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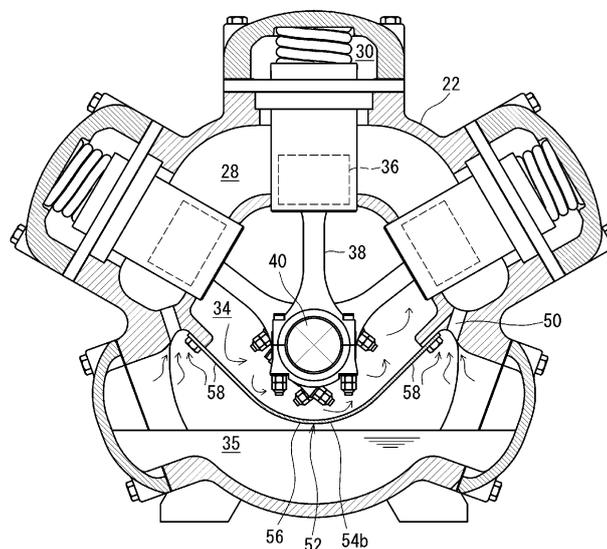
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(54) **RECIPROCATING COMPRESSOR**

(57) A reciprocating compressor according to at least one embodiment of the present invention includes a housing which includes an intake chamber, a discharge chamber, a cylinder, and a crank chamber, the crank chamber having a lower portion formed as an oil storage chamber configured to store lubricant; a piston which is reciprocally located in the cylinder; a crank shaft which is rotatably arranged in the crank chamber and is coupled to the piston via a connecting rod; a pressure equalization

path through which the intake chamber and the crank chamber communicates, the pressure equalization path having an opening end open to the crank chamber; and a partition member which is located between the crank shaft and the opening end of the pressure equalization path. The partition member extends below the crank shaft from one side of the crank shaft to the other side of the crank shaft so as to cover at least the lower side of the crank shaft.

FIG. 2



Description

TECHNICAL FIELD

5 **[0001]** The present application relates to a reciprocating compressor.

BACKGROUND

[0002] A reciprocating compressor is applied to, for example, a refrigeration cycle and is used for compressing a coolant.

10 **[0003]** For example, as described in Patent Document 1, an intake chamber, a discharge chamber, a cylinder, and a crank chamber are defined in a housing of the reciprocating compressor. A lower portion of the crank chamber is used as an oil storage chamber configured to store lubricant. A piston is reciprocally located in the cylinder. A crank shaft is rotatably arranged in the crank chamber via a bearing. The piston is coupled to the crank shaft via a connecting rod. Thus, rotational movement of the crank shaft is converted into the reciprocating movement of the piston.

15 **[0004]** The cylinder can communicate with the intake chamber and the discharge chamber via an intake valve and a discharge valve, respectively. When power is supplied to the crank shaft from the outside and thus the piston makes the reciprocating movement in the reciprocating compressor under operation, gas as the compression target is sucked into the cylinder from the intake chamber via the intake valve, compressed, and then is discharged into the discharge chamber via the discharge valve.

20 **[0005]** While the gas is being compressed in the cylinder, the gas as the compression target (leak gas) leaks through a gap between an inner circumference surface of the cylinder and a piston ring, to flow into the crank chamber. To prevent the pressure in the crank chamber from rising due to the leak gas, a pressure equalization path, through which the crank chamber and the intake chamber communicate, is provided.

25 **[0006]** Thus, when the compressor is under a normal operation (load operation), the leak gas in the crank chamber is returned to the intake chamber through the pressure equalization path. The reciprocating compressor in Patent Document 1 includes an unload mechanism, and thus can operate in a state where the intake valve is opened (no load operation). When the load operation transitions to the no load operation, the pressure in the intake chamber rises, and gas flows from the intake chamber to the crank chamber through the pressure equalization path.

30 **[0007]** In the reciprocating compressor in Patent Document 1, a pressure equalization pipe is formed outside of the housing, as the pressure equalization path. Alternatively, the pressure equalization path may be disposed in the housing.

[0008] The reciprocating compressor disclosed in Patent Document 1 includes a pump. In the reciprocating compressor under operation, the lubricant in the oil storage chamber is sucked up by the pump to be supplied to the bearing, which supports the crank shaft, and the like through an oil path disposed in the housing and the crank shaft.

35 Citation List

Patent Literature

40 **[0009]** Patent Document 1: US Patent No. 4,887,514 (Specification)

SUMMARY

Technical Problem

45 **[0010]** In the reciprocating compressor disclosed in Patent Document 1 under operation, the pressure difference between the crank chamber and the intake chamber causes the leak gas in the crank chamber to return to the intake chamber through the pressure equalization path. In particular, when the reciprocating compressor transitions from the no load operation to the normal operation due to the load change, the pressure in the intake chamber sharply drops. Thus, the pressure difference between the crank chamber and the intake chamber increases. As a result, the flow speed (returning speed) of the leak gas returning to the intake chamber through the pressure equalization path increases.

50 **[0011]** In the reciprocating compressor under operation, the lubricant which has lubricated the bearings spatters in the form of droplets in the crank chamber. The spattered droplets of the lubricant flow into the intake chamber through the pressure equalization path, together with the flowing leak gas. The lubricant stored in the intake chamber is sucked into the cylinder and then is discharged. The amount of the lubricant which flows into the intake chamber increases with the returning speed of the leak gas. Thus, when the return speed is high, the amount of the lubricant discharged from the reciprocating compressor is large, and as a result, the amount of the lubricant in the reciprocating compressor is reduced. This might eventually lead to oil loss.

55 **[0012]** In the reciprocating compressor disclosed in Patent Document 1, the pressure equalization pipe, formed as

the pressure equalization path, has a function as an oil separator. When the returning speed of the leak gas is high, the lubricant in the pressure equalization path is blown up by the leak gas. Thus, the amount of the lubricant discharged from the reciprocating compressor increases, and thus the amount of the lubricant in the reciprocating compressor is reduced, even in the reciprocating compressor having the oil separator in the pressure equalization path. This might eventually lead to oil loss.

[0013] An object of at least one embodiment of the present invention is to provide a reciprocating compressor in which reduction of lubricant is prevented.

Solution to Problem

[0014] A reciprocating compressor according to at least one embodiment of the present invention includes a housing which includes an intake chamber, a discharge chamber, a cylinder, and a crank chamber, the crank chamber having a lower portion formed as an oil storage chamber configured to store lubricant; a piston which is reciprocally located in the cylinder; a crank shaft which is rotatably arranged in the crank chamber and is coupled to the piston via a connecting rod; a pressure equalization path through which the intake chamber and the crank chamber communicates, the pressure equalization path having an opening end open to the crank chamber; and a partition member which is located between the crank shaft and the opening end of the pressure equalization path. The partition member extends below the crank shaft from one side of the crank shaft to the other side of the crank shaft so as to cover at least the lower side of the crank shaft.

[0015] In this configuration, droplets of the lubricant scattering from the crank shaft collide on the partition member, and thus do not directly flow into the opening end of the pressure equalization path. Thus, the amount of the lubricant which flows into the intake chamber through the pressure equalization path is reduced, and thus the lubricant is prevented from being discharged from the reciprocating compressor.

[0016] In a reciprocating compressor according to one embodiment, the partition member includes a plurality of partition plates, and the plurality of partition plates are arranged along an axial direction of the crank shaft.

[0017] In this configuration, the partition member includes a plurality of partition plates, and thus can be easily arranged in the crank chamber.

[0018] In a reciprocating compressor according to one embodiment, the partition plates each include: a lower portion which has a quarter cylinder shape and is curved along a lower side of the crank shaft; and an upper portion which continues to the lower portion and is positioned on a side closer to the crank shaft.

[0019] In this configuration, droplets which have collided on the partition plates are collected in the lower portion of the partition plates, and then smoothly flow into the oil storage chamber.

[0020] In a reciprocating compressor according to one embodiment, end portions of the plurality of partition plates which are adjacent to each other in the axial direction of the crank shaft overlap one another in a thickness direction of the partition plates with a gap in between.

[0021] In this configuration, droplets collected in the lower portion of each of the partition plates smoothly flow into the oil storage chamber through the gap between the partition plates.

[0022] A reciprocating compressor according to one embodiment further includes a collecting member which is located between the gap between the partition plates and collects the lubricant which passes through the gap.

[0023] In this configuration, the amount of the lubricant which flows into the opening end of the pressure equalization path is further reduced, and thus the lubricant is further prevented from being discharged from the reciprocating compressor.

[0024] A reciprocating compressor according to one embodiment further includes an oil separator located between the partition member and the opening end of the pressure equalization path. The oil separator includes: a labyrinth portion which is formed on a side closer to the partition member and defines a winding flow path; and a hollow portion which is formed on a side closer to the opening end and defines a flow path having a larger cross-sectional area than the flow path defined by the labyrinth portion.

[0025] In this configuration, the diameter of oil droplets increases as the oil droplets pass through the labyrinth portion, and the separation of the oil droplets passing through the hollow portion from gas is facilitated by gravitational settling. As a result, the oil droplets are efficiently collected by the oil separator. Thus, the amount of the lubricant which flows into the opening end of the pressure equalization path is further reduced, whereby the amount of the lubricant discharged from the reciprocating compressor is further reduced.

Advantageous Effects

[0026] With at least one embodiment of the present invention, a reciprocating compressor in which reduction of lubricant is prevented is provided.

BRIEF DESCRIPTION OF DRAWINGS

[0027]

- 5 [FIG. 1] FIG. 1 is a schematic vertical cross-sectional view of a reciprocating compressor according to one embodiment of the present invention, also illustrating the configuration of a refrigeration cycle.
- [FIG. 2] FIG. 2 is a schematic horizontal cross-sectional view of the reciprocating compressor in FIG. 1.
- [FIG. 3] FIG. 3 is a perspective view schematically illustrating partition plates in FIGs. 1 and 2.
- 10 [FIG. 4] FIG. 4 is a schematic horizontal cross-sectional view of a reciprocating compressor according to another embodiment.
- [FIG. 5] FIG. 5 is a partial schematic horizontal cross-sectional view of a reciprocating compressor according to another embodiment.
- [FIG. 6] FIG. 6 is a schematic outer view of an oil separator in FIG. 6.
- 15 [FIG. 7] FIG. 7 is a partial schematic horizontal cross-sectional view of a reciprocating compressor according to still another embodiment.
- [FIG. 8] FIG. 8 is a view illustrating a state in which a collecting member is disposed in the gap between the partition plates in FIG. 3.

DETAILED DESCRIPTION

- 20 **[0028]** Embodiments of the present invention are described below with reference to the drawings. The sizes, materials, shapes, relative positions, and the like of the components described in the embodiments or illustrated in the drawings are merely examples for the description and there is no intention to limit the scope of the present invention thereto.
- 25 **[0029]** FIG. 1 is a schematic vertical cross-sectional view of a reciprocating compressor according to one embodiment, and is also a schematic view illustrating the configuration of a refrigeration cycle employing the reciprocating compressor.
- [0030]** The refrigeration cycle includes a circulation path 10 in which a coolant circulates. The circulation path 10 includes the reciprocating compressor, a condenser (high pressure side heat exchanger) 12, an expansion valve (expander) 14, and an evaporator (low pressure side heat exchanger) 16, arranged in this order in a circulation direction of the coolant. In the present embodiment, an oil separator 18 and a liquid receiver 20 are disposed on the circulation path 10.
- 30 **[0031]** In the refrigeration cycle, for example, the reciprocating compressor sucks a coolant at a pressure of 1 MPa to 3 MPa (intake pressure), compresses the coolant, and discharges the coolant at a pressure of 4 MPa to 6 MPa (discharge pressure). The ranges of the intake pressure and the discharge pressure are not limited to those described above. The coolant is, for example, ammonia or carbon dioxide.
- 35 **[0032]** The reciprocating compressor includes a housing 22 provided with an intake port 24 and a discharge port 26. The intake port 24 is connected to an outlet of the evaporator 16 through a pipe, and the discharge port 26 is connected to an inlet to the oil separator 18 through a pipe.
- [0033]** The housing 22 incorporates an intake chamber 28, a discharge chamber 30, a cylinder 32, and a crank chamber 34. A piston 36 is reciprocally located in the cylinder 32. A compression chamber is defined by the piston 36 in the cylinder 32. The intake chamber 28 and the discharge chamber 30 communicate with the intake port 24 and the discharge port 26, and can communicate with the compression chamber through an intake valve and a discharge valve, respectively.
- 40 **[0034]** The reciprocating compressor according to the present embodiment is a multicylinder reciprocating compressor including a plurality of pistons 36 and a plurality of cylinders 32. Each of the cylinders 32, defined by a cylinder sleeve, may alternatively be defined by a cylinder block.
- 45 **[0035]** One end of the cylinder 32 communicates with the crank chamber 34. A connecting rod 38 connected to the piston 36 extends into the crank chamber 34. In the crank chamber 34, a crank shaft 40 is rotatably disposed and the connecting rod 38 is connected to the crank shaft 40. More specifically, the crank shaft 40 is rotatably supported by the housing 22 via a plain bearing as a radial bearing. The plain bearing as the radial bearing is also located between the connecting rod 38 and the piston 36 and the crank shaft 40.
- 50 **[0036]** One end side of the crank shaft 40 is airtightly disposed through the housing 22, and an unillustrated driving source is connected to an outer end of the crank shaft 40. When the driving source rotates the crank shaft 40, the piston 36 reciprocates in the cylinder 32, whereby intake, compressing, and discharging steps for the coolant are repeatedly executed.
- 55 **[0037]** The reciprocating compressor according to the present embodiment includes an unloader mechanism (capacity control mechanism) configured to change a discharge capacity in accordance with a load. More specifically, the unloader mechanism includes an unloader piston 37 capable of operating in accordance with a load, and can control the opening/closing of an intake valve in accordance with the position of the unloader piston 37.
- [0038]** More specifically, the intake valve is constantly opened by a link member, operating together with the unloader

piston 37, when the load is reduced, whereby an intake capacity is reduced.

[0039] When the state where the intake capacity is reduced continues and a load side temperature rises, evaporation of the coolant in the evaporator 16 is facilitated, whereby the intake pressure rises.

[0040] To increase the intake capacity to lower the intake pressure, the capacity control mechanism is operated to change the position of the unloader piston 37. Thus, the intake valve is no longer constantly opened, whereby the intake capacity increases to return to the original level.

[0041] In the reciprocating compressor under operation, lubricant is supplied to sliding members such as the radial bearings and the pistons 36. Thus, a bottom portion of the crank chamber 34 is defined as an oil storage chamber 35 for the lubricant. The reciprocating compressor includes an oil pump 42 which operates together with the crank shaft 40. The lubricant sucked up from the oil storage chamber 35 by the oil pump 42 is supplied to the sliding members through an oil path disposed in or out of the housing 22. The oil path is, for example, formed also in the crank shaft 40 as illustrated with a dotted line in FIG. 1.

[0042] In the present embodiment, oil filters 46 and 48 for cleaning the lubricant are disposed in the oil storage chamber 35 and out of the housing 22, respectively.

[0043] FIG. 2 is a schematic horizontal cross-sectional view of the reciprocating compressor in FIG. 1.

[0044] In the reciprocating compressor under operation, the coolant leaks through a gap between the piston 36 and a wall surface of the cylinder 32, and flows into the crank chamber 34. The reciprocating compressor includes a pressure equalization path 50 through which the intake chamber 28 and the crank chamber 34 communicate, to prevent the leaked coolant (leak gas) from raising the pressure in the crank chamber 34. In the present embodiment, a through hole as the pressure equalization path 50 is formed in the housing 22.

[0045] The pressure equalization path 50 includes an opening end (inlet end) open to the crank chamber 34 and an opening end (outlet end) open to the intake chamber 28. The inlet end of the pressure equalization path 50 is positioned above a normal oil surface level of the lubricant in the oil storage chamber 35.

[0046] As shown in FIG. 1 and FIG. 2, the reciprocating compressor according to the present embodiment includes a partition member 52 which partitions the crank shaft 40 from the opening end of the pressure equalization path 50. In the present embodiment, the partition member 52 includes three partition plates 54a, 54b, and 54c. The partition plates 54a, 54b, and 54c are also collectively referred to as a partition plate 54.

[0047] As shown in FIG. 3, the partition plate 54 includes a lower portion 56 which has a substantially quarter cylinder shape and upper portions 58 which continue to the lower portion 56 and have a flat plate shape. Upper end sides of the upper portions 58 are fixed to the housing 22 with fixing members such as bolts.

[0048] When the partition plate 54 is fixed to the housing 22, the lower portion 56 of the partition plate 54 is curved to protrude downward along the lower side of the crank shaft 40. The upper portions 58 are inclined to have a portion farther from the crank shaft 40 in a horizontal direction positioned at a higher portion, and are positioned on both sides of the crank shaft 40 in the horizontal direction orthogonal to the crank shaft 40.

[0049] In other words, the partition plate 54 extends from a portion of the housing 22 on one side of the crank shaft 40 to a portion of the housing 22 on another side of the crank shaft 40 below a lower side of the crank shaft 40 so as to cover at least the lower side of the crank shaft 40. The lower portion 56 of the partition plate 54 has a most recessed portion positioned directly below the crank shaft 40.

[0050] The partition plate 54 extends along an axial direction of the crank shaft 40. The three partition plates 54a, 54b, and 54c are arranged along the axial direction of the crank shaft 40 with end portions of the partition plates 54a, 54b, and 54c adjacent to each other overlapping one another in a thickness direction of the partition plates 54a, 54b, and 54c with a gap in between.

[0051] In the reciprocating compressor according to the embodiment described above, the partition plate 54 partitions the crank shaft 40 from the inlet end of the pressure equalization path 50. Thus, in the reciprocating compressor under operation, even when droplets of the lubricant, which has lubricated the bearings and the like, scatter from the crank shaft 40 and the bearings, the droplets collide on the partition plate 54, and thus do not directly flow into the inlet end of the pressure equalization path 50. Thus, the amount of the lubricant which flows into the intake chamber 28 through the pressure equalization path 50 is reduced, and thus the lubricant is prevented from being discharged from the reciprocating compressor.

[0052] In conventional reciprocating compressors, when the unloader mechanism operates to reduce the intake capacity and temporarily establish a no load operation state, and then the intake capacity increases and the state transitions to a normal operation state, the intake pressure sharply drops. Thus, the droplets are likely to flow into the pressure equalization path. In the reciprocating compressor according to the embodiment described above, the partition plate 54 prevents the droplets from directly flowing into the inlet end of the pressure equalization path 50 when the no load operation state transitions to the normal operation state.

[0053] In the reciprocating compressor according to the embodiment, the partition member 52 includes a plurality of partition plates 54, and thus can be easily arranged in the crank chamber 34.

[0054] In the reciprocating compressor according to the embodiment, the droplets which have collided on the partition

plates 54 are collected in the lower portion 56 protruding downward, and then smoothly flow into the oil storage chamber 35 through the gap between the partition plates 54.

[0055] The present invention is not limited to the embodiment described above, and includes embodiments obtained by modifying the embodiment described above, as exemplarily described below. In the description of the embodiments below, the configurations which are the same as or similar to the embodiment described above are denoted with the same reference numerals and the description thereof will be omitted.

[0056] FIG. 4 is a schematic horizontal cross-sectional view of a reciprocating compressor according to another embodiment.

[0057] In the reciprocating compressor in FIG. 4, a pressure equalization pipe 60 is formed outside of the housing 22, as the pressure equalization path 50.

[0058] Also in this configuration, the partition plate 54 prevents the droplets from directly flowing into the inlet end of the pressure equalization path 50.

[0059] FIG. 5 is a partial schematic horizontal cross-sectional view of a reciprocating compressor according to still another embodiment.

[0060] The reciprocating compressor in FIG. 5 further includes an oil separator 64 arranged in the crank chamber 34.

[0061] FIG. 6 is a schematic outer perspective view of the oil separator 64. As shown in FIG. 5 and FIG. 6, the oil separator 64 includes a labyrinth portion 66 on a side closer to the partition plate 54 and a hollow portion 68 on a side closer to the inlet end of the pressure equalization path.

[0062] The labyrinth portion 66 defines a winding flow path, and the hollow portion 68 defines a flow path having a larger cross-sectional area than that of the flow path defined by the labyrinth portion 66.

[0063] More specifically, the oil separator 64 includes a circumference wall 70 forming a cylinder shape and a flange 72 extending outward from one end of the circumference wall 70. The axial direction of the circumference wall 70 is arranged towards the crank shaft 40. A plurality of partition walls 76, each being orthogonal to the circumference wall 70, are disposed on the inner side of the circumference wall 70. The partition walls 76 are separated from each other in an axial direction of the circumference wall 70, and define the winding flow path in the labyrinth portion 66. The flange 72 is provided with a through hole (gas return aperture 78) which communicates with the inlet end of the pressure equalization path 50.

[0064] In the present embodiment, a through hole (oil dropping aperture 80), through which an intermediate portion of the pressure equalization path 50 and the crank chamber 34 communicate, is provided. The lubricant, which has flowed down from the intake chamber 28, returns to the crank chamber 34 through the oil dropping aperture 80. The cross-sectional area of the oil dropping aperture 80 is set in such a manner that the lubricant stays on the oil dropping aperture 80. Thus, the oil droplets in the crank chamber 34 does not directly flow into the oil dropping aperture 80 to reach the intake chamber 28.

[0065] A check valve which prevents a fluid from flowing into the intake chamber 28 from the crank chamber 34 may be disposed at the position of the oil dropping aperture 80.

[0066] In the reciprocating compressor, the diameter of the oil droplets increases as the oil droplets pass through the labyrinth portion 66 of the oil separator 64, and the separation of the oil droplets passing through the hollow portion 68 from gas is facilitated by gravitational settling. As a result, the oil droplets are efficiently collected by the oil separator 64. Thus, the amount of the lubricant which flows into the inlet end of the pressure equalization path 50 is further reduced, whereby the amount of the lubricant discharged from the reciprocating compressor is further reduced.

[0067] In the reciprocating compressor, the upper portions 58 of the partition plate 54 are inclined. Thus, the oil separator 64 can be arranged in the crank chamber 34 without preparing the housing 22 of a large size.

[0068] FIG. 7 is a partial schematic horizontal cross-sectional view of a reciprocating compressor according to yet still another embodiment.

[0069] In the reciprocating compressor, an oil return path 82, through which the intake chamber 28 and the crank chamber 34 communicate, is provided separately from the pressure equalization path 50. The cross-sectional area of the oil return path 82 is set in such a manner that the oil return path 82 is constantly closed by the lubricant. Thus, the oil droplets in the crank chamber 34 do not directly flow into the oil return path 82 to reach the intake chamber 28.

[0070] FIG. 8 exemplarily illustrates a configuration in which a collecting member 84 is disposed in the gap between the end portions of the partition plates 54. The collecting member 84 has a mesh structure. The droplets passing through the collecting member 84 are collected to be large and the resultant large droplet flows down in the oil storage chamber.

[0071] With the collecting member 84, the amount of the lubricant flowing into the inlet end of the pressure equalization path 50 is further reduced, whereby the amount of the lubricant discharged from the reciprocating compressor is further reduced.

[0072] The oil separator 18, located between the reciprocating compressor and the condenser 12 in the refrigeration cycle described above, may be omitted because the amount of the lubricant discharged from the reciprocating compressor is reduced.

[0073] The number of partition plates 54, which is three in the partition member 52 described above, is not particularly

limited. The plate member, as the component of the partition plate 54, may be provided with a slit. Furthermore, the partition plate 54 may be formed by a mesh or punching metal member, and the like.

Reference Signs List

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[0074]

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- 22 housing
- 28 intake chamber
- 30 discharge chamber
- 32 cylinder
- 34 crank chamber
- 35 oil storage chamber
- 36 piston
- 38 connecting rod
- 40 crank shaft
- 50 pressure equalization path
- 52 partition member
- 54 (54a, 54b, 54c) partition plate
- 56 lower portion
- 58 upper portion
- 64 oil separator
- 66 labyrinth portion
- 68 hollow portion

Claims

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1. A reciprocating compressor comprising:

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a housing which includes an intake chamber, a discharge chamber, a cylinder, and a crank chamber, the crank chamber having a lower portion formed as an oil storage chamber configured to store lubricant;
 a piston which is reciprocatively located in the cylinder;
 a crank shaft which is rotatably arranged in the crank chamber and is coupled to the piston via a connecting rod;
 a pressure equalization path through which the intake chamber and the crank chamber communicates, the pressure equalization path having an opening end open to the crank chamber; and
 a partition member which is located between the crank shaft and the opening end of the pressure equalization path, wherein
 the partition member extends below the crank shaft from one side of the crank shaft to the other side of the crank shaft so as to cover at least the lower side of the crank shaft.

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2. The reciprocating compressor according to claim 1, wherein the partition member includes a plurality of partition plates, and the plurality of partition plates are arranged along an axial direction of the crank shaft.

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3. The reciprocating compressor according to claim 2, wherein the partition plates each include: a lower portion which has a quarter cylinder shape and is curved along a lower side of the crank shaft; and an upper portion which continues to the lower portion and is positioned on a side of the crank shaft.

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4. The reciprocating compressor according to claim 3, wherein end portions of the plurality of partition plates which are adjacent to each other in the axial direction of the crank shaft overlap one another in a thickness direction of the partition plates with a gap in between.

5. The reciprocating compressor according to claim 3 further comprising a collecting member which is located between the gap between the partition plates and collects the lubricant which passes through the gap.

6. The reciprocating compressor according to claim 1 further comprising an oil separator located between the partition member and the opening end of the pressure equalization path, wherein

EP 2 891 800 A1

the oil separator includes:

a labyrinth portion which is formed on a side of the partition member and defines a curved flow path; and
a hollow portion which is formed on a side of the opening end and defines a flow path having a larger cross-sectional area than the flow path defined by the labyrinth portion.

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FIG. 1

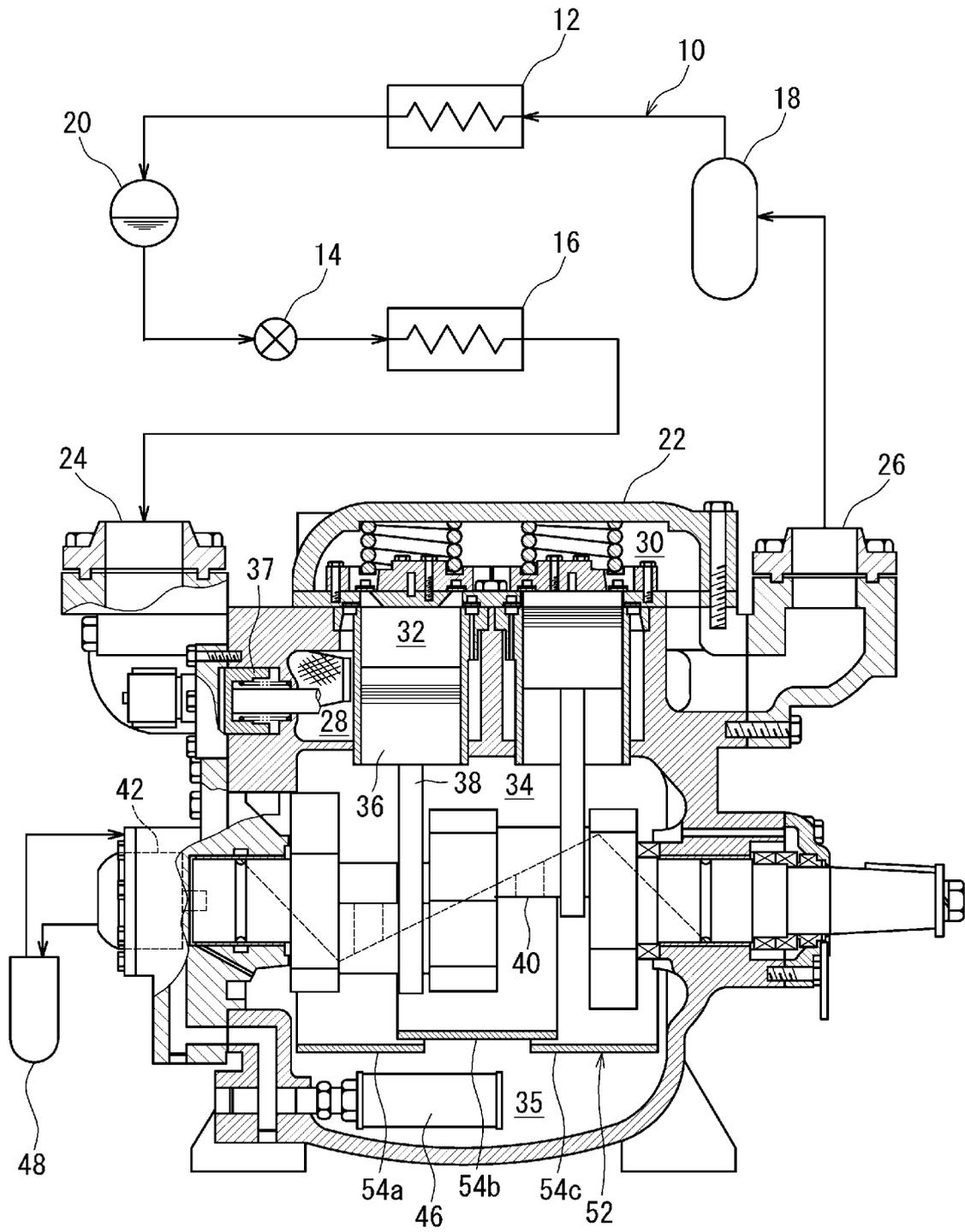


FIG. 2

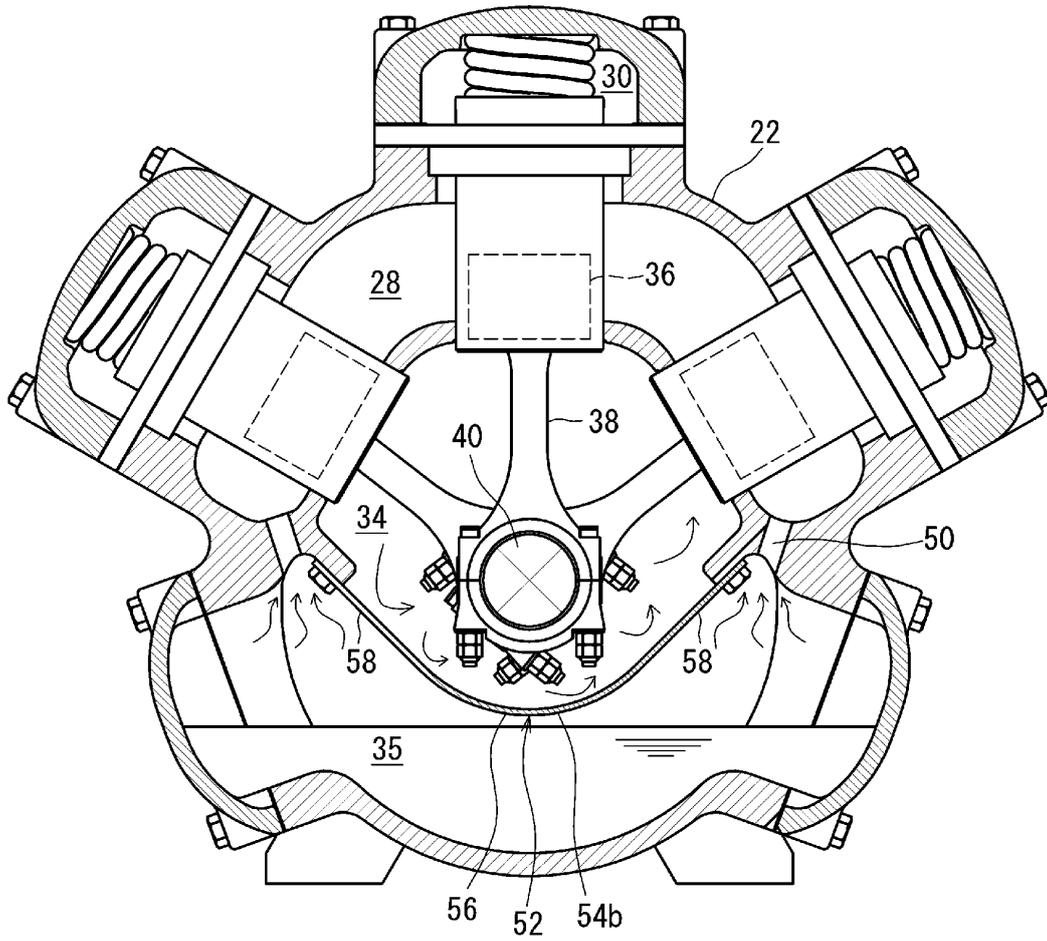


FIG. 3

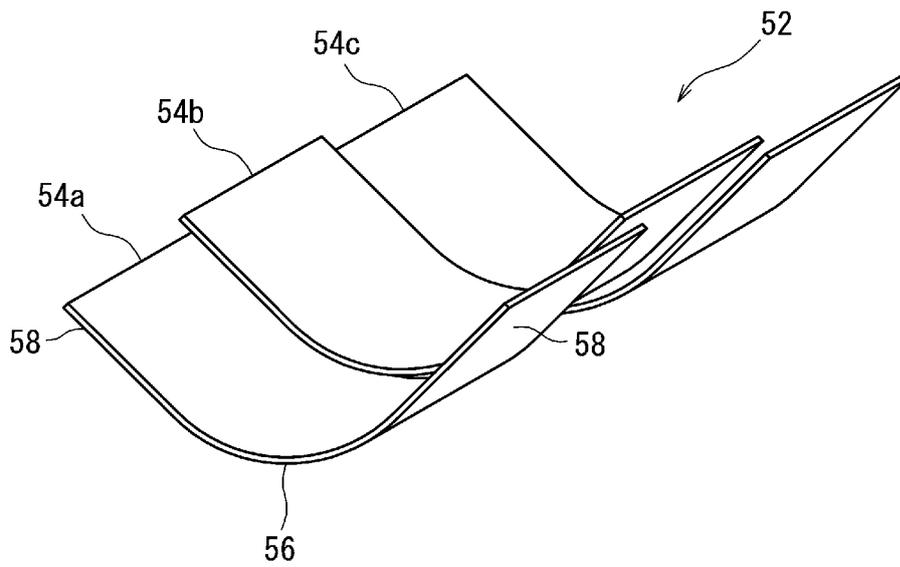


FIG. 4

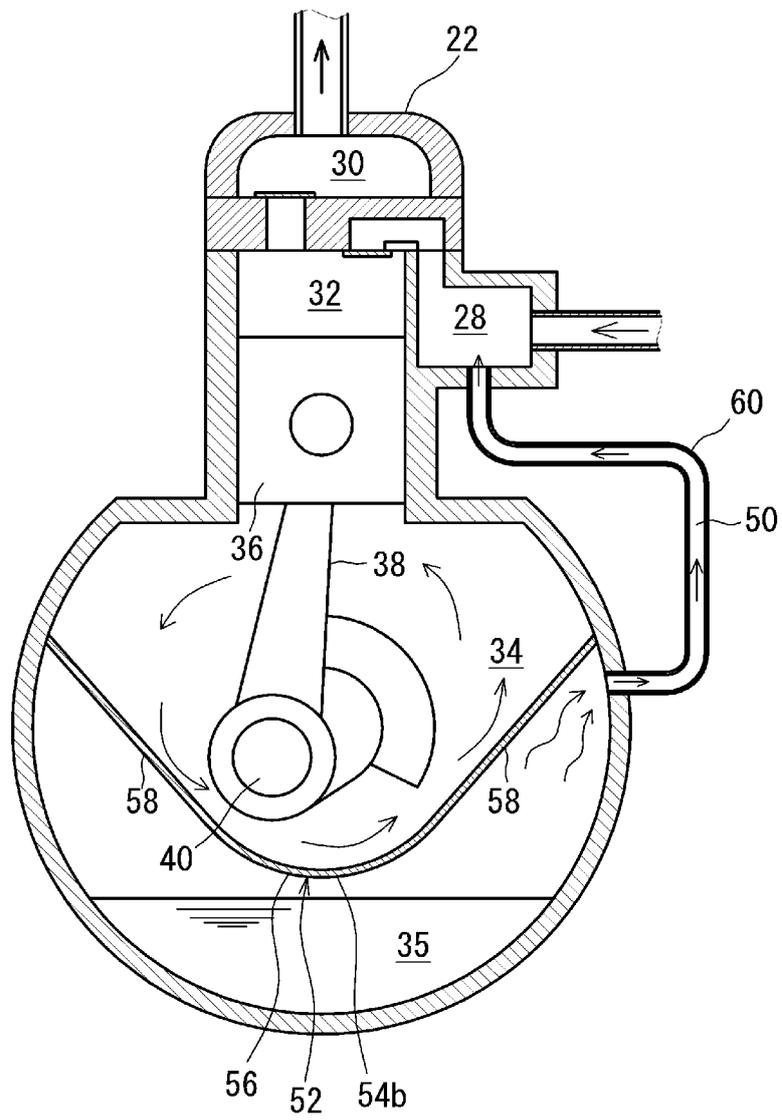


FIG. 5

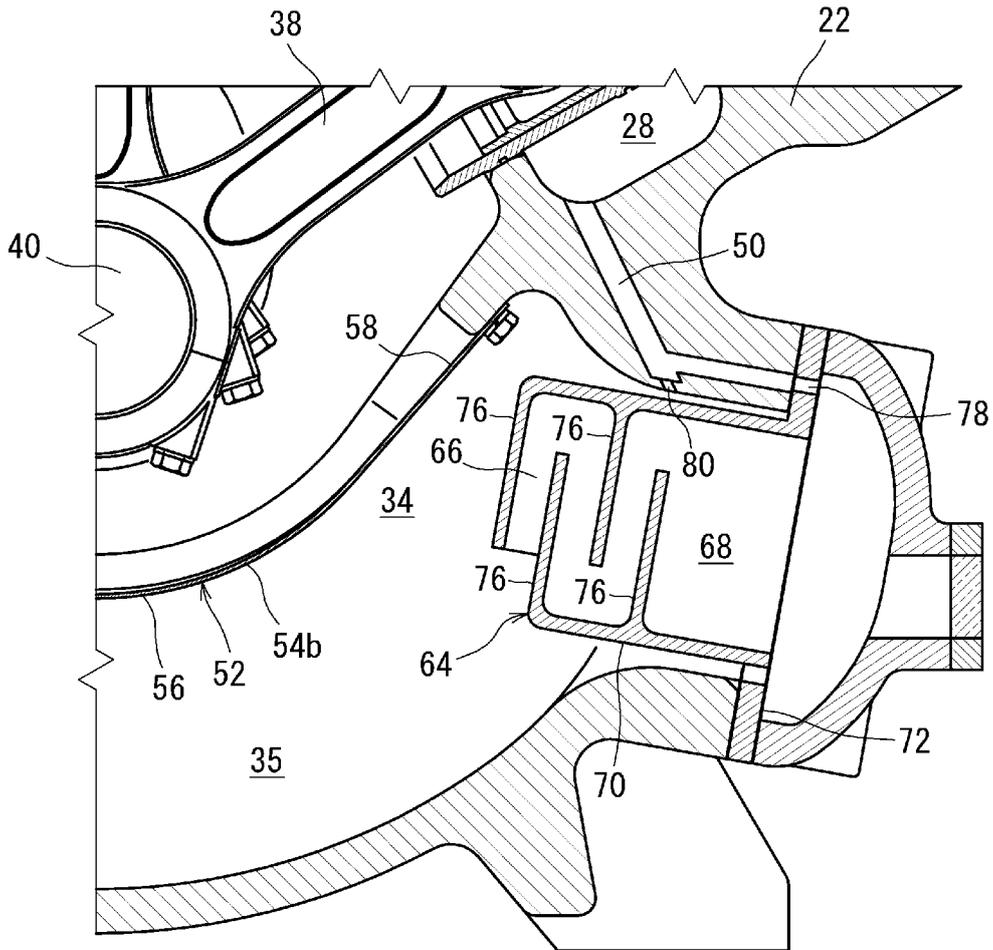


FIG. 6

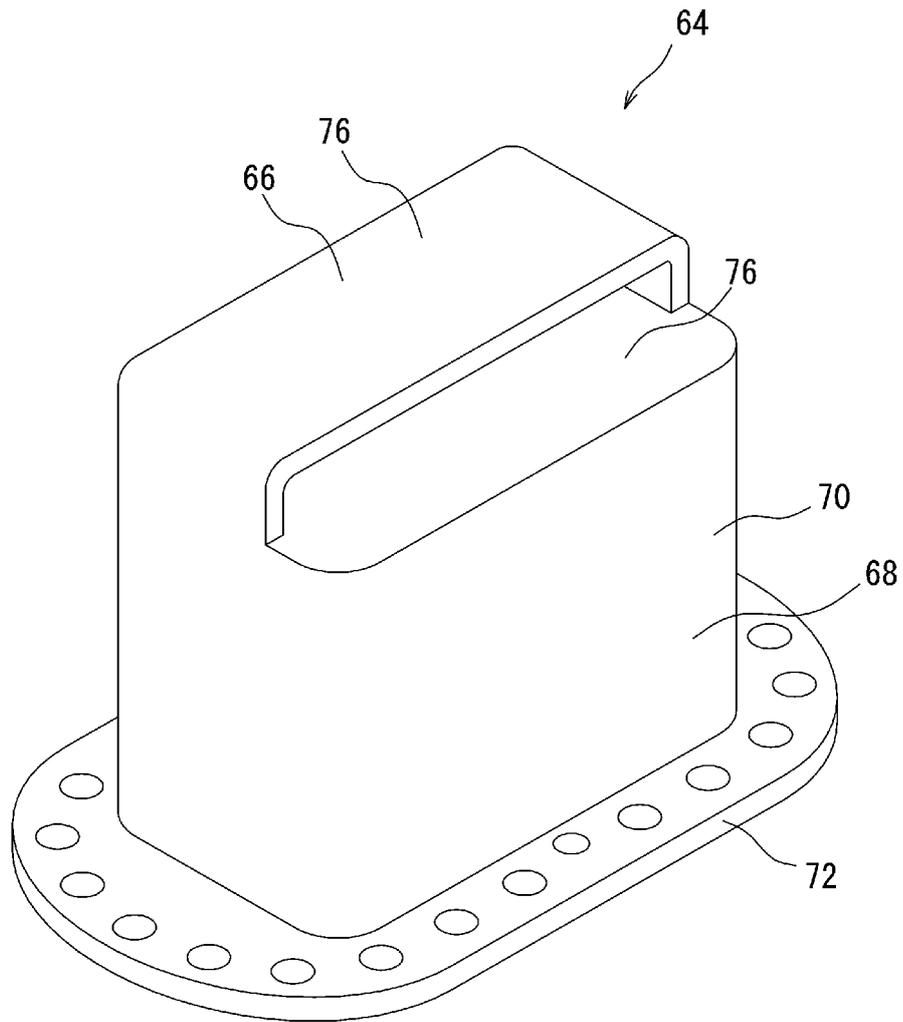


FIG. 7

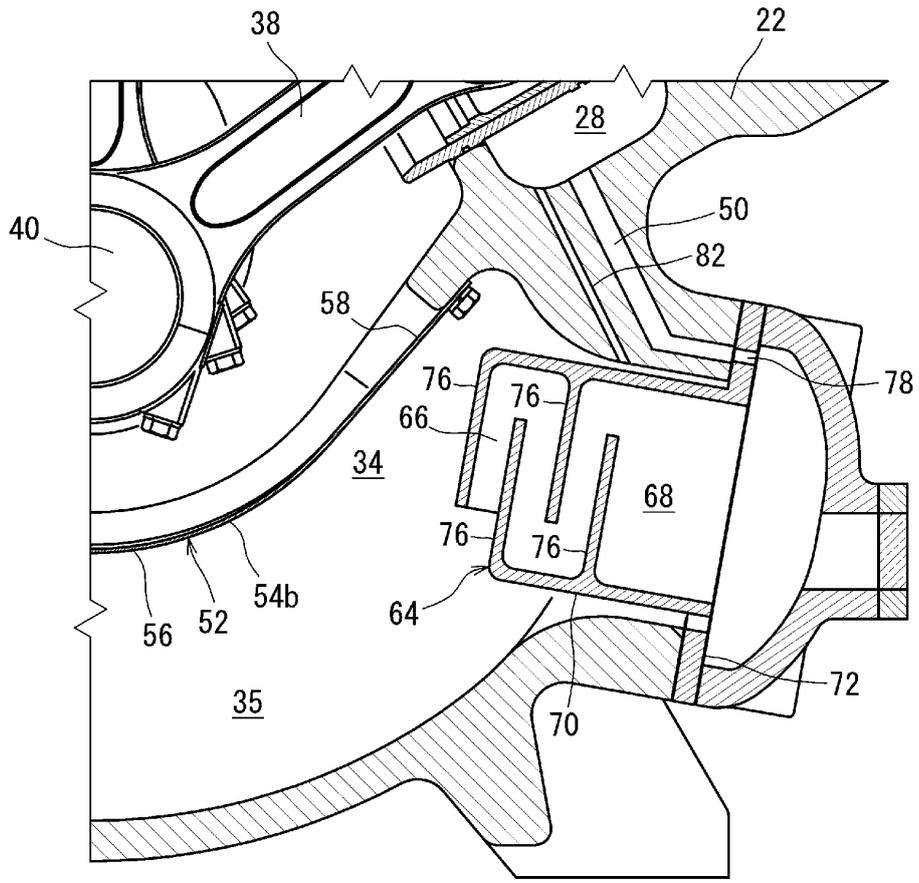
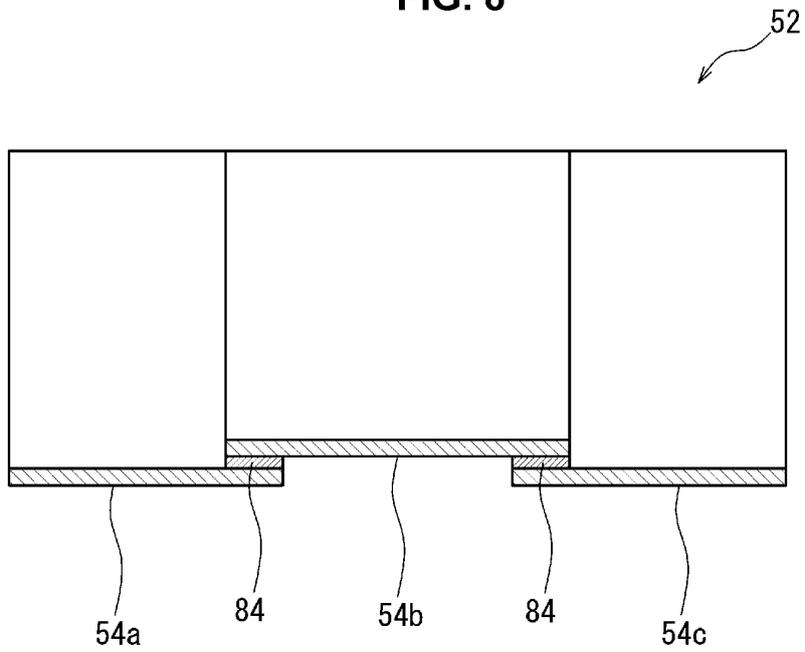


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/075324

| | | |
|----|---|--|
| 5 | A. CLASSIFICATION OF SUBJECT MATTER F04B27/04(2006.01) i | |
| | According to International Patent Classification (IPC) or to both national classification and IPC | |
| 10 | B. FIELDS SEARCHED | |
| | Minimum documentation searched (classification system followed by classification symbols) F04B27/04 | |
| 15 | Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012 Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012 | |
| | Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) | |
| 20 | C. DOCUMENTS CONSIDERED TO BE RELEVANT | |
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| 35 | A | WO 2001/088374 A1 (Zexel Cold Systems Co.), 22 November 2001 (22.11.2001), entire text; all drawings & EP 1283364 A1 |
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