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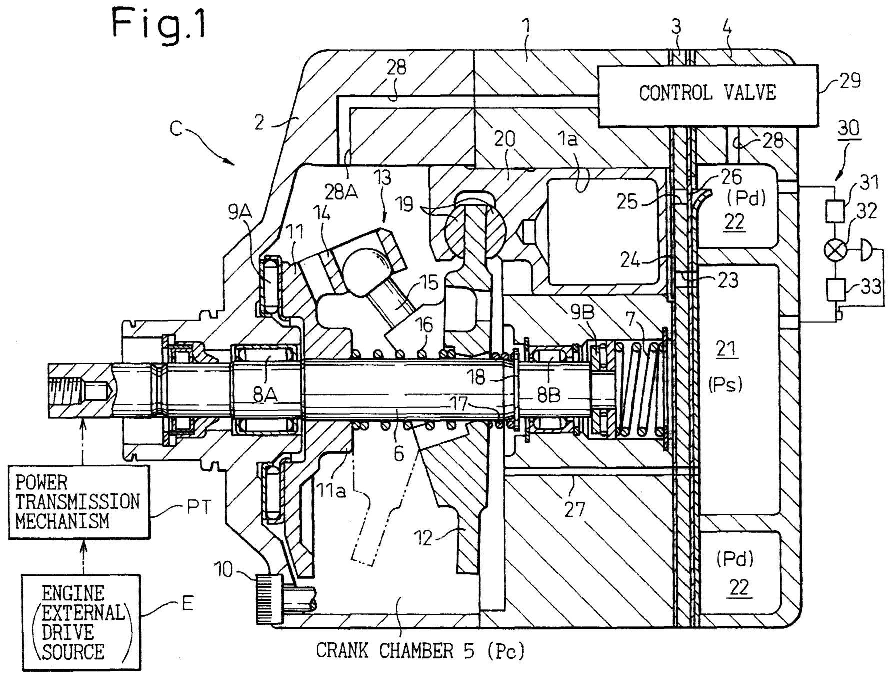
(54) **Swash plate compressor**

(57) In the piston type variable displacement compressor of the present invention, in the crank chamber 5 in which the crank mechanism is arranged, the outlet 28A of the gas supply passage 28, for supplying refrigerant from the discharge chamber 22, is open at an upper position of the crank mechanism in the peripheral wall section of the housing. The control valve 29 is arranged in the middle of the gas supply passage 28, so that a flow rate of the refrigerant supplied into the crank chamber 5 via the gas supply passage 28 can be adjusted. Mist-like lubricant is mixed with the refrigerant. Therefore, even when the flow rate of the refrigerant is low, the crank chamber 5 can be excellently lubricated.

Fig.1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a piston type variable displacement compressor. For example, the present invention relates to a piston type variable displacement compressor having a characteristic lubrication structure in its crank chamber.

2. Description of the Related Art

[0002] In general, a piston type variable displacement compressor includes: a drive shaft rotated by an external drive source; and a piston for sucking, compressing and discharging refrigerant according to a rotational motion of the drive shaft. A rotational motion of the drive shaft is transformed into a reciprocating motion of the piston by a crank mechanism provided in a crank chamber. This crank mechanism functions as a variable displacement mechanism for changing a stroke of the piston according to the inner pressure in the crank chamber. This crank mechanism is composed of a plurality of parts, and a large number of sliding sections, in which the parts slide on each other, are arranged in the crank mechanism. In order to operate the crank mechanism smoothly, it is necessary to ensure a smooth sliding motion in each sliding section. In order to ensure the smooth sliding motion, there is commonly used a structure in which lubricant is made into mist and this mist of lubricant is mixed in the refrigerant gas flowing in the compressor, so that the compressor can be lubricated by this mist of lubricant. An example of this structure is disclosed in Japanese Unexamined Patent Publication No. 10-299647, which will be described as follows. In a cylinder block arranged between a crank chamber and a region, the pressure of which is higher than that in the crank chamber, such as, for example, in a cylinder block arranged between a crank chamber and a discharge chamber, the pressure of which is higher than that in the crank chamber, there is provided a communicating passage for communicating the crank chamber with the high pressure region. Further, there is provided a lubricant sucking passage for connecting this communicating passage with an oil reservoir section in the crank chamber. The lubricant is sucked up by the pressure of the refrigerant gas, which passes through this communicating passage from the high pressure region to the crank chamber, from the oil reservoir section via the lubricant sucking passage. The thus sucked lubricant is atomized in the crank chamber. In this structure, there is provided a hinge mechanism for changing an inclination angle of a swash plate. This hinge mechanism is arranged on the opposite side to the cylinder block with respect to the swash plate. In this structure, the lubricant is atomized on the cylinder block side of the swash plate.

[0003] However, the above structure disclosed in the above unexamined patent publication has the following disadvantages. Since the communicating passage is formed in the cylinder block, it must be formed between the cylinder bores which are composed in the cylinder block. In this structure, the hinge mechanism is arranged on the opposite side to the cylinder block with respect to the swash plate. Therefore, it is difficult for the lubricant, which has been atomized in the communicating passage, to reach the hinge mechanism. Further, in this structure, an outlet for the refrigerant gas in the communicating passage is arranged at a position lower than the drive shaft. Therefore, it is very difficult to spread the lubricant all over the crank chamber. Especially when a flow rate of the refrigerant gas passing in the communicating passage is low, the above disadvantages become remarkable.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to provide a piston type variable displacement compressor having a simple structure by which a piston chamber can be excellently lubricated in any operating condition.

[0005] In order to solve the above problems, the present invention provides a piston type variable displacement compressor comprising: a crank chamber defined in a housing; and a crank mechanism, arranged in the crank chamber, for transforming a rotational motion of a drive shaft into a reciprocating motion of a piston which sucks, compresses and discharges refrigerant and also for changing a stroke of the piston according to an inner pressure in the crank chamber, wherein an outlet of a gas supply passage for supplying the refrigerant from a high pressure region into the crank chamber is open at an upper position of the crank mechanism in the crank chamber.

[0006] Due to the above structure, the degree of freedom in designing the arrangement of the outlet can be increased as compared with an arrangement in which the outlet is open to the cylinder block. Therefore, the above structure is very effective in the case where parts, which require complete lubrication, such as parts receiving high intensity compressive reaction forces from the piston, are arranged separate from the cylinder block. When the above outlet is open at an upper position of the crank mechanism, the mist-like lubricant mixed in the refrigerant easily spreads all over the crank chamber, so that the crank chamber can be excellently lubricated, especially, the crank mechanism can be effectively lubricated. For example, even when a flow rate of the refrigerant supplied into the crank chamber via the gas supply passage is low, a relatively large quantity of the lubricant can be supplied to the crank mechanism because the lubricant is supplied from an upper portion of the crank mechanism. Since the above effects can be provided by a simple structure in which the outlet is arranged in the housing on the crank chamber side, it is possible to expect a reduction in the manufacturing cost.

[0007] In this connection, in the present invention, the upper portion of the crank mechanism is defined as a region on the upper side of the horizontal face passing through the drive shaft except for the crank mechanism.

[0008] The present invention will be more fully understood with reference to the accompanying drawings and the preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWING

[0009] In the drawing:

Fig. 1 is a cross-sectional view showing an outline of a piston type variable displacement compressor of an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] Referring to Fig. 1, an embodiment of the present invention will be explained below. In this embodiment, the upper side of Fig. 1 is defined as upper, and the left of Fig. 1 is defined as front.

[0011] As shown in Fig. 1, a compressor C includes: a cylinder block 1; a front housing 2 joined to the front end of the cylinder block 1; and a rear housing 4 joined to the rear end of the cylinder block 1 via a valve forming body 3. These cylinder block 1, front housing 2, valve forming body 3 and rear housing 4 are joined and fixed to each other by a plurality of through-bolts 10 (Only one through-bolt 10 is shown in Fig. 1.), so that the housing of compressor C is completed. In a region surrounded by the cylinder block 1 and the front housing 2, there is defined a crank chamber 5. In the crank chamber 5, the drive shaft 6 is rotatably supported by a pair of radial bearings 8A, 8B which are respectively arranged in the front and the rear portion of the drive shaft 6. In an accommodation recess formed at the center of the cylinder block 1, there are provided a spring 7 and a rear thrust bearing 9B. On the other hand, the lug plate 11 is fixed to the drive shaft 6 in the crank chamber 5 in such a manner that the lug plate 11 can be rotated integrally with the drive shaft 6. The front side thrust bearing 9A is arranged between the lug plate 11 and the inner wall face of the front housing 2. The drive shaft 6 and the lug plate 11, which are integrated with each other, are positioned in the direction of thrust (the axial direction of the drive shaft) by the rear thrust bearing 9B, which is pushed to the front side by a spring 7, and the front thrust bearing 9A.

[0012] The front end portion of the drive shaft 6 is connected with a vehicle engine E, which is an external drive source, via a power transmission PT. The power transmission PT may be a clutch mechanism (for example, an electromagnetic clutch) by which power can be transmitted and/or shut off by electrically controlling the clutch mechanism from outside. Alternatively, the power transmission PT may be a clutchless mechanism (for example, a combination of a belt with a pulley) having no clutch mechanism, by which power can be transmitted at all times. In this connection, in this embodiment, the clutchless type power transmission mechanism is adopted.

[0013] As shown in Fig. 1, in the crank chamber 5, there is provided a swash plate 12 which is a cam plate. A through-hole is formed at the center of the swash plate 12. The drive shaft 6 is arranged penetrating this through-hole formed at the center of the swash plate 12. The swash plate 12 is connected with the lug plate 11 and the drive shaft 6 via the hinge mechanism 13. The hinge mechanism 13 includes: two support arms 14 (Only one support arm is shown in the drawing.) protruding from the rear face of the lug plate 11; and two guide pins 15 (Only one guide pin is shown in the drawing.) protruding from the front face of the swash plate 12. Since the support arms 14 are connected with the guide pins 15 and the drive shaft 6 comes into contact with the central insertion hole of the swash plate 12, the swash plate 12 can be simultaneously rotated with the lug plate 11 and the drive shaft 6, and further the swash plate 12 can be tilted with respect to the drive shaft 6 while the swash plate 12 is being slid in the axial direction of the drive shaft 6.

[0014] Between the lug plate 11 and the swash plate 12, there is provided an inclination angle reducing spring 16 which is arranged round the drive shaft 6. This inclination angle reducing spring 16 pushes the swash plate 12 in a direction so that the swash plate 12 can approach the cylinder block 1, that is, the inclination angle can be reduced. Between a restriction ring 18, which is fixed to the drive shaft 6, and the swash plate 12, there is provided a return spring 17 which is arranged around the drive shaft 6. When the swash plate 12 is tilted by a large angle as shown by a two-dotted chain line, this return spring 17 is only wound round the drive shaft 6 and has no influence on the swash plate and other members. However, when the swash plate 12 is tilted by a small angle as shown by a solid line, this return spring 17 is compressed between the restriction ring 18 and the swash plate 12, and the swash plate 12 is pushed in a direction so that the swash plate 12 can be separated from the cylinder block 1, that is, the inclination angle can be increased. In this connection, in this embodiment, the inclination angle of the swash plate 12 is defined as an angle formed between a virtual plane, which is perpendicular to the drive shaft 6, and the swash plate 12.

[0015] In the cylinder block 1, there are provided a plurality of cylinder bores 1a (Only one cylinder bore is shown in the drawing.) which are arranged round the drive shaft 6. An end on the rear side of each cylinder bore 1a is closed by the valve forming body 3. In each cylinder bore 1a, there is provided a single-headed type piston 20 capable of reciprocating. In each cylinder bore 1a, there is provided a compression chamber, the volume of which is changed according to the reciprocating motion of the piston 20. The front end portion of each piston 20 is engaged with the outer peripheral portion of the swash plate 12 via a pair of shoes 19. Each piston 20 is connected with the swash plate 12 via these shoes 19. Due to the above structure, when the swash plate 12 is simultaneously rotated with the drive shaft 6, the rotational motion of the swash plate 12 is converted into the reciprocating linear motion of the piston 20, the stroke of which corresponds to the inclination angle of the swash plate 12.

[0016] In this connection, a crank mechanism is composed in which the front side thrust bearing 9A, lug plate 11, swash plate 12, support arm 14, guide pin 15 and shoes 19 convert the rotational motion of the drive shaft 6 into the reciprocating motion of the piston 20 and at the same time the stroke of the piston 20 is changed.

[0017] Between the valve forming body 3 and the rear housing 4, there are provided a suction chamber 21 which is a low pressure region located at the central region, and a discharge chamber 22 which is a high pressure region surrounding the suction chamber 21. The valve forming body 3 is composed of a suction valve forming plate, port forming plate, discharge valve forming plate and retainer forming plate which are put on each other. In this valve forming body 3, corresponding to each cylinder bore 1a, there are provided a suction port 23, suction valve 24 for opening and closing the suction port 23, discharge port 25 and discharge valve 26 for opening and closing the discharge port 25. The suction chamber 21 and each cylinder bore 1a are communicated with each other via the suction port 23. Each cylinder bore 1a and the discharge chamber 22 are communicated with each other via the discharge port 25.

[0018] The suction chamber 21 and the crank chamber 5 are connected with each other by the gas extraction passage 27 formed so that the cylinder block 1 and the valve forming body 3 can be penetrated by the gas extraction passage 27. The discharge chamber 22 and crank chamber 5 are connected with each other by the gas supply passage 28. In the middle of the gas supply passage 28, there is provided a control valve 29. The gas supply passage 28 is formed in the peripheral wall section of the housing. The outlet 28A, which is an opening on the crank chamber 5 side, is open to an upper portion of the crank mechanism in the above peripheral wall section.

[0019] The control valve 29 adjusts the degree of opening of the gas supply passage 28 according to a signal sent from a control computer not shown in the drawing. When the degree of opening of the gas supply passage 28 is adjusted, a quantity of high pressure gas introduced into the crank chamber 5 via the gas supply passage 28 and a quantity of gas introduced out from the crank chamber 5 via the gas extraction passage 27 are controlled so that both the quantities can be appropriately balanced. In this way, crank pressure Pc (inner pressure in the crank chamber) can be determined. According to a change in crank chamber pressure Pc, a difference between crank pressure Pc via the piston 20 and the inner pressure in the cylinder bore 1a is changed, so that an inclination angle of the swash plate 12 is changed. As a result, the stroke of the piston 20 can be changed, that is, the discharge capacity can be changed.

[0020] The suction chamber 21 and the discharge chamber 22 are connected with each other by the external refrigerant circuit 30. The external refrigerant circuit 30 includes a condenser 31, expansion valve 32 and evaporator 33.

The external refrigerant circuit 30 and the compressor C compose a refrigerating circuit of the vehicle air-conditioner.

[0021] In this connection, the mist-like lubricant is mixed in the refrigerant gas flowing in the compressor C. Sliding portions of the movable parts provided in the compressor C can be lubricated by this mist-like lubricant.

[0022] Next, an action of the compressor composed as described above will be explained below.

[0023] When power is supplied from the vehicle engine E to the drive shaft 6 via the power transmission mechanism PT, the swash plate 12 is rotated together with the drive shaft 6. According to the rotation of the swash plate 12, each piston 20 is reciprocated by a stroke corresponding to the inclination angle of the swash plate 12, so that the refrigerant can be repeatedly sucked, compressed and discharged in each cylinder bore 1a in this order. The refrigerant gas supplied from the external refrigerant circuit 30 into the suction chamber 21 is sucked into the cylinder bore 1a via the suction port 23 and compressed by the piston 20 when the piston 20 is moved. After that, the refrigerant gas is discharged into the discharge chamber 22 via the discharge port 25, so that it is sent out into the external refrigerant circuit 30.

[0024] In the case where the cooling load is heavy, the control valve 29 is adjusted so that the degree of opening of the gas supply passage 28 can be decreased. Due to the foregoing, a quantity of high pressure refrigerant gas supplied from the discharge chamber 22 into the crank chamber 5 via the gas supply passage 28 is decreased. Therefore, the pressure in the crank chamber 5 is reduced, and the inclination angle of the swash plate 12 is increased. Accordingly, the discharge capacity of compressor C can be increased. When the gas supply passage 28 is completely closed, the pressure in the crank chamber 5 is greatly reduced, and the inclination angle of the swash plate 12 is increased to the maximum. Accordingly, the discharge capacity of the compressor C becomes maximum.

[0025] On the contrary, in the case where the cooling load is light, the control valve 29 is adjusted so that the degree of opening of the gas supply passage 28 can be increased. Due to the foregoing, the pressure in the crank chamber 5 is raised, and the inclination angle of the swash plate 12 is decreased. Accordingly, the discharge capacity of the compressor C is reduced. When the gas supply passage 28 is completely opened, the pressure in the crank chamber 5 is greatly raised, and the inclination angle of the swash plate 12 is decreased to the minimum. Accordingly, the discharge capacity of the compressor C becomes minimum.

[0026] The refrigerant gas sent from the gas supply passage 28 is supplied to the crank chamber 5 from an upper portion of the crank mechanism via the outlet 28A. At this time, mist-like lubricant mixed in the refrigerant gas is also supplied from the outlet 28A into the crank chamber 5. Therefore, the crank mechanism is mainly lubricated, and also sliding portions of the movable parts in the crank chamber 5 and sliding portions of the movable parts on the cylinder block 1 side are lubricated.

[0027] According to this embodiment, the following effects can be provided.

[0028] (1) The gas supply passage 28 including the outlet 28A is arranged in the peripheral wall section of the compressor housing. Due to the foregoing, the degree of freedom of the arrangement of the outlet 28A can be enhanced. For example, compared with a case in which the gas supply passage 28 is formed so that it can penetrate the cylinder block 1 and the valve forming body 3 and in which the outlet 28A is arranged so that it can be opened to the cylinder block 1, it becomes easy to arrange that the outlet 28A can be opened to the opposite side to the cylinder block 1 with respect to the swash plate 12. A reaction force given to the piston 20 in the case of compression mainly acts in a direction so that the crank mechanism and the drive shaft 6 can be pushed to the front side of the compressor C. Therefore, the front side thrust bearing 9A and the hinge mechanism 13 mainly receive the reaction force. For the above reasons, in order to smoothly operate those parts and the mechanism and in order to extend the life of those parts and the mechanism, it becomes necessary to sufficiently lubricate the sliding portions. Since the outlet 28A is arranged in the peripheral wall section of the compressor housing, it becomes possible to arrange the outlet 28A at a position where the front side thrust bearing 9A and the hinge mechanism 13, which are arranged on the opposite side to the cylinder block 1 with respect to the swash plate 12, can be effectively lubricated. As a result, the compressor C can be smoothly operated and the life of the compressor C can be extended. Since the above effect can be provided by the simple structure in which the outlet 28A is arranged in the peripheral wall section of the compressor housing, it is possible to expect that the manufacturing cost can be reduced.

[0029] (2) The outlet 28A is open to an upper portion of the crank mechanism in the peripheral wall section of the housing of the compressor C. Due to the above structure, the mist-like lubricant can be easily spread all over the crank chamber 5. Accordingly, the crank chamber 5 can be excellently lubricated. Especially, the crank mechanism can be effectively lubricated. For example, even when a quantity of the refrigerant supplied to the crank chamber 5 via the gas supply passage 28 is small, a quantity of the lubricant supplied to the crank mechanism can be relatively increased because the lubricant is supplied from the upper portion of the crank mechanism.

[0030] In this connection, a state in which a quantity of the refrigerant supplied to the crank case 5 via the gas supply passage 28 is small is caused not only by a case in which the degree of opening of the gas supply passage 28 is adjusted to be small by the control valve 29 but also by a case in which a small inclination angle of the swash plate 12 (a small discharge capacity) is kept over a long period of time. The reason is described as follows. When operation is continued over a long period of time under the condition that the discharge capacity is small, the inner pressure in the discharge chamber 22 is gradually lowered, so that a difference between the inner pressure in the discharge chamber 22 and crank chamber pressure Pc becomes small. Compared with a case in which the degree of opening of the gas supply passage 28 is adjusted to be small by the control valve 29, this state in which the discharge capacity is small is kept over a long period of time such as a period in which no operation is conducted in winter. Therefore, in a state in which the discharge capacity is small, a great advantage can be provided by the enhancement of the lubrication efficiency.

[0031] (3) The control valve 29 is provided in the gas supply passage 28. Due to the foregoing, the gas supply passage 28 can be also used as a pressure adjusting hole for adjusting the inner pressure in the crank chamber 5 by the control valve 29. Accordingly, it becomes unnecessary to form the pressure adjusting hole differently from the gas supply passage 28. Accordingly, the structure can be made simple.

[0032] It should be noted that the present invention is not limited to the above specific embodiment. For example, the following embodiment may be adopted.

[0033] The compressor C may be of a type in which a wobble plate and a drive shaft 6 are not integrally rotated, for example, the compressor C may be of the wobble type.

[0034] Instead of arranging the control valve 29 in the gas supply passage 28, the control valve may be arranged in the gas extraction passage 27. According to this arrangement, when the control valve adjusts the degree of opening of the gas extraction passage 27, a quantity of the refrigerant introduced out from the crank chamber 5 via the gas extraction passage 27 and a quantity of refrigerant introduced in via the gas supply passage 28 are controlled so that they can be balanced. In this way, the crank chamber pressure Pc can be changed.

[0035] The type of control may not be an external control type in which the degree of opening of the control valve 29 is adjusted by the control conducted from the outside, but the type of control may be an internal control type in which the degree of opening of the control valve

29 is adjusted by the independent control of the control valve itself. However, in the clutchless type compressor described in the above embodiment, it is preferable to use the control valve 29 of the external control type.

[0036] The piston type variable displacement compressor of the present invention may be any of the compressor in which the swash plate and the drive shaft are integrally rotated and the compressor in which the swash plate and the drive shaft are not integrally rotated. In this case, in any of the piston type variable displacement compressors, the crank chamber can be excellently lubricated by a simple structure in any operating condition.

[0037] Further, the aforementioned outlet 28A may be formed toward the thrust bearing for supporting the crank mechanism in the axial direction of the drive shaft and/or the hinge mechanism for changing a stroke of the piston. In this case, the thrust bearing and the hinge mechanism can be effectively lubricated.

[0038] Further, in the piston type variable displacement compressor of the present invention, a gas extraction passage for introducing the refrigerant from the crank chamber into the low pressure region may be provided, and a control valve for changing a quantity of the refrigerant introduced from the crank chamber into the low pressure region may be provided in this gas extraction passage. In this case, the gas extraction passage can be also used as a pressure adjusting hole for adjusting the inner pressure in the crank chamber by the control valve.

[0039] As described above in detail, in the piston type variable displacement compressor according to the present invention, it is possible to lubricate the crank chamber by a simple structure in any operating condition.

[0040] While the invention has been described by reference to specific embodiments chosen for purposes of illustration, it should be apparent that numerous modifications could be made thereto by those skilled in the art without departing from the basic concept and scope of the invention.

Claims

1. A piston type variable displacement compressor comprising:

   a crank chamber defined in a housing; and
   a crank mechanism, arranged in the crank chamber, for transforming a rotational motion of a drive shaft into a reciprocating motion of a piston which sucks, compresses and discharges refrigerant and also for changing a stroke of the piston according to inner pressure in the crank chamber, wherein
   an outlet of a gas supply passage for supplying the refrigerant from a high pressure region into the crank chamber is open at an upper position of the crank mechanism in the crank chamber.

2. A piston type variable displacement compressor according to claim 1, wherein a control valve for controlling a quantity of the refrigerant supplied from the gas supply passage into the crank chamber is arranged in the gas supply passage.

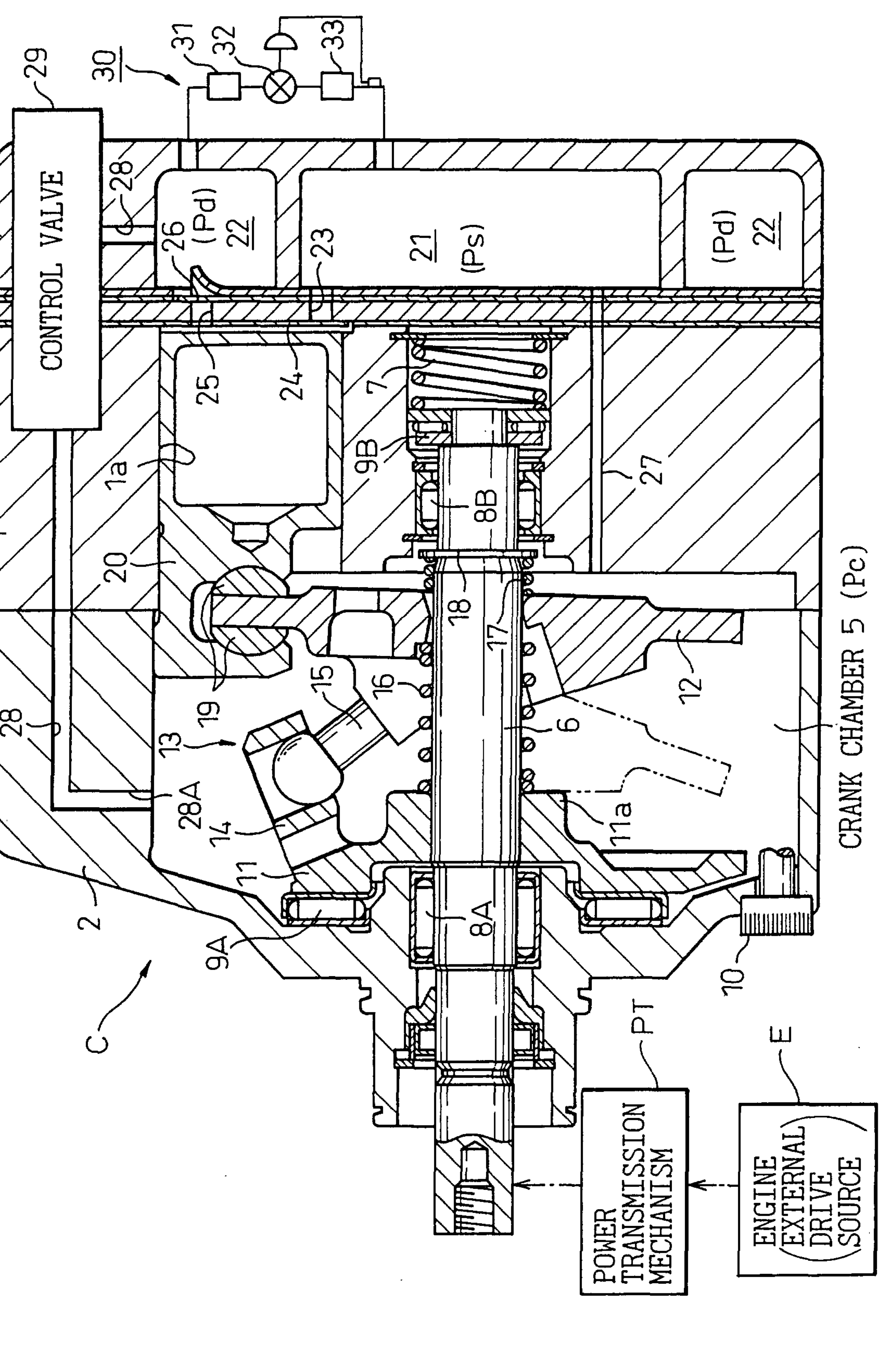
3. A piston type variable displacement compressor according to claim 1, wherein the piston type variable displacement compressor is of the type in which a swash plate and the drive shaft are integrated and rotated with each other.

4. A piston type variable displacement compressor according to claim 1, wherein the piston type variable displacement compressor is of the type in which a swash plate and the drive shaft are rotated, but not integrated, with each other.

5. A piston type variable displacement compressor according to claim 1, wherein the outlet is formed toward a thrust bearing for supporting the crank mechanism in the direction of the drive shaft and/or a hinge mechanism for changing the stroke of the piston.

6. A piston type variable displacement compressor according to claim 1, wherein a gas extraction passage for introducing the refrigerant from the crank chamber into a low pressure region is provided, and a control valve for controlling a quantity of the refrigerant introduced from the crank chamber into the low pressure region is arranged in the gas extraction passage.

Fig.1


CONTROL VALVE
CRANK CHAMBER 5 (Pc)
POWER TRANSMISSION MECHANISM
ENGINE (EXTERNAL DRIVE SOURCE)
PT
E
C
(Pd)
22
21
(Ps)
(Pd)
22
1
2
3
4
6
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8B
9A
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