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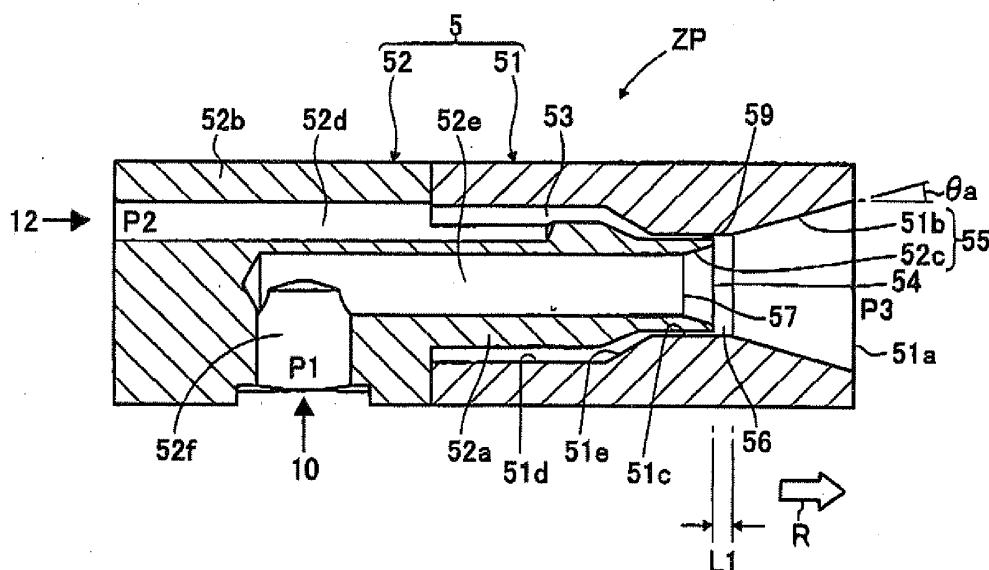
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(54) **Jet pump and air conditioner**

(57) A jet pump includes a discharge outlet (51a) configured to discharge refrigerant in which relatively high pressure refrigerant and relatively low pressure refrigerant are mixed, a diffuser (55) disposed coaxially with the discharge outlet in an upstream side of the discharge outlet, the diffuser including an inside diameter which gradually reduces in size away from the discharge outlet, a suction hole (52a) following from a minimum diameter

portion of the diffuser in an upstream side of the minimum diameter portion, disposed coaxially with the discharge outlet, and to which the lower pressure refrigerant is guided, a high pressure refrigerant path (53) configured to guide the high pressure refrigerant to the diffuser, and a nozzle portion (59) configured to eject the high pressure refrigerant from the high pressure refrigerant path into the diffuser in a downstream side of the minimum diameter portion.

FIG.1



Description

BACKGROUND

Technical Field

[0001] The present invention relates to a jet pump and an air conditioner using the jet pump.

Description of the Related Art

[0002] There is a known air conditioner for a vehicle which provides an ejector instead of providing an expansion valve between a radiator and an evaporator of a refrigerating cycle for improving a refrigerating effect in the evaporator, as well as for improving an effect of a compressor by increasing pressure on the intake side of the compressor (refer to, for example, Japanese Patent Application Publication No. 2005-308384).

[0003] This ejector includes a tubular main body and a nozzle portion provided inside the main body. This main body includes, in order, a reduced portion whose diameter is gradually reduced in a refrigerant flowing direction, a narrow tubular mixing portion following the minimum diameter portion of the reduced portion, and a diffuser whose diameter is gradually increased in the downstream direction. The nozzle portion is provided in the upstream side of the reduced portion. A suction section is formed between the reduced portion and the outer circumference of the leading end of the nozzle portion. Gas-phase refrigerant which has passed through the expansion valve and the first evaporator is guided from a suction port to the suction section while liquid-phase refrigerant is guided from the compressor to the nozzle portion via the radiator.

[0004] Accordingly, the liquid-phase refrigerant from the compressor is sprayed from the nozzle portion, to be decompressed and expanded, so that the gas-phase refrigerant from the evaporator is sucked from the suction section of the outer circumference of the nozzle portion. Then, both refrigerants are mixed in the mixing portion, and are sent to the second evaporator after slowing down and rising pressure based on the increased diameter shape of the diffuser.

[0005] However, the above-described conventional art includes the ejector configuration in which the reduced portion, the mixing portion and the diffuser are provided in series in the axis direction in the downstream side of the nozzle portion, resulting in the increasing in the size in the axial direction. For this reason, when mounting the ejector integrally with both evaporators in the air conditioner as described in Japanese patent application publication No. 2005-308384, the mounting direction of the ejector is limited in both evaporators.

SUMMARY

[0006] The present invention has been made in view

of the above circumstances, and an object of the present invention is to provide a compact jet pump suitable for an air conditioner.

[0007] In order to achieve the above object, an embodiment of the present invention provides a jet pump, including: a discharge outlet configured to discharge refrigerant in which relatively high pressure refrigerant and relatively low pressure refrigerant are mixed; a diffuser disposed coaxially with the discharge outlet in an upstream side of the discharge outlet, the diffuser including an inside diameter which gradually reduces in size away from the discharge outlet; suction hole following from a minimum diameter portion of the diffuser in an upstream side of the minimum diameter portion, disposed coaxially with the discharge outlet, and to which the lower pressure refrigerant is guided; a high pressure refrigerant path configured to guide the high pressure refrigerant to the diffuser; and a nozzle portion configured to eject the high pressure refrigerant from the high pressure refrigerant path into the diffuser in a downstream side of the minimum diameter portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The accompanying drawings are included to provide further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate an embodiment of the invention and, together with the specification, serve to explain the principle of the invention.

FIG. 1 is a sectional view illustrating a jet pump ZP in Embodiment 1.

FIG. 2 is a perspective view illustrating a main portion of the jet pump ZP in Embodiment 1.

FIG. 3 is a schematic view illustrating an air conditioner AC for a vehicle having the jet pump ZP in Embodiment 1.

FIG. 4 is a Mollier diagram illustrating a relationship between pressure and enthalpy of a refrigerating cycle of the air conditioner AC for a vehicle.

FIG. 5 is a Mollier diagram illustrating one example of a conventional art for the comparison with the air conditioner AC for a vehicle.

FIG. 6 is a view illustrating a relationship between an inlet length L1 and suction power in the jet pump ZP in Embodiment 1.

FIG. 7 is a sectional view illustrating a jet pump ZP2 in Embodiment 2.

FIG. 8 is a sectional view illustrating a jet pump ZP3 in Embodiment 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0009] Hereinafter, embodiments of the present invention will be described with reference to the drawings. According to an embodiment of the present invention, a jet

pump (ZP), includes; a discharge outlet (51a) configured to discharge refrigerant in which relatively high pressure refrigerant and relatively low pressure refrigerant are mixed; a diffuser (55) disposed coaxially with the discharge outlet in an upstream side of the discharge outlet, the diffuser including an inside diameter which gradually reduces in size away from the discharge outlet; a suction hole (52e) following from a minimum diameter portion of the diffuser in an upstream side of the minimum diameter portion, disposed coaxially with the discharge outlet, and to which the lower pressure refrigerant is guided; a high pressure refrigerant path (53) configured to guide the high pressure refrigerant to the diffuser; and a nozzle portion (59) configured to eject the high pressure refrigerant from the high pressure refrigerant path into the diffuser in a downstream side of the minimum diameter portion.

[Embodiment 1]

[0010] An air conditioner AC for a vehicle having a jet pump ZP in Embodiment 1 will be described with reference to FIGs. 1-5 as follows.

[0011] FIG. 3 is a view illustrating an overview of the air conditioner AC for a vehicle. This air conditioner AC includes a refrigerating cycle S having a compressor 1, a condenser 2, an expansion valve 3, a capillary 4, a jet pump ZP, a first evaporator 10, and a second evaporator 20. As refrigerant of the refrigerating cycle S, for example, replacing halon (134a, 1234yf) is used, but carbon hydride, carbon dioxide, ammonia or the like can be used.

[0012] The compressor 1 is configured to drive by a driving force such as an engine or a motor for driving a vehicle to suck and compress refrigerant, and has an exit side connected to the condenser 2.

[0013] The condenser 2 is configured to heat-exchange high pressure gas-phase refrigerant discharged from the compressor 1 with outside air blowing by a not shown cooling fan, and to cool the refrigerant so as to obtain high pressure liquid-phase refrigerant. A liquid tank 2a for gas-liquid separation is provided in the end portion of the condenser 2 on the downstream side.

[0014] The expansion valve 3 is connected to the exit side of the condenser 2, and is configured to adjust the opening of the valve (refrigerant flow volume) such that the overheat temperature of the exit of the second evaporator 20 becomes a predetermined value according to the refrigerant temperature of the exit of the second evaporator 20 which is detected by a temperature detector 3a.

[0015] The exit side of the expansion valve 3 is branched into a first guiding branch 11 connected to the entrance side of the first evaporator 10 via a capillary 4 and a second guiding branch 12 connected to the jet pump ZP at a branching point 31. In addition, the first evaporator 10, the second evaporator 20, the jet pump ZP and the capillary 4 surrounded by the dotted line in FIG. 3 are integrally assembled.

[0016] In the first guiding branch 11, the refrigerant is

expanded and decompressed in the capillary 4. In the first evaporator 10, air is thereby cooled by absorbing heat from air.

[0017] The jet pump ZP provided in the second guiding branch 12 ejects intermediate pressure refrigerant which has passed through the expansion valve 3 from the after-described nozzle portion 59, generates a driving flow by the expansion, operates as a pump which sucks low pressure refrigerant from the first evaporator 10 by the suction power, and mixes the low pressure refrigerant with the intermediate pressure refrigerant from the expansion valve 3 to send the mixed refrigerant to the second evaporator 20. In addition, the details of the structure of the jet pump ZP will be described later.

[0018] The second evaporator 20 includes an entrance side connected to a discharge outlet 51a of the jet pump ZP, and an exit side connected to the entrance side of the compressor 1. The low temperature and low pressure gas-phase refrigerant obtained by absorbing heat with gas-liquid two-phase refrigerant in the second evaporator 20 is sent to the compressor 1 by the suction of the compressor 1.

[0019] The first evaporator 10 and the second evaporator 20 are arranged in series such that the first evaporator 10 is arranged in the downstream side and the second evaporator 20 is arranged in the upstream side relative to blast W in a housing unit HU housing a configuration (both evaporators 10, 20 and a not illustrated heater) which performs heat exchange with the blast W by the fan 6 in the air conditioner AC for a vehicle. The configuration of the first evaporator 10 is the same as that of the second evaporator 20. The low pressure gas-liquid two-phase refrigerant absorbs heat to evaporate and to cool the blast by the vaporization heat. Each of the evaporators 10, 20 has a known configuration and includes tanks provided up and down, a tube which communicates with the tanks and through which the refrigerant passes, and a fin provided in the outer circumference of the tube.

[0020] Next, the structure of the jet pump ZP will be described in detail.

The jet pump ZP is housed in a not illustrated tank formed in a side plate which is a framework of the first and second evaporators 10, 20, and includes a main body 5 having a nozzle outside member 51 and a nozzle inside member 52.

[0021] The nozzle outside member 51 is formed in a tubular shape and has the discharge outlet 51a in the end portion in the right direction (the arrow R direction in FIG. 1 which is referred to as the first direction) of the axis direction which is the right and left direction in the figure. The nozzle outside member 51 also includes a first diffuser 51b, an inlet hole (tube insertion hole) 51c and a tube insertion hole 51d. These are coaxially formed following the discharge outlet 51 a toward the second direction which is the left direction of the axial direction in the figure.

[0022] The first diffuser 51b is formed to have a shape whose diameter is gradually reduced toward the second

direction from the discharge outlet 51a. In Embodiment 1, the broadening angle θ_a which is an angle to the axial direction is within a range of 11-17°.

[0023] The inlet hole 51c is formed from the minimum diameter portion of the first diffuser 51b to have a constant inside diameter toward the second direction end portion in the axial direction, which is a diameter the same as that of the minimum diameter portion of the first diffuser 51b.

[0024] The tube insertion hole 51d is formed to have a diameter larger than that of the inlet hole 51c. An inclination surface 51e is formed between the inlet hole 51c and the tube insertion hole 51d on the basis of the diameter difference. In addition, the tube insertion hole 51d can be formed to have a diameter the same as that of the inlet hole 51c.

[0025] The nozzle inside member 52 includes a nozzle tube section 52a inserted into the tube insertion hole 51d and the inlet hole 51c and a base section 52b which has a diameter larger than that of the nozzle tube section 52a and hits the end portion of the nozzle outside member 51 in the second direction. In addition, the tube insertion hole 51d and the inlet hole 51c correspond to the tube insertion hole into which the nozzle tube section 52a is inserted.

[0026] The nozzle tube section 52a is disposed approximately coaxially with the inlet hole 51c and the tube insertion hole 51d, and the leading end portion of the nozzle tube section 52a is inserted into the intermediate portion of the inlet hole 51c. This nozzle tube section 52b has an outside diameter formed to be smaller than the inside diameter of the inlet hole 51c and the tube insertion hole 51d. An outer circumference refrigerant path (high pressure refrigerant path) 53 is formed between the nozzle tube section 52a and the inner circumference of the tube insertion hole 51d. A nozzle portion 59 which ejects low pressure refrigerant into the diffuser 55 from the inner circumferential face of the diffuser 55 is formed between the nozzle tube section 52a and the inlet hole 51c. The outer circumference refrigerant path 53 can be formed based on the diameter difference between the nozzle tube section 52a and the tube insertion hole 51d. However, when the tube insertion hole 51d is formed to be a diameter the same as that of the inlet hole 51c, the outer circumferential refrigerant path 53 may be formed by providing in the axial direction a groove in one or both of the inner circumference of the tube insertion hole 51d and the outer circumference of the nozzle tube section 52a.

[0027] The outer circumference refrigerant path 53 communicates with the second guiding branch 12, i.e., the exit side of the expansion valve 3 via the communication path 52d which penetrates through the base section 52b of the nozzle inside member 52.

[0028] The nozzle tube section 52a includes an opening 54 which opens toward the first diffuser 51b, a second diffuser 52c whose inside diameter is gradually reduced from the opening 54, and a suction hole 52e having a diameter the same as that of a suction port 57 of the

minimum diameter portion of the second diffuser portion 52c. The end portion of the suction hole 52e in the second direction is connected to the exit side of the first evaporator 10 via a side hole 52f which penetrates through in the direction orthogonal to the axial direction.

[0029] The second diffuser 52e is formed to have an expanding diameter the same as an expanding diameter θ_a of the first diffuser 51b, and this expanding diameter is formed to be a diameter within 11-17°. This second diffuser 52c forms the diffuser 55 together with the first diffuser 51b.

[0030] The nozzle portion 59 formed between the leading end of the nozzle tube section 52a and the inlet hole 51c is formed by a plurality of nozzle recesses 52h. More specifically, as illustrated in FIG. 2, the outer circumference of the nozzle tube section 52a includes a convex portion 52g which has contact with the inner circumference of the inlet hole 51c, and a plurality of nozzle recesses 52h which separates from the inlet hole 51c in the inside diameter direction. The convex portion 52g and the nozzle recesses 52h are alternately formed in a spline form. A plurality of recesses 52h is thereby provided along the outer circumference of the opening 54 between the outer circumference of the leading end of the nozzle tube section 52a and the inner circumference of the inlet hole 51c. The nozzle portion 59 which connects the outer circumference refrigerant path 53 to the intermediate portion of the diffuser 55 in the axial direction is formed by the plurality of nozzle recesses 52h. In addition, the opening area of the nozzle portion 59, i.e., the total area of the opening of the nozzle recesses 52h is formed in a size which is less than 1/4 of the sectional area of the suction hole 52e.

[0031] Returning to FIG. 1, the inlet hole 51c includes between the leading end of the nozzle tube section 52a and the first diffuser 51b in the axial direction an inlet portion 56 which mixes the low pressure refrigerant from the exit side of the first evaporator 10 and the intermediate pressure refrigerant from the expansion valve 3. It is preferable for the size of the inlet portion 56 in the axial direction (hereinafter, referred to as an inlet length L1) to be a size of $L1 \leq 3D$ where the diameter of the suction hole 52e is D. In this embodiments, the inlet length L1 is formed to a length which is slightly shorter than D.

[0032] Next, the operation of the air conditioner AC for a vehicle of Embodiment 1 will be described with reference to the schematic view in FIG. 3 and the Mollier diagram in FIG. 4.

[0033] In the compressor 1, low pressure gas-phase refrigerant illustrated by the dot a in the Mollier diagram of FIG. 4 is sucked, and the sucked air is sent to the condenser 2 as high temperature and high pressure gas-phase refrigerant illustrated by the dot b. In the condenser 2, the heat of the refrigerant is released and is condensed to be normal temperature and high pressure liquid-phase refrigerant illustrated by the dot c. In the expansion valve 3, the high pressure liquid-phase refrigerant illustrated by the dot c is decompressed and the flow volume of the

refrigerant is also controlled to be low temperature and lower pressure gas-liquid two-phase refrigerant, and the gas-liquid two-phase refrigerant is sent to the first guiding branch 11 and the second guiding branch 12 divided at the dot d.

[0034] In this case, after the refrigerant sent to the first guiding branch 11 is expanded and decompressed by the capillary 4, the refrigerant is heat-exchanged in the first evaporator 10, and absorbs the heat of the blast W to be low temperature and low pressure refrigerant having a large amount of gas-phase. In the Mollier diagram of FIG. 4, the change in the capillary 4 is illustrated between the dot d and the dot e1, and the enthalpy change in the first evaporator 10 is illustrated between the dot e1 and the dot f1.

[0035] On the other hand, the refrigerant which has passed through the second guiding branch 12 is sent to the nozzle recesses 52h from the outer circumference refrigerant path 53 in the jet pump ZP to be narrowed down, so that the refrigerant ejects at high speed from the nozzle portion 59 between the second diffuser 52c and the first diffuser 51b of the diffuser 55, and is decompressed and expanded by the expanded diameter.

[0036] In the jet pump ZP, by the two pressure difference of the pressure difference by the speed difference of the refrigerant which is ejected from the nozzle portion 59 and the refrigerant in the suction hole 52e and the pressure difference by the decompression and expansion function in the spraying from the nozzle recesses 52h to the diffuser 55, the pressure P1 of the suction hole 52e to which the refrigerant which has passed through the first evaporator 10 and the pressure P3 of the diffuser 55 become $P1 > P3$, and by the suction power of the compressor 1, the refrigerant of the suction hole 52e is effectively sucked to the diffuser 55 from the suction hole 57.

[0037] In the Mollier diagram of FIG. 4, the dot e2 illustrates the portion where the intermediate pressure refrigerant which has passed through the second guiding branch 12 is expanded, and is mixed with the low pressure refrigerant from the first evaporator 10, and the dot f2 illustrates the condition of the exit of the second evaporator 20.

[0038] Accordingly, the area of A1 in FIG. 4 illustrates the enthalpy change in the first evaporator 10 and the area of A2 illustrates the enthalpy change in the second evaporator 20.

[0039] The cooling performance in both evaporators 10, 20 can be determined by multiplying the difference between the enthalpy of the entrance of the evaporator and the enthalpy of the exit of the evaporator by the refrigerant flow volume.

[0040] In this Embodiment 1, the cooling performance of both evaporators 10, 20 is a value in which a value obtained by multiplying the difference between the enthalpy (e1) of the entrance of the first evaporator and the enthalpy (f1) of the exit of the first evaporator by the refrigerant flow volume by is added to the value obtained

by multiplying the difference between the enthalpy (e2) of the entrance of the second evaporator and the enthalpy (f2) of the exit of the second evaporator by the refrigerant flow volume. Therefore, in this Embodiment 1, the cooling performance can be improved by increasing the refrigerant flow volume of the first evaporator 10 by the suction power of the jet pump P.

[0041] FIG. 5 illustrates a Mollier diagram in a conventional art. The conventional art described in Japanese Patent Application Publication No. 2005-308384 aims to control the work volume of the compressor by obtaining the pressure rising effect with the ejector. As illustrated in FIG. 5, the pressure of the refrigerant which has passed through the first evaporator rises by the ejector to be sent to the second evaporator, so that the pressure of the exit of the second evaporator is increased, and the pressure rising amount in the compressor can be thereby controlled.

[0042] On the other hand, since the jet pump ZP in Embodiment 1 aims to improve the cooling performance in the first evaporator 10 by increasing the refrigerant flow volume with the pump operation, the work volume of the compressor 1 or the like can be thereby reduced. Accordingly, the pressure of the exit of the second compressor 20 is lower than the pressure of the exit of the first evaporator 10 as illustrated in FIG. 4.

[0043] Hereinafter, the effects of the jet pump ZP and the air conditioner AC for a vehicle having the jet pump ZP in Embodiment 1 will be described.

[0044]

a) The jet pump ZP of Embodiment 1 includes the discharge outlet 51a configured to discharge refrigerant in which relatively high pressure refrigerant and relatively low pressure refrigerant are mixed, the diffuser 55 disposed coaxially with the discharge outlet 51a in the upstream side of the discharge outlet 51a, the diffuser 55 including an inside diameter which gradually reduces in size away from the discharge outlet 51a, the suction hole 53e following from the minimum diameter portion of the diffuser 55 in the upstream side of the minimum diameter portion, disposed coaxially with the discharge outlet 51a, and to which the lower pressure refrigerant is guided, the high pressure refrigerant path 53 configured to guide the high pressure refrigerant to the diffuser 55, and the nozzle portion 59 configured to eject the high pressure refrigerant from the high pressure refrigerant path 53 into the diffuser 55 in the downstream side of the minimum diameter portion.

[0045] With this configuration, the driving flow is generated by ejecting the refrigerant from the expansion valve 3 in the diffuser 55 from the nozzle portion 59 of the intermediate portion of the diffuser 55 in the axial direction, and the low pressure refrigerant which is sent from the first evaporator 10 can be sucked from the suction port 57.

[0046] Consequently, it becomes unnecessary to dispose the reduced diameter portion and the mixing portion in series in the downstream side of the conventional nozzle portion, so that the size in the axial direction is reduced, and the jet pump ZP can be downsized. In fact, the size in the axial direction can be reduced to about 1/3 of the conventional ejector.

[0047] Since the jet pump ZP can be downsized, the degree of freedom in disposing the jet pump ZP integrally with both evaporators 10, 20 of the air conditioner AC for a vehicle can be improved,

[0048]

b) Because the jet pump ZP in Embodiment 1 is a decompressor for refrigerant, high suction power, namely, a high pump performance can be obtained by the suction using the pressure difference between the pressure P1 of the suction hole 52e and the pressure P3 of the diffuser 55 by the pressure difference due to the speed difference between the refrigerant in the suction hole 52e and the refrigerant ejected at high speed from the nozzle portion 59 in the intermediate portion of the diffuser 55 and the pressure difference due to the decompression and expansion operation in the spraying from the nozzle portion 59 to the diffuser 55.

[0049]

c) The jet pump ZP in Embodiment 1 includes the tubular nozzle outside member 51 and the tubular nozzle inside member 52 disposed inside the nozzle outside member 51 in the radial direction, the discharge outlet 51a is formed in one end portion of the nozzle outside member 51, the suction hole 52e is formed in the nozzle inside member 52, and each of the high pressure refrigerant path 53 and the nozzle portion 59 is formed between the nozzle outside member 51 and the nozzle inside member 52.

[0050] Therefore, the nozzle portion 59 and the high pressure refrigerant path 53 can be easily formed compared to the case in which the diffuser main body is formed by one member when providing the nozzle portion 59 in the downstream side of the minimum diameter portion of the diffuser 55.

[0051]

d) According to the jet pump ZP of Embodiment 1, the nozzle inside member 52 includes the nozzle tube section 52a, and the nozzle portion 59 is formed between the nozzle tube section 52a and the nozzle outside member 51.

[0052] As described above, the nozzle portion 59 is formed by using the tubular nozzle tube portion 52a, so that the flow path sectional area with the nozzle inside member 52 can be easily controlled, and the pressure

difference (P1-P3) can be effectively formed.

[0053]

e) According to the jet pump ZP of Embodiment 1, the nozzle portion 59 includes a plurality of nozzle recesses 52h disposed in a circumferential direction of the nozzle inside member 52.

[0054] As described above, the nozzle portion 59 is formed by a plurality of nozzle holes 52h, so that the sectional area of the nozzle portion 59 can be easily controlled, and high suction power can be easily obtained by ensuring the pressure difference, compared to the case in which the nozzle portion 59 is formed over the entire circumference of the nozzle tube portion 52a.

[0055] Since the total area of the nozzle recesses 52h is set to less than 1/4 of the sectional area of the suction hole 52e in the jet pump ZP in Embodiment 1, the refrigerant flow speed which is sprayed from the nozzle portion 59 can be a speed significantly faster than the refrigerant flow speed on the suction hole 52e side, and high suction power can be obtained by ensuring the pressure difference due to the speed difference of both.

[0056]

f) According to the jet pump ZP in Embodiment 1, the nozzle portion includes the convex portion 52g which has contact with the inner circumference of the nozzle outside member 51 and extends in a longitudinal direction of the nozzle tube section 52a, the nozzle recesses 53h and the convex portion 52a are alternately disposed in the outer circumferential face of the nozzle tube section 52a in the circumferential direction, and the nozzle recesses 52h extend in the axial direction of the diffuser 55.

[0057] Consequently, the leading end portion of the nozzle tube portion 52a can be prevented by the convex portion 52g from displacing in the radial direction in the state in which the leading end portion is inserted into the inlet hole 51c. The size of the nozzle portion 59 can be thereby stabilized between the nozzle tube portion 52a and the inlet hole 51c, and the stabilized suction power, i.e., the stabilized pump performance can be obtained.

[0058]

g) According to the jet pump ZP of Embodiment 1, the diffuser 55 includes the first diffuser 51b formed in an inner face of the one end portion of the nozzle outside member 51 and the second diffuser 52c formed in the inner circumferential portion of the leading end of the nozzle inside member 52 on the discharge outlet 51a side, the second diffuser 52c including a diameter which gradually reduces toward the suction hole from the opening 54 of the leading end.

[0059] As described above, the second diffuser 52c is

formed in the nozzle inside member 52, so that the nozzle portion 59 can be easily provided in the intermediate portion of the diffuser 55 in the axial direction.

[0060]

h) According to the jet pump ZP of Embodiment 1, the nozzle portion 59 ejects the high pressure refrigerant into the diffuser 55 between the first diffuser 51b and the second diffuser 52c.

[0061] Therefore, as described in the above b), high suction power can be obtained by the suction using the pressure difference between the pressure P1 of the suction hole 52e and the pressure P3 of the diffuser 55 by the pressure difference due to the speed difference between the refrigerant in the suction hole 52e and the refrigerant ejected at high speed from the nozzle portion 59 in the intermediate portion of the diffuser and the pressure difference due to the decompression and expansion operation in the spraying from the nozzle portion 59 to the diffuser 55. Since both of the diffusers 51b, 52c are formed in the nozzle outside member 51 and the nozzle inside member 52, the jet pump ZP having such high suction power can be obtained.

[0062]

i) According to the jet pump ZP of Embodiment 1, the nozzle inside member 52 includes the nozzle tube section 52a, and the nozzle portion 59 is formed between the nozzle tube section 52a and the nozzle outside member 51, and the second diffuser 52c is formed in the inner circumferential face of the nozzle tube section 52a.

[0063] As described above, the second diffuser 52 is formed in the inner circumferential face of the nozzle tube section 52a of the nozzle inside member 52, so that the nozzle 59 can be easily formed in the intermediate portion of the diffuser 55 in the axial direction, and the second diffuser 52c can be easily manufactured.

[0064]

j) According to the jet pump ZP of Embodiment 1, the nozzle inside member 52 includes the nozzle tube section 52a, and the nozzle portion 59 is formed between the nozzle tube section 52a and the nozzle outside member 51, the nozzle outside member 51 includes the tube insertion hole 51d connected to the minimum diameter portion of the first diffuser 51b, and the nozzle tube section is inserted into the tube insertion hole 51d, and the nozzle portion 59 is formed between the nozzle tube section 52a and the inner circumference of the tube insertion hole 51 d.

[0065] Therefore, by inserting the nozzle tube section 52a of the nozzle inside member 52 into the tube insertion hole 51d of the nozzle outside member 51, the nozzle portion 59 is formed.

[0066]

k) According to the jet pump ZP of Embodiment 1, the angle of the inner circumference of the second diffuser 52c relative to the axis of the diffuser 55 is the same as the angle of the inner circumference of the first diffuser 51b relative to the axis of the diffuser 55.

[0067] Therefore, the expansion relative to the axial direction is constant between the first diffuser 51b and the second diffuser 52c in the diffuser 55 to stabilize the flow of the fluid, and the stabilized pump performance can be obtained.

[0068]

l) According to the jet pump ZP of Embodiment 1, the diffuser includes in the position on the discharge outlet 51a side of the nozzle portion 59 the inlet portion 56 having a constant inside diameter in the axial direction.

[0069] FIG. 6 is a view illustrating the suction power characteristic of the jet pump ZP. As illustrated in FIG. 6, if the length of the inlet portion 56 in the axial direction (= inlet length L1) is ensured, the suction power is increased compared to a case without having the inlet length L1. In addition, D in the horizontal axis denotes the diameter of the suction hole 52e. As illustrated in FIG. 6, when the inlet length L1 is formed to be a value about 3D, the maximum suction power can be obtained.

[0070] With respect to this suction power feature, according to the jet pump ZP of Embodiment 1, the size L1 of the inlet portion 56 in the axial direction is set to satisfy the relationship of $L1 \leq 3D$ where the diameter of the suction hole 52e is D, large suction power can be obtained compared to the case in which the inlet portion 56 is not provided and the inlet portion 56 is set to be larger than 3D.

[0071] Moreover, in Embodiment 1, the inlet distance L1 is set to be the length slightly shorter than the diameter D of the suction hole 52e, so that the jet pump ZP can be downsized by reducing the size in the axial direction while ensuring the suction power.

[0072]

m) According to the jet pump ZP of Embodiment 1, in the air conditioner AC for a vehicle, the jet pump ZP is provided in the downstream side of the expansion valve 3, and the refrigerant flow volume of the first evaporator 10 is increased by the suction power of the jet pump ZP, so that the cooling performance can be improved as well as reducing the work volume of the compressor 1. The suction power of the jet pump ZP uses the driving power generated by the flow of the refrigerant without using special power; thus, the air conditioner AC for a vehicle is very effective and economic.

(Other Embodiments)

[0073] Hereinafter, other embodiments will be described. Since these embodiments are modified examples of Embodiment 1, the difference will be only described, and the effects which are common to those in Embodiment 1 will be omitted as well as omitting the description by applying the same reference numbers to the configurations which are common to those in Embodiment 1 or other embodiments.

[Embodiment 2]

[0074] A jet pump ZP2 of Embodiment 2 illustrated in FIG. 7 is a modified example of Embodiment 1, and is an example in which the length of an inlet hole 251c in the axial direction is made longer compared to Embodiment 1 and the inlet length L1 of the length of an inlet portion 256 is set to about 3 times of the diameter D of the suction hole 52e.

[0075] Accordingly, as described in the above c), in the jet pump ZP2 of Embodiment 2, by setting the inlet length L1 to about 3D, the maximum suction power of the jet pump ZP2 can be obtained. Even if the inlet length L1 is set to 3D as in Embodiment 2, the size of the jet pump ZP2 in the axial direction can be a size less than 1/2 of a conventional ejector.

[0076] In addition, as illustrated in FIG. 6, the maximum inlet length L1 is obtained when the length L1 is set to the length of 3D relative to the diameter D of the suction hole 52e. Consequently, by setting the inlet length L1 to the length less than 3D as illustrated in Embodiments 1, 2, necessary pump performance can be obtained while downsizing.

[Embodiment 3]

[0077] A jet pump ZP3 of Embodiment 3 is an example in which the length of an inlet portion 356 is made to be variable by providing a moving device 300 which moves a nozzle inside member 352 in the axial direction. In addition, the jet pump ZP3 of Embodiment 3 is applied to the air conditioner AC for a vehicle similar to that in Embodiment 1.

[0078] The moving device 300 is configured to detect the temperature of the refrigerant from the first evaporator 10, set the inlet length L1 to long (namely, closer to the length of 3D) from the initial state in which the inlet portion 356 is set to the minimum length as the temperature of the refrigerant relatively increases, and set the inlet length L to long (namely, closer to the length of 3D) according to the pressure difference between the refrigerant pressure of the exit of the expansion valve 3 and the refrigerant pressure of the exit of the first evaporator 10 as the pressure difference lowers.

[0079] Hereinafter, the jet pump ZP3 of Embodiment 3 will be described with reference to FIG. 8.

[0080] As illustrated in FIG. 8, a nozzle outside mem-

ber 351 is formed in a tubular shape, and coaxially includes, in order from the end portion of one side, a first diffuser 51b, an inlet hole (tube insertion hole) 351c and a nozzle housing hole (tube insertion hole) 351d.

[0081] The nozzle inside member 352 is formed in a tubular shape, and includes a nozzle tube section 352a, a pressure receiving portion 352p, and a suction hole 352e formed in the shaft center to penetrate in the axial direction.

[0082] The nozzle tube section 352a is disposed coaxially with the nozzle housing hole 351d and the inlet hole 351c, and the leading end portion of the nozzle tube section 352a is inserted into the inlet hole 351c. The leading end portion includes in the outer circumference thereof a convex portion 52g and a nozzle recess 52h similar to those in Embodiment 1. A nozzle portion 59 is formed between the nozzle tube section 352a and the inlet hole 351c.

[0083] The pressure receiving portion 352p zones the nozzle housing hole 351d into a first room 311 and a second room 312, and is housed in the nozzle housing hole 351d movably in the axial direction. In addition, the first room 311 is connected to a second guiding branch 12, and the second room 312 is connected to the exit side of the first evaporator 10. Therefore, a first pressure receiving portion 352g which is the end face of the pressure receiving portion 352p in the first direction (the arrow R direction) receives the pressure of the intermediate pressure refrigerant on the exit side of the expansion valve 3, and a second pressure receiving portion 352f which is the end face of the pressure receiving portion 352p in the second direction (the direction opposite the arrow R direction) receives the pressure of the lower pressure refrigerant on the exit side of the first evaporator 10.

[0084] The moving device 300 includes a first spring 301 which presses the pressure receiving portion 352p of the nozzle inside member 352 in the second direction (the direction opposite the arrow R direction) and a second spring 302 which presses the pressure receiving portion 352p in the first direction (the arrow R direction). The second spring 302 is a metal permanent-press spring having a property that is proportional to the refrigerant temperature on the exit side of the first evaporator 10 in a previously set temperature or above, and the spring constant lowers as this refrigerant temperature increases.

[0085] As the first spring 301, a spring having a spring force, which presses the nozzle inside member 352 in the second direction when the spring constant of the second spring 302 becomes a relatively low condition, disposes the nozzle inside member 352 in a position where the inlet length L becomes a length of about 3D, and disposes the nozzle inside member 352 in a position where the inlet length L becomes about 0 in a state in which the spring constant of the second spring 302 is relatively high, is used.

[0086] A spring receiver 303 in which the second

spring 302 is provided has on the outer circumference thereof a male spring engaged with a female spring formed in the inner circumference of the nozzle housing hole 351d. By moving the spring receiver 303 in the axial direction by rotating about the shaft center, the initial feature based on the balancing of both springs 301, 302 can be set.

[0087] Consequently, in the jet pump ZP3, as the pressure difference between the refrigerant pressure on the exit side of the expansion valve 3 and the increased refrigerant pressure on the exit side of the first evaporator 10 is reduced, the reaction force to the pressing force of the first spring 301 is reduced, and the nozzle inside member 352 is moved in the second direction in which the inlet length L1 is increased.

[0088] The air conditioner AC for a vehicle having the jet pump ZP3 of Embodiment 3 operates as follows according to air conditioning load.

[0089] When the air conditioning load is low, the refrigerant flow volume is reduced in the air conditioner AC for a vehicle. In this case, the refrigerant flow volume passing through both evaporators 10, 20 is small, causing variation in a temperature distribution; thus, local freezing easily occurs.

[0090] On the other hand, in Embodiment 1, when the refrigerant flow volume is small, the pressure difference between the refrigerant pressure on the exit side of the first evaporator 10 and the refrigerant pressure on the exit side of the expansion valve 3 is reduced. For this reason, in the jet pump ZP3, the nozzle inside member 352 is disposed in the second direction, and the inlet length L is increased.

[0091] Accordingly, the suction power by the jet pump ZP3 is increased to increase the refrigerant flow volume, and the temperature distribution in each evaporator 10, 20 is improved, enabling effective cooling.

[0092] On the other hand, when the air conditioning load is high, the refrigerant temperature on the exit side of the first evaporator 10 is increased in the air conditioner AC for a vehicle.

[0093] For this reason, in the jet pump ZP3, the refrigerant temperature of the second room 312 is increased, and the spring constant of the second spring 302 is lowered. Accordingly, in the jet pump ZP, the nozzle inside member 352 is moved in the second direction, so that the inlet length L1 is increased.

[0094] In the jet pump ZP3, the suction power is thereby increased to increase the refrigerant flow volume, and the cooling performance in high load can be ensured.

[0095] As described above, in the jet pump ZP3 of Embodiment 3, the suction power feature of the jet pump ZP3 can be varied according to the air conditioning load condition of the air conditioner AC for a vehicle, enabling effective cooling.

[0096] Moreover, the moving device 300 which operates according to such an air conditioning load does not use an electric drive temperature sensor, an actuator and a controller which drives these. In particular, the nozzle

inside member 352 includes the pressure receiving portion 352p which receives the refrigerant pressure on the exit side of the first evaporator 10 and the refrigerant pressure on the exit side of the expansion valve, and the second spring 302 which presses the nozzle inside member 352 in the axial direction includes a permanent-pressure spring which senses the refrigerant temperature on the exit side of the first evaporator 10.

[0097] Consequently, compared to a device using an electric drive temperature sensor, an actuator and a controller, the device can be downsized with low costs.

[0098] In Embodiment 3, since the convex portion 52g which has contact with the inner circumference of the inlet hole 351c is provided in the leading end portion of the nozzle inside member 352, even if the nozzle inside member 352 moves in the axial direction, the shaft center position of the nozzle inside member 352 can conform to the shaft center position of the nozzle outside member 351, the area of the nozzle hole 51h can be constantly maintained, and the stable suction operation can be obtained.

[0099] Although the embodiments of the present invention have been described above, the present invention is not limited thereto. It should be appreciated that variations may be made in the embodiments described by persons skilled in the art without departing from the scope of the present invention.

[0100] In Embodiments 1-3, the example in which the jet pump is applied to the air conditioner for a vehicle is illustrated, but the jet pump can be applied to an air conditioner in addition to one in a vehicle.

[0101] As a nozzle portion, the nozzle portion 59 in which the convex portions 52g and the nozzle recesses 52h are alternately formed in a spline form is illustrated, but the nozzle portion is not limited thereto. The convex portions 52g and the nozzle recesses 52h can be formed in the entire circumference of the outer circumference of the leading end of the nozzle member. Moreover, the size of the convex portion 52a and the nozzle recesses 52h in the circumferential direction is not limited to the size illustrated in the embodiments. As a device which controls the movement of the leading end portion of the nozzle inside member 52 in the radial direction, the convex portion 52g extending in the axial direction is illustrated, but it is not limited thereto. A simple projection can be used instead.

[0102] In Embodiment 3, the movement device 300 using the first spring 301 and the second spring 302 is illustrated, but as a device which moves a nozzle member in the axial direction, it is not limited to such a device using the springs. A device which moves the nozzle member is used such that the inlet length L becomes close to 3D when the refrigerant temperature on the exit side of the first evaporator is high by driving an actuator with the output from a controller based on detection values of a temperature sensor and a pressure sensor and when the pressure difference on the exit side of the first evaporator and on the exit side of the evaluation valve is small.

[0103] In the embodiments, the pump main body formed by two members of the nozzle outside member and the nozzle inside member is illustrated, but the pump main body can be formed by one member. Namely, the jet pump can be manufactured by providing the discharge outlet, the diffuser and the suction hole from one end or both ends in the axial direction relative to the pump main body, and providing the nozzle portion in the middle of the diffuser, and connecting the nozzle portion and the high pressure refrigerant path.

Claims

1. A jet pump, comprising:

a discharge outlet (51a) configured to discharge refrigerant in which relatively high pressure refrigerant and relatively low pressure refrigerant are mixed;

a diffuser (55) disposed coaxially with the discharge outlet, the diffuser including an inside diameter which gradually reduces in size away from the discharge outlet;

a suction hole (52e) following from a minimum diameter portion of the diffuser in an upstream side of the minimum diameter portion, disposed coaxially with the discharge outlet, and to which the lower pressure refrigerant is guided;

a high pressure refrigerant path (53) configured to guide the high pressure refrigerant to the diffuser; and

a nozzle portion (59) configured to eject the high pressure refrigerant from the high pressure refrigerant path into the diffuser in a downstream side of the minimum diameter portion.

2. The jet pump according to Claim 1, comprising:

a tubular nozzle outside member (51) and a tubular nozzle inside member (52) disposed inside the nozzle outside member in a radial direction, wherein

the discharge outlet (51a) is formed in one end portion of the nozzle outside member,

the suction hole (52e) is formed in the nozzle inside member, and

each of the high pressure refrigerant path (53) and the nozzle portion (59) is formed between the nozzle outside member (51) and the nozzle inside member (52).

3. The jet pump according to Claim 2, wherein the nozzle inside member (52) includes a nozzle tube section (52a), and the nozzle portion (59) is formed between the nozzle tube section and the nozzle outside member.

4. The jet pump according to Claim 3, wherein the nozzle portion (59) includes a plurality of nozzle recesses (52h) disposed in a circumferential direction of the nozzle inside member.

5. The jet pump according to Claim 4, wherein the nozzle portion (59) includes a convex portion (52g) which has contact with an inner circumference of the nozzle outside member and extends in a longitudinal direction of the nozzle tube section, the nozzle recesses and the convex portion are alternately disposed in an outer circumferential face of the nozzle tube section in a circumferential direction, and

the nozzle recesses extend in an axial direction of the diffuser.

6. The jet pump according to Claim 2, wherein the diffuser (55) includes a first diffuser (51b) formed in an inner face of the one end portion of the nozzle outside member and a second diffuser (52c) formed in an inner circumferential portion of a leading end of the nozzle inside member on the discharge outlet side, the second diffuser including a diameter which gradually reduces toward the suction hole from an opening of a leading end.

7. The jet pump according to Claim 6, wherein the nozzle portion (59) ejects the high pressure refrigerant into the diffuser between the first diffuser (51b) and the second diffuser (52c).

8. The jet pump according to Claim 6, wherein the nozzle inside member (52) includes a nozzle tube section (52a), and the nozzle portion is formed between the nozzle tube section and the nozzle outside member, and the second diffuser is formed in an inner circumferential face of the nozzle tube section.

9. The jet pump according to Claim 6, wherein the nozzle inside member includes a nozzle tube section (52a), and the nozzle portion is formed between the nozzle tube section and the nozzle outside member, the nozzle outside member includes a tube insertion hole connected to a minimum diameter portion of the first diffuser, and the nozzle tube section is inserted into the tube insertion hole, and the nozzle portion is formed between the nozzle tube section and an inner circumference of the tube insertion hole.

10. The jet pump according to Claim 6, wherein an angle of an inner circumference of the second diffuser (52c) relative to an axis of the diffuser is the same as an angle of an inner circumference of the first diffuser (51b) relative to an axis of the diffuser.

11. The jet pump according to Claim 1, wherein the diffuser includes in a position on the discharge outlet side of the nozzle portion an inlet portion (56) having a constant inside diameter in an axial direction. 5
12. The jet pump according to Claim 11, wherein a length L1 of the inlet portion (56) in the axial direction satisfies a relationship of $L1 \leq 3D$ where a diameter of the suction hole is D. 10
13. An air conditioner having the jet pump according to Claim 1 disposed in a downstream side of an expansion valve (3) in a refrigerating cycle having a compressor (1), a condenser (2), the expansion valve, and an evaporator (10, 20), comprising 15
a first evaporator (10) and a second evaporator (20) as the evaporator,
wherein refrigerant which has passed through the expansion valve is branched into a first guiding 20
branch (11) and a second guiding branch (12),
the first guiding branch is connected to an entrance side of the first evaporator via a capillary (4),
an exit side of the first evaporator is connected to 25
the suction hole of the jet pump,
the second guiding branch is connected to the high pressure refrigerant path of the jet pump,
the discharge outlet is connected to an entrance side of the second evaporator,
an exit side of the second evaporator is connected 30
to an entrance side of the compressor, and
the refrigerant which has passed through the first evaporator is sucked into the diffuser from the suction hole by a driving flow formed by ejecting of the refrigerant which has passed through the expansion 35
valve into the diffuser from the nozzle portion.

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FIG.3

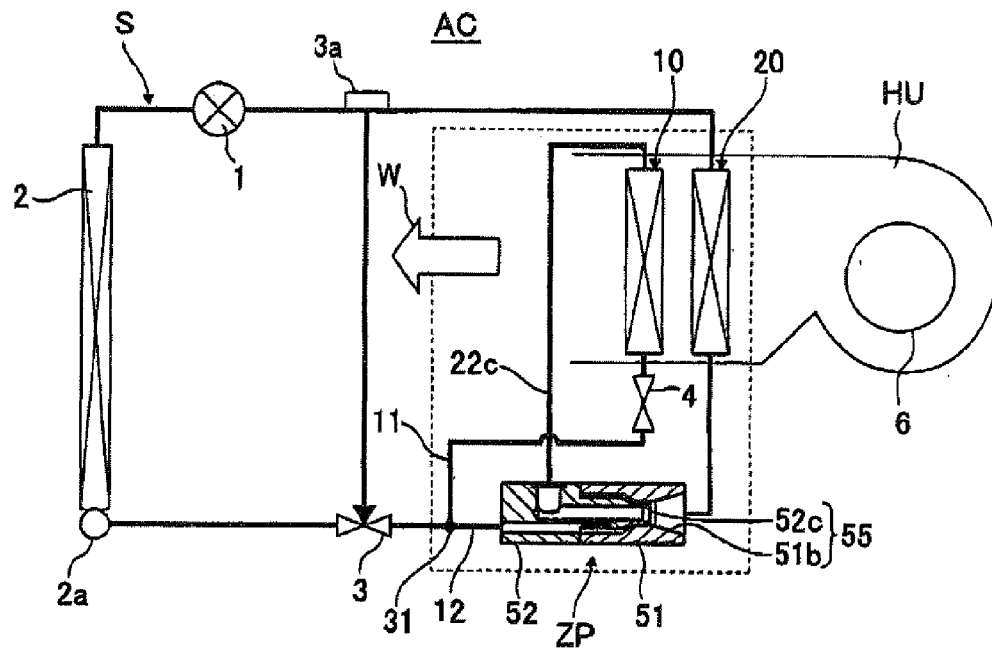


FIG.4

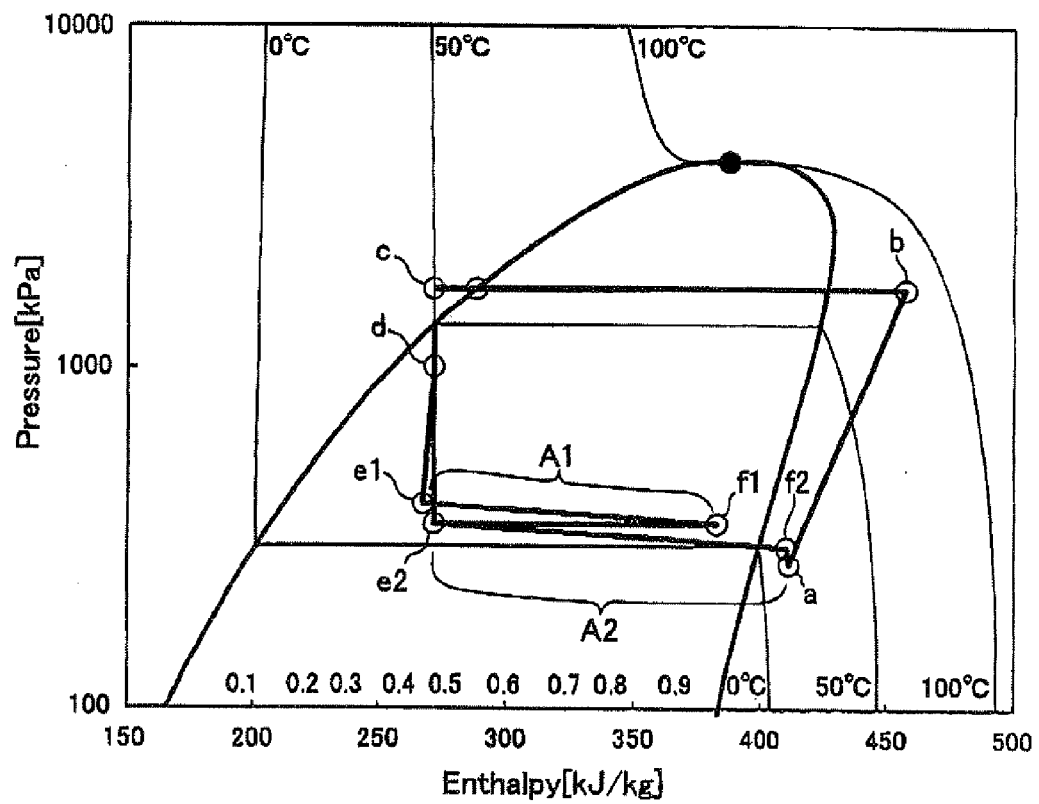


FIG.5

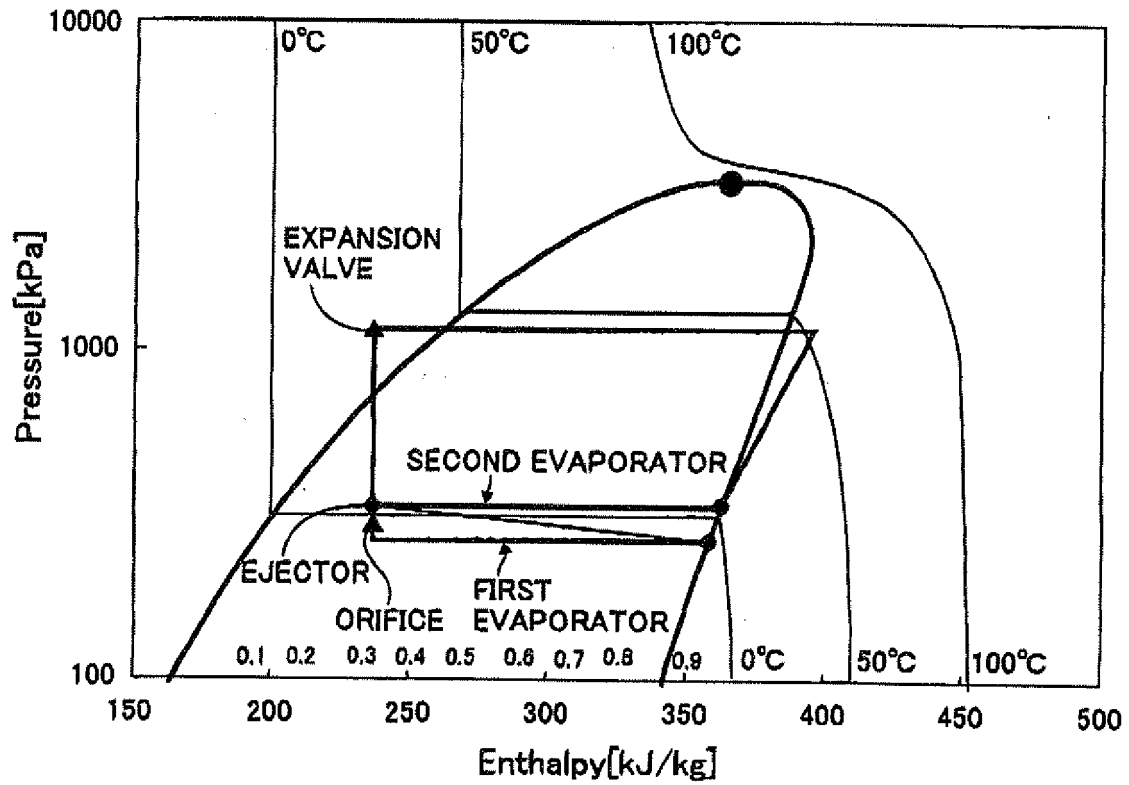


FIG.6

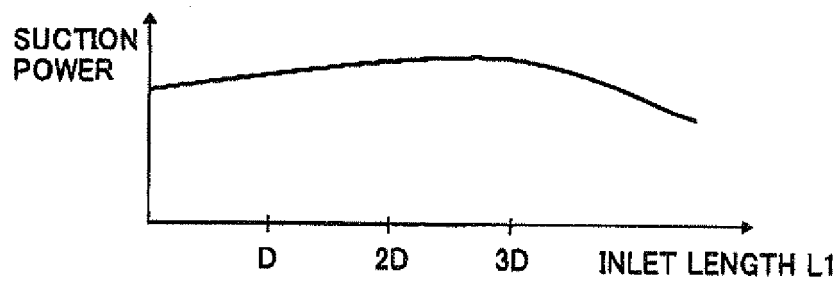


FIG. 7

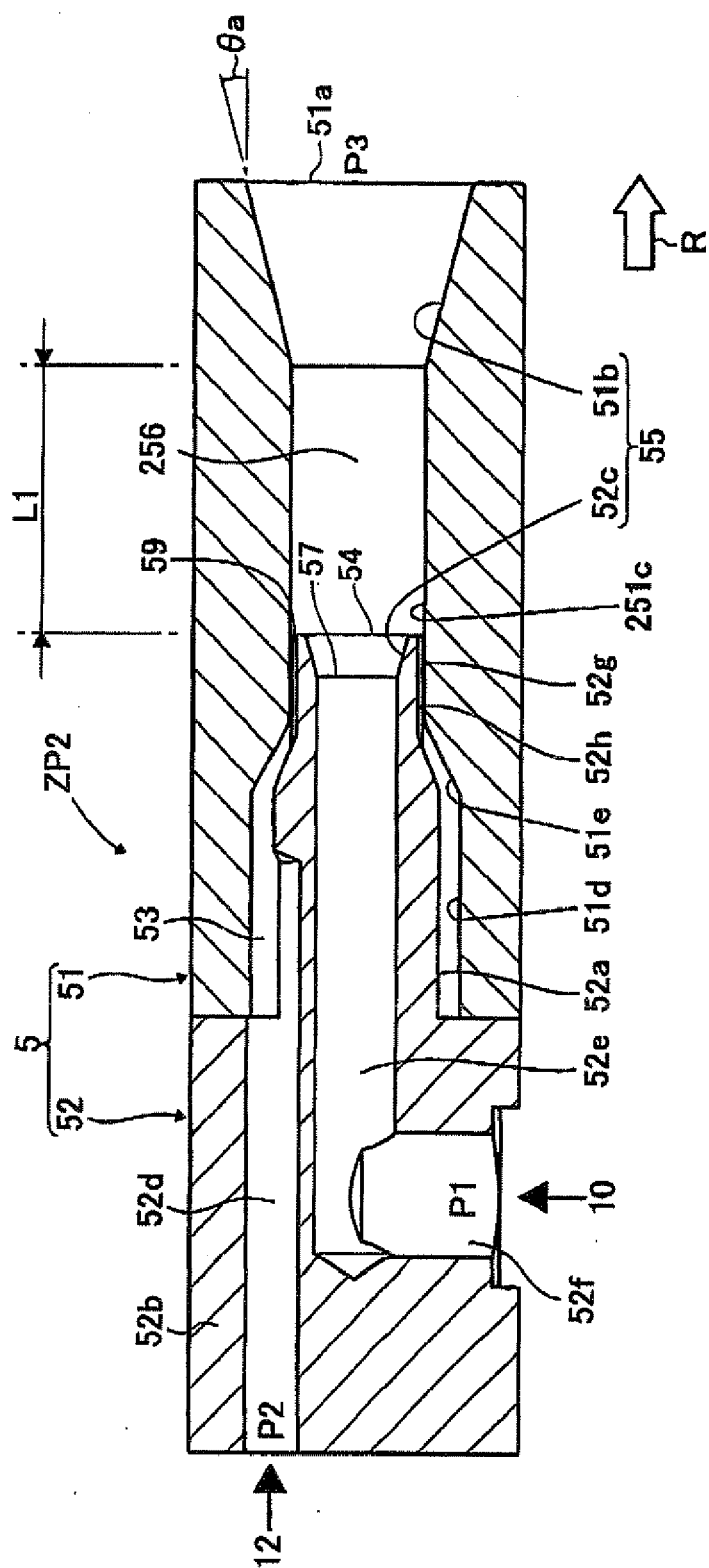
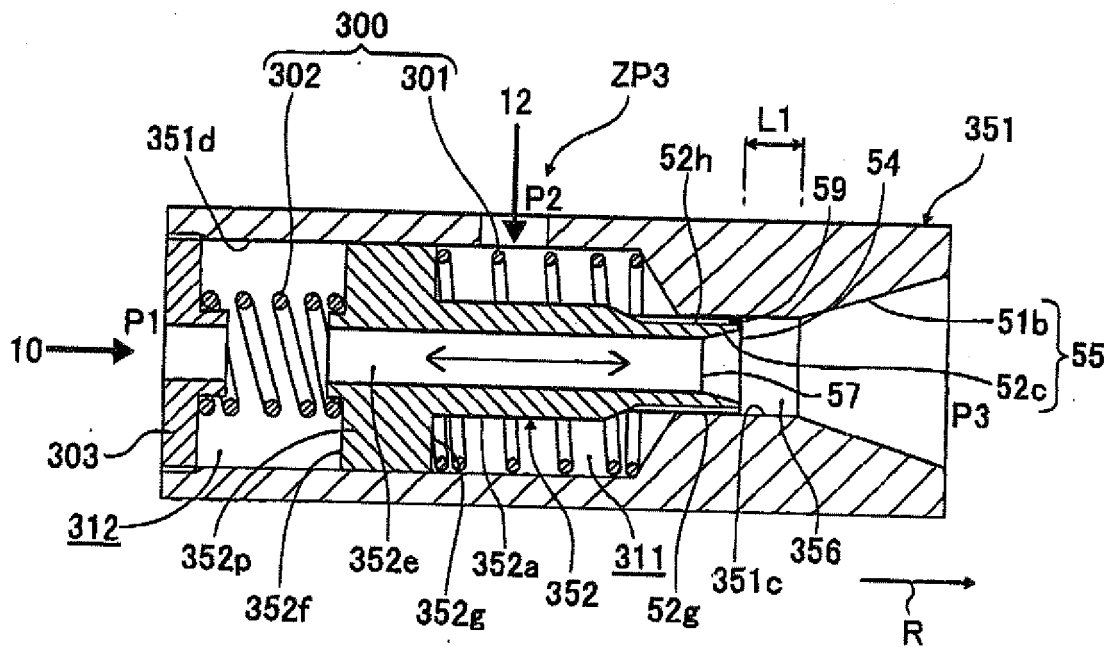


FIG.8



REFERENCES CITED IN THE DESCRIPTION

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