US 20220128315A1

(19) **United States**
(12) **Patent Application Publication**
Nakamura
(10) **Pub. No.: US 2022/0128315 A1**
(43) **Pub. Date: Apr. 28, 2022**

(54) **STRUCTURE, AND METHOD FOR MANUFACTURING SAME**

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(21) Appl. No.: **17/571,436**

(22) Filed: **Jan. 7, 2022**

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2020/028557, filed on Jul. 22, 2020.

(30) **Foreign Application Priority Data**

Aug. 9, 2019 (JP) 2019-147749

Publication Classification

(51) **Int. Cl.**

F28D 15/04	(2006.01)
B23P 15/26	(2006.01)

(52) **U.S. Cl.**
CPC ***F28D 15/04*** (2013.01); *B23P 2700/09* (2013.01); ***B23P 15/26*** (2013.01)

(57) **ABSTRACT**

A structure includes: a heat insulating layer; an evaporator provided on one surface side of the heat insulating layer; a condenser provided on the other surface side of the heat insulating layer; a vapor flow path for guiding refrigerant vapor generated as a result of evaporation at the evaporator to the condenser; and a liquid refrigerant flow path for guiding a liquid refrigerant generated as a result of condensation at the condenser to the evaporator, in which the evaporator has a wick layer for evaporating the refrigerant stored on a lower portion side with heat from one surface side of the evaporator while suctioning up the refrigerant by capillarity and holding the refrigerant, and the evaporator and the condenser are installed so as to overlap by ½ or more in the direction in which the wick layer suctions up the refrigerant.

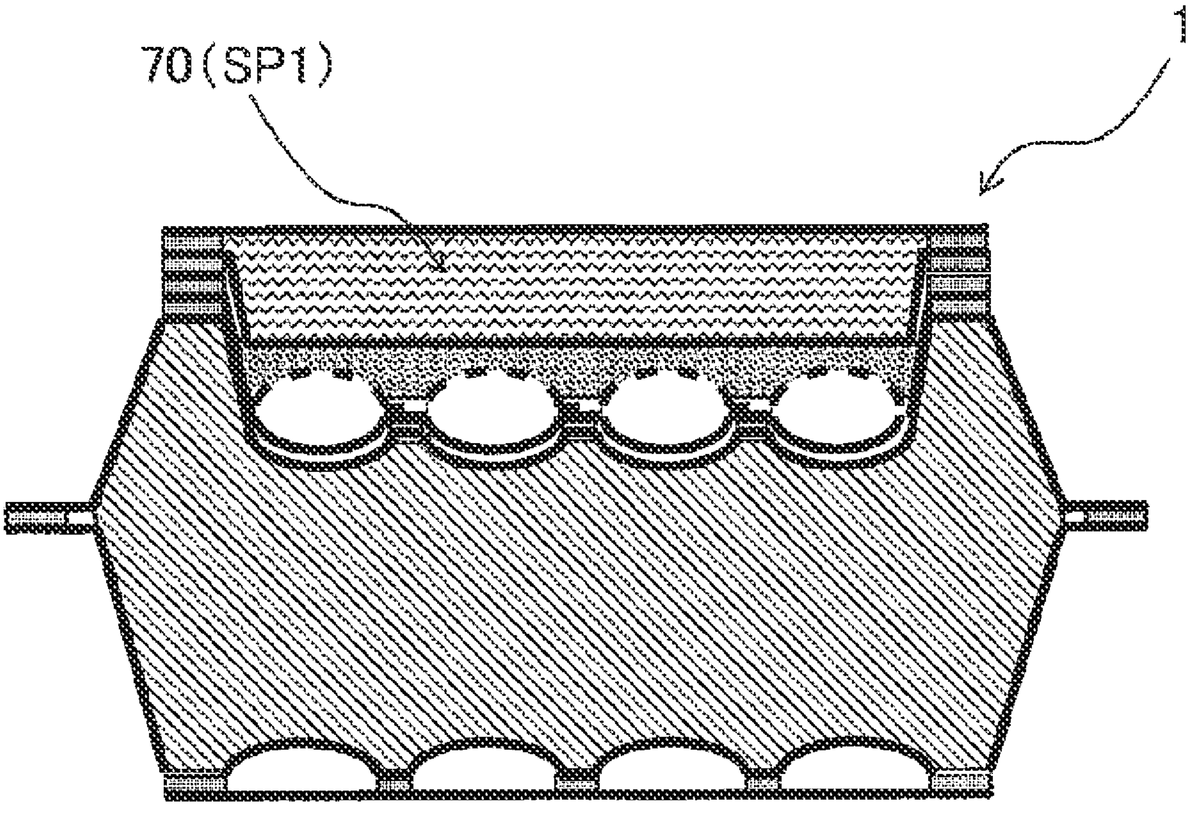
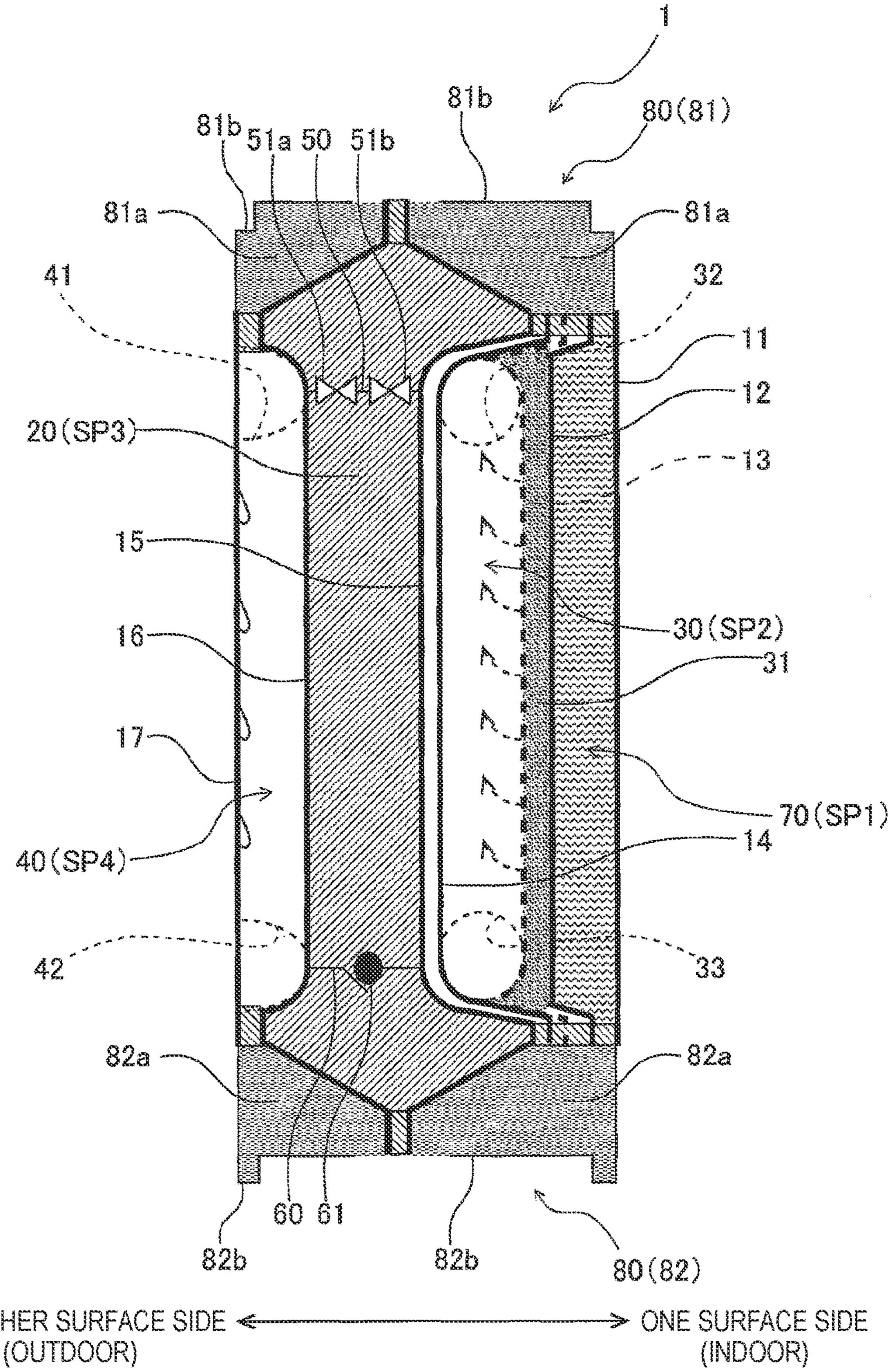


FIG. 1



THE OTHER SURFACE SIDE (OUTDOOR) ⟵⟶ ONE SURFACE SIDE (INDOOR)

FIG. 2

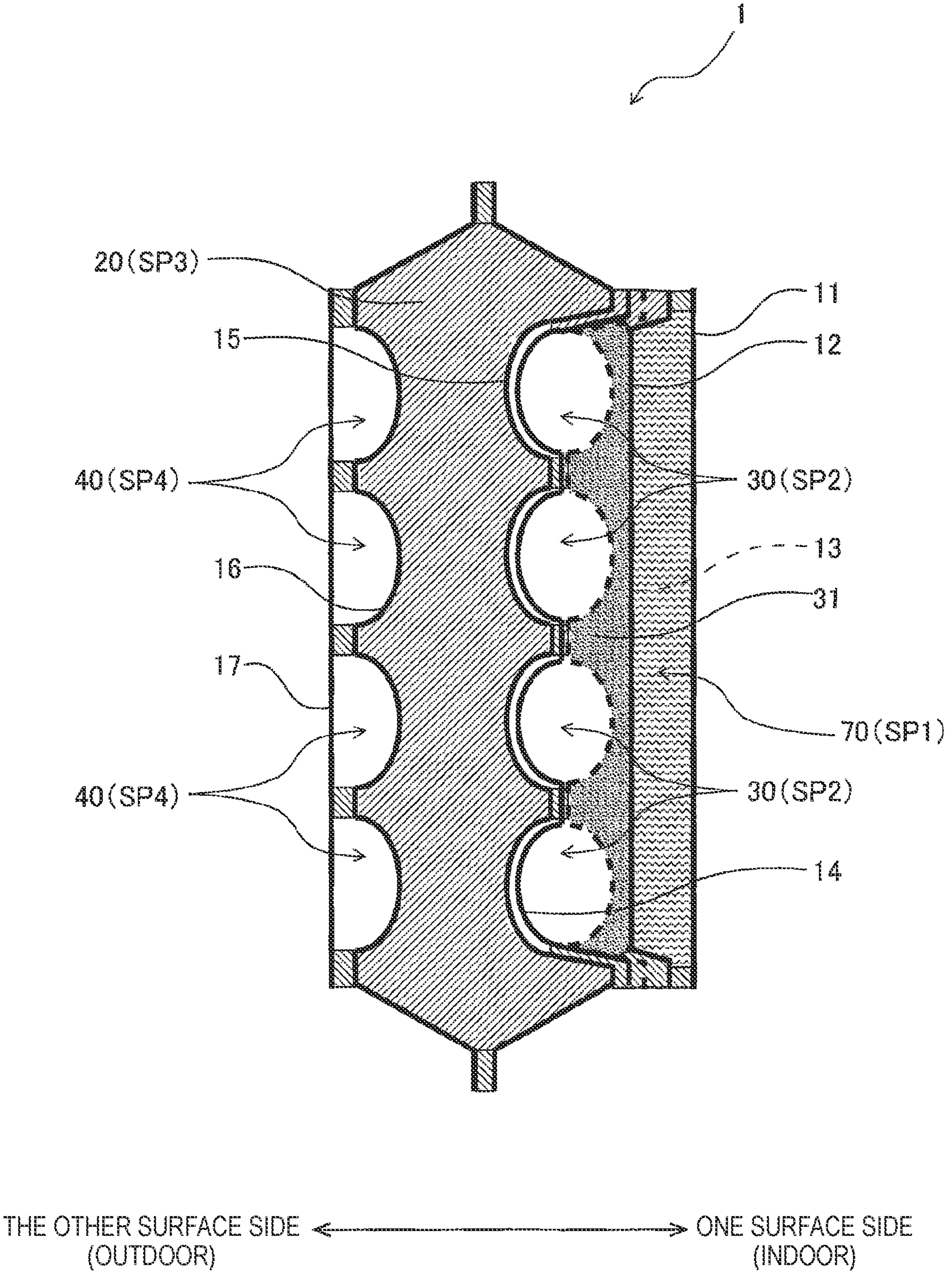

1
20(SP3)
11
15
12
40(SP4)
30(SP2)
13
16
31
17
70(SP1)
40(SP4)
30(SP2)
14
THE OTHER SURFACE SIDE
(OUTDOOR)
ONE SURFACE SIDE
(INDOOR)

FIG. 3A

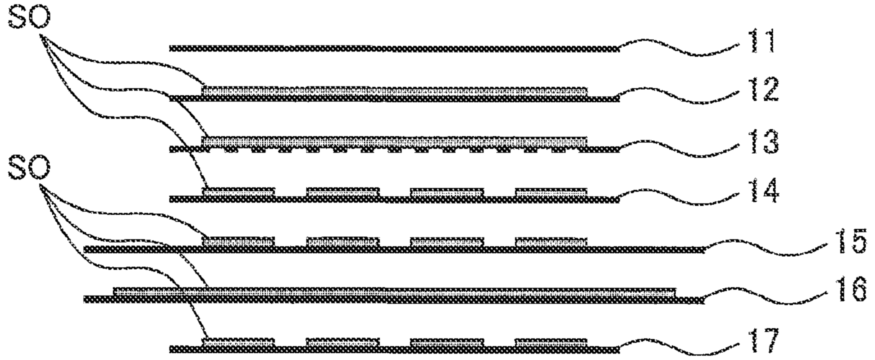


FIG. 3B

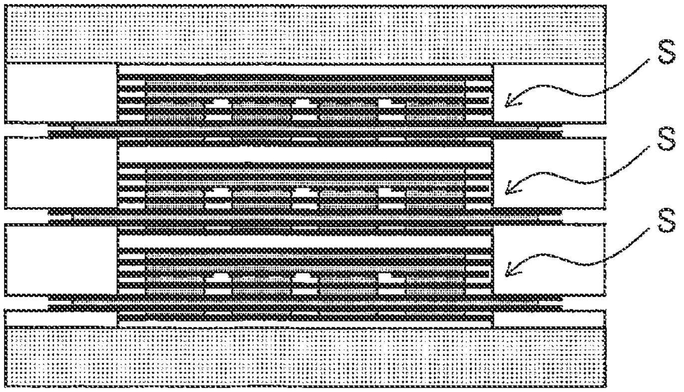


FIG. 3C

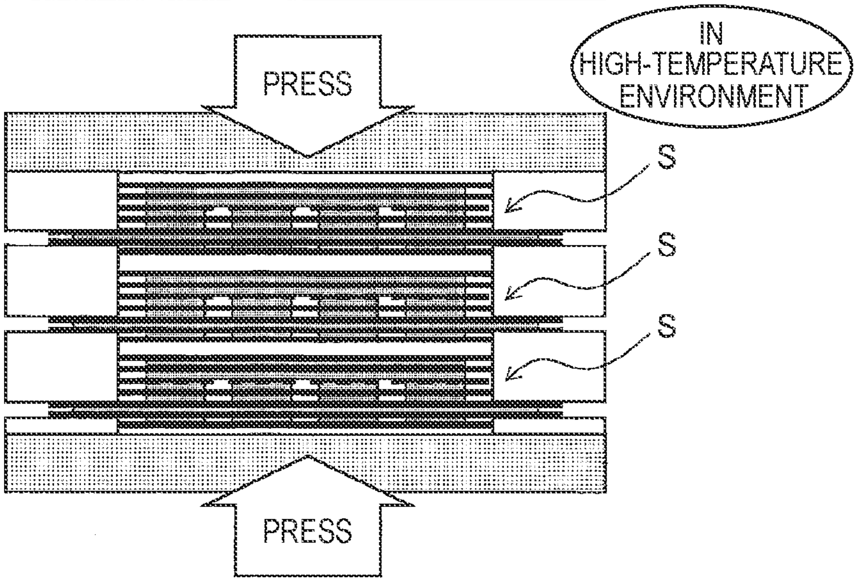


FIG. 3D

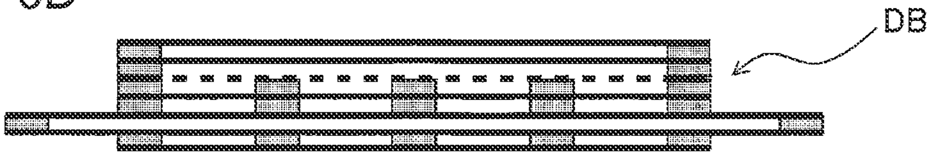


FIG. 4A

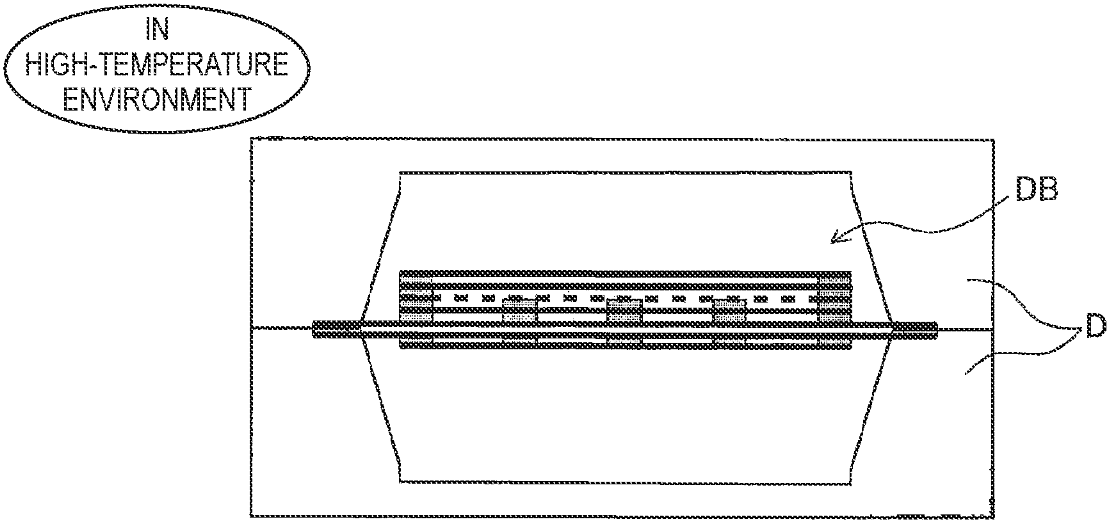


FIG. 4B

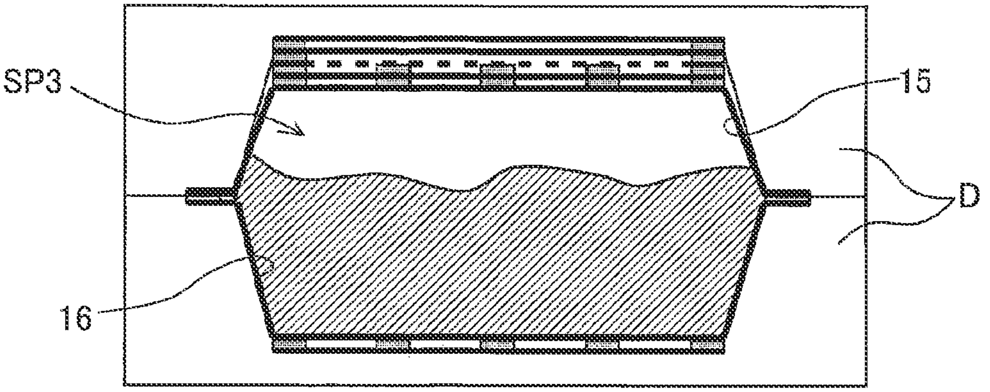


FIG. 4C

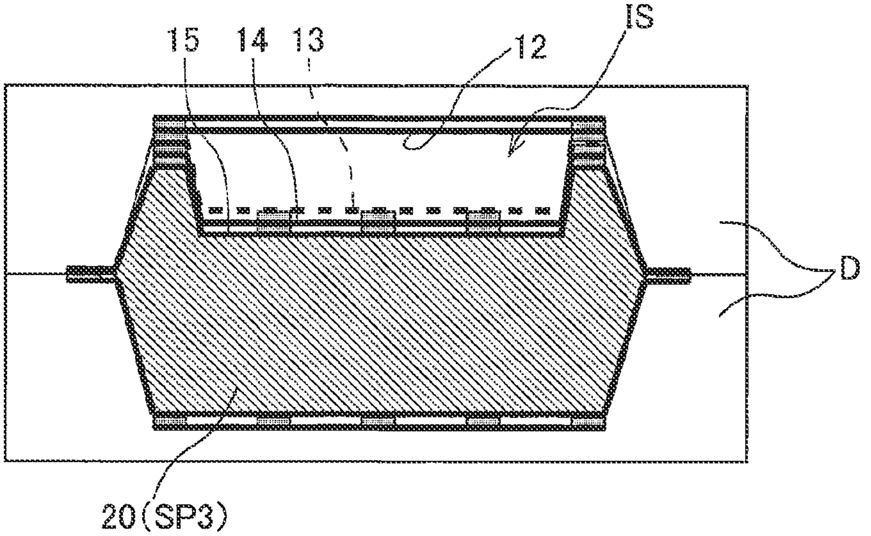


FIG. 5A

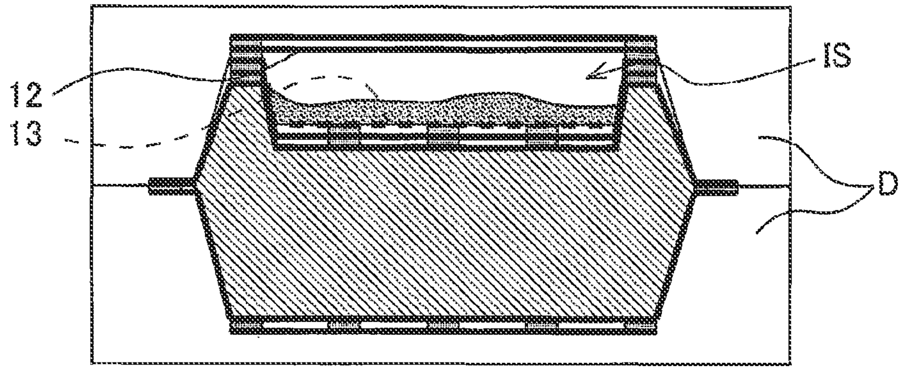


FIG. 5B

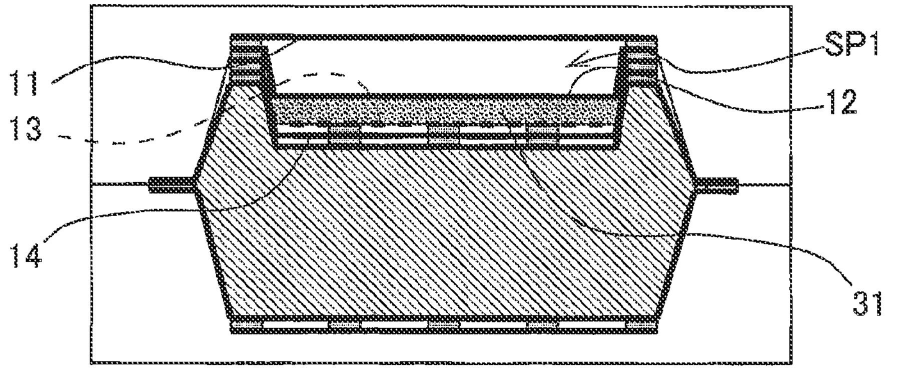


FIG. 5C

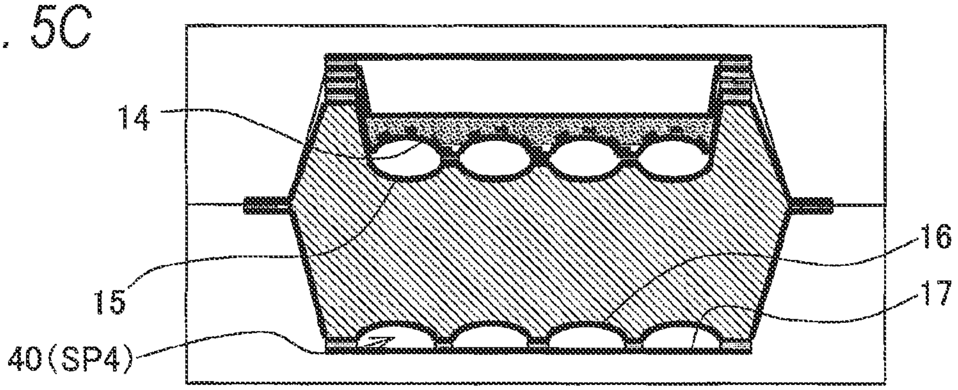


FIG. 5D

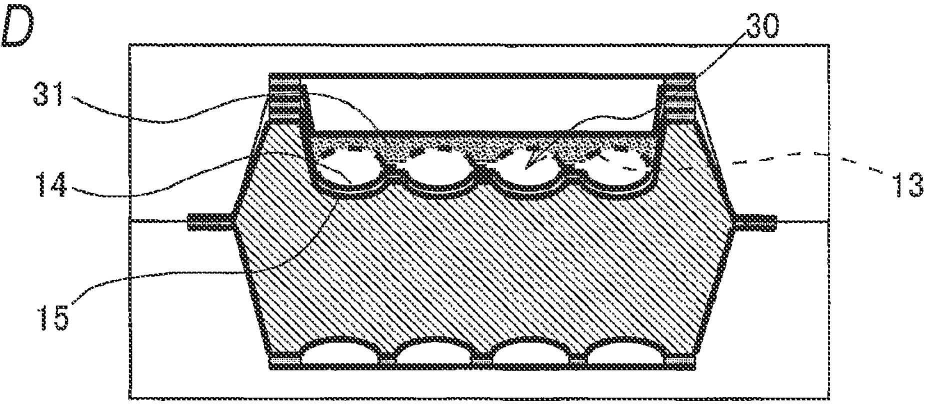


FIG. 6A

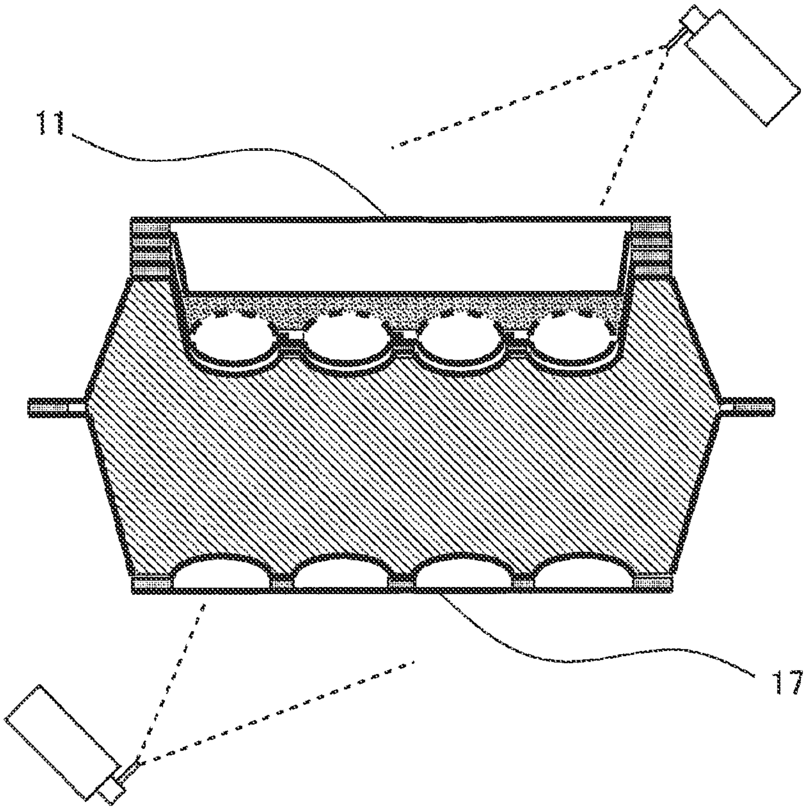


FIG. 6B

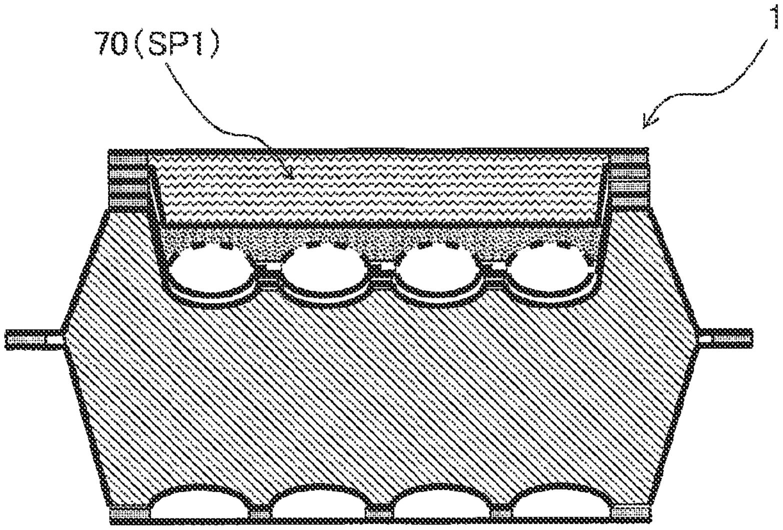
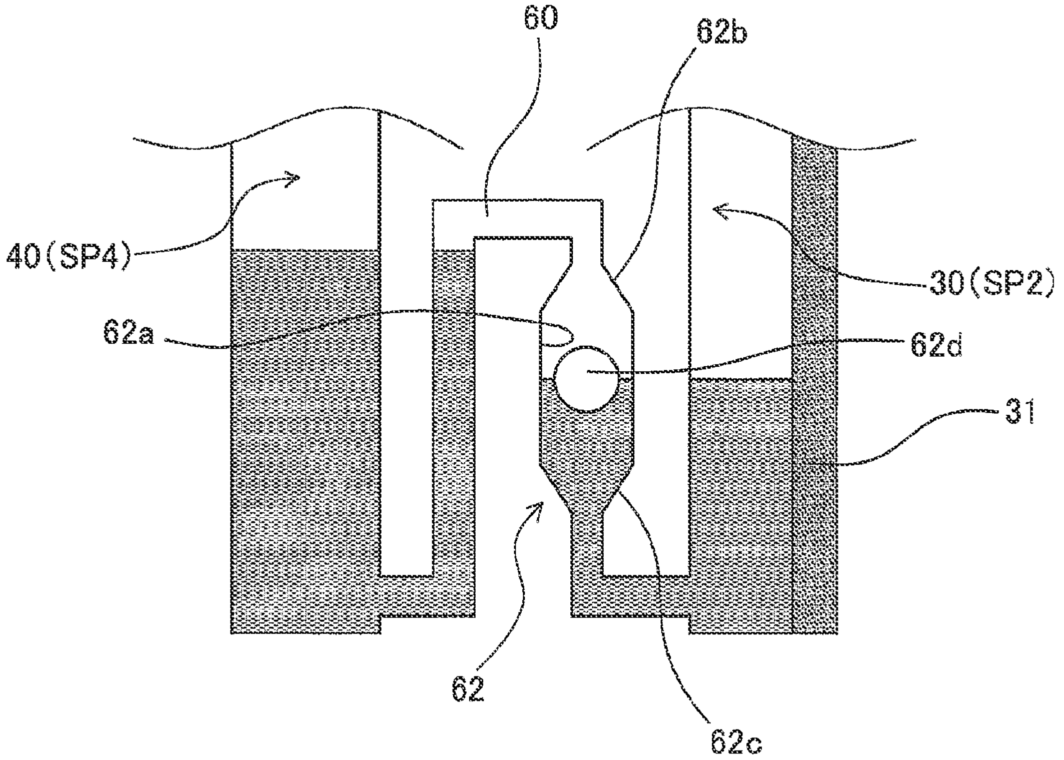


FIG. 7



STRUCTURE, AND METHOD FOR MANUFACTURING SAME

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of PCT application No. PCT/JP2020/028557, which was filed on Jul. 22, 2020 based on Japanese patent application 2019-147749 filed on Aug. 9, 2019, whose contents are incorporated herein by reference. Also, all the references cited herein are incorporated as a whole.

BACKGROUND OF THE INVENTION

Technical Field

[0002] The present invention relates to a structure and a method for manufacturing the same.

Background Art

[0003] In the related art, a wall structure for heat dissipation has been proposed in which substantially N-shaped heat pipes are provided in multiple stages above and below a heat insulating material (see Patent Literature 1). In this wall structure for heat dissipation, the substantially N-shaped heat pipe is a hollow body in which a refrigerant is stored. The heat pipe includes a heat dissipation portion having a wick, a connecting portion, and a condensation portion. After evaporation in the heat dissipation portion, the refrigerant passes through the connecting portion and condenses on the condensation portion side. As a result, the wall structure for heat dissipation is capable of transferring heat from one surface side having the heat dissipation portion to the other surface side having the condensation portion.

CITATION LIST

Patent Literature

[0004] [Patent Literature 1] JP-A-H06-129787

SUMMARY

[0005] Here, the wall structure for heat dissipation described in Patent Literature 1 is provided with the wick in order to solve the problem that the heat pipes need to be provided in multiple stages and the height direction with respect to one wall. By this wick being provided, the area of evaporation is expanded in the height direction and the number of heat pipe stages is reduced.

[0006] However, in the wall structure for heat dissipation described in Patent Literature 1, the condensation portion of each heat pipe is installed higher than the evaporation portion, and thus dead spaces arise in the uppermost portion on the heat dissipation portion side (one surface side) and the lowermost portion on the condensation portion side (the other surface side) of the surface where the heat pipe is installed and the space corresponding to one heat pipe stage in total is wasted. In particular, the wall structure for heat dissipation described in Patent Literature 1 tends to cause dead space expansion because the wick is provided and the heat dissipation portion is expanded in the height direction.

[0007] An embodiment of the present invention, a structure and a method for manufacturing the structure can achieve a decrease in the number of stages and a decrease in dead space.

[0008] A structure according to the present invention includes: a heat insulating layer; an evaporator formed using a space portion between a plurality of plate materials provided on one surface side of the heat insulating layer; a condenser formed using a space portion between a plurality of other plate materials provided on the other surface side of the heat insulating layer; a vapor flow path for guiding refrigerant vapor generated as a result of evaporation at the evaporator to the condenser; and a liquid refrigerant flow path for guiding a liquid refrigerant generated as a result of condensation at the condenser to the evaporator, in which the evaporator has a wick layer for evaporating the refrigerant stored on a lower portion side with heat from one surface side of the evaporator while suctioning up the refrigerant by capillarity and holding the refrigerant, and the evaporator and the condenser are installed so as to overlap by ½ or more in the direction in which the wick layer suctions up the refrigerant.

[0009] As for this structure, the evaporator has the wick layer for evaporating the refrigerant stored on the lower portion side with the heat from the one surface side of the evaporator while suctioning up the refrigerant by capillarity and holding the refrigerant. Accordingly, the wick layer is capable of extending the evaporation part in the suction direction, a larger area can be covered with a smaller number of stages, and a contribution can be made to reducing the number of stages.

[0010] In addition, in a case where the wick layer vertically suctions up the refrigerant, the evaporator and the condenser are installed so as to overlap by ½ or more in the vertical direction. Accordingly, the amount of suction-direction misalignment between the evaporator and the condenser decreases and a dead space is unlikely to arise. Accordingly, a decrease in the number of stages and a decrease in dead space can be achieved.

[0011] A structure manufacturing method according to the present invention includes: a joining step of partially joining four or more plate materials; a space forming step of forming a wick powder introduction space by performing pressurization in a high-temperature environment of 800° C. or higher between the four or more plate materials partially joined in the joining step; a powder introduction step of introducing wick layer forming powder into the introduction space formed in the space forming step; and a solidification step of solidifying the powder introduced in the powder introduction step in a state where the high-temperature environment is maintained.

[0012] According to this structure manufacturing method, the wick powder introduction space is formed by performing the inter-plate material pressurization in the high-temperature environment of 800° C. or higher, the wick layer forming powder is introduced into the formed introduction space, and the introduced powder is solidified with the high-temperature environment maintained. Accordingly, the powder can be solidified and a wick layer can be formed without any change in the high-temperature environment in which the plate material is processed and a contribution can be made to the smooth manufacturing of the structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is a first schematic cross-sectional view illustrating a structure according to an embodiment of the present invention, in which a cross section cut along a height direction is illustrated.

[0014] FIG. **2** is a second schematic cross-sectional view illustrating the structure according to the embodiment of the present invention, in which a cross section cut along a horizontal direction is illustrated.

[0015] FIGS. **3**A to **3**D are process diagrams illustrating a structure manufacturing method according to the present embodiment, in which a first step, a second step, a third step, and a diffusion-joined body are illustrated in FIGS. **3**A to **3**D, respectively.

[0016] FIGS. **4**A to **4**C are process diagrams illustrating the structure manufacturing method according to the present embodiment, in which fourth to sixth steps are illustrated in FIGS. **4**A to **4**C, respectively.

[0017] FIGS. **5**A to **5**D are process diagrams illustrating the structure manufacturing method according to the present embodiment, in which seventh to tenth steps are illustrated in FIGS. **5**A to **5**D, respectively.

[0018] FIGS. **6**A and **6**B are process diagrams illustrating the structure manufacturing method according to the present embodiment, in which eleventh and twelfth steps are illustrated in FIGS. **6**A and **6**B, respectively.

[0019] FIG. **7** is a schematic configuration diagram illustrating the lower portion side of a structure according to a second embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0020] Hereinafter, the present invention will be described with reference to preferred embodiments. It should be noted that the present invention is not limited to the following embodiments and can be appropriately modified without departing from the spirit of the present invention.

[0021] Although the illustration and description of some configurations are omitted in the following embodiments, it is a matter of course that publicly known or well-known techniques not contradictory to the content described below are appropriately applied as to details of the omitted techniques.

[0022] FIG. **1** is a first schematic cross-sectional view illustrating a structure according to an embodiment of the present invention, in which a cross section cut along a height direction is illustrated. FIG. **2** is a second schematic cross-sectional view illustrating the structure according to the embodiment of the present invention, in which a cross section cut along a horizontal direction is illustrated.

[0023] A structure **1** illustrated in FIGS. **1** and **2** is used as, for example, a vertically extending wall material (wall material for indoor-outdoor separation). The structure **1** includes seven (a plurality of) plate materials **11** to **17**, a heat insulating layer **20**, an evaporator **30**, a condenser **40**, a vapor flow path **50**, a liquid refrigerant flow path **60**, a latent heat storage material **70**, and a vertical stacking member **80**.

[0024] The seven plate materials **11** to **17** are metallic plate materials such as stainless steel and titanium plate materials. Of the plate materials **11** to **17**, the third plate material **13**, which is the third from the indoor side (one surface side), is configured by a plate material having an opening portion such as a punch mesh.

[0025] First to fourth space portions SP**1** to SP**4** are formed between the first plate material **11** and the second plate material **12**, between the second plate material **12** and the fourth plate material **14**, between the fifth plate material **15** and the sixth plate material **16**, and between the sixth plate material **16** and the seventh plate material **17**, respectively.

[0026] The heat insulating layer **20** exhibits heat insulation performance between the one surface side and the other surface side. Solidified pearlite powder or the like is used as the heat insulating layer **20** in the present embodiment. The heat insulating layer **20** is stored in the third space portion SP**3** between the fifth plate material **15** and the sixth plate material **16**.

[0027] Further, the third space portion SP**3** is in a vacuum state. Accordingly, the structure **1** according to the present embodiment has a vacuum heat insulating portion.

[0028] The evaporator **30** is provided on the one surface side of the heat insulating layer **20** and is formed using the second space portion SP**2** between the second plate material **12** and the fourth plate material **14** (plurality of plate materials). The second space portion SP**2** is in, for example, a vacuum state. The evaporator **30** functions as an evaporator evaporating a liquid refrigerant (for example, water) with heat from the one surface side. Further, the evaporator **30** includes a wick layer **31** between the second plate material **12** and the third plate material **13**. The wick layer **31** suctions up the refrigerant stored on the lower portion side of the evaporator **30** via the third plate material **13** by capillarity and holds the refrigerant. With the wick layer **31**, the evaporation area of the evaporator **30** expands along the height direction and high-efficiency evaporation is possible in the height direction.

[0029] It should be noted that the evaporator **30** is divided into a plurality of (four) rooms as illustrated in FIG. **2**. Each room extends in the height direction, is provided with a header member **32** and a footer member **33** in the uppermost portion and the lowermost portion, and is connected to other rooms via the header member **32** and the footer member **33**.

[0030] The condenser **40** is provided on the other surface side of the heat insulating layer **20** and is formed using the fourth space portion SP**4** between the sixth plate material **16** and the seventh plate material **17** (plurality of other plate materials). The fourth space portion SP**4** is also in, for example, a vacuum state. The condenser **40** functions as a condenser condensing the refrigerant with heat from the other surface side (for example, outside air temperature). The condensed liquid refrigerant is stored in the lowermost portion of the condenser **40**.

[0031] In addition, the condenser **40** is also divided into a plurality of (four) rooms as illustrated in FIG. **2**. Each room extends in the height direction, is provided with a header member **41** and a footer member **42** in the uppermost portion and the lowermost portion, and is connected to other rooms via the header member **41** and the footer member **42**.

[0032] The vapor flow path **50** is a flow path for guiding the refrigerant vapor generated as a result of the evaporation at the evaporator **30** to the condenser **40**. The vapor flow path **50** interconnects the header member **32** of the evaporator **30** and the header member **41** of the condenser **40**.

[0033] In addition, the vapor flow path **50** includes two temperature-sensitive valves **51***a* and **51***b*. The temperature-sensitive valve Ma is open when the temperature on the one surface side of the structure **1** (for example, temperature of the latent heat storage material **70** (or room temperature)) is equal to or higher than a predetermined temperature (for example, temperature appropriately set in the range of 24° C. or higher and 30° C. or lower) and is closed when the temperature is lower than the predetermined temperature. In addition, the temperature-sensitive valve **51***b* is closed when the temperature on the other surface side of the structure **1** (for example, outdoor atmospheric temperature) is equal to or higher than a predetermined temperature (for example, temperature appropriately set in the range of 24° C. or higher and 30° C. or lower) and is open when the temperature is lower than the predetermined temperature. It should be noted that the vapor flow path **50** may be formed inside the plurality of plate materials **11** to **17** or may be formed with a pipe attached outside.

[0034] The liquid refrigerant flow path **60** is a flow path for guiding the liquid refrigerant generated as a result of the condensation at the condenser **40** to the evaporator **30**. The liquid refrigerant flow path **60** interconnects the footer member **33** of the evaporator **30** and the footer member **42** of the condenser **40**.

[0035] In addition, the liquid refrigerant flow path **60** includes a check valve **61**. The check valve **61** is a valve for automatically preventing backflow. For example, the check valve **61** prevents the refrigerant from flowing in the direction from the evaporator **30** to the condenser **40** and allows the refrigerant to flow in the direction from the condenser **40** to the evaporator **30**. It should be noted that the liquid refrigerant flow path **60** may be formed inside the plurality of plate materials **11** to **17** or may be formed with a pipe attached outside as in the case of the vapor flow path **50**.

[0036] The latent heat storage material **70** has a phase change temperature (melting and freezing points) in a specific temperature range (for example, 24° C. or higher and 30° C. or lower). The latent heat storage material **70** is formed using the first space portion SP**1** between the first plate material **11** and the second plate material **12**. The latent heat storage material **70** is disposed closest to the one surface side of the structure **1**, and thus the latent heat storage material **70** functions to keep a specific indoor temperature range. In addition, by including the latent heat storage material **70**, the structure **1** is capable of, for example, performing indoor cooling with the latent heat storage material **70** by day in summer and dissipating the heat of the latent heat storage material **70** to the other surface side when the outdoor temperature drops at night as will be described later.

[0037] The vertical stacking member **80** is provided at the upper and lower ends of the structure **1**. The vertical stacking member **80** includes an upper end member **81** and a lower end member **82**.

[0038] The upper end member **81** is put on the seven plate materials **11** to **17**. The upper end member **81** includes a hard heat insulating material **81***a* such as a calcium silicate board and a stainless steel plate **81***b* as the outer skin of the hard heat insulating material **81**a. The upper end member **81** as a whole has a projecting structure having a protruding middle portion with both end portions chipped in part. In the upper end member **81**, the stainless steel plate **81***b* is separated on the one surface side and the other surface side and prevents heat transfer through the stainless steel plate **81***b*.

[0039] The lower end member **82** is put beneath the seven plate materials **11** to **17**. The lower end member **82** includes a hard heat insulating material **82***a* such as a calcium silicate board and a stainless steel plate **82***b* as the outer skin of the hard heat insulating material **82***a*. The lower end member **82** as a whole has a recessed structure having a recessed middle portion. The projecting structure of the upper end member **81** fits into the recessed structure of the lower end member **82**. Accordingly, a plurality of the structures **1** can be vertically stacked. Also in the lower end member **82**, the stainless steel plate **82***b* is separated on the one surface side and the other surface side and prevents heat transfer through the stainless steel plate **82***b*.

[0040] Further, as illustrated in FIG. **1** in the present embodiment, the evaporator **30** and the condenser **40** overlap by ½ or more (completely overlap in FIG. **1**) in the direction in which the wick layer **31** suctions up the liquid refrigerant (height direction in the present embodiment (vertical direction in particular)). It should be noted that the evaporator **30** and the condenser **40** preferably overlap by ⅔ or more and more preferably overlap by ¾ or more in the suction direction. It should be noted that the overlap of ½ or more referred to here means that the value obtained by dividing the sum of the part of the suction-direction length of the evaporator **30** that overlaps the condenser **40** in the suction direction and the part of the suction-direction length of the condenser **40** that overlaps the evaporator **30** in the suction direction by the sum of the suction-direction lengths of the entire evaporator **30** and the entire condenser **40** is ½ or more. The same applies to the overlap of ⅔ or more and the like.

[0041] As described above, in the structure **1** according to the present embodiment, the evaporator **30** and the condenser **40** overlap by at least ½ in the suction direction. Accordingly, dead space suppression can be achieved as compared with a case where the positions of both are misaligned by more than ½ in the suction direction.

[0042] In addition, the wick layer **31** is formed by solidifying powder non-uniform in particle size in a particle size range of 150 micrometers or less (for example, pearlite powder). Specifically, powder with a particle size of 80 micrometers or more and 150 micrometers or less is approximately ⅓ (¼ or more and ½ or less), powder with a particle size of 50 micrometers or more and less than 80 micrometers is approximately ⅓, and powder with a particle size of less than 50 micrometers is approximately ⅓.

[0043] Here, the present inventor has found that the suction effect is enhanced as compared with the case of a uniform particle size by making the particle size of the wick layer **31** sparse as described above. As a result, the structure **1** according to the present embodiment is capable of suctioning up the liquid refrigerant up to a height of 2 m, more preferably, approximately 0.2 m or more and 1.0 m or less and holding the liquid refrigerant.

[0044] In addition, the wick layer **31** according to the present embodiment preferably has a heat resistance of 850° C. or higher. Here, the structure **1** highly resistant to heat as a whole can be obtained by using a material having a heat resistance of 850° C. or higher and used as, for example, a building material for the other parts of the structure **1** (for example, the plate materials **11** to **17** and the heat insulating layer **20** with the exception of the latent heat storage material **70**).

[0045] Further, in the structure **1** according to the present embodiment, the outer surfaces of the first plate material **11** and the seventh plate material **17** are enameled at least in part. With this enamel, the structure **1** is capable of having a reflectance of 80% or more for infrared rays and visible light and an absorption rate (emissivity) of 80% or more for far infrared rays. Such characteristics are particularly suitable for outdoor and indoor surfaces in the case of use for heat dissipation and an indoor surface in the case of use for heat collection. In the case of use for heat collection, a film for selective sunlight absorption or the like having a high infrared absorption rate and a low far infrared absorption rate (emissivity) may be used on an outdoor surface.

[0046] Next, the operation of the structure **1** according to the present embodiment in a case where the structure **1** is used as a wall material for indoor-outdoor separation for the purpose of indoor-to-outdoor heat dissipation in summer will be described.

[0047] First, in a case where the room temperature is higher than a specific temperature range by day in summer, indoor cooling is performed by the latent heat storage material **70** provided in the first space portion SP**1**. During the cooling, the inside of the evaporator **30** is saturated with refrigerant vapor in equilibrium with the liquid refrigerant accumulated in the lower portion thereof and the temperature-sensitive valve **51***a* is released. In the present embodiment, the condenser **40** is installed at the same height as the evaporator **30**, and thus the liquid refrigerant is accumulated in the lower portion of the condenser **40** as well and the condenser **40** is also saturated with the refrigerant vapor in equilibrium with the liquid refrigerant. While the outdoor temperature is higher than the indoor temperature, the refrigerant vapor in the condenser **40** is higher in pressure than the refrigerant vapor in the evaporator **30**, and yet the refrigerant vapor does not flow back from the condenser **40** to the evaporator **30** since the temperature-sensitive valve **51***b* is closed. As an example, in a case where the refrigerant is water, the temperature of the condenser **40** (outdoor surface temperature) is 40° C., and the temperature of the evaporator **30** (indoor surface temperature) is 28° C., the difference in saturated water vapor pressure corresponds to the water column pressure of 355 mm. Accordingly, in a case where the evaporator **30** and the condenser **40** are installed in a lower end height-aligned manner, it is necessary to ensure a height of 355 mm or more for the refrigerant pool in the evaporator **30** in this temperature state by adjusting the amount of the refrigerant to be sealed and prevent the vapor refrigerant from blowing from the condenser **40** to the evaporator **30** through the liquid refrigerant flow path **60**. As a matter of course, the total height of the evaporator **30** needs to be higher.

[0048] When the outside air temperature subsequently becomes lower than the specific temperature range at night in summer, the refrigerant vapor pressure in the condenser **40** drops below the refrigerant vapor pressure in the evaporator **30**, the temperature-sensitive valve **51***b* is released, and the refrigerant vapor in the evaporator **30** reaches the condenser **40** via the vapor flow path **50**. The vapor refrigerant that has reached the condenser **40** is condensed into a liquid refrigerant. The heat of condensation is dissipated outdoors via the seventh plate material **17**. In the evaporator **30**, where a decline in pressure has occurred as a result of the outflow of the refrigerant vapor, the liquid refrigerant in the evaporator **30** suctioned up by the wick layer **31** evaporates. At this time, the heat of vaporization is taken from the latent heat storage material **70**. As a result, even in a case where the room temperature is high in summer, the heat can be dissipated outdoors. Even in a case where the outdoor temperature is higher than the indoor temperature by day in summer, in particular, the heat can be dissipated outdoors by the latent heat storage material **70** functioning as a buffer.

[0049] In winter, it is undesirable to dissipate the indoor heat outdoors. In such a case, the temperature-sensitive valve **51***a* is closed, and then the circulation of the refrigerant can be stopped and the indoor heat can be prevented from escaping outdoors. As an example, in a case where the refrigerant is water, the temperature of the condenser **40** (outdoor surface temperature) is 0° C., and the temperature of the evaporator **30** (indoor surface temperature) is 20° C., the evaporator **30** is higher in pressure, there is a difference corresponding to the water column pressure of 230 mm, and yet the check valve **61** is capable of preventing the liquid refrigerant from flowing back from the evaporator **30** to the condenser **40** through the liquid refrigerant flow path **60**.

[0050] The structure **1** according to the present embodiment can be used as a wall material for indoor-outdoor separation for the purpose of outdoor-to-indoor heat collection in winter. In this case, surface treatment such as enameling and a selective absorption film is appropriately changed, the wall is turned inside out, and the evaporator **30** is installed on the outdoor side and the condenser **40** is installed on the indoor side. As an example of when it is undesirable to take outdoor heat indoors in summer, in a case where the refrigerant is water, the condenser temperature (indoor surface temperature) is 28° C., and the temperature of the evaporator exposed to direct sunlight or the like (outdoor surface temperature) is 50° C., the saturated water vapor pressure in the evaporator **30** is higher than the saturated water vapor pressure in the condenser **40** so as to correspond to the water column pressure of 840 mm, it is difficult to seal this only by the height of the refrigerant pool in the condenser **40**, and yet the check valve **61** is capable of preventing the liquid refrigerant from flowing back from the evaporator **30** to the condenser **40** through the liquid refrigerant flow path **60**.

[0051] It should be noted that the temperature-sensitive valve **51***a* and the temperature-sensitive valve **51***b* are provided in the present embodiment, the temperature-sensitive valve **51***a* is open when the temperature on the one surface side is equal to or higher than a predetermined temperature and is closed when the temperature is lower than the predetermined temperature, the temperature-sensitive valve **51***b* is closed when the temperature on the other surface side of the structure **1** is equal to or higher than a predetermined temperature and is open when the temperature is lower than the predetermined temperature, and yet the present invention is not limited thereto. The temperature-sensitive valves **51***a* and **51***b* may be manual valves or may have temperature hysteresis. In addition, the refrigerant may lose the fluidity thereof as a result of, for example, solidification or gelation at a temperature lower than a predetermined temperature.

[0052] Next, a method for manufacturing the structure **1** according to the present embodiment will be described. FIGS. **3**A to **6**B are process diagrams illustrating the method for manufacturing the structure **1** according to the present embodiment. First, as illustrated in FIG. **3**A, the first plate material **11** to the seventh plate material **17** cut to a predetermined size are stacked and a stacked body S (see FIG. **3**B) is obtained. As for this stacking, a stop-off material SO is pre-applied to parts not subject to joining.

[0053] Next, as illustrated in FIG. **3**B, a ceramic sheet is interposed between a plurality of the stacked bodies S and the plurality of stacked bodies S are stacked. After the stacking, the plurality of stacked bodies S are put into a vacuum furnace and pressed in a high-temperature environment of, for example, 1000° C. as illustrated in FIG. **3**C. At this time, the first plate material **11** to the seventh plate material **17** are diffusion-joined at the parts where the stop-off material SO (see FIG. **3**A) is not applied (joining step).

[0054] As a result, a diffusion-joined body DB in which predetermined parts are diffusion-joined is manufactured as illustrated in FIG. **3**D.

[0055] Next, as illustrated in FIG. **4**A, the diffusion-joined body DB is put into a mold D having a predetermined shape. The inside of the mold D itself has airtightness and a heater function or is heated in a state where the inside of the mold D can be vacuumized by installation in the vacuum furnace. For example, the inside of the mold D is in a high-temperature environment of 900° C. (800° C. or higher).

[0056] Subsequently, as illustrated in FIG. **4**B, pressurization with a gas such as argon is performed between the fifth plate material **15** and the sixth plate material **16**. The third space portion SP**3** is formed as a result. Next, the inside of the mold D is vacuumized, the inside of the third space portion SP**3** is also depressurized, and pearlite powder is drawn thereinto.

[0057] Next, as illustrated in FIG. **4**C, pressurization with a gas such as argon is performed between the second plate material **12** and the fourth plate material **14** (or between the second plate material **12** and the third plate material **13**). As a result, the third to fifth plate materials **13** to **15** protrude to the other surface side and the pearlite powder in the third space portion SP**3** is pressed to result in diffusion joining. The heat insulating layer **20** is formed as a result. Further, by the third to fifth plate materials **13** to **15** protruding to the other surface side, an introduction space IS for introducing pearlite powder for forming the wick layer **31** (see the drawings including FIG. **1**) in a later step is formed.

[0058] Next, as illustrated in FIG. **5**A, the introduction space IS (between the second plate material **12** and the third plate material **13**) is also depressurized and pearlite powder is drawn thereinto with the inside of the mold D kept in a vacuum (powder introduction step). Subsequently, as illustrated in FIG. **5**B, pressurization with a gas such as argon is performed between the first plate material **11** and the second plate material **12**. As a result, the first space portion SP**1** is formed and the pearlite powder between the second plate material **12** and the third plate material **13** is pressed and diffused-joined (solidified) to form the wick layer **31** (solidification step). Here, although the third plate material **13** has an opening portion and the pearlite powder is to pass through the opening portion, the pearlite powder can be stopped by the fourth plate material **14** after entering the opening portion since the fourth plate material **14** is positioned adjacent to the third plate material **13**.

[0059] It should be noted that the wick layer **31** is formed by baking while the high-temperature environment at the time when the introduction space IS is formed is maintained (that is, the wick layer **31** is formed as a sintered body) and yet the present invention is not limited thereto. The wick layer **31** may be formed by a solidified body using a change in phase or a change in fluidity. In this case, the wick layer **31** can be configured by, for example, a mixture of pearlite and a fusion material such as powdered glass fluidizing at approximately 800° C. In this case, introduction in a high-temperature environment results in a viscous substance by the powdered glass of the mixture fluidizing, which functions as a binder binding pearlite grains.

[0060] Next, as illustrated in FIG. **5**C, pressurization with a gas such as argon is performed between the fourth plate material **14** and the fifth plate material **15** and between the sixth plate material **16** and the seventh plate material **17**. In particular, the condenser **40** (fourth space portion SP**4**) is formed as a result of the latter pressurization.

[0061] Subsequently, as illustrated in FIG. **5**D, pressurization with a gas such as argon is performed between the third plate material **13** and the fourth plate material **14**. As a result, the fourth plate material **14** adjacent to the third plate material **13** side moves to the fifth plate material **15** side. The evaporator **30** having the wick layer **31** is formed as a result.

[0062] Next, as illustrated in FIG. **6**A, the above is taken out of the mold D (see the drawings including FIG. **5**D) and at least a part of the outer surfaces of the first plate material **11** and the seventh plate material **17** in a high-temperature state (approximately 900° C.) is sprayed with enameling glaze powder (for example, surface treatment material fusing at a melting temperature of 850° C. or higher). After the spraying, the glaze is fused to the outer surfaces of the plate materials **11** and **17** and then cooled to form a strong heat-resistant coating film (enamel). In a case where the wick layer **31** is configured by pearlite and powdered glass, the pearlite grain-bound glass is solidified as it is by cooling and the entire wick layer **31** is solidified as a result. The enameling, in particular is performed with the first plate material **11** and the seventh plate material **17** in a high-temperature state (approximately 900° C.). Accordingly, the labor of reheating the whole structure **1** in a furnace after performing spraying or the like on the cooled structure **1** is omitted.

[0063] Subsequently, the latent heat storage material **70** is introduced into the first space portion SP**1** as illustrated in FIG. **6**B.

[0064] As for the structure **1** according to the present embodiment described above, the evaporator **30** has the wick layer **31** for evaporating the refrigerant stored on the lower portion side with heat from the one surface side of the evaporator **30** while suctioning up the refrigerant by capillarity and holding the refrigerant. Accordingly, the wick layer **31** is capable of extending the evaporation part in the suction direction and a larger area can be covered with a smaller number of stages. In addition, since the evaporator **30** and the condenser **40** are installed so as to overlap by ½ or more in the refrigerant suction direction of the wick layer **31**, the amount of suction-direction misalignment between the evaporator **30** and the condenser **40** decreases and a dead space is unlikely to arise. Accordingly, a decrease in the number of stages and a decrease in dead space can be achieved.

[0065] In addition, by having the vapor flow path **50**, the temperature-sensitive valves **51***a* and **51***b*, the liquid refrigerant flow path **60**, and the check valve **61**, it is possible to switch between a heat insulation state (for example, winter and summer daytime) and a heat dissipation state (for example, summer night) or between a heat insulation state (for example, summer and winter night) and a heat collection state (for example, winter daytime). Although it is necessary to be capable of responding to significant refrigerant liquid surface fluctuations in order to realize a heat insulation state, the necessity can be responded to by increasing the heights of the evaporator **30** and the condenser **40** with the wick layer **31**. In addition, since the number of stages is small, the temperature-sensitive valves **51***a* and **51***b* and the check valve **61** to be installed can be reduced in number.

[0066] In addition, the wick layer **31** is configured by a solidified body or a sintered body made of pearlite powder non-uniform in particle size in a particle size range of 150 micrometers or less. Here, the present inventor has found that the suction effect is enhanced by the wick layer **31** having different particle sizes equal to or less a predetermined value (150 micrometers). As a result, it is possible to provide the wick layer capable of suctioning up a refrigerant (for example, water) up to a height of, for example, 2 m, more preferably, approximately 0.2 m or more and 1.0 m or less and holding the refrigerant.

[0067] In addition, the latent heat storage material **70** is further provided on the one surface side of the evaporator **30**. Accordingly, in a case where the one surface side is an indoor side, for example, the indoor temperature environment is maintained by the latent heat storage material **70** even with the temperature on the other surface side (for example, outdoor side) high and the heat of the latent heat storage material **70** can be transferred to the other surface side at a timing when the temperature on the other surface side has become low.

[0068] In addition, the wick layer **31** has a heat resistance of 850° C. or higher. Accordingly, the structure **1** highly resistant to heat as a whole can be provided by constructing the structure **1** by combining, for example, the heat insulating layer **20** having a heat resistance of 850° C. or higher and used as a building material or the like.

[0069] Further, according to the method for manufacturing the structure **1** according to the present embodiment, the wick powder introduction space IS is formed by performing pressurization between the second plate material **12** and the fourth plate material **14** in a high-temperature environment of 800° C. or higher, the wick powder is introduced into the formed introduction space IS, and the introduced wick powder is solidified with the high-temperature environment maintained. Accordingly, the wick powder can be solidified and the wick layer **31** can be formed without any change in the high-temperature environment in which the second plate material **12** and the fourth plate material **14** are processed and a contribution can be made to the smooth manufacturing of the structure **1**.

[0070] Next, a second embodiment of the present invention will be described. The structure **1** according to the second embodiment is similar to the structure **1** according to the first embodiment and both are partially different from each other in configuration. Hereinafter, the differences from the first embodiment will be described.

[0071] FIG. **7** is a schematic configuration diagram illustrating the lower portion side of the structure **1** according to the second embodiment. In the second embodiment, a float valve **62** instead of the check valve **61** is used on the liquid refrigerant flow path **60**. The other configurations of the second embodiment are identical to those of the first embodiment. The float valve **62** has a cylindrical float chamber **62***a* installed in the vertical direction. An upper end **62***b* of the float valve **62** is squeezed in a reverse funnel shape and connected to the condenser **40**. A lower end **62***c* of the float valve **62** is squeezed in a funnel shape and connected to the evaporator **30**. A float **62***d* in the float chamber **62***a* is capable of blocking the refrigerant flow path **60** when pressed against either the funnel at the lower end or the reverse funnel at the upper end. Accordingly, the float valve **62** opens the refrigerant flow path **60** only when a refrigerant liquid surface is within the range of the height of the float chamber **62***a*.

[0072] During normal heat pipe operation (during heat transmission operation from the evaporator **30** side to the condenser **40** side) such as nighttime heat pipe operation in summer, the refrigerant liquid surface height in the float valve **62** is the same as the refrigerant liquid surface height in the evaporator **30**. Accordingly, the float **62***d* temporarily descends and the liquid refrigerant is allowed to flow into the float valve **62** from the condenser **40** in the event of a decrease in the height of the refrigerant in the evaporator **30** and the liquid refrigerant is allowed to flow into the evaporator **30** from the inside of the float valve **62** when the float **62***d* floats away from the funnel. Even in a case where the refrigerant in the condenser **40** has vaporized and the vapor refrigerant pressure has risen by day in summer, the refrigerant liquid surface in the evaporator **30** remains lower than the height of the reverse funnel of the float valve **62**. As a result, there is no need for the refrigerant liquid surface height in the evaporator **30** to be 355 mm or more as described above.

[0073] Even in a case where the evaporator **30** is higher in pressure than the condenser **40**, examples of which include winter, the float **62***d* ascends and is pressed against the reverse funnel to result in blocking when a small amount of liquid refrigerant flows into the float valve **62** from the evaporator **30**. As a result, an effect similar to that of the check valve **61** described in the first embodiment can be exhibited.

[0074] Although the float **62***d* is floated in the float valve **62** in the second embodiment, the valve provided in the liquid refrigerant flow path **60** may be opened and closed via an arm with the float **62***d* floated in the evaporator **30** by a structure similar to a float valve used in the water tank of a flush toilet or the like.

[0075] In this manner, effects similar to those of the first embodiment can be exhibited with the structure **1** according to the second embodiment.

[0076] Although the present invention has been described above based on the embodiments, the present invention is not limited to the above embodiments. Changes may be made without departing from the spirit of the present invention, and publicly known or well-known techniques may be appropriately combined to a possible extent.

[0077] For example, although it is assumed that the seven plate materials **11** to **17** in the present embodiments are configured by metal plates, the present invention is not limited thereto. If possible, the seven plate materials **11** to **17** may be configured by another material such as resin. Further, although the structure **1** has the seven plate materials **11** to **17**, the number is not particularly limited to seven and may be, for example, four. In this case, the heat insulating layer **20**, the evaporator **30**, and the condenser **40** may be provided with the second to fourth space portions SP**2** to SP**4** formed in the structure **1**. In addition, the structure **1** according to the present embodiments may be used for another building material such as a roofing material and a window without being limited to the wall material. In addition, the structure **1** according to the present embodiments may be used for, for example, a box material requiring internal cooling without being limited to the building material.

[0078] In addition, the powder forming the wick layer **31** is slurry in which powder is dissolved in a solvent in the event of introduction and the solvent may be vaporized in a high-temperature environment.

[0079] An example in which the powder forming the wick layer **31** is introduced in the powder introduction step illustrated in FIG. **5**A has been illustrated. In another example, the powder may be applied between the plate material **12** and the plate material **13**, for example, to the lower surface of the plate material **12** (powder placement step) in the step of applying the stop-off material SO illustrated in FIG. **3**A and the powder may be solidified in the joining step of FIG. **3**C (joining and solidification step). In that case, alumina powder highly resistant to heat and functioning as the stop-off material SO or the like and pearlite powder likely to be solidified in the joining step of FIG. **3**C may be mixed or stacked. As a result, the formation of the space IS and the powder introduction step illustrated in FIG. **5**A can be omitted and the solidified wick layer **31** at the point in time of FIG. **5**C is softened by the high temperature and is capable of allowing deformation of the plate material **14**. Further, the material of the wick layer is not limited to powder and carbon fibers and so on may be used. In that case, solidification may be performed in the joining step of FIG. **3**C after pearlite powder is stacked on the carbon fibers arranged on the plate material **13** in the step of applying the stop-off material SO illustrated in FIG. **3**A.

[0080] Although various embodiments have been described above with reference to the drawings, it is a matter of course that the present invention is not limited to such examples. It is clear that those skilled in the art can come up with various examples of change or modification within the scope of the claims, which naturally and understandably belong to the technical scope of the present invention. In addition, the above components of the embodiments may be combined in any manner without departing from the spirit of the present invention.

[0081] According to the present invention, it is possible to provide a structure and a method for manufacturing the structure with which a decrease in the number of stages and a decrease in dead space can be achieved.

1. A structure comprising:

a heat insulating layer;

an evaporator formed using a space portion between a plurality of plate materials provided on one surface side of the heat insulating layer;

a condenser formed using a space portion between a plurality of other plate materials provided on the other surface side of the heat insulating layer;

a vapor flow path for guiding refrigerant vapor generated as a result of evaporation at the evaporator to the condenser; and

a liquid refrigerant flow path for guiding a liquid refrigerant generated as a result of condensation at the condenser to the evaporator, wherein

the evaporator has a wick layer for evaporating the refrigerant stored on a lower portion side with heat from one surface side of the evaporator while suctioning up the refrigerant by capillarity and holding the refrigerant, and

the evaporator and the condenser are installed so as to overlap by ½ or more in the direction in which the wick layer suctions up the refrigerant.

2. The structure according to claim **1**, further comprising blocking means for blocking at least one of the vapor flow path and the liquid refrigerant flow path.

3. The structure according to claim **1**, wherein the wick layer is formed by solidifying powder non-uniform in particle size in a particle size range of 150 micrometers or less.

4. The structure according to claim **1**, further comprising a latent heat storage material on the one surface side of the evaporator.

5. The structure according to claim **1**, wherein the wick layer has a heat resistance of 850° C. or higher.

6. A structure manufacturing method comprising:

a joining step of partially joining four or more plate materials;

a space forming step of forming a wick powder introduction space by performing pressurization in a high-temperature environment of 800° C. or higher between the four or more plate materials partially joined in the joining step;

a powder introduction step of introducing wick layer forming powder into the introduction space formed in the space forming step; and

a solidification step of solidifying the powder introduced in the powder introduction step in a state where the high-temperature environment is maintained.

7. A structure manufacturing method comprising:

a powder placement step of placing wick layer forming powder in at least one place between four or more plate materials; and

a joining and solidification step of partially joining the four or more plate materials by pressurization in a high-temperature environment of 800° C. or higher and solidifying the powder placed in the powder placement step by the high-temperature environment and pressurization.

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