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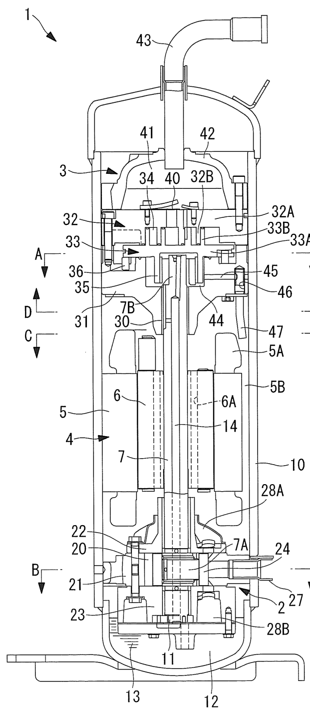
(54) **FLUID MACHINE**

(57) Provided is a fluid machine that achieves a static balance or a dynamic balance for reciprocating components of at least two fluid suction/discharge mechanisms provided at both end positions of a driving shaft, to thereby enable a reduction in vibrations and noise. A fluid machine (1) includes two or more fluid suction/discharge mechanisms (2) and (3) provided at both end positions of a driving shaft (7), the fluid suction/discharge mechanisms (2) and (3) each including a reciprocating component (36). The respective reciprocating components (36) of the fluid suction/discharge mechanisms (2) and (3) are arranged so as to be mutually reciprocatable in an opposing direction or the same direction.

FIG. 1



Description

Technical Field

[0001] The present invention relates to a fluid machine including at least two fluid suction/discharge mechanisms provided at both end positions of a driving shaft, the fluid machine being suitably applied to a compressor, an expander, a pump, and the like.

[0002] The present invention also relates to a hermetic compressor including a hermetic housing, a motor built in the hermetic housing, and a compression mechanism provided above the motor.

{Background Art}

[0003] With regard to a fluid machine including at least two fluid suction/discharge mechanisms provided at both end positions of a driving shaft, fluid machines having various configurations have been provided. Examples of the provided fluid machines include: a machine including compression mechanisms in different forms provided at both end positions of a driving shaft; a machine including a compression mechanism provided on one end of a driving shaft and an expansion mechanism provided on another end thereof; a machine including a pump mechanism provided on one end of a driving shaft and an expansion mechanism provided on another end thereof; and a two-stage compressor including a lower-stage compression mechanism provided on one end of a driving shaft and a higher-stage compression mechanism provided on another end thereof.

[0004] For example, PTL 1 discloses, as an example of such fluid machines, a two-stage compressor including a lower-stage rotary compression mechanism provided on the lower end side of a driving shaft and a higher-stage scroll compression mechanism provided on the upper end side thereof. Then, in this two-stage compressor, an eccentric portion of a crankshaft that drives the rotary compression mechanism and an eccentric pin of a crankshaft that drives a scroll compression mechanism are provided in an opposing direction by 180° or the same direction, whereby a shafting balance of a rotary portion is achieved. Specifically, the eccentric portion and the eccentric pin are provided in the opposing direction, whereby a static balance is mainly achieved. The eccentric portion and the eccentric pin are provided in the same direction, whereby a dynamic balance is mainly achieved.

[0005] Meanwhile, in a compressor including a plurality of sets of compression mechanisms in the same form, such as a multi-cylinder rotary compressor, generally, as disclosed in PTL 2, a plurality of eccentric portions are provided in one end portion of a crankshaft, and the eccentric portions are provided in an opposing direction by 180°, whereby a shafting balance of a rotary portion is achieved.

[0006] Further, in a hermetic compressor including: a hermetic housing; a motor installed at a central position of the hermetic housing; and a compression mechanism that is arranged above the motor and is driven through a driving shaft, lubricant oil that fills an oil reservoir in a bottom portion of the hermetic housing is fed to a desired lubrication site of the compression mechanism through an oil feed pump and an oil feed hole in the driving shaft, and the oil that has been used for the lubrication of the site is returned to the oil reservoir through an oil discharge hole provided in a support member of the compression mechanism. In such a hermetic compressor, the oil that has been used for the lubrication of the desired lubrication site and is discharged from the oil discharge hole to flow down to the oil reservoir is blown up by a refrigerant gas flow. The oil is suctioned into the compression mechanism together with the refrigerant gas to be compressed by the compression mechanism. Then, the oil is ejected to the outside of the compressor. In the case where such an oil loss phenomenon is remarkable, the lubricant oil in the oil reservoir tends to be insufficient. Consequently, the compressor may have a trouble in lubrication, and the system efficiency may decrease.

[0007] In view of the above problems, the following configurations have been proposed. That is, a guide plate is installed by welding or the like in a hermetic housing so as to cover a flow-down route of oil that is discharged from an oil discharge hole to flow down after the lubrication of a desired lubrication site (see, for example, PTL 3). Further, one end of an oil discharge pipe is connected to an oil discharge hole, and the lower end thereof is extended to a portion above an oil reservoir, or is extended to a portion above the position of a stator cut provided in the stator outer periphery of a motor (see, for example, PTL 4 and PTL 5). In these configurations, contact between the oil discharged from the oil discharge hole and refrigerant gas is suppressed, and an oil loss is reduced.

Citation List

Patent Literature

[0008]

{PTL 1}
Japanese Unexamined Patent Application, Publication No. 2008-175340
{PTL 2}
Japanese Unexamined Patent Application, Publication No. 2008-63973
{PTL 3}
Japanese Unexamined Patent Application, Publication No. 2000-291552
{PTL 4}
Japanese Unexamined Patent Application, Publication No. 2005-273463
{PTL 5}
Japanese Unexamined Patent Application, Publication No. Hei 7-158569

Summary of Invention

Technical Problem

[0009] As disclosed in PTL 1 and PTL 2, in a fluid machine including two or more fluid suction/discharge mechanisms (for example, compression mechanisms) provided at both end positions of a driving shaft, the fluid suction/discharge mechanisms each including a reciprocating component, normally, a shafting balance of a rotary portion is achieved, whereas a balance is not achieved unfortunately for reciprocating components such as an Oldham's ring of a scroll compression mechanism and a blade of a rotary compression mechanism. This is estimated to be because it is difficult for a reciprocating component alone to achieve a balance, leading to a loss of a driving shafting balance and causes of vibrations and noise.

[0010] Further, if a guide plate is provided as disclosed in PTL 3, a gap is easily formed between a support member provided with an oil discharge hole and the guide plate, and oil is blown up therethrough. Hence, an oil loss cannot be sufficiently suppressed. Moreover, the guide plate needs to be welded to a hermetic housing, and hence assembling properties decrease. Further, if the lower end of an oil discharge pipe is extended to a portion above an oil reservoir as disclosed in PTL 4, the oil discharge pipe needs to be extended downward through a stator cut provided in a stator outer periphery. In order to enable the oil discharge pipe to pass through the stator cut, if the size of the stator cut is increased, the motor efficiency decreases. Meanwhile, if the size of a hermetic housing is increased, the size of a compressor increases.

[0011] Moreover, if the lower end of an oil discharge pipe is extended to a portion above a stator cut as disclosed in PTL 5, it is necessary to increase the size of the stator cut, in order to reliably introduce, into the stator cut, oil that flows out of the lower end of the oil discharge pipe. Otherwise, it is necessary to make the oil discharge pipe thinner, thus enhance the directionality of the oil that flows out, and reliably introduce the oil into the stator cut. Hence, a flow path pressure loss increases, and the orientation of the pipe needs to be adjusted, so that it is more difficult to introduce the oil into the stator cut.

[0012] The present invention, which has been made in view of the above-mentioned circumstances, has an object to provide a fluid machine that achieves a static balance or a dynamic balance for reciprocating components of at least two fluid suction/discharge mechanisms provided at both end positions of a driving shaft, to thereby enable a reduction in vibrations and noise.

[0013] The present invention has another object to provide a hermetic compressor that reliably introduces, into a stator cut, oil discharged from an oil discharge pipe and allows the oil to smoothly flow down to an oil reservoir, to thereby enable prevention of an oil loss, while suppressing a flow path pressure loss without increasing a housing diameter and a stator cut size.

Solution to Problem

[0014] In order to solve the above-mentioned problems, the present invention adopts the following solutions.

[0015] That is, a first aspect of the present invention provides a fluid machine including two or more fluid suction/discharge mechanisms provided at both end positions of a driving shaft, the fluid suction/discharge mechanisms each including a reciprocating component. The respective reciprocating components of the fluid suction/discharge mechanisms are arranged so as to be mutually reciprocatable in an opposing direction or the same direction.

[0016] According to the first aspect, the two or more fluid suction/discharge mechanisms are provided at both end positions of the driving shaft, and the respective reciprocating components of the fluid suction/discharge mechanisms are arranged so as to be mutually reciprocatable in the opposing direction or the same direction. Hence, in the case where the reciprocating components are arranged so as to be mutually reciprocatable in the opposing direction, a static balance can be mainly achieved. In the case where the reciprocating components are arranged so as to be mutually reciprocatable in the same direction, a dynamic balance can be mainly achieved. Accordingly, if a balance is achieved for the reciprocating component of each fluid suction/discharge mechanism, it is possible to prevent a loss of a shafting balance due to an unbalanced moment of the reciprocating component and reduce vibrations and noise.

[0017] Moreover, in the fluid machine according to the first aspect, the opposing direction or the same direction in which the respective reciprocating components of the fluid suction/discharge mechanisms are mutually reciprocatable may include a range within ±45° with respect to a straight line in the direction.

[0018] According to the first aspect, the opposing direction or the same direction in which the respective reciprocating components of the fluid suction/discharge mechanisms are mutually reciprocatable includes the range within ±45° with respect to the straight line in the direction. Hence, the present invention is not limited to a configuration in which the reciprocating components are arranged so as to be reciprocatable in the opposing direction by 180° or the same direction (direction by 0°). If the reciprocating components are arranged within ±45° with respect to their respective directions, the amount of static unbalance or the amount of dynamic unbalance can be made sufficiently small due to a component of force thereof. Accordingly, even in the case where the reciprocating components cannot be arranged in the opposing direction by 180° or the same direction (direction by 0°), if the reciprocating components are arranged in the range within ±45° with respect to their respective directions, unbalanced moments of the reciprocating components can be expeditiously reduced, and vibrations and noise can be reduced.

[0019] Moreover, in the fluid machine according to the first aspect, in a case where the respective reciprocating components of the fluid suction/discharge mechanisms are arranged so as to be mutually reciprocatable in the opposing direction, $m1 \times l1 \approx m2 \times l2$ may be satisfied, assuming that: a mass of a first reciprocating component of a first fluid suction/discharge mechanism is m1; a stroke thereof is l1; a mass of a second reciprocating component of a second fluid suction/discharge mechanism is m2; and a stroke thereof is l2.

[0020] According to the first aspect, in the case where the respective reciprocating components of the fluid suction/discharge mechanisms are arranged so as to be mutually reciprocatable in the opposing direction, $m1 \times l1 \approx m2 \times l2$ is satisfied, assuming that: the mass of the first reciprocating component of the first fluid suction/discharge mechanism is m1; the stroke thereof is l1; the mass of the second reciprocating component of the second fluid suction/discharge mechanism is m2; and the stroke thereof is l2. Hence, unbalanced moments of the first reciprocating component of the first fluid suction/discharge mechanism and the second reciprocating component of the second fluid suction/discharge mechanism can be substantially cancelled, and a dynamic balance can be achieved. Accordingly, it is possible to prevent a loss of a shafting balance due to the unbalanced moments of the respective reciprocating components of the fluid suction/discharge mechanisms and reliably reduce vibrations and noise.

[0021] Moreover, in the fluid machine according to the first aspect, when the masses m1 and m2 of the first and second reciprocating components satisfy $m1 > m2$, the strokes l1 and 12 of the first and second reciprocating components may be set to satisfy $l1 < 12$, and when the masses m1 and m2 thereof satisfy $m1 < m2$, the strokes l1 and l2 thereof may be set to satisfy $l1 > l2$.

[0022] According to the first aspect, when the masses m1 and m2 of the first and second reciprocating components satisfy $m1 > m2$, the strokes l1 and 12 of the first and second reciprocating components are set to satisfy $11 < l2$, and when the masses m1 and m2 thereof satisfy $m1 < m2$, the strokes l1 and 12 thereof are set to satisfy $l1 > l2$. Hence, the masses m1 and m2 and the strokes l1 and l2 of the first and second reciprocating components do not necessarily need to be the same, and the masses m1 and m2 and the strokes l1 and l2 can be set to proper values as appropriate. Accordingly, the present invention can be easily applied to a configuration in which mechanisms of fluid suction/discharge mechanisms are different from each other and reciprocating components of the fluid suction/discharge mechanisms have different masses and different strokes.

[0023] Moreover, in the fluid machine according to the first aspect, the fluid suction/discharge mechanisms may be each configured as any of a compression mechanism, an expansion mechanism, and a pump mechanism or a combination thereof.

[0024] According to the first aspect, the fluid suction/discharge mechanisms are each configured as any of a compression mechanism, an expansion mechanism, and a pump mechanism or a combination thereof. Hence, if the fluid suction/discharge mechanisms provided at both end positions of the driving shaft are configured as compression mechanisms, expansion mechanisms, pump mechanisms, a combination of a compression mechanism and an expansion mechanism, a combination of a pump mechanism and an expansion mechanism, or the like, fluid machines having various configurations can be provided, and a static balance or a dynamic balance can be achieved for the reciprocating component of each fluid suction/discharge mechanism. Accordingly, if a balance is achieved for reciprocating components of various fluid suction/discharge mechanisms, it is possible to prevent a loss of a shafting balance due to unbalanced moments of the reciprocating components and reduce vibrations and noise.

[0025] Moreover, in the fluid machine according to the first aspect, one of the fluid suction/discharge mechanisms may be configured as a lower-stage compression mechanism, another one of the fluid suction/discharge mechanisms may be configured as a higher-stage compression mechanism, and a two-stage compressor may be configured by the lower-stage and higher-stage compression mechanisms.

[0026] According to the first aspect, one of the fluid suction/discharge mechanisms is configured as the lower-stage compression mechanism, another one of the fluid suction/discharge mechanisms is configured as the higher-stage compression mechanism, and the two-stage compressor is configured by the lower-stage and higher-stage compression mechanisms. Hence, if reciprocating components of the lower-stage compression mechanism and the higher-stage compression mechanism in the two-stage compressor are arranged so as to be mutually reciprocatable in the opposing direction or the same direction, a static balance or a dynamic balance can be achieved for the reciprocating components of the lower-stage compression mechanism and the higher-stage compression mechanism. Accordingly, if a balance is achieved for the reciprocating component of each compression mechanism, it is possible to prevent a loss of a shafting balance due to an unbalanced moment of the reciprocating component and reduce vibrations and noise.

[0027] Moreover, in the fluid machine according to the first aspect, one of the fluid suction/discharge mechanisms may be configured as a scroll fluid suction/discharge mechanism including an Oldham's ring as the reciprocating component, and another one of the fluid suction/discharge mechanisms may be configured as a rotary fluid suction/discharge mechanism including a blade as the reciprocating component.

[0028] According to the above-mentioned configuration, one of the fluid suction/discharge mechanisms is configured as the scroll fluid suction/discharge mechanism including the Oldham's ring as the reciprocating component, and another one of the fluid suction/discharge mechanisms is configured as the rotary fluid suction/discharge mechanism including the blade as the reciprocating component. Hence, even in the case where the configurations of the fluid suction/discharge mechanisms are different from each other and where one of the fluid suction/discharge mechanisms is the scroll fluid suction/discharge mechanism including the Oldham's ring as the reciprocating component while another one thereof is the rotary fluid suction/discharge mechanism including the blade as the reciprocating component, if the Oldham's ring and the blade are arranged so as to be mutually reciprocatable in the opposing direction or the same direction, a static balance or a dynamic balance can be achieved for the reciprocating components of the scroll fluid suction/discharge mechanism and the rotary fluid suction/discharge mechanism. Accordingly, it is possible to prevent a loss of a shafting balance due to unbalanced moments of the reciprocating components of the fluid suction/discharge mechanisms having different configurations and reduce vibrations and noise. Comparing the Oldham's ring with the blade, the Oldham's ring and the blade are different in component size and stroke. Hence, if the masses thereof are further made different from each other by changing materials used therefor, a sufficient static balance or a sufficient dynamic balance can be achieved.

[0029] Moreover, in the fluid machine according to the configuration including the rotary fluid suction/discharge mechanism, the rotary fluid suction/discharge mechanism may be configured as a two-cylinder rotary fluid suction/discharge mechanism, two blades of the two-cylinder rotary fluid suction/discharge mechanism may be arranged so as to be mutually reciprocatable in an opposing direction, and the blade closer to the scroll fluid suction/discharge mechanism may be arranged so as to be reciprocatable in an opposing direction with respect to the Oldham's ring of the scroll fluid suction/discharge mechanism.

[0030] According to the above-mentioned configuration, the rotary fluid suction/discharge mechanism is configured as the two-cylinder rotary fluid suction/discharge mechanism, the two blades of the two-cylinder rotary fluid suction/discharge mechanism are arranged so as to be mutually reciprocatable in the opposing direction, and the blade closer to the scroll fluid suction/discharge mechanism is arranged so as to be reciprocatable in the opposing direction with respect to the Oldham's ring of the scroll fluid suction/discharge mechanism. Hence, even in the case where the rotary fluid suction/discharge mechanism is configured as the two-cylinder rotary fluid suction/discharge mechanism in order to deal with the volume, fluctuations in torque, and the like of the rotary fluid suction/discharge mechanism, if the two blades of the two-cylinder rotary fluid suction/discharge mechanism are arranged so as to be mutually reciprocatable in the opposing direction, a static balance can be achieved. In this case, a static unbalance remains unachieved for the Oldham's ring of the scroll fluid suction/discharge mechanism, but if the reciprocating directions of the Oldham's ring and the blade farther from the scroll fluid suction/discharge mechanism are adjusted to be the same in phase, the amount of dynamic unbalance can be made smaller. Accordingly, the amount of dynamic unbalance caused by the reciprocating components can be reduced, and a shafting balance can be secured.

[0031] Moreover, in the fluid machine according to the configuration including the two-cylinder rotary fluid suction/discharge mechanism, the blade closer to the scroll fluid suction/discharge mechanism, of the two-cylinder rotary fluid suction/discharge mechanism may be set to be larger in mass or longer in stroke than the blade thereof farther from the scroll fluid suction/discharge mechanism.

[0032] According to the above-mentioned configuration, the blade closer to the scroll fluid suction/discharge mechanism, of the two-cylinder rotary fluid suction/discharge mechanism is set to be larger in mass or longer in stroke than the blade thereof farther from the scroll fluid suction/discharge mechanism. Hence, a static balance cannot be achieved between the two blades of the two-cylinder rotary fluid suction/discharge mechanism, and a static unbalance remains. However, if the remaining static unbalance is cancelled by a static balance of the Oldham's ring of the scroll fluid suction/discharge mechanism, the amount of dynamic unbalance can be minimized. With this configuration, the amount of dynamic unbalance of the reciprocating components can be expeditiously reduced, and a shafting balance can be secured.

[0033] A second aspect of the present invention provides a hermetic compressor including: a hermetic housing; a motor built in the hermetic housing; and a compression mechanism that is provided above the motor and is driven by the motor through a driving shaft, the hermetic compressor being configured to: feed lubricant oil that fills an oil reservoir in a bottom portion of the hermetic housing, to a desired lubrication site of the compression mechanism through an oil feed pump and an oil feed hole provided in the driving shaft; and return the oil that has been used for lubrication of the site, to the oil reservoir through an oil discharge hole provided in a support member of the compression mechanism and an oil discharge pipe. The oil discharge pipe has a lower end that is opened at a position below a stator coil end of the motor and above an upper end of a stator so as to be opposed to a stator cut provided in an outer periphery of the stator, the oil discharge pipe has a lower portion curved toward the outer periphery of the stator, and the oil discharge pipe has an outer diameter that is set to be larger than a radial width of the stator cut.

[0034] According to the second aspect, in the hermetic compressor that is configured to return the oil that has been used for the lubrication of the lubrication site of the compression mechanism, to the oil reservoir through the oil discharge hole provided in the support member of the compression mechanism and the oil discharge pipe, the oil discharge pipe has the lower end that is opened at the position below the stator coil end of the motor and above the upper end of the stator so as to be opposed to the stator cut provided in the outer periphery of the stator, the oil discharge pipe has the lower portion curved toward the outer periphery of the stator, and the oil discharge pipe has the outer diameter that is set to be larger than the radial width of the stator cut. Hence, the oil that has been used for the lubrication of the lubrication site of the compression mechanism can be guided to the oil discharge pipe from the oil discharge hole provided in the support member. While a flow path pressure loss is suppressed by the oil discharge pipe having the outer diameter that is set to be larger than the radial width of the stator cut, the oil is caused to flow out in the centrifugal direction by the lower portion of the pipe curved toward the outer periphery of the stator, and the oil can be reliably introduced from the opened lower end of the oil discharge pipe into the stator cut to which the opened lower end thereof is opposed. Accordingly, while a flow path pressure loss in an oil discharge route is suppressed without increasing the housing diameter and the stator cut width, the oil that flows out of the oil discharge pipe can be reliably introduced into the stator cut, and can be caused to smoothly flow down to the oil reservoir, so that an oil loss from the hermetic compressor can be prevented.

[0035] Moreover, in the hermetic compressor according to the second aspect, the oil discharge pipe may have an upper end portion inserted and installed in a downward pipe insertion hole that intersects with the oil discharge hole that is provided outward in a radial direction in the support member, and oil discharged from the oil discharge hole may be introducible into the oil discharge pipe through a side hole or a cutout provided on an outer peripheral surface of the upper end portion of the oil discharge pipe.

[0036] According to the second aspect, the oil discharge pipe has the upper end portion inserted and installed in the downward pipe insertion hole that intersects with the oil discharge hole that is provided outward in the radial direction in the support member, and the oil discharged from the oil discharge hole is introducible into the oil discharge pipe through the side hole or the cutout provided on the outer peripheral surface of the upper end portion of the oil discharge pipe. Hence, if the upper end portion of the oil discharge pipe is inserted into the downward pipe insertion hole that intersects with the oil discharge hole, the oil discharge hole can be communicated with the side hole or the cutout provided on the outer peripheral surface of the upper end portion of the oil discharge pipe, whereby the oil discharge route that guides, to the stator cut, the oil that has been used for the lubrication of the lubrication site of the compression mechanism can be formed. Accordingly, an outer end portion of the oil discharge hole does not need to be closed, the formation of the oil discharge route can be facilitated, and the oil can be reliably suppressed from being blown up by refrigerant gas.

[0037] Moreover, in the hermetic compressor according to the second aspect, the opened lower end portion of the oil discharge pipe may be obliquely cut so as to be opened along an inner peripheral surface of the hermetic housing.

[0038] According to the second aspect, the opened lower end portion of the oil discharge pipe is obliquely cut so as to be opened along the inner peripheral surface of the hermetic housing. Hence, the opened lower end portion of the oil discharge pipe can be opened so as to be downwardly long in substantially parallel to the inner peripheral surface of the hermetic housing. As a result, the directionality of the oil that flows out of the opened lower end of the oil discharge pipe toward the stator cut can be enhanced, and the oil can be more reliably introduced into the stator cut.

[0039] Further, a third aspect of the present invention provides a hermetic compressor including: a hermetic housing; a motor built in the hermetic housing; and a compression mechanism that is provided above the motor and is driven by the motor through a driving shaft, the hermetic compressor being configured to: feed lubricant oil that fills an oil reservoir in a bottom portion of the hermetic housing, to a desired lubrication site of the compression mechanism through an oil feed pump and an oil feed hole provided in the driving shaft; and return the oil that has been used for lubrication of the site, to the oil reservoir through an oil discharge hole provided in a support member of the compression mechanism and an oil discharge pipe. The oil discharge pipe has an upper end portion inserted and installed in a downward pipe insertion hole that intersects with the oil discharge hole that is provided outward in a radial direction in the support member, and oil discharged from the oil discharge hole is introducible into the oil discharge pipe through a side hole or a cutout provided on an outer peripheral surface of the upper end portion of the oil discharge pipe.

[0040] According to the third aspect, in the hermetic compressor that is configured to return the oil that has been used for the lubrication of the desired lubrication site of the compression mechanism, to the oil reservoir through the oil discharge hole provided in the support member of the compression mechanism and the oil discharge pipe, the oil discharge pipe has the upper end portion inserted and installed in the downward pipe insertion hole that intersects with the oil discharge hole that is provided outward in the radial direction in the support member, and the oil discharged from the oil discharge hole is introducible into the oil discharge pipe through the side hole or the cutout provided on the outer peripheral surface of the upper end portion of the oil discharge pipe. Hence, if the upper end portion of the oil discharge pipe is inserted into the downward pipe insertion hole that intersects with the oil discharge hole, the oil discharge hole can be communicated with the side hole or the cutout provided on the outer peripheral surface of the upper end portion of the oil discharge pipe, whereby the oil discharge route that guides, to the stator cut, the oil that has been used for the lubrication of the lubrication site of the compression mechanism can be formed. Accordingly, an outer end portion of the oil discharge hole does not need to be closed, the formation of the oil discharge route can be facilitated, and the oil can be reliably suppressed from being blown up by refrigerant gas.

[0041] Moreover, in the hermetic compressor according to the second aspect or the third aspect, the upper end portion of the oil discharge pipe may be inserted and installed by press-fitting in the pipe insertion hole.

[0042] According to the above-mentioned configuration, the upper end portion of the oil discharge pipe is inserted and installed by press-fitting in the pipe insertion hole. Hence, gaps for oil leakage from between the oil discharge pipe and the pipe insertion hole and oil leakage to the outer end portion of the oil discharge hole from the oil discharge pipe can be eliminated. As a result, such oil leakage from the oil discharge hole and the pipe insertion hole can be eliminated, the oil can be effectively guided to the oil reservoir, an oil loss can be suppressed, and the oil discharge pipe can be reliably prevented from falling off.

[0043] Moreover, in the hermetic compressor according to the second aspect or the third aspect, an attachment plate may be integrally provided to the oil discharge pipe at a position below the upper end portion thereof inserted and installed in the pipe insertion hole, and the oil discharge pipe may be inserted and installed in the support member by means of the attachment plate so as to close the pipe insertion hole.

[0044] According to the above-mentioned configuration, the attachment plate is integrally provided to the oil discharge pipe at the position below the upper end portion thereof inserted and installed in the pipe insertion hole, and the oil discharge pipe is inserted and installed in the support member by means of the attachment plate so as to close the pipe insertion hole. Hence, if the upper end portion of the oil discharge pipe to which the attachment plate is integrally provided is inserted into the pipe insertion hole and the oil discharge pipe is thus installed in the support member, the pipe insertion hole can be closed by the attachment plate so as to avoid oil leakage. Accordingly, oil leakage from the pipe insertion hole can be eliminated, the oil can be effectively guided to the oil reservoir, an oil loss can be suppressed, and the oil discharge pipe can be prevented from falling off.

[0045] Moreover, in the hermetic compressor according to the configuration including the attachment plate, the attachment plate may be screwed to the support member, and the attachment plate may be integrated in advance with the oil discharge pipe such that a relative position between: the oil discharge hole; and the side hole or the cutout provided in the oil discharge pipe, and a direction of the oil discharge pipe are set to a predetermined position and a predetermined direction, in a state where the attachment plate is screwed to the support member.

[0046] According to the above-mentioned configuration, the attachment plate is screwed to the support member, and the attachment plate is integrated in advance with the oil discharge pipe such that the relative position between: the oil discharge hole; and the side hole or the cutout provided in the oil discharge pipe, and the direction of the oil discharge pipe are set to the predetermined position and the predetermined direction, in the state where the attachment plate is screwed to the support member. Hence, the oil discharge pipe to which the attachment plate is integrally attached is inserted into the pipe insertion hole, and the attachment plate is screwed to the support member. Through such a simple process, the relative position between: the oil discharge hole; and the side hole or the cutout provided in the oil discharge pipe, and the direction of the oil discharge pipe can be set to the predetermined position and the predetermined direction. As a result, the incorporation of the oil discharge pipe can be facilitated, the incorporation accuracy thereof can be improved, and the oil can be more reliably introduced into the stator cut.

[0047] Moreover, in the hermetic compressor according to the configuration including the attachment plate, the oil discharge pipe may be configured as a stepped pipe having a diameter that becomes smaller at the position below the upper end portion thereof inserted and installed in the pipe insertion hole, and the attachment plate may be joined to this stepped portion.

[0048] According to the above-mentioned configuration, the oil discharge pipe is configured as the stepped pipe having the diameter that becomes smaller at the position below the upper end portion thereof inserted and installed in the pipe insertion hole, and the attachment plate is joined to this stepped portion. Hence, the attachment plate can be easily joined by brazing, bonding, or the like and integrally attached to a prescribed position of the oil discharge pipe, with the use of the stepped portion of the pipe. Accordingly, the manufacture and incorporation of the oil discharge pipe with the attachment plate can be facilitated, and assembling properties of the hermetic compressor can be improved. Advantageous Effects of Invention

[0049] According to the present invention, in the case where the reciprocating components of the two or more fluid suction/discharge mechanisms provided at both the end positions of the driving shaft are arranged so as to be mutually reciprocatable in the opposing direction, a static balance can be mainly achieved. In the case where the reciprocating components are arranged so as to be mutually reciprocatable in the same direction, a dynamic balance can be mainly achieved. Accordingly, if a balance is achieved for the reciprocating component of each fluid suction/discharge mechanism, it is possible to prevent a loss of a shafting balance due to an unbalanced moment of the reciprocating component and reduce vibrations and noise.

[0050] Further, according to the present invention, the oil that has been used for the lubrication of the lubrication site of the compression mechanism can be guided to the oil discharge pipe from the oil discharge hole provided in the support member. While a flow path pressure loss is suppressed by the oil discharge pipe having the outer diameter that is set to be larger than the radial width of the stator cut, the oil is caused to flow out in the centrifugal direction by the lower portion of the pipe curved toward the outer periphery of the stator, and the oil can be reliably introduced from the opened lower end of the oil discharge pipe into the stator cut to which the opened lower end thereof is opposed. Accordingly, while a flow path pressure loss in the oil discharge route is suppressed without increasing the housing diameter and the stator cut width, the oil that flows out of the oil discharge pipe can be reliably introduced into the stator cut, and can be caused to smoothly flow down to the oil reservoir, so that an oil loss from the hermetic compressor can be prevented.

[0051] Moreover, according to the present invention, if the upper end portion of the oil discharge pipe is inserted into the downward pipe insertion hole that intersects with the oil discharge hole, the oil discharge hole can be communicated with the side hole or the cutout provided on the outer peripheral surface of the upper end portion of the oil discharge pipe, whereby the oil discharge route that guides, to the stator cut, the oil that has been used for the lubrication of the lubrication site of the compression mechanism can be formed. Accordingly, the outer end portion of the oil discharge hole does not need to be closed, the formation of the oil discharge route can be facilitated, and the oil can be reliably suppressed from being blown up by the refrigerant gas.

Brief Description of Drawings

[0052]

{Fig. 1}
Fig. 1 is a longitudinal sectional view of a fluid machine (two-stage compressor) according to a first embodiment of the present invention.
{Fig. 2}
Fig. 2 is a view corresponding to an A-A cross section in Fig. 1.
{Fig. 3}
Fig. 3 is a view corresponding to a B-B cross section in Fig. 1.
{Fig. 4}
Fig. 4 is a schematic view of a fluid machine (two-stage compressor) according to a second embodiment of the present invention.
{Fig. 5}
Fig. 5 is a schematic view of a comparative example for the second embodiment in Fig. 4.
{Fig. 6}
Fig. 6 is a graph showing a relation between: a phase of a blade motion direction to an Oldham's ring motion direction; and the amount of static unbalance, in the fluid machine according to the first embodiment in Fig. 1.
{Fig. 7}
Fig. 7 is a graph showing a relation between: a phase of an upper blade motion direction to an Oldham's ring motion direction; and the amount of dynamic unbalance, in the fluid machine according to the second embodiment in Fig. 4.
{Fig. 8}
Fig. 8 is a view on an arrow C, of a hermetic compressor illustrated in Fig. 1.
{Fig. 9}
Fig. 9 is a view on an arrow D, of the hermetic compressor illustrated in Fig. 1.
{Fig. 10}
Fig. 10 is a configuration view of an oil discharge pipe installation portion of the hermetic compressor illustrated in Fig. 1.
{Fig. 11}
Fig. 11 is a configuration view of a connection portion between an oil discharge hole and an oil discharge pipe of a hermetic compressor according to a fourth embodiment of the present invention.
{Figs. 12}
Figs. 12 are partial configuration views of Modified Examples (A) and (B) of the connection portion between the oil discharge hole and the oil discharge pipe illustrated in Fig. 11.
{Fig. 13}
Fig. 13 is a configuration view of an oil discharge pipe installation portion according to a fifth embodiment of the present invention.
{Figs. 14}
Figs. 14 are a front view (A), a left side view (B), a right side view (C), and a plan view (D) of an oil discharge pipe assembly illustrated in Fig. 13.
{Fig. 15}
Fig. 15 is a configuration view of an oil discharge pipe installation portion according to a sixth embodiment of the present invention.

Description of Embodiments

[0053] Hereinafter, embodiments according to the present invention are described with reference to the drawings.

First Embodiment

[0054] Hereinafter, a first embodiment of the present invention is described with reference to Fig. 1 to Fig. 3 and Fig. 6.

[0055] Fig. 1 is a longitudinal sectional view of a fluid machine according to the first embodiment of the present invention, Fig. 2 is a view corresponding to an A-A cross section in Fig. 1, and Fig. 3 is a view corresponding to a B-B cross section in Fig. 1. In the present embodiment, for convenience sake, an example of a two-stage compressor 1 is described as an example of a fluid machine including at least two fluid suction/discharge mechanisms coupled at both end positions of a driving shaft. In the two-stage compressor 1, a rotary compression mechanism 2 is used for a lower-stage compression mechanism corresponding to one fluid suction/discharge mechanism, and a scroll compression mechanism 3 is used for a higher-stage compression mechanism corresponding to another fluid suction/discharge mechanism. It goes without saying that a fluid machine of the present invention is not limited to the two-stage compressor 1 as described above.

[0056] The two-stage compressor (fluid machine) 1 of the present embodiment includes a hermetic housing 10. A motor 4 including a stator 5 and a rotor 6 is fixed and installed in a substantially central part inside of the hermetic housing 10, and a driving shaft (crankshaft) 7 is integrally joined to the rotor 6. The lower-stage rotary compression mechanism 2 corresponding to one fluid suction/discharge mechanism is provided at a position below the motor 4, that is, on one end side of the driving shaft 7.

[0057] The lower-stage rotary compression mechanism 2 includes a cylinder chamber 20, and further includes: a cylinder main body 21 that is fixed and installed by plug welding or the like at a plurality of portions in the hermetic housing 10; an upper bearing 22 and a lower bearing 23 that are respectively fixed and installed in upper and lower portions of the cylinder main body 21, and respectively hermetically close upper and lower portions of the cylinder chamber 20; a rotor 24 that is fitted to an eccentric portion 7A of the driving shaft 7, and turns on the inner peripheral surface of the cylinder chamber 20; a blade 25 (see Fig. 3) that partitions the inside of the cylinder chamber 20 into a suction side and an ejection side; and a blade holding spring 26 (see Fig. 3) that presses the blade 25.

[0058] The lower-stage rotary compression mechanism 2 itself may be known one. Low-pressure refrigerant gas (actuation gas) is suctioned into the cylinder chamber 20 through a suction pipe 27, and the refrigerant gas is compressed to an intermediate pressure by turns of the rotor 24. Then, the compressed gas is ejected into ejection chambers 28A and 28B, and the ejected gas joins together in the ejection chamber 28A. Then, the resultant gas is ejected into the hermetic housing 10. The intermediate-pressure refrigerant gas circulates through a gas passage hole 6A and the like provided in the rotor 6 of the motor 4, flows to a space above the motor 4, and is suctioned into the higher-stage scroll compression mechanism 3 corresponding to another fluid suction/discharge mechanism, whereby the refrigerant gas is compressed in two stages.

[0059] The higher-stage scroll compression mechanism 3 corresponding to another fluid suction/discharge mechanism is provided at a position above the motor 4, that is, on another end side of the driving shaft 7. The higher-stage scroll compression mechanism 3 is provided with a bearing 30 that supports the driving shaft 7, and is incorporated on a support member 31 (also referred to as a frame member or a bearing member) fixed and installed in the hermetic housing 10. The support member 31 is fixed and installed by plug welding or the like at a plurality of portions on the circumference of the hermetic housing 10. A cutout portion 31A (see Fig. 2) is formed on the outer peripheral surface of the support member 31, and forms a suction flow path for the refrigerant gas between the support member 31 and the inner peripheral surface of the hermetic housing 10.

[0060] The higher-stage scroll compression mechanism 3 includes spiral laps 32B and 33B respectively erected on end plates 32A and 33A, and further includes: a pair of a fixed scroll member 32 and a whirling scroll member 33 that form a compression chamber 34 by meshing the spiral laps 32B and 33B with each other and incorporating the resultant structure on the support member 31; a whirling boss portion 35 that joins the whirling scroll member 33 to an eccentric pin 7B provided to a shaft end of the driving shaft 7, and drives the whirling scroll member 33 to revolve and whirl; an Oldham's ring 36 that is provided between the whirling scroll member 33 and the support member 31, and serves as a rotation prevention mechanism that drives the whirling scroll member 33 to revolve and whirl while preventing the whirling scroll member 33 from rotating; an ejection valve 40 provided on the rear surface of the fixed scroll member 32; and an ejection cover 42 that is fixed and installed on the rear surface of the fixed scroll member 32, and forms an ejection chamber 41 between the ejection cover 42 and the fixed scroll member 32.

[0061] The higher-stage scroll compression mechanism 3 itself may be known one. The intermediate-pressure refrigerant gas that is compressed by the lower-stage rotary compression mechanism 2 and is ejected into the hermetic housing 10 is suctioned into the compression chamber 34, and the suctioned gas is compressed to an ejection pressure (high pressure) by revolution whirl driving of the whirling scroll member 33. Then, the compressed gas passes through the ejection valve 40, and is ejected into the ejection chamber 41. The resultant high-pressure refrigerant gas passes through an ejection pipe 43 from the ejection chamber 41, and is ejected to the outside of the compressor, that is, to a refrigeration cycle.

[0062] A known displacement oil feed pump 11 is incorporated between a lowermost end portion of the driving shaft 7 and the lower bearing 23 of the lower-stage rotary compression mechanism 2. The oil feed pump 11 pumps lubricant oil (hereinafter, may be simply referred to as oil) 13 that fills an oil reservoir 12 formed in a bottom portion of the hermetic housing 10, and forcibly feeds the lubricant oil 13 to desired lubrication sites such as bearing portions of the lower-stage rotary compression mechanism 2 and the higher-stage scroll compression mechanism 3, through an oil feed hole 14 provided in the driving shaft 7.

[0063] Further, the higher-stage scroll compression mechanism 3 is provided with an oil discharge route that returns the lubricant oil that has been used for the lubrication of desired lubrication sites such as the bearing portions, to the oil reservoir 12 in the bottom portion of the hermetic housing 10. The oil discharge route is defined by a space portion 44 of the support member 31, an oil discharge hole 45, and an oil discharge pipe 47. The whirling boss portion 35 of the whirling scroll member 33 is housed in the space portion 44, and the oil that has been used for the lubrication of a desired lubrication site is collected in the space portion 44. The oil discharge hole 45 is formed so as to connect the space portion 44 and the outer peripheral portion of the support member 31. The oil discharge pipe 47 is inserted and installed into a downward pipe insertion hole 46 that intersects with the oil discharge hole 45. The oil discharge pipe 47 is extended downward from the lower surface of the support member 31, and the lower end of the oil discharge pipe 47 is opened toward one of stator cuts 5B provided in an outer periphery of the stator 5, at a position below a stator coil end 5A of the motor 4.

[0064] In the above-mentioned two-stage compressor 1, the eccentric portion 7A of the driving shaft 7 that drives the lower-stage rotary compression mechanism 2 corresponding to a first fluid suction/discharge mechanism and the eccentric pin 7B of the driving shaft 7 that drives the higher-stage scroll compression mechanism 3 corresponding to a second fluid suction/discharge mechanism are provided in an opposing direction or the same direction. With this configuration, a shafting balance of a rotary portion of each of the compression mechanisms 2 and 3 is achieved. Specifically, if the eccentric portion 7A and the eccentric pin 7B are provided in the opposing direction, a static balance is mainly achieved. If the eccentric portion 7A and the eccentric pin 7B are provided in the same direction, a dynamic balance is mainly achieved.

[0065] Moreover, in the higher-stage scroll compression mechanism (second fluid suction/discharge mechanism) 3, as illustrated in Fig. 2, the Oldham's ring 36 that prevents the whirling scroll member 33 from rotating is configured such that paired keys 36B and 36C are respectively provided on the front surface side and the rear surface side in a cross shape to an elliptical ring portion 36A. The key 36B on the front surface side is slidably fitted into a key groove (not illustrated) provided on the rear surface of the end plate 33A of the whirling scroll member 33, and the key 36C on the rear surface side is slidably fitted into a key groove 31B provided on a thrust bearing surface of the support member 31. The Oldham's ring (second reciprocating component) 36 is arranged so as to be reciprocatable on a straight line S (in Fig. 2) that passes through the center of the key groove 31B.

[0066] Meanwhile, in the lower-stage rotary compression mechanism (first fluid suction/discharge mechanism) 2, as illustrated in Fig. 3, the blade 25 that partitions the inside of the cylinder chamber 20 into the suction side and the ejection side is slidably fitted with the intermediation of the blade holding spring 26 into a blade groove 21A that is provided in the radial direction to the cylinder main body 21, such that a leading end portion of the blade 25 protrudes in the cylinder chamber 20. It is the most desirable that the blade (first reciprocating component) 25 be arranged so as to be reciprocatable in an opposing direction by 180° with respect to the Oldham's ring 36, but the present invention is not necessarily limited to the opposing direction by 180°. Here, a range within ±45° of the opposing direction by 180° with respect to the straight line S is adopted considering the magnitude of a component of force thereof.

[0067] In the present embodiment, the blade 25 is arranged so as to be reciprocatable on a straight line R inclined by 20° with respect to the straight line S on which the Oldham's ring 36 reciprocates. Note that it is the most desirable that the reciprocating direction of the blade 25 be set to be an opposing direction by 180° with respect to the Oldham's ring 36, and the allowable maximum range is a range within ±45°, preferably within ±30°, and more preferably within ±20°.

[0068] Further, the blade (first reciprocating component) 25 of the lower-stage rotary compression mechanism (first fluid suction/discharge mechanism) 2 and the Oldham's ring (second reciprocating component) 36 of the higher-stage scroll compression mechanism (second fluid suction/discharge mechanism) 3 are configured so as to satisfy the following Expression (1), assuming that: the mass of the blade (first reciprocating component) 25 is m1; the stroke thereof during reciprocation is 11; the mass of the Oldham's ring (second reciprocating component) 36 is m2; and the stroke thereof during reciprocation is l2.

$$m1 \times l1 \approx m2 \times l2 \ldots (1)$$

[0069] In general, depending on the sizes, materials, and the like of the two components, in the case where the masses m1 and m2 satisfy $m1 > m2$, the strokes l1 and l2 are set to satisfy $l1 < 12$, whereby Expression (1) is satisfied. Meanwhile, in the case where the masses m1 and m2 satisfy $m1 < m2$, the strokes l1 and l2 are set to satisfy $l1 > l2$, whereby Expression (1) is satisfied. In the present embodiment, the Oldham's ring (second reciprocating component) 36 is remarkably larger than the blade (first reciprocating component) 25, so that $m2 > m1$. Then, the strokes of the two components during reciprocation are $l2 < l1$. Because the sizes of the two components are significantly different, if the two components are made of the same material, it is difficult to satisfy Expression (1). Hence, the Oldham's ring (second reciprocating component) 36 is made of a light aluminum alloy material, whereby Expression (1) is satisfied.

[0070] Note that, in the present embodiment, the blade 25 corresponding to the reciprocating component of the lower-stage rotary compression mechanism 2 and the

Oldham's ring 36 corresponding to the reciprocating component of the higher-stage scroll compression mechanism 3 are arranged so as to be mutually reciprocatable in an opposing direction, whereby a static balance is mainly achieved for the blade 25 and the Oldham's ring 36 corresponding to the reciprocating components. Alternatively, the blade 25 and the Oldham's ring 36 may be arranged so as to be mutually reciprocatable in the same direction (a direction by 0° including a range within ±45° of the direction by 0°), whereby a dynamic balance may be mainly achieved for the blade 25 and the Oldham's ring 36 corresponding to the reciprocating components.

[0071] With the configuration described above, the present embodiment produces the following operations and effects.

[0072] Low-pressure refrigerant gas that is suctioned into the cylinder chamber 20 of the lower-stage rotary compression mechanism 2 through the suction pipe 27 is compressed to an intermediate pressure by turns of the rotor 24. Then, the compressed gas is ejected into the ejection chambers 28A and 28B. The intermediate-pressure refrigerant gas joins together in the ejection chamber 28A, and is ejected into a space below the electric motor 4. Then, the intermediate-pressure refrigerant gas circulates through the gas passage hole 6A and the like provided in the rotor 6 of the motor 4, and flows to a space above the motor 4.

[0073] The intermediate-pressure refrigerant gas that has flown to the space above the motor 4 passes through the cutout portion 31A provided on the outer peripheral surface of the support member 31 constituting the higher-stage scroll compression mechanism 3, is guided to a suction port of the higher-stage scroll compression mechanism 3, and is suctioned into the compression chamber 34. The intermediate-pressure refrigerant gas is compressed in two stages to a high pressure by the higher-stage scroll compression mechanism 3. Then, the compressed gas is ejected into the ejection chamber 41 from the ejection valve 40, and is sent to the outside of the compressor, that is, to the refrigeration cycle through the ejection pipe 43.

[0074] The oil 13 that is fed by the oil feed pump 11 to a lubrication site of the lower-stage rotary compression mechanism 2 through the oil feed hole 14 in the driving shaft 7 during this two-stage compression process is used for the lubrication of the desired site, and then flows down to the oil reservoir 12 in the bottom portion of the hermetic housing 10. Further, the oil 13 that is fed to a lubrication site of the higher-stage scroll compression mechanism 3 is used for the lubrication of the desired site. Then, part of the oil 13 dissolves in the refrigerant gas, and is sent out to the refrigeration cycle together with the ejected gas. Most of the oil 13 is collected in the space portion 44, passes through the oil discharge hole 45 and the oil discharge pipe 47, is guided into the stator cut 5B of the motor 4 from the opened lower end of the oil discharge pipe 47, and flows down to the oil reservoir 12 in the bottom portion of the hermetic housing 10 through the stator cut 5B.

[0075] Further, the eccentric portion 7A and the eccentric pin 7B of the driving shaft 7 respectively joined to the lower-stage rotary compression mechanism 2 and the higher-stage scroll compression mechanism 3 are provided in an opposing direction or the same direction. With this configuration, the amount of static unbalance or the amount of dynamic unbalance is reduced for the rotary portion of the lower-stage rotary compression mechanism 2 and the rotary portion of the higher-stage scroll compression mechanism 3 that are coupled at both end positions of the driving shaft 7 and are driven by rotation of the driving shaft 7, and a shafting balance of the driving shaft 7 is achieved. As a result, a reduction in vibrations and noise is achieved.

[0076] Similarly, in the present embodiment, the blade 25 corresponding to the reciprocating component of the lower-stage rotary compression mechanism 2 corresponding to the first fluid suction/discharge mechanism and the Oldham's ring 36 corresponding to the reciprocating component of the higher-stage scroll compression mechanism 3 corresponding to the second fluid suction/discharge mechanism are arranged so as to be mutually reciprocatable in an opposing direction or the same direction. With this configuration, the amount of static unbalance or the amount of dynamic unbalance can be expeditiously reduced also for the blade 25 and the Oldham's ring 36 corresponding to the reciprocating components.

[0077] In this way, according to the present embodiment, in addition to a shafting balance of the rotary portions of the lower-stage rotary compression mechanism 2 corresponding to the first fluid suction/discharge mechanism and the higher-stage scroll compression mechanism 3 corresponding to the second fluid suction/discharge mechanism, a balance can be achieved also for the reciprocating components such as the blade 25 and the Oldham's ring 36 respectively provided to the compression mechanisms 2 and 3. Accordingly, it is possible to prevent a loss of the shafting balance due to unbalanced moments of the reciprocating components 25 and 36 and reliably achieve a reduction in vibrations and noise.

[0078] A graph of Fig. 6 shows a relation between: a phase {deg} of the motion direction of the blade 25 to the motion direction of the Oldham's ring 36; and the amount of static unbalance {g*mm}. As is apparent also from this graph, if the Oldham's ring 36 and the blade 25 are arranged so as to be mutually reciprocatable in an opposing direction by 180°, the amount of static unbalance is minimized. Note that curved lines x and y in the graph of Fig. 6 respectively represent changes in the amount of static unbalance in an x direction and a y direction passing through the center of the driving shaft 7, and a curved line R represents a total line thereof. When the phase is 180 {deg}, the amount of static unbalance {g*mm} is minimum.

[0079] Further, the opposing direction or the same direction in which the reciprocating components such as the blade 25 and the Oldham's ring 36 are mutually reciprocatable includes a range within ±45° with respect to a straight line in the direction. Hence, the present invention is not limited to a configuration in which the blade 25 and the Oldham's ring 36 are arranged so as to be mutually reciprocatable in an opposing direction by 180° or the same direction (direction by 0°). If the blade 25 and the Oldham's ring 36 are arranged within ±45° with respect to their respective directions, the amount of static unbalance or the amount of dynamic unbalance can be made sufficiently small due to a component of force thereof. Accordingly, even in the case where the blade 25 and the Oldham's ring 36 cannot be arranged in the opposing direction by 180° or the same direction (direction by 0°), if the blade 25 and the Oldham's ring 36 are arranged in a range within ±45° with respect to their respective directions, unbalanced moments of the reciprocating components can be expeditiously reduced, and vibrations and noise can be reduced.

[0080] Moreover, in the present embodiment, the blade (first reciprocating component) 25 of the lower-stage rotary compression mechanism (first fluid suction/discharge mechanism) 2 and the Oldham's ring (second reciprocating component) 36 of the higher-stage scroll compression mechanism (second fluid suction/discharge mechanism) 3 that are mutually reciprocatable in an opposing direction satisfy $m1 \times l1 \approx m2 \times l2$, assuming that: the mass of the blade (first reciprocating component) 25 is m1; the stroke thereof is l1; the mass of the Oldham's ring (second reciprocating component) 36 is m2; and the stroke thereof is l2. Hence, unbalanced moments of the blade (first reciprocating component) 25 and the Oldham's ring (second reciprocating component) 36 can be substantially cancelled, and a dynamic balance can be achieved. Accordingly, it is possible to prevent a loss of a shafting balance due to the unbalanced moments of the reciprocating components 25 and 36 of the compression mechanisms and reliably reduce vibrations and noise.

[0081] Further, in the above, when the masses m1 and m2 of the blade (first reciprocating component) 25 and the Oldham's ring (second reciprocating component) 36 satisfy $m1 > m2$, the respective strokes l1 and l2 thereof are set to satisfy $l1 < 12$. When the masses m1 and m2 thereof satisfy $m1 < m2$, the respective strokes l1 and l2 thereof are set to satisfy $l1 > l2$. Hence, the masses m1 and m2 and the strokes l1 and l2 of the blade (first reciprocating component) 25 and the Oldham's ring (second reciprocating component) 36 do not necessarily need to be the same, and the masses m1 and m2 and the strokes l1 and l2 can be set to proper values as appropriate. Accordingly, the present invention can be easily applied to a configuration in which mechanisms of compression mechanisms (fluid suction/discharge mechanisms) are different from each other and reciprocating components of the compression mechanisms have different masses and different strokes.

[0082] Further, in the present embodiment, one of the fluid suction/discharge mechanisms is configured as the lower-stage rotary compression mechanism 2, another one of the fluid suction/discharge mechanisms is configured as the higher-stage scroll compression mechanism 3, and these fluid suction/discharge mechanisms respectively include the blade 25 and the Oldham's ring 36 corresponding to the reciprocating components, whereby the two-stage compressor 1 is configured. Then, the blade 25 and the Oldham's ring 36 corresponding to the reciprocating components are arranged so as to be mutually reciprocatable in an opposing direction or the same direction, whereby a static balance or a dynamic balance is achieved for the blade 25 and the Oldham's ring 36 corresponding to the reciprocating components of the lower-stage rotary fluid suction/discharge mechanism 2 and the higher-stage scroll compression mechanism 3.

[0083] As a result, it is possible to prevent a loss of a shafting balance due to unbalanced moments of the reciprocating components 25 and 36 of the two fluid suction/discharge mechanisms (the lower-stage rotary compression mechanism 2 and the higher-stage scroll compression mechanism 3) having different configurations and reduce vibrations and noise. Comparing the blade 25 with the Oldham's ring 36, the Oldham's ring 36 is remarkably larger in component size, and the blade 25 is slightly larger in the strokes l1 and l2 during reciprocation. In other words, the blade 25 and the Oldham's ring 36 are different from each other in size and stroke. If the masses m1 and m2 are made different from each other by changing materials used therefor, a sufficient static balance or a sufficient dynamic balance can be achieved, and vibrations and noise can be reduced.

Second Embodiment

[0084] Next, a second embodiment of the present invention is described with reference to Fig. 4, Fig. 5, and Fig. 7.

[0085] The present embodiment is different from the first embodiment in that the lower-stage rotary compression mechanism is configured as a two-cylinder rotary compression mechanism 2A. The present embodiment is the same as the first embodiment in the other features, and hence description thereof is omitted.

[0086] In the present embodiment, the lower-stage rotary compression mechanism is configured as the two-cylinder rotary compression mechanism 2A in order to deal with the volume, fluctuations in torque, and the like of the rotary compression mechanism. Eccentric portions 7A are respectively provided at two upper and lower positions to a lower end portion of the driving shaft 7. Two cylinder chambers 20 are correspondingly formed in the cylinder main body 21. The rotor 24 is provided so as to be turnable by the eccentric portion 7A of the driving shaft 7 in each cylinder chamber 20.

[0087] In the two-cylinder rotary compression mechanism 2A, as illustrated in Fig. 4, two upper and lower blades 25A and 25B corresponding to each cylinder chamber 20 are arranged so as to be reciprocatable in the radial direction. Then, the two upper and lower blades 25A and 25B and the eccentric portions 7A at the two upper and lower positions are arranged in an opposing direction by 180°. In the two-cylinder rotary compression mechanism 2A, a static balance is achieved for rotary portions thereof and the blades 25A and 25B corresponding to the reciprocating components.

[0088] Here, in the case where the lower-stage rotary compression mechanism corresponding to one fluid suction/discharge mechanism is configured as the two-cylinder rotary compression mechanism 2A and where, in the two-cylinder rotary compression mechanism 2A, a static balance is achieved for the rotary portions thereof and the blades 25A and 25B corresponding to the reciprocating components, a static balance remains unachieved for the Oldham's ring 36 of the higher-stage scroll compression mechanism 3 corresponding to another fluid suction/discharge mechanism. To deal with this, as illustrated in Fig. 4, the reciprocating directions of the Oldham's ring 36 and the lower blade 25B (that is, the blade 25B farther from the higher-stage scroll compression mechanism 3) of the two-cylinder rotary compression mechanism 2A are adjusted to be the same in phase, and the upper blade 25A is arranged so as to be reciprocatable in an opposing direction with respect to the Oldham's ring 36.

[0089] That is, in the case where the one fluid suction/discharge mechanism is configured as the two-cylinder rotary compression mechanism 2A, the following two configurations are conceivable. In the first configuration, as illustrated in Fig. 5, the reciprocating direction of the upper blade 25A (that is, the blade 25A closer to the higher-stage scroll compression mechanism 3) of the two-cylinder rotary compression mechanism 2A is adjusted to be the same in phase as that of the Oldham's ring 36 of the higher-stage scroll compression mechanism 3. In the second configuration, as illustrated in Fig. 4, the reciprocating direction of the upper blade 25A (that is, the blade 25A closer to the higher-stage scroll compression mechanism 3) is adjusted to be an opposing direction to that of the Oldham's ring 36. In the present embodiment, the second configuration is adopted.

[0090] In this way, even in the case where the one fluid suction/discharge mechanism is configured as the two-cylinder rotary compression mechanism 2A, the two upper and lower blades 25A and 25B corresponding to the reciprocating components of the two-cylinder rotary compression mechanism 2A are arranged so as to be mutually reciprocatable in an opposing direction, whereby a static balance can be achieved for the two-cylinder rotary compression mechanism 2A. Then, in this case, a static unbalance remains unachieved for the Oldham's ring 36 corresponding to the reciprocating component of the higher-stage scroll compression mechanism 3, but if the reciprocating directions of the Oldham's ring 36 and the blade 25B farther from the higher-stage scroll compression mechanism 3 are adjusted to be the same in phase, unbalanced moments of the reciprocating components acting on the axial center of the driving shaft 7 can be cancelled, and the amount of dynamic unbalance can be minimized. As a result, the amount of dynamic unbalance caused by the reciprocating components can be reduced, and a shafting balance can be secured.

[0091] A graph of Fig. 7 shows a relation between: a phase {deg} of the motion direction of the two upper blades 25A and 25B to the motion direction of the Oldham's ring 36; and the amount of dynamic unbalance {g*mm2}. As is apparent also from this graph, if the Oldham's ring 36 and the upper blade 25A are arranged so as to be mutually reciprocatable in an opposing direction by 180° (the reciprocating directions of the Oldham's ring 36 and the lower blade 25B are the same in phase), the amount of dynamic unbalance is minimized. Note that curved lines x and y in the graph of Fig. 7 respectively represent changes in the amount of dynamic unbalance in an x direction and a y direction passing through the center of the driving shaft 7, and a curved line R represents a total line thereof. When the phase is 180 {deg}, the amount of dynamic unbalance {g*mm2} is minimum.

[0092] Further, in the present embodiment, in the two-cylinder rotary compression mechanism 2A, the upper blade 25A closer to the higher-stage scroll compression mechanism 3 can be set to be larger in mass than the lower blade 25B farther from the higher-stage scroll compression mechanism 3, or can be set to be longer in stroke than the lower blade 25B. With this configuration, even if a static balance cannot be achieved between the two upper and lower blades 25A and 25B in the two-cylinder rotary compression mechanism 2A and if a static unbalance remains, the remaining static unbalance is cancelled by a static balance of the Oldham's ring 36 of the higher-stage scroll compression mechanism 3, whereby the amount of dynamic unbalance can be minimized. Accordingly, also with this configuration, the amount of dynamic unbalance of the reciprocating components can be expeditiously reduced, and a shafting balance can be secured.

Third Embodiment

[0093] Next, a third embodiment of the present invention is described with reference to Fig. 1 and Fig. 8 to Fig. 10.

[0094] In the present embodiment, configurations similar to those in the first embodiment are omitted.

[0095] Fig. 1 is a longitudinal sectional view of a hermetic compressor according to the third embodiment of the present invention, Fig. 8 is a view on an arrow C in Fig. 1, Fig. 9 is a view on an arrow D in Fig. 1, and Fig. 10 is a configuration view of an oil discharge pipe installation portion of the hermetic compressor. In the present embodiment, for convenience sake, description is given of an example of the hermetic multi-stage compressor (hermetic compressor) 1, in which a rotary compression mechanism is used for the lower-stage compression mechanism 2, and a scroll compression mechanism is used for the higher-stage compression mechanism 3. It goes without saying that the hermetic compressor does not necessarily need to be the multi-stage compressor, and may be a single-stage compressor. It also goes without saying that the compression mechanism is not limited to the rotary or scroll compression mechanism.

[0096] The hermetic multi-stage compressor 1 according to the present embodiment includes: the lower-stage rotary compression mechanism 2 having a configuration similar to that in the first embodiment; and the higher-stage scroll compression mechanism 3. The higher-stage scroll compression mechanism 3 is provided with an oil discharge route that returns oil that has been used for the lubrication of desired lubrication sites such as bearing portions, to the oil reservoir 12 in the bottom portion of the hermetic housing 10. The oil discharge route is defined by the space portion 44 of the support member 31, the oil discharge hole 45, and the oil discharge pipe 47. The whirling boss portion 35 of the whirling scroll member 33 is housed in the space portion 44, and the oil that has been used for the lubrication of a desired lubrication site is collected in the space portion 44. The oil discharge hole 45 is formed so as to connect the space portion 44 and the outer peripheral portion of the support member 31. The oil discharge pipe 47 is inserted and installed into the downward pipe insertion hole 46 that intersects with the oil discharge hole 45.

[0097] As illustrated in Fig. 10, the oil discharge pipe 47 is extended downward from the lower surface of the support member 31, and the lower end of the oil discharge pipe 47 is arranged in a range H below the stator coil end 5A of the motor 4 placed below the higher-stage scroll compression mechanism 3 and above the upper end of the stator 5. Further, a lower portion of the oil discharge pipe 47 is smoothly curved toward the outer periphery of the stator 5, and the opened lower end thereof is formed so as to be opposed to one of the plurality of stator cuts 5B (see Fig. 1) provided in the outer periphery of the stator 5. Moreover, the oil discharge pipe 47 has an outer diameter D that is set to be larger than a radial width L of the stator cut 5B. With this configuration, a flow path pressure loss in the oil discharge route can be reduced, and the oil can be smoothly discharged.

[0098] Note that, in the present invention, "the lower portion of the oil discharge pipe 47 is smoothly curved toward the outer periphery of the stator 5" refers to not only that the lower portion is smoothly curved in an arc-like shape but also that the lower portion is bent toward the outer periphery and is smoothly bent as a whole.

[0099] With the configuration described above, the present embodiment produces the following operations and effects.

[0100] Low-pressure refrigerant gas that is directly suctioned into each cylinder chamber 20 of the lower-stage rotary compression mechanism 2 through the suction pipe 27 is compressed to an intermediate pressure by turns of the rotor 24. Then, the compressed gas is ejected into the ejection chambers 28A and 28B. The intermediate-pressure refrigerant gas joins together in the ejection chamber 28A, and is ejected into a space below the electric motor 4. Then, the intermediate-pressure refrigerant gas circulates through the gas passage hole 6A and the like provided in the rotor 6 of the motor 4, and flows to a space above the motor 4.

[0101] The intermediate-pressure refrigerant gas that has flown to the space above the motor 4 passes through the cutout portion 31A provided on the outer peripheral surface of the support member 31 constituting the higher-stage scroll compression mechanism 3, is guided to a suction port of the higher-stage scroll compression mechanism 3, and is suctioned into the compression chamber 34. The intermediate-pressure refrigerant gas is compressed in two stages to a high pressure by the higher-stage scroll compression mechanism 3. Then, the compressed gas is ejected into the ejection chamber 41 from the ejection valve 40, and is sent to the outside of the compressor, that is, to the refrigeration cycle through the ejection pipe 43.

[0102] The lubricant oil 13 that is fed by the oil feed pump 11 to a lubrication site of the lower-stage rotary compression mechanism 2 through the oil feed hole 14 during this two-stage compression process is used for the lubrication of the desired lubrication site. Then, part of the lubricant oil 13 flows down to the oil reservoir 12. Another part of the lubricant oil 13 dissolves in the refrigerant gas, is ejected into the space below the motor 4 together with the intermediate-pressure refrigerant gas, is separated in the space, and flows down to the oil reservoir 12. Meanwhile, the lubricant oil 13 that is fed to a lubrication site of the higher-stage scroll compression mechanism 3 through the oil feed hole 14 is used for the lubrication of the desired lubrication site. Then, part of the lubricant oil 13 dissolves in the refrigerant gas, to be thereby sent out to the refrigeration cycle together with the ejected gas, whereas most of the lubricant oil 13 is collected in the space portion 44 of the support member 31.

[0103] The lubricant oil 13 collected in the space portion 44 passes through the oil discharge hole 45 and the oil discharge pipe 47 communicated with the space portion 44, is guided into the stator cut 5B of the motor 4 from the opened lower end of the oil discharge pipe 47, and flows down to the oil reservoir 12 in the bottom portion of the hermetic housing 10 through the stator cut 5B. In this way, an oil loss from the hermetic compressor 1 to the refrigeration cycle can be reduced, the system efficiency can be improved, and an insufficiency of the lubricant oil in the compressor 1 can be solved.

[0104] Moreover, in the present embodiment, the oil that has been used for the lubrication of a desired lubrication site of the higher-stage scroll compression mechanism 3 is returned to the oil reservoir 12 through the oil discharge hole 45 and the oil discharge pipe 47, so as not to be blown up by the refrigerant gas. The lower end of the oil discharge pipe 47 is arranged in the range H below the stator coil end 5A of the motor 4 and above the upper end of the stator 5. The lower end of the oil discharge pipe 47 is opened so as to be opposed to one of the stator cuts 5B provided in the outer periphery of the stator 5. Moreover, the lower portion of the oil discharge pipe 47 is smoothly curved toward the outer periphery of the stator 5, and the oil discharge pipe 47 has the outer diameter D that is set to be larger than the radial width L of the stator cut 5B.

[0105] With this configuration, the oil that has been used for the lubrication of a desired lubrication site of the higher-stage scroll compression mechanism 3 can be guided to the oil discharge hole 45 and the oil discharge pipe 47 from the space portion 44 provided in the support member 31. While a flow path pressure loss is suppressed by the oil discharge pipe 47 having the outer diameter D that is set to be larger than the radial width L of the stator cut 5B, the oil is caused to flow out in the centrifugal direction by the lower portion of the oil discharge pipe 47 curved toward the outer periphery of the stator 5, and the oil can be reliably introduced from the opened lower end of the oil discharge pipe 47 into the stator cut 5B to which the opened lower end thereof is opposed. Accordingly, while a flow path pressure loss in the oil discharge route is suppressed without increasing the outer diameter of the hermetic housing 10 and the width L of the stator cut 5B, the oil that flows out of the oil discharge pipe 47 can be reliably introduced into the stator cut 5B, and can be caused to smoothly flow down to the oil reservoir 12, so that an oil loss from the hermetic compressor 1 can be prevented.

Fourth Embodiment

[0106] Next, a fourth embodiment of the present invention is described with reference to Fig. 11 and Figs. 12.

[0107] The present embodiment is different from the third embodiment in an installation structure of the oil discharge pipe 47. The present embodiment is the same as the third embodiment in the other features, and hence description thereof is omitted.

[0108] In the present embodiment, an upper end portion of the oil discharge pipe 47 is press-fitted (including light press-fitting) into the downward pipe insertion hole 46 that intersects with the oil discharge hole 45, whereby the oil discharge pipe 47 is fixed and installed in the pipe insertion hole 46. Further, a side hole 49 provided on the outer peripheral surface of the upper end portion of the oil discharge pipe 47 is communicated with the oil discharge hole 45, and oil discharged from the oil discharge hole 45 is introducible into the oil discharge pipe 48 through the side hole 49.

[0109] In the present embodiment, the side hole 49 is provided on the outer peripheral surface of the upper end portion of the oil discharge pipe 47. Instead of the side hole 49, as illustrated in Figs. 12A and 12B, part of the upper end portion of the oil discharge pipe 47 may be cut out in a rectangle shape or a triangle shape, the part being opposed to the oil discharge hole 45, whereby a cutout 50A or 50B may be provided on the outer peripheral surface thereof.

[0110] As described above, the upper end portion of the oil discharge pipe 47 is inserted and installed in the downward pipe insertion hole 46 that intersects with the oil discharge hole 45 that is provided outward in the radial direction in the support member 31, whereby the oil discharged from the oil discharge hole 45 is introducible into the oil discharge pipe 47 through the side hole 49 or the cutout 50A or 50B provided in the upper end portion of the oil discharge pipe 47. In this configuration, the upper end portion of the oil discharge pipe 47 is inserted into the downward pipe insertion hole 46 that intersects with the oil discharge hole 45, and the oil discharge hole 45 is thus communicated with the side hole 49 or the cutout 50A or 50B provided on the outer peripheral surface of the upper end portion of the oil discharge pipe 47, whereby the oil discharge route that guides, to the stator cut 5B, the oil that has been used for the lubrication of a desired lubrication site of the higher-stage scroll compression mechanism 3 can be formed. As a result, an outer end portion of the oil discharge hole 45 does not need to be closed, the formation of the oil discharge route can be facilitated, and the oil can be reliably suppressed from being blown up by the refrigerant gas.

[0111] Further, because the upper end portion of the oil discharge pipe 47 is inserted and installed by press-fitting in the pipe insertion hole 46, gaps for oil leakage from between the oil discharge pipe 47 and the pipe insertion hole 46 and oil leakage to the outer end portion of the oil discharge hole 45 from the oil discharge pipe 47 can be eliminated. As a result, such oil leakage from the oil discharge hole 45 and the pipe insertion hole 46 can be eliminated, the oil can be effectively guided to the oil reservoir 12, an oil loss can be suppressed, and the oil discharge pipe 47 can be reliably prevented from falling off the support member 31.

Fifth Embodiment

[0112] Next, a fifth embodiment of the present invention is described with reference to Fig. 13 and Figs. 14.

[0113] The present embodiment is different from the third and fourth embodiments in an attachment structure of an oil discharge pipe 47A. The present embodiment is the same as the third and fourth embodiments in the other features, and hence description thereof is omitted.

[0114] In the present embodiment, the oil discharge pipe 47A is configured as a stepped oil discharge pipe that is provided with a tapered stepped portion 51 at a position below an upper end portion of the oil discharge pipe 47A, the upper end portion being inserted and installed in the pipe insertion hole 46 and having a slightly larger diameter. Further, the oil discharge pipe 47A has an assembly structure in which an attachment plate 52 is integrally joined by brazing, bonding, or the like to the stepped portion 51.

[0115] The stepped oil discharge pipe assembly (oil discharge pipe) 47A is inserted and installed in the pipe insertion hole 46 by means of the attachment plate 52, and the attachment plate 52 is screwed to the support member 31 by means of a bolt 53. Further, as illustrated in Fig. 13, the attachment plate 52 includes a bolt hole 54, and the attachment plate 52 is integrated in advance by brazing, bonding, or the like with the oil discharge pipe 47A such that the relative position between: the oil discharge hole 45; and the side hole 49 or the cutout 50A or 50B provided in the oil discharge pipe 47A, and the curving direction of the oil discharge pipe 47A are set to a predetermined position and a predetermined direction, in the state where the attachment plate 52 is screwed to the support member 31 by means of the bolt 53.

[0116] As described above, the attachment plate 52 is integrally provided to the oil discharge pipe 47A at the position below the upper end portion of the oil discharge pipe 47A, the upper end portion being inserted and installed in the pipe insertion hole 46, and the oil discharge pipe 47A is inserted and installed in the support member 31 by means of the attachment plate 52 so as to close the pipe insertion hole 46. Hence, if the upper end portion of the oil discharge pipe 47A to which the attachment plate 52 is integrally provided is inserted into the pipe insertion hole 46 and the oil discharge pipe 47A is thus installed in the support member 31, the pipe insertion hole 46 can be closed by the attachment plate 52 so as to avoid oil leakage. Accordingly, oil leakage from the pipe insertion hole 46 can be eliminated, the oil can be effectively guided to the oil reservoir 12, an oil loss can be suppressed, and the oil discharge pipe 47A can be prevented from falling off.

[0117] Further, the attachment plate 52 is integrated in advance with the oil discharge pipe 47A such that the relative position between: the oil discharge hole 45; and the side hole 49 or the cutout 50A or 50B provided in the oil discharge pipe 47A, and the curving direction of the oil discharge pipe 47A are set to a predetermined position and a predetermined direction, in the state where the attachment plate 52 is screwed to the support member 31 by means of the bolt 53. Hence, the oil discharge pipe 47A to which the attachment plate 52 is integrally attached is inserted into the pipe insertion hole 46, and the attachment plate 52 is screwed to the support member 31. Through such a simple process, the relative position between: the oil discharge hole 45; and the side hole 49 or the cutout 50A or 50B provided in the oil discharge pipe 47A, and the direction of the oil discharge pipe 47A can be set to a predetermined position and a predetermined direction. Accordingly, the incorporation of the oil discharge pipe 47A can be facilitated, the incorporation accuracy thereof can be improved, and the oil can be more reliably introduced into the stator cut 5B.

[0118] Moreover, in the present embodiment, the oil discharge pipe 47A is configured as the stepped oil discharge pipe having a diameter that becomes smaller at the position below the upper end portion of the oil discharge pipe 47A, the upper end portion being inserted and installed in the pipe insertion hole 46, and the attachment plate 52 is joined to the stepped portion 51. Hence, the attachment plate 52 can be easily joined by brazing, bonding, or the like and integrally attached to a prescribed position of the oil discharge pipe 47A, with the use of the stepped portion 51 of the pipe. Accordingly, the manufacture and incorporation of the oil discharge pipe 47A with the attachment plate 52 can be facilitated, and assembling properties of the hermetic compressor 1 can be improved.

Sixth Embodiment

[0119] Next, a sixth embodiment of the present invention is described with reference to Fig. 15.

[0120] The present embodiment is different from the third to fifth embodiments in a configuration of an oil discharge pipe 47B. The present embodiment is the same as the third to fifth embodiments in the other features, and hence description thereof is omitted.

[0121] In the present embodiment, as illustrated in Fig. 15, an opened lower end portion 47C of the oil discharge pipe 47B from which the oil flows out toward the stator cut 5B is obliquely cut so as to be opened along the inner peripheral surface of the hermetic housing 10.

[0122] As described above, if the opened lower end portion 47C of the oil discharge pipe 47B is obliquely cut so as to be opened along the inner peripheral surface of the hermetic housing 10, the opened lower end portion 47C of the oil discharge pipe 47B can be opened so as to be downwardly long in substantially parallel to the inner peripheral surface of the hermetic housing 10. Hence, the directionality of the oil that flows out of the opened lower end portion 47C of the oil discharge pipe 47B toward the stator cut 5B can be enhanced, and the oil can be more reliably introduced into the stator cut 5B.

[0123] Note that the present invention is not limited to the inventions according to the above-mentioned embodiments, and can be modified as appropriate within a range not departing from the scope thereof. For example, in the first embodiment, description is given of an example in which the present invention is applied to the two-stage compressor 1 including the fluid suction/discharge mechanisms configured as compression mechanisms. Alternatively, expansion mechanisms, pump mechanisms, or a combination thereof may be adopted instead of the compression mechanisms. If the fluid suction/discharge mechanisms provided at both the end positions of the driving shaft 7 are configured as compression mechanisms, expansion mechanisms, pump mechanisms, a combination of a compression mechanism and an expansion mechanism, a combination of a pump mechanism and an expansion mechanism, or the like, fluid machines having various configurations can be provided. If a static balance or a dynamic balance is achieved for a reciprocating component of each fluid suction/discharge mechanism, it is possible to prevent a loss of a shafting balance due to an unbalanced moment of the reciprocating component and reduce vibrations and noise. Further, the present invention can be applied to any hermetic compressor regardless of whether the hermetic compressor is of single-stage or multi-stage and regardless of the type of compression mechanism, as long as: the compression mechanism is provided above a motor in a hermetic housing; lubricant oil that fills an oil reservoir in a hermetic housing bottom portion is fed to the compression mechanism through an oil feed pump and an oil feed hole; and the lubricant oil flows down to the oil reservoir after the lubrication of a desired lubrication site.

Reference Signs List

[0124]

1	two-stage compressor (fluid machine, hermetic multi-stage compressor, hermetic compressor)
2	lower-stage rotary compression mechanism (first fluid suction/discharge mechanism, lower-stage compression mechanism)
2A	two-cylinder rotary compression mechanism (first fluid suction/discharge mechanism)
3	higher-stage scroll compression mechanism (second fluid suction/discharge mechanism, higher-stage compression mechanism)
4	motor
5	stator
5A	stator coil end
5B	stator cut
7	driving shaft (crankshaft)
10	hermetic housing
11	oil feed pump
12	oil reservoir
13	lubricant oil (oil)
14	oil feed hole
25, 25A, 25B	blade (first reciprocating component)
36	Oldham's ring (second reciprocating component)
31	support member
45	oil discharge hole
46	pipe insertion hole
47, 47A, 47B	oil discharge pipe
47C	opened lower end portion
49	side hole
50A, 50B	cutout
51	stepped portion
52	attachment plate
53	bolt
D	outer diameter of oil discharge pipe
L	radial width of stator cut

Claims

1. A fluid machine comprising two or more fluid suction/discharge mechanisms provided at both end positions of a driving shaft, the fluid suction/discharge mechanisms each including a reciprocating component, wherein
the respective reciprocating components of the fluid suction/discharge mechanisms are arranged so as to be mutually reciprocatable in an opposing direction or the same direction.

2. The fluid machine according to claim 1, wherein
the opposing direction or the same direction in which the respective reciprocating components of the fluid suction/discharge mechanisms are mutually reciprocatable includes a range within ±45° with respect to a straight line in the direction.

3. The fluid machine according to claim 1 or 2, wherein in a case where the respective reciprocating components of the fluid suction/discharge mechanisms are arranged so as to be mutually reciprocatable in the opposing direction, the following expression is satisfied:

$$m1 \times l1 \approx m2 \times l2$$

assuming that: a mass of a first reciprocating component of a first fluid suction/discharge mechanism is m1; a stroke thereof is 11; a mass of a second reciprocating component of a second fluid suction/discharge mechanism is m2; and a stroke thereof is l2.

4. The fluid machine according to claim 3, wherein
when the masses m1 and m2 of the first and second reciprocating components satisfy $m1 > m2$, the strokes l1 and l2 of the first and second reciprocating components are set to satisfy $l1 < l2$, and
when the masses m1 and m2 thereof satisfy $m1 < m2$, the strokes l1 and l2 thereof are set to satisfy $11 > l2$.

5. The fluid machine according to any of claims 1 to 4, wherein
the fluid suction/discharge mechanisms are each configured as any of a compression mechanism, an expansion mechanism, and a pump mechanism or a combination thereof.

6. The fluid machine according to any of claims 1 to 5, wherein
one of the fluid suction/discharge mechanisms is configured as a lower-stage compression mechanism,

another one of the fluid suction/discharge mechanisms is configured as a higher-stage compression mechanism, and
a two-stage compressor is configured by the lower-stage and higher-stage compression mechanisms.

7. The fluid machine according to any of claims 1 to 6, wherein
one of the fluid suction/discharge mechanisms is configured as a scroll fluid suction/discharge mechanism including an Oldham's ring as the reciprocating component, and
another one of the fluid suction/discharge mechanisms is configured as a rotary fluid suction/discharge mechanism including a blade as the reciprocating component.

8. The fluid machine according to claim 7, wherein
the rotary fluid suction/discharge mechanism is configured as a two-cylinder rotary fluid suction/discharge mechanism,
two blades of the two-cylinder rotary fluid suction/discharge mechanism are arranged so as to be mutually reciprocatable in an opposing direction, and
the blade closer to the scroll fluid suction/discharge mechanism is arranged so as to be reciprocatable in an opposing direction with respect to the Oldham's ring of the scroll fluid suction/discharge mechanism.

9. The fluid machine according to claim 8, wherein
the blade closer to the scroll fluid suction/discharge mechanism, of the two-cylinder rotary fluid suction/discharge mechanism is set to be larger in mass or longer in stroke than the blade thereof farther from the scroll fluid suction/discharge mechanism.

10. A hermetic compressor comprising:

a hermetic housing;
a motor built in the hermetic housing; and
a compression mechanism that is provided above the motor and is driven by the motor through a driving shaft,
the hermetic compressor being configured to:

feed lubricant oil that fills an oil reservoir in a bottom portion of the hermetic housing, to a desired lubrication site of the compression mechanism through an oil feed pump and an oil feed hole provided in the driving shaft; and
return the oil that has been used for lubrication of the site, to the oil reservoir through an oil discharge hole provided in a support member of the compression mechanism and an oil discharge pipe, wherein

the oil discharge pipe has a lower end that is opened at a position below a stator coil end of the motor and above an upper end of a stator so as to be opposed to a stator cut provided in an outer periphery of the stator,
the oil discharge pipe has a lower portion curved toward the outer periphery of the stator, and
the oil discharge pipe has an outer diameter that is set to be larger than a radial width of the stator cut.

11. The hermetic compressor according to claim 10, wherein
the oil discharge pipe has an upper end portion inserted and installed in a downward pipe insertion hole that intersects with the oil discharge hole that is provided outward in a radial direction in the support member, and
oil discharged from the oil discharge hole is introducible into the oil discharge pipe through a side hole or a cutout provided on an outer peripheral surface of the upper end portion of the oil discharge pipe.

12. The hermetic compressor according to claim 10 or 11, wherein
the opened lower end portion of the oil discharge pipe is obliquely cut so as to be opened along an inner peripheral surface of the hermetic housing.

13. A hermetic compressor comprising:

a hermetic housing;
a motor built in the hermetic housing; and
a compression mechanism that is provided above the motor and is driven by the motor through a driving shaft,
the hermetic compressor being configured to:

feed lubricant oil that fills an oil reservoir in a bottom portion of the hermetic housing, to a desired lubrication site of the compression mechanism through an oil feed pump and an oil feed hole provided in the driving shaft; and
return the oil that has been used for lubrication of the site, to the oil reservoir through an oil discharge hole provided in a support member of the compression mechanism and an oil discharge pipe, wherein

the oil discharge pipe has an upper end portion inserted and installed in a downward pipe insertion hole that intersects with the oil discharge hole that is provided outward in a radial direction in the support member, and
oil discharged from the oil discharge hole is introducible into the oil discharge pipe through a side hole or a cutout provided on an outer peripheral surface of the upper end portion of the

oil discharge pipe.

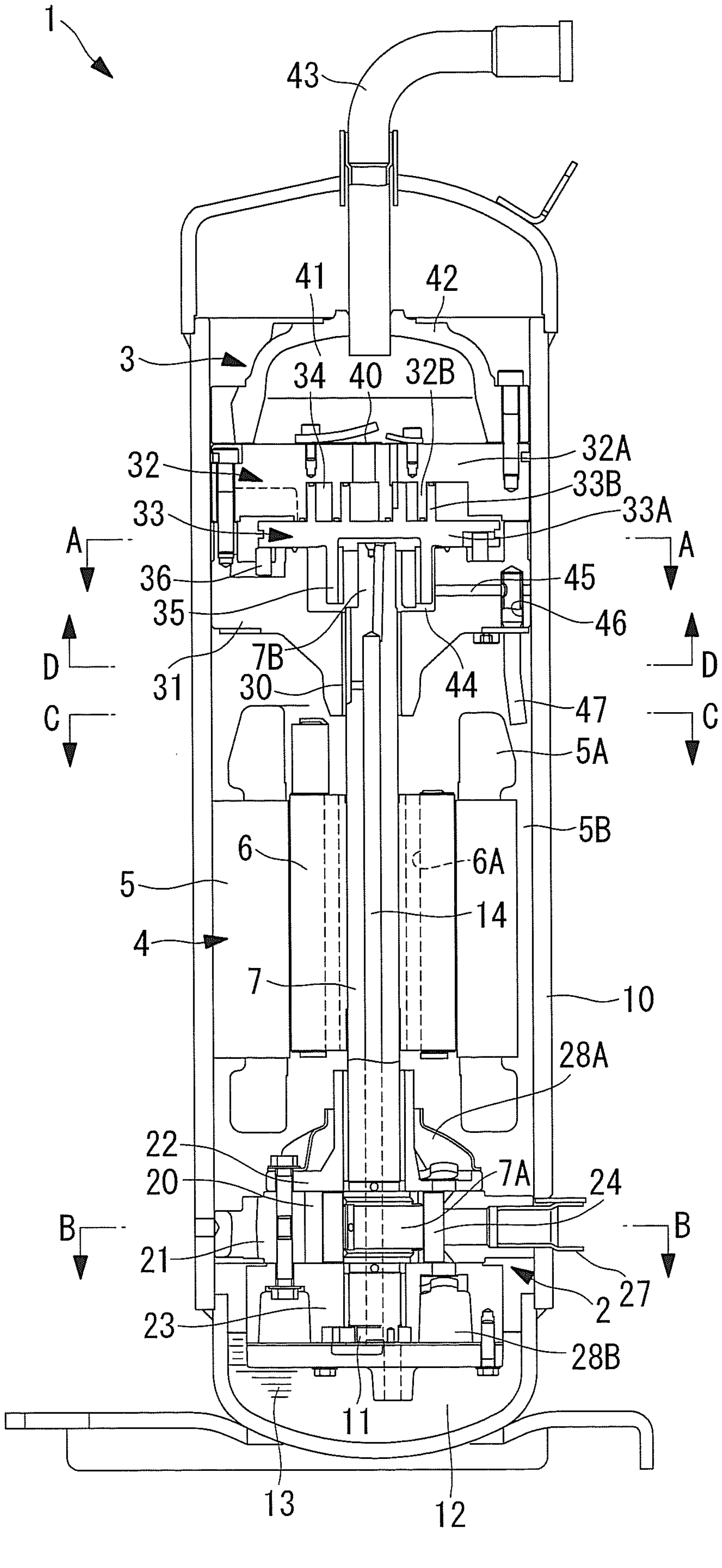
14. The hermetic compressor according to any of claims 11 to 13, wherein
the upper end portion of the oil discharge pipe is inserted and installed by press-fitting in the pipe insertion hole.

15. The hermetic compressor according to any of claims 11 to 13, wherein
an attachment plate is integrally provided to the oil discharge pipe at a position below the upper end portion thereof inserted and installed in the pipe insertion hole, and
the oil discharge pipe is inserted and installed in the support member by means of the attachment plate so as to close the pipe insertion hole.

16. The hermetic compressor according to claim 15, wherein
the attachment plate is screwed to the support member, and
the attachment plate is integrated in advance with the oil discharge pipe such that a relative position between: the oil discharge hole; and the side hole or the cutout provided in the oil discharge pipe, and a direction of the oil discharge pipe are set to a predetermined position and a predetermined direction, in a state where the attachment plate is screwed to the support member.

17. The hermetic compressor according to claim 15 or 16, wherein
the oil discharge pipe is configured as a stepped pipe having a diameter that becomes smaller at the position below the upper end portion thereof inserted and installed in the pipe insertion hole, and
the attachment plate is joined to a stepped portion of the stepped pipe.

FIG. 1


1
43
41
42
3
34
40
32B
32A
32
33B
33
33A
A
A
36
45
35
46
D
7B
D
31
30
44
47
C
C
5A
5B
6
6A
5
14
4
7
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20
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21
27
2
23
28B
11
13
12

FIG. 2

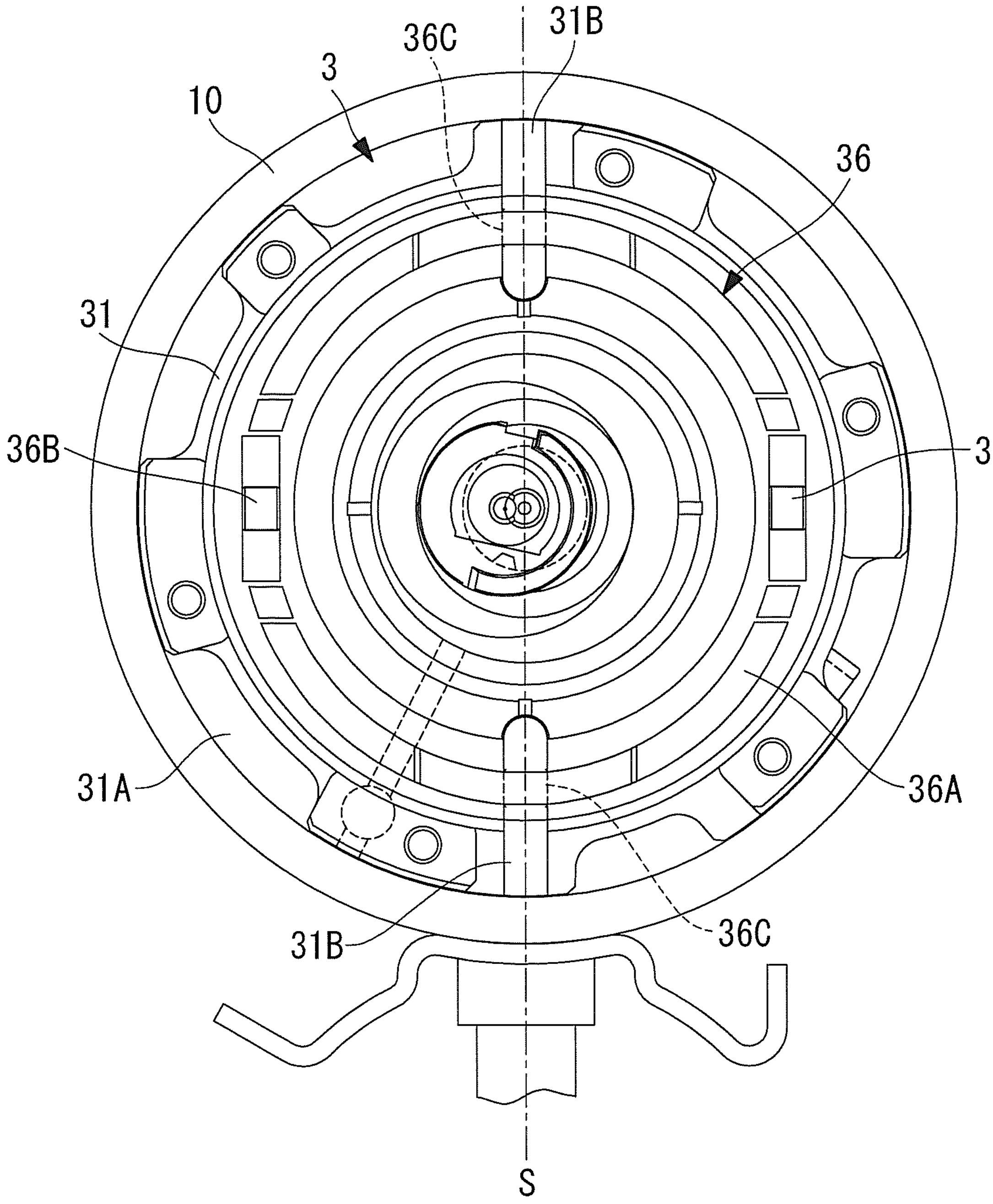


FIG. 3

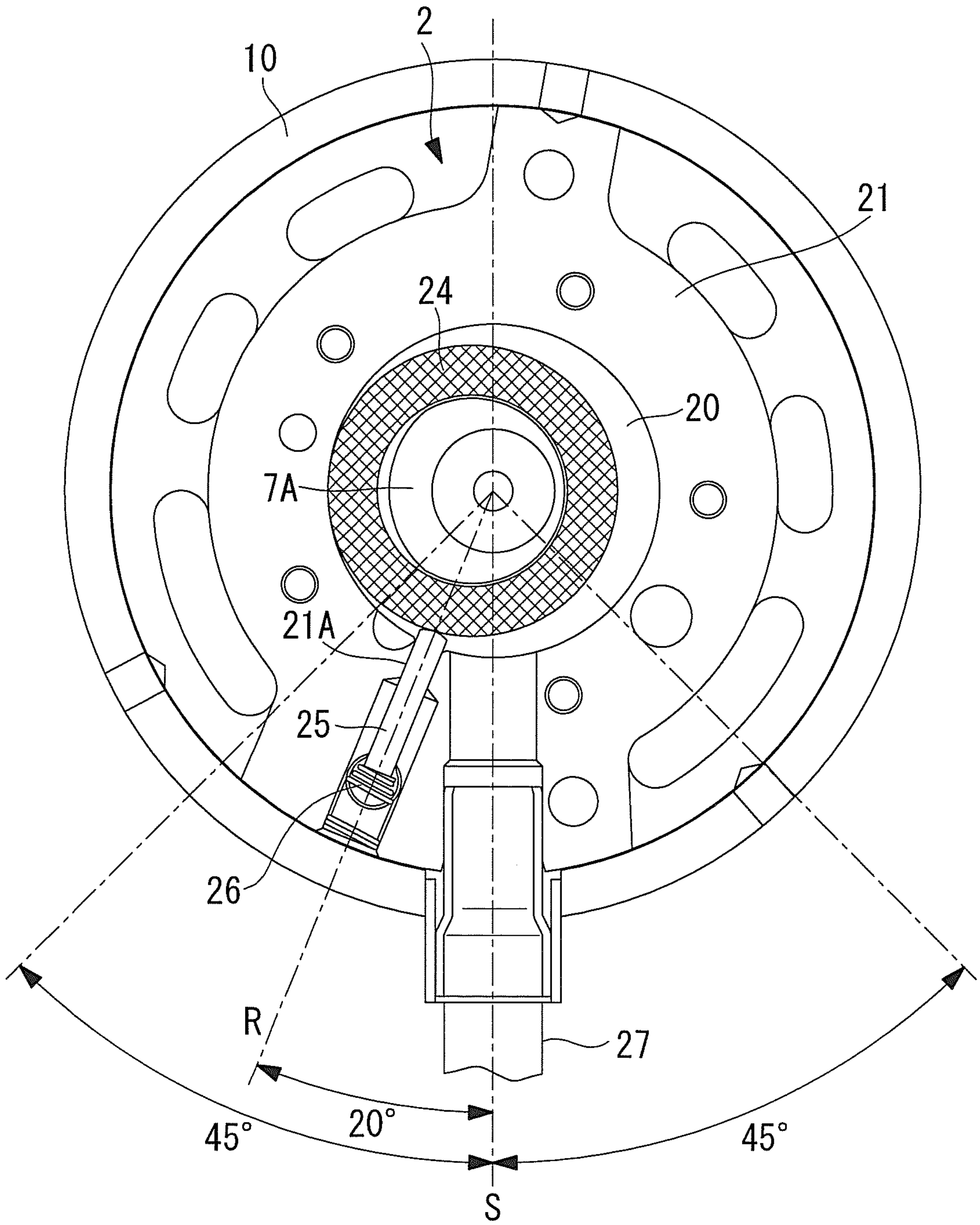


FIG. 4

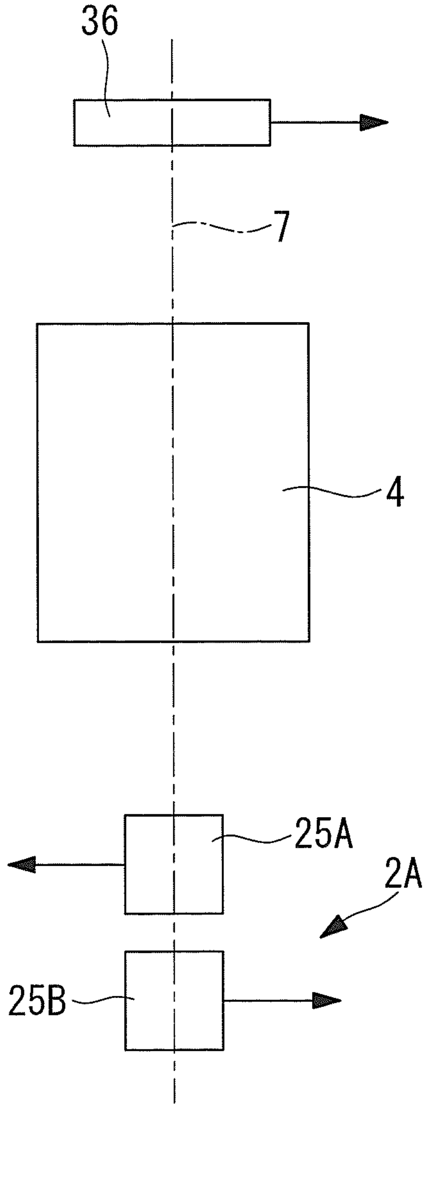


FIG. 5

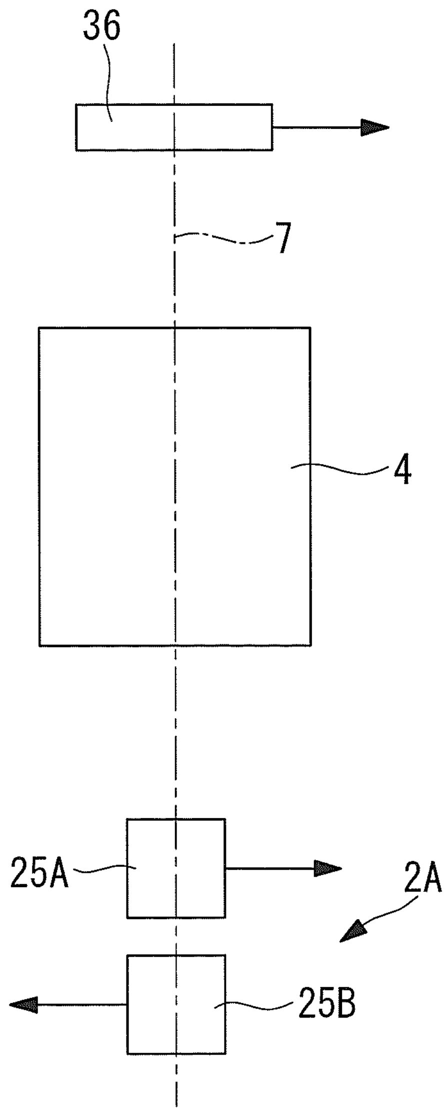


FIG. 6

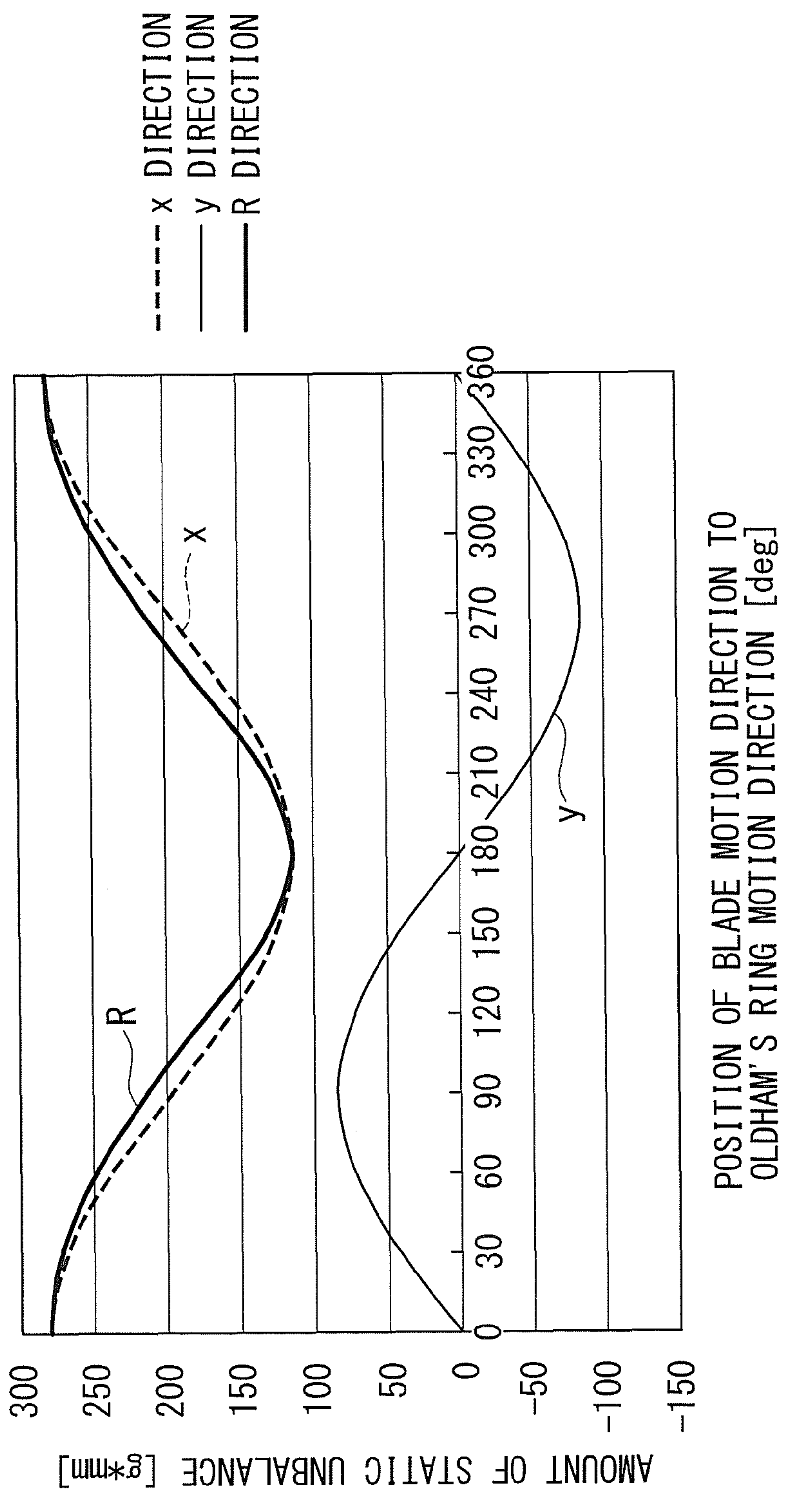

x DIRECTION
y DIRECTION
R DIRECTION
AMOUNT OF STATIC UNBALANCE [g*mm]
300
250
200
150
100
50
0
-50
-100
-150
0
30
60
90
120
150
180
210
240
270
300
330
360
POSITION OF BLADE MOTION DIRECTION TO OLDHAM'S RING MOTION DIRECTION [deg]
R
x
y

FIG. 7

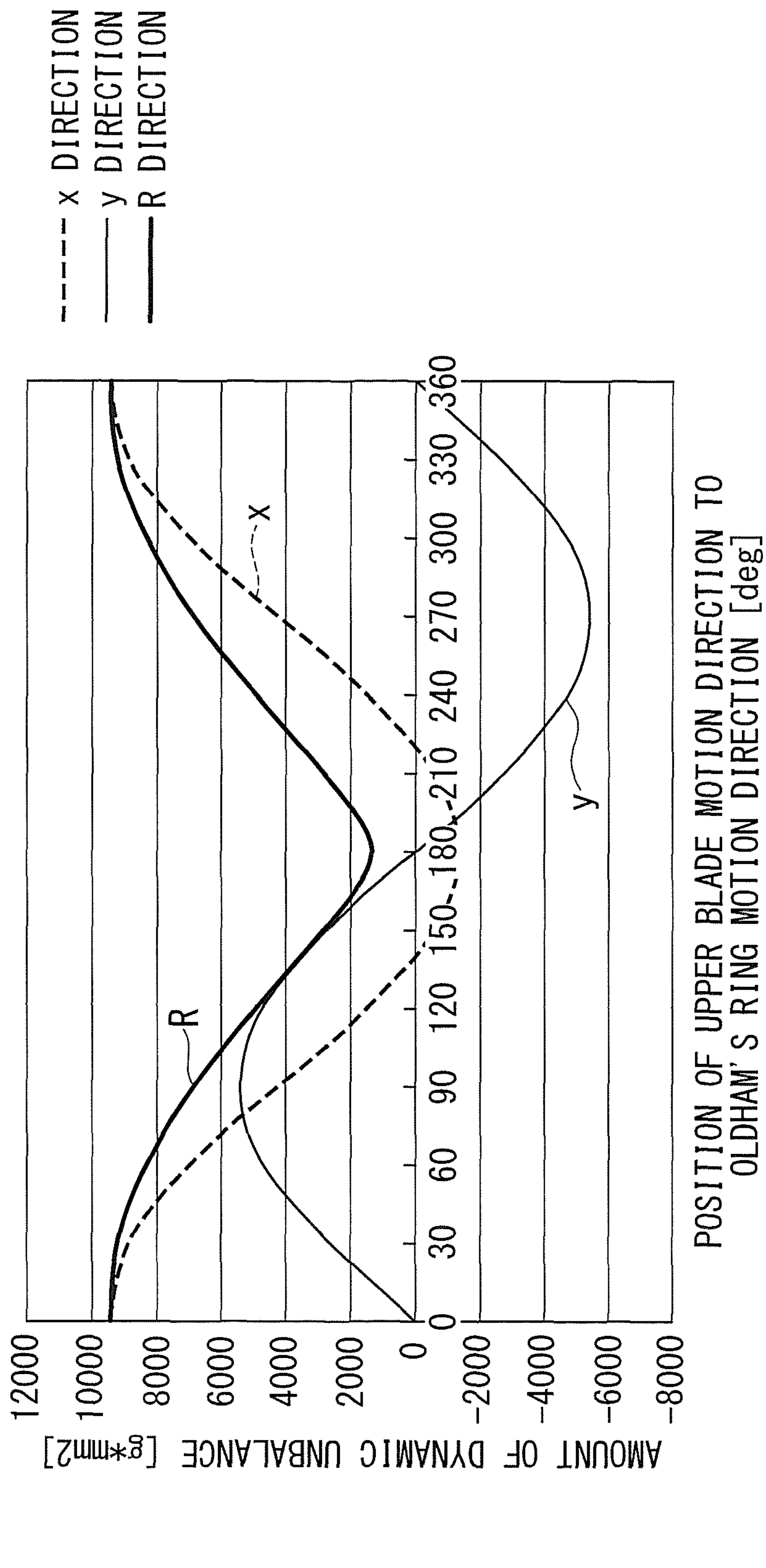

x DIRECTION
y DIRECTION
R DIRECTION
AMOUNT OF DYNAMIC UNBALANCE [g*mm2]
12000
10000
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
0
30
60
90
120
150
180
210
240
270
300
330
360
R
x
y
POSITION OF UPPER BLADE MOTION DIRECTION TO OLDHAM'S RING MOTION DIRECTION [deg]

FIG. 8

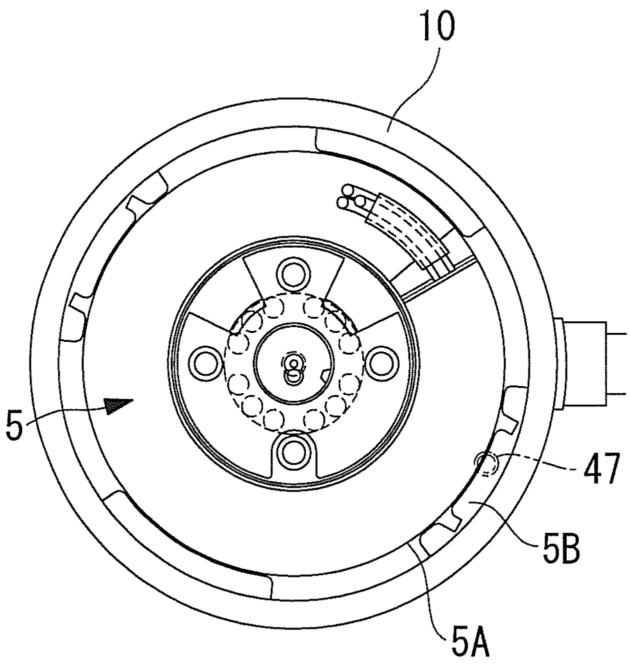


FIG. 9

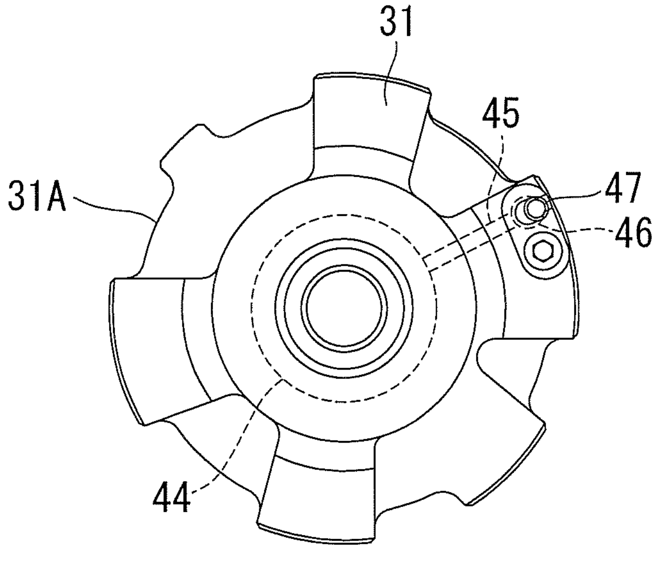


FIG. 10

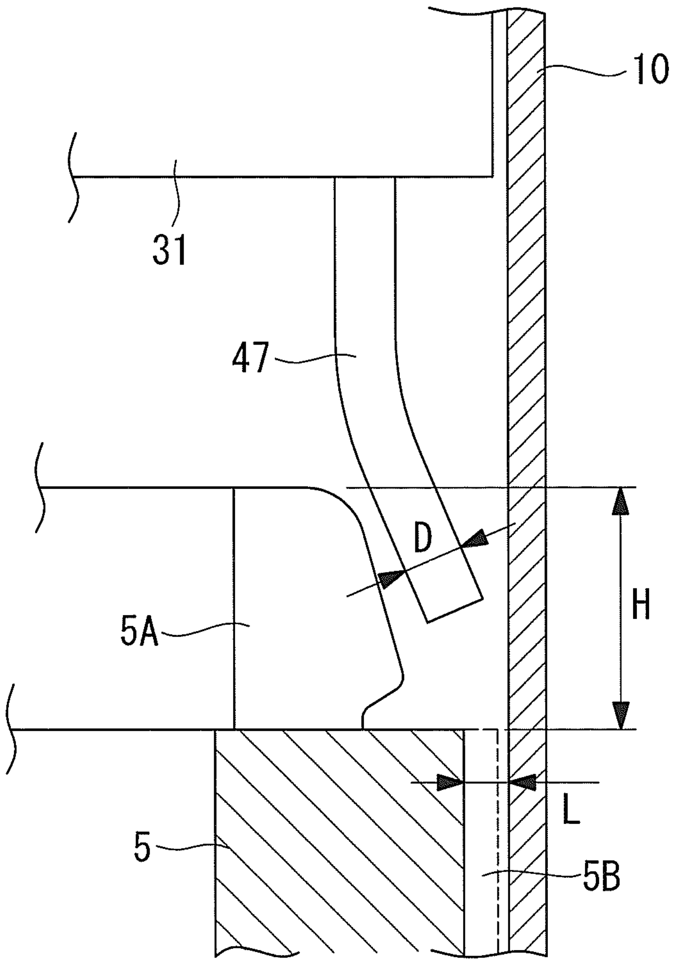


FIG. 11

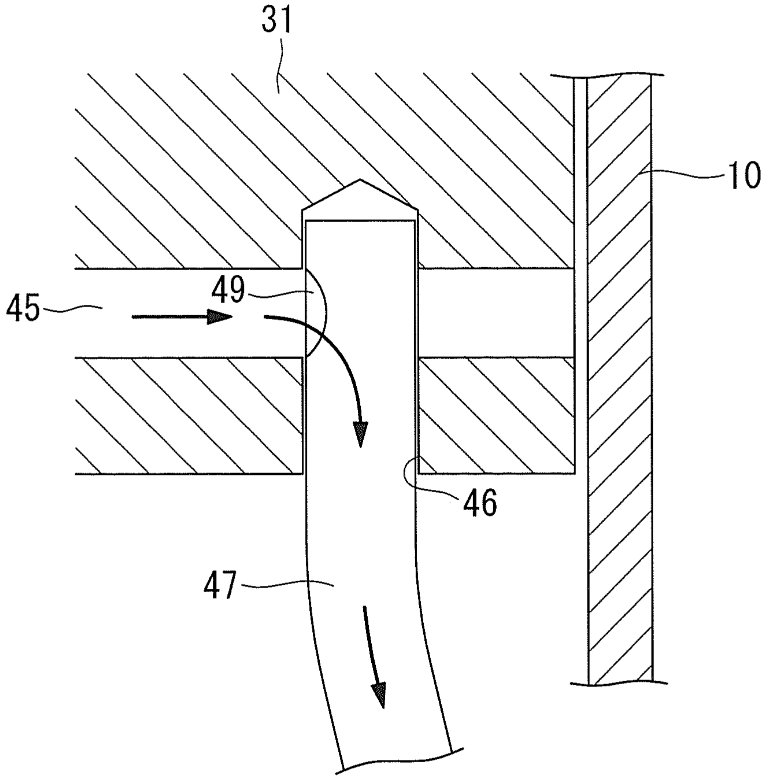


FIG. 12

(A) (B)

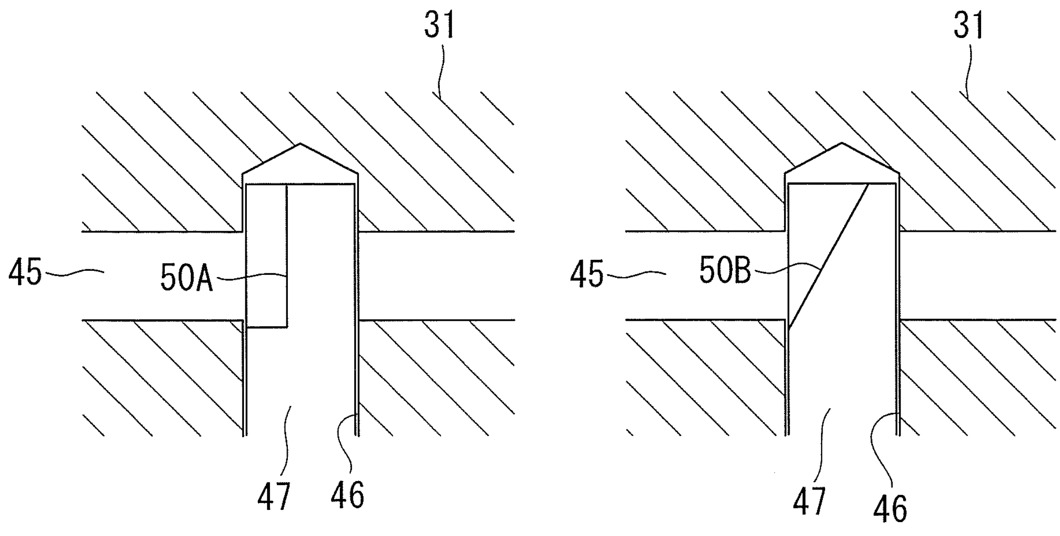


FIG. 13

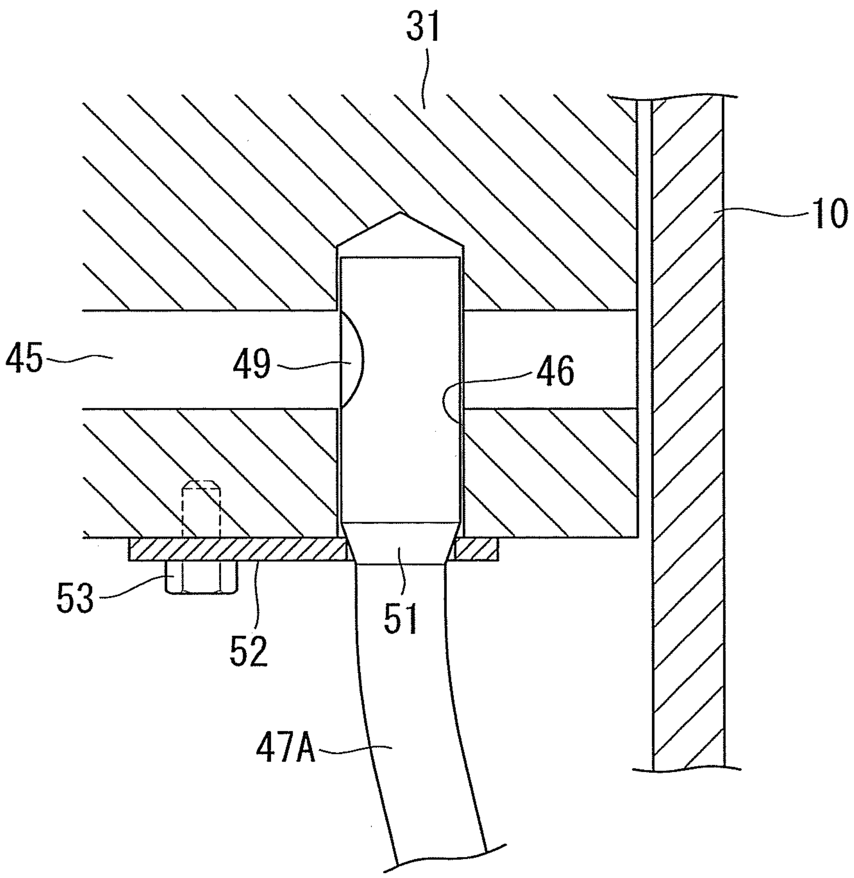


FIG. 14

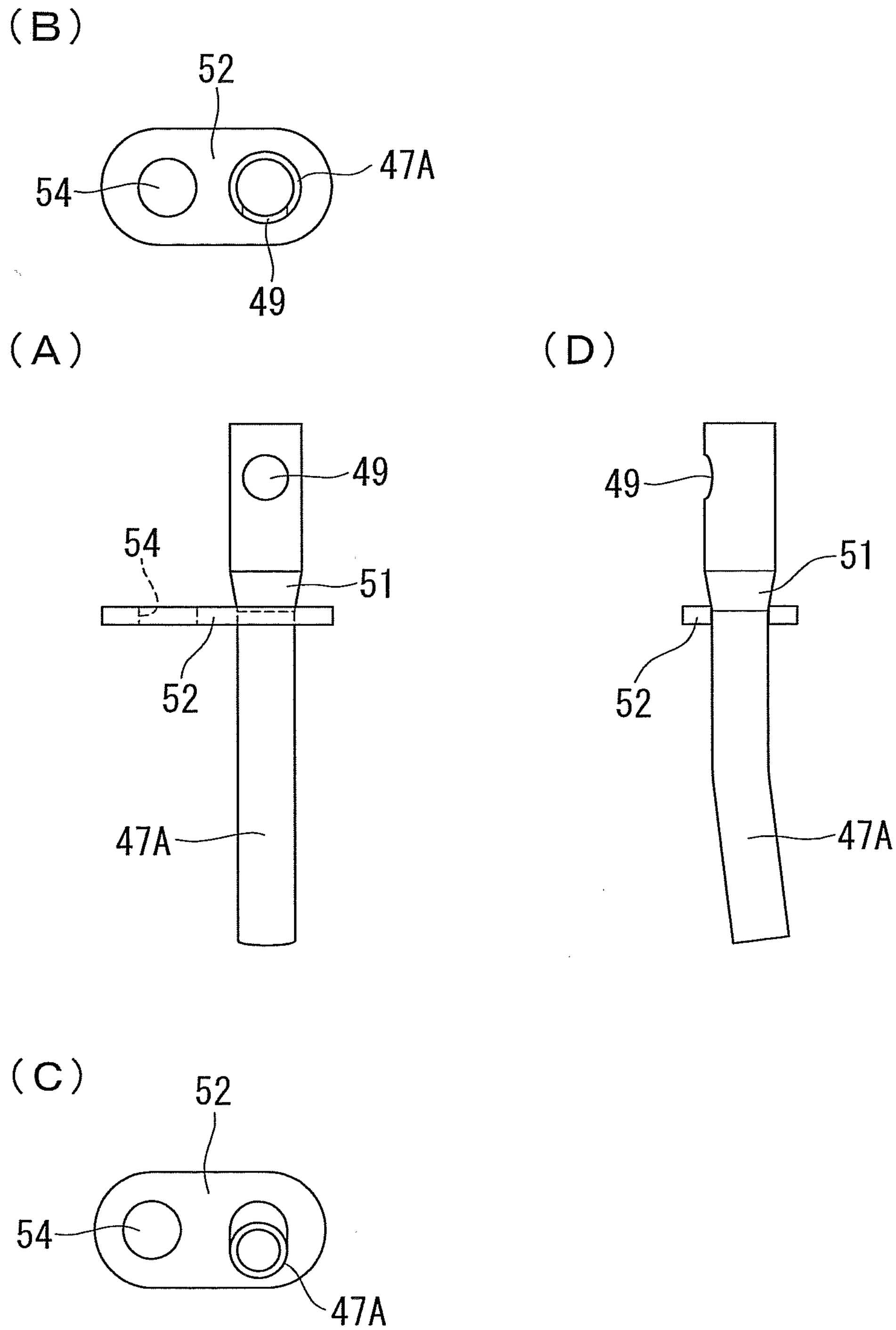
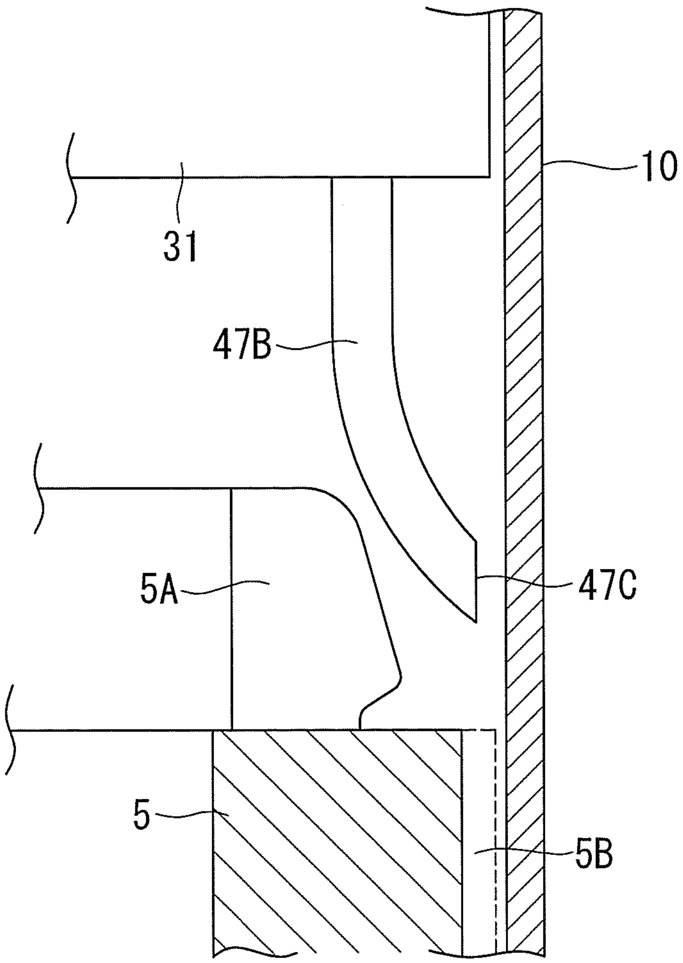


FIG. 15



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/068435

A. CLASSIFICATION OF SUBJECT MATTER
F04C29/02(2006.01)i, *F04B27/02*(2006.01)i, *F04B39/00*(2006.01)i, *F04B39/12*(2006.01)i, *F04C23/00*(2006.01)i, *F04C29/12*(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)
F04C29/02, F04B27/02, F04B39/00, F04B39/12, F04C23/00, F04C29/12

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2003-254271 A (Teijin Ltd.), 10 September 2003 (10.09.2003), entire text; all drawings (Family: none)	1-3,5 4,6-9
X A	JP 2000-356193 A (Tokico, Ltd.), 26 December 2000 (26.12.2000), entire text; all drawings (Family: none)	1-3,5-6 4,7-9
X A	JP 2009-97485 A (Mitsubishi Heavy Industries, Ltd.), 07 May 2009 (07.05.2009), entire text; all drawings & US 2009/0104060 A1 & EP 2050965 A2	1-2,5-7 3-4,8-9

☐ 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
03 October, 2012 (03.10.12)

Date of mailing of the international search report
16 October, 2012 (16.10.12)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/068435

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

(Invention 1) The inventions according to Claims 1-9 pertain to the arrangement of a reciprocating member of a fluid machine.

(Invention 2) The inventions according to Claims 10-12 and Claims 14-17 which cite Claims 11-12 pertain to the arrangement of an oil discharge pipe for a sealed compressor.

(Invention 3) The inventions according to Claim 13 and Claims 14-17 which cite Claim 13 pertain to the shape and the attachment configuration for an oil discharge pipe for a sealed compressor.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
Claims 1-9

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2008175340 A **[0008]**
- JP 2008063973 A **[0008]**
- JP 2000291552 A **[0008]**
- JP 2005273463 A **[0008]**
- JP HEI7158569 B **[0008]**