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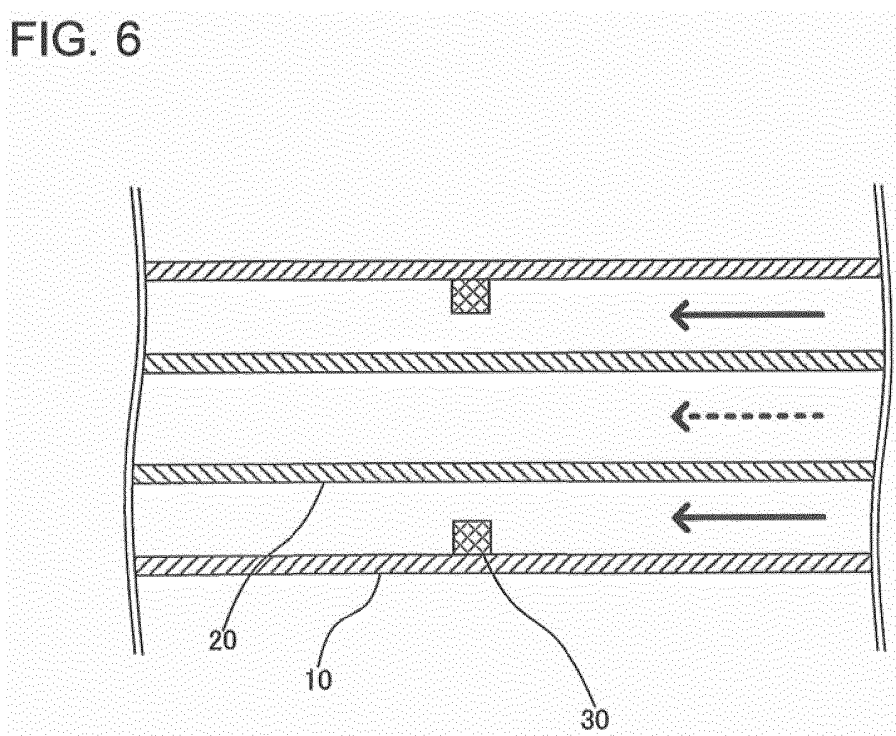
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(54) **HEAT EXCHANGER AND HEAT PUMP WATER HEATER**

(57) A heat exchanger includes: a first pipe which is formed of resin, and allows fluid to flow through the first pipe; a second pipe which is formed of metal, provided in the first pipe, and allows refrigerant to flow through the second pipe; and a resin element which is formed as an

element separate from the first pipe and the second pipe, and provided in a region in space between an inner surface of the first pipe and an outer surface of the second pipe.

FIG. 6



Description

Technical Field

[0001] The present invention relates to a double-pipe heat exchanger including a first pipe and a second pipe provided in the first pipe, and a heat pump water heater including the heat exchanger.

Background Art

[0002] Double-pipe heat exchangers each including a first pipe and a second pipe provided in the first pipe have been known. In an example of such a heat exchanger, water is made to flow through the first pipe, refrigerant is made to flow through the second pipe, and the water and the refrigerant can be made to exchange heat with each other.

[0003] As such a heat exchanger, the following heat exchanger has been proposed: "heat exchanger including: a water flow passage which allows water to flow therethrough; and a refrigerant flow passage which is provided in the water flow passage, and allows refrigerant to flow through the refrigerant flow passage, the heat exchanger causing heat exchange to be performed between the water and the refrigerant, wherein a wall for the water flow passage is made of a transparent resin material, whereby in an appearance of the heat exchanger, a refrigerant pipe forming the water flow passage is visible from the wall for the water flow passage" (see, for example, Patent Literature 1).

[0004] In the heat exchanger disclosed in Patent Literature 1, a first pipe is formed of a transparent resin material, whereby the inside of the first pipe is visible. Therefore, in the heat exchanger disclosed in Patent Literature 1, a second pipe provided in a first pipe can be confirmed from the outside of the heat exchanger, thus improving serviceability.

Citation List

Patent Literature

[0005] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2013-011387

Summary of Invention

Technical Problem

[0006] When the heat exchanger disclosed in Patent Literature 1 is used as a condenser, high-temperature refrigerant flows through the second pipe which serves as the refrigerant pipe. Thus, when an outer surface of the second pipe contacts an inner surface of the first pipe, which is made of a resin material, the first pipe may be deformed by the heat of the refrigerant flowing in the second pipe. Furthermore, if the first pipe is deformed, a hole

can be formed in the first pipe. If a hole is formed in the first pipe, water flowing in the first pipe leaks from the first pipe, thus reducing the reliability of the heat exchanger. Though it is conceivable that the first pipe is formed of a high heat-resistant resin, if it is formed of a high heat-resistant resin, the manufacturing cost of the first pipe is increased.

[0007] In the heat exchanger disclosed in Patent Literature 1, the first pipe is made of a transparent resin material in order to improve serviceability. However, this Literature does not consider that the first pipe is deformed. That is, the double-pipe heat exchanger including the first pipe formed of resin need to be further modified in order to improve their reliability.

[0008] The present invention has been made in view of the above circumstances, and an object of the invention is to provide a heat exchanger and a heat pump water heater, which are both capable of preventing a first pipe formed of resin and a second pipe formed of metal from contacting each other without applying a complexed structure.

Solution to Problem

[0009] The heat exchanger according to an embodiment of the present invention includes: a first pipe which is formed of resin, and allows fluid to flow through the first pipe; a second pipe which is formed of metal, provided in the first pipe, and allows refrigerant to flow through the second pipe; and a resin element which is formed as an element separate from the first pipe and the second pipe, and provided in a region in space between an inner surface of the first pipe and an outer surface of the second pipe.

[0010] A heat pump water heater according to another embodiment of the present invention includes the above heat exchanger as a condenser.

Advantageous Effects of Invention

[0011] In the heat exchanger according to the embodiment of the present invention, a resin element formed as an element separate from the first pipe and the second pipe is provided in a region in space between an inner surface of the first pipe and an outer surface of the second pipe. Because of this configuration, it is possible to prevent contact between the first pipe and the second pipe without applying a complexed structure.

[0012] The heat pump water heater according to the other embodiment of the present invention includes the above exchanger. Thus, because of provision of the resin element, it is possible to prevent contact between the first pipe and the second pipe, thereby reducing deformation of the first pipe, and thus improving the reliability.

Brief Description of Drawings

[0013]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram schematically illustrating an example of a circuit configuration of a heat pump water heater according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a perspective view schematically illustrating an appearance of a first heat exchanger according to the embodiment of the present invention.

[Fig. 3] Fig. 3 is a transparent perspective view schematically illustrating an internal configuration of the first heat exchanger according to the embodiment of the present invention.

[Fig. 4] Fig. 4 is a schematic view schematically illustrating an example of a sectional configuration of the first heat exchanger according to the embodiment of the present invention.

[Fig. 5] Fig. 5 is a schematic view schematically illustrating an example of a configuration of the first heat exchanger according to the embodiment of the present invention.

[Fig. 6] Fig. 6 is an enlarged vertical-view schematically illustrating an example of a sectional configuration of part of the first heat exchanger according to the embodiment of the present invention.

[Fig. 7] Fig. 7 is a graph illustrating a refrigerant temperature distribution of the first heat exchanger according to the embodiment of the present invention.

[Fig. 8] Fig. 8 is an enlarged vertical-sectional view of another example of a sectional configuration of part of the first heat exchanger, which includes bent portions, according to the embodiment of the present invention.

[Fig. 9] Fig. 9 is an enlarged vertical-sectional view of still another example of the sectional structure of the part of the first heat exchanger, which includes the bent portions, according to the embodiment of the present invention.

[Fig. 10] Fig. 10 is an enlarged vertical cross-sectional view schematically illustrating an example of a sectional configuration of a resin member of the first heat exchanger according to the embodiment of the present invention.

[Fig. 11] Fig. 11 is an enlarged vertical-sectional view schematically illustrating another example of the sectional configuration of the resin member of the first heat exchanger according to the embodiment of the present invention.

[Fig. 12] Fig. 12 is an enlarged vertical-sectional view schematically illustrating still another example of the sectional configuration of the resin member of the first heat exchanger according to the embodiment of the present invention.

[Fig. 13] Fig. 13 is an enlarged vertical-sectional view schematically illustrating a further example of the sectional configuration of the resin member of the first heat exchanger according to the embodiment of the present invention.

[Fig. 14] Fig. 14 is an enlarged vertical-sectional view

schematically illustrating a still further example of the sectional configuration of the resin member of the first heat exchanger according to the embodiment of the present invention.

[Fig. 15] Fig. 15 is an enlarged vertical-sectional view schematically illustrating a further example of the sectional configuration of the part of the first heat exchanger, which includes the bent portions, according to the embodiment of the present invention.

[Fig. 16] Fig. 16 is an enlarged vertical-sectional view schematically illustrating an example of the sectional configuration of the resin member of the first heat exchanger according to the embodiment of the present invention.

[Fig. 17] Fig. 17 is an enlarged vertical-sectional view schematically illustrating an example of the sectional configuration of the resin member of the first heat exchanger according to the embodiment of the present invention.

[Fig. 18] Fig. 18 is a table indicating upper temperature limits of resin.

Description of Embodiments

[0014] The heat exchanger and the heat pump water heater according to an embodiment of the present invention will be described below with reference to the drawings.

[0015] The configurations, operations, etc., as described below, are merely examples, and the heat exchanger and the heat pump water heater according to the embodiment of the present invention are not limited to those described below. In each of the figures, elements which are the same as or similar to those as illustrated in a previous figure are denoted by the same reference signs or no reference signs. Furthermore, detailed configurations are simplified or omitted as appropriate. After the configurations, operations, etc., are each described, their descriptions will not be repeated or will be simplified as appropriate, or similar configurations, operations, etc., to previously described ones will be simply described or their descriptions will be omitted as appropriate.

[0016] Fig. 1 is a refrigerant circuit diagram schematically illustrating an example of a circuit configuration of a heat pump water heater 100 according to an embodiment of the present invention. The heat pump water heater 100 will be described with reference to Fig. 1.

<Configuration of heat pump water heater 100 >

[0017] The heat pump water heater 100 includes a refrigerant circuit A and a fluid circuit B. For example, the fluid circuit B is connected to at least one of various load-side devices in each of which hot water is used, such as a household tap and a bath, and configured to supply hot water to the load-side apparatus. The fluid circuit B is also connected to a water-supply pipe (not illustrated) such as a water pipe, and configured to supply water

through the water-supply pipe.

[0018] In the refrigerant circuit A, refrigerant circulates through a refrigerant pipe 20A. As the refrigerant, for example, carbon dioxide can be used. The refrigerant circuit A is provided with a compressor 101 which compresses the refrigerant, a first heat exchanger 50 serving as a condenser (gas cooler), an expansion device 102 and a second heat exchanger 103 serving as an evaporator.

[0019] The compressor 101 compresses the refrigerant. The refrigerant compressed by the compressor 101 is discharged from the compressor 101, and sent into the first heat exchanger 50. As the compressor 101, for example, a rotary compressor, a scroll compressor, a screw compressor or a reciprocating compressor can be used.

[0020] The first heat exchanger 50 serves as a condenser, and causes heat exchange to be performed between high-temperature and high-pressure refrigerant which flows through the refrigerant circuit A and fluid which flows through the fluid circuit B, to thereby condense the refrigerant. As it will be described in detail later, the first heat exchanger 50 is a double-pipe heat exchanger which includes a first pipe 10 and a second pipe 20 provided in the first pipe 10. The first pipe 10 allows the fluid such as water to flow therethrough. The second pipe 20 allows the refrigerant to flow therethrough.

[0021] The first heat exchanger 50 corresponds to "heat exchanger" of the present invention.

[0022] The expansion device 102 expands the refrigerant having flowed out of the first heat exchanger 50 to reduce the pressure of the refrigerant. It is appropriate that as the expansion device 102, for example, an electric expansion valve capable of adjusting the flow rate of refrigerant is used. Besides the electric expansion valve, for example, a mechanical expansion valve using a diaphragm as a pressure-receiving portion or a capillary tube can be used as the expansion device 102.

[0023] The second heat exchanger 103 serves as an evaporator, and cause heat exchange to be performed between low-temperature and low-pressure refrigerant having flowed out of the expansion device 102 and air sent by a fan 105, to thereby evaporate the low-temperature and low-pressure liquid refrigerant or two-phase refrigerant. As the second heat exchanger 103, for example, a fin-and-tube heat exchanger, a microchannel heat exchanger, a shell-and-tube heat exchanger, a heat pipe heat exchanger, a double-pipe heat exchanger or a plate heat exchanger can be used. Fig. 1 illustrates by way of example the case where the second heat exchanger 103 is a fin-and-tube heat exchanger which causes heat exchange to be performed between air and refrigerant.

[0024] In the fluid circuit B, the fluid circulates through the fluid pipe 10A. As the fluid, for example, water or antifreeze can be adopted. The fluid circuit B includes the first heat exchanger 50 and a pump (not illustrated) which transfers the fluid.

[0025] The heat pump water heater 100 further includes a controller 60 which exerts a centralized control

of the entire heat pump water heater 100. To be more specific, the controller 60 controls the driving frequency of the compressor 101 in accordance with a required water heating capacity. The controller 60 further controls the opening degree of the expansion device 102 in accordance with operation conditions. The controller 60 also controls driving of the fan 105 and the pump (not illustrated) in accordance with the operation conditions.

[0026] To be more specific, the controller 60 controls each of actuators (including the compressor 101, the expansion device 102, the fan 105 and the pump not illustrated) in response to a user's instructions and based on information sent from temperature sensors (not illustrated) and pressure sensors (not illustrated). It should be noted that the controller 60 may be included in a unit incorporating the compressor 101 or may be included in another unit.

[0027] Each of function portions included in the controller 60 is dedicated hardware or a micro processing unit (MPU) which executes a program stored in a memory.

<Operation of heat pump water heater 100>

[0028] Next, an operation of the heat pump water heater 100 will be described.

[0029] The heat pump water heater 100 is capable of supplying hot water in response to an instruction from a load-side device.

[0030] It should be noted that the operation of each actuator is controlled by the controller 60.

[0031] The low-temperature and low-pressure refrigerant is compressed by the compressor 101 to change into high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant is discharged from the compressor 101, and flows into the first heat exchanger 50. The refrigerant having flowed into the first heat exchanger 50 passes through the second pipe 20 which forms part of the refrigerant circuit A, and exchanges heat with the fluid flowing through the first pipe 10 which forms part of the fluid circuit B. At this time, the refrigerant is condensed to change into low-temperature and high-pressure liquid refrigerant, and then flows out of the first heat exchanger 50. It should be noted that in the case where carbon dioxide is used as the refrigerant, the refrigerant changes in temperature while remaining in a supercritical state.

[0032] On the other hand, the fluid having flowed into the first pipe 10 is heated by the refrigerant flowing through the second pipe 20, and then supplied to the load-side device.

[0033] The low-temperature and high-pressure liquid refrigerant having flowed out of the first heat exchanger 50 is changed into low-temperature and low-pressure liquid refrigerant (or two-phase refrigerant) by the expansion device 102. The low-temperature and low-pressure liquid refrigerant (or two-phase refrigerant) flows into the second heat exchanger 103, then exchanges heat with

air sent by the fan 105 provided close to the second heat exchanger 103 to change into low-temperature and low-pressure gas refrigerant, and flows out of the second heat exchanger 103. The refrigerant having flowed out of the second heat exchanger 103 is re-sucked into the compressor 101.

[0034] Fig. 1 illustrates the case where in the refrigerant circuit A, the refrigerant flows in a constant direction. However, a flow-passage switching device may be provided on a discharge side of the compressor 101 such that the flow of refrigerant can be reversed. In the case where the flow-passage switching device is provided, the first heat exchanger 50 also serves as an evaporator, and the second heat exchanger 103 also serves as a condenser. It should be noted that as the flow-passage switching device, a combination of two-way valves, a combination of three-way valves or a four-way valve can be adopted.

[0035] Furthermore, it is preferable that as the refrigerant for use in the heat pump water heater 100, carbon dioxide be used; however, the refrigerant for use in the heat pump water heater 100 is not limited to carbon dioxide. Besides carbon dioxide, for example, natural refrigerant (for example, carbon hydride or helium), chlorine-based substitute refrigerant (for example, HFC410A, HFC407C or HFC404A) or fluorocarbon-based refrigerant (for example R22 or R134a) for use in existing products may be used.

[Details of first heat exchanger 50]

[0036] Fig. 2 is a perspective view schematically illustrating an appearance of the first heat exchanger 50. Fig. 3 is a transparent perspective view schematically illustrating an internal configuration of the first heat exchanger 50. Fig. 4 is a schematic view schematically illustrating an example of a sectional configuration of the first heat exchanger 50. Fig. 5 is a schematic view schematically illustrating an example of a configuration of the first heat exchanger 50. With reference to Figs. 2 to 5, the first heat exchanger 50 provided in the heat pump water heater 100 according to the embodiment of the present invention will be described.

[0037] The first heat exchanger 50 includes the first pipe 10 which allows fluid to flow through the first pipe 10 and the second pipe 20 which allows refrigerant to flow through the second pipe 20. The second pipe 20 is provided in the first pipe 10. That is, the first heat exchanger 50 is a double-pipe heat exchanger as described above. The first pipe 10 is connected to the fluid pipe 10A, and forms along with the fluid pipe 10A part of the fluid circuit B. The second pipe 20 is connected to the refrigerant pipe 20A, and forms along with the refrigerant pipe 20A part of the refrigerant circuit A.

[0038] As illustrated in Figs. 2 to 5, in the first heat exchanger 50, the first pipe 10 and the second pipe 20 are bent a number of times. It should be noted that in Figs. 4 and 5, bent portions of the first pipe 10 are denoted

by 10X, and bent portions of the second pipe 20 are denoted by 20X; and each of the bent portions of the second pipe 20 will thus be referred to as bent portion 10X, and each of the bent portions of the second pipe 20 will thus be referred to as bent portion 20X.

[0039] In an example, in the first heat exchanger 50, the first pipe 10 and the second pipe 20 may be bent a number of times such that turns of these pipes are stacked together as illustrated in Figs. 2 and 3. That is, the first heat exchanger 50 may be configured to have such an appearance that the turns of the first pipe 10 are stacked in a direction from lower part of each of Figs. 2 and 3 toward upper part of each of these figures.

[0040] In another example, in the first heat exchanger 50, the first pipe 10 and the second pipe 20 may be bent a number of times to extend toward the center as illustrated in Fig. 4; that is, the first heat exchanger 50 can be configured to have such an appearance that the first pipe 10 is turned a number of times to extend from outer part of Fig. 4 toward inner part thereof.

[0041] In still another example, in the first heat exchanger 50, the first pipe 10 and the second pipe 20 may be bent a number of times in a zigzag manner as illustrated in Fig. 5. That is, the first heat exchanger can be configured to have such an appearance that the first pipe 10 is turned in a zigzag manner and turns of the first pipes are stacked in a direction from lower part of Fig. 5 toward upper part of Fig. 5.

[0042] At ends of the first pipe 10, a fluid inlet 10a and a fluid outlet 10b are provided. The fluid inlet 10a allows the fluid to flow into the first pipe 10 through the fluid inlet 10a, and the fluid outlet 10b allows the fluid to flow out of the first pipe 10 through the fluid outlet 10b. The first pipe 10 is made of a resin material. The resin material for the first pipe 10 will be described in detail later.

[0043] At respective ends of the second pipe 20, a refrigerant inlet 20a and a refrigerant outlet 20b are provided. The refrigerant inlet 20a allows the refrigerant to flow into the second pipe 20 through the refrigerant inlet 20a, and the refrigerant outlet 20b allows the refrigerant to flow out of the second pipe 20 through the refrigerant outlet 20b. The second pipe 20 is made of a metal material such as copper or aluminum.

[0044] Figs. 2 to 5 each illustrates by way of example the case where the fluid inlet 10a and the refrigerant inlet 20a are paired with each other, and the fluid outlet 10b and the refrigerant outlet 20b are paired with each other, whereby the fluid and the refrigerant flow in parallel to each other. However, the fluid inlet 10a and the refrigerant outlet 20b may be paired with each other, and the fluid outlet 10b and the refrigerant inlet 20a may be paired with each other, whereby the fluid and the refrigerant flow in opposite directions.

[0045] Since the first heat exchanger 50 serves as a condenser, high-temperature refrigerant flows through the second pipe 20. If an outer surface of the second pipe 20 contacts an inner surface of the first pipe 10, the first pipe 10 may be deformed since it is made of resin. In

view of this point, the first heat exchanger 50 is provided with resin elements 30.

[0046] Fig. 6 is an enlarged vertical-sectional view schematically illustrating an example of a sectional configuration of part of the first heat exchanger 50. Fig. 7 is a graph indicating a refrigerant temperature distribution of the first heat exchanger 50. With references to Figs. 6 and 7, preferred positions of the resin element 30 will be described. In Fig. 7, the vertical axis represents the temperature of the refrigerant, and the horizontal axis represents a dimensionless number of a distance of the first heat exchanger 50.

[0047] In Fig. 6, flows of the fluid in the first pipe 10 are indicated by solid arrows, and a flow of the refrigerant in the second pipe 20 is indicated by a dashed arrow. Fig. 6 illustrates by way of example the case where resin elements 30 provided on the inner surface of the first pipe 10. Also, Fig. 6 schematically illustrates sections of the first pipe 10 and the second pipe 20 which are taken along flow passages.

[0048] The resin elements 30 are provided in the first pipe 10 as elements separate from the first pipe 10 and the second pipe 20. In other words, the resin elements 30 are not formed by deforming part of the outer surface of the second pipe 20 or part of the inner surface of the first pipe 10, that is, the resin elements 30 are not part of the outer surface of the second pipe 20 or part of the inner surface of the first pipe 10. Also, the resin elements 30 are disposed at regions in space between the inner surface of the first pipe 10 and the outer surface of the second pipe 20. That is, the space between the inner surface of the first pipe 10 and the outer surface of the second pipe 20 is not filled with the resin elements 30.

[0049] The resin elements 30 are each intended to prevent the outer surface of the second pipe 20 and the inner surface of the first pipe 10 from contacting each other. To be more specific, because of provision of the resin elements 30, it is possible to prevent contact between the outer surface of the second pipe 20 and the inner surface of the first pipe 10, thus preventing heat of the refrigerant flowing through the second pipe 20 from being transmitted to the first pipe 10. Thus, even when the high-temperature refrigerant flows through the second pipe 20, its heat is not transmitted to the first pipe 10. Therefore, the first pipe 10, which is made of resin, is not deformed.

[0050] In the case where the first heat exchanger 50 operates as a condenser or a gas cooler, the temperature of the refrigerant at the inlet of the first heat exchanger 50 reaches the highest temperature. As the refrigerant flows forward through the first heat exchanger 50, its temperature gradually decreases. Then, from the time when the refrigerant flows forward to some extent in the first heat exchanger 50, its temperature is substantially constant until the refrigerant flows out of the first heat exchanger 50. Thus, in the case where the resin elements 30 are provided at portions of the first pipe 10 where the temperature of the refrigerant flowing in the second pipe

20 reaches the highest temperature, it is more unlikely that the heat of the refrigerant flowing through the second pipe 20 will be transmitted to the first pipe 10.

[0051] It is therefore preferable that the resin element 30 be provided at least between the refrigerant inlet 20a of the second pipe 20 and a position which is separated from the refrigerant inlet 20a by 5% of the entire length of the second pipe 20, as seen from Fig. 7. If the resin element 30 is provided in such a manner, it is located close to part of the second pipe 20 where the temperature of the refrigerant reaches the highest temperature. Thereby, the heat of the refrigerant flowing through the second pipe 20 is not easily transmitted to the first pipe 10, thus reducing deformation of the first pipe 10. Also, it is possible to the number of resin elements 30 to be provided.

[0052] Next, another example of the position of the resin element 30 will be described.

[0053] Fig. 8 is an enlarged vertical-sectional view schematically illustrating an example of the sectional configuration of part of the first heat exchanger 50 that includes bent portions. Fig. 9 is an enlarged vertical-sectional view of still another example of the sectional configuration of the part of the first heat exchanger 50, which includes the bent portions. With reference to Figs. 8 and 9, specific positions of resin elements 30 will be described.

[0054] Figs. 8 and 9 each illustrate the case where the resin elements 30 are provided on the inner surface of the first pipe 10. Figs. 8 and 9 each illustrate sections of the first pipe 10 and the second pipe 20, which are taken along the flow passages.

[0055] As illustrated in Figs. 2 to 5, the first pipe 10 and the second pipe 20 of the first heat exchanger 50 are bent a lot of times. Thus, the first pipe 10 and the second pipe 20 can be easily brought into contact with each other at the bent portions 10X of the first pipe 10 and the bent portions 20X of the second pipe 20. In view of this point, it is preferable that resin elements 30 be provided at least at the bent portions 10X and the bent portions 20X, as illustrated in Figs. 8 and 9, though the positions of the resin elements 30 is not limited to such positions.

[0056] Besides at the bent portions 10X of the first pipe 10 and the bent portions 20X of the second pipe 20, the resin elements 30 may also be provided at linear portions of the first pipe 10 and second pipe 20, as illustrated in Figs. 8 and 9. Because of this configuration, it is possible to more reliably prevent contact between the first pipe 10 and the second pipe 20.

[0057] Furthermore, in the first heat exchanger 50, the first pipe 10 and the second pipe 20 can be easily brought into contact with each other at parts of an outer region of the flow passage for the fluid, which are located between the bent portions 10X and the bent portions 20X. This is because when the fluid flows through each of the bent portions 10X, and the refrigerant flows through each of the bent portions 20X, centrifugal forces are applied to the first pipe 10 and the second pipe 20, they cause

the first pipe 10 and the second pipe to be deformed outwards. In view of this point, as illustrated in Fig. 9, it is appropriate that resin elements 30 are provided at least the outer region of the flow passage for the fluid in the first pipe 10. If the resin elements 30 are provided in such a manner, it is possible to prevent contact between the first pipe 10 and the second pipe 20 with a simpler structure.

[0058] Besides the positions described with reference to Figs. 8 and 9, the positions described with reference to Fig. 7 may be added as the positions of the resin elements 30. If these positions are added, that is, the resin elements 30 are provided at the positions, it is possible to prevent contact between the first pipe 10 and the second pipe 20 at a location on which heat has a great effect, with a simple structure.

[0059] It should be noted that the number of resin elements 30 to be provided is not limited to a specific number. The smaller the number of resin elements 30, the lower the cost. Furthermore, in the case where the number of resin elements 30 is limited to a given number, it is appropriate that the resin elements 30 are provided at least the outer region of the flow passage for the fluid in the first pipe 10, as illustrated in Fig. 9. Furthermore, the sectional shape of each of the resin elements 30 which is taken along the flow passages in the first pipe 10 and the second pipe 20 is not limited to a particular shape. For example, each resin element 30 may be shaped to have a polygonal section as illustrated in Figs. 6, 8 and 9. Alternatively, each resin element 30 may be shaped to have a circular section or a polygonal section with rounded corners.

[0060] Next, the shape of the resin element 30 will be described.

[0061] Fig. 10 is an enlarged vertical-sectional view schematically illustrating an example of a sectional configuration of the resin element 30 of the first heat exchanger 50. Fig. 10 schematically illustrates a section taken along a direction perpendicular to the flow passages of the first pipe 10 and the second pipe 20.

[0062] As illustrated in Fig. 10, the resin element 30 can be formed to have a circular section. Thereby, the resin element 30 can be provided on the entire circumference of part of the inner surface of the first pipe 10. Resin elements 30 provided in such a manner are illustrated in Figs. 6 and 8.

[0063] Fig. 11 is an enlarged vertical-sectional view schematically illustrating another example of the sectional configuration of the resin element 30 of the first heat exchanger 50. Fig. 11 schematically illustrates a section taken along the direction perpendicular to the flow passages of the first pipe 10 and the second pipe 20.

[0064] As illustrated in Fig. 11, the resin element 30 can be formed to have a semicircular section. Thereby, the resin element 30 can be provided only on part of the inner surface of the first pipe 10 which is located in the outer region of the flow passage therein. Resin elements 30 provided in such a manner are illustrated in Fig. 9.

[0065] Fig. 11 illustrates by way of example the case where two second pipes 20 are provided in the first pipe 10. In such a manner, two second pipes 20 may be provided. The number of the second pipes 20 is not limited to a specific number.

[0066] Fig. 12 is an enlarged vertical-sectional view schematically illustrating still another example of the sectional configuration of the resin element 30 of the first heat exchanger 50. Fig. 13 is an enlarged vertical-sectional view schematically illustrating a further example of the sectional configuration of the resin element 30 of the first heat exchanger 50. Fig. 14 is an enlarged vertical-sectional view schematically illustrating a still further example of the sectional configuration of the resin element 30 of the first heat exchanger 50. Figs. 12 to 14 each schematically illustrate sections taken along the direction perpendicular to the flow passages of the first pipe 10 and the second pipe 20.

[0067] In each of the examples illustrated in Figs. 12 to 14, the resin element 30 is formed to have a circular section having grooves 30A extending in the flow direction of the fluid. Thereby, the resin element 30 can be provided on the entire circumference of part of the inner surface of the first pipe 10, as in the example illustrated in Fig. 10. Further, since the resin element 30 is provided with the grooves 30A, it is possible to prevent flowing of the fluid from being hindered by the resin element 30.

[0068] The resin element 30 is located in the first pipe 10, and thus acts as a resistance to the flow of the fluid. In view of this, in the resin element 30, the grooves 30A are formed to cause the fluid to flow smoothly, as illustrated in Figs. 12 to 14.

[0069] It should be noted that the shape, size and number of the grooves 30A are not limited to specific ones, and it is appropriate that the shape, size and number of the grooves 30A are determined in accordance with the shape, size and number of the resin elements 30. Alternatively, a plurality of resin elements 30 may be circumferentially arranged and spaced from each other to form the grooves 30A. In this case, each of the resin elements 30 is not circular.

[0070] The sectional shape of the resin element 30 which is taken along the direction perpendicular to the flow passages of the first pipe 10 and the second pipe 20 is not limited to a specific shape. For example, the resin element 30 can be formed to have an even inner surface, as illustrated in Figs. 10 and 11. Alternatively, the resin element 30 may be formed to have a polygonal section, as illustrated in Figs. 12 and 13 or may be formed to have a section with arcuate portions, as illustrated in Fig. 14.

[0071] Fig. 15 is an enlarged vertical cross-sectional view schematically illustrating a further example of the sectional configuration of the part of the first heat exchanger 50, which includes the bent portions. The resin element 30 will be described with reference to Fig. 15. Unlike Figs. 6, 8 and 9, Fig. 15 illustrates by way of example the case where resin elements 30 are provided

on the outer surface of the second pipe 20. Fig. 15 schematically illustrates a section taken along the flow passages of the first pipe 10 and the second pipe 20.

[0072] Figs. 6, 8 and 9 each illustrate by way of example the case where the resin elements 30 are provided on the inner surface of the first pipe 10, whereas Fig. 15 illustrates by way of example the case where the resin elements 30 are provided on the outer surface of the second pipe 20. This provision of the resin elements 30 means that the resin elements 30 are provided in regions in space between the inner surface of the first pipe 10 and the outer surface of the second pipe 20. It should be noted that the function of the resin elements 30 is described above with reference to Figs. 6 to 9.

[0073] Though the position of each of the resin elements 30 is not limited to a specific one, it is appropriate that the resin elements 30 are provided at locations where at least the bent portions 10X and 20X are present, as illustrated in Fig. 15. Because of this configuration, it is possible to prevent contact between the first pipe 10 and the second pipe 20.

[0074] It should be noted that though the length of each of the resin elements 30 along the flow direction of the fluid is not limited to a specific one, the resin elements 30 along the flow direction of the fluid, as illustrated in Fig. 15, may be formed to be longer than those of the resin elements 30 as illustrated in Figs. 6, 8 and 9. Alternatively, the resin elements 30 as illustrated in Figs. 6, 8 and 9 may be provided on the outer surface of the second pipe 20.

[0075] The number of resin elements 30 to be provided is not limited to a specific one. Also, the shape of the section of each of the resin elements 30 which is taken along the flow passages of the first pipe 10 and the second pipe 20 is not limited to a specific one. For example, each resin element 30 may be formed to have a polygonal section as illustrated in Fig. 15 or may be formed to have a section having arcuate portions.

[0076] Next, the shape of the resin element 30 will be described.

[0077] Figs. 16 and 17 are enlarged vertical-sectional views schematically illustrating respective examples of the sectional configuration of the resin element 30 of the first heat exchanger 50. Figs. 16 and 17 schematically illustrate respective sections taken along the direction perpendicular to the flow passages of the first pipe 10 and the second pipe 20.

[0078] As illustrated in Figs. 16 and 17, the resin elements 30 can be each formed to have a circular section. Thereby, each resin element 30 can be provided on the entire circumference of part of the outer surface of the second pipe 20. The resin elements 30 formed as illustrated in Fig. 16 are provided as illustrated in Fig. 15.

[0079] Fig. 17 illustrates by way of example the case where two second pipes 20 are provided in the first pipe 10. In the case where two second pipes 20 are provided in such a manner, though resin elements 30 each having a circular section may be provided on the outer surfaces

of the respective two second pipes 20, a resin element 30 having a circular section may be provided on both the outer surfaces of the two second pipes 20 as illustrated in Fig. 17. It should be noted that the number of the second pipes 20 is not limited to a specific one.

[Resin material of first pipe 10]

[0080] It is assumed that the resin element 30 is made of resin having a heat resistance temperature of 100 degrees C or higher. In this case, even if any kind of refrigerant is applied to the heat pump water heater 100, the resin element 30 will not be deformed by heat of the refrigerant flowing in the first heat exchanger 50.

[0081] Fig. 18 is a table indicating heat resistance temperatures of resin. As indicated in Fig. 18, as examples of the resin having a heat resistance temperature of 100 degrees C or higher, the following kinds of resin are present: high density polyethylene; polypropylene; AS resin; ABS resin; polyethylene terephthalate; vinylidene chloride resin; polycarbonate; polyamide; acetal resin; polybutylene terephthalate; fluorine resin; phenol resin; melamine resin; polyurethane; epoxy resin; and unsaturated polyester resin. Therefore, it is appropriate that the material of the resin element 30 is selected in accordance with the kind of refrigerant to be circulated in the refrigerant circuit A.

[Advantages of first heat exchanger 50 or heat pump water heater 100]

[0082] The first heat exchanger 50 includes the first pipe 10 formed of resin, the second pipe 20 formed of metal, and resin elements 30. The first pipe 10 allows fluid to flow through the first pipe 10. The second pipe 20 is provided in the first pipe 10, and allows refrigerant to flow through the second pipe 20. The resin elements 30 are each formed as an element separate from the first pipe 10 and the second pipe 20, and provided in regions in space between the inner surface of the first pipe 10 and the outer surface of the second pipe 20.

[0083] Therefore, in the first heat exchanger 50, since the resin elements 30 each formed as an element separate from the first pipe 10 and the second pipe 20 are provided in regions in space provided between the inner surface of the first pipe 10 and the outer surface of the second pipe 20, it is possible to prevent contact between the first pipe 10 and second pipe 20 without adopting a complexed structure. Furthermore, in the first heat exchanger 50, it is possible to prevent contact between the first pipe 10 and the second pipe 20 at a low cost, as compared with the case where a complexed structure is applied.

[0084] In the first heat exchanger 50, since the resin elements 30 and the first pipe 10 are formed of different kinds of resin, the resin elements 30 can prevent the first heat exchanger 50 without deforming the first pipe 10.

[0085] In the first heat exchanger 50, the resin elements 30 are each provided at least within an area from

the refrigerant inlet 20a of the second pipe 20 to a position which is separated from the refrigerant inlet 20a by 5% of the entire length of the second pipe 20. Thus, the resin elements 50 are each located at a region on which heat of the refrigerant has a great effect. Thereby, the heat of the refrigerant flowing in the second pipe 20 is not easily transmitted to the first pipe 10.

[0086] In the first heat exchanger 50, since the resin elements 30 are each formed of resin having a heat resistance temperature of 100 degrees C or higher, they are not deformed by the heat of the refrigerant flowing in the first heat exchanger 50. Therefore, in the first heat exchanger 50, the first pipe 10 and the second pipe 20 can be kept in noncontact with each other for a long time period.

[0087] In the first heat exchanger 50, the first pipe 10 includes the bent portions 10X, the second pipe 20 includes the bent portions 20X, and resin elements 30 are provided at the bent portions 10X and bent portions 20X. Therefore, since the resin elements 30 are provided at locations where the first pipe 10 and the second pipe 20 can be easily brought into contact with each other, it is possible to effectively prevent the first pipe 10 and the second pipe 20 from contacting each other.

[0088] In the first heat exchanger 50, since the resin elements 30 are provided only at outer peripheral sides of the bent portions 20X of the second pipe 20, it is possible to prevent contact between the first pipe 10 and the second pipe 20 with a simpler structure.

[0089] In the first heat exchanger 50, the resin elements 30 are located on the inner surface of the first pipe 10. Thus, it is possible to provide the resin elements 30 in the first pipe 10 without using a specific element.

[0090] In the first heat exchanger 50, the resin elements 30 are located on the outer surface of the second pipe 20. Thus, it is possible to provide the resin elements 30 in the first pipe 10 without using a specific element.

[0091] In the first heat exchanger 50, the grooves 30A are formed at least in part of each of the resin elements 30 to extend along the flow direction of the fluid. It is therefore possible to reduce a pressure loss which is caused by provision of the resin elements 30, and thus cause the fluid to flow smoothly.

[0092] In the heat pump water heater 100, because of provision of the first heat exchanger 50 serving as a condenser (gas cooler), deformation of the first pipe 10 can be reduced, and the reliability is thus improved. Furthermore, the resin elements 30 provided in the first heat exchanger 50 are not complicated in configuration, and the heat pump water heater 100 is thus made at a low cost.

[0093] Features of the present invention are explained in the above descriptions of the embodiment; however, specific configurations of the present invention are not limited to the configurations as described above with respect to the embodiment, and can be modified without departing from the scope of the present invention. Reference Signs List

[0094]

10 first pipe 10A fluid pipe 10X bent portion 10a fluid inlet

10b fluid outlet 20 second pipe 20A refrigerant pipe 20X bent portion 20a refrigerant inlet 20b refrigerant outlet 30 resin element 30A groove 50 first heat exchanger 60 controller 100 heat pump water heater 101 compressor 102 expansion device 103 second heat exchanger 105 fan A refrigerant circuit B fluid circuit

Claims

1. A heat exchanger comprising:

a first pipe formed of resin and configured to allow fluid to flow through the first pipe;
a second pipe formed of metal, provided in the first pipe, and configured to allow refrigerant to flow through the second pipe;
a resin element formed as an element separate from the first pipe and the second pipe, and provided in a region in space between an inner surface of the first pipe and an outer surface of the second pipe.

2. The heat exchanger of claim 1, wherein the resin element and the first pipe are formed of different kinds of resin.

3. The heat exchanger of claim 1 or 2, wherein the resin element is provided in an area from a refrigerant inlet of the second pipe to a position which is separated from the refrigerant inlet by 5% of an entire length of the second pipe.

4. The heat exchanger of any one of claims 1 to 3, wherein the resin element is formed of resin having a heat resistance temperature of 100 degrees C or higher.

5. The heat exchanger of any one of claims 1 to 4, wherein the first pipe and the second pipe include respective bent portions, and the resin element is provided at the bent portion.

6. The heat exchanger of claim 5, wherein the resin element is provided only on an outer peripheral side of the bent portion of the second pipe.

7. The heat exchanger of any one of claims 1 to 6, wherein the resin element is provided on the inner surface of the first pipe.

8. The heat exchanger of any one of claims 1 to 6, wherein the resin element is provided on the outer

surface of the second pipe.

9. The heat exchanger of any one of claims 1 to 8, wherein the resin element includes a groove formed in at least part of the resin element and extending in a flow direction of the fluid. 5
10. A heat pump water heater comprising the heat exchanger of any one of claims 1 to 9 as a condenser. 10

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FIG. 1

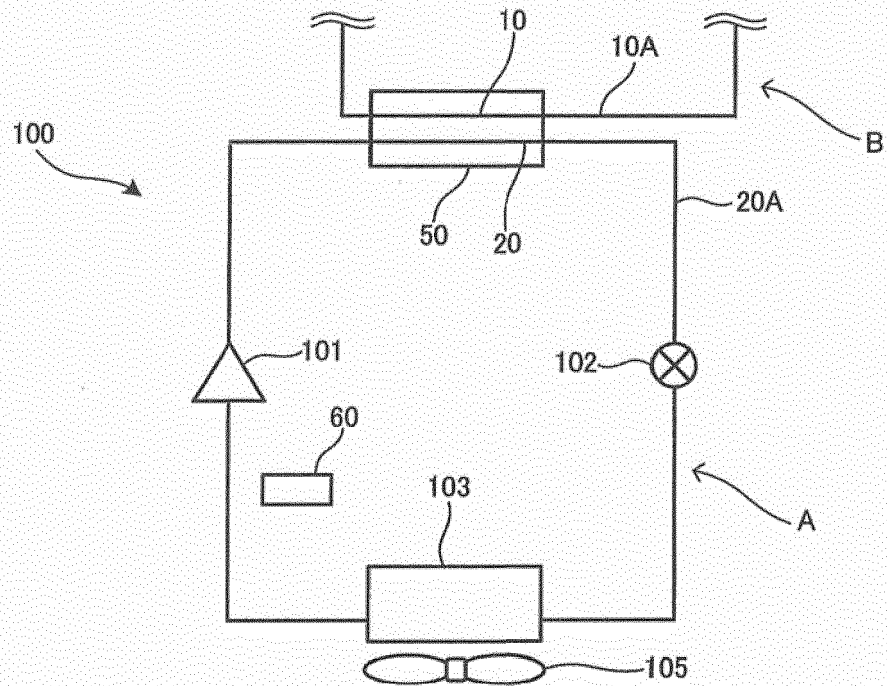


FIG. 2

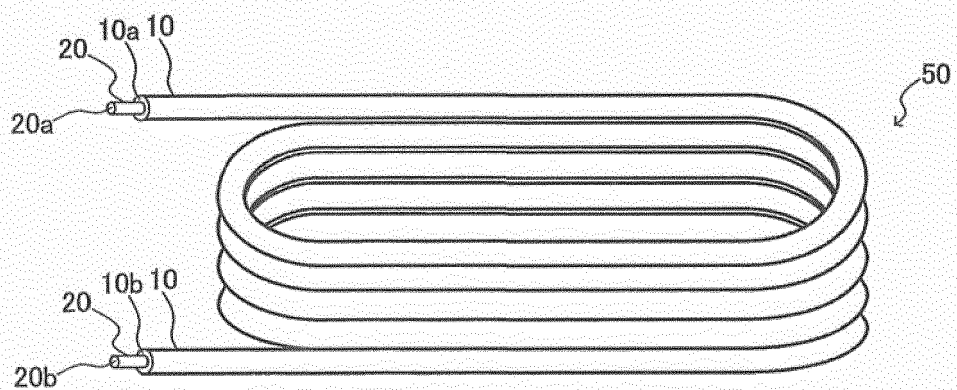


FIG. 3

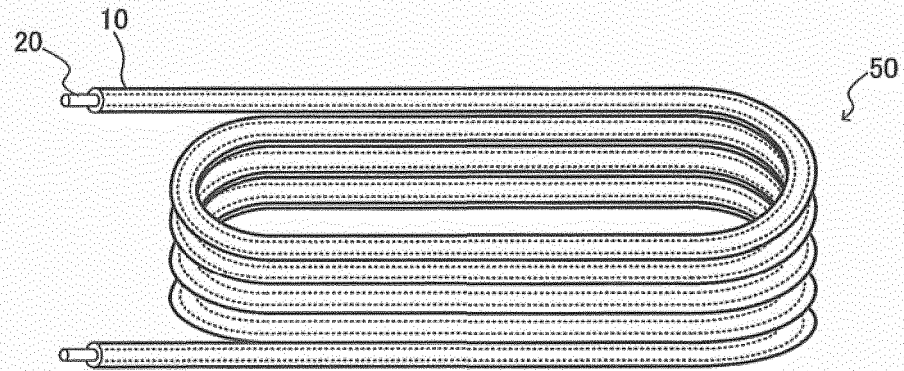


FIG. 4

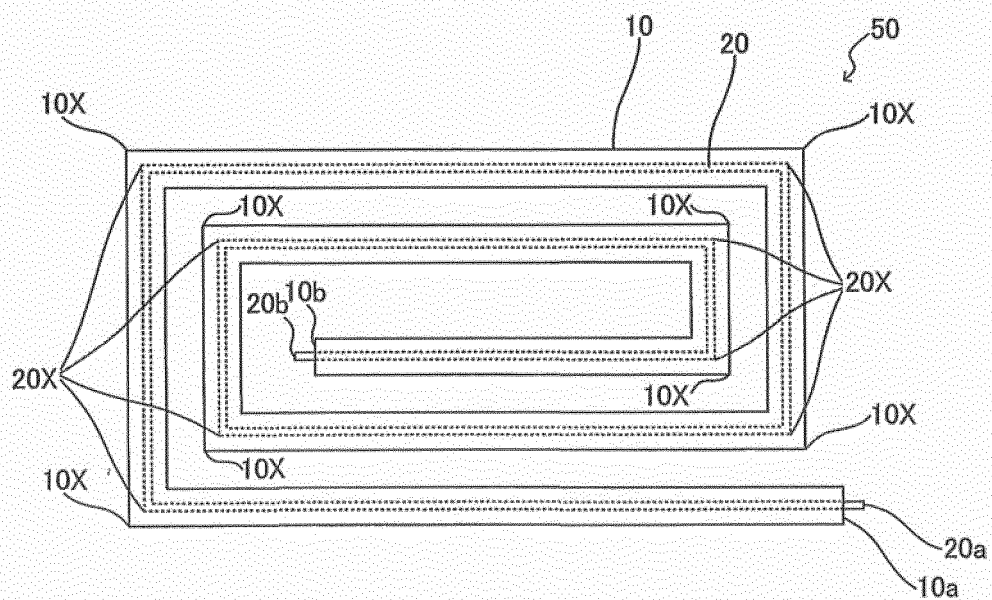


FIG. 5

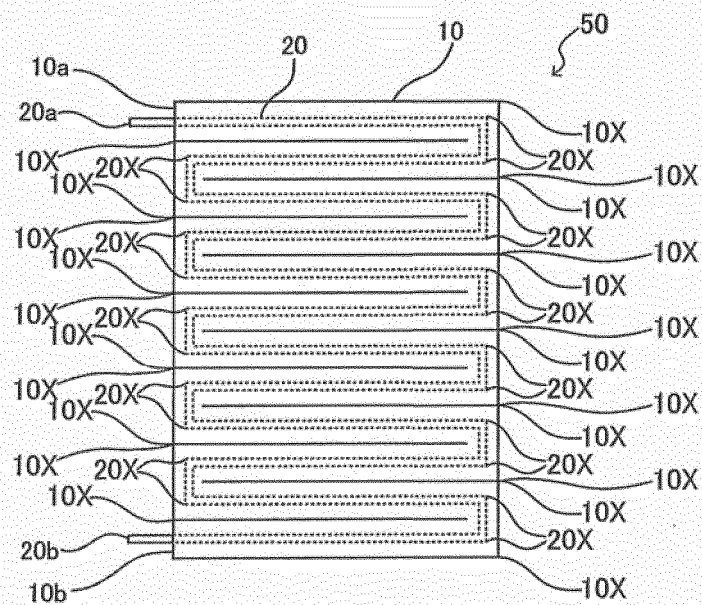


FIG. 6

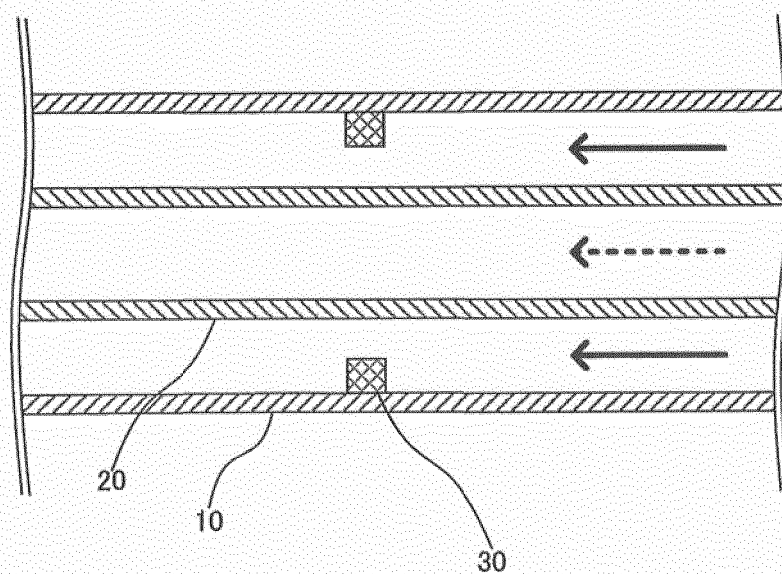


FIG. 7

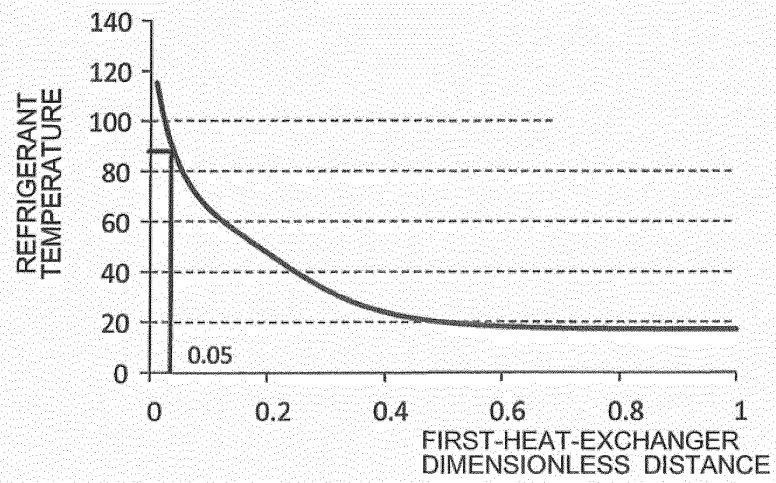


FIG. 8

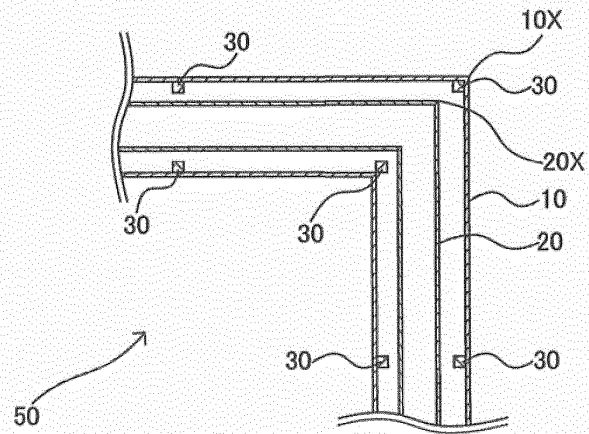


FIG. 9

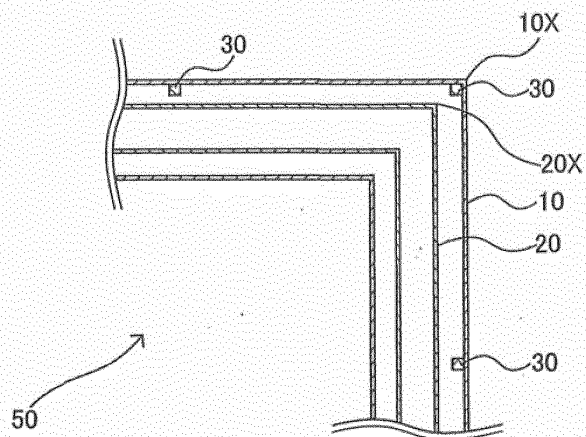


FIG. 10

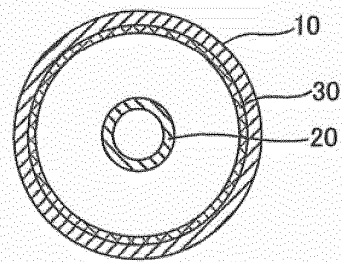


FIG. 11

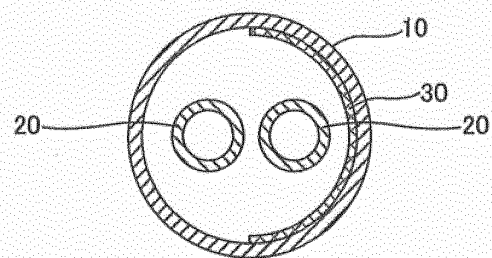


FIG. 12

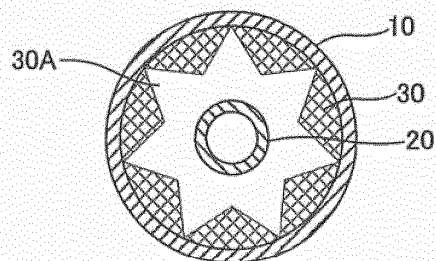


FIG. 13

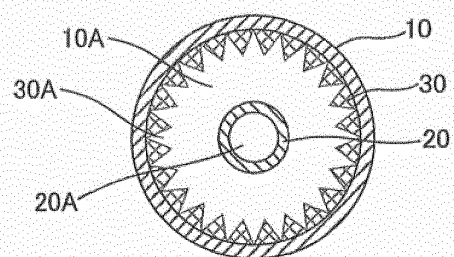


FIG. 14

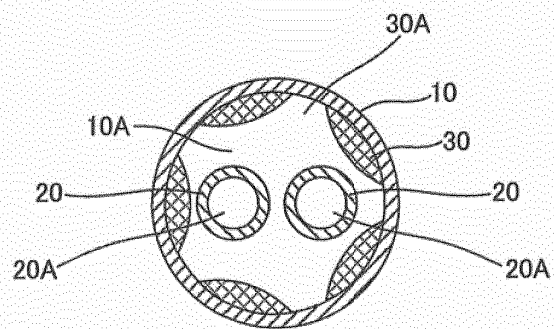


FIG. 15

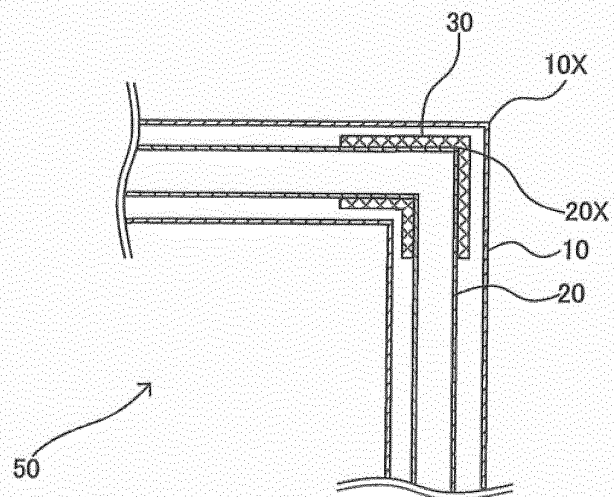


FIG. 16

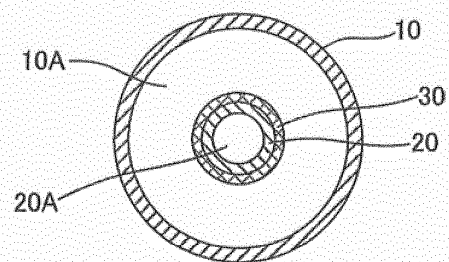


FIG. 17

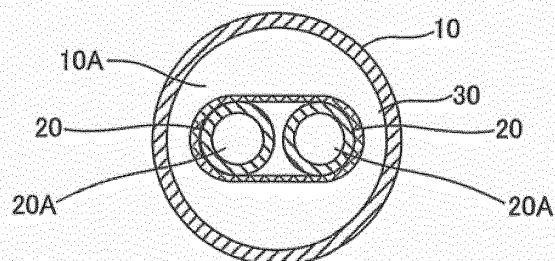


FIG. 18

		RESIN		NORMAL HEAT-RESISTANT TEMPERATURE
THERMO-PLASTIC RESIN	GENERAL-PURPOSE PLASTIC	POLYETHYLENE	LOW-DENSITY POLYETHYLENE	70°C TO 90°C
			HIGH-DENSITY POLYETHYLENE	70°C TO 110°C
			EVA RESIN	70°C TO 90°C
		POLYPROPYLENE		100°C TO 140°C
		VINYL CHLORIDE RESIN (POLYVINYL CHLORIDE)		60°C TO 80°C
		POLYSTYRENE	POLYSTYRENE	70°C TO 90°C
			FOAMED POLYSTYRENE	70°C TO 90°C
		AS RESIN		80°C TO 100°C
		ABS RESIN		70°C TO 100°C
		POLYETHYLENE TEREPHTHALATE		TO 200°C
				TO 60°C
				TO 85°C
		METHACRYL RESIN		70°C TO 90°C
		POLYVINYL ALCOHOL		40°C TO 80°C
		VINYLIDENE CHLORIDE RESIN		130°C TO 150°C
	ENGINEERING PLASTIC	POLYCARBONATE		120°C TO 130°C
		POLYAMIDE		80°C TO 140°C
		ACETAL RESIN		80°C TO 120°C
		POLYBUTYLENE TEREPHTHALATE		60°C TO 140°C
		FLUORINE RESIN		260°C
		PHENOL RESIN		150°C
THERMOSETTING RESIN			MELAMINE RESIN	110°C TO 130°C
			UREA RESIN	90°C
			POLYURETHANE	90°C TO 130°C
			EPOXY RESIN	150°C TO 200°C
			UNSATURATED POLYESTER RESIN	130°C TO 150°C

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/003147

A. CLASSIFICATION OF SUBJECT MATTER

F28D7/10(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)

F28D7/10, F16L11/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
 Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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.
X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 116883/1987 (Laid-open No. 22173/1989) (Fujitsu General Ltd.), 03 February 1989 (03.02.1989), page 3, line 6 to page 5, line 7; fig. 1, 3 (Family: none)	1-2
Y		3-10
Y	JP 57-60192 A (Ishida Sangyo Kabushiki Kaisha), 10 April 1982 (10.04.1982), page 1, right column, line 15 to page 2, upper right column, line 16; fig. 2 (Family: none)	3-10

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

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Date of the actual completion of the international search
10 February 2017 (10.02.17)Date of mailing of the international search report
07 March 2017 (07.03.17)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/003147

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2012-92962 A (Sekisui Chemical Co., Ltd.), 17 May 2012 (17.05.2012), paragraphs [0028] to [0030], [0035] to [0048]; fig. 2, 4, 7 to 8 (Family: none)	7-10
Y	JP 3-238128 A (Shinko Metal Products Kabushiki Kaisha), 23 October 1991 (23.10.1991), page 4, upper left column, lines 12 to 17; fig. 1 (Family: none)	9-10
Y	JP 58-198688 A (Matsushita Electric Industrial Co., Ltd.), 18 November 1983 (18.11.1983), page 2, upper right column, lines 7 to 19; fig. 1 to 3 (Family: none)	10

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013011387 A [0005]