion, 3b-5X protrusion, 3b-5X4 protrusion, 3bX protrusion, 5a pitch, 5aX pitch, 5b pitch, 5bX pitch, 5c pitch, 5cX pitch, 5d pitch, 5dX pitch, 5e pitch, 5eX pitch, 5f pitch, 5fX pitch, 6B jig, 6a jig, 6aX jig, 6b jig, 6bX jig, 9A gearwheel, 9AX gearwheel, 9B gearwheel, 9BX gearwheel, 9a protruding part, 9aX protruding part, 9b protruding part, 9bX protruding part, 10A heat medium tube, 20A refrigerant tube, 30a peak portion, 30b valley portion, 35 spiral groove, 60 controller, 100 heat exchanger, 200 refrigeration cycle apparatus, 201 compressor, 202 expansion device, 203 heat exchanger, 203A fan, 205 pump, 207 hot water storage tank, A1 refrigerant circuit, A2 heat medium circuit, A3 water supply circuit, FP1 first path, FP2 second path, U hot water supply utility part.

Claims**1. A heat exchanger comprising:**

a first tube through which a first heat medium flows; and
a second tube through which a second heat medium flows, the second tube being wound around the first tube, the first tube having a plurality of protrusions protruding inside of the first tube, the plurality of protrusions being provided in a plurality of streaks being provided in a spiral manner in a direction to which the first heat medium of the first path flows in the first tube,
one streak of the plurality of streaks including the plurality of protrusions each being arranged at unequal spacing intervals.

2. The heat exchanger of claim 1, wherein, from among the plurality of protrusions provided in the one streak and the

plurality of protrusions provided in an other streak of the plurality of streaks, two protrusions adjacent to each other in a tube axis direction of the first tube are each provided on one of different straight lines being in parallel to the tube axis direction.

3. The heat exchanger of claim 1 or 2, wherein, in a projection in which the first tube is projected in the tube axis direction, an angle θ between the protrusions is arranged to fall within a range given by expression (5), [Expression 5]

$$\frac{4 \times W}{D_{wi}} \leq \theta \leq \left(2 \times \pi - 2 \times \frac{W \times \sum_{i=2}^n i}{D_{wi}} \right) \dots (5)$$

where W is a width of each of the plurality of protrusions,

D_{wi} is an inner diameter of the first tube, and

n is the number of the plurality of protrusions to be provided per circumferential length of the first tube.

4. The heat exchanger of any one of claims 1 to 3, wherein the first tube is a corrugated tube.

5. The heat exchanger of any one of claims 1 to 3, wherein the first tube includes:

a peak portion protruding in a radially expanding direction in which a diameter of the first tube expands; and a valley portion in which an outer diameter of the first tube is smaller than in a portion where the peak portion is formed, and around which the second tube is wound, the peak portion being formed in a spiral manner in a direction to which the first heat medium of the first path flows, the valley portion being formed in a spiral manner along the peak portion, the plurality of protrusions being provided in a spiral direction that is the direction in which the valley portion is formed.

6. A refrigeration cycle apparatus comprising the heat exchanger of any one of claims 1 to 5 as a condenser, wherein, in the heat exchanger, the first heat medium flowing through a first path of the first tube constituting the heat exchanger is heated by the second heat medium flowing through a second path of the second tube constituting the heat exchanger.

7. A method of manufacturing a heat exchanger including: a first tube in which a first path through which a first heat medium flows is formed; and a second tube in which a second path through which a second heat medium flows is formed, the second tube being wound around the first tube, the method comprising providing a plurality of protrusions protruding inside of the first tube in a plurality of streaks in a spiral manner by pressing an outside of the first tube using a plurality of jigs each having a gearwheel on which a plurality of protruding parts are provided, wherein, in each of the jigs, the plurality of protruding parts are arranged at unequal spacing intervals on the gearwheel to provide each of the plurality of protrusions at unequal spacing intervals.

FIG. 1

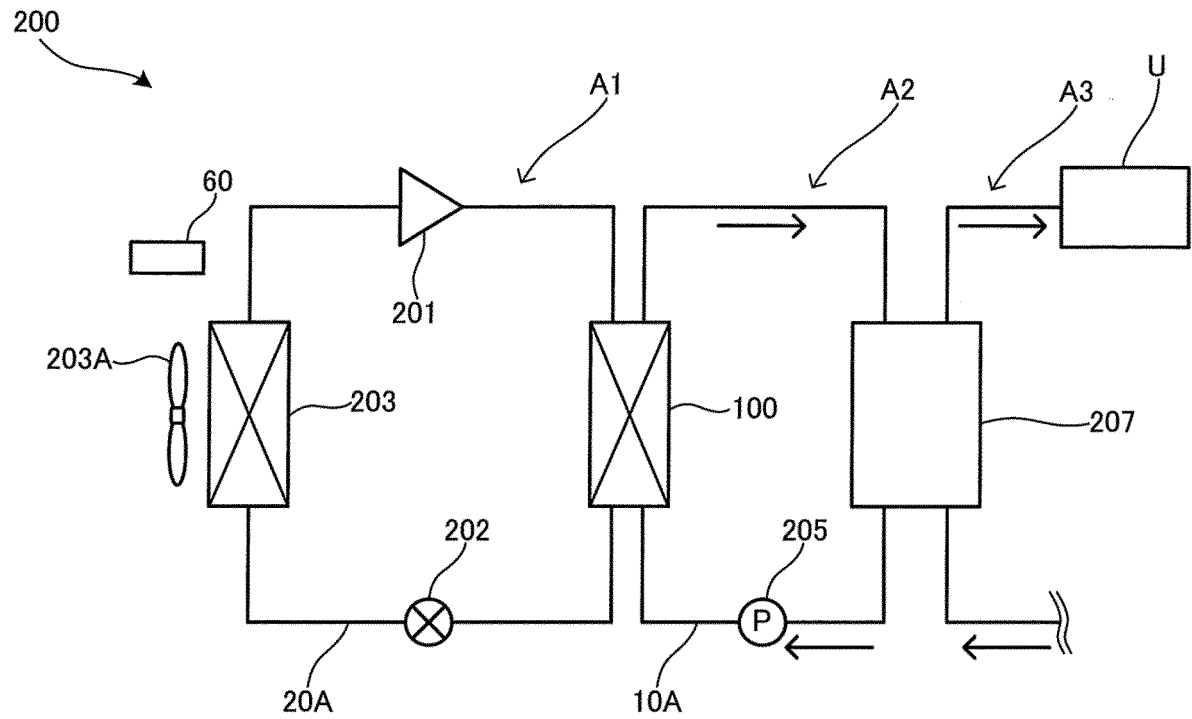


FIG. 2

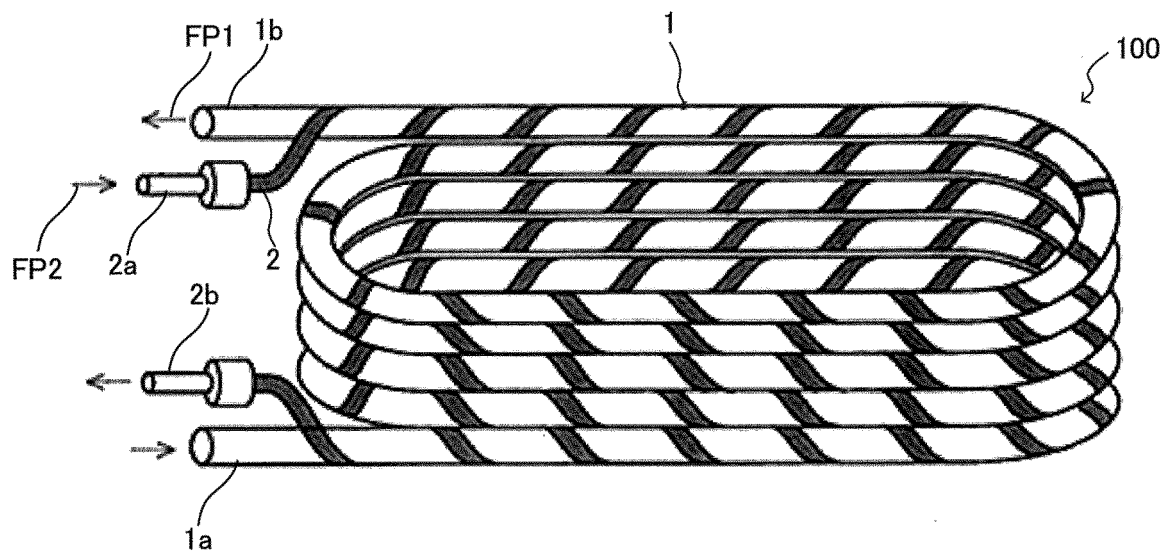


FIG. 3

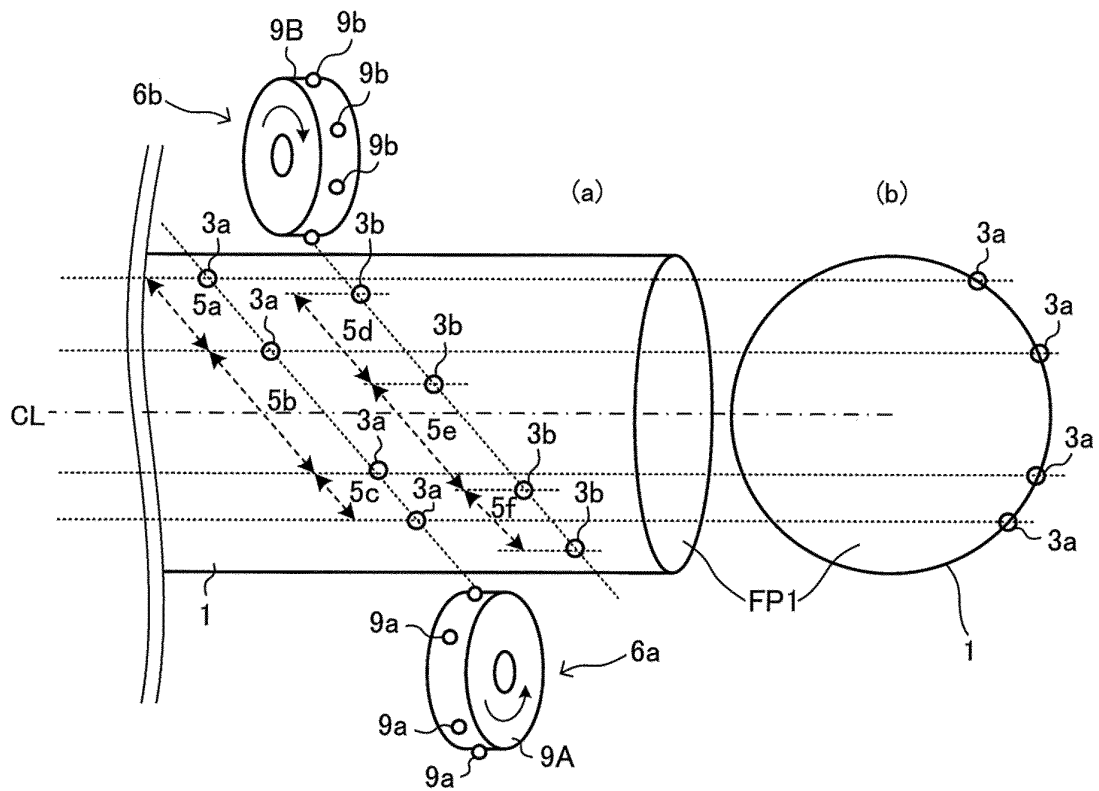


FIG. 4

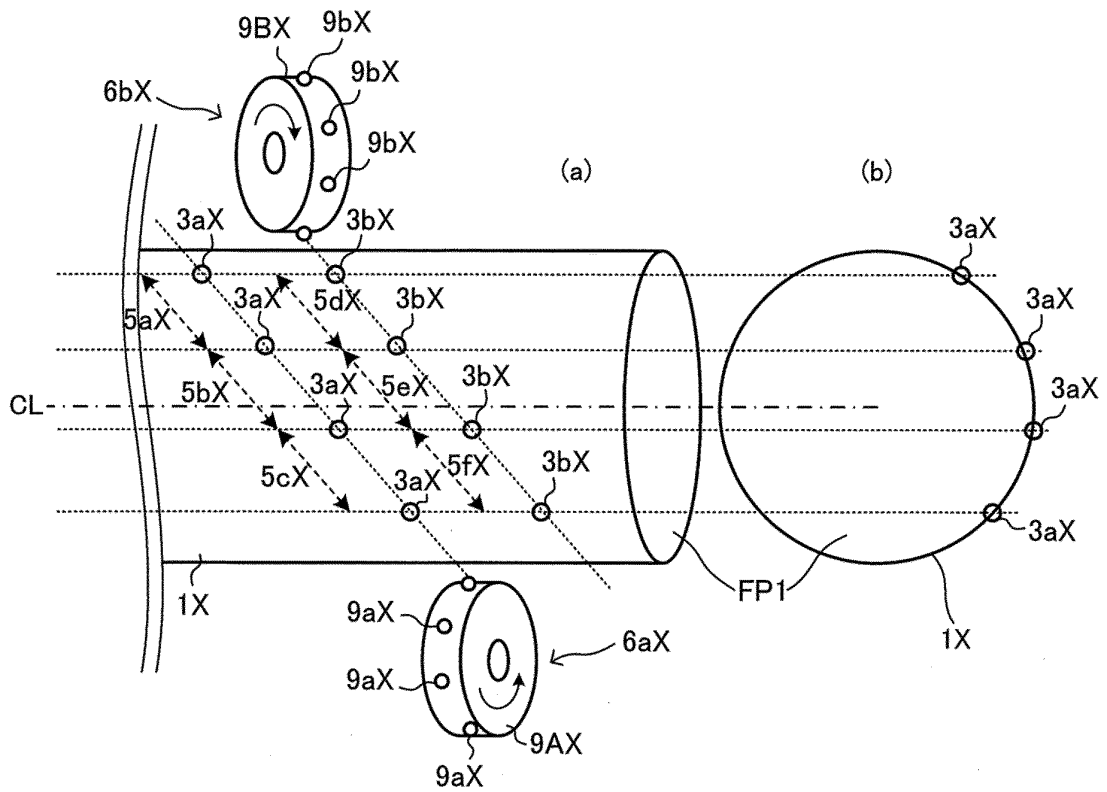


FIG. 5

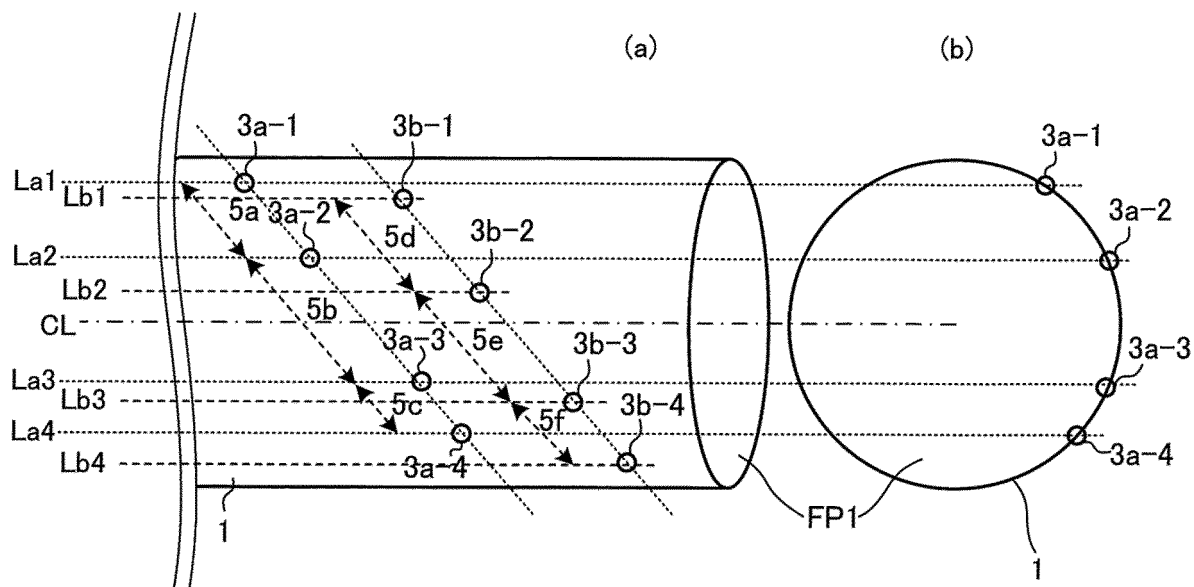


FIG. 6

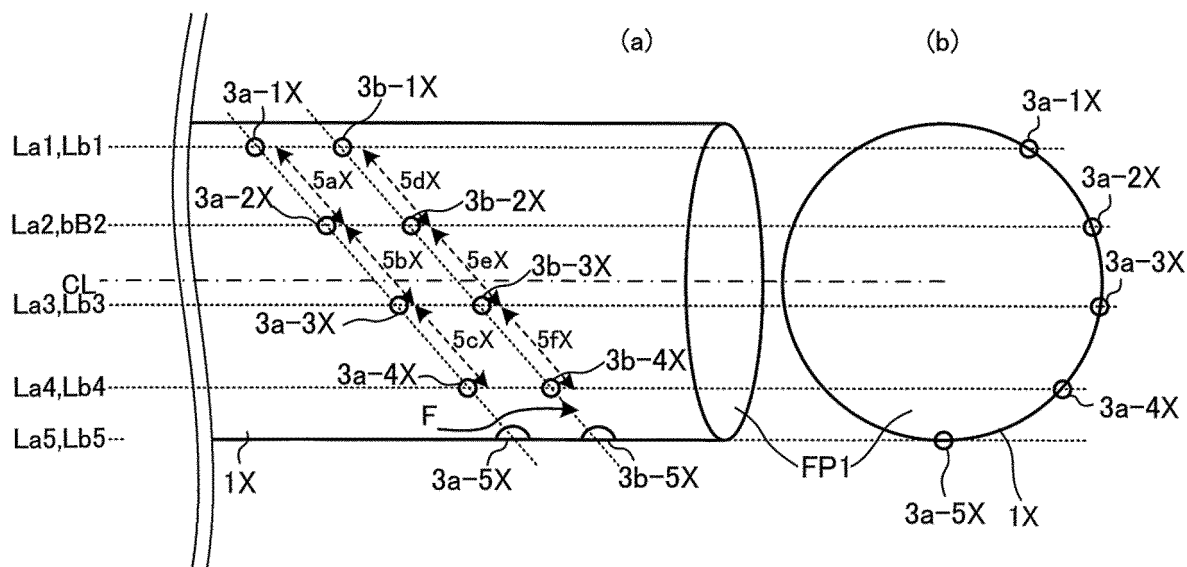


FIG. 7

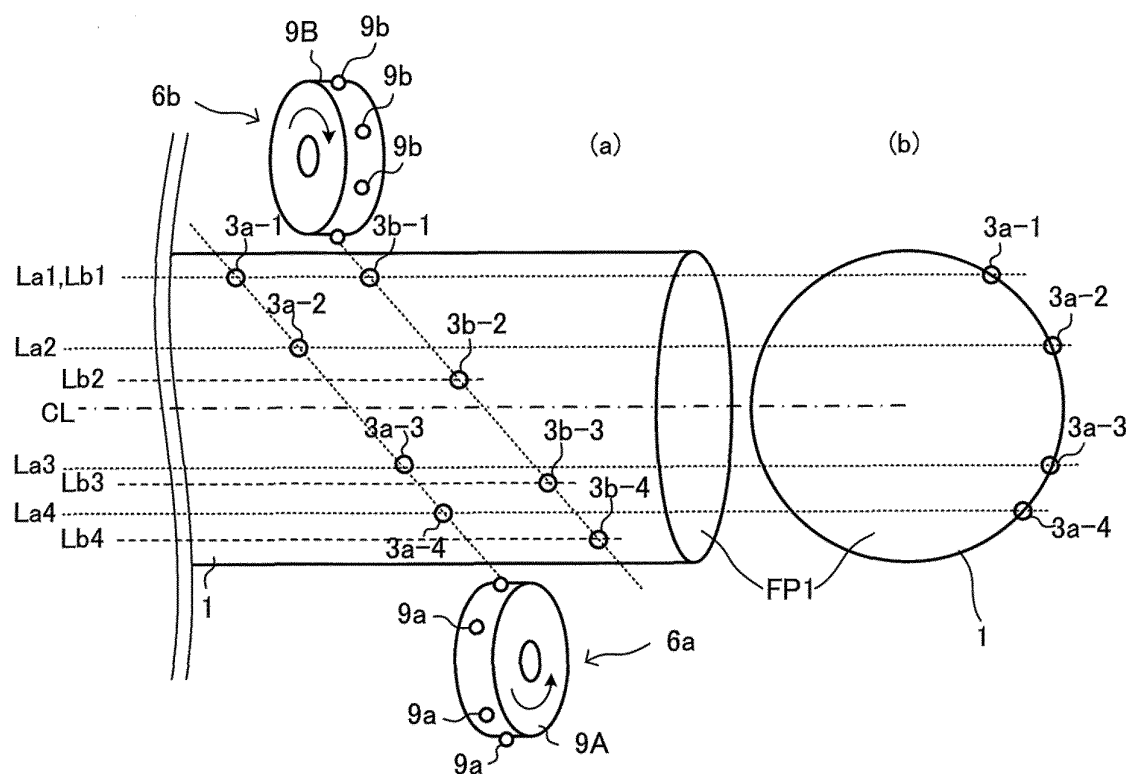


FIG. 8

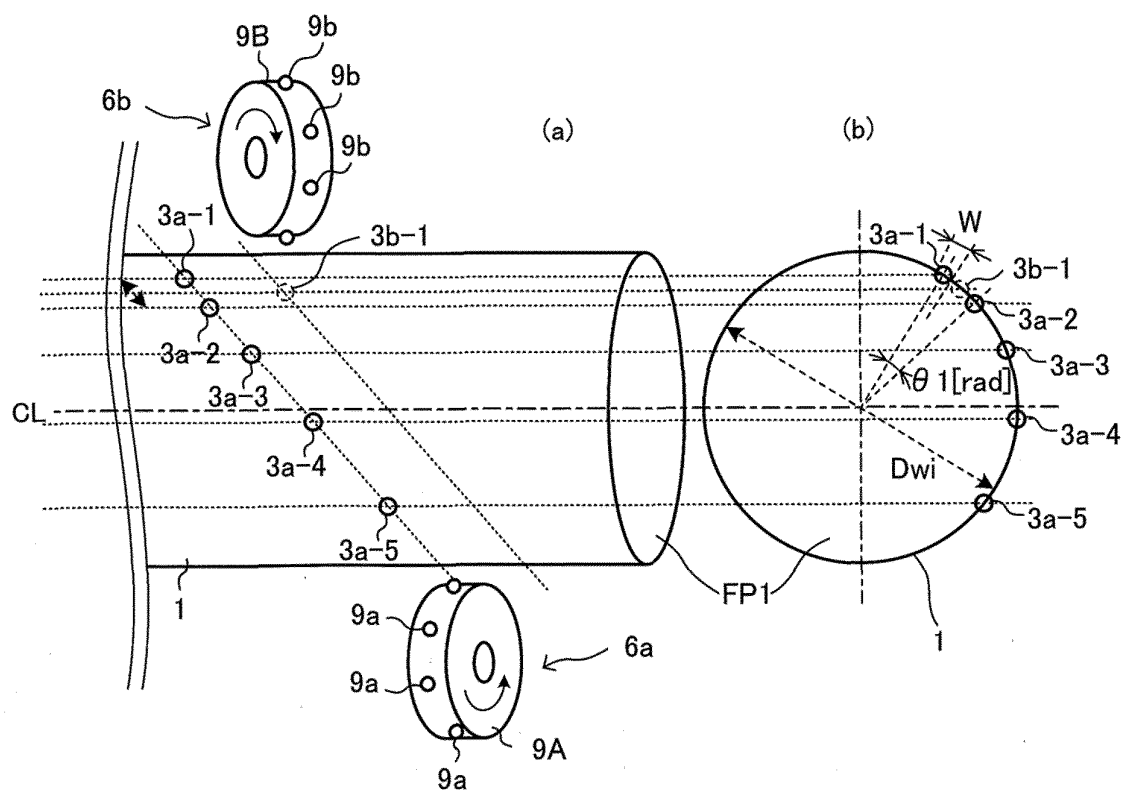


FIG. 9

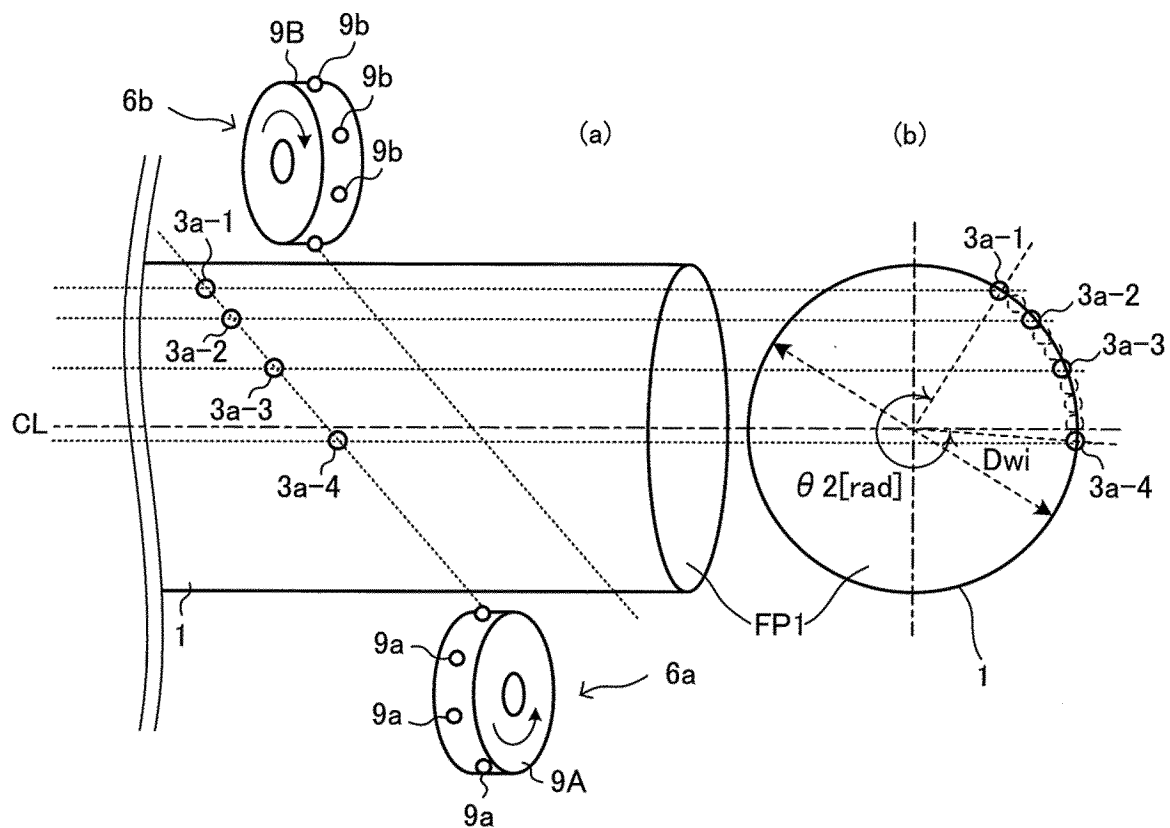


FIG. 10

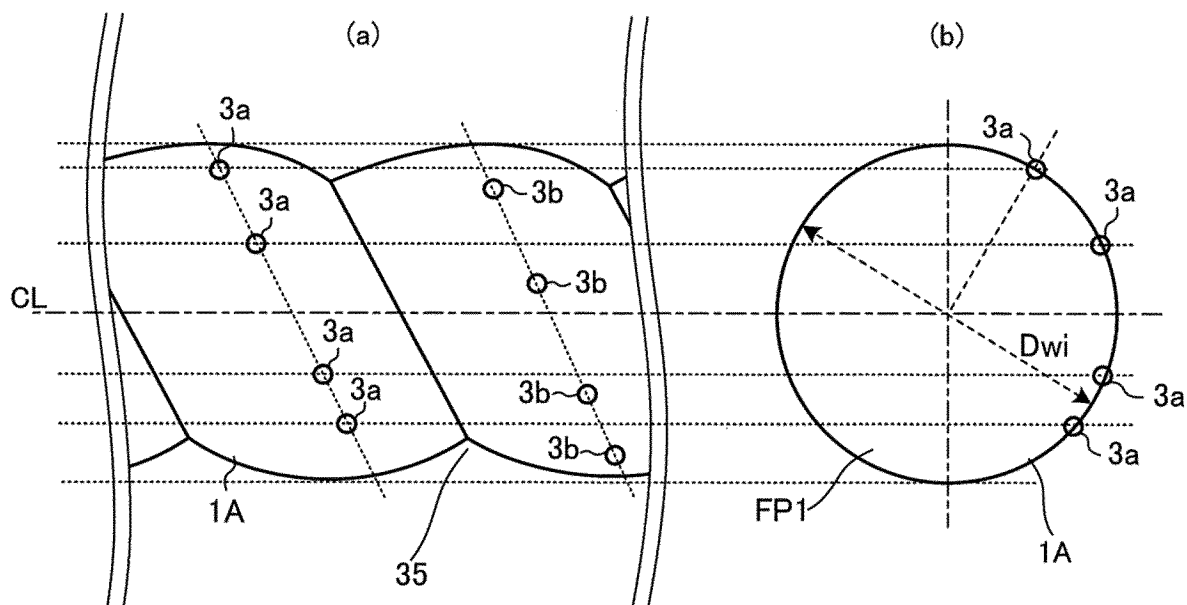
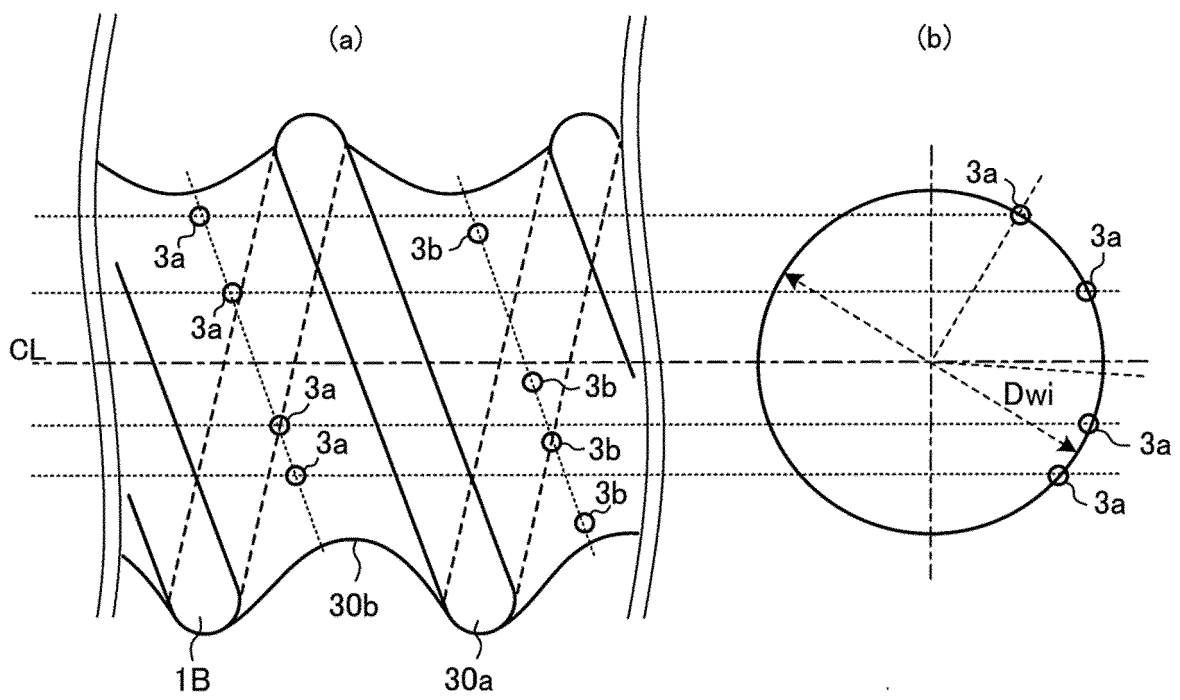


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/043818

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F28F1/40 (2006.01) i, B21D53/06 (2006.01) i, F28D7/02 (2006.01) i, F28F13/12 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl. F28F1/40, B21D53/06, F28D7/02, F28F13/12

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2006-317114 A (DAIKIN INDUSTRIES, LTD.) 24 November 2006, paragraphs [0015]-[0024], fig. 1-5 & US 2009/0071639 A1, paragraphs [0028]-[0037], fig. 1-5 & WO 2006/123535 A1 & EP 1895256 A1 & CN 101175967 A	1-6 7
Y A	JP 2009-250450 A (KUBOTA CORP.) 29 October 2009, paragraphs [0012]-[0023], fig. 1-3 (Family: none)	1-6 7
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 114040/1989 (Laid-open No. 56077/1991) (CALSONIC CORP.) 29 May 1991, description, page 13, line 12 to page 14, line 9, fig. 6 (Family: none)	1-6 7



Further documents are listed in the continuation of Box C.



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later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search
16.02.2018

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/043818

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 63-34489 A (NIPPONDENSO CO., LTD.) 15 February 1988, page 2, lower left column, line 9 to page 3, upper left column, line 2, fig. 2 (Family: none)	1-6 7
Y A	JP 2012-57856 A (HITACHI CABLE LTD.) 22 March 2012, paragraphs [0021]-[0024], fig. 1 & CN 102401597 A	4, 6 1-3, 5, 7
Y A	JP 2012-122686 A (MITSUBISHI ELECTRIC CORP.) 28 June 2012, paragraphs [0013], [0024]-[0028], fig. 6, 7 (Family: none)	5-6 1-4, 7
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A	JP 2007-218486 A (HITACHI CABLE LTD.) 30 August 2007, entire text, all drawings & US 2007/0187067 A1 & CN 101021393 A	1-7
A	JP 2008-23572 A (MORI MACHINERY CORP.) 07 February 2008, entire text, all drawings (Family: none)	1-7

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REFERENCES CITED IN THE DESCRIPTION

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