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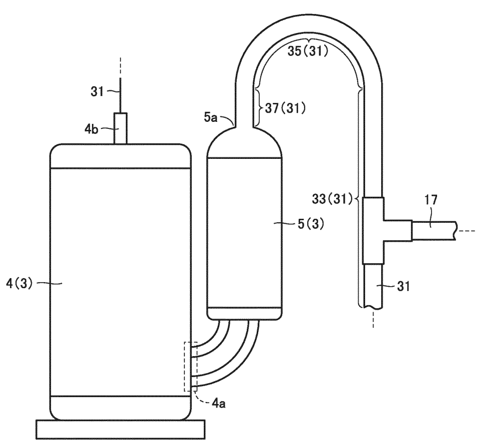
(54) AIR CONDITIONER

(57) A refrigeration cycle apparatus (1) includes a compressor (3), a four-way valve (7), an outdoor heat exchanger (9), an expansion valve (11), a gas-liquid separator (13), an indoor heat exchanger (15), and a refrigerant pipe (31) that connects these components. The gas-liquid separator (13) and a suction side of the compressor (3) are connected by a bypass pipe (17). The refrigerant pipe (31) includes a riser pipe (33), a curved pipe (35), and a down pipe (37) sequentially connected from an upstream side to a downstream side of a flow of refrigerant. The bypass pipe (17) is connected to the riser pipe (33) located upstream of the curved pipe (35).

FIG.2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to an air conditioner.

BACKGROUND ART

[0002] In recent years, it has been required to perform air conditioning while ventilating an indoor space. In order to meet such a demand, it is necessary to enhance the capability of an air conditioner by increasing the amount of refrigerant circulating through the air conditioner. However, the increased amount of circulating refrigerant causes a pressure loss of the refrigerant, and thereby, the performance of the air conditioner deteriorates.

[0003] In order to reduce such a pressure loss of the refrigerant, PTL 1 proposes an air conditioner in which a gas-liquid separator is disposed. For example, in the case of a cooling operation, the refrigerant discharged from a compressor flows through an outdoor heat exchanger and an expansion valve and then flows into a gas-liquid separator as two-phase refrigerant including liquid refrigerant and gas refrigerant.

[0004] The liquid refrigerant of the two-phase refrigerant having flowed into the gas-liquid separator flows toward an indoor heat exchanger. On the other hand, the gas refrigerant flows through a bypass pipe toward a suction side of the compressor. When part of the refrigerant circulating through the air conditioner flows from the gas-liquid separator through the bypass pipe, the amount of the refrigerant flowing into the indoor heat exchanger decreases, with the result that the pressure loss of the refrigerant flowing through the indoor heat exchanger decreases.

CITATION LIST

PATENT LITERATURE

[0005] PTL 1: Japanese Patent Laying-Open No. 2019-158308

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] In the conventional air conditioner, the bypass pipe branched from the gas-liquid separator is connected to the suction side of the compressor. In this case, the bypass pipe is connected to a position as close as possible to the compressor from the viewpoint of minimizing a pressure loss caused when the refrigerant having flowed through the bypass pipe merges into the refrigerant having flowed through the refrigerant pipe of a main stream.

[0007] The compressor is formed of a compressor body and a suction muffler. The suction muffler is connected to a body suction inlet of the compressor body. The bypass pipe is connected to a position immediately preceding to a muffler suction inlet of the suction muffler.

[0008] As described above, gas refrigerant separated in the gas-liquid separator flows through the bypass pipe. It is however also conceivable that liquid refrigerant may flow into the bypass pipe and be mixed therein. The liquid refrigerant having flowed through the bypass pipe is to flow into the compressor body through the suction muffler. When the liquid refrigerant having flowed through the bypass pipe is continuously suctioned into the compressor body, it is conceivable that liquid compression may occur in the compressor body, which may cause a failure in the compressor body.

[0009] The present disclosure has been made in order to solve the above-described problems, and an object of the present disclosure is to provide an air conditioner in which liquid compression in a compressor is suppressed.

SOLUTION TO PROBLEM

[0010] An air conditioner according to the present disclosure includes: a compressor, a first heat exchanger, an expansion valve, and a second heat exchanger; a refrigerant pipe configured to allow refrigerant to flow through the refrigerant pipe; a gas-liquid separator; and a bypass pipe. The refrigerant pipe is connected to the compressor, the first heat exchanger, the expansion valve, the second heat exchanger, and the compressor in this order. The gas-liquid separator is located at a portion of the refrigerant pipe, the portion connecting the expansion valve to the second heat exchanger, and the gas-liquid separator is configured to separate the refrigerant flowing from the expansion valve toward the second heat exchanger into gas refrigerant and liquid refrigerant. The bypass pipe is connected to the gas-liquid separator and configured to direct the refrigerant separated in the gas-liquid separator to the compressor. The compressor includes a compressor body and a suction muffler. The compressor body has a body suction inlet through which the refrigerant is suctioned in. The suction muffler has a muffler suction inlet connected to the refrigerant pipe and is connected to the body suction inlet of the compressor body. The refrigerant pipe includes a curved pipe configured to direct the refrigerant to the muffler suction inlet, the refrigerant being directed from a position lower than the muffler suction inlet to a position higher than the muffler suction inlet. The bypass pipe is connected to a position of the refrigerant pipe, the position being located away from the muffler suction inlet by a distance that is at least ten times as long as an inner diameter of the curved pipe.

ADVANTAGEOUS EFFECTS OF INVENTION

[0011] According to the air conditioner of the present disclosure, the refrigerant pipe includes a curved pipe configured to direct the refrigerant to the muffler suction inlet, the refrigerant being directed from a position lower than the muffler suction inlet to a position higher than the muffler suction inlet. The bypass pipe configured to direct the refrigerant separated in the gas-liquid separator to the compressor is connected to a position of the refrigerant pipe, the position being located away from the muffler suction inlet by a distance that is at least ten times as long as an inner diameter of the curved pipe. Thereby, even when the liquid refrigerant flows into the bypass pipe and is mixed therein, the liquid refrigerant can be suppressed from flowing into the compressor. As a result, occurrence of liquid compression in the compressor can be suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

Fig. 1 is a diagram showing an example of a refrigerant circuit of an air conditioner according to a first embodiment.

Fig. 2 is a partial side view showing a compressor and a structure around the compressor for illustrating a connection manner of a bypass pipe in the first embodiment.

Fig. 3 is a diagram showing the refrigerant circuit for illustrating an example of an operation of the air conditioner in the first embodiment.

Fig. 4 is a graph showing a relation between a degree of dryness of refrigerant and a pressure loss gradient inside a pipe in the first embodiment.

Fig. 5 is a partial side view showing a compressor and a structure around the compressor in an air conditioner according to a comparative example.

Fig. 6 is a partial side view showing a compressor and a structure around the compressor for illustrating a connection manner of a bypass pipe in an air conditioner according to a modification of the first embodiment.

Fig. 7 is a diagram showing a part of a refrigerant circuit that is located in an indoor heat exchanger in the refrigerant circuit of an air conditioner according to a second embodiment.

Fig. 8 is a cross-sectional view showing a structure inside a refrigerant pipe in the second embodiment.

Fig 9 is a cross-sectional view taken along a cross-sectional line IX-IX shown in Fig. 8 in the second embodiment.

DESCRIPTION OF EMBODIMENTS

First Embodiment

[0013] An example of an air conditioner (a refrigerant circuit) according to the first embodiment will be described. As shown in Fig. 1, an air conditioner 1 includes a compressor 3, a four-way valve 7, an outdoor heat exchanger 9 as a first heat exchanger, an expansion valve 11, a gas-liquid separator 13, an indoor heat exchanger 15 as a second heat exchanger, and a refrigerant pipe 31 that connects these components. Refrigerant pipe 31 is connected to compressor 3, four-way valve 7, outdoor heat exchanger 9, expansion valve 11, gas-liquid separator 13, indoor heat exchanger 15, four-way valve 7, and compressor 3 in this order.

[0014] Compressor 3 includes a compressor body 4 and a suction muffler 5. Indoor heat exchanger 15 includes a main heat exchange part 15a as a first part of the second heat exchanger and an auxiliary heat exchange part 15b as a second part of the second heat exchanger. Gas-liquid separator 13 and the suction side of compressor 3 are connected by a bypass pipe 17. A capillary tube 19 is connected to a certain portion of bypass pipe 17.

[0015] The following more specifically describes the configuration of compressor 3 and the structure of refrigerant pipe 31 around compressor 3. As shown in Fig. 2, compressor body 4 includes a body suction inlet 4a through which refrigerant is suctioned in and a discharge outlet 4b through which refrigerant is discharged. Suction muffler 5 has a muffler suction inlet 5a to which refrigerant pipe 31 is connected and through which refrigerant is suctioned in. Suction muffler 5 is connected to body suction inlet 4a of compressor body 4.

[0016] Refrigerant pipe 31 includes a riser pipe 33, a U-shaped (inverted U-shaped) curved pipe 35, and a down pipe 37 that are sequentially connected from the upstream side to the downstream side of the refrigerant flow. U-shaped curved pipe 35 directs the refrigerant toward muffler suction inlet 5a so as to direct the refrigerant from a position lower than muffler suction inlet 5a to a position higher than muffler suction inlet 5a. Riser pipe 33 directs the refrigerant from a position lower than muffler suction inlet 5a to the upstream side of curved pipe 35. Down pipe 37 directs the refrigerant from the downstream side of curved pipe 35 to muffler suction inlet 5a.

[0017] Bypass pipe 17 is connected to riser pipe 33 located upstream of curved pipe 35. Bypass pipe 17 is connected to a T-shaped connection pipe provided in a certain portion of riser pipe 33. Bypass pipe 17 is connected to riser pipe 33 so as to be substantially orthogonal to riser pipe 33. Air conditioner 1 according to the first embodiment is configured as described above.

[0018] Then, the cooling operation will be first described as the operation of air conditioner 1 described above. As shown in Fig. 3, the direction of the refrigerant flow in the cooling operation is indicated by a solid line. By driving compressor 3 (compressor body 4), high-temperature and high-pressure gas refrigerant is discharged from compressor 3. The discharged high-temperature and high-pressure gas refrigerant (a single phase) flows into outdoor heat exchanger 9 through four-way valve 7. Outdoor heat exchanger 9 functions as a condenser. In outdoor heat exchanger 9, heat exchange is performed between the refrigerant having flowed thereinto and air supplied, for example, by a propeller fan (not shown). The high-temperature and high-pressure gas refrigerant is condensed into high-pressure liquid refrigerant (a single phase).

[0019] The high-pressure liquid refrigerant fed out from outdoor heat exchanger 9 is converted by expansion valve 11 into two-phase refrigerant including low-pressure gas refrigerant and liquid refrigerant. The two-phase refrigerant flows into gas-liquid separator 13 and is separated into gas refrigerant and liquid refrigerant. The liquid refrigerant flows into indoor heat exchanger 15. On the other hand, the gas refrigerant flows through bypass pipe 17 to be directed to compressor 3. The refrigerant flowing through bypass pipe 17 will be described later.

[0020] Indoor heat exchanger 15 functions as an evaporator. In indoor heat exchanger 15, the refrigerant flows from auxiliary heat exchange part 15b to main heat exchange part 15a. In indoor heat exchanger 15, heat exchange is performed between the refrigerant having flowed thereinto and air fed into indoor heat exchanger 15, for example, by a fan (not shown). The liquid refrigerant evaporates into low-pressure gas refrigerant. The heat-exchanged air is fed out from indoor heat exchanger 15 into an indoor space to cool the indoor space.

[0021] The low-pressure gas refrigerant fed out from indoor heat exchanger 15 flows into compressor 3 through four-way valve 7. The low-pressure gas refrigerant having flowed into compressor 3 is compressed into high-temperature and high-pressure gas refrigerant and then discharged from compressor 3 again. This cycle is subsequently repeated.

[0022] Then, a heating operation will be described. The refrigerant in the heating operation flows opposite to the flow of the refrigerant in the cooling operation. By driving compressor 3 (compressor body 4), high-temperature and high-pressure gas refrigerant is discharged from compressor 3. The discharged high-temperature and high-pressure gas refrigerant (a single phase) flows into indoor heat exchanger 15 through four-way valve 7. Indoor heat exchanger 15 functions as a condenser. In indoor heat exchanger 15, the refrigerant flows from main heat exchange part 15a to auxiliary heat exchange part 15b.

[0023] In indoor heat exchanger 15, heat exchange is performed between the gas refrigerant having flowed thereinto and air fed thereinto by a fan (not shown). The high-temperature and high-pressure gas refrigerant is condensed into high-pressure liquid refrigerant (a single phase). The heat-exchanged air is fed out from indoor heat exchanger 15 to the indoor space to heat the indoor space. The high-pressure liquid refrigerant fed out from indoor heat exchanger 15 flows through gas-liquid separator 13 and is converted by expansion valve 11 into two-phase refrigerant including low-pressure gas refrigerant and liquid refrigerant.

[0024] The two-phase refrigerant flows into outdoor heat exchanger 9. Outdoor heat exchanger 9 functions as an evaporator. In outdoor heat exchanger 9, heat exchange is performed between the two-phase refrigerant having flowed thereinto and air supplied thereinto by a propeller fan (not shown). The liquid refrigerant of the two-phase refrigerant evaporates into low-pressure gas refrigerant (a single phase) and is fed out from outdoor heat exchanger 9.

[0025] The low-pressure gas refrigerant fed out from outdoor heat exchanger 9 flows into compressor 3 through four-way valve 7. The low-pressure gas refrigerant having flowed into compressor 3 is compressed into high-temperature and high-pressure gas refrigerant, and then discharged from compressor 3 again. This cycle is subsequently repeated.

[0026] In air conditioner 1 described above, gas-liquid separator 13 is disposed in a portion of refrigerant pipe 31 that is located between expansion valve 11 and indoor heat exchanger 15. In gas-liquid separator 13, the two-phase refrigerant having flowed thereinto is separated into gas refrigerant and liquid refrigerant. The gas refrigerant flows through bypass pipe 17 to be directed to compressor 3.

[0027] First, the effect achieved by gas-liquid separator 13 will be briefly described. As described at the beginning, when the amount of the circulating refrigerant is increased so as to enhance the capability of air conditioner 1, the pressure loss of the refrigerant occurs, which may deteriorate the performance of the air conditioner to the contrary.

[0028] Fig. 4 shows the relation between the degree of dryness of the refrigerant flowing into the indoor heat exchanger during the cooling operation and the pressure loss gradient inside a heat transfer tube. As shown in Fig. 4, in the case of the air conditioner not including a gas-liquid separator, the degree of dryness of the refrigerant flowing into the indoor heat exchanger is about 0.15 (the degree of dryness is about 0.1 to 0.2). In the case of the refrigerant whose degree of dryness is about 0.15, the value of the pressure loss gradient inside the heat transfer tube is in a relatively high range, which means that the pressure loss (the absolute value) of the refrigerant in the indoor heat exchanger is high.

[0029] On the other hand, in air conditioner 1 including gas-liquid separator 13, the refrigerant is separated in gas-liquid separator 13 into gas refrigerant and liquid refrigerant, and the liquid refrigerant whose degree of dryness is almost zero flows into indoor heat exchanger 15. Further, the amount of the refrigerant flowing into indoor heat exchanger 15 is also reduced as compared with the case where a gas-liquid separator is not provided. As shown in Fig. 4, in the case of the refrigerant whose degree of dryness is substantially zero, the value of the pressure loss gradient inside the heat transfer tube is substantially in the lowest range. Thus, the pressure loss (the absolute value) of the refrigerant in indoor heat exchanger 15 can be reduced as compared with the case where gas-liquid separator 13 is not provided.

[0030] The following describes the position at which bypass pipe 17 for directing the separated refrigerant from gas-liquid separator 13 to the compressor 3 side is connected in refrigerant pipe 31 and also describes the effect achieved thereby. In air conditioner 1 described above, starting from the upstream side, riser pipe 33, curved pipe 35, and down pipe 37 are sequentially connected to the suction side of compressor 3 (suction muffler 5). Down pipe 37 is connected to muffler suction inlet 5a of suction muffler 5. Bypass pipe 17 is connected to riser pipe 33.

[0031] Even if the liquid refrigerant is mixed into the refrigerant flowing through bypass pipe 17 due to the connection of bypass pipe 17 to riser pipe 33, the liquid refrigerant can be prevented from flowing into compressor 3. This will be described below in comparison with an air conditioner according to a comparative example.

[0032] As shown in Fig. 5, in an air conditioner 101 according to the comparative example, a compressor 103 includes a compressor body 104 and a suction muffler 105. Compressor body 104 has a body suction inlet 104a and a discharge outlet 104b. Suction muffler 105 is connected to body suction inlet 104a of compressor body 104. A refrigerant pipe 131 is connected to a muffler suction inlet 105a of suction muffler 105. A bypass pipe 117 that serves to direct the refrigerant from a gas-liquid separator (not shown) to the suction side of compressor 103 is connected to a portion of refrigerant pipe 131 immediately preceding to (immediately above) muffler suction inlet 105a.

[0033] The gas refrigerant separated in the gas-liquid separator (not shown) flows through bypass pipe 117. However, the liquid refrigerant separated in the gas-liquid separation may be mixed into gas refrigerant in bypass pipe 117. In this case, in the structure in which bypass pipe 117 is connected to a portion of refrigerant pipe 131 immediately above muffler suction inlet 105a, the mixed liquid refrigerant is directed to pass through bypass pipe 117 to flow into suction muffler 105. The liquid refrigerant having flowed into suction muffler 105 is suctioned into compressor body 104. Thus, liquid compression may occurs in compressor body 104, which may cause a failure in compressor body 104.

[0034] In contrast to air conditioner 101 according to the comparative example, in air conditioner 1 according to the first embodiment, bypass pipe 17 is connected to riser pipe 33 provided upstream of curved pipe 35. In addition, bypass pipe 17 is connected to riser pipe 33 so as to be substantially orthogonal to the direction in which riser pipe 33 extends.

[0035] Thus, when the liquid refrigerant flows into bypass pipe 17 and is mixed therein, the liquid refrigerant having flowed through bypass pipe 17 collides with an inner wall of riser pipe 33. While the liquid refrigerant having collided with the inner wall of riser pipe 33 falls down through riser pipe 33 by gravity, the liquid refrigerant exchanges heat with the refrigerant having passed through indoor heat exchanger 15 and flowed through riser pipe 33, so that the liquid refrigerant is gasified into gas refrigerant. Thereby, the liquid refrigerant can be suppressed from flowing into suction muffler 5. As a result, a failure caused in compressor body 4 by liquid compression can be prevented.

[0036] In the above description of air conditioner 1, bypass pipe 17 is connected to riser pipe 33 so as to be substantially orthogonal to the direction in which riser pipe 33 extends. As a connection manner of bypass pipe 17, bypass pipe 17 does not necessarily have to be connected to riser pipe 33 so as to be orthogonal to riser pipe 33, but should only be connected to riser pipe 33 so as to intersect with the direction in which riser pipe 33 extends.

[0037] Further, bypass pipe 17 does not necessarily have to be connected to riser pipe 33. In refrigerant pipe 31 including curved pipe 35 through which the refrigerant is directed to muffler suction inlet 5a so as to direct the refrigerant from a position lower than muffler suction inlet 5a to a position higher than muffler suction inlet 5a, bypass pipe 17 should only be connected to a position spaced apart from muffler suction inlet 5a by a distance based on the inner diameter of refrigerant pipe 31.

[0038] Specifically, as shown in Fig. 6, bypass pipe 17 should only be connected to a position of refrigerant pipe 31 that is located away from muffler suction inlet 5a by a distance L that is at least ten times as long as the inner diameter of curved pipe 35 (refrigerant pipe 31). The position located away by distance L from muffler suction inlet 5a is desirably located in curved pipe 35.

[0039] It is considered that, when bypass pipe 17 is connected to the position of refrigerant pipe 31 that is located away by distance L from muffler suction inlet 5a, the flowing state of the refrigerant having flowed to the vicinity of muffler suction inlet 5a of suction muffler 5 is substantially the same as the flowing state of the corresponding refrigerant in the air conditioner including no gas-liquid separator. Thus, the liquid refrigerant can be suppressed from flowing into suction muffler 5, so that a failure caused in compressor body 4 by liquid compression can be prevented.

Second Embodiment

[0040] In the above description about air conditioner 1 according to the first embodiment, by providing gas-liquid separator 13, the amount of the refrigerant flowing into indoor heat exchanger 15 is reduced, so that the pressure loss of the refrigerant in indoor heat exchanger 15 can be reduced. In the second embodiment, the following describes an example of an air conditioner configured to suppress a decrease in the heat transfer rate in an indoor heat exchanger resulting from a decrease in the amount of the refrigerant flowing through the indoor heat exchanger.

[0041] As shown in Fig. 7, indoor heat exchanger 15 in air conditioner 1 includes main heat exchange part 15a and auxiliary heat exchange part 15b. The heat transfer area per unit length in which refrigerant flows through main heat exchange part 15a is defined as a heat transfer area DM. The heat transfer area per unit length in which refrigerant flows through auxiliary heat exchange part 15b is defined as a heat transfer area DS. Heat transfer area DS is set to be larger than heat transfer area DM (heat transfer area DS > heat transfer area DM). The heat transfer area of refrigerant pipe 31 will be described later in detail. Other configurations are the same as those of air conditioner 1 shown in Fig. 1 and the like.

[0042] Then, the refrigerant flow in the cooling operation will be briefly described as an example of the operation of air conditioner 1 described above. The high-temperature and high-pressure gas refrigerant discharged from compressor 3 flows into outdoor heat exchanger 9 through four-way valve 7. In outdoor heat exchanger 9, heat exchange is performed between the refrigerant having flowed thereinto and air, and the high-temperature and high-pressure gas refrigerant is condensed into high-pressure liquid refrigerant (a single phase).

[0043] The high-pressure liquid refrigerant fed out from outdoor heat exchanger 9 is converted by expansion valve 11 into two-phase refrigerant including low-pressure gas refrigerant and liquid refrigerant. The two-phase refrigerant flows into gas-liquid separator 13 and is separated into gas refrigerant and liquid refrigerant. The gas refrigerant flows through bypass pipe 17 to be directed to compressor 3. The liquid refrigerant flows into indoor heat exchanger 15.

[0044] As shown in Fig. 7, in indoor heat exchanger 15, the refrigerant flows from auxiliary heat exchange part 15b to main heat exchange part 15a (see arrows). In indoor heat exchanger 15, heat exchange is performed between the refrigerant having flowed thereinto and air, and thus, the liquid refrigerant evaporates into low-pressure gas refrigerant.

[0045] The low-pressure gas refrigerant fed out from indoor heat exchanger 15 flows into compressor 3 through four-way valve 7, is compressed into high-temperature and high-pressure gas refrigerant, and then discharged from compressor 3 again. This cycle is subsequently repeated.

[0046] Then, the refrigerant flow in the heating operation will be briefly described. The high-temperature and high-pressure gas refrigerant discharged from compressor 3 flows into indoor heat exchanger 15 through four-way valve 7. In indoor heat exchanger 15, the refrigerant flows from main heat exchange part 15a to auxiliary heat exchange part 15b. In indoor heat exchanger 15, heat exchange is performed between the gas refrigerant having flowed thereinto and air, and thus, the high-temperature and high-pressure gas refrigerant is condensed into high-pressure liquid refrigerant (a single phase).

[0047] The high-pressure liquid refrigerant fed out from indoor heat exchanger 15 flows through gas-liquid separator 13 and expansion valve 11, and then flows into outdoor heat exchanger 9 as two-phase refrigerant. In outdoor heat exchanger 9, heat exchange is performed between the two-phase refrigerant having flowed thereinto and air. The liquid refrigerant of the two-phase refrigerant evaporates into low-pressure gas refrigerant (a single phase) and is fed out from outdoor heat exchanger 9.

[0048] The low-pressure gas refrigerant fed out from outdoor heat exchanger 9 flows into compressor 3 through four-way valve 7, is compressed into high-temperature and high-pressure gas refrigerant, and then discharged from compressor 3 again. This cycle is subsequently repeated.

[0049] In air conditioner 1 described above, in the cooling operation, the liquid refrigerant among the gas refrigerant and the liquid refrigerant separated in gas-liquid separator 13 flows into auxiliary heat exchange part 15b. Since the amount of the refrigerant flowing into auxiliary heat exchange part 15b decreases by the amount of the gas refrigerant that does not flow thereinto, the heat transfer rate (heat transfer amount) between the refrigerant and air in auxiliary heat exchange part 15b may decrease.

[0050] On the other hand, in auxiliary heat exchange part 15b, heat transfer area DS is set to be relatively large. In addition, the liquid refrigerant whose degree of dryness is almost zero flows into auxiliary heat exchange part 15b. Thus, the heat transfer rate (heat transfer amount) that tends to decrease as the amount of the refrigerant decreases can be increased by increasing the heat transfer area.

[0051] The increased heat transfer rate in auxiliary heat exchange part 15b increases a difference between the enthalpy (specific enthalpy) of the refrigerant on the inlet side of auxiliary heat exchange part 15b and the enthalpy (specific enthalpy) of the refrigerant on the outlet side of auxiliary heat exchange part 15b. Thus, under certain conditions of the cooling capacity, the enthalpy difference in main heat exchange part 15a can be reduced by the increased enthalpy difference in auxiliary heat exchange part 15b. Thereby, the frequency at which compressor 3 is driven can be lowered, which makes it possible to contribute to reduction in power consumption of air conditioner 1.

[0052] On the other hand, in the heating operation, in indoor heat exchanger 15, the high-temperature and high-pressure gas refrigerant flows through main heat exchange part 15a and thereafter flows through auxiliary heat exchange part 15b. While flowing through main heat exchange part 15a, the high-temperature and high-pressure gas refrigerant is condensed into liquid refrigerant, which then flows through auxiliary heat exchange part 15b. In auxiliary heat exchange part 15b, heat transfer area DS is set to be relatively large.

[0053] Thereby, the liquid refrigerant flowing through auxiliary heat exchange part 15b may cause a pressure loss, whereas the heat transfer rate (heat transfer amount) can be increased by increasing heat transfer area DS. As a result, the performance of the heat exchanger can be improved as an overall indoor heat exchanger 15.

[0054] The following describes a specific method of setting heat transfer area DS to be larger than heat transfer area DM. One of parameters controlling heat transfer areas DS and DM is the surface area of the inner wall surface of refrigerant pipe 31. As shown in Figs. 8 and 9, refrigerant pipe 31 has an inner wall surface provided with a ridge 41 having a protruding shape and formed in a helical shape. The surface area of the inner wall surface of refrigerant pipe 31 depends on the height of ridge 41, the number of ridges 41, and the lead angle of ridge 41.

[0055] The height of ridge 41 is a height of ridge 41 from the inner wall surface, and as the height is higher, the surface area becomes larger, so that the heat transfer area increases. The number of ridges 41 is the number of ridges 41 provided in a cross section of refrigerant pipe 31 that is taken along the direction orthogonal to the extending direction of refrigerant pipe 31, and as the number of ridges 41 is larger, the surface area becomes larger, so that the heat transfer area increases. The lead angle of ridge 41 is an angle θ formed by the extending direction of refrigerant pipe 31 and the extending direction of ridge 41 in a cross section of refrigerant pipe 31 that is taken along the extending direction of refrigerant pipe 31, and as angle θ is larger, the surface area becomes larger, so that the heat transfer area increases.

[0056] In air conditioner 1 described above, the height of ridge 41, the number of ridges 41, and the lead angle of ridge 41 in each of auxiliary heat exchange part 15b and main heat exchange part 15a are set such that heat transfer area DS of auxiliary heat exchange part 15b is larger than heat transfer area DM of main heat exchange part 15a.

[0057] For example, if two values among three values of the height of ridge 41, the number of ridges 41, and the lead angle of ridge 41 are the same, one remaining value is set such that one remaining value in auxiliary heat exchange part 15b is larger than one remaining value in main heat exchange part 15a.

[0058] It should be noted that the air conditioners described in the respective embodiments can be variously combined with one another as required.

[0059] The embodiments disclosed herein are merely by way of example and not limited thereto. The present disclosure is defined by the scope of the claims, rather than the scope described above, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

INDUSTRIAL APPLICABILITY

[0060] The present disclosure is effectively applicable to an air conditioner including a gas-liquid separator.

REFERENCE SIGNS LIST

[0061] 1 refrigeration cycle apparatus, 3 compressor, 4 compressor body, 4a body suction inlet, 4b discharge outlet, 5 suction muffler, 5a muffler suction inlet, 7 four-way valve, 9 outdoor heat exchanger, 11 expansion valve, 13 gas-liquid separator, 15 indoor heat exchanger, 15a main heat exchange part, 15b auxiliary heat exchange part, 17 bypass pipe, 19 capillary tube, 31 refrigerant pipe, 33 riser pipe, 35 curved pipe, 37 down pipe, 41 ridge.

Claims

1. An air conditioner comprising:

    a compressor, a first heat exchanger, an expansion valve, and a second heat exchanger;
    a refrigerant pipe connected to the compressor, the first heat exchanger, the expansion valve, the second heat exchanger, and the compressor in this order, and configured to allow refrigerant to flow through the refrigerant pipe;
    a gas-liquid separator located at a portion of the refrigerant pipe, the portion connecting the expansion valve to the second heat exchanger, the gas-liquid separator being configured to separate the refrigerant flowing from the expansion valve toward the second heat exchanger into gas refrigerant and liquid refrigerant; and
    a bypass pipe connected to the gas-liquid separator and configured to direct the refrigerant separated in the gas-liquid separator to the compressor, wherein
    the compressor comprises

        a compressor body having a body suction inlet through which the refrigerant is suctioned in, and
        a suction muffler having a muffler suction inlet connected to the refrigerant pipe, the suction muffler being connected to the body suction inlet of the compressor body,

    the refrigerant pipe comprises a curved pipe configured to direct the refrigerant to the muffler suction inlet, the refrigerant being directed from a position lower than the muffler suction inlet to a position higher than the muffler suction inlet, and
    the bypass pipe is connected to a position of the refrigerant pipe, the position being located away from the muffler suction inlet by a distance that is at least ten times as long as an inner diameter of the curved pipe.

2. The air conditioner according to claim 1, wherein

    the refrigerant pipe comprises a riser pipe that extends upward and configured to direct the refrigerant from a position lower than the muffler suction inlet to an upstream side of the curved pipe, and the bypass pipe is connected to the riser pipe.

3. The air conditioner according to claim 2, wherein the bypass pipe is connected to the riser pipe to be orthogonal to the riser pipe.

4. The air conditioner according to any one of claims 1 to 3, wherein

the second heat exchanger comprises

a first part of the second heat exchanger, and
a second part of the second heat exchanger, the second part being connected in series to the first part of the second heat exchanger and connected to the gas-liquid separator,

in the first part of the second heat exchanger, a heat transfer area per unit length in which the refrigerant flows is defined as a first heat transfer area,
in the second part of the second heat exchanger, a heat transfer area per unit length in which the refrigerant flows is defined as a second heat transfer area, and
the second heat transfer area is set to be larger than the first heat transfer area.

5. The air conditioner according to claim 4, wherein

the refrigerant pipe has an inner wall surface provided with a ridge formed in a helical shape, and
at least one value of a height of the ridge, a number of the ridges, and a lead angle is set such that the second heat transfer area is larger than the first heat transfer area, the height of the ridge being a height of the ridge from the inner wall surface, the number of the ridges being a number of the ridges provided in a first cross section of the refrigerant pipe, the first cross section being taken along a direction intersecting with an extending direction of the refrigerant pipe, and the lead angle being formed by the extending direction of the refrigerant pipe and an extending direction of the ridge in a second cross section of the refrigerant pipe, the second cross section being taken along the extending direction of the refrigerant pipe.

FIG.1

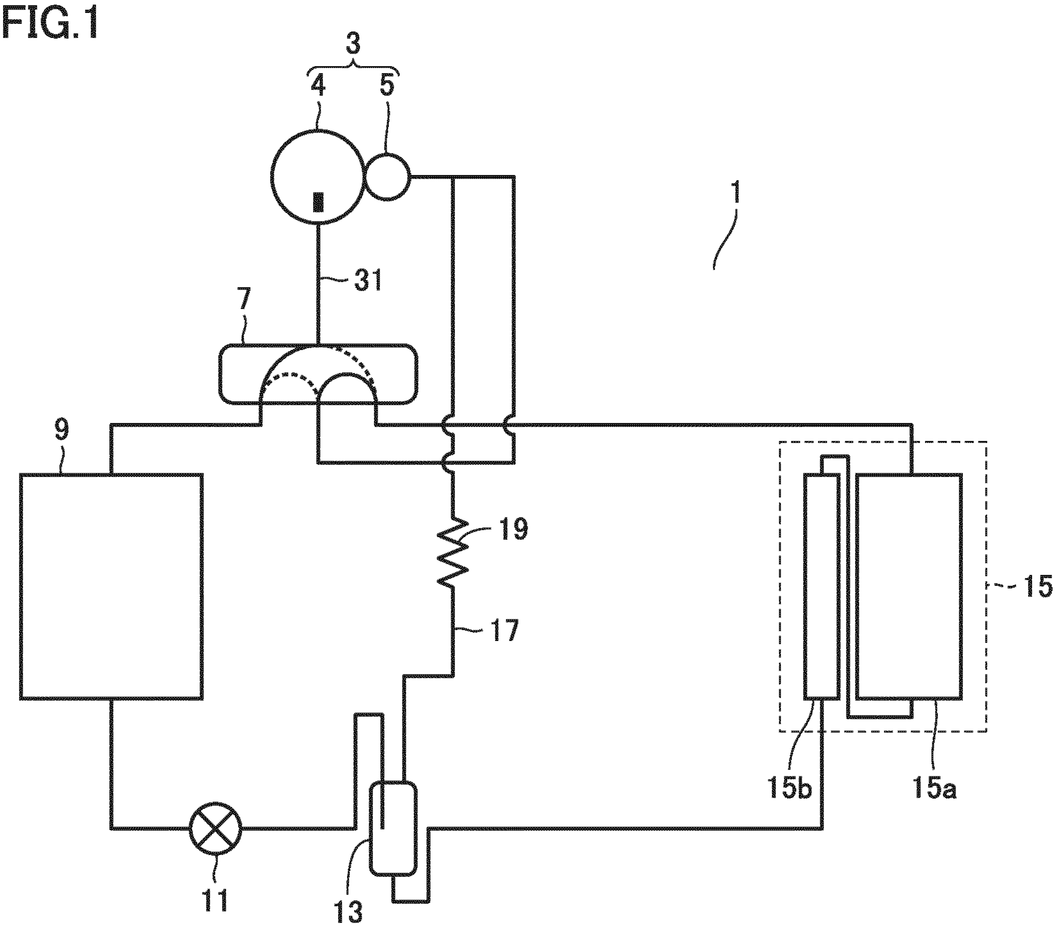


FIG.2

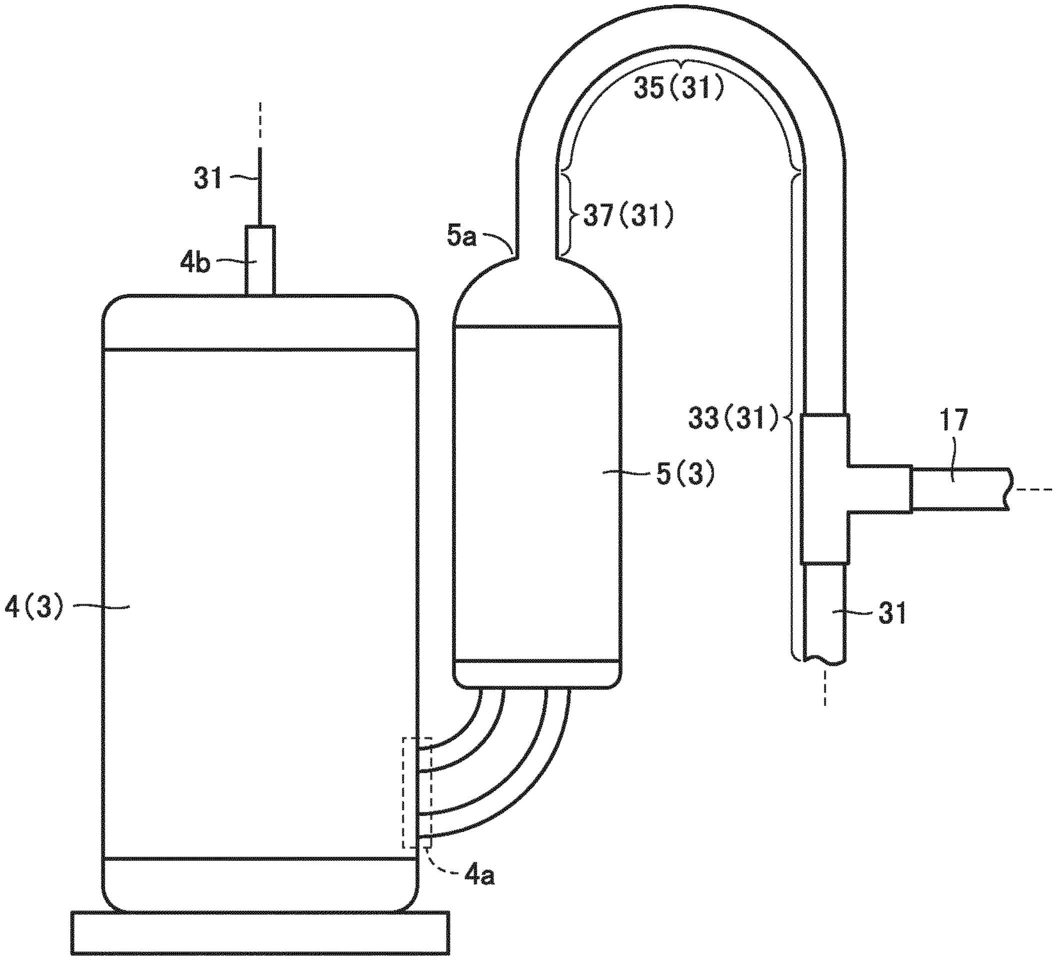


FIG.3

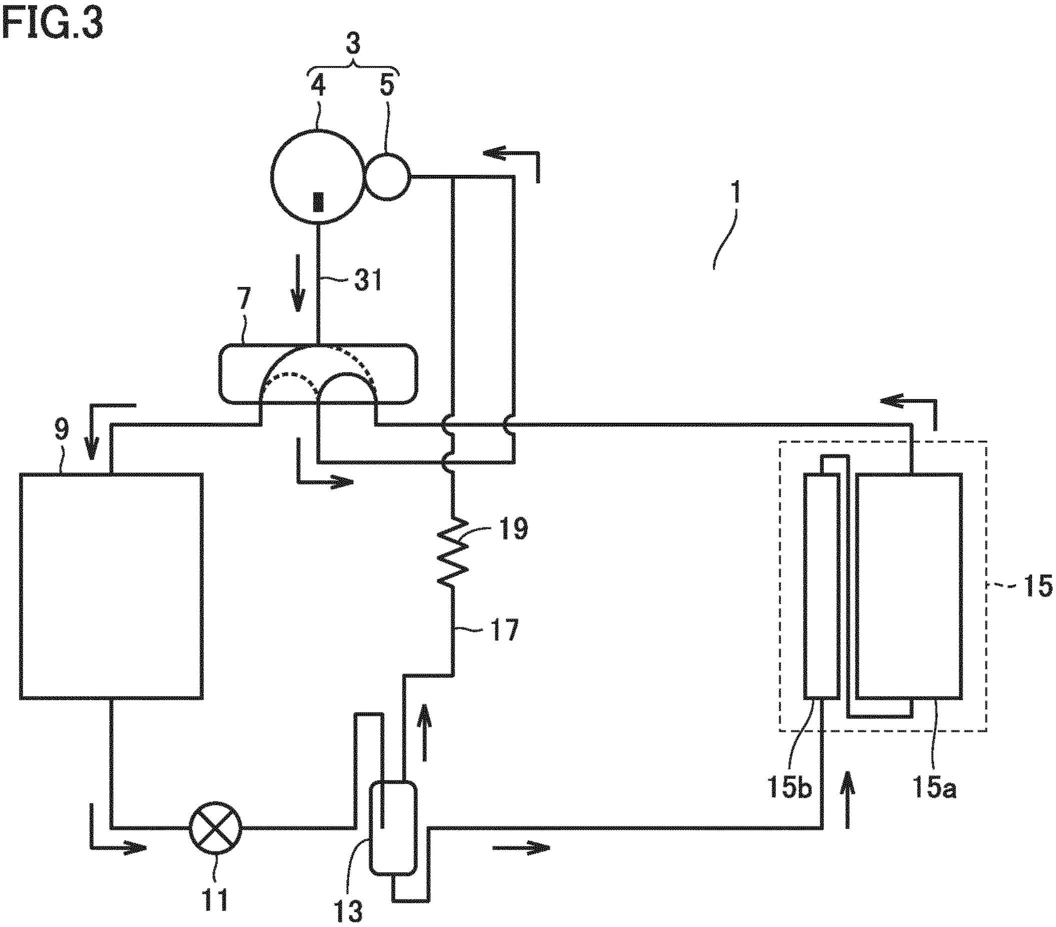

3
4
5
1
31
7
9
19
15
17
15b
15a
11
13

FIG.4

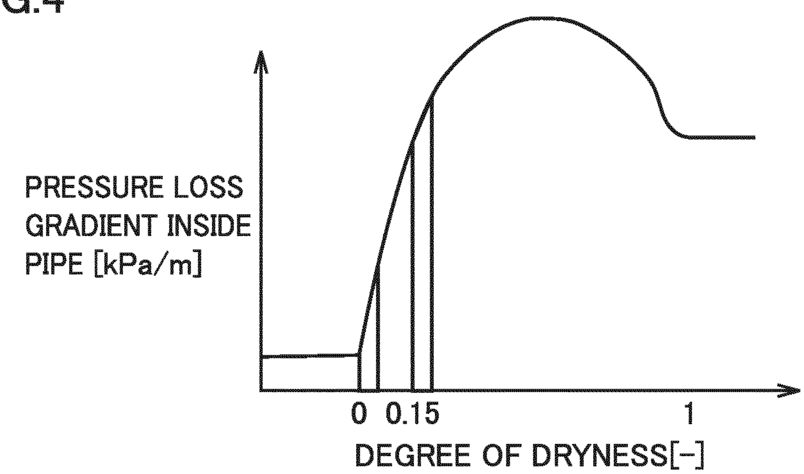

PRESSURE LOSS
GRADIENT INSIDE
PIPE [kPa/m]
0
0.15
1
DEGREE OF DRYNESS[–]

FIG.5

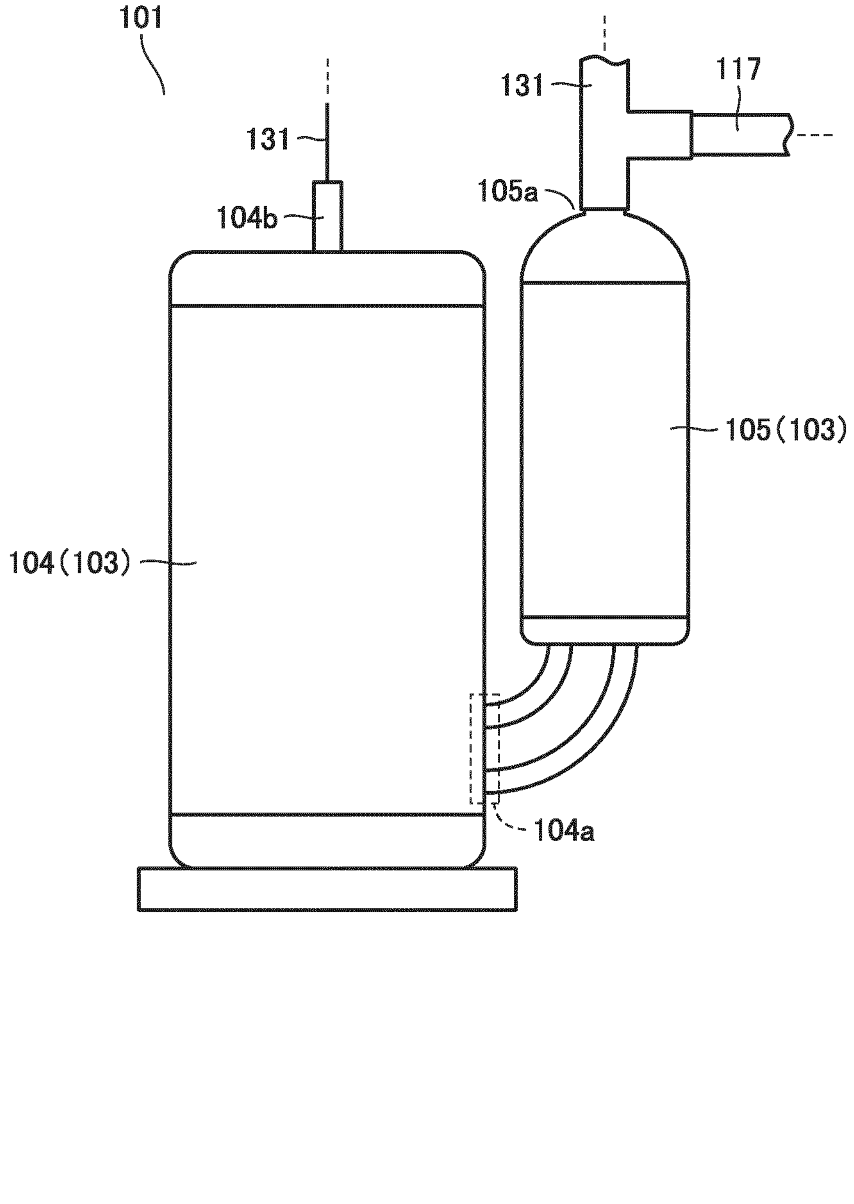


FIG.6

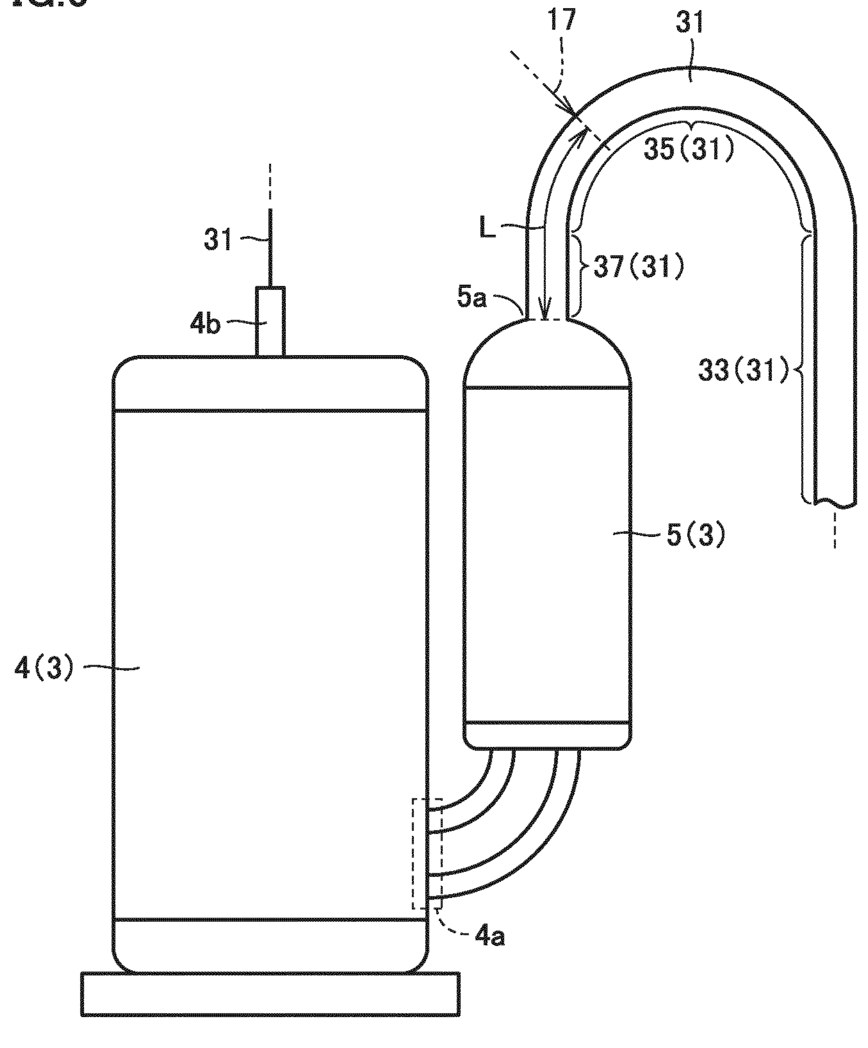


FIG.7

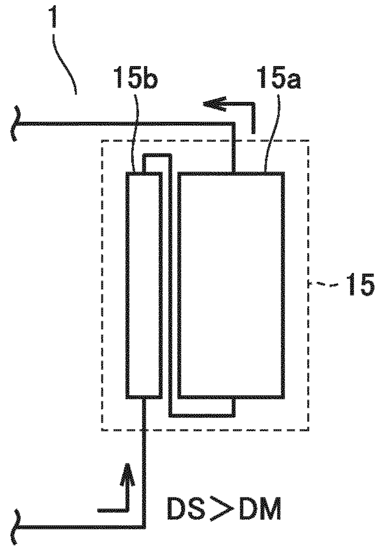


FIG.8

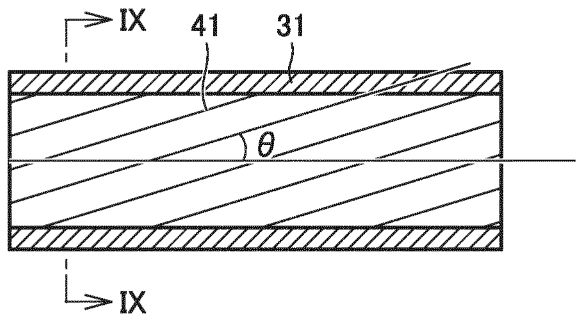
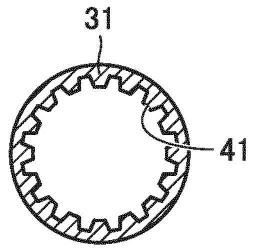


FIG.9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/023582

A. CLASSIFICATION OF SUBJECT MATTER
F25B 1/00(2006.01)i
FI: F25B1/00 101D

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)
F25B1/00

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2019-158308 A (MITSUBISHI ELECTRIC CORP) 19 September 2019 (2019-09-19) paragraphs [0016]-[0035], fig. 1-2	1-5
Y	JP 2013-148294 A (PANASONIC CORP) 01 August 2013 (2013-08-01) paragraphs [0014]-[0030], fig. 4	1-5
Y	JP 2017-150810 A (KOBE STEEL LTD) 31 August 2017 (2017-08-31) paragraphs [0011]-[0018]	4-5
Y	JP 2007-218566 A (DAIKIN IND LTD) 30 August 2007 (2007-08-30) paragraphs [0045]-[0075], fig. 1-2	5

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 July 2021 (08.07.2021)	03 August 2021 (03.08.2021)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/023582

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2019-158308 A	19 Sep. 2019	(Family: none)	
JP 2013-148294 A	01 Aug. 2013	(Family: none)	
JP 2017-150810 A	31 Aug. 2017	(Family: none)	
JP 2007-218566 A	30 Aug. 2007	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2019158308 A **[0005]**