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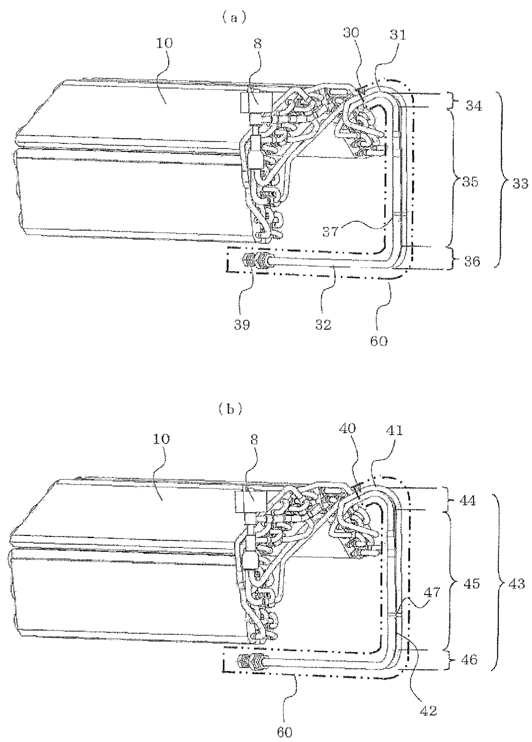
(54) Heat exchanger and air-conditioning apparatus having the same

(57) It is an objective to achieve suppressing progress of electrolytic corrosion (galvanic corrosion) by aluminum or an aluminum alloy caused by diffusion of copper ions to a connection pipe formed of aluminum or an aluminum alloy. The copper ions are diffused through water having condensed and staying in a small gap between the thermally insulating material and the connection pipe.

In a gas pipe 30 and a liquid pipe 40 of a connection pipe unit 20, connection portions 37 and 47, in which aluminum pipes 31 and 41 (first refrigerant pipes: refrigerant pipes formed of aluminum or an aluminum alloy) and copper pipes 32 and 42 (second refrigerant pipes: refrigerant pipes formed of copper or a copper alloy) are respectively connected to each other, are disposed in fall portions of the aluminum pipes 31 and 41. The connection pipe unit 20 is covered with a thermally insulating material 60. An anti-corrosion treatment is applied to the aluminum pipes 31 and 41 covered with the thermally insulating material 60.

F I G. 2



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Description

[Technical Field]

[0001] The present invention relates to a heat exchanger and an air-conditioning apparatus equipped with the heat exchanger.

[Background Art]

[0002] Heat exchangers equipped with heat exchangers having heat transfer pipes formed of aluminum or an aluminum alloy (hereafter, referred to as "aluminum heat exchanger") are known. The heat transfer pipes formed of aluminum or an aluminum alloy (or refrigerant pipes formed of aluminum or an aluminum alloy and connected to the heat transfer pipes. These pipes are referred to as "aluminum pipes" hereafter) of such a heat exchanger are connected to refrigerant pipes formed of copper or a copper alloy (hereafter, referred to as "copper pipes"), thereby incorporating the heat exchanger in a refrigeration cycle. In the case where the aluminum heat exchanger is incorporated in the refrigeration cycle using the copper pipes in the above-described manner, when water staying on the copper pipes adheres to the heat transfer pipes or the aluminum pipes, there arises a problem in that electrolytic corrosion (galvanic corrosion) occurs in the heat transfer pipes or the aluminum pipes.

[0003] For this reason, technologies for heat exchangers have been proposed so as to prevent electrolytic corrosion (galvanic corrosion) in the heat transfer pipes formed of aluminum or aluminum alloys and aluminum pipes from occurring. Such a technology has been proposed, for example, as follows: "An air-conditioning apparatus includes a main body of the air-conditioning apparatus, a compressor, and a securing member that secures a refrigeration cycle unit to the main body of the air-conditioning apparatus. The refrigeration cycle unit includes a heat exchanger formed of aluminum or an aluminum alloy and a refrigerant pipe, which is formed of copper or a copper alloy and connected to the heat exchanger. An entire portion of the refrigerant pipe above the heat exchanger serves as a water droplet prevention pipe portion, which is inclined downward from the heat exchanger toward the refrigerant pipe, so that water droplets flow downward along the refrigerant pipe, thereby preventing electrolytic corrosion of the heat exchanger due to copper ions from occurring" (see, for example, Patent Literature 1).

[Citation List]

[Patent Literature]

[0004] [Patent Literature 1] Japanese Unexamined Patent Application Publication No. 6-300303 (Abstract and Fig. 1)

[Summary of Invention]

[Technical Problem]

[0005] In an air-conditioning apparatus (for example, an indoor unit) equipped with a related-art aluminum heat exchanger, in order to prevent water droplets having condensed on connection pipes (including connection unit in which the aluminum side and the copper side are connected to each other) for the aluminum heat exchanger from leaking to the outside of the air-conditioning apparatus, the connection pipes need to be covered with a thermally insulating material so as to suppress condensation. However, condensation cannot be completely prevented even by covering the connection pipes with the thermally insulating material, and accordingly, a small amount of water having condensed on the connection pipes stays in a small gap between the thermally insulating material and the connection pipes. Thus, copper ions on the side of the connection pipes being formed of copper or a copper alloy diffuse toward the side of the connection pipes formed of aluminum or an aluminum alloy through water, which has condensed and stays. As a result, there arises a problem in that electrolytic corrosion (galvanic corrosion) occurs in the connection pipes formed of aluminum or an aluminum alloy.

[0006] The present invention is proposed in order to solve the above-described problem. An object of the present invention is to provide a heat exchanger and an air-conditioning apparatus including the heat exchanger, in which progress of electrolytic corrosion (galvanic corrosion) of aluminum or an aluminum alloy can be suppressed. Electrolytic corrosion (galvanic corrosion) of aluminum or an aluminum alloy is caused by diffusion of copper ions to connection pipes formed of aluminum or an aluminum alloy through water having condensed and staying in a small gap between the thermally insulating material and the connection pipe unit.

[Solution to Problem]

[0007] A heat exchanger according to the present invention includes a heat transfer pipe formed of aluminum or an aluminum alloy; and a connection pipe unit through which a refrigerant flowing out of the heat transfer pipe and a refrigerant flowing into the heat transfer pipe pass, the connection pipe unit including a gas pipe through which the refrigerant in a gaseous state flows, and a liquid pipe through which the refrigerant in a liquid state or in a two-phase gas-liquid state flows, the gas pipe and the liquid pipe each having a first refrigerant pipe formed of aluminum or an aluminum alloy, and a second refrigerant pipe formed of copper or a copper alloy, the first refrigerant pipe and the second refrigerant pipe being connected to each other, the first refrigerant pipe having a fall portion connected to the heat transfer pipe, the fall portion extending downward relative to the heat transfer pipe. In the heat exchanger, each connection portion between the first refrigerant pipe and the second refrigerant pipe is disposed in the fall portion of the first refrigerant pipe, the connection pipe unit is covered with a thermally insulating material, and anti-corrosion treatment is applied to each first refrigerant pipe covered with the thermally insulating material.

[0008] An air-conditioning apparatus according to the present invention includes the heat exchanger.

[Advantageous Effects of Invention]

[0009] In the heat exchanger according to the present invention, in each of the gas pipe and the liquid pipe of the connection pipe unit, the connection portion, in which the first refrigerant pipe (refrigerant pipe formed of aluminum or an aluminum alloy) and the second refrigerant pipe (refrigerant pipe formed of copper or a copper alloy) are connected to each other, is disposed in the fall portion of the first refrigerant pipe. The connection pipe unit is covered with the thermally insulating material, and anti-corrosion treatment is applied to the first refrigerant pipe (a refrigerant pipe formed of aluminum or an aluminum alloy) covered with the thermally insulating material. Thus, even when condensation occurs in the connection pipe unit covered with the thermally insulating material and water having condensed stays in a small gap between the thermally insulating material and the connection pipe unit, progress of corrosion of the first refrigerant pipe (a refrigerant pipe formed of aluminum or an aluminum alloy) can be suppressed, and accordingly, the heat exchanger can have a long life.

[0010] Since the air-conditioning apparatus according to the present invention includes the heat exchanger, progress of corrosion of the first refrigerant pipe (a refrigerant pipe formed of aluminum or an aluminum alloy) can be suppressed, and accordingly, the air-conditioning apparatus can have a long life.

[Brief Description of Drawings]

[0011]

Fig. 1 is an explanatory diagram illustrating a state in which an air-conditioning apparatus according to Embodiment of the present invention is installed.

Fig. 2 includes perspective views of a heat exchanger according to Embodiment of the present invention.

Fig. 3 is an enlarged front view of the main part of the heat exchanger according to Embodiment of the present invention.

Fig. 4 is a side view of the heat exchanger according to Embodiment of the present invention.

Fig. 5 is a longitudinal sectional view of a connection portion, in which an aluminum pipe and a copper pipe are connected to each other, according to Embodiment of the present invention.

Fig. 6 is a cross-sectional view (arrow sectional view taken along line A-A in Fig. 5) of the connection portion, in which the aluminum pipe and the copper pipe are connected to each other, according to Embodiment of the present invention.

Fig. 7 is a sectional view of a state in which the aluminum pipe and a copper pipe according to Embodiment of the present invention are connected to each other.

[Description of Embodiments]

[0012] In Embodiment below, a heat exchanger according to the present invention installed in an indoor unit of an air-conditioning apparatus will be described. An example of the indoor unit according to the present invention is a wall-mounting indoor unit.

[0013] Fig. 1 is an explanatory diagram illustrating a state in which the air-conditioning apparatus according to Embodiment of the present invention is installed.

As illustrated in Fig. 1, the air-conditioning apparatus according to Embodiment of the present invention includes an indoor unit 100 and an outdoor unit 101. The indoor unit 100 is mounted on a wall 111 of a conditioned space 110. The outdoor unit 101 is installed outside the conditioned space 110.

[0014] The indoor unit 100 includes components such as a housing 1, a fan 5, and an indoor heat exchanger 10. The housing 1 has, for example, a substantially rectangular box shape and has an air inlet 2 formed on an upper portion thereof and an air outlet 3 formed on a lower portion thereof. The air inlet 2 is provided with a filter 2a, which collects dust and the like from indoor air sucked into the housing 1. The air outlet 3 is provided with a wind direction adjustment mechanism 4, which adjust directions of conditioned air being blown through the air outlet 3.

[0015] The fan 5 includes, for example, a cross flow fan disposed in the housing 1. The indoor heat exchanger 10 is disposed so as to cover a front, top, and rear sides of the fan 5.

[0016] The indoor heat exchanger 10 according to Embodiment of the present invention includes fin-tube heat exchangers. The indoor heat exchanger 10 includes a plurality of heat exchangers 10a and a plurality of heat exchangers 10b. The heat exchangers 10a include cylindrical heat transfer pipes 12. The heat exchangers 10b include flat heat transfer pipes 16. Each heat exchanger 10a includes a plurality of fins 11 and the plurality of heat transfer pipes (cylindrical pipes) 12. The fins 11 are formed of aluminum or an aluminum alloy. The heat transfer pipes 12 are formed of aluminum or an aluminum alloy. The fins 11 are stacked so as to be spaced apart from one another by a specified gap. The heat transfer pipes (cylindrical pipes) 12 extend through the stacked fins 11. Each heat exchanger 10b includes a plurality of fins 15 and the plurality of heat transfer pipes (flat pipes) 16. The fins 15 are formed of aluminum or an aluminum alloy. The heat transfer pipes 16 are formed of aluminum or an aluminum alloy. The fins 15 are stacked so as to be spaced apart from one another by a specified gap. The heat transfer pipes (flat pipes) 16 extend through the stacked fins 15.

[0017] When the fan 5 is driven, room air in the conditioned space 110 is sucked into the housing 1 through the air inlet 2. The room air is heated or cooled into conditioned air while flowing through the indoor heat exchanger 10. The conditioned air is blown through the air outlet 3. In the indoor heat exchanger 10 according to Embodiment of the present invention, the heat exchangers 10a using the cylindrical heat transfer pipes 12 are located upstream in an air flow direction, and the heat exchangers 10b using the flat heat transfer pipes 16 are located downstream in the air flow direction. The indoor heat exchanger 10 has a capability of having a plurality of independent refrigerant circuits, so that the indoor heat exchanger 10 can be thermally divided into, for example, two sections (for example, a section of the heat exchangers 10a and a section of the heat exchangers 10b). A pressure reducing device for reheat dehumidification 8 (for example, an expansion valve: Fig. 2) is connected between thermally divided two sections of heat exchangers. This can cause, while, for example, cooling operation is being performed, part of the indoor heat exchanger 10 to function as a condenser and part of the remaining part of the indoor heat exchanger 10 to function as an evaporator. Thus, by thermally dividing the indoor heat exchanger 10 into two sections, when dehumidification is performed during cooling operation, the temperature of the conditioned air to be blown through the air outlet 3 can be prevented from being excessively decreased.

[0018] The indoor heat exchanger 10 includes connection pipe unit 20. An end of the connection pipe unit 20 is connected to the heat transfer pipes (connected to either the heat transfer pipes 12 or the heat transfer pipes 16, or the heat transfer pipes 12 and 16) of the indoor heat exchanger 10. The connection pipe unit 20 is formed of copper or a copper alloy and is routed to the outdoor side through a hole 112 formed in the wall 111. A flare nut connection unit 29 is provided at the other end of the connection pipe unit 20. By connecting the flare nut connection unit 29 to a flare nut connection unit 51 of an extended pipe unit 50, which is connected to the outdoor unit 101, the indoor unit 100 is connected to the outdoor unit 101. That is, by connecting the flare nut connection unit 29 to the flare nut connection unit 51, the indoor heat exchanger 10 is connected to elements of a refrigeration cycle (such as an outdoor heat exchanger and a compressor, both of which are not shown), the elements being provided in the outdoor unit 101, thereby forming the refrigeration cycle.

[0019] As will be described later, the connection pipe unit 20 includes two pipes (a gas pipe 30 and a liquid pipe 40). In order to accommodate these, the flare nut connection unit 29 includes two flare nut connection sub-units (a flare nut connection sub-unit 39 for the gas pipe 30 and a flare nut connection sub-unit 49 for the liquid pipe 40). Accordingly, the extended pipe unit 50 also includes two pipes and the flare nut connection unit 51 of the extended pipe unit 50 includes two flare nut connection sub-units.

[0020] Next, the details of the connection pipe unit 20 will be described.

[0021] Fig. 2 includes perspective views of the heat exchanger according to Embodiment of the present invention. Fig. 3 is an enlarged front view of the main part of the heat exchanger. Fig. 4 is a side view of the heat exchanger. Although Fig. 2 includes separate views (a) and (b) for description of the gas pipe 30 and the liquid pipe 40, the views (a) and (b) are the same except for reference numerals. The details of the connection pipe unit 20 according to Embodiment of the present invention will be described below with reference to Figs. 2 to 4.

[0022] The connection pipe unit 20 includes the gas pipe 30 and and the liquid pipe 40.

[0023] The gas pipe 30 is a refrigerant pipe through which mainly the refrigerant in a gaseous state flows. Thus, when cooling operation is being performed (when the indoor heat exchanger 10 functions as an evaporator), the refrigerant having flowed through the heat transfer pipes 12 and 16 of the indoor heat exchanger 10 flows out of the indoor unit 100 through the gas pipe 30. In contrast, when heating operation is being performed (when the indoor heat exchanger

10 functions as an condenser), the refrigerant to flow through the heat transfer pipes 12 and 16 of the indoor heat exchanger 10 flows into the indoor unit 100 through the gas pipe 30.

[0024] The liquid pipe 40 is a refrigerant pipe through which mainly the refrigerant in a liquid state flows. Thus, when cooling operation is being performed (when the indoor heat exchanger 10 functions as an evaporator), the refrigerant to flow through the heat transfer pipes 12 and 16 of the indoor heat exchanger 10 flows into the indoor unit 100 through the liquid pipe 40. In contrast, when heating operation is being performed (when the indoor heat exchanger 10 functions as an condenser), the refrigerant having flowed through the heat transfer pipes 12 and 16 of the indoor heat exchanger 10 flows out of the indoor unit 100 through the liquid pipe 40. The refrigerant having flowed through a pressure reducing device, which is an element of the refrigeration cycle, may flow through the liquid pipe 40 depending on the configuration of the refrigeration cycle. In this case, the refrigerant flowing through the liquid pipe 40 is a liquid-rich two-phase gas-liquid refrigerant.

[0025] In the heat exchanger according to Embodiment of the present invention, the gas pipe 30 is made of an aluminum pipe 31 formed of aluminum or an aluminum alloy and a copper pipe 32 formed of copper or a copper alloy. Likewise, the liquid pipe 40 is made of an aluminum pipe 41 formed of aluminum or an aluminum alloy and a copper pipe 42 formed of copper or a copper alloy. The aluminum pipes 31 and 41 correspond to a first refrigerant pipe, and the copper pipes 32 and 42 correspond to a second refrigerant pipe. The reason for using the gas pipe 30 and the liquid pipe 40 having the above-described structure is as follows.

[0026] In general, in the flare nut connection units 29 and 51 connecting the extended pipe unit 50 to the gas pipe 30 and the liquid pipe 40, pipes on one side of connection (for example, the pipes of the extended pipe unit 50) each have an internal thread portion, and pipes on the other side of the connection (for example, the gas pipe 30 and the liquid pipe 40) each have an external thread portion. Each internal thread portion has an internal thread formed in an inner surface thereof and a through hole communicating with a space in which the internal thread is formed. At the end of a pipe unit on the one side of the connection (for example, the extended pipe unit 50), each pipe is inserted through the through hole while the diameter of the end of the pipe is enlarged by forming a flare. The external thread portion is brazed to the end of each pipe on the other side of the connection (for example, the gas pipe 30 and the liquid pipe 40). The external thread portions and the respective internal thread portions are screwed to each other. Thus, each end of the pipes at which the flares is formed (for example, the pipe of the extended pipe unit 50) on the one side of the connection is firmly held between the corresponding one of the internal thread portions and the corresponding one of the external thread portions. Thus, the extended pipe unit 50 is connected to the gas pipe 30 and the liquid pipe 40. In general, the external and the internal thread portions are formed of brass with consideration of, for example, suitability of the material for brazing and workability.

[0027] Here, in the case where, for example, the gas pipe 30 is formed only of the aluminum pipe 31 and the flare nut connection sub-unit 39 of the gas pipe 30 has the brass external thread portion, it is difficult for the flare nut connection sub-unit 39 to be brazed to the aluminum pipe 31. Also in this case, metal materials of the aluminum pipe 31 and the flare nut connection sub-unit 39 are different from each other, and accordingly, electrolytic corrosion (galvanic corrosion) as described later occurs in a portion where the aluminum pipe 31 and the flare nut connection sub-unit 39 are connected to each other. For example, in the case where the gas pipe 30 is formed only of the aluminum pipe 31 and the flare nut connection sub-unit 39 of the gas pipe 30 has the brass internal thread portion, metal materials of the aluminum pipe 31 and the flare nut connection sub-unit 39 are different from each other, and accordingly, electrolytic corrosion (galvanic corrosion) as described later occurs in a portion where the aluminum pipe 31 and the flare nut connection sub-unit 39 are in contact with each other.

[0028] For example, in the case where the gas pipe 30 is formed only of the aluminum pipe 31 and the flare nut connection sub-unit 39 of the gas pipe 30 has the external thread portion formed of aluminum or an aluminum alloy, the strength of the screw thread of the flare nut connection sub-unit 39 is insufficient. Also in this case, since the flare nut connection unit 51 of the copper extended pipe unit 50 has the brass internal thread portions, electrolytic corrosion (galvanic corrosion) as described later occurs between the flare nut connection sub-unit 39 of the gas pipe 30 and the flare nut connection unit 51 of the extended pipe unit 50.

[0029] For example, in the case where the gas pipe 30 is formed only of the aluminum pipe 31 and the flare nut connection sub-unit 39 of the gas pipe 30 has the internal thread portion formed of aluminum or an aluminum alloy, the strength of the screw thread of the flare nut connection sub-unit 39 is insufficient. Furthermore, when forming a flare at an end of the aluminum pipe 31, there is a concern that the end of the aluminum pipe 31 may crack. Since the flare nut connection unit 51 of the copper extended pipe unit 50 has the brass external thread portions, electrolytic corrosion (galvanic corrosion) as described later occurs between the flare nut connection sub-unit 39 of the gas pipe 30 and the flare nut connection unit 51 of the extended pipe unit 50.

[0030] For example, in the case where the gas pipe 30 is formed only of the aluminum pipe 31 and the flare nut connection sub-unit 39 of the gas pipe 30 and the flare nut connection unit 51 of the extended pipe unit 50 are formed of aluminum or an aluminum alloy, the strengths of the screw threads of the flare nut connection sub-unit 39 and the flare nut connection unit 51 are insufficient. In the case where the flare nut connection sub-unit 39 of the gas pipe 30 has the internal thread portion, when forming the flare at the end of the aluminum pipe 31, there is a concern that the end of the aluminum pipe 31 may crack. Furthermore, in order to prevent electrolytic corrosion (galvanic corrosion) as described later from occurring in a portion where the extended pipe unit 50 and the flare nut connection unit 51 are connected to each other, the pipes of the extended pipe unit 50 need to be formed of aluminum or an aluminum alloy. For this reason, in the case where the flare nut connection unit 51 of the extended pipe unit 50 has the internal thread portions, when forming the flares at the end of the pipes of the extended pipe unit 50, there is a concern that the end of the pipes of the extended pipe unit 50 may crack.

[0031] Thus, in the heat exchanger according to Embodiment of the present invention, the gas pipe 30 is formed of the aluminum pipe 31 and the copper pipe 32. In the gas pipe 30, the brass flare nut connection sub-unit 39 having an internal or external thread portion is provided at an end of the copper pipe 32, thereby preventing the strength of the screw thread from becoming insufficient and the end of the pipe from cracking, which might otherwise occur when the flare is formed. Likewise, the liquid pipe 40 is formed of the aluminum pipe 41 and the copper pipe 42, and the brass flare nut connection sub-unit 49 having an internal or external thread portion is provided at an end of the copper pipe 42, thereby preventing the strength of the screw thread from becoming insufficient and the end of the pipe from cracking, which might otherwise occur when the flare is formed.

[0032] Here, in the heat exchanger according to Embodiment of the present invention, the aluminum pipe 31 and the copper pipe 32 are connected to each other at a connection portion 37 by eutectic bonding (bonding in which metals are contacted with each other at a certain temperature so as to form a eutectic alloy). The end of the aluminum pipe 31 opposite to the connection portion 37 is connected to one of the heat transfer pipes 12 or one of the heat transfer pipes 16 by, for example, brazing. Likewise, the aluminum pipe 41 and the copper pipe 42 are connected to each other at a connection portion 47 by eutectic bonding (bonding in which metals are contacted with each other at a certain temperature so as to form a eutectic alloy). The end of the aluminum pipe 41 opposite to the connection portion 47 is connected to one of the heat transfer pipes 12 or one of the heat transfer pipes 16 by, for example, brazing.

[0033] In particular, the connection portion 37, in which the aluminum pipe 31 and the copper pipe 32 are connected to each other, and the connection portion 47, in which the aluminum pipe 41 and the copper pipe 42 are connected to each other, have a structure as illustrated in Fig. 7. That is, the ends of the copper pipes 32 and 42 are respectively inserted into the ends of the aluminum pipes 31 and 41 so as to be connected to each other by eutectic bonding (bonding in which metals are contacted with each other at a certain temperature so as to form a eutectic alloy). When water adheres to the connection portions 37 and 47, in particular, adheres to the ends of the aluminum pipes 31 and 41, into which the copper pipes 32 and 42 are inserted, electrolytic corrosion (galvanic corrosion) occurs in the connection portions 37 and 47 (in particular, parts of the connection portions 37 and 47 formed of aluminum or an aluminum alloy) in accordance with a principle, which will be described later. Thus, in order to make the connection portions 37 and 47 waterproof, it is desirable that the connection portions 37 and 47 be covered with heat shrinkable tubes or coated.

[0034] In the air-conditioning apparatus according to Embodiment of the present invention, as illustrated in Fig. 1, when the indoor unit 100 is installed, the connection pipe unit 20 (gas pipe 30 and the liquid pipe 40) is routed to the outdoor side through the hole 112 formed in the wall 111. In so doing, the position of the hole 112 of the wall 111 and an installation position of the indoor unit 100 change in accordance with the installation environment. Thus, lower curved portions 36 and 46 are repeatedly bent and stretched. In order to prevent the lower curved portions 36 and 46 from being flattened or damaged, the lower curved portions 36 and 46 are formed of copper or a copper alloy, which have strengths higher than that of aluminum or an aluminum alloy.

[0035] In Embodiment, the aluminum pipe 31 of ϕ9.52 mm x t1.0 mm and the copper pipe 32 of ϕ9.52 mm x t0.8 mm are connected to each other so as to form the gas pipe 30, and the aluminum pipe 41 of ϕ7.00 mm x t0.75 mm and the copper pipe 42 of ϕ7.00 mm x t0.60 mm are connected to each other so as to form the liquid pipe 40.

[0036] Also in Embodiment, in order to prevent electrolytic corrosion (galvanic corrosion) of the aluminum pipes 31 and 41 from occurring, the gas pipe 30 and the liquid pipe 40 are formed to have the following shapes.

[0037] When water including copper ions (Cu^{2+}) is in contact with aluminum or an aluminum alloy, aluminum or the aluminum alloy undergoes the following reaction due to the difference in ionization tendency:

$$2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu.$$

That is, aluminum is ionized, and accordingly, electrolytic corrosion (galvanic corrosion) of aluminum or an aluminum alloy occurs.

[0038] In contrast, adhesion of water droplets including aluminum ions (Al^{3+}) to aluminum or an aluminum alloy does not cause electrolytic corrosion (galvanic corrosion) of aluminum or an aluminum alloy, because the water including aluminum ions is composed of the same atom as aluminum or an aluminum alloy. When water droplets including aluminum ions (Al^{3+}) adhere to copper or a copper alloy, ionization tendency of copper is smaller than that of aluminum, and accordingly, electrolytic corrosion (galvanic corrosion) of copper or a copper alloy does not occur.

[0039] The gas pipe 30 and the liquid pipe 40 in between upper curved portions 34 and 44 and the heat transfer pipes

12 and 16 of the indoor heat exchanger 10 are inclined such that droplets of water having condensed flow toward the indoor heat exchanger 10. Thus, when the connection portions 37 and 47 are located closer to the heat transfer pipes 12 and 16 of the indoor heat exchanger 10 than the upper curved portions 34 and 44 are, water droplets including copper ions flow toward the indoor heat exchanger 10. This causes electrolytic corrosion (galvanic corrosion) to occur in portions of the gas pipe 30 and the liquid pipe 40, the portions being formed of aluminum or an aluminum alloy, and the heat transfer pipes 12 and 16 of the indoor heat exchanger 10 formed of aluminum or an aluminum alloy.

[0040] Thus, in Embodiment, the connection portion 37 is disposed in a linear portion 35, which is in a substantially vertical portion of the gas pipe 30, such that an upper part of the linear portion 35 is to be the aluminum pipe 31 and the lower part of the linear portion 35 of the gas pipe 30 is to be the copper pipe 32.

[0041] Likewise, the connection portion 47 is disposed in a linear portion 45, which is in a substantially vertical portion of the liquid pipe 40, such that an upper part of the linear portion 45 is to be the aluminum pipe 41 and the lower part of the linear portion 45 of the liquid pipe 40 is to be the copper pipe 42.

[0042] That is, the connection portions 37 and 47 are located above the lower curved portions 36 and 46 in the linear portions 35 and 45 of fall portions 33 and 43.

Although the fall portions 33 and 43 are substantially vertical in Embodiment, it is clear that the fall portions 33 and 43 may be inclined.

[0043] The connection portion 37 of the gas pipe 30 and the connection portion 47 of the liquid pipe 40 are desirably located at the same height level because, in many cases, the gas pipe 30 and the liquid pipe 40 are disposed so as to be close to each other. By locating the connection portion 37 of the gas pipe 30 and the connection portion 47 of the liquid pipe 40 at the same height level, a situation in which electrolytic corrosion (galvanic corrosion) occurs in the aluminum pipe 41 of the liquid pipe 40 due to contact of the aluminum pipe 41 of the liquid pipe 40 with the copper pipe 32 of the gas pipe 30 can be prevented from occurring. Furthermore, a situation in which electrolytic corrosion (galvanic corrosion) occurs in the aluminum pipe 31 of the gas pipe 30 due to contact of the aluminum pipe 31 of the gas pipe 30 with the copper pipe 42 of the liquid pipe 40 can be also prevented from occurring.

[0044] In Embodiment, condensation is suppressed by covering the connection pipe unit 20 with a thermally insulating material 60 in order to prevent leakage of water droplets having condensed on the connection pipe unit 20 to the outside of the air-conditioning apparatus.

[0045] Fig. 5 is a longitudinal sectional view of the connection portion of the aluminum pipe and the copper pipe according to Embodiment of the present invention. Fig. 6 is a cross-sectional view (arrow sectional view taken along line A-A in Fig. 5) of the connection portion.

Condensation cannot be completely prevented by covering the connection pipe unit 20 with the thermally insulating material 60 as described above. Thus, a small amount of water having condensed stays in a small space 70 (Figs. 5 and 6) between the thermally insulating material 60 and the connection pipe unit 20. The water having condensed and staying in the small space 70 covers surfaces of the aluminum pipes 31 and 41 and the copper pipes 32 and 42 in a continuous manner. As a result, copper ions Cu2+ of the copper pipes 32 and 42 diffuse toward the aluminum pipes 31 and 41 against gravity through the water having condensed and staying, thereby causing electrolytic corrosion (galvanic corrosion) of aluminum or an aluminum alloy to occur.

[0046] According to Embodiment, even when copper ions Cu2+ of the copper pipes 32 and 42, which are formed of copper or an copper alloy, diffuse against gravity toward the aluminum pipes 31 and 41 through the water having condensed and staying in the small space 70, a zinc diffusion layer is formed on the surface of each of the aluminum pipes 31 and 41 so that corrosion of the aluminum pipes 31 and 41 can be suppressed. By doing this, progress of corrosion of the aluminum pipes 31 and 41 formed of aluminum or an aluminum alloy can be suppressed, and accordingly, reliability of measures against leakage of the refrigerant can be improved.

It is desirable that formation of the zinc diffusion layer on the surfaces of the aluminum pipes 31 and 41 formed of aluminum or an aluminum alloy be performed on original pipes of the aluminum pipes 31 and 41.

[0047] Alternatively, as an anti-corrosion treatment of the aluminum pipes 31 and 41 formed of the aluminum or an aluminum alloy, the heat shrinkable tubes or coatings attached or applied to the connection portions 37 and 47 may be applied or attached entirely to ranges of the aluminum pipes 31 and 41, the ranges being covered by the thermally insulating material 60, in order to prevent water from adhering to the connection portions 37 and 47. In this case, it is desirable that the heat shrinkable tubes are attached or coatings be applied to the aluminum pipes 31 and 41 while the aluminum pipes 31 and 41 are still connection pipes in an assembled state before being brazed to the heat transfer pipes 12 and 16 of the indoor heat exchanger 10.

[0048] Alternatively, as the anti-corrosion treatment of the aluminum pipes 31 and 41 formed of the aluminum or an aluminum alloy, the aluminum pipes 31 and 41 may be anodized or plated with metal such as zinc or manganese. Also in this case, it is desirable that the aluminum pipes 31 and 41 be anodized or plated while the aluminum pipe 31 and 41 are connection pipes in an assembled state before being brazed to the heat transfer pipes 12 and 16 of the indoor heat exchanger 10.

[0049] Alternatively, a clad material, which is formed of a core material and a high corrosion-resistant aluminum alloy (for example, A7072) superposed on the core material, may be used for the aluminum pipes 31 and 41 as the material to which the anti-corrosion treatment is applied.

[0050] In above-described Embodiment, an example of the heat exchanger according to the present invention is installed in the indoor unit 100. However, it is clear that the heat exchanger according to the present invention may be installed in the outdoor unit 101. That is, in above-described Embodiment, an example of the heat exchanger according to the present invention is used as the indoor heat exchanger 10. However, it is clear that the heat exchanger according to the present invention may be used as an outdoor heat exchanger.

[0051] In above-described Embodiment, an example of the cylindrical heat transfer pipes 12 and the flat heat transfer pipes 16 are used in the indoor heat exchanger 10. However, the indoor heat exchanger 10 may use either the heat transfer pipes 12 or the heat transfer pipes 16.

[0052] In above-described Embodiment, an example of the heat exchanger (indoor heat exchanger 10) includes fin-tube heat exchangers. However, it is clear that the present invention is applicable to a variety of heat exchangers. That is, the present invention can be implemented by connecting the gas pipe 30 and the liquid pipe 40, which have been described in Embodiment of the present invention, to a heat exchanger equipped with heat transfer pipes formed of aluminum or an aluminum alloy.

[Reference Signs List]

[0053] 1 housing, 2 air inlet, 2a filter, 3 air outlet, 4 wind direction adjustment mechanism, 5 fan, 8 pressure reducing device for reheat dehumidification, 10 indoor heat exchanger, 10a, 10b heat exchanger, 11 fin, 12 heat transfer pipe (cylindrical), 15 fin, 16 heat transfer pipe (flat), 20 connection pipe unit, 29, 51 flare nut connection unit, 30 gas pipe, 31, 41 aluminum pipe (first refrigerant pipe), 32, 42 copper pipe (second refrigerant pipe), 33, 43 fall portion, 34, 44 upper curved portion, 35, 45 linear portion, 36, 46 lower curved portion, 37, 47 connection portion, 39, 49 flare nut connection sub-unit, 40 liquid pipe, 50 extended pipe unit, 60 thermally insulating material, 70 small space, 100 indoor unit, 101 outdoor unit, 110 conditioned space, 111 wall, and 112 hole.

Claims

1. A heat exchanger (10) comprising:

a heat transfer pipe (12, 16) formed of aluminum or an aluminum alloy; and
a connection pipe unit (20) through which a refrigerant flowing out of the heat transfer pipe (12, 16) and a refrigerant flowing into the heat transfer pipe (12, 16) pass,
the connection pipe unit (20) including

a gas pipe (30) through which the refrigerant in a gaseous state flows, and
a liquid pipe (40) through which the refrigerant in a liquid state or in a two-phase gas-liquid state flows,

the gas pipe (30) and the liquid pipe (40) each having

a first refrigerant pipe (31, 41) formed of aluminum or an aluminum alloy, and
a second refrigerant pipe (32, 42) formed of copper or a copper alloy,

the first refrigerant pipe (31, 41) and the second refrigerant pipe (32, 42) being connected to each other,

the first refrigerant pipe (31, 41) having a fall portion (33, 43) connected to the heat transfer pipe (12, 16), the fall portion (33, 43) extending downward relative to the heat transfer pipe (12, 16), wherein
each connection portion (37, 47) between the first refrigerant pipe (31, 41) and the second refrigerant pipe (32, 42) is disposed in the fall portion (33, 43) of the first refrigerant pipe (31, 41),
the connection pipe unit (20) is covered with a thermally insulating material (60), and
anti-corrosion treatment is applied to each first refrigerant pipe (31, 41) covered with the thermally insulating material (60).

2. The heat exchanger (10) of Claim 1, wherein
the gas pipe (30) and the liquid pipe (40) each have a curved portion (36, 46) in a lower part of the fall portion (33, 43) of the first refrigerant pipe (31, 41), and
each connection portion (37, 47) is located above the corresponding curved portions (36, 46).

3. The heat exchanger (10) of Claim 1 or 2, wherein
the connection portion (37) of the gas pipe (30) and the connection portion (47) of the liquid pipe (40) are located at a same height level.

4. An air-conditioning apparatus comprising:

the heat exchanger (10) of any one of Claims 1 to 3.

F I G. 1

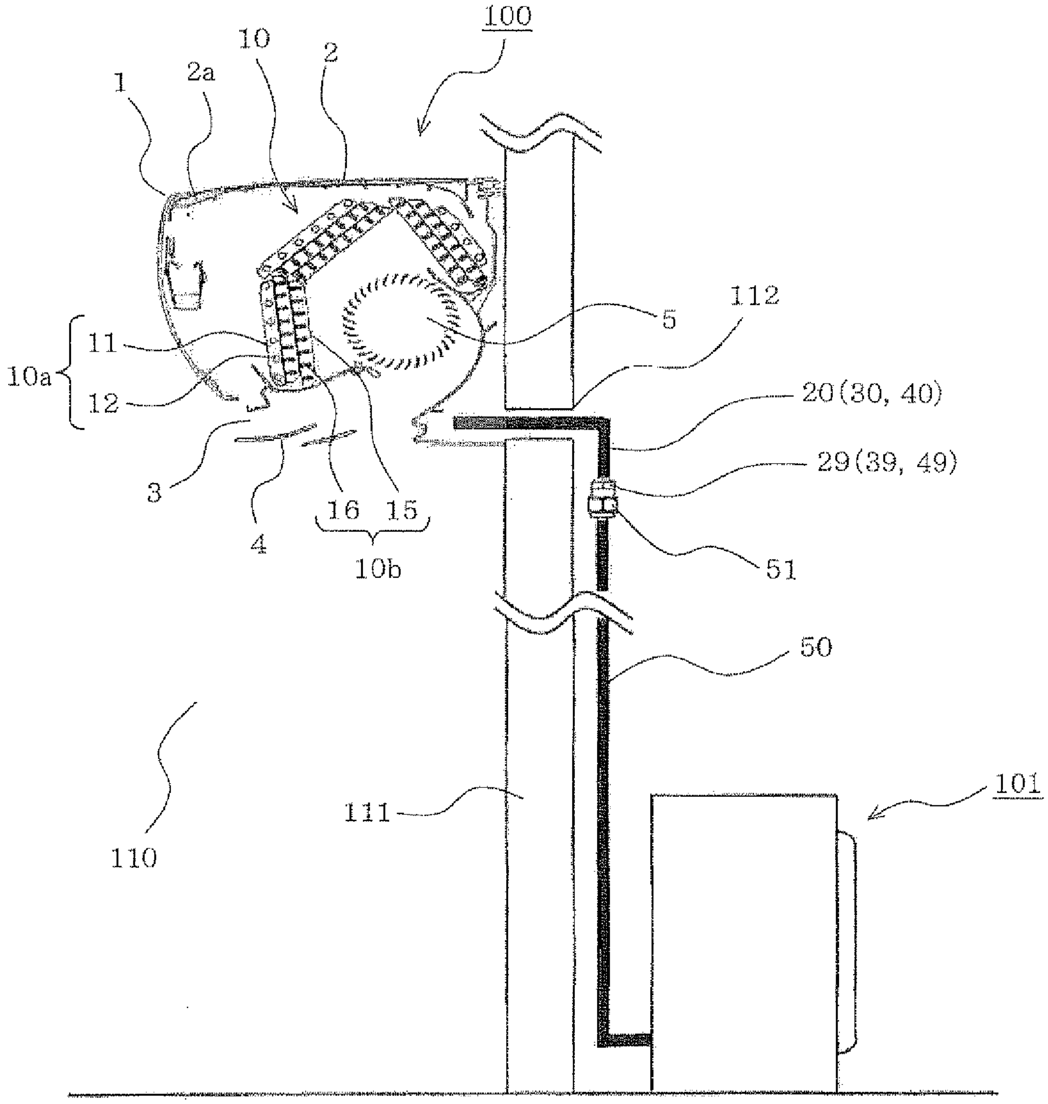
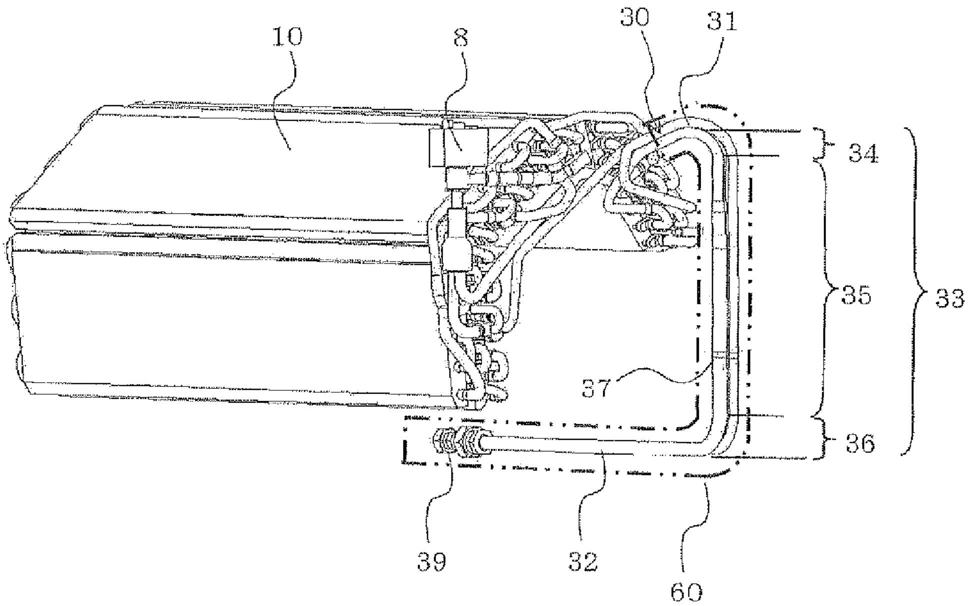
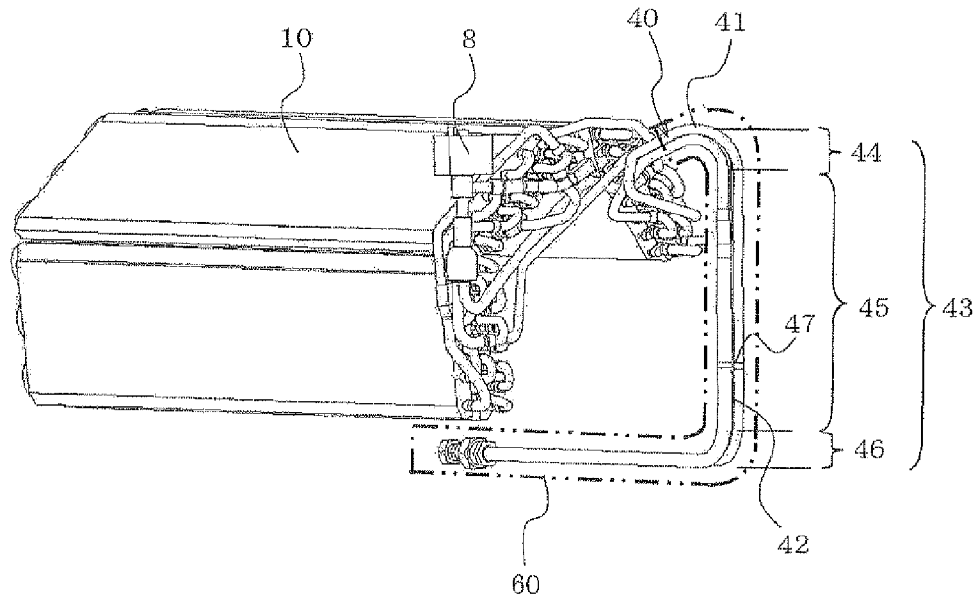

100
10
2
1
2a
5
112
11
10a
12
20(30, 40)
29(39, 49)
3
16
15
4
10b
51
50
110
111
101

FIG. 2

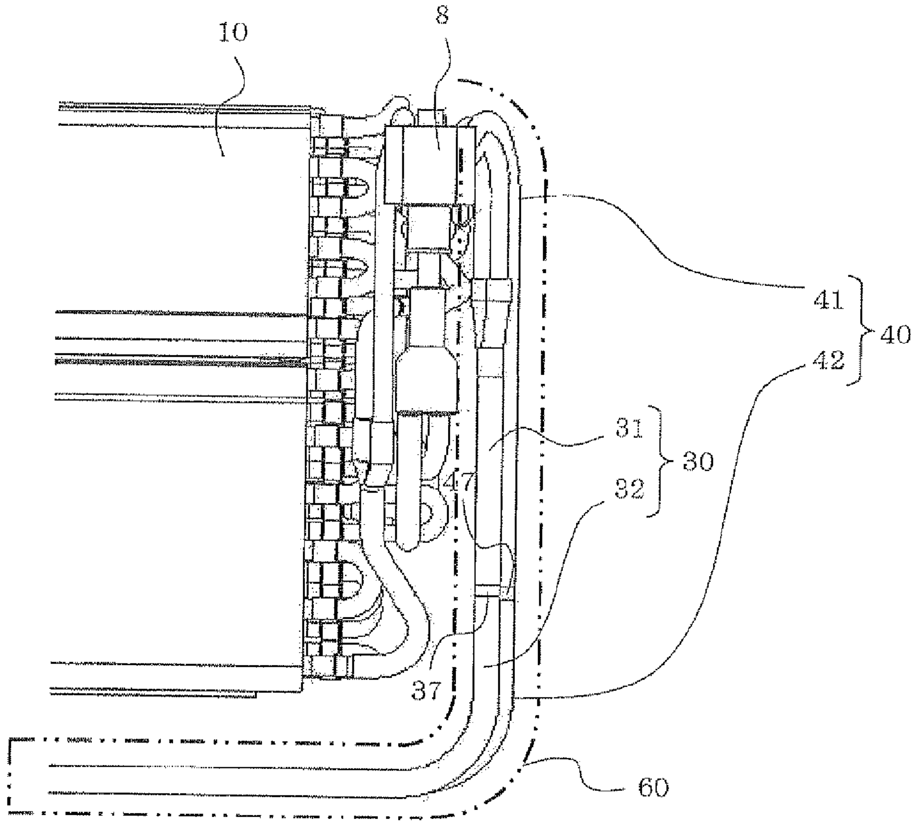
(a)



(b)



F I G. 3



F I G. 4

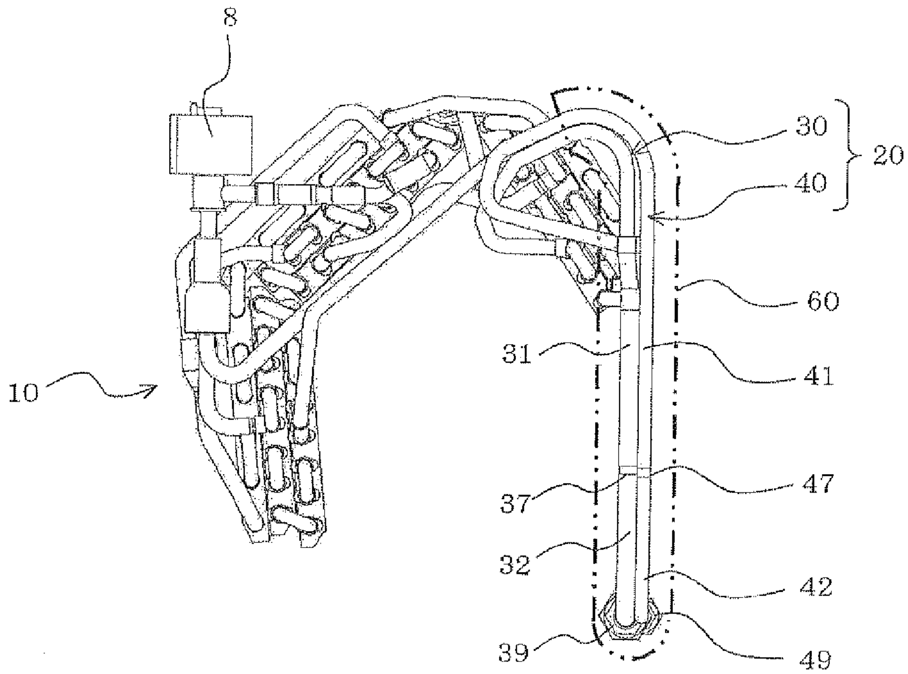


FIG. 5

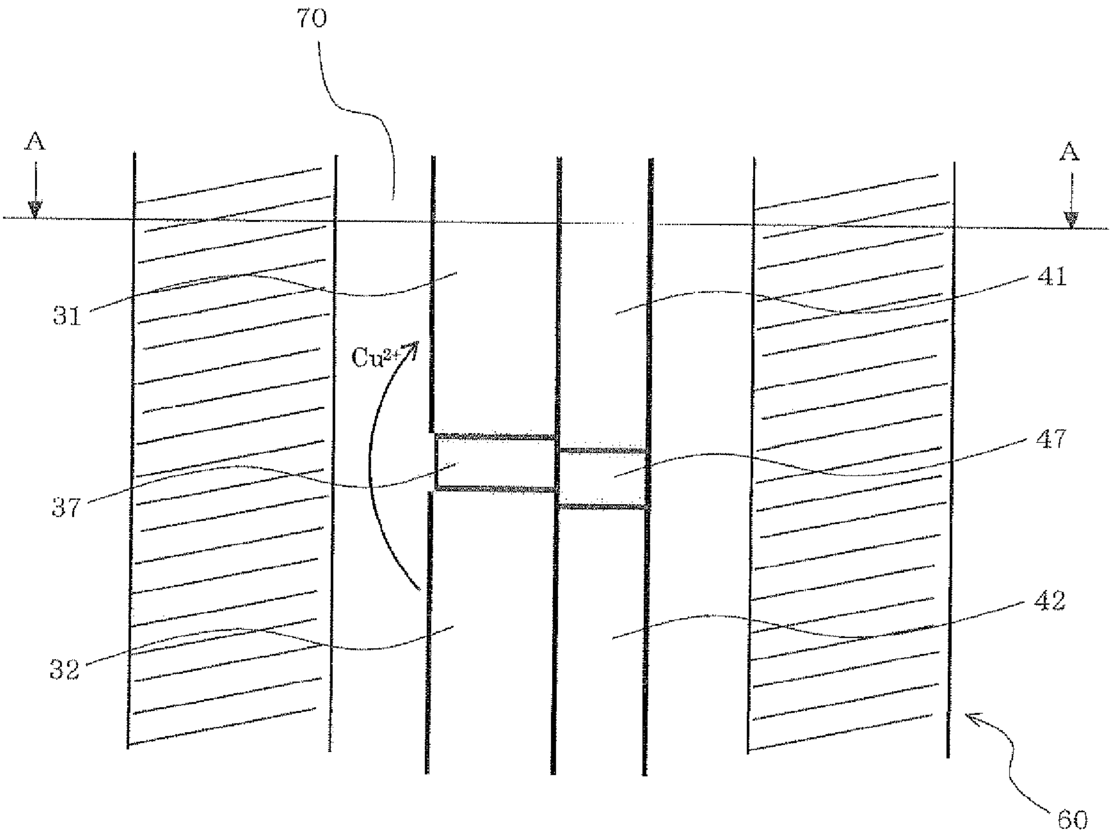
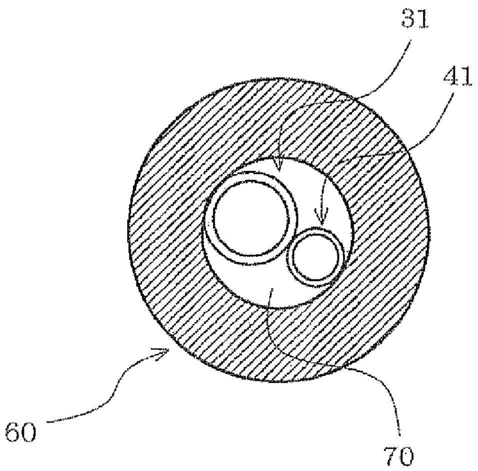
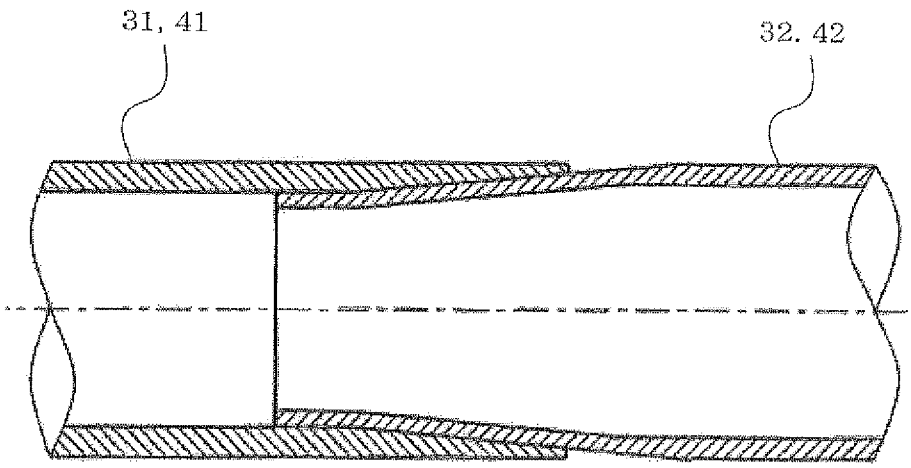


FIG. 6



SECTION A-A

FIG. 7



REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 6300303 A **[0004]**