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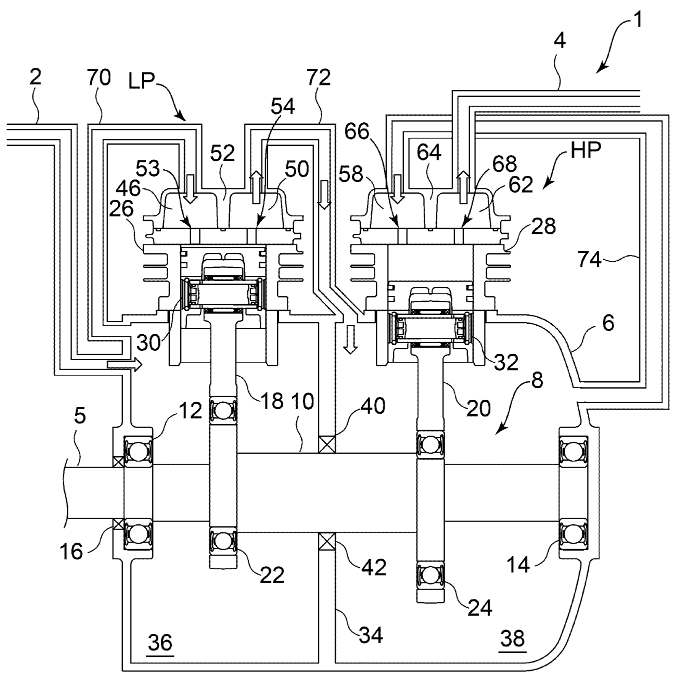
(54) RECIPROCATING BOOSTER COMPRESSOR

(57) In a reciprocating booster compressor, the inside of a crank case accommodating a crank mechanism is separated into a first space and a second space by a separation wall. At least one of the first space or the second space is pressurized by having a gas pressurized in the first cylinder unit or the second cylinder unit introduced thereinto, and set to a pressure corresponding to a first cylinder unit or a second cylinder unit.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a reciprocating booster compressor capable of further compressing a pressurized gas supplied from outside by reciprocating motions of pistons in cylinders.

BACKGROUND

[0002] Generally in a reciprocating compressor, a gas supplied from outside is compressed by converting a rotational motion of an input shaft, to which power is input from a power source such as an electric motor, into a reciprocating motion of a piston in a cylinder by a crank mechanism accommodated in a crank case. In recent years, a so-called booster compressor for further boosting a gas pressurized to or above an atmospheric pressure in view of energy saving in addition to an increasing demand for a compressed gas having a higher pressure is known among compressors of this type.

[0003] In a reciprocating booster compressor, a gas having an atmospheric pressure or higher is compressed. Thus, if a pressure in a crank case is an atmospheric pressure, a pressure difference between a compression chamber and the crank case specified by a cylinder and a piston becomes larger and a large load is applied to components such as a bearing member of a crankshaft constituting a crank mechanism. As a result, a product life is shortened. Further, if the pressure in the crank case is the atmospheric pressure, it is hard to obtain an energy saving effect. Accordingly, in the reciprocating booster compressor of this type, a load during a suction stroke is suppressed and a high energy saving effect is obtained by pressurizing the inside of the crank case and reducing the pressure difference between the crank case and the compression chamber. For example, in Patent Document 1, a pressure difference between a compression chamber and a crank case is reduced by accumulating a pressurized gas generated in a compression chamber in a tank and supplying part of the pressurized gas into a crank case.

Citation List

Patent Literature

[0004] Patent Document 1: JP2009-133282A

SUMMARY

Technical Problem

[0005] Among compressors of this type, a multi-stage reciprocating booster compressor is required to meet a demand for a pressurized gas having a higher pressure. For example, in the case of a two-stage reciprocating booster compressor in which a first cylinder unit having a low-pressure side compression chamber and a second cylinder unit having a high-pressure side compression chamber are connected in series, a pressurized gas supplied from outside is further compressed in the second cylinder unit after being compressed in the first cylinder unit. It is considered to drive the first and second cylinder units performing such compression by a common crank mechanism. However, since the first and second cylinder units handle the pressurized gases having mutually different pressures, if the pressure of the crank case is pressurized to a pressure appropriate for one cylinder unit, that pressure of the crank case is not appropriate for the other cylinder unit, whereby a pressure difference between the crank case and the other cylinder unit becomes inappropriate. Thus, if a configuration having a single cylinder unit as in Patent Document 1 is directly applied to a configuration having a plurality of cylinder units, such an inappropriate pressure difference is unavoidable. As a result, a load to a drive shaft and the like becomes larger and it becomes hard to obtain a high energy saving effect.

[0006] It should be noted that such a large load causes the shortening of the product life as described above. To prevent a reduction of the product life, a design thick enough to withstand a pressure difference is, for example, considered, but this leads to a heavy design and increases product cost.

[0007] At least one embodiment of the present invention was developed in view of the above situation and it is an object of the present invention to provide a reciprocating booster compressor capable of achieving a long life and obtaining a high energy saving effect by appropriately setting an internal pressure of a crank case in each cylinder unit for performing multi-stage compression.

Solution to Problem

[0008]

(1) In order to solve the above problem, a reciprocating booster compressor according to at least one embodiment of the present invention is provided with a crank mechanism for converting a rotational motion of an input shaft to which power is input into a reciprocating motion, a crank case accommodating the crank mechanism, and a plurality of cylinder units capable of compressing a gas by being driven by the reciprocating motion converted in the crank mechanism, wherein the plurality of cylinder units include a first cylinder unit compressing a pressurized gas supplied from outside and generating a first pressurized gas having a higher pressure than the pressurized gas, and a second cylinder unit connected in series to the first cylinder unit, the second cylinder unit further compressing the first pressurized gas and generating a second pressurized gas having a

higher pressure than the first pressurized gas, the crank case includes a first space corresponding to the first cylinder unit and a second space corresponding to the second cylinder unit, the first space and the second space are separated from each other by a separation wall provided inside the crank case, and at least one of the first space or the second space is pressurized by having any one of the pressurized gas, the first pressurized gas or the second pressurized gas introduced thereinto.

According to the above configuration (1), the crank case has the first space and the second space corresponding to the plurality of cylinder units. Since the first and second spaces are separated from each other by the separation wall, the first and second spaces can respectively generate independent pressures. At least one of the first space or the second space is pressurized by having any one of the pressurized gas, the first pressurized gas or the second pressurized gas introduced thereinto, whereby a pressure difference between each cylinder unit and the crank case can be suppressed.

(2) In several embodiments, in the above configuration (1), the pressurized gas is introduced into the first space, and the first pressurized gas is introduced into the second space.

According to the above configuration (2), the pressurized gas supplied to the first cylinder unit is introduced into the first space, whereby a pressure corresponding to an intake pressure of the first cylinder unit is set. On the other hand, the first pressurized gas supplied to the second cylinder unit is introduced into the second space, whereby a pressure corresponding to an intake pressure of the second cylinder unit and different from that in the first space is set.

(3) In several embodiments, the above configuration (2) is provided with a first passage connecting an intake port for the pressurized gas and the first space, and a second passage connecting the first space and a suction side of the first cylinder unit.

According to the above configuration (3), the pressurized gas to be compressed by the booster compressor is supplied to the first space via the first passage. The pressurized gas supplied to the first space passes through the first space and is supplied to the first cylinder unit via the second passage. Since the pressurized gas is supplied to the first cylinder unit by way of the first space in this way, a pressure corresponding to the first cylinder unit can be effectively generated by a dynamic pressure of the pressurized gas in the first space.

(4) In several embodiments, the above configuration (2) or (3) is provided with a third passage connecting a discharge side of the first cylinder unit and the second space, and a fourth passage connecting the second space and a suction side of the second cylinder unit.

According to the above configuration (4), the first pressurized gas discharged from the first cylinder unit is supplied to the second space via the third passage. The pressurized gas supplied to the second space passes through the second space and is supplied to the second cylinder unit via the fourth passage. Since the first pressurized gas is supplied to the second cylinder unit by way of the second space in this way, a pressure corresponding to the second cylinder unit can be effectively generated by a dynamic pressure of the pressurized gas.

(5) In several embodiments, in the above configuration (4), a radiating fin is provided on an outer surface of the third passage.

Since the first pressurized gas is hot by being compressed in the first cylinder unit, the first pressurized gas is preferably cooled before being supplied to the second cylinder unit. According to the above configuration (5), the radiating fin is provided on the outer surface of the third passage in which the first pressurized gas discharged from the first cylinder unit passes. Thus, the cooling of the first pressurized gas is promoted by the radiating fin when the first pressurized gas passes in the third passage. In this way, an intermediate cooler provided between the first and second cylinder units can be reduced in size or the intermediate cooler needs not be provided if a cooling effect by the radiating fin is sufficient, and the device can be reduced in size.

(6) In several embodiments, the above configuration (2) or (3) is provided with a fifth passage connecting a discharge side of the first cylinder unit and a suction side of the second cylinder unit, and a sixth passage branched from the fifth passage and connected to the second space.

According to the above configuration (6), the first pressurized gas discharged from the first cylinder unit is supplied to the second cylinder unit via the fifth passage. Here, the sixth passage is branched from the fifth passage and connected to the second space, and the second space can be pressurized by supplying part of the first pressurized gas to the second space. In this case, since the sixth passage can be designed independently of the fifth passage for supplying the first pressurized gas to the second cylinder unit, a more flexible device configuration can be obtained.

(7) In several embodiments, in the above configuration (6), a radiating fin is provided on an outer surface of the sixth passage.

Since the first pressurized gas is hot by being compressed in the first cylinder unit, the first pressurized gas is preferably cooled before being supplied to the second cylinder unit. According to the above configuration (7), the radiating fin is provided on the outer surface of the sixth passage in which part of the first pressurized gas discharged from the first cylinder unit passes. Thus, the cooling of the first pressurized gas is promoted by the radiating fin when the first pressurized gas passes in the sixth passage. In this way, the intermediate cooler provided between the first and second cylinder units can be reduced in size or the intermediate cooler needs not be provided if a cooling effect by the radiating fin is sufficient, and the device can be reduced in size.

(8) In several embodiments, in any one of the above configurations (1) to (7), the separation wall includes an opening through which the input shaft penetrates, and a sealing member sealing the opening while rotatably supporting the input shaft.

According to the above configuration (8), the input shaft penetrates through the opening provided in the separation wall, whereby power can be input to the first and second cylinder units separated by the separation wall. On the other hand, since the input shaft is sealed in the opening by the sealing member while being rotatably supported, the independence of the first and second spaces partitioned by the separation wall can be ensured. In this way, the first and second spaces can be respectively appropriately pressurized to pressures corresponding to the respective cylinder units.

(9) In several embodiments, in the above configuration (8), the first space is configured such that the pressurized gas introduced into the first space is injected toward the sealing member.

The sealing member for sealing the opening provided in the separation wall while rotatably supporting the input shaft tends to get hot during the rotation of the input shaft. According to the above configuration (9), the sealing member can be cooled along with the pressurization of the first space by injecting the pressurized gas introduced into the first space toward such a sealing member.

(10) In several embodiments, in the above configuration (8) or (9), the second space is configured such that the first pressurized gas introduced into the second space is injected toward the sealing member.

The sealing member for sealing the opening provided in the separation wall while rotatably supporting the input shaft tends to get hot during the rotation of the input shaft. According to the above configuration (10), the sealing member can be cooled along with the pressurization of the second space by injecting the first pressurized gas introduced into the second space toward such a sealing member.

(11) In several embodiments, in the above configuration (1), the first pressurized gas is introduced into the first space, and the second pressurized gas is introduced into the second space.

According to the above configuration (11), the first space is pressurized by having the first pressurized gas discharged from the first cylinder unit introduced thereinto, whereby a pressure difference between the first cylinder unit and the first space can be suppressed, and the second space is pressurized by having the second pressurized gas discharged from the second cylinder unit introduced thereinto, whereby a pressure difference between the second cylinder unit and the second space can be suppressed.

(12) In several embodiments, in the above configuration (1), the pressurized gas is introduced into the first space, and the second pressurized gas is introduced into the second space.

According to the above configuration (12), the first space is pressurized by having the pressurized gas, which is intake air into the first cylinder unit, introduced thereinto, whereby a pressure difference between the first cylinder unit and the first space can be suppressed, and the second space is pressurized by having the second pressurized gas discharged from the second cylinder unit introduced thereinto, whereby a pressure difference between the second cylinder unit and the second space can be suppressed.

(13) In several embodiments, in the above configuration (1), the second pressurized gas is introduced into the first space and the second space.

According to the above configuration (13), the first and second spaces are pressurized by having the second pressurized gas discharged from the second cylinder unit introduced thereinto, whereby a pressure difference between each cylinder unit and the crank case can be suppressed.

(14) In several embodiments, in any one of the above configurations (1) to (13), the reciprocating booster compressor is an oil-free compressor.

[0009] According to the above configuration (14), a load during an operation can be reduced, a heavy design of each component such as bearings and pistons can be avoided and a long product life can be obtained by appropriately setting a pressure in the crank case in the oil-free booster compressor desired to increase a discharge pressure in the future.

Advantageous Effects

[0010] According to at least one embodiment of the present invention, it is possible to provide a reciprocating booster compressor capable of avoiding a heavy design and achieving a long life by appropriately setting an internal pressure of a crank case in each cylinder unit for performing multi-stage compression.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

FIG. 1 is a sectional view showing the configuration of a reciprocating booster compressor according to a first embodiment,

FIG. 2 is one modification of FIG. 1,

FIG. 3 is a sectional view showing the configuration of a reciprocating booster compressor according to a second embodiment,

FIG. 4 is a sectional view showing the configuration of a reciprocating booster compressor according to a third embodiment,

FIG. 5 is a sectional view showing the configuration of a reciprocating booster compressor according to a fourth embodiment, and

FIG. 6 is a sectional view showing the configuration of a reciprocating booster compressor according to a fifth embodiment.

DETAILED DESCRIPTION

[0012] Hereinafter, several embodiments of the present invention will be described with reference to the accompanying drawings. It is intended, however, that dimensions, materials, shapes, relative arrangements and the like of components described in the embodiments or shown in the drawings shall be interpreted as illustrative only and not limitative of the scope of the present invention.

[0013] For example, an expression indicating a relative or absolute arrangement such as "in a certain direction", "along a certain direction", "parallel", "orthogonal", "center", "concentric" or "coaxial" shall be interpreted as not only strictly indicating such an arrangement, but also indicating a relatively displaced state with tolerances or at such an angle or with such a distance as to provide the same functions.

[0014] Further, for example, an expression indicating a shape such as a rectangular shape or a cylindrical shape shall be interpreted as not only indicating a shape such as a rectangular shape or a cylindrical shape in a geometrically strict sense, but also indicating a shape including an uneven part or a chamfered part in such a range that the same effects are obtained.

[0015] On the other hand, an expression such as "comprise", "include", "have", "contain" and "constitute" are not intended to be exclusive of other components.

<First Embodiment>

[0016] FIG. 1 is a sectional view showing the configuration of a reciprocating booster compressor (hereinafter, referred to as a "compressor" as appropriate) according to a first embodiment. The compressor 1 is an oil-free reciprocating compressor, and a pressurized gas having a higher pressure than an atmospheric pressure is introduced into the compressor 1 via a first passage 2, which is a supply pipe, from an external gas supply source (not shown). The compressor 1 compresses the pressurized gas introduced from the first passage 2 in a plurality of cylinder units (first cylinder unit LP and second cylinder unit HP) connected in series to each other and discharges the compressed gas toward an external supply destination (not shown) from a discharge pipe 4.

[0017] It should be noted that although the oil-free compressor 1 is mainly described below, an application to an oil lubricated compressor 1 is also possible unless otherwise specified.

[0018] The compressor 1 has an input shaft 5 which can be rotationally driven by power input from an external power source (not shown) such as an electric motor. The input shaft 5 is integrally formed to a crankshaft 10 constituting a crank mechanism 8 accommodated in a crank case 6 provided in a lower part of the compressor 1. The crankshaft 10 is rotatably supported by bearings 12, 14 provided in the crank case 6. Further, the input shaft 5 penetrates through the crank case 6 on the side of the bearing 12, and the inside of the crank case 6 is tightly sealed from outside by a sealing member 16.

[0019] One end of each of connecting rods 18, 20 corresponding to the first and second cylinder units LP, HP provided above the crank case 6 is pivotally supported on the crankshaft 10 via a sealing member 22, 24. The other ends of the connecting rods 18, 20 are pivotally supported on pistons 30, 32 inserted into cylinders 26, 28 constituting the first and second cylinder units LP, HP.

[0020] It should be noted that since the compressor 1 is oil-free, composite pistons (composite resin pistons) are, for example, used as the pistons 30, 32 and a method for fixing unillustrated piston ring abutments at positions where no leakage is theoretically made during compression is employed to suppress leakage from compression chambers.

[0021] Further, a separation wall 34 is provided in an inner wall of the crank case 6. In this way, the inside of the crank case 6 is divided into a first space 36 corresponding to the first cylinder unit LP and a second space 38 corresponding to the second cylinder unit HP. The separation wall 34 is formed with an opening 40 through which the crankshaft 10 configured integrally to the input shaft 5 penetrates. A sealing member 42 for sealing the opening 40 is disposed in the opening 40 while rotatably supporting the crankshaft 10. In this way, the first and second spaces 36, 38 are separated from each other by the separation wall 34 provided inside the crank case 6.

[0022] An intake chamber 46 having an inlet port for introducing intake air and an exhaust chamber 50 having an outlet port for discharging a first pressurized gas after compression in the first cylinder unit LP are defined via a separation wall 52 on a top wall of the cylinder 26 of the first cylinder unit LP. The intake chamber 46 and the exhaust chamber 50 communicate with the inside of the cylinder 26 through an intake port 53 and an exhaust port 54. A valve (not shown) for preventing a backflow is provided in each of the intake port 53 and the exhaust port 54.

[0023] An intake chamber 58 having an inlet port for introducing intake air and an exhaust chamber 62 having an outlet port for discharging a second pressurized gas after compression in the second cylinder unit HP are defined via a separation wall 64 on a top wall of the cylinder 28 of the second cylinder unit HP. The intake chamber 58 and the exhaust chamber 62 communicate with the inside of the cylinder 28 through an intake port 66 and an exhaust port 68. A valve (not shown) for preventing a backflow is provided in each of the intake port 66 and the exhaust port 68.

[0024] The first passage 2 to which the pressurized gas is supplied is connected to communicate with the first space 36 of the crank case 6, and the first space 36 is connected to a suction side of the first cylinder unit LP via a second passage 70. Thus, the pressurized gas supplied from the first passage 2 is sucked into the first cylinder unit LP via the first space 36. In this way, the first space 36 is pressurized to a pressure substantially equal to a pressure in the intake chamber 46 by the pressurized gas. As a result, a pressure difference between the first space 36 and the intake chamber 46 is reduced and a load of the first cylinder unit LP during driving is mitigated.

[0025] A discharge side of the first cylinder unit LP is connected to the second space 38 of the crank case 6 by a third passage 72, and the second space 38 is connected to a suction side of the second cylinder unit HP by a fourth passage 74. Thus, the first pressurized gas discharged from the first cylinder unit LP is sucked into the second cylinder unit HP via the second space 38. In this way, the second space 38 is pressurized to a pressure substantially equal to a pressure in the intake chamber 58 by the first pressurized gas. As a result, a pressure difference between the second space 38 and the intake chamber 58 is reduced and a load of the second cylinder unit HP during driving is mitigated. It should be noted that an intermediate cooler (not shown) may be provided in the third passage 72.

[0026] Since the first and second spaces 36, 38 are separated from each other by the separation wall 34 here, the first and second spaces 36, 38 can respectively generate independent pressures. Since the inside of the crank case 6 can be divided into a plurality of spaces corresponding to the respective cylinder units and each cylinder unit can be set to a corresponding pressure in this way, a pressure difference between each cylinder unit and the crank case 6 can be appropriately suppressed. Thus, a load to components such as the bearings 12, 14 of the crankshaft 10 constituting the crank mechanism 8 can be reduced and a long product life can be achieved. Further, a high energy saving effect can be obtained.

[0027] FIG. 2 is one modification of FIG. 1. As shown in FIG. 2, the third passage 72 is constituted by a pipe-like member in which the first pressurized gas discharged from the first cylinder unit LP passes, and a radiating fin 76 is provided on the outer surface of the third passage 72. Since the first pressurized gas discharged from the first cylinder unit LP has a high temperature, the first pressurized gas is preferably cooled when being supplied to the second cylinder unit HP on a high-pressure side. Conventionally, such a hot compressed gas from a low-pressure side has been often cooled using an external device such as an intermediate cooler. However, in this embodiment, the first pressurized gas can be effectively cooled when passing in the third passage 72 by providing the radiating fin 76 on the outer surface of the third passage 72. In this way, in the case of providing an intermediate cooler (not shown) between the first and second cylinder units LP, HP, the intermediate cooler can be reduced in size. Alternatively, if a cooling effect by the radiating fin 76 is sufficient, the intermediate cooler needs not be provided. As a result, the device can be reduced in size.

[0028] Further, the third passage 72 is connected between the separation wall 34 of the crank case 6 and the second cylinder unit HP, and an outlet side thereof is open toward the sealing member 42. The sealing member 42 tends to get hot during driving since the sealing member 42 seals the opening 32 provided in the separation wall 34 while rotatably supporting the crankshaft 10. Accordingly, the sealing member 42 can be cooled along with the pressurization of the second space 38 by injecting the first pressurized gas introduced into the first space 36 toward such a sealing member 42. Particularly in the case of providing the radiating fin 76 on the third passage 72 as shown in FIG. 2, the sealing member 42 can be more effectively cooled since the first pressurized gas after cooling can be supplied from the third passage 72.

[0029] It should be noted that, similarly to the aforementioned third passage 72, the first passage 2 may also be connected between the separation wall 34 of the crank case 6 and the first cylinder unit LP, and an outlet side thereof may be open toward the sealing member 42. By injecting the introduced pressurized gas toward the sealing member 42 also in the first space 36 in this way, the sealing member 42 can be cooled along with the pressurization of the first space 36.

[0030] Particularly, if the first and third passages 2, 72 are both configured such that the outlet sides thereof are open toward the sealing member 42, the sealing member 42 is cooled from both sides (first space 36 and second space 38), wherefore temperature can be more effectively suppressed.

<Second Embodiment>

[0031] FIG. 3 is a sectional view showing the configuration of a reciprocating booster compressor (hereinafter, referred to as a "compressor" as appropriate) according to a second embodiment. It should be noted that components corresponding to those of the aforementioned first embodiment are denoted by common reference signs in FIG. 3 and overlapping description is omitted as appropriate.

[0032] In the second embodiment, an exhaust chamber 50 on a discharge side of a first cylinder unit LP is connected to an intake chamber 58 on a suction side of a second cylinder unit HP by a fifth passage 82. That is, the discharge side of the first cylinder unit LP is connected to the suction side of the second cylinder unit HP by way of the second space 38 in the first embodiment, whereas both sides are directly connected without by way of a second space 38 in the second embodiment.

[0033] A sixth passage 86 connected to the second space 38 is branched from a branch point 84 at an intermediate position of the fifth passage 82. In this way, part of a first pressurized gas flowing in the fifth passage 82 is supplied to the second space 38 via the sixth passage 86. As just described, since the sixth passage 86 can be designed independently of the fifth passage 82 for supplying the first pressurized gas to the second cylinder unit HP, a more flexible device configuration can be obtained.

[0034] Similarly to the third passage 72 shown in FIG. 2, the sixth passage 86 connected to the second space 38 may be provided with a radiating fin 76 on the outer surface thereof. In this way, the first pressurized gas supplied to the second space 38 can be cooled and a cooling effect of cooling the second space 38 (particularly, sealing member 42) can be enhanced.

[0035] Further, similarly to the third passage 72 of the first embodiment, the sixth passage 86 connected to the second space 38 may also be configured such that the first pressurized gas supplied from the sixth passage 86 to the second space 38 is injected toward the sealing member 42 provided in a separation wall 34 from the side of the second space 38. Also in this case, the first pressurized gas supplied from the sixth passage 86 is supplied to the sealing member 42, whereby the sealing member 42 is effectively cooled.

<Third Embodiment>

[0036] FIG. 4 is a sectional view showing the configuration of a reciprocating booster compressor according to a third embodiment. It should be noted that components corresponding to those of each aforementioned embodiment are denoted by common reference signs in FIG. 4 and overlapping description is omitted as appropriate.

[0037] In the present embodiment, a first pressurized gas discharged from a first cylinder unit LP is introduced into a first space 36. The first pressurized gas introduced into the first space 36 has a pressure at least higher than a pressure in the first space 36. In an example of FIG. 4, the first pressurized gas supplied to the first space 36 is introduced via a sixth passage 86 branched from a fifth passage 82 allowing communication between a discharge side of the first cylinder unit LP and a suction side of a second cylinder unit HP.

[0038] It should be noted that a pressure reducing valve for adjusting a pressure of the first pressurized gas to an appropriate value may be arranged in the sixth passage 86 for supplying the first pressurized gas to the first space 36. In this way, the first space 36 is pressurized using the first pressurized gas discharged from the first cylinder unit LP, whereby a pressure difference between the first cylinder unit LP and the first space 36 can be suppressed.

[0039] A second pressurized gas discharged from the second cylinder unit HP is introduced into another second space 38. The second pressurized gas introduced into the second space 38 has a pressure at least higher than a pressure in the second space 38. In the example of FIG. 4, the second pressurized gas supplied to the second space 38 is introduced via a seventh passage 88 branched from a discharge pipe 4 of the second cylinder unit HP.

[0040] It should be noted that a pressure reducing valve for adjusting a pressure of the second pressurized gas to an appropriate value may be arranged in the seventh passage 88 for supplying the first pressurized gas to the second space 38. In this way, the second space 38 is pressurized using the second pressurized gas discharged from the second cylinder unit HP, whereby a pressure difference between the second cylinder unit HP and the second space 38 can be suppressed.

<Fourth Embodiment>

[0041] FIG. 5 is a sectional view showing the configuration of a reciprocating booster compressor according to a fourth embodiment. It should be noted that components corresponding to those of each aforementioned embodiment are denoted by common reference signs in FIG. 5 and overlapping description is omitted as appropriate.

[0042] In the present embodiment, a pressurized gas supplied from a first passage (supply pipe) 2 is introduced into a first space 36 as in the aforementioned first and second embodiments. In this way, the first space 36 is pressurized using the pressurized gas supplied from the supply pipe 2, whereby a pressure difference between a first cylinder unit LP and the first space 36 can be suppressed.

[0043] A second pressurized gas discharged from a second cylinder unit HP is introduced into another second space 38. The second pressurized gas introduced into the second space 38 has a pressure at least higher than a pressure in the second space 38. In an example of FIG. 5, the second pressurized gas supplied to the second space 38 is introduced via a seventh passage 88 branched from a discharge pipe 4 of the second cylinder unit HP as in the aforementioned third embodiment.

[0044] It should be noted that a pressure reducing valve for adjusting a pressure of the second pressurized gas to an appropriate value may be arranged in the seventh passage 88 for supplying the first pressurized gas to the second space 38. In this way, the second space 38 is pressurized using the second pressurized gas discharged from the second cylinder unit HP, whereby a pressure difference between the second cylinder unit HP and the second space 38 can be suppressed.

<Fifth Embodiment>

[0045] FIG. 6 is a sectional view showing the configuration of a reciprocating booster compressor according to a fifth embodiment. It should be noted that components corresponding to those of each aforementioned embodiment are denoted by common reference signs in FIG. 6 and overlapping description is omitted as appropriate.

[0046] In the present embodiment, a second pressurized gas supplied from a second cylinder unit HP is introduced into a first space 36. The second pressurized gas introduced into the first space 36 has a pressure at least higher than a pressure in the first space 36. In an example of FIG. 6, the second pressurized gas supplied to the first space 36 is introduced via an eighth passage 90 branched from a discharge pipe 4 of the second cylinder unit HP.

[0047] It should be noted that a pressure reducing valve for adjusting a pressure of the second pressurized gas to an appropriate value may be arranged in the eighth passage 90 for supplying the second pressurized gas to the first space 36. In this way, the first space 36 is pressurized using the second pressurized gas discharged from the second cylinder unit HP, whereby a pressure difference between the first cylinder unit LP and the first space 36 can be suppressed.

[0048] The second pressurized gas discharged from the second cylinder unit HP is introduced into another second space 38. The second pressurized gas introduced into the second space 38 has a pressure at least higher than a pressure in the second space 38. In the example of FIG. 6, the second pressurized gas supplied to the second space 38 is introduced via a seventh passage 88 branched from the discharge pipe 4 of the second cylinder unit HP as in the aforementioned third and fourth embodiments.

[0049] It should be noted that a pressure reducing valve for adjusting the pressure of the second pressurized gas to an appropriate value may be arranged in the seventh passage 88 for supplying the first pressurized gas to the second space 38. In this way, the second space 38 is pressurized using the second pressurized gas discharged from the second cylinder unit HP, whereby a pressure difference between the second cylinder unit HP and the second space 38 can be suppressed.

[0050] As described above, according to the above embodiments, a reciprocating booster compressor can be provided which can achieve a long life and obtain a high energy saving effect by appropriately setting an internal pressure of a crank case in each cylinder unit for performing multi-stage compression.

Industrial Applicability

[0051] At least one embodiment of the present invention is applicable to a reciprocating booster compressor capable of further compressing a pressurized gas supplied from outside by reciprocating motions of pistons in cylinders.

Reference Signs List

[0052]

1	compressor
2	first passage (supply pipe)
4	discharge pipe
5	input shaft
6	crank case
8	crank mechanism
10	crankshaft
12, 14	bearing
16, 22, 24, 42	sealing member
18, 20	connecting rod
26, 28	cylinder
30, 32	piston
34	separation wall
36	first space
38	second space
70	second passage
72	third passage
74	fourth passage
76	radiating fin
82	fifth passage
86	sixth passage
88	seventh passage
90	eighth passage
LP	first cylinder unit
HP	second cylinder unit

Claims

1. A reciprocating booster compressor, comprising:

a crank mechanism for converting a rotational motion of an input shaft to which power is input into a reciprocating motion;
a crank case accommodating the crank mechanism; and
a plurality of cylinder units capable of compressing a gas by being driven by the reciprocating motion converted in the crank mechanism,
wherein
the plurality of cylinder units include:

a first cylinder unit compressing a pressurized gas supplied from outside and generating a first pressurized gas having a higher pressure than the pressurized gas; and
a second cylinder unit connected in series to the first cylinder unit, the second cylinder unit further compressing the first pressurized gas and generating a second pressurized gas having a higher pressure than the first pressurized gas,

the crank case includes a first space corresponding to the first cylinder unit and a second space corresponding to the second cylinder unit, the first space and the second space are separated from each other by a separation wall pro-

vided inside the crank case, and
at least one of the first space or the second space is pressurized by having any one of the pressurized gas, the first pressurized gas or the second pressurized gas introduced thereinto.

2. The reciprocating booster compressor according to claim 1, wherein:

the pressurized gas is introduced into the first space, and
the first pressurized gas is introduced into the second space.

3. The reciprocating booster compressor according to claim 2, further comprising:

a first passage connecting an intake port for the pressurized gas and the first space; and
a second passage connecting the first space and a suction side of the first cylinder unit.

4. The reciprocating booster compressor according to claim 2 or 3, further comprising:

a third passage connecting a discharge side of the first cylinder unit and the second space; and
a fourth passage connecting the second space and a suction side of the second cylinder unit.

5. The reciprocating booster compressor according to claim 4, wherein a radiating fin is provided on an outer surface of the third passage.

6. The reciprocating booster compressor according to claim 2 or 3, further comprising:

a fifth passage connecting a discharge side of the first cylinder unit and a suction side of the second cylinder unit; and
a sixth passage branched from the fifth passage and connected to the second space.

7. The reciprocating booster compressor according to claim 6, wherein a radiating fin is provided on an outer surface of the sixth passage.

8. The reciprocating booster compressor according to any one of claims 1 to 7, wherein the separation wall includes:

an opening through which the input shaft penetrates; and
a sealing member sealing the opening while rotatably supporting the input shaft.

9. The reciprocating booster compressor according to claim 8, wherein the first space is configured such that the pressurized gas introduced into the first space is injected toward the sealing member.

10. The reciprocating booster compressor according to claim 8 or 9, wherein the second space is configured such that the first pressurized gas introduced into the second space is injected toward the sealing member.

11. The reciprocating booster compressor according to claim 1, wherein:

the first pressurized gas is introduced into the first space, and
the second pressurized gas is introduced into the second space.

12. The reciprocating booster compressor according to claim 1, wherein:

the pressurized gas is introduced into the first space, and
the second pressurized gas is introduced into the second space.

13. The reciprocating booster compressor according to claim 1, wherein the second pressurized gas is introduced into the first space and the second space.

14. The reciprocating booster compressor according to any one of claims 1 to 13, wherein the reciprocating booster compressor is an oil-free compressor.

FIG. 1

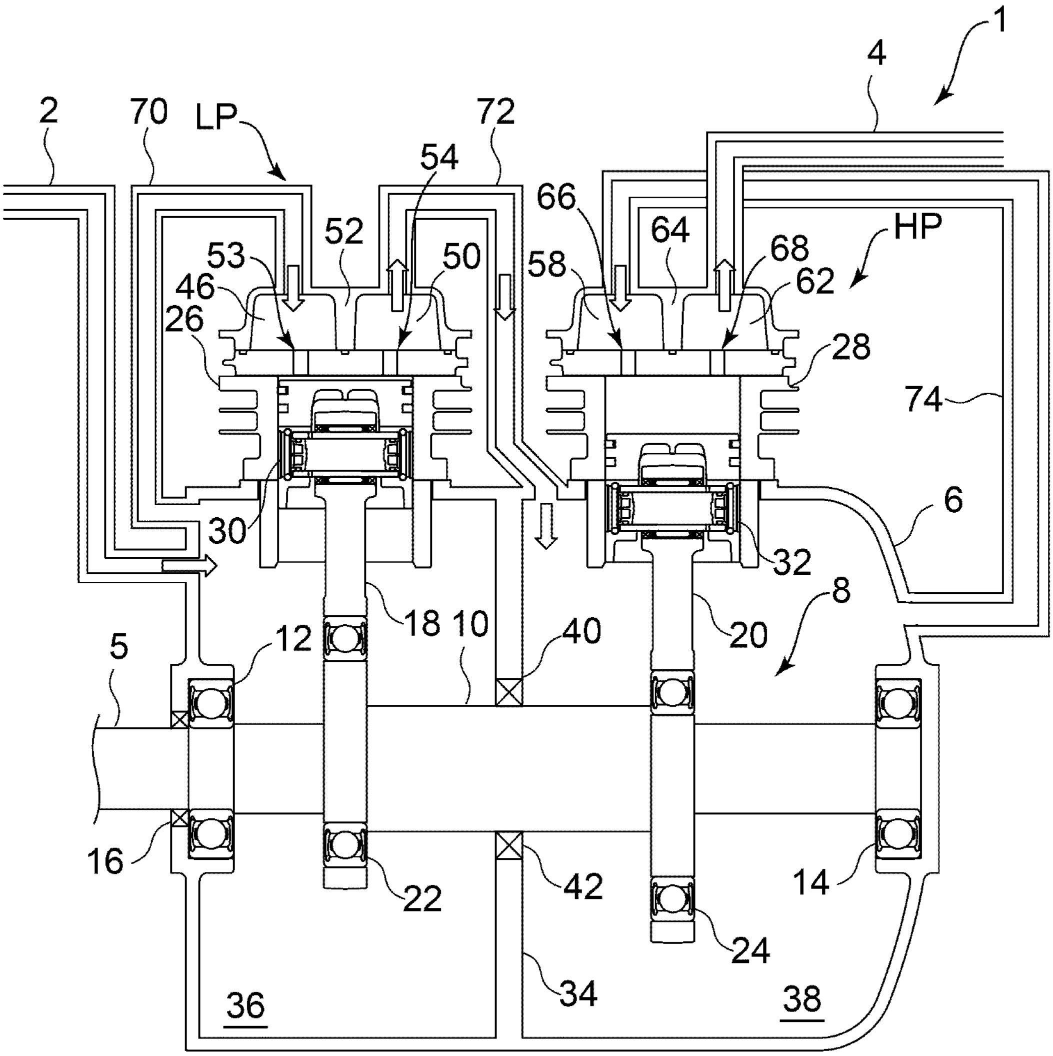
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FIG. 2

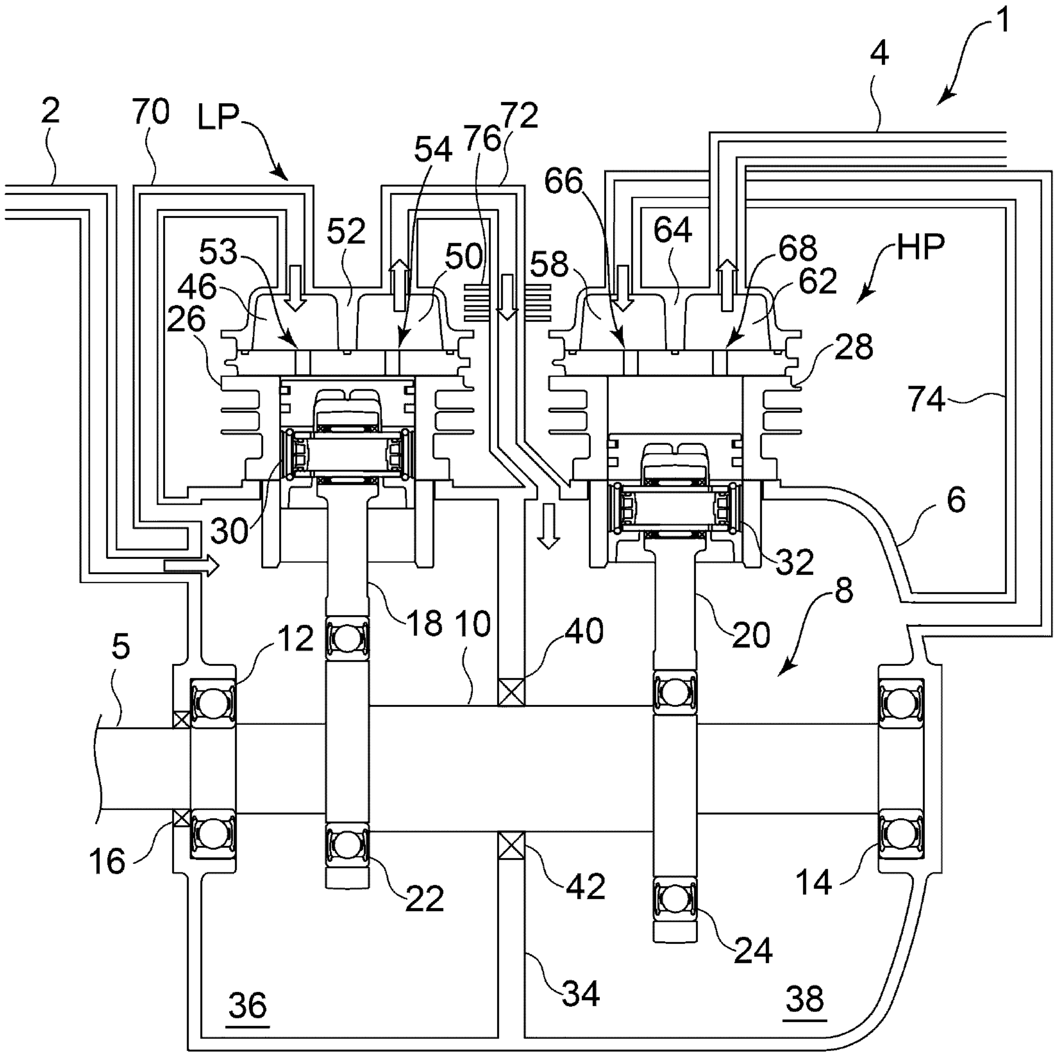
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FIG. 3

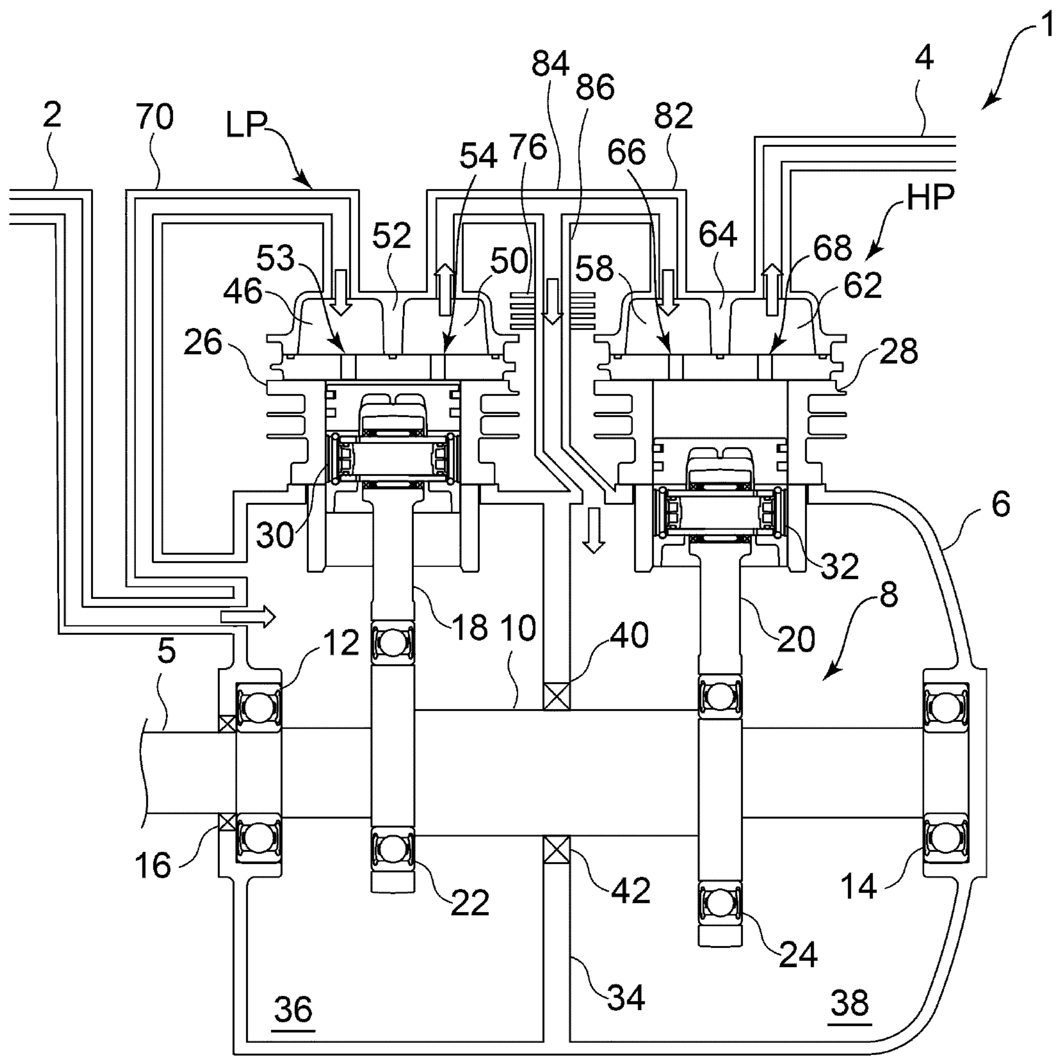
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FIG. 4

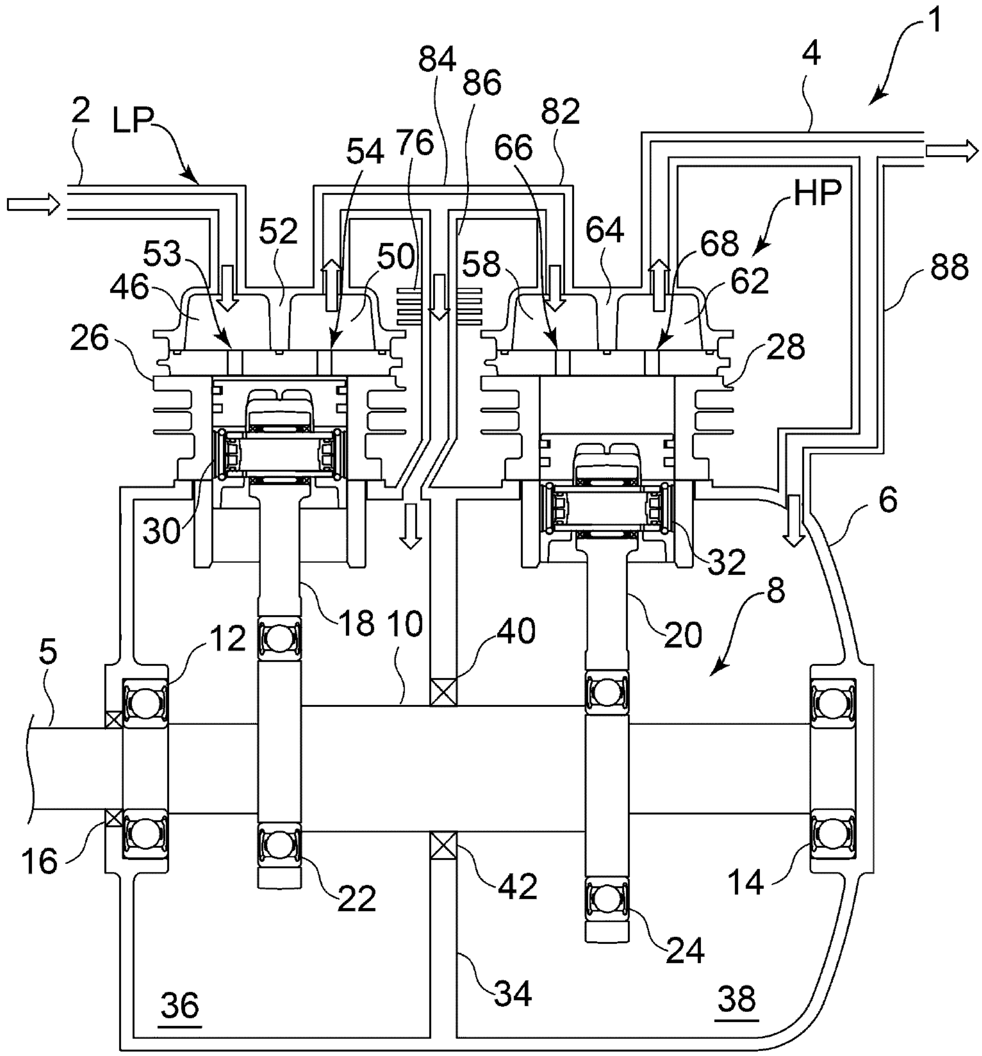
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FIG. 5

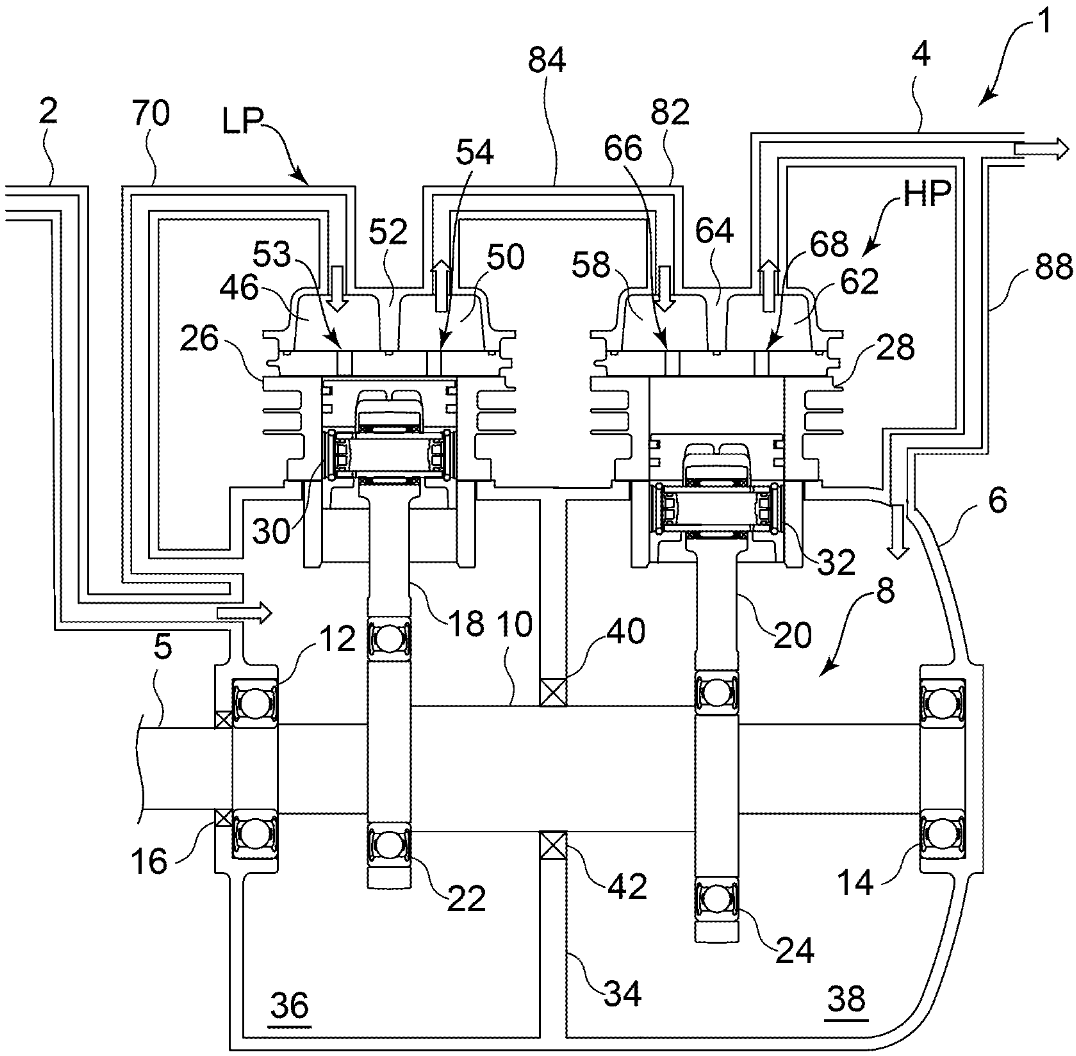
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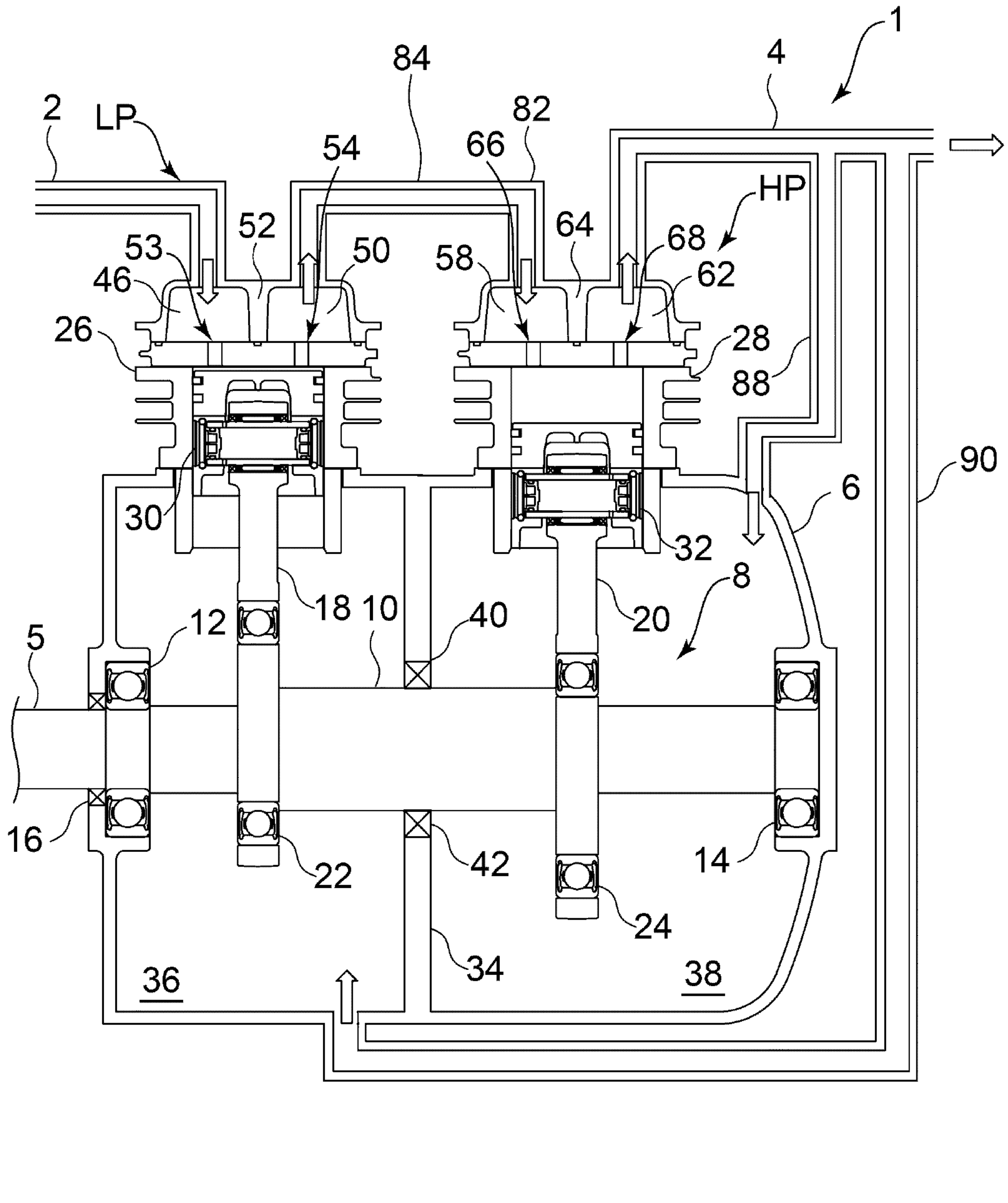
FIG. 6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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/013815

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F04B37/12(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. F04B37/12

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	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

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 A	JP 2008-286067 A (ANEST IWATA CORPORATION) 27 November 2008, entire text, all drawings & US 2009/0047159 A1, entire text, all drawings & CN 101307754 A & KR 10-2008-0101735 A	1-8, 14 9-13
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 056056/1975 (Laid-open No. 135806/1976) (KYOEI-SEISAKU. CO., LTD.) 02 November 1976, specification, page 2, line 14 to page 5, line 4, fig. 1-6 (Family: none)	1-8, 14
Y	JP 2011-106373 A (HITACHI INDUSTRIAL EQUIPMENT SYSTEM CO., LTD.) 02 June 2011, paragraphs [0023]-[0031], fig. 1 (Family: none)	6-8, 14

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

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"O" document referring to an oral disclosure, use, exhibition or other means
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 June 2018 (19.06.2018)	03 July 2018 (03.07.2018)

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)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009133282 A **[0004]**