

DESCRIPTION

Title of Invention

EVAPORATOR

[Technical Field]

[0001]

The present disclosure relates to an evaporator.

[Background Art]

[0002]

A liquid film-type evaporator in which a liquid-phase refrigerant is supplied from above to a heat transfer pipe group through which a medium to be cooled circulates is known as an evaporator used in a chiller. In the liquid film-type evaporator, in the heat transfer pipe group, a plate-shaped member may be provided above or beside the heat transfer pipe group for the purpose of suitably evaporating the refrigerant (for example, Patent Document 1).

[0003]

The evaporator described in Patent Document 1 includes a hood positioned above a tube bundle so as to substantially prevent the cross-flow of a steam refrigerant or liquid and steam refrigerants between the tubes of the tube bundle and a wall extending from both

ends of the upper end portion of the hood to the lower part of a shell.

[Citation List]

[Patent Document]

[0004]

[Patent Document 1] Japanese Unexamined Patent
Publication No. 2008-516187

[Summary of Invention]

[Technical Subject]

[0005]

In the evaporator of Patent Document 1, the end portion of the hood positioned above the tube bundle and the upper end of the wall positioned beside the tube bundle are connected to each other. In other words, in the evaporator of Patent Document 1, a space closed above is formed between the hood and the wall and the tube bundle is disposed in this space. In such a configuration, when the flash gas of the supplied refrigerant and the refrigerant evaporated in the tube bundle are discharged from the space provided with the tube bundle, most of the refrigerant passes between the tubes, which leads to an increase in resistance (pressure loss). Accordingly, the pressure in the space rises. When the pressure in the space where the tube side is disposed rises, it becomes difficult for the refrigerant to evaporate on the surface

of the tube bundle. Accordingly, the heat exchange efficiency of the tube bundle may decrease and the performance of the evaporator may decrease.

[0006]

In addition, the evaporator described in Patent Document 1, in which the end portion of the hood and the upper end of the wall are connected to each other, has only a route that passes through the lower end of the space when the refrigerant evaporated in the tube flows out of the space. In such a case, at the lower end of the space (that is, in the vicinity of the lower end of the wall), the flow speed of a vaporized refrigerant heading for the outlet of a pressure vessel increases. As a result, a phenomenon may arise in which the gas-phase refrigerant that is discharged to the outside of a pressure vessel accompanies a liquid-phase refrigerant (so-called carryover).

[0007]

The present disclosure has been made in view of such circumstances, and an object of the present disclosure is to provide an evaporator capable of improving the heat exchange efficiency of a heat transfer pipe group.

[Subject to be solved]

[0008]

In order to solve the above subjects, the evaporator of the present disclosure employs the following means.

An evaporator according to one aspect of the present disclosure includes: a housing provided with a refrigerant outlet discharging an evaporated refrigerant to an outside and forming an outer shell; a liquid film-type heat transfer pipe group accommodated in the housing and having a plurality of liquid film heat transfer pipes in which a medium to be cooled circulates; a refrigerant supply unit accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group; a side plate portion covering the liquid film-type heat transfer pipe group from a side; and an upper plate portion covering the liquid film-type heat transfer pipe group from above, in which a gap is formed between the side plate portion and the upper plate portion.

[Advantageous Effects of Invention]

[0009]

According to the present disclosure, the heat exchange efficiency of the heat transfer pipe group can be improved.

[Brief Description of Drawings]

[0010]

Fig. 1 is a perspective view illustrating an evaporator according to a first embodiment of the present disclosure.

Fig. 2 is a schematic vertical cross-sectional view illustrating the evaporator according to the first embodiment of the present disclosure.

Fig. 3 is a schematic vertical cross-sectional view illustrating an evaporator according to a second embodiment of the present disclosure.

Fig. 4 is a schematic vertical cross-sectional view illustrating a modification example of Fig. 3.

Fig. 5 is a schematic vertical cross-sectional view illustrating a modification example of Fig. 3.

Fig. 6 is a schematic vertical cross-sectional view illustrating a modification example of Fig. 3.

Fig. 7 is a schematic vertical cross-sectional view illustrating a modification example of Fig. 3.

Fig. 8 is a schematic vertical cross-sectional view illustrating an evaporator according to a third embodiment of the present disclosure.

Fig. 9 is a schematic vertical cross-sectional view illustrating a modification example of Fig. 8.

Fig. 10 is a schematic vertical cross-sectional view illustrating an evaporator according to a fourth embodiment of the present disclosure.

Fig. 11 is a schematic vertical cross-sectional view illustrating a modification example of Fig. 10.

Fig. 12 is a schematic vertical cross-sectional view illustrating a modification example of Fig. 10.

Fig. 13 is a schematic perspective view illustrating an evaporator according to a fifth embodiment of the present disclosure.

Fig. 14 is a schematic vertical cross-sectional view illustrating the evaporator according to the fifth embodiment of the present disclosure.

Fig. 15 is a schematic perspective view illustrating a modification example of Fig. 13.

[Description of Embodiments]

[0011]

Hereinafter, an embodiment of the evaporator according to the present disclosure will be described with reference to the drawings.

[First Embodiment]

Hereinafter, a first embodiment of the present disclosure will be described with reference to Figs. 1 and 2. It should be noted that in the following description and drawings, the vertical up-down direction is the Z-axis direction, the extension direction of a heat transfer pipe is the X-axis direction, and the Y-axis direction is

orthogonal to the Z-axis direction and the X-axis direction.

[0012]

An evaporator 10 according to the present embodiment is applied to a centrifugal chiller. The centrifugal chiller includes, for example, a turbo compressor (not illustrated) compressing a refrigerant, a condenser (not illustrated) condensing the refrigerant compressed by the turbo compressor, an expansion valve (not illustrated) expanding the refrigerant condensed by the condenser, and an evaporator evaporating the refrigerant expanded by the expansion valve and is configured in a unit shape. Each device is connected by a refrigerant circulation pipe. Used as the refrigerant is, for example, a low-pressure refrigerant such as R1233zd used at a maximum pressure of less than 0.2 MPaG. It should be noted that the applicable refrigerant is not limited to the low-pressure refrigerant. For example, a high-pressure refrigerant may be used as the refrigerant.

[0013]

As illustrated in Figs. 1 and 2, the evaporator 10 has a pressure vessel (housing) 11 forming an outer shell, a refrigerant inlet pipe 12 introducing a refrigerant into the pressure vessel 11, a refrigerant tray (refrigerant supply unit) 13 provided below the refrigerant inlet pipe

12, a flooded-type heat transfer pipe group 14 immersed in the liquid-phase refrigerant stored in the lower portion of the pressure vessel 11, a liquid film-type heat transfer pipe group 15 provided above a liquid surface S (see Figs. 2 and 3) of the liquid-phase refrigerant stored in the lower portion of the pressure vessel 11, a refrigerant outlet pipe (refrigerant outlet) 16 discharging the evaporated refrigerant from the pressure vessel 11, a baffle plate (side plate portion) 17 covering the liquid film-type heat transfer pipe group 15 from the side, and a blow-up prevention plate (upper plate portion) 18 covering the liquid film-type heat transfer pipe group 15 from above. It should be noted that in Fig. 1, for the sake of illustration, the pressure vessel 11, the flooded-type heat transfer pipe group 14, and the refrigerant outlet pipe 16 are omitted.

[0014]

As illustrated in Fig. 2, the pressure vessel 11 integrally has a cylindrical portion 11a with a central axis extending along the X-axis direction and two pipe plates (not illustrated) closing both end portions of the cylindrical portion 11a in the direction along the central axis (X-axis direction). The cylindrical portion 11a is disposed so as to have a substantially horizontal central axis. Each pipe plate is a disk-shaped plate member. In

addition, the liquid-phase refrigerant is stored in the lower portion of the pressure vessel 11. Hereinafter, the region where the liquid-phase refrigerant is stored will be referred to as a storage portion 11c.

It should be noted that in the following description, the terms of "inside" and "outside" simply referred to mean "inside" and "outside" with reference to the central axis of the cylindrical portion 11a. In other words, "inside" means the central axis side of the cylindrical portion 11a, and "outside" means the inner peripheral surface side of the cylindrical portion 11a.

[0015]

As illustrated in Figs. 1 and 2, the refrigerant inlet pipe 12 is a cylindrical member extending in the up-down direction and is formed in a substantially linear shape. The refrigerant inlet pipe 12 is provided so as to penetrate the upper portion of the cylindrical portion 11a in the up-down direction. The refrigerant inlet pipe 12 is provided substantially at the center of the cylindrical portion 11a in the X-axis direction. The refrigerant inlet pipe 12 is connected to the pipe (not illustrated) by which the evaporator 10 and the expansion valve are connected. In other words, the refrigerant expanded by the expansion valve is guided into the pressure vessel 11 via the refrigerant inlet pipe 12.

[0016]

The refrigerant tray 13 is a substantially rectangular plate-shaped member. The refrigerant tray 13 is disposed in the upper portion of the inner portion of the pressure vessel 11 so as to have a substantially horizontal plate surface. In addition, the refrigerant tray 13 is provided such that the lower end of the refrigerant inlet pipe 12 and the plate surface face each other. Both end portions of the refrigerant tray 13 in the Y-axis direction are disposed apart by a predetermined distance from the inner peripheral surface of the cylindrical portion 11a of the pressure vessel 11. In addition, the refrigerant tray 13 is provided over substantially the entire area of the pressure vessel 11 in the X-axis direction. Both end portions of the refrigerant tray 13 in the X-axis direction are fixed to the pipe plates, respectively. Multiple holes penetrating the refrigerant tray 13 in the up-down direction are formed in the refrigerant tray 13. The multiple holes are formed in substantially the entire area of the refrigerant tray 13. The liquid refrigerant ejected from the refrigerant inlet pipe 12 is discharged onto the refrigerant tray 13. The refrigerant discharged to the refrigerant tray 13 flows on the upper surface of the refrigerant tray 13 and then falls downward through the

multiple holes. In this manner, the refrigerant tray 13 distributes the refrigerant supplied from the refrigerant inlet pipe 12 in the X-axis direction and the Y-axis direction.

[0017]

The flooded-type heat transfer pipe group 14 is accommodated in the pressure vessel 11 as illustrated in Fig. 2. In addition, the flooded-type heat transfer pipe group 14 is immersed in the refrigerant stored in the storage portion 11c. In other words, the flooded-type heat transfer pipe group 14 is disposed below the liquid surface S of the stored refrigerant. The flooded-type heat transfer pipe group 14 has a plurality of flooding heat transfer pipes 14a extending along the X-axis direction. The plurality of flooding heat transfer pipes 14a are disposed substantially in parallel. The plurality of flooding heat transfer pipes 14a are disposed side by side at predetermined intervals in the up-down direction (Z-axis direction) and the Y-axis direction. Specifically, the plurality of flooding heat transfer pipes 14a are arranged in a plurality of stages in the up-down direction and in a plurality of rows in the Y-axis direction. Water as a medium to be cooled (hereinafter, referred to as "water to be cooled") circulates in each flooding heat transfer pipe 14a. In addition, each flooding heat

transfer pipe 14a is formed in a linear shape. In addition, each flooding heat transfer pipe 14a extends from one end to the other end of the pressure vessel 11 in the X-axis direction and penetrates each pipe plate.

[0018]

The liquid film-type heat transfer pipe group 15 is accommodated in the pressure vessel 11 as illustrated in Figs. 1 and 2. The liquid film-type heat transfer pipe group 15 is disposed above the liquid surface S of the stored refrigerant. The liquid film-type heat transfer pipe group 15 has a plurality of liquid film heat transfer pipes 15a extending along the X-axis direction. The plurality of liquid film heat transfer pipes 15a are disposed substantially in parallel. The plurality of liquid film heat transfer pipes 15a are disposed side by side at predetermined intervals in the up-down direction (Z-axis direction) and the Y-axis direction. Specifically, the plurality of liquid film heat transfer pipes 15a are arranged in a plurality of stages in the up-down direction and in a plurality of rows in the Y-axis direction. Water as a medium to be cooled circulates in each liquid film heat transfer pipe 15a. In addition, each liquid film heat transfer pipe 15a is formed in a linear shape. In addition, each liquid film heat transfer pipe 15a extends

from one end to the other end of the pressure vessel 11 in the X-axis direction and penetrates each pipe plate.

[0019]

As illustrated in Fig. 2, the refrigerant outlet pipe 16 is a cylindrical member extending so as to be inclined with respect to the Z-axis direction. The refrigerant outlet pipe 16 is provided so as to communicate with the opening that is formed in the upper portion of the cylindrical portion 11a. The refrigerant outlet pipe 16 is provided on the end portion of the cylindrical portion 11a in the X-axis direction. In other words, the refrigerant outlet pipe 16 is provided in the vicinity of the pipe plate of the pressure vessel 11. The refrigerant evaporated by the evaporator 10 is discharged to the outside of the pressure vessel 11 via the refrigerant outlet pipe 16. The refrigerant outlet pipe 16 is provided above the baffle plate 17.

[0020]

The baffle plate 17 is a flat plate-shaped member disposed so as to have a vertical plate surface. The baffle plate 17 is disposed on both sides of the liquid film-type heat transfer pipe group 15. In other words, the baffle plate 17 is disposed outside the liquid film-type heat transfer pipe group 15 in the Y-axis direction. Each baffle plate 17 is disposed so as to have a plate

surface facing the liquid film-type heat transfer pipe group 15. The baffle plates 17 extend downward and by a predetermined distance from both end portions of the refrigerant tray 13 in the Y-axis direction. The lower end of the baffle plate 17 is positioned above the lower end of the liquid film-type heat transfer pipe group 15. Specifically, the baffle plate 17 covers, from the side, substantially the entire area of the liquid film-type heat transfer pipe group 15 in the Z-axis direction except the lower end portion of the liquid film-type heat transfer pipe group 15.

The upper end of the baffle plate 17 is positioned below the blow-up prevention plate 18. A gap G is formed between the upper end of the baffle plate 17 and the blow-up prevention plate 18.

In addition, the baffle plate 17 extends over substantially the entire area of the pressure vessel 11 in the X-axis direction along the liquid film-type heat transfer pipe group 15. It should be noted that the baffle plate 17 may be provided only at a part in the X-axis direction.

[0021]

The blow-up prevention plate 18 has a flat plate-shaped flat plate portion 18a disposed so as to have a horizontal plate surface and inclined portions 18b bent

and extending diagonally downward from both end portions of the flat plate portion 18a in the Y-axis direction. The blow-up prevention plate 18 is disposed above the refrigerant tray 13. The blow-up prevention plate 18 is disposed apart from the baffle plate 17. The refrigerant inlet pipe 12 penetrates the central portion of the flat plate portion 18a of the blow-up prevention plate 18 in the X-axis direction and the Y-axis direction. The lower end of the inclined portion 18b is positioned above the baffle plate 17. The gap G is formed between the lower end of the inclined portion 18b and the upper end of the baffle plate 17. In addition, the blow-up prevention plate 18 extends over substantially the entire area of the pressure vessel 11 in the X-axis direction along the liquid film-type heat transfer pipe group 15. It should be noted that the blow-up prevention plate 18 may be provided only at a part in the X-axis direction.

[0022]

The refrigerant circulates as follows in the evaporator 10 configured as described above.

As illustrated in Fig. 1, in the evaporator 10, the refrigerant flows into the pressure vessel 11 from the refrigerant inlet pipe 12. The refrigerant that has flowed into the pressure vessel 11 is distributed in the X-axis direction and the Y-axis direction of the pressure

vessel 11 by the refrigerant tray 13 and then passes through the multiple holes formed in the refrigerant tray 13 to fall downward. The liquid-phase refrigerant that has fallen from the refrigerant tray 13 comes into contact with the liquid film heat transfer pipe 15a disposed in the uppermost stage of the liquid film-type heat transfer pipe group 15 and covers the outer peripheral surface of the liquid film heat transfer pipe 15a in a film shape. The refrigerant that covers the outer peripheral surface of the liquid film heat transfer pipe 15a in the film shape exchanges heat with the water to be cooled in the liquid film heat transfer pipe 15a. The refrigerant that exceeds the boiling point as a result of the heat exchange evaporates, and the refrigerant that does not exceed the boiling point falls to the liquid film heat transfer pipe 15a disposed further below. Such heat exchange is repeated continuously. The refrigerant that does not evaporate even by heat exchange with the water in the liquid film heat transfer pipe 15a disposed in the lowermost portion is stored in the storage portion 11c provided in the lower portion of the pressure vessel 11 (see Fig. 2). In this manner, a pool of the liquid-phase refrigerant is formed in the storage portion 11c in the pressure vessel 11. The level of the liquid surface S of

this refrigerant pool is automatically adjusted to a predetermined height.

[0023]

Meanwhile, as illustrated in Fig. 2, the mainstream of the refrigerant evaporated in the liquid film-type heat transfer pipe group 15 bypasses the lower end of the baffle plate 17, rises, and is guided to the refrigerant outlet pipe 16 as indicated by the arrow A1. In addition, a part of the refrigerant evaporated in the liquid film-type heat transfer pipe group 15 passes through the gap G formed between the baffle plate 17 and the blow-up prevention plate 18 and is guided to the refrigerant outlet pipe 16 as indicated by the arrow A2.

The flooding heat transfer pipe 14a of the flooded-type heat transfer pipe group 14 is in a state of being immersed in the liquid-phase refrigerant stored in the storage portion 11c. The water to be cooled circulating in the liquid film heat transfer pipe 15a exchanges heat with the refrigerant stored in the storage portion 11c. The refrigerant that has exchanged heat with the liquid film heat transfer pipe 15a evaporates and is released upward from the liquid surface S. The refrigerant released from the liquid surface S is guided to the refrigerant outlet pipe 16 as indicated by the arrow A3.

[0024]

The refrigerant evaporated in the liquid film-type heat transfer pipe group 15 and the flooded-type heat transfer pipe group 14 and guided to the refrigerant outlet pipe 16 is discharged to the outside of the pressure vessel 11. The refrigerant discharged from the refrigerant outlet pipe 16 is suctioned and compressed by the turbo compressor.

[0025]

The action and effect of the present embodiment are as follows.

In the present embodiment, the baffle plate 17 covers the liquid film-type heat transfer pipe group 15 from the side. In addition, the blow-up prevention plate 18 covers the liquid film-type heat transfer pipe group 15 from above. In other words, the baffle plate 17 and the blow-up prevention plate 18 form a space where the liquid film-type heat transfer pipe group 15 is provided (hereinafter, referred to as "inside space S1"). In addition, the baffle plate 17 and the blow-up prevention plate 18 separate the inside space S1 from the space formed outside the inside space S1 (hereinafter, referred to as "outside space S2"). In the present embodiment, the gap G is formed between the blow-up prevention plate 18 and the baffle plate 17. In other words, the gap G connects the inside space S1 and the outside space S2. In

the present embodiment, the refrigerant evaporates when the refrigerant is supplied from the refrigerant tray 13 to the liquid film-type heat transfer pipe group 15. When the refrigerant evaporates, the evaporated refrigerant diffuses in the inside space S1. A part of the diffused refrigerant passes through the gap G formed between the blow-up prevention plate 18 and the baffle plate 17 and moves to the outside space S2. As a result, it is possible to suppress a rise in pressure in the inside space S1 as compared with a case where the gap G is not formed (that is, a case where the baffle plate 17 and the blow-up prevention plate 18 are connected). Accordingly, the environment around the liquid film-type heat transfer pipe group 15 can be made suitable for heat exchange, and thus the heat exchange efficiency of the liquid film-type heat transfer pipe group 15 can be improved. Accordingly, the performance of the evaporator 10 can be improved.

[0026]

In addition, in the present embodiment, two refrigerant circulation routes are formed from the inside space S1 to the outside space S2, one passes through the lower end of the inside space S1, and the other passes through the gap G. Accordingly, it is possible to suppress a situation in which the flow speed of the vaporized refrigerant increases at the lower end of the

inside space S1 (that is, in the vicinity of the lower end of the baffle plate 17). As a result, a phenomenon in which the gas-phase refrigerant discharged to the outside of the pressure vessel 11 accompanies a liquid-phase refrigerant (so-called carryover) can be made unlikely to occur.

[0027]

In addition, a part of the refrigerant supplied from the refrigerant tray 13 vaporizes before reaching the liquid film-type heat transfer pipe group 15 due to a decrease in pressure. In the present embodiment, the vaporized refrigerant (hereinafter, referred to as "flash gas") easily moves to the outside space S2 through the gap G formed between the blow-up prevention plate 18 and the baffle plate 17. Accordingly, a rise in pressure in the inside space S1 attributable to the flash gas can be suppressed. In addition, the flash gas is discharged from the inside space S1, and thus the liquid-phase refrigerant supplied to the liquid film-type heat transfer pipe group 15 without vaporizing is not easily affected by the flash gas. Accordingly, the refrigerant can be accurately supplied to the liquid film-type heat transfer pipe group 15.

[0028]

In addition, the baffle plate 17 is provided in the present embodiment. As a result, it is possible to block a refrigerant flow from the side with respect to the liquid film-type heat transfer pipe group 15, and thus it is possible to suppress a situation in which the refrigerant supplied in the liquid film-type heat transfer pipe group 15 is scattered.

In addition, the blow-up prevention plate 18 is provided in the present embodiment. As a result, it is possible to suppress a situation in which the refrigerant supplied to the liquid film-type heat transfer pipe group 15 is blown up.

[0029]

In addition, in the present embodiment, the refrigerant outlet pipe 16 is provided above the lower end of the baffle plate 17. In the evaporator 10 having such a structure, the refrigerant evaporating in the liquid film-type heat transfer pipe group 15 and heading for the refrigerant outlet pipe 16 is easily blocked by the baffle plate 17 and the blow-up prevention plate 18. Accordingly, the evaporated refrigerant easily stays in the inside space S1 and the pressure in the inside space S1 easily rises. Meanwhile, in the present embodiment, the gap G is formed between the baffle plate 17 and the blow-up prevention plate 18, and thus the refrigerant evaporated

in the liquid film-type heat transfer pipe group 15 is capable of moving to the outside space S2 through the gap G. As a result, it is possible to make it difficult for the refrigerant to stay in the inside space S1. Accordingly, it is possible to more suitably suppress a rise in pressure in the inside space S1 despite the structure in which the refrigerant outlet pipe 16 is provided above the lower end of the baffle plate 17. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group 15 can be suitably improved and the performance of the evaporator 10 can be suitably improved.

[0030]

In addition, in the present embodiment, the refrigerant tray 13 is provided above the liquid film-type heat transfer pipe group 15. In the evaporator 10 having such a structure, the flash gas easily stays in the inside space S1, and thus the pressure in the inside space S1 easily rises. Meanwhile, in the present embodiment, the gap G is formed between the baffle plate 17 and the blow-up prevention plate 18, and thus the flash gas is capable of moving to the outside space S2 through the gap G. As a result, it is possible to make it difficult for the refrigerant to stay in the inside space S1. Accordingly, it is possible to more suitably suppress a rise in

pressure in the inside space S1 despite the structure in which the refrigerant tray 13 is provided above the liquid film-type heat transfer pipe group 15. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group 15 can be more suitably improved and the performance of the evaporator 10 can be more suitably improved.

[0031]

[Second Embodiment]

Next, the evaporator according to a second embodiment of the present disclosure will be described with reference to Fig. 3.

An evaporator 20 according to the present embodiment is different from the first embodiment in that a lower plate portion 21 provided between the lower end of the liquid film-type heat transfer pipe group 15 and the liquid surface S is provided instead of the baffle plate 17. The embodiments are similar to each other as to the other points, and thus similar configurations will be denoted by the same reference numerals with detailed description thereof omitted.

[0032]

As illustrated in Fig. 3, the evaporator 20 includes a pair of the lower plate portions 21 provided between the lower end of the liquid film-type heat transfer pipe group

15 and the liquid surface S. The pair of lower plate portions 21 are disposed apart from each other in the Y-axis direction. The pair of lower plate portions 21 are provided symmetrically with reference to the center in the Y-axis direction. Each lower plate portion 21 is inclined such that the outside end portion in the Y-axis direction is above the inside end portion in the Y-axis direction. The outside end portion of each lower plate portion 21 in the Y-axis direction is disposed outside the outside end portion of the liquid film-type heat transfer pipe group 15 in the Y-axis direction.

The pair of lower plate portions 21 extend over substantially the entire area of the pressure vessel 11 in the X-axis direction along the liquid film-type heat transfer pipe group 15. It should be noted that the pair of lower plate portions 21 may be provided only at a part in the X-axis direction.

[0033]

The action and effect of the present embodiment are as follows.

In the present embodiment, the lower plate portion 21 is provided between the liquid film-type heat transfer pipe group 15 and the liquid surface S. As a result, the refrigerant evaporated by the flooded-type heat transfer pipe group 14 and heading for the liquid film-type heat

transfer pipe group 15 from the liquid surface S is blocked by the lower plate portion 21. The refrigerant blocked by the lower plate portion 21 bypasses the outside of the lower plate portion 21 and is guided to the refrigerant outlet pipe 16 as indicated by the broken-line arrow in Fig. 3. Accordingly, it is possible to make it difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group 14 to reach the liquid film-type heat transfer pipe group 15. Accordingly, it is possible to suppress a situation in which the refrigerant supplied to the liquid film-type heat transfer pipe group 15 is scattered by the refrigerant evaporated in the flooded-type heat transfer pipe group 14, and thus the environment around the liquid film-type heat transfer pipe group 15 can be made suitable for heat exchange. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group 15 can be improved and the performance of the evaporator 10 can be improved.

[0034]

In addition, in the present embodiment, it is possible to suppress a situation in which the refrigerant supplied to the liquid film-type heat transfer pipe group 15 is scattered by the refrigerant evaporated in the flooded-type heat transfer pipe group 14. As a result, carryover can be made unlikely to occur.

[0035]

In addition, in the present embodiment, the inside end portions of the pair of lower plate portions 21 are separated from each other. In addition, each lower plate portion 21 is inclined such that the inside end portion is downward. As a result, even in a case where the liquid-phase refrigerant heading for the storage portion 11c without completely evaporating in the liquid film-type heat transfer pipe group 15 has fallen to the upper surface of the lower plate portion 21, as indicated by the solid-line arrow in Fig. 3, the liquid-phase refrigerant moves on the upper surface of the lower plate portion 21 up to the inner end and falls from the inner end to the storage portion 11c. As a result, the refrigerant that is not supplied to each heat transfer pipe group can be reduced, and thus the performance of the evaporator 10 can be improved.

[0036]

[Modification Example 1]

It should be noted that the shape of the lower plate portion is not limited to the shape described above. For example, as in a lower plate portion 26 illustrated in Fig. 4, the lower plate portion may be a plate-shaped member inclined so as to be positioned downward from both end portions in the Y-axis direction toward the central

portion. In addition, the lower plate portion 26 may be provided with a refrigerant discharge pipe 27 in the central portion in the Y-axis direction. The refrigerant discharge pipe 27 is formed in a linear shape extending in the Z-axis direction. The upper end of the refrigerant discharge pipe 27 is connected to the lower plate portion 26, and the lower end of the refrigerant discharge pipe 27 is disposed below the flooded-type heat transfer pipe group 14. The upper end of the refrigerant discharge pipe 27 is open on the upper surface of the lower plate portion 26.

[0037]

With such a configuration, the refrigerant stored on the upper surface of the lower plate portion 26 is guided to the lower side of the flooded-type heat transfer pipe group 14 via the refrigerant discharge pipe 27. Accordingly, the refrigerant on the upper surface of the lower plate portion 26 can be guided to the storage portion 11c. As a result, the refrigerant that is not supplied to each heat transfer pipe group can be reduced, and thus the performance of the evaporator 10 can be improved.

[0038]

In addition, the refrigerant on the upper surface of the lower plate portion 26 is guided to the lower side of

the flooded-type heat transfer pipe group 14. As a result, the refrigerant guided from the upper surface of the lower plate portion 26 to the storage portion 11c can be made unlikely to interfere with the refrigerant evaporating in the flooded-type heat transfer pipe group 14 and heading for the liquid surface S. Accordingly, heat exchange can be suitably performed in the flooded-type heat transfer pipe group 14, and thus the performance of the evaporator 10 can be improved.

[0039]

[Modification Example 2]

In addition, as in a lower plate portion 31 illustrated in Fig. 5, the lower plate portion may have the same shape as the lower plate portion 26 illustrated in Modification Example 1 and a plurality of through-holes penetrating the lower plate portion from the upper surface to the lower surface. With such a configuration, the refrigerant that has fallen to the lower plate portion 31 is guided to the storage portion 11c through the through-holes. Accordingly, it is possible to make the refrigerant unlikely to be stored on the upper surface of the lower plate portion 31. Accordingly, the refrigerant that is not supplied to each heat transfer pipe group can be reduced, and thus the performance of the evaporator 10 can be improved. It should be noted that the lower plate

portion 31 may be formed of a wire mesh instead of forming the plurality of through-holes.

[0040]

[Modification Example 3]

In addition, as in a lower plate portion 36 illustrated in Fig. 6, the lower plate portion may be a dish-shaped member integrally having a flat plate-shaped bottom surface portion 36a and inclined portions 36b bent and extending diagonally upward from both end portions of the bottom surface portion 36a in the Y-axis direction. In addition, the lower plate portion 36 may be provided with a plurality of (three as an example in the present embodiment) refrigerant discharge pipes 37 on the bottom surface portion 36a. The plurality of refrigerant discharge pipes 37 are disposed side by side in the Y-axis direction. The upper end of the refrigerant discharge pipe 37 is connected to the lower plate portion 36, and the lower end of the refrigerant discharge pipe 37 is disposed below the flooded-type heat transfer pipe group 14.

[0041]

With such a configuration, the refrigerant stored on the upper surface of the lower plate portion 36 is guided to the lower side of the flooded-type heat transfer pipe group 14 via the refrigerant discharge pipe 37.

Accordingly, the refrigerant on the upper surface of the lower plate portion 36 can be guided to the storage portion 11c. As a result, the refrigerant that is not supplied to each heat transfer pipe group can be reduced, and thus the performance of the evaporator 10 can be improved.

[0042]

[Modification Example 4]

In addition, as in a lower plate portion 41 illustrated in Fig. 7, the lower plate portion may have the same shape as the lower plate portion 31 illustrated in Modification Example 2 and a plurality of through-holes penetrating the lower plate portion from the upper surface to the lower surface. With such a configuration, the refrigerant that has fallen to the lower plate portion 41 is guided to the storage portion 11c through the through-holes. Accordingly, it is possible to make the refrigerant unlikely to be stored on the upper surface of the lower plate portion 41. Accordingly, the refrigerant that is not supplied to each heat transfer pipe group can be reduced, and thus the performance of the evaporator 10 can be improved. It should be noted that the lower plate portion 41 may be formed of a wire mesh instead of forming the plurality of through-holes.

[0043]

[Third Embodiment]

Next, the evaporator according to a third embodiment of the present disclosure will be described with reference to Fig. 8.

An evaporator 50 according to the present embodiment is different from the first embodiment in that a pressure loss increasing portion is provided instead of the baffle plate 17. The embodiments are similar to each other as to the other points, and thus similar configurations will be denoted by the same reference numerals with detailed description thereof omitted.

[0044]

As illustrated in Fig. 8, the evaporator 50 is provided with a pair of lower end side plate portions (pressure loss increasing portions) 51 disposed on both sides of the lower end portion of the liquid film-type heat transfer pipe group 15. The pair of lower end side plate portions 51 are disposed to sandwich the lower end portion of the liquid film-type heat transfer pipe group 15. In other words, the pair of lower end side plate portions 51 cover the liquid film-type heat transfer pipe group 15 from the Y-axis direction. The pair of lower end side plate portions 51 increase the pressure loss of the route passing through the region where the lower end portion of the liquid film-type heat transfer pipe group

15 is disposed (hereinafter, referred to as "lower end region P"). Each lower end side plate portion 51 is a flat plate-shaped member. It should be noted that the lower end side plate portion 51 may be formed with a plurality of through-holes penetrating the lower end side plate portion 51 in the plate thickness direction. In addition, the lower end side plate portion 51 may be formed of a wire mesh instead of forming the plurality of through-holes.

[0045]

The length of the lower end side plate portion 51 in the Z-axis direction is half or less of the length of the liquid film-type heat transfer pipe group 15 in the Z-axis direction. In other words, a wide gap is formed between the upper side of the lower end side plate portion 51 and the blow-up prevention plate 18.

The pair of lower end side plate portions 51 extend over substantially the entire area of the pressure vessel 11 in the X-axis direction along the liquid film-type heat transfer pipe group 15. It should be noted that the pair of lower end side plate portions 51 may be provided only at a part in the X-axis direction.

[0046]

The action and effect of the present embodiment are as follows.

In the present embodiment, the pair of lower end side plate portions 51 are provided as pressure loss increasing portions increasing the pressure loss in the lower end region P. The pair of lower end side plate portions 51 cover the lower end portion of the liquid film-type heat transfer pipe group 15 from both sides. As a result, the pressure loss in the lower end region P can be increased, and thus it is difficult, as indicated by the broken-line arrow in Fig. 10, for the refrigerant evaporated by the flooded-type heat transfer pipe group 14 and heading for the refrigerant outlet pipe 16 from the liquid surface S to flow into the lower end region P. Accordingly, it is possible to make it difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group 14 to reach the liquid film-type heat transfer pipe group 15. Accordingly, it is possible to suppress a situation in which the refrigerant supplied to the liquid film-type heat transfer pipe group 15 is scattered by the refrigerant evaporated in the flooded-type heat transfer pipe group 14, and thus the environment around the liquid film-type heat transfer pipe group 15 can be made suitable for heat exchange. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group 15 can be improved and the performance of the evaporator 10 can be improved.

[0047]

[Modification Example 5]

In addition, as illustrated in Fig. 9, instead of the pair of lower end side plate portions 51, a plurality of dummy pipes 56 may be provided as pressure loss increasing portions on both sides of the lower end portion of the liquid film-type heat transfer pipe group 15. The inner portion of the dummy pipe 56 is a cavity, and no fluid or the like circulates through the inner portion. The plurality of dummy pipes 56 are disposed such that the distance between the adjacent dummy pipes 56 is shorter than the distance between the adjacent liquid film heat transfer pipes 15a. As a result of the disposition, the pressure loss of the flow path passing between the dummy pipes 56 can be increased. Accordingly, the pressure loss in the lower end region P can be increased.

It should be noted that a fluid such as water may be circulated in the dummy pipe 56. With such a configuration, heat exchange with the refrigerant can be performed also in the dummy pipe 56, and thus the heat exchange efficiency can be improved. Accordingly, the performance of the evaporator 10 can be improved.

[0048]

[Fourth Embodiment]

Next, the evaporator according to a fourth embodiment of the present disclosure will be described with reference to Fig. 10.

An evaporator 60 according to the present embodiment is different from the first embodiment in that a rectification portion is provided instead of the baffle plate 17. The embodiments are similar to each other as to the other points, and thus similar configurations will be denoted by the same reference numerals with detailed description thereof omitted.

[0049]

As illustrated in Fig. 10, the evaporator 60 is provided with a pair of lower side plate portions (rectification portions) 61 disposed on both sides of the lower portion of the liquid film-type heat transfer pipe group 15. The pair of lower side plate portions 61 are disposed to sandwich the lower portion of the liquid film-type heat transfer pipe group 15. In other words, the pair of lower side plate portions 61 cover the liquid film-type heat transfer pipe group 15 from the Y-axis direction. The pair of lower side plate portions 61 guide the refrigerant evaporated in the flooded-type heat transfer pipe group 14 to the refrigerant outlet pipe 16. In other words, the refrigerant evaporated in the flooded-type heat transfer pipe group 14 flowing into the region

where the liquid film-type heat transfer pipe group 15 is provided is suppressed.

Each lower side plate portion 61 is a flat plate-shaped member. In addition, each lower side plate portion 61 is disposed so as to have a vertical plate surface. It should be noted that the lower side plate portion 61 may be formed with a plurality of through-holes penetrating the lower side plate portion 61 in the plate thickness direction. In addition, the lower end side plate portion 51 may be formed of a wire mesh instead of forming the plurality of through-holes.

[0050]

The length of the lower side plate portion 61 in the Z-axis direction is half or less of the length of the liquid film-type heat transfer pipe group 15 in the Z-axis direction. In other words, a wide gap is formed between the upper side of the lower side plate portion 61 and the blow-up prevention plate 18. It should be noted that the lower portion of the liquid film-type heat transfer pipe group 15 may be below the central portion of the liquid film-type heat transfer pipe group 15 in the Z-axis direction.

The pair of lower side plate portions 61 extend over substantially the entire area of the pressure vessel 11 in the X-axis direction along the liquid film-type heat

transfer pipe group 15. It should be noted that the pair of lower side plate portions 61 may be provided only at a part in the X-axis direction.

In addition, as illustrated in Fig. 11, each lower side plate portion 61 may be inclined with respect to a vertical plane such that the lower end thereof is positioned inside in the Y-axis direction.

[0051]

The action and effect of the present embodiment are as follows.

In the present embodiment, the pair of lower side plate portions 61 are provided as rectification portions guiding the refrigerant evaporated in the flooded-type heat transfer pipe group 14 to the refrigerant outlet pipe 16. The pair of lower side plate portions 61 cover the lower portion of the liquid film-type heat transfer pipe group 15 from both sides. As a result, the refrigerant evaporating in the flooded-type heat transfer pipe group 14 and heading for the liquid film-type heat transfer pipe group 15 from the side is guided to the refrigerant outlet pipe 16 by the pair of lower side plate portions 61 as indicated by the broken-line arrow in Fig. 10. Accordingly, it is possible to make it difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group 14 to reach the liquid film-type heat transfer

pipe group 15. Accordingly, it is possible to suppress a situation in which the refrigerant supplied to the liquid film-type heat transfer pipe group 15 is scattered by the refrigerant evaporated in the flooded-type heat transfer pipe group 14, and thus the environment around the liquid film-type heat transfer pipe group 15 can be made suitable for heat exchange. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group 15 can be improved and the performance of the evaporator 10 can be improved.

In addition, the lower side plate portions 61 are disposed to sandwich the lower portion of the liquid film-type heat transfer pipe group 15, and thus the refrigerant rising from the liquid surface S can be guided to the refrigerant outlet pipe 16 relatively early. Accordingly, it is possible to make it more difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group 14 to reach the liquid film-type heat transfer pipe group 15.

[0052]

[Modification Example 6]

In addition, as illustrated in Fig. 12, instead of the pair of lower side plate portions 61, a plurality of dummy pipes 66 may be provided as rectification portions on both sides of the lower portion of the liquid film-type

heat transfer pipe group 15. The inner portion of the dummy pipe 66 is a cavity, and no fluid or the like circulates through the inner portion. The plurality of dummy pipes 66 are disposed such that the distance between the adjacent dummy pipes 66 is shorter than the distance between the adjacent liquid film heat transfer pipes 15a. As a result of the disposition, the pressure loss of the flow path passing between the dummy pipes 66 can be increased. Accordingly, the refrigerant evaporated in the flooded-type heat transfer pipe group 14 flowing into the region where the liquid film-type heat transfer pipe group 15 is provided can be suppressed.

It should be noted that a fluid such as water may be circulated in the dummy pipe 66. With such a configuration, heat exchange with the refrigerant can be performed also in the dummy pipe 66, and thus the heat exchange efficiency can be improved. Accordingly, the performance of the evaporator 10 can be improved.

[0053]

[Fifth Embodiment]

Next, the evaporator according to a fifth embodiment of the present disclosure will be described with reference to Figs. 13 and 14.

An evaporator 70 according to the present embodiment is different from the first embodiment in that a cross

plate portion is provided instead of the baffle plate 17. The embodiments are similar to each other as to the other points, and thus similar configurations will be denoted by the same reference numerals with detailed description thereof omitted. It should be noted that in Fig. 13, for the sake of illustration, the pressure vessel 11, the flooded-type heat transfer pipe group 14, and so on are omitted. In addition, in Fig. 13, for the sake of illustration, the liquid film heat transfer pipes 15a are collectively illustrated as the liquid film-type heat transfer pipe group 15 without being illustrated one by one.

[0054]

As illustrated in Figs. 13 and 14, the evaporator 70 is provided with a plurality of (three as an example in the present embodiment) cross plate portions 71 disposed to intersect the X-axis direction on both sides of the liquid film-type heat transfer pipe group 15 in the Y-axis direction. The plurality of cross plate portions 71 are disposed side by side at predetermined intervals in the X-axis direction. The length of the cross plate portion 71 in the Z-axis direction is substantially equal to the length of the liquid film-type heat transfer pipe group 15 in the Z-axis direction. Each cross plate portion 71 is formed of a flat plate-shaped member.

[0055]

The action and effect of the present embodiment are as follows.

The refrigerant outlet pipe 16 is provided in the end portion of the pressure vessel 11 in the X-axis direction. Accordingly, the refrigerant evaporated in the flooded-type heat transfer pipe group 14 and the liquid film-type heat transfer pipe group 15 is guided to the refrigerant outlet pipe 16 while moving in the X-axis direction. For example, in a case where the cross plate portion 71 is not provided, the refrigerant evaporated in the liquid film-type heat transfer pipe group 15 moves along the X-axis direction with little rise up to the region below the refrigerant outlet pipe 16 and merges in the region below the refrigerant outlet pipe 16 to rise sharply. Accordingly, the flow speed of the refrigerant rising toward the refrigerant outlet pipe 16 increases.

Meanwhile, in the present embodiment, the cross plate portion 71 disposed to intersect the X-axis direction is provided on the side of the liquid film-type heat transfer pipe group 15. In other words, the space formed in the pressure vessel 11 is divided into a plurality of spaces in the X-axis direction by the cross plate portion 71. As a result, as indicated by the broken-line arrows in Figs. 13 and 14, the refrigerant

evaporated in the liquid film-type heat transfer pipe group 15 moves upward in each divided space. Accordingly, it is possible to suppress a sharp rise of the refrigerant in the region below the refrigerant outlet pipe 16. Accordingly, carryover can be made unlikely to occur.

[0056]

In addition, in the present embodiment, the cross plate portion 71 is capable of increasing the pressure loss with respect to the movement of the refrigerant in the X-axis direction. Accordingly, the flow speed of the refrigerant can be reduced, and thus carryover can be made unlikely to occur.

[0057]

It should be noted that the cross plate portion is not limited to the structure described above. As in a cross plate portion 76 of Fig. 15, a plurality of through-holes penetrating the cross plate portion in the plate thickness direction may be formed. In addition, the lower end side plate portion 51 may be formed of a wire mesh instead of forming the plurality of through-holes. With such a configuration, it is possible to reduce the flow speed of the refrigerant while ensuring the movement of the refrigerant in the X-axis direction.

[0058]

It should be noted that the present disclosure is not limited to the above embodiments and can be appropriately modified without departing from the gist thereof.

[0059]

For example, the present disclosure is not limited to the embodiments described as examples in which the refrigerant tray is used as a device supplying a refrigerant to the liquid film-type heat transfer pipe group or the like. The refrigerant supply device may be any structure capable of supplying a refrigerant to the liquid film-type heat transfer pipe group and may be, for example, a pipe-shaped member extending along the X-axis direction.

For example, the present disclosure is not limited to the embodiments described as examples in which the refrigerant outlet pipe 16 is provided on the upper portion of the pressure vessel 11. For example, the refrigerant outlet pipe 16 may be provided on the side portion of the pressure vessel 11. In addition, the refrigerant outlet pipe 16 may be provided on the lower portion of the pressure vessel 11.

In addition, for example, the above embodiments may be mutually combined.

[0060]

The evaporator described in the present embodiment described above is, for example, grasped as follows.

An evaporator (10) according to one aspect of the present disclosure includes: a housing provided with a refrigerant outlet (16) discharging an evaporated refrigerant to an outside; a liquid film-type heat transfer pipe group (15) accommodated in the housing and having a plurality of liquid film heat transfer pipes (15a) in which a medium to be cooled circulates; a refrigerant supply unit (13) accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group; a side plate portion (17) covering the liquid film-type heat transfer pipe group from a side; and an upper plate portion (18) covering the liquid film-type heat transfer pipe group from above, in which a gap (G) is formed between the side plate portion and the upper plate portion.

[0061]

In the above configuration, the side plate portion covers the liquid film-type heat transfer pipe group from the side. In addition, the upper plate portion covers the liquid film-type heat transfer pipe group from above. In other words, the side plate portion and the upper plate portion form a space where the liquid film-type heat transfer pipe group is provided (hereinafter, referred to

as "inside space"). In addition, the side plate portion and the upper plate portion separate the inside space from the space formed outside the inside space (hereinafter, referred to as "outside space"). In the above configuration, the gap is formed between the upper plate portion and the side plate portion. In other words, the gap connects the inside space and the outside space. In the above configuration, the refrigerant evaporates when the refrigerant is supplied from the refrigerant supply unit to the liquid film-type heat transfer pipe group. When the refrigerant evaporates, the evaporated refrigerant diffuses in the inside space. A part of the diffused refrigerant passes through the gap formed between the upper plate portion and the side plate portion and moves to the outside space. As a result, it is possible to suppress a rise in pressure in the inside space as compared with a case where the gap is not formed. Accordingly, the environment around the liquid film-type heat transfer pipe group can be made suitable for heat exchange, and thus the heat exchange efficiency of the liquid film-type heat transfer pipe group can be improved. Accordingly, the performance of the evaporator can be improved.

In addition, since it is possible to suppress a rise in pressure in the inside space, it is possible to

suppress a situation in which the flow speed of the vaporized refrigerant increases at the lower end of the inside space (that is, in the vicinity of the lower end of the side plate portion). As a result, a phenomenon in which the gas-phase refrigerant discharged to the outside of the housing accompanies a liquid-phase refrigerant (so-called carryover) can be made unlikely to occur.

In addition, a part of the refrigerant supplied from the refrigerant supply unit vaporizes before reaching the liquid film-type heat transfer pipe group due to a decrease in pressure. In the above configuration, the vaporized refrigerant (hereinafter, referred to as "flash gas") easily moves to the outside space through the gap formed between the upper plate portion and the side plate portion. Accordingly, a rise in pressure in the inside space attributable to the flash gas can be suppressed. In addition, the flash gas is discharged from the inside space, and thus the liquid-phase refrigerant supplied to the liquid film-type heat transfer pipe group without vaporizing is not easily affected by the flash gas. Accordingly, the refrigerant can be accurately supplied to the liquid film heat transfer pipe.

[0062]

In addition, the evaporator according to one aspect of the present disclosure further includes a flooded-type

heat transfer pipe group (14) accommodated in the housing, immersed in a liquid-phase refrigerant stored in a lower portion of the housing, and having a plurality of flooding heat transfer pipes (14a) in which a medium to be cooled circulates, in which the liquid film-type heat transfer pipe group (15) is provided above a liquid surface (S) of the liquid-phase refrigerant stored in the lower portion of the housing.

[0063]

In the above configuration, a part of the refrigerant evaporated in the flooded-type heat transfer pipe group is also capable of heading for the refrigerant outlet through the gap formed between the upper plate portion and the side plate portion. As a result, it is possible to suppress a rise in pressure in the inside space.

[0064]

In addition, in the evaporator according to one aspect of the present disclosure, the refrigerant outlet is provided above a lower end of the side plate portion.

[0065]

In the above configuration, the refrigerant outlet is provided above the lower end of the side plate portion. In the evaporator having such a structure, the refrigerant evaporating in the liquid film-type heat transfer pipe

group and heading for the refrigerant outlet is easily blocked by the side plate portion and the upper plate portion. Accordingly, the evaporated refrigerant easily stays in the inside space, and thus and the pressure in the internal space easily rises.

In the above configuration, the gap is formed between the side plate portion and the upper plate portion, and thus the refrigerant evaporated in the liquid film-type heat transfer pipe group is capable of moving to the outside space through the gap. As a result, it is possible to make it difficult for the refrigerant to stay in the inside space. Accordingly, it is possible to more suitably suppress a rise in pressure in the inside space. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group can be more suitably improved and the performance of the evaporator can be more suitably improved.

[0066]

In addition, in the evaporator according to one aspect of the present disclosure, the refrigerant supply unit is provided above the liquid film-type heat transfer pipe group, and the side plate portion covers an upper portion of the liquid film-type heat transfer pipe group from a side.

[0067]

In the above configuration, the refrigerant supply unit is provided above the liquid film-type heat transfer pipe group. In the evaporator having such a structure, the flash gas easily stays in the inside space, and thus and the pressure in the internal space easily rises.

In the above configuration, the gap is formed between the side plate portion and the upper plate portion, and thus the flash gas is capable of moving to the outside space through the gap. As a result, it is possible to make it difficult for the refrigerant to stay in the inside space. Accordingly, it is possible to more suitably suppress a rise in pressure in the inside space. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group can be more suitably improved and the performance of the evaporator can be more suitably improved.

[0068]

In addition, an evaporator (20) according to one aspect of the present disclosure includes: a housing (11) having a refrigerant outlet (16) discharging an evaporated refrigerant to an outside and forming an outer shell; a flooded-type heat transfer pipe group (14) accommodated in the housing, immersed in a liquid-phase refrigerant stored in a lower portion of the housing, and having a plurality of flooding heat transfer pipes (14a) in which a medium to

be cooled circulates; a liquid film-type heat transfer pipe group (15) accommodated in the housing, provided above a liquid surface (S) of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of liquid film heat transfer pipes (15a) in which a medium to be cooled circulates; a refrigerant supply unit (13) accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group; and a lower plate portion (21) provided between the liquid film-type heat transfer pipe group and the liquid surface.

[0069]

In the above configuration, the lower plate portion is provided between the liquid film-type heat transfer pipe group and the liquid surface. As a result, the refrigerant evaporated by the flooded-type heat transfer pipe group and heading for the liquid film-type heat transfer pipe group from the liquid surface is blocked by the lower plate portion. Accordingly, it is possible to make it difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group to reach the liquid film-type heat transfer pipe group. Accordingly, it is possible to suppress a situation in which the refrigerant supplied to the liquid film-type heat transfer pipe group is scattered by the refrigerant evaporated in the flooded-

type heat transfer pipe group, and thus the environment around the liquid film-type heat transfer pipe group can be made suitable for heat exchange. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group can be improved and the performance of the evaporator can be improved.

In addition, in the above configuration, it is possible to suppress a situation in which the refrigerant supplied to the liquid film-type heat transfer pipe group is scattered by the refrigerant evaporated in the flooded-type heat transfer pipe group. As a result, a phenomenon in which the gas-phase refrigerant flowing toward the refrigerant outlet accompanies a liquid-phase refrigerant (so-called carryover) can be made unlikely to occur.

[0070]

In addition, the evaporator according to one aspect of the present disclosure further includes a refrigerant discharge pipe (27) with an upper end connected to the lower plate portion and a lower end disposed below the flooded-type heat transfer pipe group, in which the lower plate portion is provided below the liquid film-type heat transfer pipe group.

[0071]

In the above configuration, the lower plate portion is provided below the liquid film-type heat transfer pipe

group. As a result, the liquid-phase refrigerant that does not completely evaporate in the liquid film-type heat transfer pipe group is stored on the upper surface of the lower plate portion. In the above configuration, the refrigerant discharge pipe is provided with the upper end connected to the lower plate portion and the lower end disposed below the flooded-type heat transfer pipe group. As a result, the refrigerant stored on the upper surface of the lower plate portion is guided to the lower side of the flooded-type heat transfer pipe group via the refrigerant discharge pipe. Accordingly, the refrigerant on the upper surface of the lower plate portion can be guided to the part where the refrigerant is stored in the lower portion of the housing (hereinafter, referred to as "storage portion"). As a result, the refrigerant that is not supplied to each heat transfer pipe group can be reduced, and thus the performance of the evaporator can be improved.

In addition, the refrigerant on the upper surface of the lower plate portion is guided to the lower side of the flooded-type heat transfer pipe group. As a result, the refrigerant guided from the upper surface of the lower plate portion to the storage portion can be made unlikely to interfere with the refrigerant evaporating in the

flooded-type heat transfer pipe group and heading for the liquid surface.

[0072]

In addition, in the evaporator according to one aspect of the present disclosure, the lower plate portion has a hole penetrating the lower plate portion from an upper surface to a lower surface.

[0073]

In the above configuration, the lower plate portion has the hole penetrating the lower plate portion from the upper surface to the lower surface. As a result, the refrigerant that has fallen to the lower plate portion without completely evaporating in the liquid film-type heat transfer pipe group is guided to the storage portion below the lower plate portion through the hole. Accordingly, it is possible to make it difficult for the refrigerant to be stored on the upper surface of the lower plate portion. Accordingly, the refrigerant that is not guided to the liquid film-type heat transfer pipe group can be reduced, and thus the performance of the evaporator can be improved.

[0074]

In addition, an evaporator (50) according to one aspect of the present disclosure includes: a housing (11) provided with a refrigerant outlet (16) discharging an

evaporated refrigerant to an outside and forming an outer shell; a flooded-type heat transfer pipe group (14) accommodated in the housing, immersed in a liquid-phase refrigerant stored in a lower portion of the housing, and having a plurality of flooding heat transfer pipes (14a) in which a medium to be cooled circulates; a liquid film-type heat transfer pipe group (15) accommodated in the housing, provided above a liquid surface (S) of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of liquid film heat transfer pipes (15a) in which a medium to be cooled circulates; a refrigerant supply unit (13) accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group; and a pressure loss increasing portion (51) disposed on a side of a lower end portion of the liquid film-type heat transfer pipe group and increasing pressure in a region where the lower end portion of the liquid film-type heat transfer pipe group is disposed.

[0075]

In the above configuration, the pressure loss increasing portion increasing the pressure in the region where the lower end portion of the liquid film-type heat transfer pipe group is disposed (hereinafter, referred to as "lower end region") is provided. As a result, the

pressure in the lower end region can be increased, and thus the refrigerant evaporated by the flooded-type heat transfer pipe group and heading for the liquid film-type heat transfer pipe group from the liquid surface does not easily flow into the lower end region. Accordingly, it is possible to make it difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group to reach the liquid film-type heat transfer pipe group. Accordingly, it is possible to suppress a situation in which the refrigerant supplied to the liquid film-type heat transfer pipe group is scattered by the refrigerant evaporated in the flooded-type heat transfer pipe group, and thus the environment around the liquid film-type heat transfer pipe group can be made suitable for heat exchange. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group can be improved and the performance of the evaporator can be improved.

[0076]

In addition, in the evaporator according to one aspect of the present disclosure, the pressure loss increasing portion has a pair of lower end side plate portions (51) disposed to sandwich the lower end portion of the liquid film-type heat transfer pipe group and covering the liquid film-type heat transfer pipe group from a side.

[0077]

In the above configuration, the pair of lower end side plate portions cover the lower end portion of the liquid film-type heat transfer pipe group from both sides. As a result, the pressure in the lower end region can be increased more than in another region. Accordingly, it is possible to make it difficult for the refrigerant evaporated by the flooded-type heat transfer pipe group and heading for the liquid film-type heat transfer pipe group from the liquid surface to flow into the lower end region. Accordingly, it is possible to make it difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group to reach the liquid film-type heat transfer pipe group.

[0078]

In addition, an evaporator (60) according to one aspect of the present disclosure includes: a housing (11) provided with a refrigerant outlet (16) discharging an evaporated refrigerant to an outside and forming an outer shell; a flooded-type heat transfer pipe group (14) accommodated in the housing, immersed in a liquid-phase refrigerant stored in a lower portion of the housing, and having a plurality of flooding heat transfer pipes (14a) in which a medium to be cooled circulates; a liquid film-type heat transfer pipe group (15) accommodated in the

housing, provided above a liquid surface (S) of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of liquid film heat transfer pipes (15a) in which a medium to be cooled circulates; a refrigerant supply unit (13) accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group; and a rectification portion (61) disposed to sandwich a lower portion of the liquid film-type heat transfer pipe group and guiding a refrigerant evaporated in the flooded-type heat transfer pipe group to the refrigerant outlet.

[0079]

In the above configuration, the rectification portions guiding the refrigerant evaporated in the flooded-type heat transfer pipe group to the refrigerant outlet are provided on both sides of the liquid film-type heat transfer pipe group. As a result, the refrigerant evaporating in the flooded-type heat transfer pipe group and heading for the liquid film-type heat transfer pipe group from the side is guided to the refrigerant outlet by the rectification portion. Accordingly, it is possible to make it difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group to reach the liquid film-type heat transfer pipe group. Accordingly, it is possible to suppress a situation in which the refrigerant

supplied to the liquid film-type heat transfer pipe group is scattered by the refrigerant evaporated in the flooded-type heat transfer pipe group, and thus the environment around the liquid film-type heat transfer pipe group can be made suitable for heat exchange. Accordingly, the heat exchange efficiency of the liquid film-type heat transfer pipe group can be improved and the performance of the evaporator can be improved.

In addition, the rectification portions are disposed to sandwich the lower portion of the liquid film-type heat transfer pipe group, and thus the refrigerant rising from the liquid surface can be guided to the refrigerant outlet relatively early. Accordingly, it is possible to make it more difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group to reach the liquid film-type heat transfer pipe group.

[0080]

In addition, in the evaporator according to one aspect of the present disclosure, the rectification portion has a pair of lower side plate portions (61) covering the liquid film-type heat transfer pipe group from both sides.

[0081]

In the above configuration, the pair of lower side plate portions cover the lower portion of the liquid film-

type heat transfer pipe group from both sides. As a result, the refrigerant evaporated in the flooded-type heat transfer pipe group and heading for the liquid film-type heat transfer pipe group from the side is blocked by the lower side plate portion. Accordingly, it is possible to make it difficult for the refrigerant evaporated in the flooded-type heat transfer pipe group to reach the liquid film-type heat transfer pipe group.

[0082]

In addition, in an evaporator (70) according to one aspect of the present disclosure, the housing extends in a predetermined direction, and a plurality of cross plate portions (71) disposed to intersect the predetermined direction are provided on the side of the liquid film-type heat transfer pipe group.

[0083]

The refrigerant evaporated in the flooded-type heat transfer pipe group and the liquid film-type heat transfer pipe group is guided to the refrigerant outlet while moving in a predetermined direction. In the above configuration, the cross plate portion disposed to intersect the predetermined direction is provided on the side of the liquid film-type heat transfer pipe group. As a result, it is possible to increase the pressure loss with respect to the movement of the refrigerant in the

predetermined direction. Accordingly, the flow speed of the refrigerant can be reduced, and thus a phenomenon in which the gas-phase refrigerant flowing toward the refrigerant outlet accompanies a liquid-phase refrigerant (so-called carryover) can be made unlikely to occur.

[Reference Signs List]

[0084]

10: evaporator

11: pressure vessel (housing)

11a: cylindrical portion

11c: storage portion

12: refrigerant inlet pipe

13: refrigerant tray (refrigerant supply unit)

14: flooded-type heat transfer pipe group

14a: flooding heat transfer pipe

15: liquid film-type heat transfer pipe group

15a: liquid film heat transfer pipe

16: refrigerant outlet pipe (refrigerant outlet)

17: baffle plate (side plate portion)

18: blow-up prevention plate (upper plate portion)

18a: flat plate portion

18b: inclined portion

20: evaporator

21: lower plate portion

26: lower plate portion

27: refrigerant discharge pipe
31: lower plate portion
36: lower plate portion
36a: bottom surface portion
36b: inclined portion
37: refrigerant discharge pipe
41: lower plate portion
50: evaporator
51: lower end side plate portion (pressure loss
increasing portion)
56: dummy pipe
60: evaporator
61: lower side plate portion (rectification portion)
66: dummy pipe
70: evaporator
71: cross plate portion
76: cross plate portion

Claims

[Claim 1]

An evaporator comprising:

a housing provided with a refrigerant outlet discharging an evaporated refrigerant to an outside and forming an outer shell;

a liquid film-type heat transfer pipe group accommodated in the housing and having a plurality of liquid film heat transfer pipes in which a medium to be cooled circulates;

a refrigerant supply unit accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group;

a side plate portion covering the liquid film-type heat transfer pipe group from a side; and

an upper plate portion covering the liquid film-type heat transfer pipe group from above,

wherein a gap is formed between the side plate portion and the upper plate portion.

[Claim 2]

The evaporator according to Claim 1, further comprising a flooded-type heat transfer pipe group accommodated in the housing, immersed in a liquid-phase refrigerant stored in a lower portion of the housing, and

having a plurality of flooding heat transfer pipes in which a medium to be cooled circulates,

wherein the liquid film-type heat transfer pipe group is provided above a liquid surface of the liquid-phase refrigerant stored in the lower portion of the housing.

[Claim 3]

The evaporator according to Claim 1 or 2, wherein the refrigerant outlet is provided above a lower end of the side plate portion.

[Claim 4]

The evaporator according to any one of Claims 1 to 3, wherein the refrigerant supply unit is provided above the liquid film-type heat transfer pipe group, and

the side plate portion covers an upper portion of the liquid film-type heat transfer pipe group from a side.

[Claim 5]

An evaporator comprising:
a housing having a refrigerant outlet discharging an evaporated refrigerant to an outside and forming an outer shell;

a flooded-type heat transfer pipe group accommodated in the housing, immersed in a liquid-phase refrigerant stored in a lower portion of the housing, and having a plurality of flooding heat transfer pipes in which a medium to be cooled circulates;

a liquid film-type heat transfer pipe group accommodated in the housing, provided above a liquid surface of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of liquid film heat transfer pipes in which a medium to be cooled circulates;

a refrigerant supply unit accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group; and

a lower plate portion provided between the liquid film-type heat transfer pipe group and the liquid surface.

[Claim 6]

The evaporator according to Claim 5, further comprising a refrigerant discharge pipe with an upper end connected to the lower plate portion and a lower end disposed below the flooded-type heat transfer pipe group,

wherein the lower plate portion is provided below the liquid film-type heat transfer pipe group.

[Claim 7]

The evaporator according to Claim 5 or 6, wherein the lower plate portion has a hole penetrating the lower plate portion from an upper surface to a lower surface.

[Claim 8]

An evaporator comprising:

a housing provided with a refrigerant outlet discharging an evaporated refrigerant to an outside and forming an outer shell;

a flooded-type heat transfer pipe group accommodated in the housing, immersed in a liquid-phase refrigerant stored in a lower portion of the housing, and having a plurality of flooding heat transfer pipes in which a medium to be cooled circulates;

a liquid film-type heat transfer pipe group accommodated in the housing, provided above a liquid surface of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of liquid film heat transfer pipes in which a medium to be cooled circulates;

a refrigerant supply unit accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group; and

a pressure loss increasing portion disposed on a side of a lower end portion of the liquid film-type heat transfer pipe group and increasing a pressure loss in a region

where the lower end portion of the liquid film-type heat transfer pipe group is disposed.

[Claim 9]

The evaporator according to Claim 8, wherein the pressure loss increasing portion has a pair of lower end side plate portions disposed to sandwich the lower end portion of the liquid film-type heat transfer pipe group and covering the liquid film-type heat transfer pipe group from a side.

[Claim 10]

An evaporator comprising:
a housing provided with a refrigerant outlet discharging an evaporated refrigerant to an outside and forming an outer shell;

a flooded-type heat transfer pipe group accommodated in the housing, immersed in a liquid-phase refrigerant stored in a lower portion of the housing, and having a plurality of flooding heat transfer pipes in which a medium to be cooled circulates;

a liquid film-type heat transfer pipe group accommodated in the housing, provided above a liquid surface of the liquid-phase refrigerant stored in the lower portion of the housing, and having a plurality of

liquid film heat transfer pipes in which a medium to be cooled circulates;

a refrigerant supply unit accommodated in the housing and supplying a liquid-phase refrigerant from above to the liquid film-type heat transfer pipe group; and

a rectification portion disposed to sandwich a lower portion of the liquid film-type heat transfer pipe group and guiding a refrigerant evaporated in the flooded-type heat transfer pipe group to the refrigerant outlet.

[Claim 11]

The evaporator according to Claim 10, wherein the rectification portion has a pair of lower side plate portions covering the liquid film-type heat transfer pipe group from both sides.

[Claim 12]

The evaporator according to any one of Claims 1 to 11, wherein the housing extends in a predetermined direction, and

a plurality of cross plate portions disposed to intersect the predetermined direction are provided on the side of the liquid film-type heat transfer pipe group.