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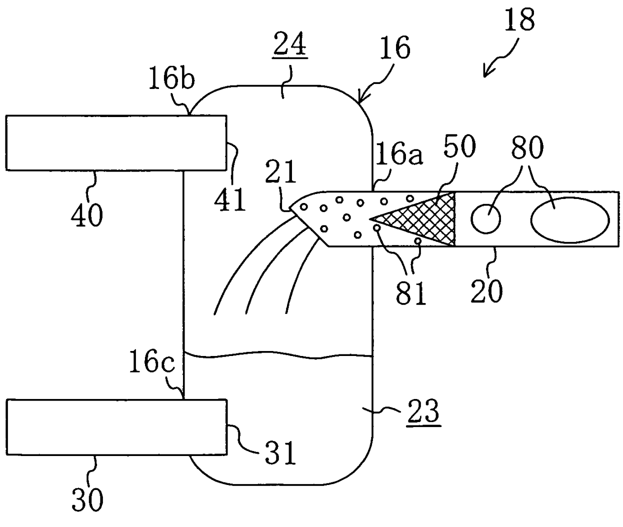
(54) **GAS-LIQUID SEPARATOR AND REFRIGERATION DEVICE WITH THE GAS-LIQUID SEPARATOR**

(57) A refrigeration system includes a refrigerant circuit including a gas-liquid separator (**18**) and operating in a two-stage compression and two-stage expansion refrigeration cycle. In the refrigerant circuit, intermediate-pressure gas-liquid two-phase refrigerant having flowed through an intermediate expansion valve after flowing through an outdoor heat exchanger is introduced through an inflow pipe (**20**) of the gas-liquid separator (**18**) into the vessel body (**16**) thereof and separated therein into liquid refrigerant and gas refrigerant. The liquid refrigerant flows out through a liquid outflow pipe (**30**), then flows through a main expansion valve and then through a refrigeration heat exchanger and is then sucked into a low-pressure stage compressor. The gas refrigerant flows out through a gas outflow pipe (**40**), is then fed to the suction side of a high-pressure stage compressor and is then sucked into the high-pressure stage compressor together with refrigerant discharged from the low-pressure stage compressor. The inflow pipe (**20**) is provided with a mesh member (**50**) for fragmentizing gas bubbles (**80**) of gas refrigerant in the gas-liquid two-phase refrigerant.

FIG. 2



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Description

Technical Field

[0001] This invention relates to gas-liquid separators for separating gas-liquid two-phase fluid into liquid fluid and gaseous fluid and refrigeration systems including a refrigerant circuit with such a gas-liquid separator.

Background Art

[0002] Conventional refrigeration systems include those including a refrigerant circuit operating in a two-stage compression and two-stage expansion refrigeration cycle. Furthermore, among such refrigeration systems include those including a gas-liquid separator for separating gas-liquid two-phase fluid into liquid fluid and gaseous fluid (see, for example, Patent Document 1).

[0003] The refrigeration system disclosed in the above Patent Document 1 is an air conditioning system including a refrigerant circuit operating in a two-stage compression and two-stage expansion refrigeration cycle during a heating operation. The refrigerant circuit is provided with a gas-liquid separator for separating gas-liquid two-phase refrigerant into gas refrigerant and liquid refrigerant. During a heating operation in a two-stage compression and two-stage expansion refrigeration cycle, refrigerant discharged from a high-pressure stage compressor condenses in an indoor heat exchanger to heat room air. The condensed refrigerant passes through an intermediate expansion valve to reach an intermediate-pressure, gas-liquid two-phase state, is then introduced into the gas-liquid separator and is separated therein into gas refrigerant and liquid refrigerant. The liquid refrigerant flows out of the gas-liquid separator, is then reduced to a low pressure by an outdoor expansion valve to expand, and then evaporates in an outdoor heat exchanger. The evaporated refrigerant is sucked into a low-pressure stage compressor and compressed therein into intermediate-pressure discharge refrigerant. Then, the intermediate-pressure discharge refrigerant is joined with gas refrigerant coming from the gas-liquid separator and the refrigerant mixture is sucked into the high-pressure stage compressor and compressed therein to a high pressure.

[0004] The gas-liquid separator includes, as specifically shown in Figure **8**, a cylindrical vessel body (**a**). The vessel body (**a**) is connected at its top to an inflow pipe (**b**), a liquid outflow pipe (**c**) and a gas outflow pipe (**d**) that pass through the top. The interior of the vessel body (**a**) is divided into a liquid refrigerant pool (**e**) located in an upper side thereof and a gas refrigerant pool (**f**) located in a lower side thereof. Furthermore, an opening end of the liquid outflow pipe (**c**) is located in the liquid refrigerant pool (**e**), an opening end of the gas outflow pipe (**d**) is located in the gas refrigerant pool (**f**) and an opening end of the inflow pipe (**b**) is located at a height between the opening end of the liquid outflow pipe (**c**) and the opening end of the gas outflow pipe (**d**).

[0005] Another example of the gas-liquid separator is shown in Figure **9**. In the gas-liquid separator, a gas outflow pipe (**d**) is connected to the top of a vertically long vessel body (**a**) to pass through the top. An inflow pipe is connected to an upper part of the peripheral wall of the vessel body (**a**) to pass through it. Furthermore, a liquid outflow pipe is connected to a lower part of the peripheral wall of the vessel body (**a**) to pass through it.

Patent Document 1: Published Japanese Patent Application No. 2001-235245

Disclosure of the Invention

Problems to Be Solved by the Invention

[0006] In the gas-liquid separator described in the above Patent Document 1, refrigerant flowing through the inflow pipe (**b**) is gas-liquid two-phase refrigerant and, therefore, may cause a slug flow in which large gas bubbles of gas refrigerant and masses of liquid refrigerant irregularly flow. If such a slug flow is introduced through the inflow pipe (b) into the vessel body (**a**), a problem arises that the liquid level of the liquid refrigerant pool (**e**) is disturbed and the disturbance of the liquid level incurs spattering of the liquid refrigerant, resulting in mixing of the liquid refrigerant into gas refrigerant flowing out of the vessel body (**a**) and through the gas outflow pipe (**d**). In addition, another problem arises that gas bubbles are mixed into the liquid refrigerant pool (**e**) and, therefore, gas refrigerant is mixed into liquid refrigerant flowing out of the vessel body (**a**) and through the liquid outflow pipe (**c**).

[0007] Furthermore, in the gas-liquid separator shown in Figure **9**, the vessel body (**a**) is vertically long and the opening end of the inflow pipe (**b**) is close to opposite part of the inside wall of the vessel body (**a**). Therefore, if large gas bubbles in a slug flow flow through the inflow pipe (**b**) so that refrigerant therein temporarily reaches a high flow rate, the gas-liquid two-phase refrigerant having flowed through the inflow pipe (**b**) into the vessel body (**a**) hits the inside wall of the vessel body (**a**) and spatters, as shown in the arrows in Figure 9. This causes a problem that spattered refrigerant directly flows out through the gas outflow pipe (**d**). In addition, another problem arises that the spattered refrigerant falls into the liquid refrigerant pool (**e**), thereby disturbing the liquid level and mixing gas bubbles into the liquid refrigerant pool (**e**).

[0008] As seen from the above, the known gas-liquid separators have a problem that if gas-liquid two-phase refrigerant flowing through the inflow pipe forms a slug flow, they deteriorate its performance of separation of the gas-liquid two-phase refrigerant or deteriorate the reliability as a gas-liquid separator. Furthermore, if the gas-liquid separator in a refrigeration system varies its refrigerant separation performance because of flow conditions of gas-liquid two-phase refrigerant, this causes variations in evaporation capacity of the evaporator and variations in condensation capacity of the condenser. As a result, a problem arises that the refrigeration system cannot perform a stable operation.

[0009] The present invention has been made in view of the foregoing points and, therefore, an object thereof is to enhance the refrigerant separation performance of a gas-liquid separator for separating gas-liquid two-phase fluid into gaseous fluid and liquid fluid and stabilize the operation of a refrigeration system including the gas-liquid separator.

Means to Solve the Problems

[0010] A first aspect of the invention is directed to a gas-liquid separator including: a vessel body (**16**) for separating gas-liquid two-phase fluid into liquid fluid and gaseous fluid; an inflow pipe (**20**) through which the gas-liquid two-phase fluid flows into the vessel body (**16**); a liquid outflow pipe (**30**) through which liquid fluid in the vessel body (**16**) flows out of the vessel body (16); and a gas outflow pipe (**40**) through which gaseous fluid in the vessel body (**16**) flows out of the vessel body (16). Furthermore, the inflow pipe (**20**) is provided with a fragmentation device (**50**) for fragmentizing gas bubbles in the gas-liquid two-phase fluid.

[0011] In the first aspect of the invention, since the inflow pipe (**20**) is provided with a fragmentation device (**50**), even if gas-liquid two-phase fluid flowing through the inflow pipe (**20**) forms a slug flow, gas bubbles of gaseous fluid are fragmentized to homogenize the gas-liquid two-phase fluid. Thus, the gas-liquid two-phase fluid is introduced in a regular and stable flow condition into the vessel body (**16**).

[0012] On the other hand, in the interior of the vessel body (16), the gas-liquid two-phase fluid is separated into liquid fluid and gaseous fluid. Thus, a pool (**23**) of liquid fluid is formed in a lower side of the interior of the vessel body (**16**), while a pool (**24**) of gaseous fluid is formed in an upper side thereof. Since regularly flowing gas-liquid two-phase fluid is introduced into the vessel body (**16**), this reduces the disturbance of the liquid level of the pool (**23**) of liquid fluid, the spattering of the liquid fluid due to the disturbance and the mixing of gas bubbles into the pool (**23**) of liquid fluid.

[0013] A second aspect of the invention is the gas-liquid separator according to the first aspect of the invention, wherein the fragmentation device (**50**) comprises a mesh member (50).

[0014] In the second aspect of the invention, since the fragmentation device (**50**) comprises a mesh member (**50**), gas bubbles are surely fragmentized and the resistance that gas-liquid two-phase fluid meets on the fragmentation device (**50**) becomes relatively small.

[0015] A third aspect of the invention is the gas-liquid separator according to the first aspect of the invention, wherein an opening end (**21**) of the inflow pipe (**20**) and an opening end (**41**) of the gas outflow pipe (**40**) are placed in an upper part of the vessel body (**16**) and arranged to face each other at opposite sides of the vessel body (**16**), and an opening end (**31**) of the liquid outflow pipe (**30**) is placed in a lower part of the vessel body (**16**).

[0016] In the third aspect of the invention, an opening end (**21**) of the inflow pipe (**20**) and an opening end (**41**) of the gas outflow pipe (**40**) are placed to face each other in an upper part of the vessel body (**16**) and at opposite sides of the vessel body (**16**). Therefore, the opening end (**21**) of the inflow pipe (**20**) is free from being immersed in the pool (**23**) of liquid fluid in a lower part of the vessel body (**16**). As a result, it is prevented that gas-liquid two-phase fluid is directly introduced into the pool (**23**) of liquid fluid to mix gas bubbles into the pool (**23**) of liquid fluid and disturb the liquid level of the pool (**23**).

[0017] Furthermore, the opening end (**21**) of the inflow pipe (**20**) is prevented from being close to opposite part of the inside wall of the vessel body (**16**). This reduces the likelihood of hitting of gas-liquid two-phase fluid having flowed into the vessel body (**16**) through the inflow pipe (**20**) against the inside wall of the vessel body (**16**) and in turn the likelihood of the resultant spattering of the gas-liquid two-phase fluid. Furthermore, since the opening end (**41**) of the gas outflow pipe (**40**) is placed a certain distance away from the opening end (**21**) of the inflow pipe (**20**) in the vessel body (**16**), gas-liquid two-phase fluid flowing through the inflow pipe (**20**) into the vessel body (**16**) is free from directly flowing out through the opening end (**41**) of the gas outflow pipe (**40**). Furthermore, the opening end (**31**) of the liquid outflow pipe (**30**) is placed in the pool (**23**) of liquid fluid in a lower part of the interior of the vessel body (**16**).

[0018] A ninth aspect of the invention is directed to a gas-liquid separator including: a vessel body (**16**) for separating gas-liquid two-phase fluid into liquid fluid and gaseous fluid; an inflow pipe (**20**) through which the gas-liquid two-phase fluid flows into the vessel body (**16**); a liquid outflow pipe (**30**) through which liquid fluid in the vessel body (**16**) flows out of the vessel body (**16**); and a gas outflow pipe (**40**) through which gaseous fluid in the vessel body (**16**) flows out of the vessel body (**16**). Furthermore, the vessel body (**16**) is formed to have a longer horizontal dimension than the vertical dimension. On the other hand, an opening end (**21**) of the inflow pipe (**20**) and an opening end (**41**) of the gas outflow pipe (**40**) are placed in an upper part of the vessel body (**16**) and arranged to face each other at longitudinally opposite sides of the vessel body (**16**). Furthermore, an opening end (**31**) of the liquid outflow pipe (**30**) is placed in a lower part of the vessel body (16).

[0019] In the ninth aspect of the invention, an opening end (**21**) of the inflow pipe (**20**) and an opening end (**41**) of the gas outflow pipe (**40**) are placed in an upper part of the vessel body (**16**) and arranged to face each other at longitudinally opposite sides of the vessel body (**16**). Therefore, the distance between the opening end (**21**) of the inflow pipe (**20**) and the opposite part of the inside wall of the vessel body (**16**) becomes long. Thus, gas-liquid two-phase fluid flowing through the inflow pipe (**20**) into the vessel body (**16**) is surely prevented from hitting the inside wall of the vessel body (**16**) and thereby spattering. This prevents not only disturbance of the liquid level of a pool (**23**) of liquid fluid in a lower side of the interior of the vessel body (**16**) and mixing of gas bubbles into the pool (**23**), but also prevents that fluid spattered by the hitting flows out through the gas outflow pipe (**40**).

[0020] Furthermore, since the opening end (**41**) of the gas outflow pipe (**40**) is surely spaced apart from the opening end (**21**) of the inflow pipe (**20**), gas-liquid two-phase fluid flowing through the inflow pipe (**20**) into the vessel body (**16**) is prevented from directly flowing out through the opening end (**41**) of the gas outflow pipe (**40**).

[0021] A fourth aspect of the invention is the gas-liquid separator according to the first aspect of the invention, wherein the vessel body (**16**) is installed so that the under surface (**16d**) thereof inclines downward towards a point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**).

[0022] Furthermore, a tenth aspect of the invention is the gas-liquid separator according to the ninth aspect of the invention, wherein the vessel body (**16**) is installed so that the under surface (**16d**) thereof inclines downward towards a point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**).

[0023] In the fourth and tenth aspects of the invention, the under surface (**16d**) of the vessel body (**16**) means a surface located on the under side of the vessel body (**16**) and includes not only a flat surface but also, for example, a curved surface portion formed continuously with the other surface portions of the vessel body (**16**). According to the fourth and tenth aspects of the invention, even if the amount of liquid fluid in the vessel body (**16**) is small, the vessel body (**16**) surely has a pool of liquid fluid around the opening end (**31**) of the liquid outflow pipe (**30**) and thereby allows the liquid fluid to flow out through the liquid outflow pipe (**30**).

[0024] A fifth aspect of the invention is the gas-liquid separator according to the first aspect of the invention, wherein the inflow pipe (**20**) is horizontally extended to the interior of the vessel body (**16**) and the opening end (**21**) of the inflow pipe (**20**) opens obliquely downward.

[0025] An eleventh aspect of the invention is the gas-liquid separator according to the ninth aspect of the invention, wherein the inflow pipe (**20**) is horizontally extended to the interior of the vessel body (**16**) and the opening end (**21**) of the inflow pipe (**20**) opens obliquely downward.

[0026] In the fifth and eleventh aspects of the invention, since the opening end (**21**) of the inflow pipe (**20**) opens obliquely downward, gas-liquid two-phase fluid is free from hitting the inside wall of the vessel body (**16**) and thereby spattering. In addition, since the gas-liquid two-phase fluid falls more gently to the liquid level of liquid fluid in the vessel body (**16**) than the case of vertically falling, this reduces the disturbance of the liquid level of the pool (**23**) of liquid fluid and the mixing of gas bubbles into the pool (**23**) of liquid fluid.

[0027] A sixth aspect of the invention is the gas-liquid separator according to the first aspect of the invention, wherein the inflow pipe (**20**) is installed to horizontally extend.

[0028] A twelfth aspect of the invention is the gas-liquid separator according to the ninth aspect of the invention, wherein the inflow pipe (**20**) is installed to horizontally extend.

[0029] In the sixth and twelfth aspects of the invention, the inflow pipe (**20**) is installed to horizontally extend. Therefore, even if gas-liquid two-phase fluid forms a slug flow, large bubble masses of gaseous fluid in the slug flow are likely to be broken.

[0030] A seventh aspect of the invention is the gas-liquid separator according to the third aspect of the invention, wherein the opening end (**41**) of the gas outflow pipe (**40**) is placed above the opening end (**21**) of the inflow pipe (**20**).

[0031] A thirteenth aspect of the invention is the gas-liquid separator according to the ninth aspect of the invention, wherein the opening end (**41**) of the gas outflow pipe (**40**) is placed above the opening end (**21**) of the inflow pipe (**20**).

[0032] In the seventh and thirteenth aspects of the invention, since the opening end (**41**) of the gas outflow pipe (**40**) is placed above the opening end (**21**) of the inflow pipe (**20**), gas-liquid two-phase fluid having flowed through the inflow pipe (**20**) into the vessel body (**16**) is free from falling towards the opening end (**41**) of the gas outflow pipe (**40**) and directly flowing out through it.

[0033] An eighth aspect of the invention is a refrigeration system including a refrigerant circuit (**10**) including the gas-liquid separator (**18**) according to the first aspect of the invention. Furthermore, a fourteenth aspect of the invention is a refrigeration system including a refrigerant circuit (**10**) including the gas-liquid separator (**18**) according to the ninth aspect of the invention.

[0034] In the eighth and fourteenth aspects of the invention, the refrigerant circuit (10) is configured so that a first expansion mechanism (**17**), an evaporator (**13**), a low-pressure stage compressor (**11**), a high-pressure stage compressor (**12**), a condenser (**14**) and a second expansion mechanism (**15**) are connected in this order therein to operate in a two-stage compression and two-stage expansion refrigeration cycle. Furthermore, the inflow pipe (**20**) of the gas-liquid separator (**18**) is connected to the downstream side of the second expansion valve (**15**) so that gas-liquid two-phase refrigerant flowing through the condenser (**14**) and then reduced to an intermediate pressure in the second expansion mechanism (**15**) flows into the vessel body (**16**) of the gas-liquid separator (**18**). Furthermore, the liquid outflow pipe (**30**) of the gas-liquid separator (**18**) is connected to the upstream side of the first expansion mechanism (**17**) so that liquid refrigerant separated by the gas-liquid separator (**18**) is fed to the first expansion mechanism (**17**). In addition, the gas outflow pipe (**40**) of the gas-liquid separator (**18**) is connected to the suction side of the high-pressure stage compressor (**12**) so that gas refrigerant separated by the gas-liquid separator (**18**) is fed to the suction side of the high-pressure stage compressor (**12**).

[0035] In the eighth and fourteenth aspects of the invention, since the refrigerant circuit (**10**) including the gas-liquid separator (**18**) according to the first or ninth aspect of the invention operates in a two-stage compression and two-stage expansion refrigeration cycle, gas-liquid two-phase refrigerant reduced to an intermediate pressure by the second expansion mechanism (**15**) is surely separated into liquid refrigerant and gas refrigerant by the gas-liquid separator (**18**). As a result, gas refrigerant to be fed to the suction side of the high-pressure stage compressor (**12**) is prevented from mixing-in of liquid refrigerant and liquid refrigerant to be fed through the first expansion mechanism (**17**) to the evaporator (**13**) is prevented from mixing-in of gas refrigerant. Thus, the evaporation capacity of the evaporator (**13**) and the condensation capacity of the condenser (**14**) are stabilized, thereby stabilizing the operation of the system.

Effects of the Invention

[0036] According to the first aspect of the invention, since the inflow pipe (**20**) is provided with a fragmentation device (**50**), even if gas-liquid two-phase fluid flowing through the inflow pipe (**20**) forms a slug flow, large gas bubbles of gaseous fluid can be fragmentized to homogenize the gas-liquid two-phase fluid. As a result, the gas-liquid two-phase fluid can be introduced in a regular and stable flow condition into the vessel body (**16**).

[0037] On the other hand, in the interior of the vessel body (**16**), the gas-liquid two-phase fluid is separated into liquid fluid and gaseous fluid. Thus, a pool (**23**) of liquid fluid is formed in a lower side of the interior of the vessel body (**16**), while a pool (**24**) of gaseous fluid is formed in an upper side thereof. Since gas-liquid two-phase fluid is introduced in a regular flow condition into the vessel body (**16**), this reduces the disturbance of the liquid level of the pool (**23**) of liquid fluid, the spattering of the liquid fluid due to the disturbance and the mixing of gas bubbles into the pool (**23**) of liquid fluid. Thus, liquid fluid flowing from the pool (**23**) of liquid fluid to the liquid outflow pipe (**30**) can be prevented from mixing-in of gas refrigerant and gaseous fluid flowing from the pool (**24**) of gaseous fluid to the gas outflow pipe (**40**) can be prevented from mixing-in of liquid fluid. Therefore, the gas-liquid separation performance can be enhanced.

[0038] According to the second aspect of the invention, since the fragmentation device (**50**) comprises a mesh member (**50**), gas bubbles can surely be fragmentized and the resistance that gas-liquid two-phase fluid meets on the fragmentation device (**50**) can be relatively small. Thus, the gas-liquid two-phase fluid flowing into the vessel body (**16**) reaches a further regular and stable flow condition.

[0039] According to the third aspect of the invention, since the opening end (**21**) of the inflow pipe (**20**) and the opening end (**41**) of the gas outflow pipe (**40**) are placed to face each other in an upper part of the vessel body (**16**) and at opposite sides of the vessel body (**16**), gas-liquid two-phase fluid can be prevented from being directly introduced from the opening end (**21**) of the inflow pipe (**20**) to the pool (**23**) of liquid fluid in a lower part of the vessel body (**16**). In addition, gas-liquid two-phase fluid flowing through the opening end (**21**) of the inflow pipe (**20**) into the vessel body (**16**) can be prevented from hitting the inside wall of the vessel body (**16**) and thereby spattering. As a result, it can surely be prevented that gas bubbles are mixed into the pool (**23**) of liquid fluid and that the liquid level of the pool (**23**) gets disturbed.

[0040] Furthermore, since the opening end (**41**) of the gas outflow pipe (**40**) can be placed a certain distance away from the opening end (**21**) of the inflow pipe (**20**) in the vessel body (**16**), gas-liquid two-phase fluid flowing through the inflow pipe (**20**) into the vessel body (**16**) can be prevented from directly flowing out through the opening end (**41**) of the gas outflow pipe (**40**). Thus, liquid fluid flowing from the pool (**23**) of liquid fluid to the liquid outflow pipe (**30**) can surely be prevented from mixing-in of gaseous fluid and gaseous fluid flowing from the pool (**24**) of gaseous fluid to the gas outflow pipe can surely be prevented from mixing-in of liquid fluid.

[0041] According to the ninth aspect of the invention, since the opening end (**21**) of the inflow pipe (**20**) and the opening end (**41**) of the gas outflow pipe (**40**) are placed in an upper part of the vessel body (**16**) and arranged to face each other at longitudinally opposite sides of the vessel body (**16**), the distance between the opening end (**21**) of the inflow pipe (**20**) and the opposite part of the inside wall of the vessel body (**16**) can be long. Thus, gas-liquid two-phase fluid flowing through the inflow pipe (**20**) into the vessel body (**16**) can surely be prevented from hitting the inside wall of the vessel body (**16**) and thereby spattering. Therefore, the pool (**23**) of liquid fluid in a lower side of the interior of the vessel body (**16**) can be prevented from disturbance of its liquid level and mixing-in of gas bubbles. In addition, it can be prevented that fluid spattered by the hitting flows out through the gas outflow pipe (**40**).

[0042] Furthermore, the opening end (**41**) of the gas outflow pipe (**40**) can surely be spaced apart from the opening end (**21**) of the inflow pipe (**20**). Therefore, gas-liquid two-phase fluid flowing through the inflow pipe (**20**) into the vessel body (**16**) can be prevented from directly flowing out through the opening end (**41**) of the gas outflow pipe (**40**). Thus, liquid fluid flowing from the pool (**23**) of liquid fluid to the liquid outflow pipe (**30**) can surely be prevented from mixing-in of gaseous fluid. In addition, gaseous fluid flowing from the pool (**24**) of gaseous fluid to the gas outflow pipe (**40**) can surely be prevented from mixing-in of liquid fluid. As a result, the gas-liquid separation performance can be enhanced.

[0043] According to the fourth and tenth aspects of the invention, since the under surface (**16d**) of the vessel body (**16**) is inclined downward towards a point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**), even if the amount of liquid fluid in the vessel body (**16**) is small, the vessel body (**16**) can surely have a pool of liquid fluid around the opening end (**31**) of the liquid outflow pipe (**30**). This ensures that liquid fluid flows out through the liquid outflow pipe (**30**), and prevents that during the outflow of liquid fluid, gaseous fluid is mixed into the liquid fluid flowing out therethrough.

[0044] According to the fifth and eleventh aspects of the invention, since the inflow pipe (**20**) is horizontally extended to the interior of the vessel body (**16**) and the opening end (**21**) of the inflow pipe (**20**) opens obliquely downward, gas-liquid two-phase fluid can be prevented from hitting the inside wall of the vessel body (**16**) and thereby spattering. In addition, since the gas-liquid two-phase fluid can fall more gently to the liquid level of liquid fluid in the vessel body (**16**) than the case of vertically falling, this reduces the disturbance of the liquid level of the pool (**23**) of liquid fluid and the mixing of gas bubbles into the pool (**23**).

[0045] According to the sixth and twelfth aspects of the invention, since the inflow pipe (**20**) is installed to horizontally extend, even if gas-liquid two-phase fluid forms a slug flow, large bubble masses of gaseous fluid in the slug flow are likely to be broken. As a result, the occurrence of a slug flow can be restrained.

[0046] According to the seventh and thirteenth aspects of the invention, since the opening end (**41**) of the gas outflow pipe (**40**) is placed above the opening end (**21**) of the inflow pipe (**20**), gas-liquid two-phase fluid having flowed through the inflow pipe (**20**) into the vessel body (**16**) can be prevented from falling towards the opening end (**41**) of the gas outflow pipe (**40**) and directly flowing out through it.

[0047] According to the eighth and fourteenth aspects of the invention, since the refrigerant circuit (**10**) including the gas-liquid separator (**18**) according to the first or ninth aspect of the invention operates in a two-stage compression and two-stage expansion refrigeration cycle, gas-liquid two-phase refrigerant reduced to an intermediate pressure by the second expansion mechanism (**15**) can surely be separated into liquid refrigerant and gas refrigerant by the gas-liquid separator (**18**). As a result, gas refrigerant to be fed to the suction side of the high-pressure stage compressor (**12**) can be prevented from mixing-in of liquid refrigerant and liquid refrigerant to be fed through the first expansion mechanism (**17**) to the evaporator (**13**) can be prevented from mixing-in of gas refrigerant. Thus, the evaporation capacity of the evaporator (**13**) and the condensation capacity of the condenser (**14**) are stabilized, thereby stabilizing the operation of the system. Therefore, the reliability of the system can be enhanced.

Brief Description of Drawings

[0048]

[Fig. 1] Figure 1 is a piping diagram of a refrigerant circuit of a refrigeration system according to Embodiment 1.

[Fig. 2] Figure 2 is a longitudinal cross-sectional view of a gas-liquid separator according to Embodiment 1.

[Fig. 3] Figure 3 is a longitudinal cross-sectional view of a gas-liquid separator according to Modification 1 of Embodiment 1.

[Fig. 4] Figure 4 is a longitudinal cross-sectional view of a gas-liquid separator according to Modification 2 of Embodiment 1.

[Fig. 5] Figure 5 is a longitudinal cross-sectional view of a gas-liquid separator according to Embodiment 2.

[Fig. 6] Figure 6 is a longitudinal cross-sectional view of a gas-liquid separator according to Modification 1 of Embodiment 2.

[Fig. 7] Figure 7 is a longitudinal cross-sectional view of a gas-liquid separator according to Modification 2 of Embodiment 2.

[Fig. 8] Figure 8 is a longitudinal cross-sectional view of a known gas-liquid separator.

[Fig. 9] Figure 9 is a longitudinal cross-sectional view of another known gas-liquid separator.

List of Reference Numerals

[0049]

1	refrigeration system
10	refrigerant circuit
11	low-pressure stage compressor
12	high-pressure stage compressor
12	refrigeration heat exchanger (evaporator)
14	outdoor heat exchanger (condenser)
15	main expansion valve (second expansion mechanism)
16	vessel body
16d	under part (under surface)
17	intermediate expansion valve (first expansion mechanism)
18	gas-liquid separator
20	inflow pipe
21	opening end
30	liquid outflow pipe
31	opening end
40	gas outflow pipe
41	opening end
50	mesh member (fragmentation device)

Best Mode for Carrying Out the Invention

[0050] Embodiments of the present invention will be described below in detail with reference to the drawings.

«Embodiment 1 of the Invention»

[0051] As shown in Figure 1, a refrigeration system (**1**) according to this embodiment is used to perform an operation of refrigerating the interior of a storage. The refrigeration system (**1**) includes a refrigerant circuit (**10**) operating in a two-stage compression and two-stage expansion refrigeration cycle.

<Configuration of Refrigerant Circuit>

[0052] The refrigerant circuit (**10**) includes a low-pressure stage compressor (**11**), a high-pressure stage compressor (**12**), a refrigeration heat exchanger (**13**), an outdoor heat exchanger (**14**), a main expansion valve (**17**), an intermediate expansion valve (**15**) and a gas-liquid separator (**18**) as a feature of the present invention.

[0053] The discharge side of the low-pressure stage compressor (**11**) is connected to the suction side of the high-pressure stage compressor (**12**). Each of the low-pressure stage compressor (**11**) and high-pressure stage compressor (**12**) is constituted, for example, by a scroll compressor.

[0054] The refrigeration heat exchanger (**13**) is placed in the storage and configured as an evaporator in which refrigerant can evaporate to cool the interior of the storage. The refrigeration heat exchanger (**13**) is connected at its exit side to the suction side of the low-pressure stage compressor (**11**). The refrigeration heat exchanger (**13**) is constituted, for example, by a fin-and-tube heat exchanger. Furthermore, the refrigeration heat exchanger (**13**) is connected at its entrance side to the exit side of the main expansion valve (**17**). The main expansion valve (**17**) is an electronic expansion valve controllable in opening and is configured as a first expansion mechanism.

[0055] The outdoor heat exchanger (**14**) is placed outside the storage and configured as a condenser in which refrigerant can condense. The outdoor heat exchanger (**14**) is connected at its entrance side to the discharge side of the high-pressure stage compressor (**12**). The outdoor heat exchanger (**14**) is constituted, for example, by a fin-and-tube heat exchanger. Furthermore, the outdoor heat exchanger (**14**) is connected at its exit side to the entrance side of the intermediate expansion valve (**15**). The intermediate expansion valve (**15**) is an electronic expansion valve controllable in opening and is configured as a second expansion mechanism.

[0056] The gas-liquid separator (**18**) includes a vessel body (**16**), an inflow pipe (**20**), a liquid outflow pipe (**30**) and a gas outflow pipe (**40**). The vessel body (**16**) is connected via the inflow pipe (**20**) to the exit side of the intermediate expansion valve (**15**), which is the downstream side thereof, connected via the liquid outflow pipe (**30**) to the entrance side of the main expansion valve (**17**), which is the upstream side thereof, and connected via the gas outflow pipe (**40**) to the suction side of the high-pressure stage compressor (**12**). Thus, the exit side of the intermediate expansion valve (**15**) is connected via the gas-liquid separator (**18**) to the entrance side of the main expansion valve (**17**), which is the upstream side thereof, and the suction side of the high-pressure stage compressor (**12**).

<Configuration of Gas-Liquid Separator>

[0057] Next, the configuration of the gas-liquid separator (**18**) is described in more detail with reference to Figure 2.

[0058] The vessel body (**16**) of the gas-liquid separator (**18**) is formed in an axially long, substantially cylindrical shape and disposed to match its axial direction with the vertical direction. The vessel body (**16**) has a first through hole (**16a**), a second through hole (**16b**) and a third through hole (**16c**) all in the peripheral wall forming the side surface of the cylinder. The first through hole (**16a**) is formed in an upper part of the peripheral wall of the vessel body (**16**), the second through hole (**16b**) is formed on the opposite side of the peripheral wall of the vessel body (**16**) to the first through hole (**16a**) and at a higher point than the first through hole (**16a**), and the third through hole (**16c**) is formed in a lower part of the peripheral wall of the vessel body (**16**). In the interior of the vessel body (**16**), a pool (**23**) of liquid refrigerant is formed in a lower side thereof and a pool (**24**) of gas refrigerant is formed above the pool (**23**) of liquid refrigerant.

[0059] The inflow pipe (**20**) is disposed to horizontally extend over the length thereof. Furthermore, the inflow pipe (**20**) is extended to the interior of the vessel body (**16**) by passing through the first through hole (**16a**) of the vessel body (**16**) and is disposed substantially perpendicularly to the peripheral wall of the vessel body (**16**). The opening end (**21**) of the inflow pipe (**20**) is placed in the vessel body (**16**) closer to part of the peripheral wall having the first through hole (**16a**) than the horizontal center of the vessel body (**16**). Furthermore, the opening end (**21**) of the inflow pipe (**20**) opens obliquely downward at an angle of approximately 45° to the vertical direction.

[0060] The inflow pipe (**20**) is provided with a mesh member (**50**) as a feature of the present invention. Specifically, a through part of the inflow pipe (**20**) at which the inflow pipe (**20**) passes through the first through hole (**16a**) of the vessel body (**16**) is brazed to the vessel body (**16**), and the mesh member (**50**) is placed in the inflow pipe (**20**) in the close vicinity of the through part. The mesh member (**50**) is composed of a wire mesh formed in a hollow conical shape, opening at the bottom of the cone and having the periphery of the cone netted with metal wires. The mesh member (**50**) is disposed so that its cone point is directed to the opening end (**21**). Thus, the inflow pipe (20) is configured so that refrigerant having flowed through the intermediate expansion valve (**15**) flows through the opening at the bottom of the mesh member (**50**) towards the cone point and, during the flow through the mesh member (**50**), passes through the wire mesh at the periphery of the cone.

[0061] The gas outflow pipe (**40**) is extended to the interior of the vessel body (**16**) by passing through the second through hole (**16b**) of the vessel body (**16**) and is disposed substantially perpendicularly to the peripheral wall of the vessel body (**16**). The opening end (**41**) of the gas outflow pipe (**40**) is placed in the vessel body (**16**) closer to part of the peripheral wall having the second through hole (**16b**) than the horizontal center of the vessel body (**16**).

[0062] In this manner, the opening end (**21**) of the inflow pipe (**20**) and the opening end (**41**) of the gas outflow pipe (**40**) are placed in the pool (**24**) of gas refrigerant in an upper part of the vessel body (**16**) and arranged to face each other at opposite sides of the vessel body (**16**). Furthermore, the opening end (**41**) of the gas outflow pipe (**40**) is placed above the opening end (**21**) of the inflow pipe (**20**).

[0063] The liquid outflow pipe (**30**) passes through the third through hole (**16c**) of the vessel body (**16**) and is disposed substantially perpendicularly to the peripheral wall of the vessel body (**16**). The opening end (**31**) of the liquid outflow pipe (**30**) is placed in the pool (**23**) of liquid refrigerant in a lower part of the vessel body (**16**).

- Operational Behavior -

[0064] Next, a description is given of the operational behavior of the refrigeration system (**1**).

[0065] Upon startup of the refrigeration system (**1**), in the refrigerant circuit (**10**), the compressors (**11**, **12**) start to operate, the openings of the expansion valves (**15**, **17**) are appropriately set and refrigerant circulates through the refrigerant circuit (**10**) in a direction of the arrows in Figure 1.

[0066] High-pressure refrigerant discharged from the high-pressure stage compressor (**12**) flows through the outdoor heat exchanger (**14**) and therein releases heat to outdoor air to condense. The condensed refrigerant flows through the intermediate expansion valve (**15**), thereby being reduced to an intermediate pressure into refrigerant in a gas-liquid two-phase state.

[0067] The refrigerant in a gas-liquid two-phase state flows through the inflow pipe (**20**) of the gas-liquid separator (**18**) and passes through the mesh member (**50**). During the passage, gas bubbles in the refrigerant in a gas-liquid two-phase state are fragmentized. In other words, such a case is where, as shown in Figure **2**, gas-liquid two-phase refrigerant in the inflow pipe (**20**) forms a slug flow so that gas bubbles (**80**) formed by large masses of gas refrigerant flow through the inflow pipe (**20**). Even in such a case, gas bubbles (**80**) pass through the mesh member (**50**) and are thereby fragmentized into fine gas bubbles (**81**). As a result, the gas-liquid two-phase refrigerant becomes a homogeneous state in which fine gas bubbles (**81**) are dispersed in liquid refrigerant.

[0068] Then, since the mesh member (**50**) is placed in the vicinity of the opening end (**21**), the gas-liquid two-phase refrigerant is introduced into the interior of the vessel body (**16**) while being kept in its homogeneous state. Particularly, the gas-liquid two-phase refrigerant is introduced into the interior of the vessel body (**16**) to gently fall from the opening end (**21**) opening downward at 45° to the vertical direction towards the pool (**23**) of liquid refrigerant.

[0069] Since the gas-liquid two-phase refrigerant is thus introduced in a stable flow condition into the interior of the vessel body (**16**), this reduces the bubbling of the pool (**23**) of liquid refrigerant and resultant production of gas bubbles and reduces the disturbance of the liquid level of the pool (**23**) of liquid refrigerant and resultant spattering of liquid refrigerant. Then, the gas-liquid two-phase refrigerant introduced in the vessel body (**16**) is separated into liquid refrigerant and gas refrigerant. The gas refrigerant is accumulated in the gas refrigerant pool (**24**) in an upper part of the vessel body (**16**), while the liquid refrigerant is accumulated in the liquid refrigerant pool (**23**) in a lower part of the vessel body (**16**).

[0070] The liquid refrigerant in the vessel body (**16**) then flows through the liquid outflow pipe (**30**), then passes through the main expansion valve (**17**) and is thereby reduced to a low pressure to expand. The expanded refrigerant takes heat from in-storage air during flow through the refrigeration heat exchanger (**13**), thereby evaporating and cooling the in-storage air.

[0071] The evaporated refrigerant is sucked into the low-pressure stage compressor (**11**), compressed therein to an intermediate-pressure and then discharged therefrom. Then, the gas refrigerant in the vessel body (**16**) of the gas-liquid separator (**18**) is fed through the gas outflow pipe (**40**) to the discharged refrigerant of intermediate pressure and the refrigerant mixture is sucked into the high-pressure stage compressor (**11**).

- Effects of Embodiment 1 -

[0072] Since, in the refrigeration system (**1**), a mesh member (**50**) is placed in the inflow pipe (**20**) of the gas-liquid separator (**18**), gas bubbles (**80**) of gas refrigerant in gas-liquid two-phase refrigerant flowing through the inflow pipe (**20**) can surely be fragmentized, whereby the gas-liquid two-phase refrigerant can be homogenized. Thus, the gas-liquid two-phase refrigerant is introduced in a regular and stable flow condition into the vessel body (**16**). This reduces the disturbance of the liquid level of the pool (**23**) of liquid refrigerant, the spattering of liquid refrigerant due to the liquid level disturbance, and the mixing of gas bubbles into liquid refrigerant, such as due to bubbling of the pool (**23**) of liquid refrigerant.

[0073] Furthermore, since the inflow pipe (**20**) is disposed to horizontally extend over the length thereof, large bubble masses of gas refrigerant in the gas-liquid two-phase fluid are likely to be broken, which restrains the production of large gas bubbles (**80**) in advance of the passage of the gas-liquid two-phase fluid through the mesh member (**50**).

[0074] Furthermore, in the gas-liquid separator (**18**), the opening end (**21**) of the inflow pipe (**20**) and the opening end (**41**) of the gas outflow pipe (**40**) are placed in the pool (**24**) of gas refrigerant in an upper part of the vessel body (**16**) and arranged to face each other at opposite sides of the vessel body (**16**). Therefore, the gas-liquid two-phase refrigerant can be prevented from being directly introduced from the opening end (**21**) of the inflow pipe (**20**) to the pool (**23**) of liquid refrigerant and the gas-liquid two-phase refrigerant flowing through the opening end (**21**) of the inflow pipe (**20**) into the vessel body (**16**) can be prevented from hitting the inside wall of the vessel body (**16**) and thereby spattering. Hence, it can be prevented that gas bubbles are mixed into the pool (**23**) of liquid refrigerant and that the liquid level of the pool (**23**) gets disturbed.

[0075] Furthermore, since the opening end (**21**) of the inflow pipe (**20**) opens obliquely downward by bending at approximately 45°, this surely prevents the gas-liquid two-phase refrigerant from hitting the peripheral wall of the vessel body (**16**). Furthermore, since the gas-liquid two-phase refrigerant falls more gently to the liquid level of the pool (**23**) of liquid refrigerant in the vessel body (**16**) than the case of vertically falling, this reduces the disturbance of the liquid level of the pool (**23**) of liquid refrigerant and the bubbling of the pool (**23**) of liquid refrigerant.

[0076] Furthermore, the opening end (**41**) of the gas outflow pipe (**40**) is placed at an opposite side of the vessel body (**16**) to the opening end (**21**) of the inflow pipe (**20**) and above the opening end (**21**) of the inflow pipe (**20**). Therefore, the gas-liquid two-phase refrigerant having flowed through the inflow pipe (**20**) into the vessel body (**16**) can be prevented from directly flowing out through the gas outflow pipe (**40**).

[0077] Furthermore, since the opening end (**31**) of the liquid outflow pipe (**30**) is placed in the pool (**23**) of liquid refrigerant in a lower part of the vessel body (**16**), this prevents that during the outflow of liquid refrigerant through the liquid outflow pipe (**30**), gas refrigerant is mixed into the liquid refrigerant.

[0078] By arranging the pipes (**20**, **30**, **40**) of the gas-liquid separator (**18**) in the above manner, liquid refrigerant flowing from the pool (**23**) of liquid refrigerant to the liquid outflow pipe (**30**) can be prevented from mixing-in of gas refrigerant. In addition, gas refrigerant flowing from the pool (**24**) of gas refrigerant to the gas outflow pipe (**40**) can be prevented from mixing-in of liquid refrigerant. As a result, the gas-liquid separation performance can be enhanced.

[0079] Furthermore, since in the refrigeration system (**1**) the gas-liquid separator (**18**) of the refrigerant circuit (**10**) can be enhanced in gas-liquid separation performance, this stabilizes the evaporation capacity of the refrigeration heat exchanger (**13**) and the condensation capacity of the outdoor heat exchanger (**14**), thereby stabilizing the operation of the refrigeration system (**1**). As a result, the reliability of the refrigeration system (**1**) can be enhanced.

<Modification 1 of Embodiment 1>

[0080] This embodiment has a configuration that, although in Embodiment 1 the inflow pipe (**20**) of the gas-liquid separator (**18**) is composed of a single pipe, the inflow pipe (**20**) is, as shown in Figure **3**, composed of a main pipe part (**20a**), a mesh pipe part (**20b**) and a brazing pipe part (**20c**) instead.

[0081] Specifically, the brazing pipe part (**20c**) is brazed to the first through hole (**16a**) in the vessel body (**16**). The mesh pipe part (**20b**) is formed with a larger pipe diameter than the brazing pipe part (**20c**) and the main pipe part (**20a**) and includes a conically shaped mesh member (**50**) placed therein like Embodiment 1. The main pipe part (**20a**) is connected through the mesh pipe part (**20b**) to the brazing pipe part (**20c**).

[0082] In other words, the main pipe part (**20a**), the mesh pipe part (**20b**) and the brazing pipe part (**20c**) are connected in this order.

[0083] According to this embodiment, since the inflow pipe (**20**) is composed of the three pipe parts (**20a**, **20b**, **20c**), maintenance and replacement of the mesh member (**50**) can be easily performed. Furthermore, although in the mesh pipe part (**20b**) the mesh member (**50**) resists the flow of refrigerant in a gas-liquid two-phase state, the resistance can be reduced by the formation of the mesh pipe part (**20b**) with a slightly larger diameter than the other parts.

[0084] The rests of the configuration and operational behavior and the other effects are the same as in Embodiment 1.

<Modification 2 of Embodiment 1>

[0085] This embodiment has a configuration that, although in Embodiment 1 the vessel body (**16**) of the gas-liquid separator (**18**) is formed in a substantially cylindrical shape, the under surface (**16d**) of the vessel body (**16**) is, as shown in Figure **4**, inclined downward towards a point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**).

[0086] According to this embodiment, since the under surface (**16d**) of the vessel body (**16**) inclines downward towards a point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**), even if the amount of liquid refrigerant in the vessel body (**16**) is small, the vessel body (**16**) can surely have a pool of liquid refrigerant around the opening end (**31**) of the liquid outflow pipe (**30**). As a result, liquid refrigerant can surely flow out through the liquid outflow pipe (**30**). In addition, the opening end (**31**) of the liquid outflow pipe (**30**) is free from being exposed to the gas refrigerant pool (**24**). This prevents gas refrigerant from flowing out through the liquid outflow pipe (**30**).

[0087] The rests of the configuration and operational behavior and the other effects are the same as in Embodiment 1.

[«Embodiment 2 of the Invention»

[0088] This embodiment is, like Embodiment 1, a refrigeration system that includes a refrigerant circuit operating in a two-stage compression and two-stage expansion refrigeration cycle and performs an operation of refrigerating the interior of a storage, but is different from Embodiment 1 only in the configuration of the gas-liquid separator (**18**) in the refrigerant circuit.

[0089] As shown in Figure **5**, in the gas-liquid separator (**18**) of this embodiment, the vessel body (**16**) is formed to have a longer horizontal dimension than the vertical dimension. Furthermore, the inflow pipe (**20**) of the gas-liquid separator (**18**) does not include a mesh member (**50**) serving as a fragmentation device.

[0090] Specifically, the vessel body (**16**) of the gas-liquid separator (**18**) is horizontally installed to match the axial direction of the cylindrical vessel body (**16**) in Embodiment 1 with the horizontal direction. Thus, the vessel body (**16**) is formed to have a longer horizontal dimension than the vertical dimension.

[0091] Furthermore, one of two end surfaces of the cylinder of the vessel body (**16**) has a first through hole (**16a**) formed in an upper part thereof and a third through hole (**16c**) formed in a lower part thereof. The inflow pipe (**20**) and a liquid outflow pipe (**30**) are connected to the vessel body (**16**) to pass through the first through hole (**16a**) and the third through hole (**16c**), respectively, substantially perpendicular to the associated end surfaces of the vessel body (**16**).

[0092] On the other hand, the other end surface of the vessel body (**16**) has a second through hole (**16b**) formed above a point thereof corresponding to the first through hole (**16a**). A gas outflow pipe (**40**) is connected to the vessel body (**16**) to pass through the second hole (**16b**). The opening end (**21**) of the inflow pipe (**20**) and the opening end (**31**) of the liquid outflow pipe (**30**) are placed in the vessel body (**16**) closer to the end surface having the first through hole (**16a**) and the third through hole (**16c**) than the horizontal center of the vessel body (**16**). The opening end (**41**) of the gas outflow pipe (**40**) is placed in the vessel body (**16**) closer to the end surface having the second through hole (**16b**) than the horizontal center of the vessel body (**16**).

[0093] In this manner, the opening end (**21**) of the inflow pipe (**20**) and the opening end (**41**) of the gas outflow pipe (**40**) are placed in the pool (**24**) of gas refrigerant in an upper part of the vessel body (**16**) and arranged to face each other at longitudinally opposite sides of the vessel body (**16**). Furthermore, the opening end (**41**) of the gas outflow pipe (**40**) is placed above the opening end (**21**) of the inflow pipe (**20**). On the other hand, the opening end (**31**) of the liquid outflow pipe (**30**) is placed in the pool (**23**) of liquid refrigerant in a lower part of the vessel body (**16**).

[0094] Although in this embodiment the vessel body (**16**) having the same shape as in Embodiment 1 is used, this embodiment exhibits the following effects since the vessel body (**16**) is installed to match its horizontal direction (**16**) with its longitudinal direction.

[0095] First, the distance between the opening end (**21**) of the inflow pipe (**20**) and an opposite part of the inside wall of the vessel body (**21**) (i.e., the end surface having the second through hole (**16b**)) can be long. Therefore, even if gas-liquid two-phase refrigerant flowing through the inflow pipe (**20**) forms a slug flow to temporarily reaches a high flow rate, the gas-liquid two-phase refrigerant having flowed through the inflow pipe (**20**) into the vessel body (**16**) can be prevented from hitting the inside wall of the vessel body (**16**).

[0096] This prevents spattering of gas-liquid two-phase refrigerant due to the hitting and in turn prevents that spattered refrigerant flows out through the gas outflow pipe (**40**). In addition, disturbance of the liquid level of the pool (**23**) of liquid refrigerant due to falling of spattered refrigerant, spattering of liquid refrigerant due to the disturbance of the liquid level and mixing of gas bubbles into the pool (**23**) of liquid refrigerant can surely be prevented.

[0097] Furthermore, since the opening end (**21**) of the inflow pipe (**20**) and the opening end (**41**) of the gas outflow pipe (**40**) can surely be spaced apart from each other, gas-liquid two-phase refrigerant having flowed through the inflow pipe (**20**) into the vessel body (**16**) can surely be prevented from directly flowing out through the gas outflow pipe (**40**).

[0098] Hence, the gas-liquid separator (**18**) can prevent gas refrigerant flowing out through the gas outflow pipe (**40**) from mixing-in of liquid refrigerant and prevent liquid refrigerant flowing out through the liquid outflow pipe (**30**) from mixing-in of gas refrigerant. As a result, the gas-liquid separation performance of the gas-liquid separator (**18**) can be enhanced.

[0099] In this embodiment, gas-liquid two-phase refrigerant having flowed through the inflow pipe (**20**) into the vessel body (**16**) is prevented from hitting the inside wall of the vessel body (**16**) by matching the longitudinal direction of the vessel body (**16**) with the horizontal direction. However, the gas-liquid two-phase refrigerant having flowed through the inflow pipe (**20**) into the vessel body (**16**) can be further surely prevented from hitting the inside wall of the vessel body (**16**) by configuring the inflow pipe (**20**) so that the opening end (**21**) thereof opens obliquely downward like Embodiment 1.

[0100] The rests of the configuration and operational behavior and the other effects are the same as in Embodiment 1.

- Modification 1 of Embodiment 2 -

[0101] This embodiment is configured, as shown in Figure 6, by placing a mesh member (**50**) in the inflow pipe (**20**) of the gas-liquid separator (**18**) according to Embodiment 2.

[0102] According to this embodiment, since the mesh member (**50**) is placed in the inflow pipe (**20**), gas-liquid two-phase refrigerant introduced through the inflow pipe (**20**) into the vessel body (**50**) is homogenized, whereby the flow condition of the gas-liquid two-phase refrigerant becomes regular and stable. This prevents disturbance of the liquid level of the pool (**23**) of liquid refrigerant, spattering of liquid refrigerant into the pool (**24**) of gas refrigerant due to the liquid level disturbance, and mixing of gas bubbles into liquid refrigerant, such as due to bubbling of the pool (**23**) of liquid refrigerant. Thus, the gas-liquid separation performance of the gas-liquid separator (**18**) can be further enhanced.

[0103] The rests of the configuration and operational behavior and the other effects are the same as in Embodiment 2.

- Modification 2 of Embodiment 2 -

[0104] This embodiment is configured, as shown in Figure 7, by installing the vessel body (**16**) of the gas-liquid separator (**18**) according to Embodiment 2 to incline it downward from its one end surface through which the gas outflow pipe (**40**) passes towards its other end surface through which the liquid outflow pipe (**30**) passes. Thus, an under part (**16d**) of the peripheral surface of the cylindrical vessel body (**16**) inclines downward towards a point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**) and is thereby constituted as the under surface of the vessel body (**16**). Furthermore, in this embodiment, only the vessel body (**16**) is placed at an angle but the pipes (**20**, **30**, **40**) are horizontally placed in and around the vessel body (**16**).

[0105] According to this embodiment, the vessel body (**16**) can surely have a pool of liquid refrigerant around the opening end (**31**) of the liquid outflow pipe (**30**) even if the amount of liquid refrigerant therein is small. This ensures that liquid refrigerant flows out through the liquid outflow pipe (**30**). In addition, the opening end (**31**) of the liquid outflow pipe (**30**) can be prevented from being exposed to the gas refrigerant pool (**24**). This prevents gas refrigerant from flowing out through the liquid outflow pipe (**30**).

[0106] In this embodiment, the under part (**16d**) of the peripheral surface of the cylindrical vessel body (**16**) is inclined downward towards the point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**) by inclining the entire vessel body (**16**). However, like Modification 2 of Embodiment 1, the vessel body (**16**) may have a shape in which only its under part (**16d**) inclines downward towards the point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**). Furthermore, the pipes (**20**, **30**, **40**) may be placed to incline in the same direction as the vessel body (**16**) by extending them to the interior of the vessel body (**16**) substantially vertically with respect to the end surfaces of the vessel body (**16**).

[0107] The rests of the configuration and operational behavior and the other effects are the same as in Embodiment 2.

«Other Embodiments»

[0108] The above embodiments may have the following configurations.

[0109] Although the refrigeration system (**1**) according to each of the above embodiments is a refrigeration system performing an operation of refrigerating the interior of a storage, the refrigeration system of the present invention is sufficient if it includes a refrigerant circuit including a gas-liquid separator and operating in a two-stage compression and two-stage expansion refrigeration cycle. In other words, the refrigeration system (**1**) may be, for example, a refrigeration system performing either one of cooling and heating operations for a room, or may be a refrigeration system switchable between the cooling and heating operations, or may be a refrigeration system switchable between a single-stage compression and single-stage expansion operation and a two-stage compression and two-stage expansion operation. The configurations of the compressors (**11**, **21**) and heat exchangers (**13**, **14**) in the refrigerant circuit are not particularly limited.

[0110] Although in Embodiment 1 the mesh member (**50**) placed in the inflow pipe (**20**) of the gas-liquid separator (**18**) is conically shaped, the shape and configuration of the mesh member (**50**) are not particularly limited. For example, the mesh member (**50**) may comprise a single or a plurality of overlaid mesh plates placed in the inflow pipe (**20**).

[0111] Furthermore, although in the above embodiments the vessel body (**16**) of the gas-liquid separator (**18**) has a cylindrical shape, the shape of the vessel body (**16**) is not particularly limited and may be a rectangular parallelepiped, for example.

[0112] The above embodiments are merely preferred embodiments in nature and are not intended to limit the scope, applications and use of the invention.

Industrial Applicability

[0113] As can be seen from the above description, the present invention is useful for a gas-liquid separator and a refrigeration system including a refrigerant circuit with the gas-liquid separator.

Claims

1. A gas-liquid separator comprising:

a vessel body (**16**) for separating gas-liquid two-phase fluid into liquid fluid and gaseous fluid;
an inflow pipe (**20**) through which the gas-liquid two-phase fluid flows into the vessel body (**16**);
a liquid outflow pipe (**30**) through which liquid fluid in the vessel body (**16**) flows out of the vessel body (**16**); and
a gas outflow pipe (**40**) through which gaseous

fluid in the vessel body (**16**) flows out of the vessel body (**16**),

wherein the inflow pipe (**20**) is provided with a fragmentation device (**50**) for fragmentizing gas bubbles in the gas-liquid two-phase fluid.

2. The gas-liquid separator of claim 1, wherein the fragmentation device (**50**) comprises a mesh member (**50**).

3. The gas-liquid separator of claim 1, wherein
an opening end (**21**) of the inflow pipe (**20**) and an opening end (**41**) of the gas outflow pipe (**40**) are placed in an upper part of the vessel body (**16**) and arranged to face each other at opposite sides of the vessel body (**16**), and
an opening end (**31**) of the liquid outflow pipe (**30**) is placed in a lower part of the vessel body (**16**).

4. The gas-liquid separator of claim 1, wherein the vessel body (**16**) is installed so that the under surface (**16d**) thereof inclines downward towards a point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**).

5. The gas-liquid separator of claim 1, wherein the inflow pipe (**20**) is horizontally extended to the interior of the vessel body (**16**) and the opening end (**21**) of the inflow pipe (**20**) opens obliquely downward.

6. The gas-liquid separator of claim 1, wherein the inflow pipe (**20**) is installed to horizontally extend.

7. The gas-liquid separator of claim 3, wherein the opening end (**41**) of the gas outflow pipe (**40**) is placed above the opening end (**21**) of the inflow pipe (**20**).

8. A refrigeration system including a refrigerant circuit (**10**) including the gas-liquid separator (**18**) of claim 1, wherein
the refrigerant circuit (**10**) is configured so that a first expansion mechanism (**17**), an evaporator (**13**), a low-pressure stage compressor (**11**), a high-pressure stage compressor (**12**), a condenser (**14**) and a second expansion mechanism (**15**) are connected in this order therein to operate in a two-stage compression and two-stage expansion refrigeration cycle,
the inflow pipe (**20**) of the gas-liquid separator (**18**) is connected to the downstream side of the second expansion valve (**15**) so that gas-liquid two-phase refrigerant flowing through the condenser (**14**) and then reduced to an intermediate pressure in the second expansion mechanism (**15**) flows into the vessel body (**16**) of the gas-liquid separator (**18**),
the liquid outflow pipe (**30**) of the gas-liquid separator (**18**) is connected to the upstream side of the first expansion mechanism (**17**) so that liquid refrigerant separated by the gas-liquid separator (**18**) is fed to the first expansion mechanism (**17**), and
the gas outflow pipe (**40**) of the gas-liquid separator (**18**) is connected to the suction side of the high-pressure stage compressor (**12**) so that gas refrigerant separated by the gas-liquid separator (**18**) is fed to the suction side of the high-pressure stage compressor (**12**).

9. A gas-liquid separator comprising:

a vessel body (**16**) for separating gas-liquid two-phase fluid into liquid fluid and gaseous fluid;
an inflow pipe (**20**) through which the gas-liquid two-phase fluid flows into the vessel body (**16**);
a liquid outflow pipe (**30**) through which liquid fluid in the vessel body (16) flows out of the vessel body (**16**); and
a gas outflow pipe (**40**) through which gaseous fluid in the vessel body (16) flows out of the vessel body (**16**),

wherein the vessel body (**16**) is formed to have a longer horizontal dimension than the vertical dimension,
an opening end (**21**) of the inflow pipe (**20**) and an opening end (**41**) of the gas outflow pipe (**40**) are placed in an upper part of the vessel body (**16**) and arranged to face each other at longitudinally opposite sides of the vessel body (**16**), and
an opening end (**31**) of the liquid outflow pipe (**30**) is placed in a lower part of the vessel body (**16**).

10. The gas-liquid separator of claim 9, wherein the vessel body (**16**) is installed so that the under surface (**16d**) thereof inclines downward towards a point thereof corresponding to the opening end (**31**) of the liquid outflow pipe (**30**).

11. The gas-liquid separator of claim 9, wherein the inflow pipe (**20**) is horizontally extended to the interior of the vessel body (16) and the opening end (**21**) of the inflow pipe (**20**) opens obliquely downward.

12. The gas-liquid separator of claim 9, wherein the inflow pipe (**20**) is installed to horizontally extend.

13. The gas-liquid separator of claim 9, wherein the opening end (**41**) of the gas outflow pipe (**40**) is placed above the opening end (**21**) of the inflow pipe (**20**).

14. A refrigeration system including a refrigerant circuit (**10**) including the gas-liquid separator (**18**) of claim 9, wherein
the refrigerant circuit (**10**) is configured so that a first

expansion mechanism (**17**), an evaporator (**13**), a low-pressure stage compressor (**11**), a high-pressure stage compressor (**12**), a condenser (**14**) and a second expansion mechanism (**15**) are connected in this order therein to operate in a two-stage compression and two-stage expansion refrigeration cycle,
the inflow pipe (**20**) of the gas-liquid separator (**18**) is connected to the downstream side of the second expansion valve (**15**) so that gas-liquid two-phase refrigerant flowing through the condenser (**14**) and then reduced to an intermediate pressure in the second expansion mechanism (**15**) flows into the vessel body (**16**) of the gas-liquid separator (**18**),
the liquid outflow pipe (**30**) of the gas-liquid separator (**18**) is connected to the upstream side of the first expansion mechanism (**17**) so that liquid refrigerant separated by the gas-liquid separator (**18**) is fed to the first expansion mechanism (**17**), and
the gas outflow pipe (**40**) of the gas-liquid separator (**18**) is connected to the suction side of the high-pressure stage compressor (**12**) so that gas refrigerant separated by the gas-liquid separator (**18**) is fed to the suction side of the high-pressure stage compressor (**12**).

FIG. 1

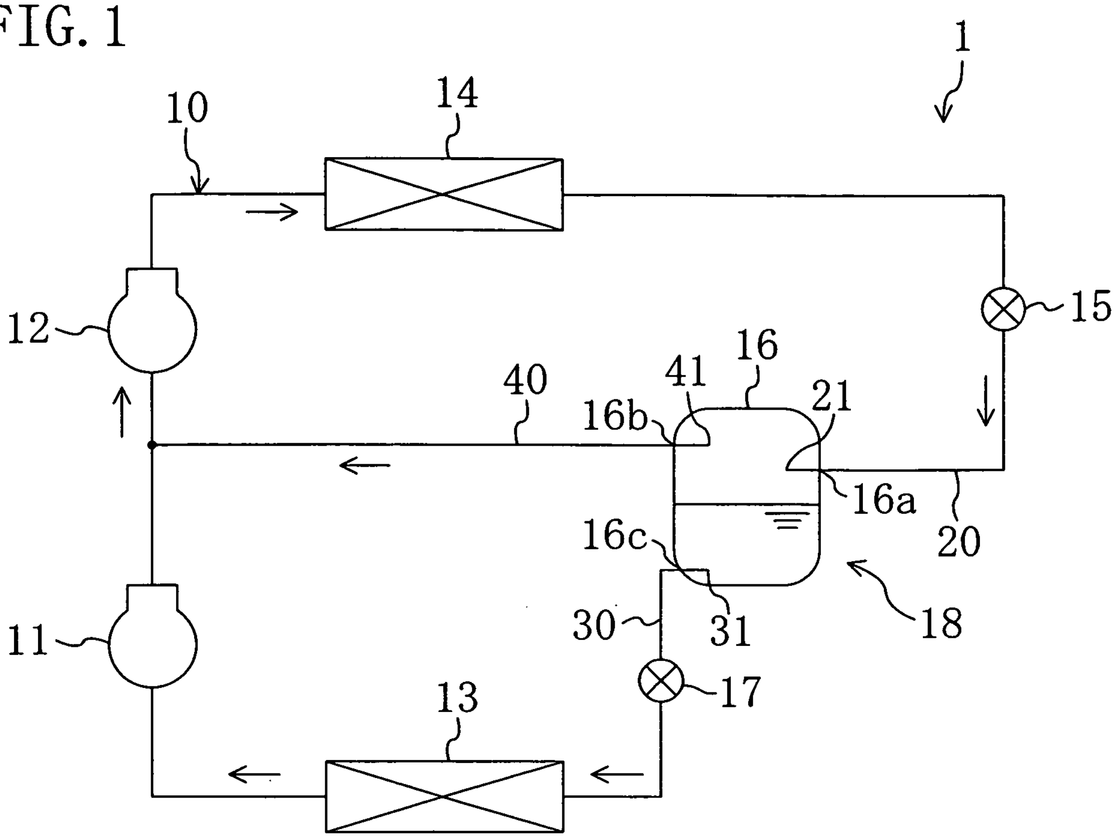
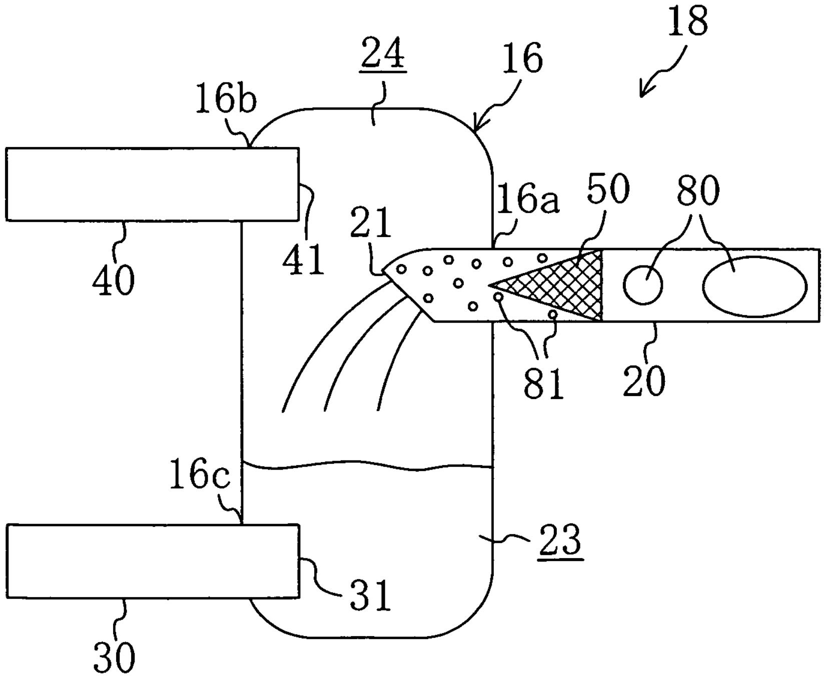

1
10
14
15
12
40
41
16
16b
21
16a
20
16c
30
31
18
11
17
13

FIG. 2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16b
16a
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41
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16c
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31
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FIG. 3

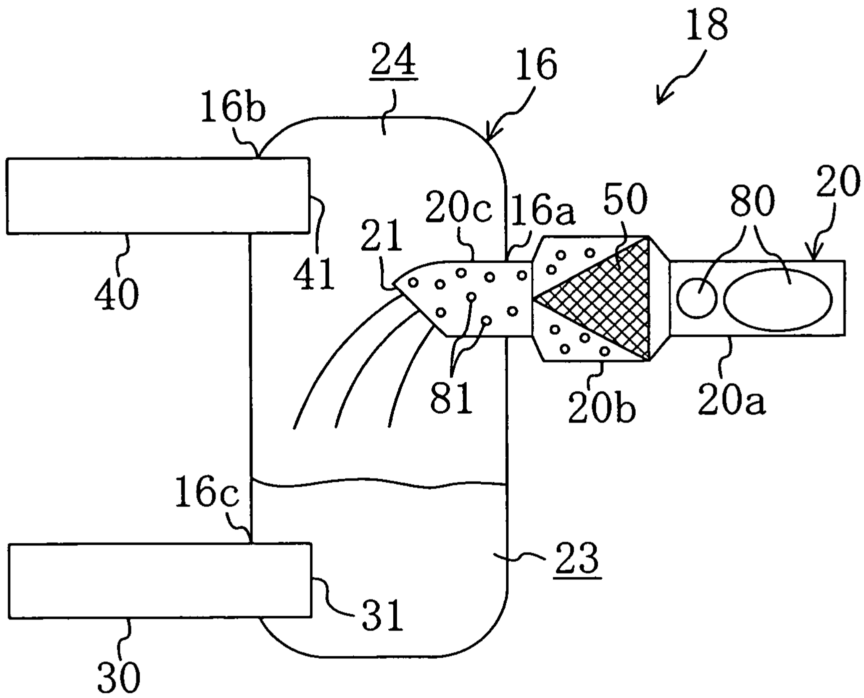
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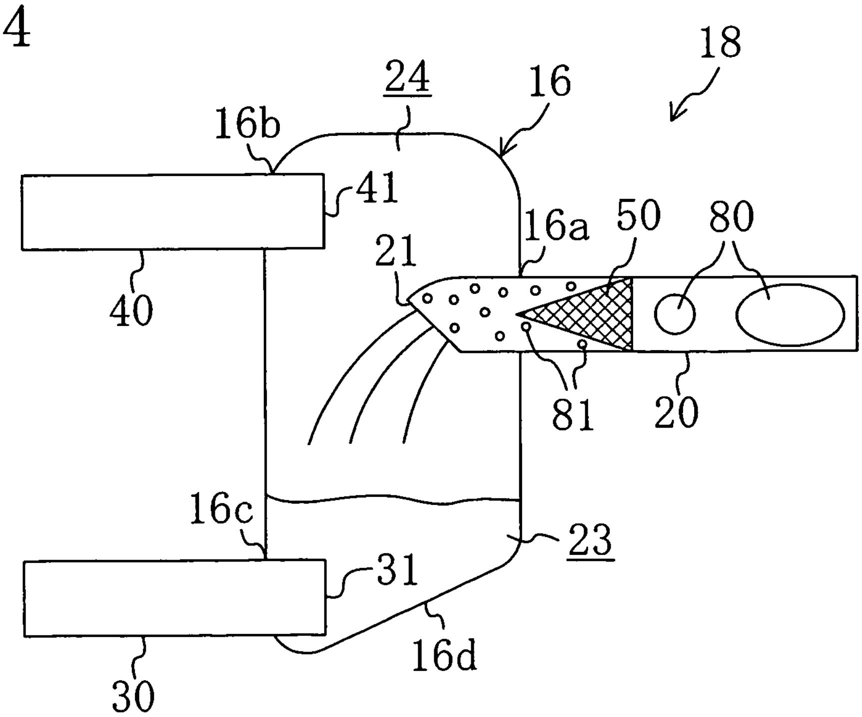
FIG. 4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16d
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FIG. 5

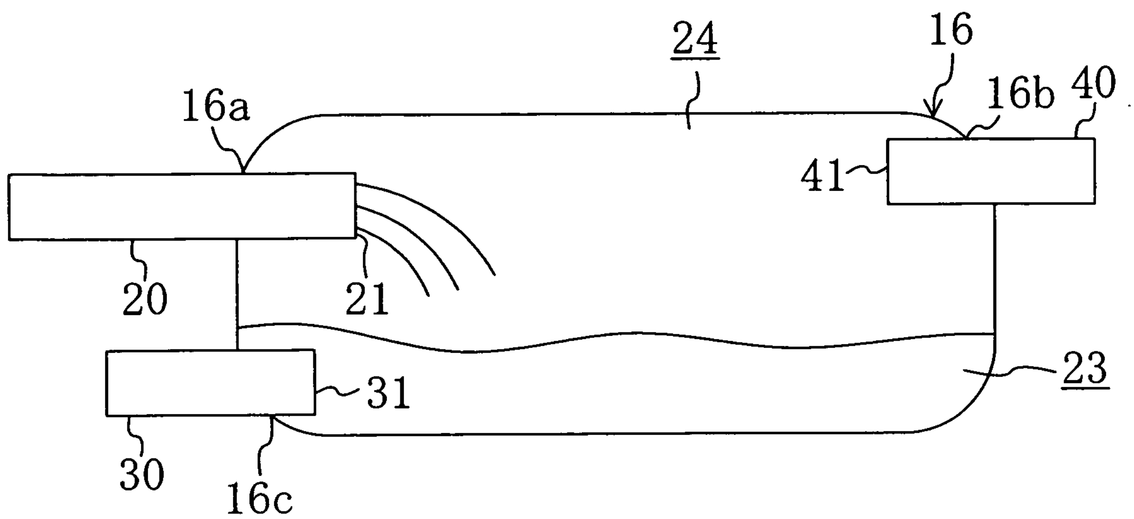
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FIG. 6

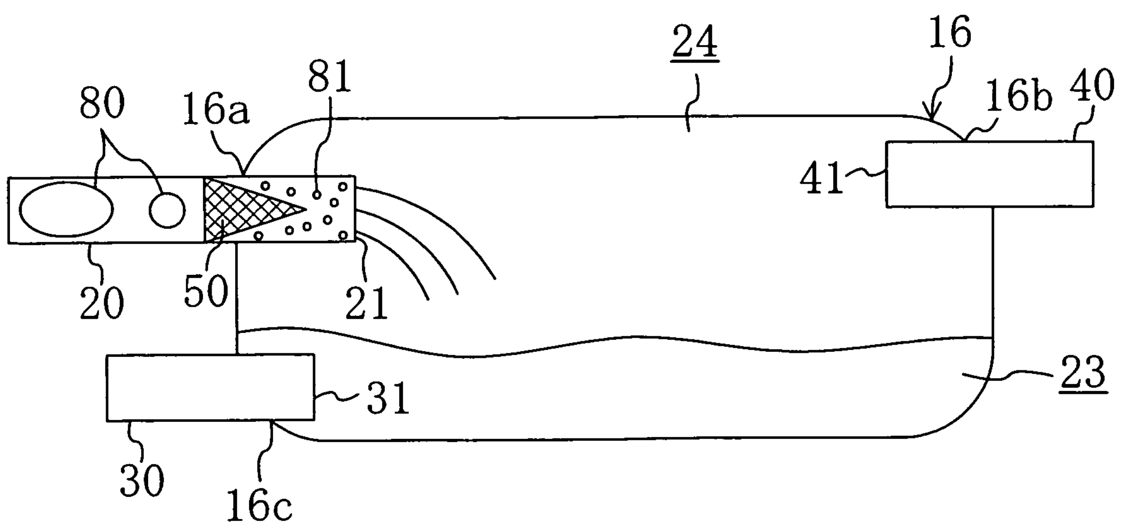
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FIG. 7

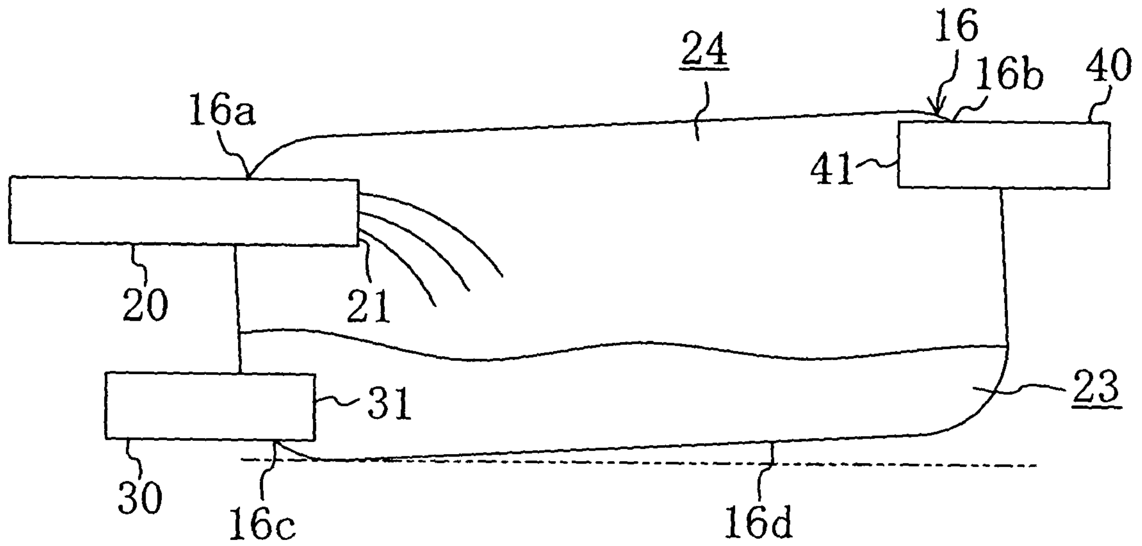


FIG. 8

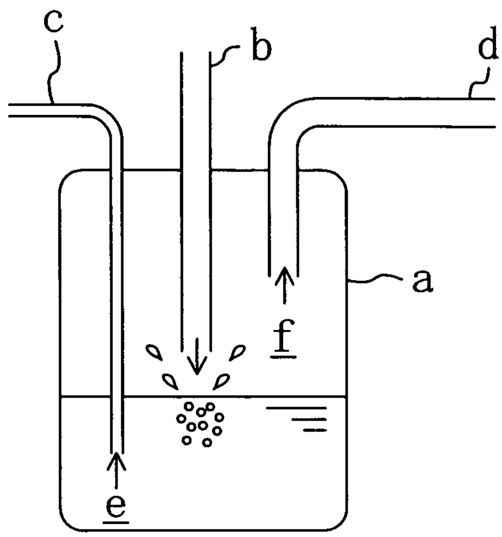
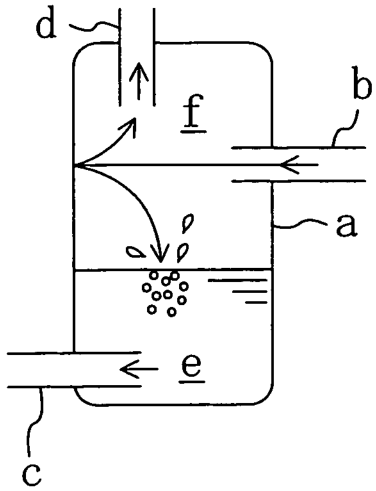


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/050492

A. CLASSIFICATION OF SUBJECT MATTER
F25B43/00(2006.01)i, *F25B1/10*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B43/00, F25B1/10

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 54002/1992(Laid-open No. 18865/1994) (Daikin Industries, Ltd.), 11 March, 1994 (11.03.94), Par. Nos. [0063] to [0068]; Fig. 9 (Family: none)	1,2,6 3-5,8
Y	JP 11-173682 A (Sanyo Electric Co., Ltd.), 02 July, 1999 (02.07.99), Par. No. [0026]; Fig. 3 (Family: none)	3,9,12

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

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Date of the actual completion of the international search	Date of mailing of the international search report
13 March, 2007 (13.03.07)	20 March, 2007 (20.03.07)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/050492

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 9-503286 A (PHILLIPPE, Gary, E.), 31 March, 1997 (31.03.97), Full text; Figs. 1 to 7 & US 5426956 A & WO 1995/012792 A1	4,5,10,11
A	JP 58-22857 A (Matsushita Electric Industrial Co., Ltd.), 10 February, 1983 (10.02.83), Full text; Figs. 1 to 6 (Family: none)	7,13
Y	JP 2005-265317 A (Sanyo Electric Co., Ltd.), 29 September, 2005 (29.09.05), Full text; Figs. 1 to 7 & EP 1577622 A2 & US 2005/0204773 A1	8,14
Y	JP 2000-320933 A (Mitsubishi Electric Corp.), 24 November, 2000 (24.11.00), Full text; Figs. 1 to 22 (Family: none)	9,10-12,14

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2001235245 A **[0005]**