(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 943 839 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.01.2022 Bulletin 2022/04

(21) Application number: 20779559.2

(22) Date of filing: 06.03.2020

(51) International Patent Classification (IPC):
F25B 43/00 (2006.01)

(52) Cooperative Patent Classification (CPC):
F25B 43/00

(86) International application number:
PCT/JP2020/009696

(87) International publication number:
WO 2020/195711 (01.10.2020 Gazette 2020/40)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: 22.03.2019 JP 2019055600

(71) Applicant: NEC Corporation
108-8001 Tokyo (JP)

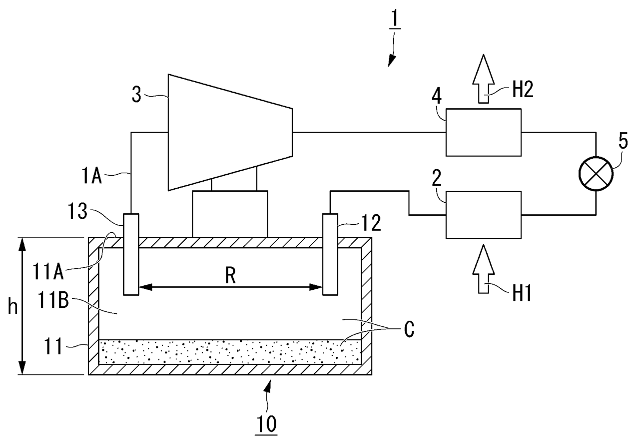
(72) Inventors:
- NATSUMEDA Takafumi
  Tokyo 108-8001 (JP)
- CHIBA Masaki
  Tokyo 108-8001 (JP)
- TODOROKI Koichi
  Tokyo 108-8001 (JP)
- YOSHIKAWA Minoru
  Tokyo 108-8001 (JP)

(74) Representative: Vossius & Partner
Patentanwälte Rechtsanwälte mbB
Siebertstraße 3
81675 München (DE)

(54) LIQUID SEPARATOR, COOLING SYSTEM, AND GAS-LIQUID SEPARATION METHOD

(57) A liquid separator including a cylindrical closed container in which a refrigerant is stored, a refrigerant inflow pipe that allows the refrigerant to flow into the closed container, and a refrigerant outflow pipe that allows the vapor-phase refrigerant in a space inside the closed container to flow out, in which the refrigerant inflow pipe and the refrigerant outflow pipe are each connected from the upper part of the closed container toward the inside thereof, and the closed container has a short cylindrical shape in which the height is smaller relative to the diameter.

FIG. 1



EP 3 943 839 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a liquid separator, a cooling system and a gas-liquid separation method, which are mainly used in a cooling system and separate a liquid flowing from an evaporator to a compressor.

BACKGROUND ART

[0002] In a cooling system including an evaporator, a compressor, a condenser and an expansion valve, an accumulator serving as a liquid separator may be installed in front of the suction port of the compressor.

[0003] For example, the cooling system shown in Patent Document 1 is provided with an evaporator, a compressor, a condenser, and a decompression expansion valve along the refrigerant flow path. The evaporator absorbs ambient heat by evaporating the liquid-phase refrigerant. The compressor compresses the vapor-phase refrigerant delivered from the evaporator. The condenser releases the heat of the refrigerant whose high pressure is increased by the compressor to condense the vapor-phase refrigerant. The decompression expansion valve decompresses and expands the liquid-phase refrigerant that has been cooled by the condenser.

[0004] This cooling system shown in Patent Document 1 is provided with a liquid separator on the upstream side of the compressor that separates the refrigerant after passing through the evaporator into gas and liquid.

[0005] This liquid separator has a vertically elongated separation container as a whole. A refrigerant inflow pipe and a vapor-phase refrigerant outflow pipe are installed on top of the separation container. In addition, a liquid-phase refrigerant outflow pipe is installed at the bottom of the separation container.

[0006] In this liquid separator, the refrigerant that has flowed into the inside through the refrigerant inflow pipe is centrifugally separated into a liquid-phase refrigerant and vapor-phase refrigerant while rotating in the circumferential direction along the inner wall of the liquid separator of the separation container.

[0007] Subsequently, the vapor-phase refrigerant in the separation container is guided to the decompression expansion valve via the upper vapor-phase refrigerant outflow pipe, and the liquid-phase refrigerant in the separation container is guided to the evaporator via the lower liquid-phase refrigerant outflow pipe.

[0008] On the other hand, a similar liquid separator is also shown in Patent Document 2.

[0009] Similar to Patent Document 1, the liquid separator disclosed in Patent Document 2 has a closed container formed vertically as a whole. At the bottom of this closed container, a first pipe that allows gas-liquid two-phase fluid to flow into the inside of the closed container, a second pipe that discharges the gas in the closed container to the outside, and a third pipe that discharges the liquid in the closed container to the outside are connected.

Prior Art Documents

Patent Documents

[0010]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 2015-172469

[Patent Document 2] Japanese Unexamined Patent Application Publication No. 2013-120028

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0011] In the cooling system shown in Patent Documents 1 and 2, the compressor is located above the accumulator, and the liquid-phase refrigerant returns to the accumulator by gravity.

[0012] Therefore, the accumulator is long in the vertical direction, and when the compressor is placed on the accumulator, the upper part of the liquid separator becomes heavy and the center of gravity is high. As a result, the liquid separator becomes unstable, and so new technology has been anticipated in order to remedy this point.

[0013] This invention was made in view of the above circumstances. Accordingly, the present invention provides a liquid separator, a cooling system and a gas-liquid separation method that enable a compressor to be placed on a closed container.

Means for Solving the Problems

[0014] In order to solve the above problem, the present invention proposes the following means.

[0015] A liquid separator according to a first aspect of the present invention includes a closed container having a cylindrical shape in which a refrigerant is stored; a refrigerant inflow pipe that allows the refrigerant to flow into the closed container; and a refrigerant outflow pipe that allows a vapor-phase refrigerant in a space inside the closed container to flow out, with each of the refrigerant inflow pipe and the refrigerant outflow pipe being connected from the upper side of the closed container to the inside thereof, and the closed container being formed in a short cylindrical shape in which the height is smaller relative to the diameter.

[0016] A cooling system according to a second aspect of the present invention includes an evaporator that absorbs ambient heat by evaporating a liquid-phase refrigerant, a compressor that compresses a vapor-phase refrigerant, a condenser that releases the heat of the refrigerant that has been pressurized by the compressor and condenses the vapor-phase refrigerant, and a decompression expansion valve that depressurizes and expands the liquid-phase refrigerant cooled by the condenser along a refrigerant path, in which a liquid separator for gas-liquid separation of the refrigerant after passing through the evaporator is provided on the upstream side of the compressor, the liquid separator has a closed container having a cylindrical shape in which a refrigerant is stored; a refrigerant inflow pipe that allows the refrigerant to flow into the closed container; and a refrigerant outflow pipe that allows the refrigerant in a space inside the closed container to flow out, the closed container being formed in a short cylindrical shape in which the height is smaller relative to the diameter.

[0017] A gas-liquid separation method according to a third aspect of the present invention comprising connecting a closed container having a cylindrical shape in which the refrigerant is stored, with a refrigerant inflow pipe that allows a refrigerant to flow into and a refrigerant outflow pipe that allows the refrigerant in a space inside the closed container to flow out, and forming the closed container in a short cylindrical shape in which the height is smaller relative to the diameter.

Effects of the Invention

[0018] According to the present invention, a liquid separator can be stably held even if a heavy compressor is arranged on the liquid separator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a configuration diagram showing a cooling system including a liquid separator according to an embodiment of the present invention.
FIG. 2 is a configuration diagram showing a cooling system including a liquid separator according to the first embodiment of the present invention.
FIG. 3 is a perspective view showing a liquid separator according to the first embodiment.
FIG. 4 is a vertical cross-sectional view showing the internal configuration of the liquid separator shown in FIG. 3.
FIG. 5A is a diagram for explaining the operation of the splash prevention plate provided in the liquid separator shown in FIG. 3.
FIG. 5B is a perspective view showing a splash prevention plate shown in FIG. 5A.
FIG. 6 is a perspective view showing a modification 1 of a splash prevention plate.
FIG. 7 is a perspective view showing a modification 2 of the splash prevention plate.
FIG. 8 is a cross-sectional view showing a liquid separator according to the second embodiment.
FIG. 9 is a perspective view showing a liquid separator according to a third embodiment.
FIG. 10 is a configuration diagram showing a cooling system including the liquid separator according to the third embodiment.

EXAMPLE EMBODIMENTS

[0020] A liquid separator 10 according to the embodiment of the present invention will be described with reference to FIG. 1.

[0021] The liquid separator 10 is located on the upstream side of a compressor 3 in a cooling system 1, and is provided for gas-liquid separation of a refrigerant after passing through an evaporator 2, for example.

[0022] This cooling system 1 is provided with the evaporator 2, the compressor 3, a condenser 4, and a decompression expansion valve 5 along a refrigerant flow path 1A. The evaporator 2 absorbs ambient heat by evaporating the liquid-phase refrigerant. The compressor compresses the vapor-phase refrigerant. The condenser 4 releases the heat of the refrigerant that has become high pressure by the compressor 3 to condense (or forcibly compress) the vapor-phase refrigerant. The decompression expansion valve 5 expands the liquid-phase refrigerant supplied from the condenser 4.

[0023] The liquid separator 10 located on the upstream side of the compressor 3 has a cylindrical closed container 11 in which the refrigerant C is stored. Inside the closed container 11 are provided a refrigerant inflow pipe 12 for flowing in a vapor phase medium or a gas-liquid two-phase refrigerant and a refrigerant outflow pipe 13 that discharges the vapor-phase refrigerant in the closed container 11 to the outside.

[0024] The refrigerant inflow pipe 12 and the refrigerant outflow pipe 13 are each installed from the upper surface 11A of the closed container 11 toward the inside of the container 11B. The refrigerant inflow pipe 12 and the refrigerant outflow pipe 13 are arranged at a mutual interval as large as possible in the radial direction (R direction) of the closed container 11.

[0025] Further, the closed container 11 of the liquid separator 10 has a height h that is relatively small with respect to a diameter along the R direction, and is configured to have a short cylindrical shape as a whole.

[0026] In such a liquid separator 10, since the closed container 11 is formed in a short cylindrical shape, even if a heavy compressor 3 is arranged on the upper surface 11A of the closed container 11, it is possible to hold the liquid separator 10 in a stable state without the upper part of the liquid separator 10 becoming heavy, that is, becoming so-called top heavy.

[0027] In such a vapor compression type cooling system 1, the vapor-phase refrigerant that has absorbed heat H1 from the heat source by the evaporator 2 and evaporated is gas-liquid separated by the liquid separator 10, compressed by the compressor 3 and then sent to the condenser 4. Subsequently, the liquid-phase refrigerant, which is condensed by heat dissipation H2 to a cold source in the condenser 4, is depressurized to a predetermined pressure by the decompression expansion valve 5 and sent to the evaporator 2 again.

[0028] Here, the liquid-phase refrigerant may not be sufficiently evaporated in the evaporator 2 due to a decrease in the load of the heat source, a failure of the decompression expansion valve 5, and the like and may be supplied to the compressor 3 as a gas-liquid mixed flow. The phenomenon in which a liquid is supplied to the compressor 3 in this way is called a liquid bag. When a liquid is supplied to the compressor 3, the performance of the compressor 3 may be deteriorated or a failure may be caused. In order to prevent this, in the liquid separator 10 according to the embodiment of the present invention, the liquid is separated from the gas-liquid mixed flow after passing through the evaporator 2, and only the gas is supplied to the compressor 3.

[0029] As described above, in the liquid separator 10 according to the embodiment of the present invention, the closed container 11 is formed with a short cylindrical shape whose height (h) is relatively small with respect to the radial direction (R direction). Accordingly, the height of the entire cooling system can be lowered, and so even if the heavy compressor 3 is arranged on the upper surface 11A of the closed container 11, the device as a whole can be installed in a stable state without becoming top heavy.

[0030] Further, in the liquid separator 10, the closed container 11 is formed in a short cylinder shape. Accordingly, the refrigerant inflow pipe 12 and the refrigerant outflow pipe 13 can be arranged on the upper surface 11A of the closed container 11 at a sufficient interval in the radial direction (R direction).

[0031] As a result, in the liquid separator 10, it is possible to prevent the effect of turbulence of the liquid level of the refrigerant caused by inflow of the refrigerant from the refrigerant inflow pipe 12 to the closed container 11 from extending to the refrigerant flowing out to the refrigerant outflow pipe 13. Therefore, it is possible to prevent beforehand the situation of the liquid-phase refrigerant in the closed container 11 flowing out from the refrigerant outflow pipe 13 as a result of being churned.

(First Embodiment)

[0032] The liquid separator 200 according to the first embodiment of the present invention will be described with reference to FIGS. 2 to 7.

[0033] This liquid separator 200 is installed in the cooling system F.

[0034] As shown in FIG. 2, the cooling system F is provided with an evaporator 100, a liquid separator 200, a compressor 300, a condenser 400, and a decompression expansion valve 500 in a refrigerant flow path (specifically, a pipeline) composed of refrigerant flow paths 610, 620, 630, 640, and 650. The evaporator 100 absorbs the ambient heat H1 by evaporating the liquid-phase refrigerant. The liquid separator 200 separates the refrigerant into gas and liquid. The compressor 300 compresses the vapor-phase refrigerant discharged from the liquid separator 200. The condenser 400 releases the heat of the refrigerant pressurized by the compressor 300 to condense the vapor-phase refrigerant. The decompression expansion valve 500 decompresses and expands the liquid-phase refrigerant cooled by the condenser 400.

[0035] The refrigerant supplied from the decompression expansion valve 500 via the refrigerant flow path 650 absorbs heat H1 from the heat source by the evaporator 100 and evaporates. The evaporated vapor-phase refrigerant passes through the refrigerant flow path 610, the liquid separator 200, and the refrigerant flow path 620 in this order, and is sent to the compressor 300.

[0036] The vapor-phase refrigerant compressed to high temperature and high pressure by the compressor 300 is sent to the condenser 400 via the refrigerant flow path 630, radiates H2 to a cold source, and condenses.

[0037] After that, the liquid-phase refrigerant condensed in the condenser 400 moves to the decompression expansion valve 500 through the refrigerant flow path 640 and is reduced to a predetermined pressure. Subsequently, the liquid-phase refrigerant is sent to the evaporator 100 again through the refrigerant flow path 650.

[0038] Here, the liquid separator 200 is arranged on the upstream side of the compressor 300 and has a role of preventing the liquid-phase refrigerant from being sucked into the compressor 300.

[0039] Since the compressor 300 is designed to compress the vapor-phase refrigerant, it is known that if the liquid-phase refrigerant is mixed in, it will lead to a failure (called a liquid-back phenomenon). Normally, the refrigerant completely evaporates in the evaporator 100 and becomes only a vapor-phase refrigerant. However, in the evaporator 100, when a disturbance such as a decrease in heat load occurs, the refrigerant may not evaporate and a part of the liquid-phase refrigerant may remain. In that case, this liquid-phase refrigerant is sent to the refrigerant flow path 610. Therefore, the liquid separator 200 separates the liquid-phase refrigerant contained in the refrigerant and supplies only the vapor-phase refrigerant to the downstream compressor 300.

[0040] Unless there are restrictions on installation, it is preferable to construct the refrigerant flow path 620 while avoiding a structure having a reverse gradient with respect to the direction of gravity or a U-shaped structure. This is because if such a reverse gradient structure or U-shaped structure exists in the refrigerant flow path 620, the liquid-phase refrigerant condensed in the refrigerant flow path 620 will accumulate at that portion when the cooling system F is stopped. In this way, since the liquid-phase refrigerant that accumulates in the refrigerant flow path 620 is sucked into the compressor 300 together with the vapor-phase refrigerant when the cooling system F is started next time, despite the fact that the liquid separator 200 is installed, there is a risk of causing the liquid-back phenomenon in the compressor 300.

[0041] With reference to FIGS. 3 and 4, the liquid separator 200 located on the upstream side of the compressor 300 has a cylindrical housing 210 that serves as a closed container in which the refrigerant is stored. Inside the housing 210 are installed a refrigerant inflow pipe 220 for flowing in a vapor-phase refrigerant or a vapor-liquid two-phase refrigerant and a refrigerant outflow pipe 230 for flowing out the vapor-phase refrigerant in the housing 210 to the outside.

[0042] The refrigerant inflow pipe 220 and the refrigerant outflow pipe 230 are installed from the upper surface 210A of the housing 210 toward the inside of the container 210B. The refrigerant inflow pipe 220 and the refrigerant outflow pipe 230 are arranged at an interval in the radial direction (R direction) of the housing 210. The refrigerant inflow pipe 220 is connected to the refrigerant flow path 610 in which the vapor-phase refrigerant or the gas-liquid two-phase refrigerant from the evaporator 100 is guided. The refrigerant outflow pipe 230 is connected to a refrigerant flow path 620 that guides the vapor-phase refrigerant to the compressor 300.

[0043] The vapor-phase refrigerant or the gas-liquid two-phase refrigerant after passing through the evaporator 100 flows into the housing 210 through the refrigerant inflow pipe 220, and the liquid-phase refrigerant in the gas-liquid mixed flow falls to the bottom of the housing 210 by gravity and accumulates there. On the other hand, the vapor-phase refrigerant in the gas-liquid mixed flow is sent to the compressor 300 through the refrigerant outflow pipe 230.

[0044] The housing 210 of the liquid separator 200 has a height h relatively small with respect to a diameter along the R direction, and is configured to have a short cylindrical shape as a whole.

[0045] As described above, in the liquid separator 200, since the housing 210 is formed in the shape of a short cylinder whose height h is relatively small with respect to the diameter in the R direction, even if the compressor 300 with weight is arranged on the upper surface 210A of the housing 210, it is possible to hold the compressor 300 in a stable state.

[0046] Referring to FIG. 2 again, in the vapor compression type cooling system F as described above, the vapor-phase refrigerant which evaporated by absorbing heat H1 from the heat source by the evaporator 2 is compressed by the compressor 300 to attain a high temperature and high pressure, and then sent to the condenser 400. Subsequently, the liquid-phase refrigerant, which is condensed by heat dissipation H2 to a cold source in the condenser 400, is depressurized to a predetermined pressure by the decompression expansion valve 500 and sent to the evaporator 100 again.

[0047] As shown in FIGS. 4 and 5A and 5B, below an inlet (opening for the liquid to flow into the liquid separator 200) 220A of the refrigerant inflow pipe 220, a mesh-shaped splash prevention plate 240 is installed to prevent the vapor-phase refrigerant C1 that is supplied through the refrigerant inflow pipe 220 from blowing up the liquid-phase refrigerant C2 that has accumulated in the housing 210.

[0048] In the housing 210, when the flow velocity of the vapor-phase refrigerant C1 supplied through the refrigerant inflow pipe 220 is large, even if the liquid-phase refrigerant is not mixed in the refrigerant C1, the liquid-phase refrigerant C2 staying on the bottom surface of the housing 210 may be blown up by the momentum of the vapor-phase refrigerant C1. In this case, there is a risk that the blown-up liquid-phase refrigerant C2 will flow out from an outlet (opening for the liquid to flow out from the housing 210) 230A of the refrigerant outflow pipe 230.

[0049] Therefore, as shown in FIGS. 5A and 5B, the mesh-shaped splash prevention plate 240 is installed below the refrigerant inflow pipe 220. The mesh-shaped splash prevention plate 240 mitigates the impact of the vapor-phase refrigerant C1 on the liquid surface of the liquid-phase refrigerant C2, thereby preventing the liquid-phase refrigerant C2 from being blown up.

[0050] As described above, in the liquid separator 200 according to the first embodiment, since the housing 210 is formed in a short cylindrical shape having a height h relatively small in the radial direction (R direction), even if the heavy compressor 300 is arranged on the upper surface 210A of the housing 210, the liquid separator 200 can be held in a stable state without becoming top heavy.

[0051] In the liquid separator 200, since the housing 210 is formed in a short cylinder shape, the refrigerant inflow pipe 220 and the refrigerant outflow pipe 230 can be arranged in the upper surface 210A of the housing 210 at a regular interval in the radial direction (R direction).

[0052] As a result, in the liquid separator 200, the effect of undulation (turbulence) of the liquid level of the liquid-phase refrigerant C2 caused by the inflow of the refrigerant from the refrigerant inflow pipe 220 into the housing 210 is prevented from extending to the refrigerant outflow pipe 230. Therefore, it is possible to prevent the liquid-phase refrigerant C2 in the housing 210 from being blown up and flowing out from the refrigerant outflow pipe 230.

[0053] Further, in the liquid separator 200, providing the mesh-shaped splash prevention plate 240 below the inlet 220A of the refrigerant inflow pipe 220 alleviates the momentum of the vapor-phase refrigerant C1 colliding with the liquid surface to prevent undulation of the liquid level of the liquid-phase refrigerant C2.

This also makes it possible to prevent the liquid-phase refrigerant C2 in the housing 210 from flowing out from the outlet 230A of the refrigerant outflow pipe 230.

[0054] Further, in the liquid separator 200, there is no complicated structure causing a large pressure loss in the flow path of the vapor-phase refrigerant from the refrigerant inflow pipe 220 to the refrigerant outflow pipe 230. As a result, in the liquid separator 200, it is possible to prevent the so-called liquid back phenomenon to the compressor 300 (damage to the pipeline and equipment of the cooling system due to droplets of the refrigerant flowing through the flow path with kinetic energy) while suppressing the pressure loss during the gas-liquid separation of the refrigerant.

(Modification 1)

[0055] In the above embodiment, a mesh-shaped plate is used as the splash prevention plate 240, but the present invention is not limited thereto. That is, as the splash prevention plate 240, a plate having a large number of through holes 240a as shown in FIG. 6, for example, a plate having a plurality of holes such as punching metal may be used.

(Modification 2)

[0056] Further, as the splash prevention plate 240, a net-like body formed by entwining a plurality of fibers 240b as shown in FIG. 7, for example, a metal scrubbing brush processed into a flat shape may be used.

(Second Embodiment)

[0057] A liquid separator 200' according to the second embodiment of the present invention will be described with reference to FIG. 8.

[0058] The liquid separator 200' according to the second embodiment differs from the liquid separator 200 according to the first embodiment on the point of a liquid intrusion prevention plate 250 being provided below the outlet of the refrigerant outflow pipe 230.

[0059] In the liquid separator 200' shown in the second embodiment, when the flow velocity of the vapor-phase refrigerant C1 is large, there is a risk of the force blowing up the liquid-phase refrigerant C2 stored in the housing 210 being strong enough such that splash prevention is insufficient with the splash prevention plate 240 alone. Therefore, in the liquid separator 200', in addition to providing the splash prevention plate 240 below the inlet (outlet when heading toward the liquid separator 200') 220A of the refrigerant inflow pipe 220, the liquid intrusion prevention plate 250 for preventing suctioning of the liquid-phase refrigerant C2 is provided below the outlet of the refrigerant outflow pipe (the port through which the liquid flows from the liquid separator 200') 230A.

[0060] As a result, in the liquid separator 200' shown in the second embodiment, by adding the liquid intrusion prevention plate 240 below the refrigerant inflow pipe 220, it is possible to prevent droplets of the liquid-phase refrigerant C2 from being sucked into the refrigerant outflow pipe 230, whereby the liquid separation function can be improved.

[0061] As the liquid intrusion prevention plate 240, in addition to a normal plate, it is possible to use a mesh-shaped plate shown in FIG. 5B, a plate having a large number of through holes shown in FIG. 6, a net-like body (or cotton-like body) formed by the entwining of fibers shown in FIG. 7, or the like.

(Third Embodiment)

[0062] The liquid separator 200" according to the third embodiment of the present invention will be described with reference to FIGS. 9 and 10.

[0063] The liquid separator 200" shown in the third embodiment differs from the liquid separators 200 and 200' shown in the first and second embodiments on the point of being provided with a liquid level sensor 260, a maintenance valve 270, and a control unit 700.

[0064] In the normal operation of the cooling system, the gaseous refrigerant is completely sent from the outlet of the evaporator 100, and the liquid-phase refrigerant is transferred from the evaporator 100 to the liquid separator 200 only when the operation becomes unstable due to a disturbance. At this time, due to the unstable operation the liquid-phase refrigerant C2 in the housing 210 gradually evaporates during the subsequent normal operation to become the vapor-phase refrigerant C1, whereby the accumulation thereof is eliminated.

[0065] However, if the unstable operation occurs continuously, it is expected that the amount of the liquid-phase refrigerant C2 staying in the housing 210 of the liquid separator 200 will gradually increase.

[0066] Therefore, in the liquid separator 200" shown in the third embodiment, as shown in FIG. 9, the liquid level sensor 260 for monitoring the amount of liquid of the liquid-phase refrigerant C2 remaining in the housing 210 is attached to this housing 210.

[0067] If the liquid level of the liquid-phase refrigerant C2 that accumulates in the housing 210 becomes higher than the position of the droplet prevention plate 240, the droplet prevention plate 240 will not function and the liquid separation function may be significantly reduced.

[0068] In this case, since the liquid-phase refrigerant C2 may flow out from the refrigerant outflow pipe 230 and cause liquid back, it will be necessary to stop the compressor 300.

[0069] Therefore, in the liquid separator 200" of the third embodiment, as shown in FIG. 10, a control unit 700 is provided that monitors the value of the liquid level sensor 260 of the liquid separator 200 and stops the entire cooling system F' including the compressor 300 when the liquid level of the liquid-phase refrigerant C2 exceeds a limit value.

[0070] Then, in the liquid separator 200" of the third embodiment, after the cooling system F' is stopped, the maintenance valve 270 at the lower part of the housing 210 is opened and the accumulated liquid-phase refrigerant C2 is discharged, whereby a return to the normal state can be achieved.

[0071] The maintenance valve 270 may be opened and closed manually by an operator, or may be opened and closed by a drive means operated by a separately provided control unit 700.

[0072] Although the embodiment of the present invention has been described in detail with reference to the drawings, the specific configuration is not limited to this embodiment, and includes design changes and the like within a range that does not deviate from the gist of the present invention.

[0073] Priority is claimed on Japanese Patent Application No. 2019-55600, filed March 22, 2019, the content of which is incorporated herein by reference.

INDUSTRIAL APPLICABILITY

[0074] The present invention is mainly used in cooling systems and can be applied to a liquid separator, a cooling system and a gas-liquid separation method that separates liquid flowing from the evaporator into the compressor. Even if a heavy compressor is arranged on top of the liquid separator, the liquid separator can be stably held.

Description of Reference Symbols

[0075]

1:	Cooling system
1A:	Refrigerant flow path
2:	Evaporator
3:	Compressor
4:	Condenser
5:	Decompression expansion valve
10:	Liquid separator
11:	Closed container
12:	Refrigerant inflow pipe
13:	Refrigerant outflow pipe
100:	Evaporator
200:	Liquid separator
200':	Liquid separator
200":	Liquid separator
210:	Housing
240:	Splash prevention plate
250:	Liquid intrusion prevention plate
260:	Liquid level sensor
270:	Maintenance valve
300:	Compressor
400:	Condenser
500:	Decompression expansion valve
610:	Refrigerant flow path
620:	Refrigerant flow path
630:	Refrigerant flow path
640:	Liquid pipe
650:	Liquid pipe
700:	Control unit
C:	Refrigerant
C1:	Vapor-phase refrigerant
C2:	Liquid-phase refrigerant
F:	Cooling cycle
F':	Cooling cycle
R:	Radial direction

Claims

1. A liquid separator comprising:
a closed container having a cylindrical shape in which a refrigerant is stored; a refrigerant inflow pipe that allows the refrigerant to flow into the closed container; and a refrigerant outflow pipe that allows the refrigerant that has flowed into a space inside the closed container to flow out, wherein:

    the refrigerant inflow pipe and the refrigerant outflow pipe are each arranged from the upper part of the closed container toward the inside thereof; and
    the closed container is formed in a short cylindrical shape in which the height is smaller relative to the diameter.

2. The liquid separator according to claim 1, wherein a splash prevention plate for preventing the scattering of refrigerant droplets is installed near the outlet of the refrigerant inflow pipe located in the closed container.

3. The liquid separator according to claim 2, wherein the splash prevention plate is composed of a mesh-shaped plate.

4. The liquid separator according to claim 2, wherein the splash prevention plate is composed of a plate having a large number of through holes.

5. The liquid separator according to claim 2, wherein the splash prevention plate is composed of a net-like body formed by entwining a plurality of fibers.

6. The liquid separator according to any one of claims 1 to 5, wherein a liquid intrusion prevention plate for preventing intrusion of the liquid-phase refrigerant in the closed container is further provided near the inlet of the refrigerant outflow pipe.

7. The liquid separator according to any one of claims 1 to 6, wherein the closed container is provided with a liquid level sensor that detects the liquid level of the liquid-phase refrigerant and a control unit that stops the entire device when the detected value of the liquid level sensor exceeds a predetermined limit value.

8. The liquid separator according to any one of claims 1 to 7, wherein a discharge valve for discharging the liquid-phase refrigerant is provided at the lower part of the closed container.

9. A cooling system comprising an evaporator that absorbs ambient heat by evaporating a liquid-phase refrigerant, a compressor that compresses a vapor-phase refrigerant, a condenser that releases the heat of the refrigerant that has been pressurized by the compressor and condenses the vapor-phase refrigerant, and a decompression expansion valve that

depressurizes and expands the liquid-phase refrigerant cooled by the condenser along a refrigerant path, wherein:

a liquid separator for gas-liquid separation of the refrigerant after passing through the evaporator is provided on the upstream side of the compressor; and
the liquid separator includes a closed container having a cylindrical shape in which a refrigerant is stored; a refrigerant inflow pipe that allows the refrigerant to flow into the closed container; and a refrigerant outflow pipe that allows the refrigerant in a space inside the closed container to flow out, the cylindrical closed container being formed in a short cylindrical shape in which the height is smaller relative to the diameter.

10. A gas-liquid separation method comprising:

connecting a closed container having a cylindrical shape in which the refrigerant is stored, with a refrigerant inflow pipe that allows a refrigerant to flow into and a refrigerant outflow pipe that allows the refrigerant in a space inside the closed container to flow out, and
forming the closed container in a short cylindrical shape in which the height is smaller relative to the diameter.

FIG. 1

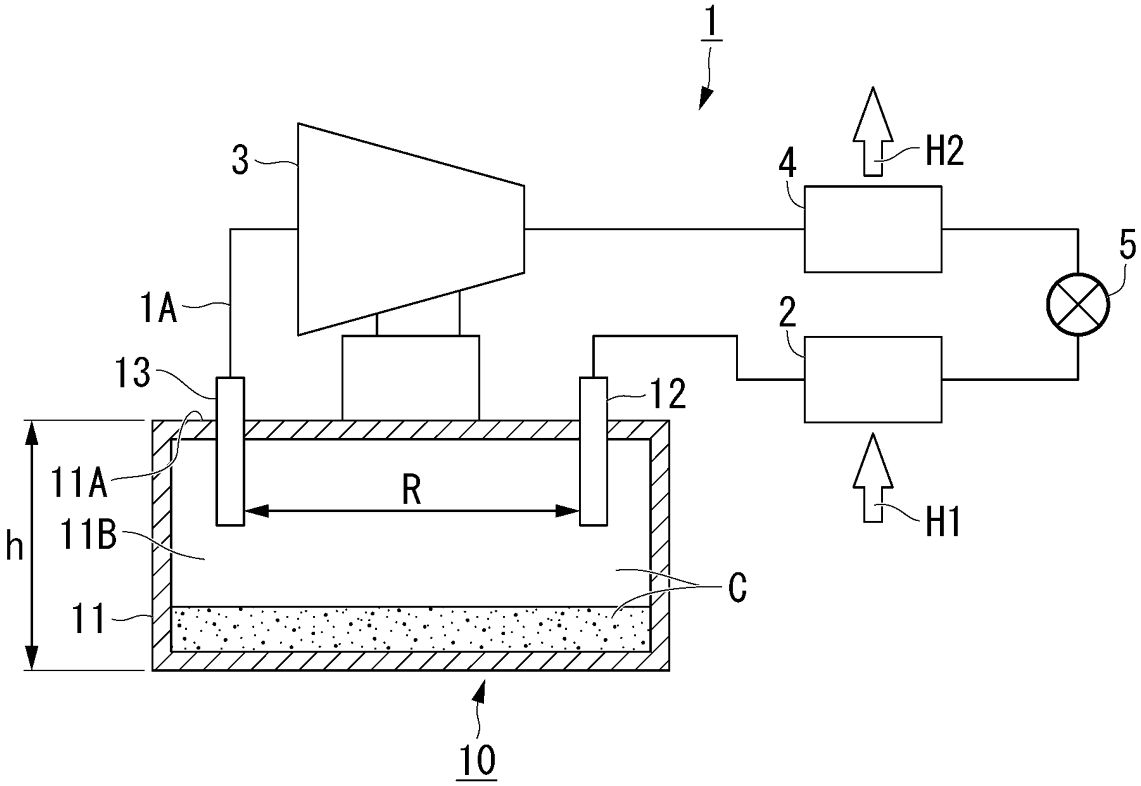

1
3
4
H2
5
1A
2
13
12
11A
R
H1
h
11B
C
11
10

FIG. 2

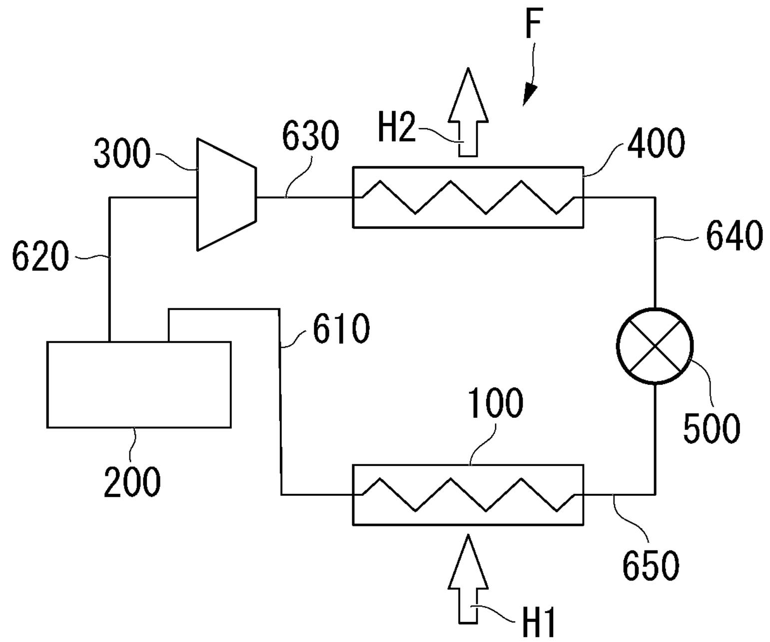

F
300
630
H2
400
620
640
610
500
100
200
650
H1

FIG. 3

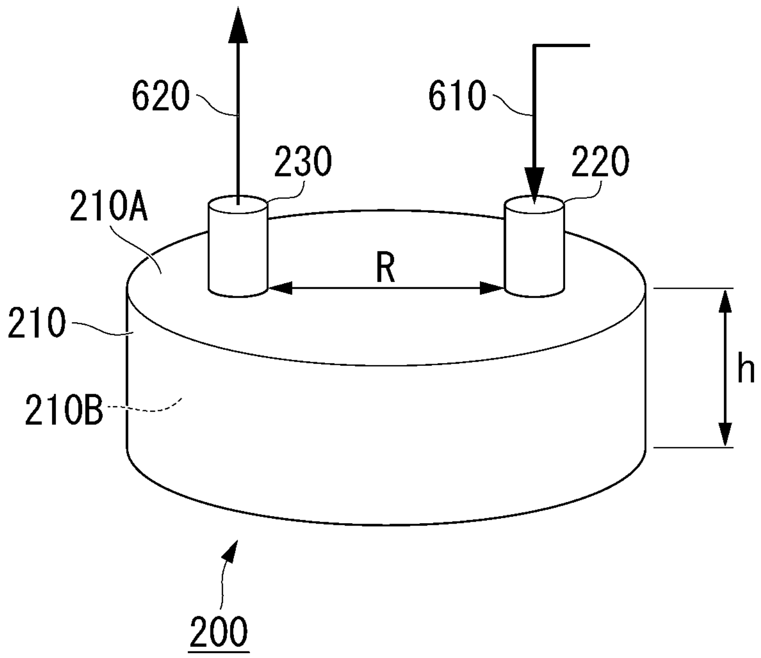

620
610
230
220
210A
R
210
h
210B
200

FIG. 4

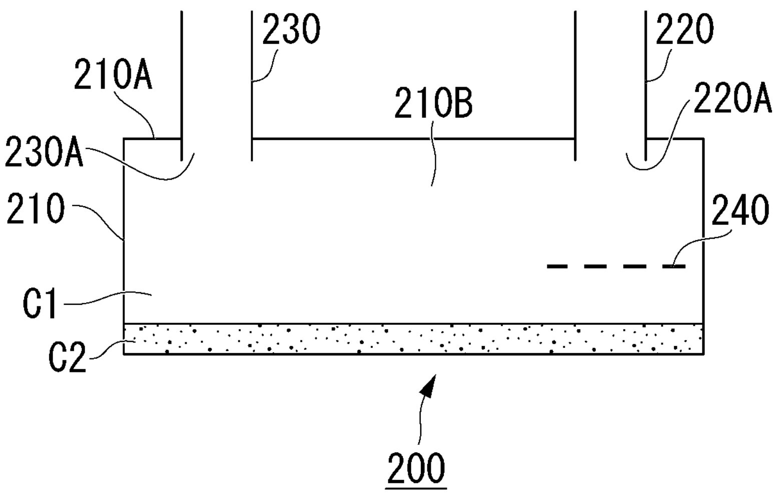

230
220
210A
210B
220A
230A
210
240
C1
C2
200

FIG. 5A

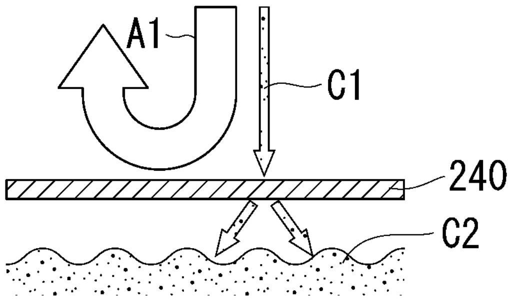


FIG. 5B

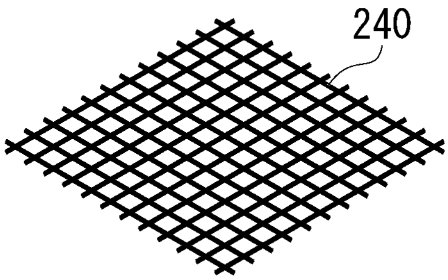


FIG. 6

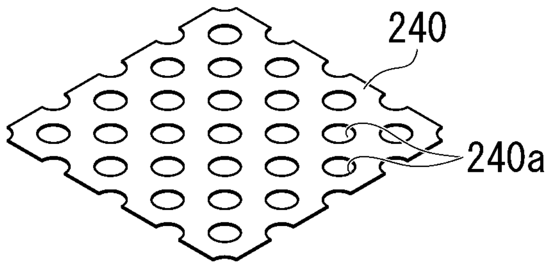


FIG. 7

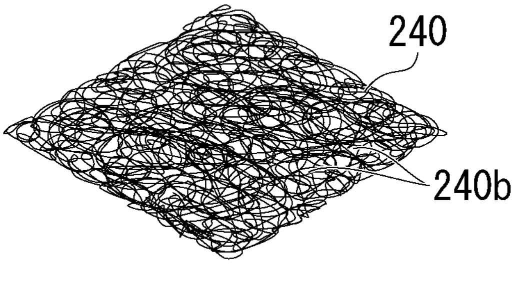


FIG.8

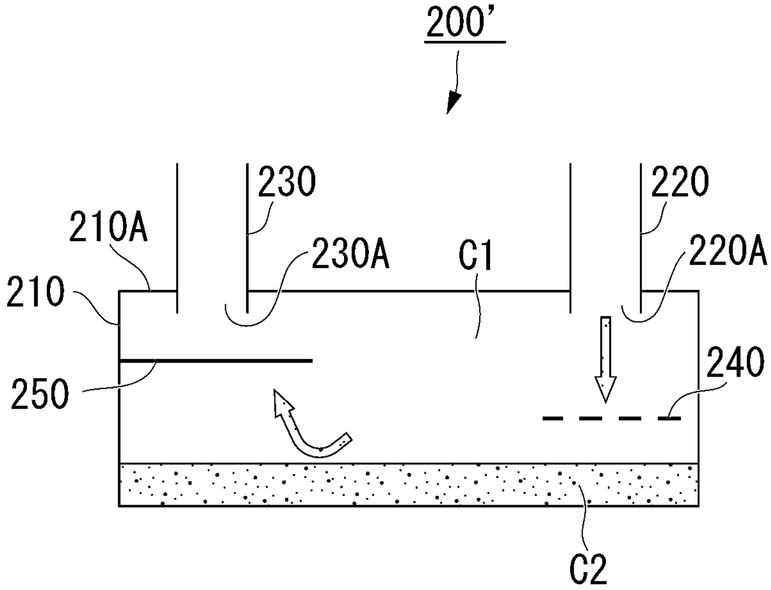

200'
230
220
210A
230A
C1
220A
210
240
250
C2

FIG. 9

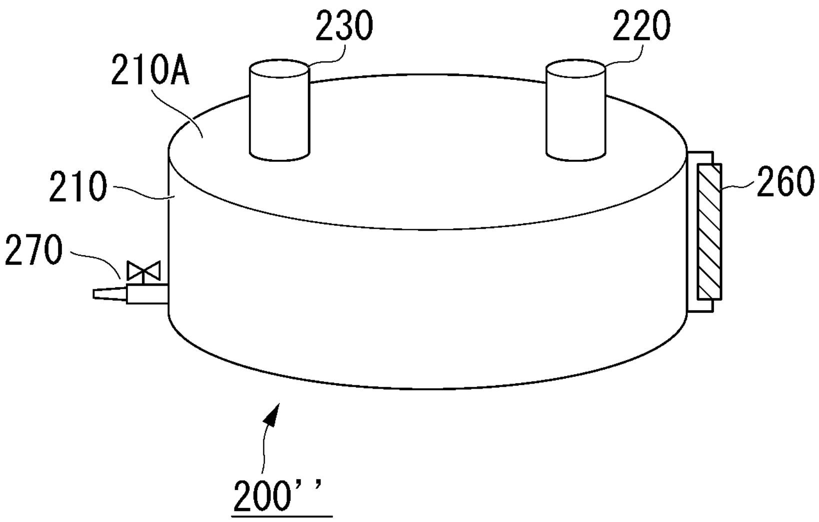
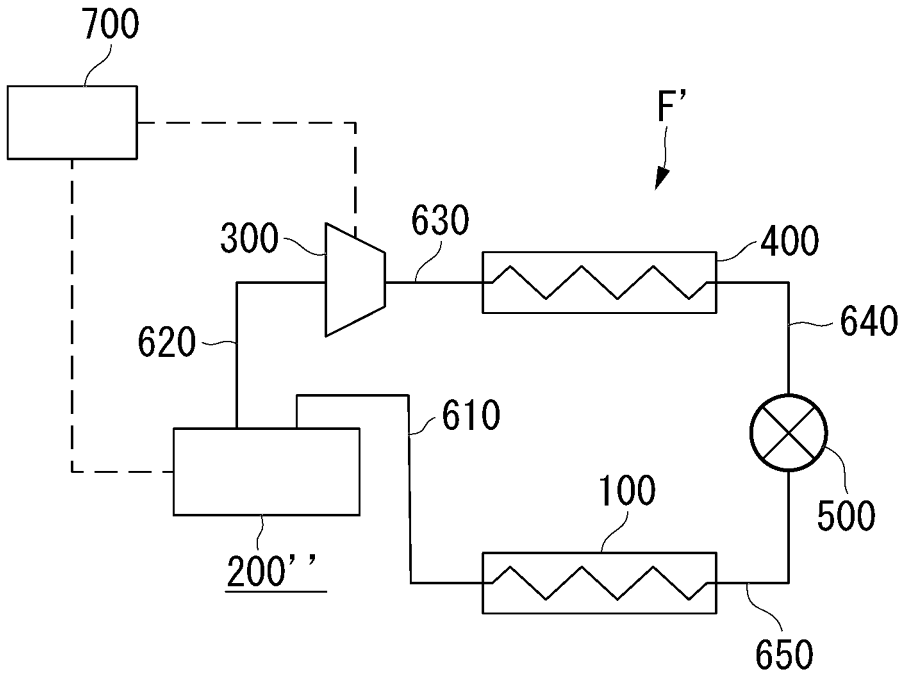

230
220
210A
210
260
270
200''

FIG.10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/009696

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F25B43/00(2006.01)i
FI: F25B43/00 C, F25B43/00 E

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F25B43/00

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-37050 A (ZEXEL VALEO CLIMATE CONTROL CORP.) 05 February 2004, paragraphs [0014]-[0028], fig. 1, 2	1-10
Y	JP 7-19667 A (MITSUBISHI ELECTRIC CORP.) 20 January 1995, paragraph [0021], fig. 1	1-10
Y	JP 8-271093 A (SANYO ELECTRIC CO., LTD.) 18 October 1996, paragraphs [0021]-[0023], fig. 1-4	1-10
Y	JP 2002-156274 A (MITSUBISHI ELECTRIC CORP.) 31 May 2002, paragraph [0007], fig. 7	7-8
Y	JP 2015-17720 A (HITACHI APPLIANCES INC.) 29 January 2015, paragraphs [0100], [0101], fig. 14	8

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26.05.2020	02.06.2020

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

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/009696

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 10-111047 A (HITACHI, LTD.) 28 April 1998, entire text, all drawings	1-10
A	JP 47-7170 Y1 (DAIKIN INDUSTRIES, LTD.) 15 March 1972, entire text, all drawings	1-10
A	EP 2659143 B1 (LG ELECTRONICS INC.) 09 September 2015, entire text, all drawings	1-10

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/009696

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2004-37050 A	05.02.2004	(Family: none)	
JP 7-19667 A	20.01.1995	(Family: none)	
JP 8-271093 A	18.10.1996	(Family: none)	
JP 2002-156274 A	31.05.2002	(Family: none)	
JP 2015-17720 A	29.01.2015	(Family: none)	
JP 10-111047 A	28.04.1998	(Family: none)	
JP 47-7170 Y1	15.03.1972	(Family: none)	
EP 2659143 B1	09.09.2015	US 2012/0171060 A1 entire text, all drawings WO 2012/091389 A1 KR 10-2012-0076141 A CN 103282669 A	

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2015172469 A **[0010]**
- JP 2013120028 A **[0010]**
- JP 2019055600 A **[0073]**