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(54) VARIABLE DISPLACEMENT TYPE RECIPROCATING COMPRESSOR

HUBKOLBENVERDICHTER MIT VARIABLER VERDRÄNGUNG

COMPRESSEUR ALTERNATIF DE TYPE À DÉPLACEMENT VARIABLE

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Description

Technical Field

[0001] The present invention relates to a variable displacement reciprocating compressor, and more specifically, to a variable displacement reciprocating compressor with a suction throttle mechanism.

Background Art

[0002] A variable displacement reciprocating compressor is installed, for example, in a refrigeration cycle system of a vehicle air-conditioning system. The refrigeration cycle system includes a circulation path through which a refrigerant circulates. In the circulation path, a compressor, a radiator, an expander, and an evaporator are interposed in the order named. The compressor performs a series of processes including the steps of sucking, compressing and discharging the refrigerant. To that end, the compressor is supplied with power from the engine, for example, through a pulley.

[0003] A suction chamber, a discharge chamber and a cylinder bore are partitioned off within a housing of the variable displacement reciprocating compressor. The suction chamber and the cylinder bore communicate with each other via a suction valve, and the discharge chamber and the cylinder bore via a discharge valve.

[0004] In the variable displacement reciprocating compressor, the rotation of a drive shaft is converted into the reciprocating movement of a piston. At this point, the stroke length of the piston is varied, for example, by making use of the pressure in a crank chamber. The discharge capacity of the pump is thus adjusted. In this case, for example, the pressure in the crank chamber is changed by opening/closing a capacity control valve that is controlled from outside, whereby the discharge capacity is adjusted.

[0005] When the stroke length is varied, the tilt angle of a swash plate serving as a cam member relative to the drive shaft is altered. In the case of a wobble plate compressor, the rotation of the swash plate is converted into the reciprocating movement of the piston through a wobble plate. A swash plate compressor uses a shoe sliding against a swash plate to convert the rotation of the swash plate into the reciprocating movement of the piston.

[0006] External control methods include a suction pressure control method that maintains a target value of low pressure of the refrigeration cycle system, namely, pressure in the suction chamber of the compressor (suction pressure), and a differential pressure control method that maintains a target value of differential pressure between the high pressure of the refrigeration cycle system, namely, pressure in the discharge chamber of the compressor (discharge pressure) and the suction pressure.

[0007] Some variable displacement swash plate compressors have an opening-degree control valve to reduce pulsations when flow rate is low. For instance, the swash plate compressor disclosed in Patent Document 1 includes an opening-degree control valve situated in a cylinder head.

[0008] Patent Document 2 discloses a suction throttle valve. This suction throttle valve also has a valve body for adjusting the opening degree of a suction path, and is considered as capable of reducing vibrations and noises caused by suction pulsations. In this suction throttle valve, moreover, the valve chamber constantly communicates with the suction and crank chambers, and it is therefore considered that the performance of the swash plate compressor is ensured over the whole flow area.

[0009] Patent Document 3 discloses a variable displacement compressor according to the preamble of claim 1.

[0010] The variable capacity compressor of Patent Document 4 includes a throttle body protruding on a shut-off surface of a shut-off body. The shut-off body abuts on a positioning surface when a swash plate inclining angle is a minimum inclination angle a communication of an intake passage and an intake chamber is shut off.

Prior Art Document

Patent Document

[0011]

Patent Document 1: Unexamined Japanese Patent Publication No. 2000-136776
Patent Document 2: Unexamined Japanese Patent Publication No. 2008-115762
Patent Document 3: Patent Abstracts of Japan No. 2008138637
Patent Document 4: Patent Abstracts of Japan No. 08159026

Summary of the Invention

Problem to be Solved by the Invention

[0012] If the opening-degree control valve mentioned in Patent Document 1 and the suction throttle valve in Patent Document 2 are employed, this requires a cylinder head of large size, and leads to the increase of size of the compressor itself and the increase of material cost. As these valves use a spring to adjust the opening degree, it is necessary to select a spring with a proper spring constant according to the type of a refrigerant, and other design matters of the refrigeration cycle system. For this reason, the versatility of these valves is low.

[0013] The invention has been made in light of the foregoing circumstances. It is an object of the invention to provide at a low price a variable displacement reciprocating compressor with a high versatility and of small size, which is equipped with a suction throttle mechanism whose opening degree properly changes according to

discharge capacity.

Means of Solving the Problem

[0014] In order to achieve the object, according to one aspect of the invention, a variable displacement reciprocating compressor has a housing in which a suction chamber, a discharge chamber and a crank chamber are partitioned, and a suction port and a discharge port connecting each of the suction and discharge chambers to the outside are formed; a cylinder block that is placed in the housing and provided with a plurality cylinder bores formed on a concentric circle, which lead to the suction chamber via a suction valve and to the discharge chamber via a discharge valve; a power conversion mechanism that converts the rotation of a drive shaft stretching through the crank chamber into a reciprocating movement of a piston situated in the cylinder bore by varying stroke length; and a variable suction throttle mechanism that is interposed in a suction path stretching from the suction port to the suction chamber, and is changed in air-flow resistance according to the stroke length of the piston. The suction path includes a space that is created in a radial center of the cylinder block. The power conversion mechanism includes a ring-like cam member that is connected through a hinge to an outer circumferential portion of a rotor fitted to the drive shaft, penetrated by the drive shaft, and is capable of tilting relative to the drive shaft while moving in an axial direction of the drive shaft; a conversion mechanism that is connected to the piston via a coupling mechanism and converts a tilt angle of the cam member into a reciprocating movement of the piston; a joint shaft that is fitted to the drive shaft through a bearing, and is supported by an inner circumferential face of a support hole formed in the cylinder block and leading to the space, so as not to be relatively rotatable but to be slidable relative to the inner circumferential face; a joint case that is integrally and tiltably formed in the conversion mechanism; and a plurality of balls rollably held between JS-side protrusions that are integrally formed in the joint shaft and JC-side protrusions that are integrally formed in the join case. The variable suction throttle mechanism uses the sliding movement of the joint shaft to change air-flow resistance in the space serving as a valve chamber (claim 1).

[0015] Preferably, the variable suction throttle mechanism is integrally formed in the joint shaft, and has an air-flow resistance increasing member that enters the space to reduce a channel sectional area of the suction path within the space (claim 2).

Advantageous Effects of the Invention

[0016] In the variable displacement reciprocating compressor according to claim 1 of the invention, the variable suction throttle mechanism uses the sliding movement of the joint shaft to change the air-flow resistance in the space formed in the cylinder block. Since the variable suction throttle mechanism changes the air-flow resistance in the space formed in the cylinder block, it is not necessary to make a cylinder head large in size, so that a compact compressor can be provided at a low price.

[0017] Moreover, since the variable suction throttle mechanism uses the sliding movement of the joint shaft to change the air-flow resistance, the opening degree is properly varied according to discharge capacity.

[0018] This variable suction throttle mechanism does not require a spring, which makes the compressor highly versatile.

[0019] In the variable displacement reciprocating compressor according to claim 2, the air-flow resistance increasing member is formed integrally with the joint shaft. The channel sectional area of the valve chamber is reduced by the air-flow resistance increasing member entering the valve chamber. This makes it possible to reliably and properly change the air-flow resistance according to the discharge capacity with a simple structure.

Brief Description of the Drawings

[0020]

FIG. 1 shows a variable displacement wobble plate compressor of a first embodiment together with a refrigeration cycle system of a vehicle air-conditioning system;

FIG. 2 is a schematic exploded view of a wobble plate rotation blocking unit that is applied to the compressor shown in FIG. 1;

FIG. 3 is a view for explaining an engagement state of a joint case, balls and JS-side protrusions;

FIG. 4 is an enlarged view of a region IV of FIG. 1 under the condition that the discharge capacity of the compressor, or the tilt angle of the wobble plate, is maximum;

FIG. 5 is a plan view of a valve plate that is applied to the compressor shown in FIG. 1;

FIG. 6 is a plan view of a cylinder block that is applied to the compressor shown in FIG. 1;

FIG. 7 is an enlarged view of a region VII of FIG. 1 under the condition that the discharge capacity of the compressor, or the tilt angle of the wobble plate, is minimum;

FIG. 8 is a perspective view showing a drive shaft and a valve body together with a cross-section of the cylinder block, taken along line VIII- VIII of FIG. 4;

FIG. 9 is a perspective view showing the drive shaft and the valve body together with a cross-section of the cylinder block, taken along line IX- IX of FIG. 7;

FIG. 10 shows a variable displacement reciprocating compressor according to a second embodiment together with a refrigeration cycle system of a vehicle air-conditioning system;

FIG. 11 is an enlarged view of a region XI of FIG. 10 under the condition that the discharge capacity of the compressor, or the tilt angle of the wobble plate,

is maximum;

FIG. 12 is an enlarged view of a region XII of FIG. 10 under the condition that the discharge capacity of the compressor, or the tilt angle of the wobble plate, is minimum;

FIG. 13 is a plan view of a valve plate that is applied to the compressor shown in FIG. 10;

FIG. 14 is a plan view of a cylinder block that is applied to the compressor shown in FIG. 10;

FIG. 15 is a perspective view showing the drive shaft and the valve body together with a cross-section of the cylinder block, taken along line XV- XV of FIG. 11; and

FIG. 16 is a perspective view showing the drive shaft and the valve body together with a cross-section of the cylinder block, taken along line XVI-XVI of FIG. 12.

Best Mode of Carrying out the Invention

[0021] FIG. 1 shows a variable displacement wobble plate compressor according to a first embodiment, which is applied to a refrigeration cycle system.

[0022] A refrigeration cycle system 10 includes a circulation path 12 through which a refrigerant serving as a working fluid circulates. A compressor, a radiator (condenser) 14, an expander (expansion valve) 16 and an evaporator 18 are interposed in the circulation path 12 in the order named in a refrigerant flow direction. When the compressor operates, the refrigerant circulates through the circulation path 12. That is to say, the compressor carries out a series of processes including the steps of sucking in the refrigerant, compressing a sucked-in refrigerant, and discharging a compressed refrigerant.

[0023] The compressor has a column-shaped cylinder block 20. The cylinder block 20 includes one end to which a circumferential wall 24 of a front housing 22 is airtightly joined. One end face of the cylinder block 20, the circumferential wall 24 of the front housing 22, and an end wall 25 of the front housing 22 define a crank chamber 26.

[0024] A drive shaft 30 is set in the center within the crank chamber. The drive shaft 30 penetrates a substantially cylindrical bearing support portion 31 that is integrally formed in an outer surface of the end wall 25 of the front housing 22. Although not shown, for example, a pulley is coupled to an outer end of the drive shaft 30, which is protruding from the bearing support portion 31. The pulley is rotatably supported by the bearing support portion 31 through a bearing, not shown. The power of the engine, not shown, is transmitted to the drive shaft 30 via the pulley.

[0025] A plurality of, for example, seven cylinder bores 32 are formed on a concentric circle in an outer circumferential portion of the cylinder block 20. The cylinder bores 32 extend parallel with the drive shaft 30 and penetrate the cylinder block 20. The cylinder bores 32 are arranged at regular intervals in a circumferential direction of the cylinder block 20.

[0026] A piston 34 is slidably disposed in each of the cylinder bores 32. A rotational movement of the drive shaft 30 is converted into a reciprocating movement of the piston 34 by a power conversion mechanism.

[0027] A coupling rod (coupling mechanism) 36 is connected to each of the pistons 34 through a bulb-shaped joint. The coupling rod 36 is protruding into the crank chamber 26, and has an end portion that is connected to a substantially ring-like wobble plate (conversion mechanism) 38 through the bulb-shaped joint.

[0028] For the purpose of reciprocating the piston 34, that is, oscillating the wobble plate 38, a substantially disc-like rotor 40 is coaxially fixed to the drive shaft 30 so as not to make a relative rotation. A thrust bearing 42 is disposed between the rotor 40 and the end wall 25 of the front housing 22. A swash plate 46 serving as a cam member is connected to the rotor 40 through a hinge 44.

[0029] The swash plate 46 has a substantially ring-like shape and is penetrated by the drive shaft 30. The hinge 44 enables the swash plate 46 to tilt relative to the drive shaft 30 while moving in an axial direction of the drive shaft 30.

[0030] A boss 48 is integrally formed in an inner circumferential rim of the wobble plate 38. The boss 48 is protruding from the wobble plate 38 towards the rotor 40 or the swash plate 46. The boss 48 is encircled by the swash plate 46. A ball bearing serving as a radial bearing 50 is disposed between the boss 48 and the swash plate 46.

[0031] An inner ring of the ball bearing is fixed to the boss 48, and an outer ring of the ball bearing to the swash plate 46. Disposed between the wobble plate 38 and the swash plate 46 is a ring-like slide bearing serving as a thrust bearing 52. The swash plate 46 and the wobble plate 38 are thus connected to each other so as to be relatively rotatable. The wobble plate 38 is also capable of tilting relative to the drive shaft 30 while moving in the axial direction of the drive shaft 30.

[0032] Since this compressor is of a wobble plate type, the power conversion mechanism includes a wobble plate rotation blocking unit for preventing the wobble plate 38 from rotating along with the rotation of the drive shaft 30. The wobble plate rotation blocking unit connects the wobble plate 38 and the cylinder block 20 to each other, and thus blocks the rotation of the wobble plate 38.

[0033] To be more specific, the wobble plate rotation blocking unit has a joint shaft 54 in a shape like a substantially hollow cylinder. The joint shaft 54 is fitted onto an inner end side of the drive shaft 30, leaving a minute gap. A cylindrical slide bearing 56 is disposed between an inner circumferential face of the joint shaft 54 and an outer circumferential face of the drive shaft 30. The joint shaft 54 is slidable against the drive shaft 30 due to the slide bearing 56 interposed therebetween.

[0034] The inner end of the drive shaft 30 is located inside a cylindrical shaft hole (support hole) 58 formed in the center of the cylinder block 20. The shaft hole 58

opens into the crank chamber 26. A plurality of grooves extending in the axial direction of the drive shaft 30 are formed in an inner circumferential face of the shaft hole 58.

[0035] As shown in an exploded view of FIG. 2, a plurality of keys 60 extending in the axial direction of the drive shaft 30 are formed in an outer circumferential face of a middle portion of the joint shaft 54 so as to slidably engage with the grooves. In other words, the joint shaft 54 is splined to an inner circumferential face of the shaft hole 58 so as to be slidable in the axial direction of the shaft hole 58. Due to this spline connection, the joint shaft 54 is prevented from rotating along with the rotation of the drive shaft 30.

[0036] The number of the grooves and keys may be one as long as the joint shaft 54 is prevented from rotating along with the rotation of the drive shaft 30 and is slidable along the drive shaft 30.

[0037] For example, three protrusions (hereinafter, referred to as joint shaft-side protrusions or JS-side protrusions) 62 are integrally formed in one end of the joint shaft 54, which is located on the crank chamber 26 side, protruding in an axial direction of the joint shaft 54. Each of the JS-side protrusions 62 has a substantially fan-like shape as viewed in the axial direction of the joint shaft 54.

[0038] The JS-side protrusions 62 are arranged at regular intervals in a circumferential direction thereof. Each of the JS-side protrusions 62 has a groove (JS-side ball groove) 64 in each side face expanding along a radial direction thereof. The JS-side ball groove 64 is tilted relative to the axis of the joint shaft 54 so as to move toward the drive shaft 30 as it moves away from the joint shaft 54.

[0039] The wobble plate rotation blocking unit has a joint case 66 as shown in FIG. 2. The joint case 66 is disposed coaxially with the joint shaft 54. The joint case 66 has a ring portion 68. The ring portion 68 is integrally and rotatably fixed to a radially inner side of the wobble plate 38. Three protrusions (hereinafter, referred to as joint case-side protrusions or JC-side protrusions) 70 are integrally formed in an inner circumferential face of the ring portion 68, protruding in a radially inward direction.

[0040] Each of the JC-side protrusions 70 has a substantially fan-like shape as viewed in an axial direction of the ring portion 68. The JC-side protrusions 70 are arranged at regular intervals in a circumferential direction thereof. Each of the JC-side protrusions 70 includes a groove (JC-side ball groove) 72 on each side face expanding along a radial direction thereof. The JC-side ball groove 72 is tilted relative to the axis of the ring portion 68 so as to move away from the drive shaft 30 as it draws away from the joint shaft 54.

[0041] FIG. 3 shows the joint case 66, the JS-side protrusions 62 and the balls 74, which are assembled together, as viewed in the axial direction of the joint case 66 from the joint shaft 54 toward the joint case 66. In FIG. 3, the joint shaft 54 is omitted, and broken-out surfaces of the JS-side protrusions 62 are hatched.

[0042] The joint case 66 is disposed on a concentric circle with the JS-side protrusions 62. Each of the JS-side protrusions 62 is located between the corresponding JC-side protrusions 70. A ball 74 is rollably disposed between the corresponding JS-side ball groove 64 and the corresponding JC-side ball groove 72 facing each other across a gap.

[0043] Referring to FIG. 2 again, the JC-side protrusion 72 has an end face located innermost in a radial direction of the ring portion 68. This end face is formed of a curved face 76. The curved face 76 has a shape of a circular arc with given curvature in a vertical section of the JC-side protrusion 72.

[0044] The wobble plate rotation blocking unit has a sleeve 80 fitted to the drive shaft 30 with a cylindrical slide bearing 78 intervening therebetween. The sleeve 80 is also slidable in the axial direction of the drive shaft 30 together with the slide bearing 78. The sleeve 80 has a barrel-like outer shape. An outer circumferential face of the sleeve 80 is in a shape of a circular arc with virtually the same curvature as the curved face 76 of the JC-side protrusion 72.

[0045] The curved faces of the JC-side protrusions 72 slide against the outer circumferential face of the sleeve 80, so that the joint case 66 is oscillatably supported by the sleeve 80. The rotation of the joint case 66 along with the rotation of the drive shaft 30, that is, the rotation of the wobble plate 38, is controlled by the joint shaft 54 through the balls 74.

[0046] Referring to FIG. 1 again, the cylinder block 20 supports the inner end side of the drive shaft 30 through the joint shaft 54 and the slide bearing 56 so as to be relatively rotatable. The front housing 22 supports an outer end side of the drive shaft 30 through a radial bearing 82 so as to be relatively rotatable. A shaft seal 84 is set in the bearing support portion 31 of the front housing 22.

[0047] A cylinder head 88 is joined to the other end side of the cylinder block 20 by using a plurality of connecting bolts 90 with a gasket, not shown, and a valve plate 86 intervening therebetween. An outer rim portion of the cylinder block 20, the front housing 22 and the cylinder head 88 form a housing of the compressor.

[0048] A discharge port, not shown, is formed in the cylinder head 88.The discharge port leads to the radiator 14 through the circulation path 12 and also leads to a discharge chamber 92 that is partitioned off within the cylinder head 88. A discharge hole 94 stretching through the valve plate 86 allows the discharge chamber 92 to communicate with the cylinder bore 32. The discharge hole 94 is opened/closed by using a discharge valve, not shown. The discharge chamber 92 communicates with the crank chamber 26, for example, through an external pipe 95. Interposed in the pipe 95 is a capacity control valve 96 that is capable of opening/closing the pipe 95. The capacity control valve 96 can be controlled from outside.

[0049] Instead of the pipe 95, an inner channel may be provided, which extends from the cylinder head 88 through the valve plate 86 and the cylinder block 20 to

the crank chamber 26. The capacity control valve 96 may be interposed in this inner channel.

[0050] A suction chamber 97 is partitioned off within the cylinder head 88. The suction chamber 97 is partitioned off in the radial center of the cylinder head 88. The discharge chamber 92 is partitioned off around the suction chamber 97 in the radial direction of the cylinder head 88. In short, the discharge chamber 92 and the suction chamber 97 are separated from each other by a partition wall 98 forming a part of the cylinder head 88. A suction hole 99 stretching through the valve plate 86 allows the suction chamber 97 to communicate with the cylinder bore 32. The suction hole 99 is opened/closed by using a reed valve, not shown, which serves as a suction valve.

[0051] A suction port 100 is integrally formed in the cylinder head 88. The suction port 100 leads to the evaporator 18 through the circulation path 12. The suction port 100 leads to the suction chamber 97 partitioned off within the cylinder head 88, via a suction throttle mechanism (suction throttle valve) whose opening degree is variable.

[0052] The suction throttle valve has a cylindrical valve chamber 101 formed in the radial center of the cylinder block 20. The valve chamber 101 is coaxially connected to the valve plate 86 side of the shaft hole 58.A valve casing of the suction throttle valve is thus made up of the cylinder block 20. The drive shaft 30 extends to the vicinity of an end wall of the valve chamber 101.

[0053] In the cylinder block 20, there are formed an inlet hole 102 and an outlet hole 103 which open in the end wall of the valve chamber 101. The inlet hole 102 and the outlet hole 103 stretch from the valve chamber 101 to an end face of the cylinder block 20, which is located on the valve plate 86 side. The inlet hole 102 and the outlet hole 103 lead to an inlet-side communication hole 104 and an outlet-side communication hole 106, respectively, which stretch through the valve plate 86. The outlet-side communication hole 106 opens into the suction chamber 97, and connects the valve chamber 101 and the suction chamber 97 to each other.

[0054] The inlet-side communication hole 104 leads to the suction port 100 through the inside of a substantially cylindrical lead-in wall 108 that is integrally formed in the cylinder head 88. The lead-in wall 108 has an edge that is in airtight contact with a circumferential rim of the inlet-side communication hole 104 in the valve plate 86 through a gasket, not shown.

[0055] FIG. 4 shows the valve chamber 101 and the periphery thereof under the condition that the discharge capacity of the compressor is maximum. As shown in FIG. 4, a valve body 109 is disposed in the valve chamber 101. The valve body 109 has a cylindrical shape and is formed coaxially and integrally with the joint shaft 54. The valve body 109 is capable of reciprocating in the valve chamber 101 along with a sliding movement of the joint shaft 54.

[0056] FIGS. 5 and 6 show the valve plate 86 and the valve plate 86-side end face of the cylinder block 20, respectively. As shown in FIGS. 5 and 6, the inlet-side and outlet-side communication holes 104 and 106 and the inlet and outlet holes 102 and 103 each have a cross section in a shape of a long hole extending in an arc. Openings of the inlet and outlet holes 102 and 103 in the valve chamber 101 are substantially positioned between inner and outer circumferential rims of the valve body 109 as viewed in a radial direction of the valve chamber 101.

[0057] The crank chamber 26 communicates with the suction chamber 97 through the shaft hole 58, the outlet hole 103 and the outlet-side communication hole 106. A minute gap in the spline connection between the joint shaft 54 and the shaft hole 58, and a minute gap between the valve body 109 and the shaft hole 58 function as throttles in a communication path connecting the crank chamber 26 and the suction chamber 97 to each other.

[0058] Operations of the foregoing compressor will be described below.

[0059] The drive shaft 30 rotates when power is transmitted from the engine to the drive shaft 30. Along with the rotation of the drive shaft 30, the rotor 40, the hinge 44 and the swash plate 46 also rotate, and this oscillates the wobble plate 38 that is supported by the swash plate 46 to be relatively rotatable. The oscillation of the wobble plate 38 is converted into a reciprocating movement of the piston 34 through the bulb-shaped joint and the coupling rod 36.

[0060] The wobble plate 38 is prevented from rotating along with the rotation of the drive shaft 30 by the joint case 66, the balls 74 and the joint shaft 54 while the wobble plate 38 is oscillating.

[0061] The reciprocating movement of the piston 34 prompts the implementation of the steps of sucking the refrigerant from the suction chamber 97 into the cylinder bore 32, compressing the refrigerant in the cylinder bore 32, and discharging the refrigerant from the cylinder bore 32 into the discharge chamber 92. In other words, in response to the reciprocating movement of the piston 34, the refrigerant vaporized in the evaporator 18 is sucked through the circulation path 12 and the suction port 100 into the compressor, and the refrigerant discharged from the discharge port of the compressor is supplied through the circulation path 12 to the radiator 14.

[0062] A discharge amount of the refrigerant, namely, the discharge capacity of the compressor, is controlled, for example, by a suction pressure control method or a differential pressure control method. The suction pressure control method controls the discharge capacity so as to make the pressure of the suction chamber 97 (suction pressure) approximate a target value. The differential pressure control method controls the discharge capacity so as to make a differential between the pressure of the discharge chamber 92 (discharge pressure) and the suction pressure approximate a target value. In either method, an amount of electric current supplied to a solenoid of the capacity control valve 96 or a duty ratio of the electric current is adjusted as operation amount.

[0063] When the discharge capacity of the compressor is maximum, the wobble plate 38 is most tilted relative to a plane perpendicular to the drive shaft 30 as shown in FIG. 1. In this condition, the radial center of the wobble plate 38 is in its closest position to the rotor 40.

[0064] When the discharge capacity of the compressor is minimum, the wobble plate 38 is substantially parallel to the plane perpendicular to the drive shaft 30. In this condition, the radial center of the wobble plate 38 is in its farthest position from the rotor 40. To put it differently, when the discharge capacity of the compressor is minimum, the radial center of the wobble plate 38 moves closer to the cylinder block 20 than when the discharge capacity is maximum.

[0065] In the compressor, radial center positions of the wobble plate 38 and the joint case 66 are linked with each other, and the positions of the sleeve 80 and the joint shaft 54 are also linked with each other, as viewed in the axial direction of the drive shaft 30.

[0066] FIG. 7 shows the valve chamber 101 and the periphery thereof under the condition that the discharge capacity of the compressor is minimum. As shown in FIG. 7, as the joint shaft 54 is linked with the wobble plate 38, the valve body 109 formed integrally with the joint shaft 54 enters the valve chamber 101, and an edge of the valve body 109 is positioned near the end wall of the valve chamber 101, leaving a minute gap.

[0067] FIG. 8 shows the position of the edge of the valve body 109 under the condition that the discharge capacity is maximum. FIG. 9 shows the position of the edge of the valve body 109 under the condition that the discharge capacity is minimum.

[0068] In the above-described compressor, the variable suction throttle mechanism uses the sliding movement of the joint shaft 54 to change air-flow resistance in the valve chamber 101 formed in the cylinder block 20. Since the variable suction throttle mechanism changes the air-flow resistance not in the cylinder head 88 but in the valve chamber 101 formed in the cylinder block 20, it is not necessary to make the cylinder head 88 large in size. This makes it possible to provide a compact compressor at a low price.

[0069] Moreover, since the variable suction throttle mechanism uses the sliding movement of the joint shaft 54 to change the air-flow resistance, the opening degree is properly varied according to the discharge capacity. Briefly speaking, the opening degree becomes maximum at a maximum discharge capacity, and minimum at a minimum discharge capacity. Consequently, when the discharge capacity is small, pulsations and resulting vibrations are properly prevented.

[0070] This variable suction throttle mechanism does not require a spring, which makes the compressor highly versatile.

[0071] In the above-described compressor, the valve body 109 serving as an air-flow resistance increasing member is formed integrally with the joint shaft 54. The channel sectional area of the valve chamber 101 is reduced by the air-flow resistance increasing member entering the valve chamber 101. This makes it possible to reliably and properly change the air-flow resistance according to the discharge capacity with a simple structure.

[0072] The invention is not limited to the first embodiment described above, and may be modified in various ways.

[0073] FIG. 10 shows a variable displacement compressor according to a second embodiment. The same constituents as those of the variable displacement compressor of the first embodiment will be provided with the same reference marks, and descriptions thereof will be omitted.

[0074] In the compressor according to the second embodiment, referring to FIGS. 11 to 16, a cylinder hole 20 is provided with one inlet hole 110, which opens in the center of an end wall of a valve chamber 101. The inlet hole 110 has a cross section, for example, in a circular shape. The opening of the inlet hole 110 has a diameter equal to or smaller than an external diameter of a valve body 109, and for example, is equal to a diameter of an inner circumferential rim of the valve body 109.

[0075] In the cylinder block 20, there is formed one or more, for example, two outlet holes 112. The outlet holes 112 are spaced away from each other across the inlet hole 110 in the radial direction. Each of the outlet holes 112 has a cross section in a shape of a long hole extending in an arc. Distance between the outlet holes 112 in the radial direction of the valve chamber 101 is equal to the diameter of the valve chamber 101. That is to say, the outlet holes 112 open in a side wall of the valve chamber 101.

[0076] An inlet-side communication hole 114 and an outlet-side communication hole 116 are formed in a valve plate 86 so as to coincide with the inlet and outlet holes 110 and 112, respectively, in shape and position.

[0077] An inner end of a drive shaft 30 is detached away from the end wall of the valve chamber 101 by given distance.

[0078] In the compressor of the second embodiment, too, a variable suction throttle mechanism uses the sliding movement of the joint shaft 54 to change air-flow resistance in the valve chamber 101 formed in the cylinder block 20.

[0079] Moreover, since the variable suction throttle mechanism uses the sliding movement of the joint shaft 54 to change the air-flow resistance, the opening degree is properly varied according to the discharge capacity. In short, the opening degree becomes maximum at the maximum discharge capacity, and minimum at the minimum discharge capacity. Consequently, when the discharge capacity is small, pulsations and resulting vibrations are reliably prevented.

[0080] Furthermore, the variable suction throttle mechanism does not require a spring, which makes the compressor highly versatile.

[0081] In the above-described compressor, the valve body 109 serving as an air-flow resistance increasing

member is formed integrally with the joint shaft 54. The channel sectional area of the valve chamber 101 is reduced by the air-flow resistance increasing member entering the valve chamber 101. This makes it possible to reliably and properly change the air-flow resistance according to the discharge capacity with a simple structure.

[0082] In the compressor according to the first and second embodiments, the number of cylinder bores 32 is not limited to seven.

[0083] In the compressor according to the first and second embodiments, the number of the inlet holes 102 and 110 of the valve chamber 101 is not limited to one as well as the number of the outlet holes 103 and 112. It is possible to properly construct a channel from the suction port 100 to the valve chamber 101 in the cylinder head 88 according to the number and position of the inlet holes 102 and 110 and the outlet holes 103 and 112.

[0084] In the compressor according to the first and second embodiments, the pressure of the crank chamber 26 is controlled on the inlet side (inlet control). The invention is, however, applicable to a compressor that controls the pressure of the crank chamber 26 on the outlet side (outlet control).

[0085] The variable displacement reciprocating compressor of the invention is applicable to a reciprocating compressor not only of a wobble plate type but also of a swash plate type. More specifically, although not shown in the drawings, in the case of the swash plate compressor, the invention can be applied to a swash plate reciprocating compressor by replacing the wobble plate 38 with a shoe sliding against the swash plate as a conversion mechanism that converts the tilt angle of the swash plate into the reciprocating movement of the piston 34, and replacing the coupling rod 36 with a bridge member for coupling the shoe to a socket portion of the piston 34 on which the shoe is mounted as a coupling mechanism.

[0086] Needless to say, the variable displacement reciprocating compressor of the invention is applicable to various other systems as well as the vehicle air-conditioning system, and the working fluid is not limited to a refrigerant.

Reference Marks

[0087]

20	cylinder block
26	crank chamber
30	drive shaft
32	cylinder bore
34	piston
54	joint shaft
58	shaft hole (support hole)
66	joint case
74	ball
101	valve chamber

Claims

1. A variable displacement reciprocating compressor comprising:

a housing in which a suction chamber (97), a discharge chamber (92) and a crank chamber (26) are partitioned, and a suction port and a discharge port connecting each of the suction and discharge chambers (97, 92) to the outside are formed;
a cylinder block (20) that is placed in the housing and provided with a plurality cylinder bores (32) formed on a concentric circle, which lead to the suction chamber via a suction valve and to the discharge chamber (92) via a discharge valve;
a power conversion mechanism that converts the rotation of a drive shaft (30) stretching through the crank chamber (26) into a reciprocating movement of a piston (34) situated in the cylinder bore (32) by varying stroke length, including:

a ring-like cam member that is connected through a hinge (44) to an outer circumferential portion of a rotor (40) fitted to the drive shaft (30), penetrated by the drive shaft (30), and is capable of tilting relative to the drive shaft (30) while moving in an axial direction of the drive shaft (30);
a conversion mechanism that is connected to the piston (34) via a coupling mechanism and converts a tilt angle of the cam member into a reciprocating movement of the piston (34);
a joint shaft (54) that is fitted to the drive shaft (30) through a bearing (56), and is supported by an inner circumferential face of a support hole (58) formed in the cylinder block (20) so as not to be relatively rotatable but
to be slidable relative to the inner circumferential face;
a joint case (66) that is integrally and tiltably formed in the conversion mechanism; and
a plurality of balls (74) rollably held between joint shaft-side protrusions that are integrally formed in the joint shaft (54) and joint case-side protrusions that are integrally formed in the joint case (66),

characterized in that:

a variable suction throttle mechanism that is interposed in a suction path stretching from the suction port to the suction chamber (97), and is changed in air-flow resistance according to the stroke length of the piston

(34),
the suction path includes a space that is created in a radial center of the cylinder block (20) ;
the support hole (58) formed in the cylinder block (20) is leading to the space,
and
the variable suction throttle mechanism uses the sliding movement of the joint shaft (54) to change air-flow resistance in the space serving as a valve chamber(101).

2. The variable displacement reciprocating compressor according to claim 1, **characterized in that** the variable suction throttle mechanism is integrally formed in the joint shaft (54), and has an air-flow resistance increasing member that enters the space to reduce a channel sectional area of the suction path within the space.

Patentansprüche

1. Hubkolbenverdichter mit variabler Verdrängung, aufweisend:

ein Gehäuse, in dem eine Ansaugkammer (97), eine Ausstoßkammer (92) und eine Kurbelkammer (26) unterteilt sind, und eine Ansaugöffnung und eine Ausstoßöffnung, die jeweils die Ansaug- und Ausstoßkammer (97, 92) mit dem Äußeren verbinden, gebildet sind;
einen Zylinderblock (20), der in dem Gehäuse platziert ist und mit einer Mehrzahl von Zylinderbohrungen (32) versehen ist, die auf einem konzentrischen Kreis gebildet sind, die über ein Ansaugventil zu der Ansaugkammer und über ein Ausstoßventil zu der Ausstoßkammer (92) führen;
einen Energieumwandlungsmechanismus, der die Rotation einer Antriebswelle (30), die sich durch die Kurbelkammer (26) erstreckt, in eine hin- und hergehende Bewegung eines Kolbens (34), der in der Zylinderbohrung (32) befindlich ist, durch Verändern einer Hublänge umwandelt, enthaltend:

ein ringartiges Kurvenscheibenelement, das durch ein Gelenk (44) mit einem äußeren Umfangsabschnitt eines an der Antriebswelle (30) aufgesetzten Rotors (40) verbunden ist, das von der Antriebswelle (30) durchdrungen ist, und das in der Lage ist, sich relativ zu der Antriebswelle (30) zu neigen während es sich in einer axialen Richtung der Antriebswelle (30) bewegt;

einen Umwandlungsmechanismus, der mit dem Kolben (34) über einen Kopplungsmechanismus verbunden ist, und der einen Neigungswinkel des Kurvenscheibenelements in eine hin- und hergehende Bewegung des Kolbens (34) umwandelt;
eine Verbindungswelle (54), die durch ein Lager (56) auf die Antriebswelle (30) aufgesetzt ist, und die durch eine innere Umfangsfläche eines Lagerungslochs (58), das so in dem Zylinderblock (20) geformt ist, dass sie sich relativ zu der Umfangsfläche nicht drehen kann aber relativ dazu verschiebbar ist, gelagert ist;
ein Verbindungsgehäuse (66), das einstückig und schwenkbar in dem Umwandlungsmechanismus gebildet ist; und
eine Mehrzahl von Kugeln (74), die rollbar durch einstückig in der Verbindungswelle (54) gebildete verbindungswellenseitige Vorsprünge und einstückig in dem Verbindungsgehäuse (66) gebildete verbindungsgehäuseseitige Vorsprünge gehalten werden,
gekennzeichnet
durch einen veränderbarer Ansaugdrosselmechanismus, der in einem Ansaugpfad, der sich von der Ansaugöffnung zu der Ansaugkammer (97) erstreckt, zwischengeschaltet ist, und dessen Luftdurchflusswiderstand gemäß der Hublänge der Kolben (34) verändert wird,
dadurch, dass der Ansaugpfad einen Raum enthält, der in einem radialen Zentrum des Zylinderblocks (20) gebildet ist;
dadurch, dass das in dem Zylinderblock (20) gebildete Lagerungsloch (58) zu dem Raum führt, und
dadurch, dass der veränderbare Ansaugdrosselmechanismus die Verschiebebewegung der Verbindungswelle (54) verwendet, um den Luftdurchflusswiderstand in dem Raum, der als eine Ventilkammer (101) dient, zu verändern.

2. Hubkolbenverdichter mit variabler Verdrängung gemäß Anspruch 1, **dadurch gekennzeichnet, dass** der veränderbare Ansaugdrosselmechanismus einstückig in der Verbindungswelle (54) gebildet ist, und ein Luftdurchflusswiderstanderhöhungselement hat, das in den Raum eintritt, um eine Kanalquerschnittsfläche des Ansaugpfads innerhalb des Raums zu verringern.

Revendications

1. Compresseur alternatif à déplacement variable comprenant :

- un carter dans lequel sont réparties une chambre d'aspiration (97), une chambre de refoulement (92) et une chambre de manivelle (26) et

un orifice d'aspiration et un orifice de refoulement reliant respectivement la chambre d'aspiration et la chambre de refoulement (97, 92) à l'extérieur sont formés,
- un bloc cylindre (20) qui est situé dans le carter et est équipé de plusieurs alésages de cylindre (32) formés sur un cercle concentrique qui conduisent à la chambre d'aspiration par l'intermédiaire d'une soupape d'aspiration et à la chambre de refoulement (92) par l'intermédiaire d'une soupape de refoulement,
- un mécanisme de conversion de puissance qui transforme la rotation d'un arbre moteur (30) s'étendant dans la chambre de manivelle (26) en un mouvement en va et vient d'un piston (34) monté dans l'alésage de cylindre (32) en faisant varier la longueur de course, comprenant :
- un élément de came de type annulaire qui est relié par une articulation (44) à la partie périphérique externe d'un rotor (40) rapporté sur l'arbre moteur (30) dans lequel pénètre l'arbre moteur (30) et qui peut basculer par rapport à l'arbre moteur (30) en se déplaçant dans la direction axiale de cet arbre (30),
- un mécanisme de conversion qui est relié au piston (34) par l'intermédiaire d'un mécanisme d'accouplement et transforme l'angle de basculement de l'élément de came en un mouvement en va et vient du piston (34),
- un arbre articulé (54) qui est fixé à l'arbre moteur (30) par l'intermédiaire d'un palier (56) et est supporté par la face périphérique interne d'un orifice support (58) réalisé dans le bloc cylindre (20) de façon à ne pas pouvoir être déplacé en rotation mais à pouvoir glisser par rapport à la face périphérique interne,
- un caisson articulé (66) qui est formé intégralement de façon à pouvoir basculer dans le mécanisme de conversion, et
- un ensemble de billes (74) maintenues mobiles en roulement entre des saillies latérales de l'arbre articulé qui sont formées intégralement dans cet arbre (54) et des saillies latérales du caisson articulé qui sont formées intégralement dans le caisson articulé (66), **caractérisé en ce qu'**
un mécanisme d'étranglement d'aspiration variable est interposé dans le chemin d'aspiration s'étendant de l'orifice d'aspiration à la chambre d'aspiration (97) et présente une résistance à l'écoulement de l'air variable selon la longueur de course du piston (34),
le chemin d'aspiration comporte un espace qui est crée au centre radial du bloc cylindre (20),
l'orifice support (58) formé dans le bloc cylindre (20) conduit à l'espace, et
le mécanisme d'étranglement d'aspiration variable utilise le mouvement de glissement de l'arbre articulé (54) pour modifier la résistance à l'écoulement dans l'espace faisant office de chambre de soupape (101).

2. Compresseur alternatif à déplacement variable conforme à la revendication 1,
caractérisé en ce que
le mécanisme d'étranglement d'aspiration variable est formé intégralement dans l'arbre articulé (54) et comporte un élément augmentant la résistance à l'écoulement de l'air qui pénètre dans l'espace pour réduire la section transversale de canal du chemin d'aspiration dans l'espace.

FIG. 1

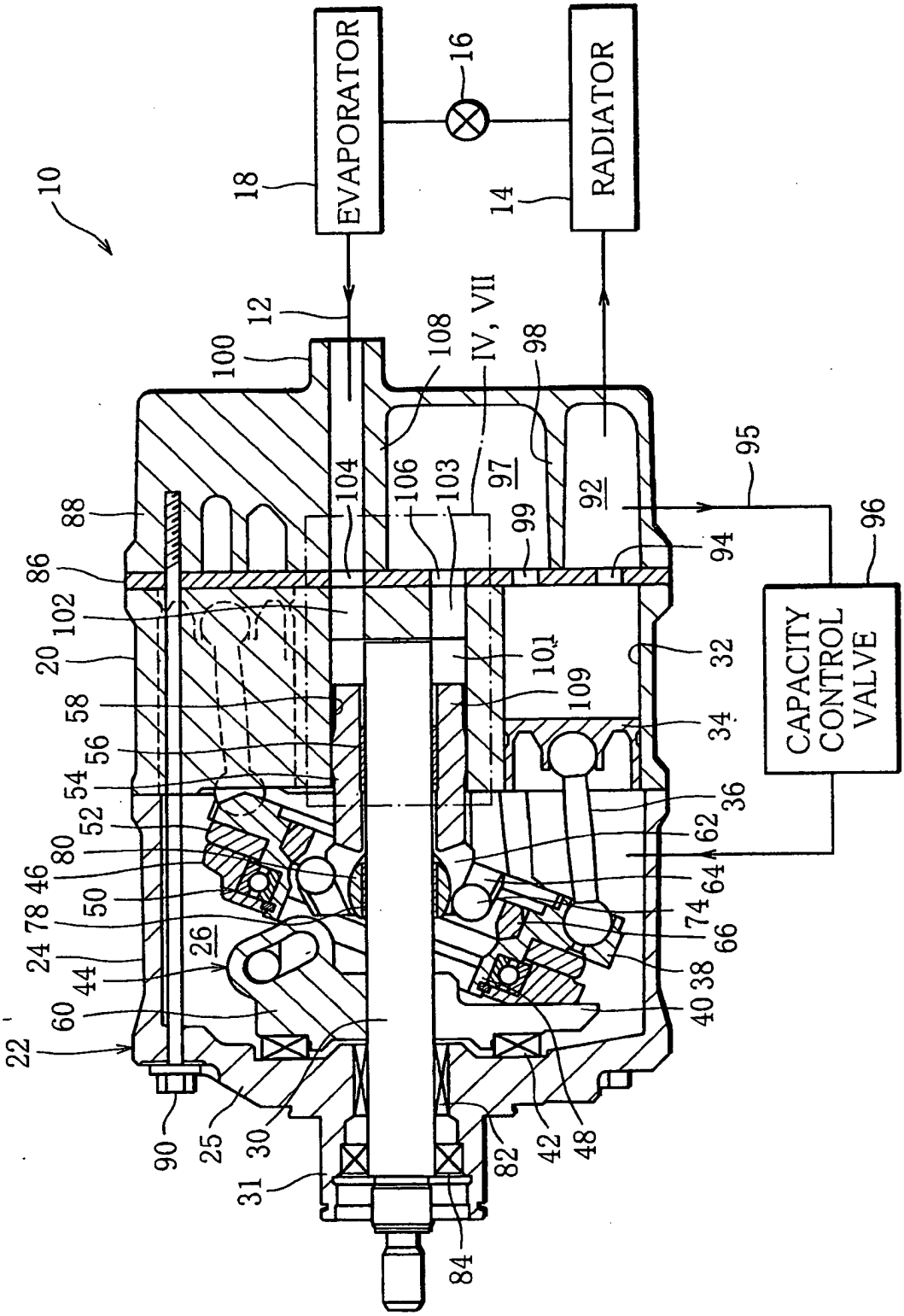

EVAPORATOR
RADIATOR
CAPACITY CONTROL VALVE
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IV, VII

FIG. 2

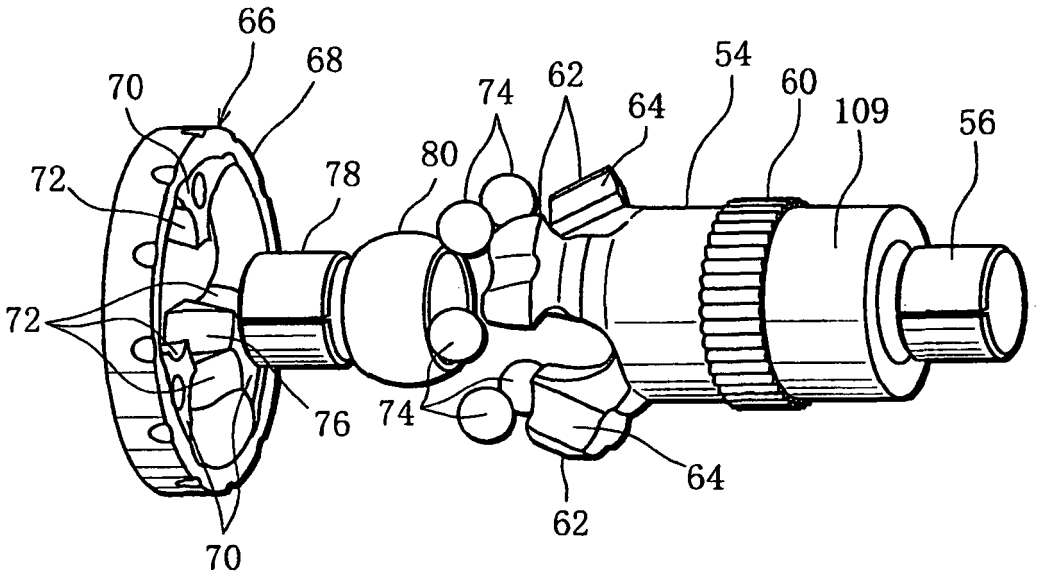


FIG. 3

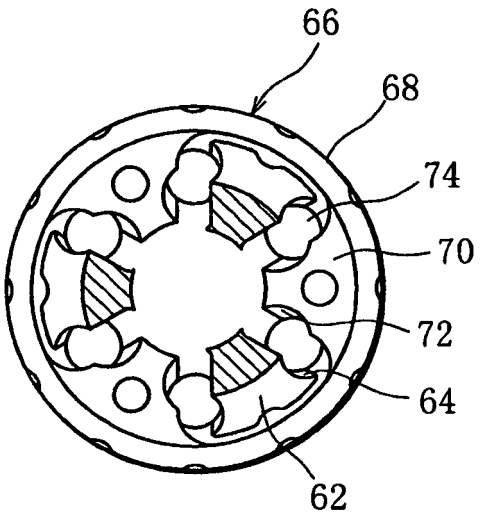

66
68
74
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72
64
62

FIG. 4

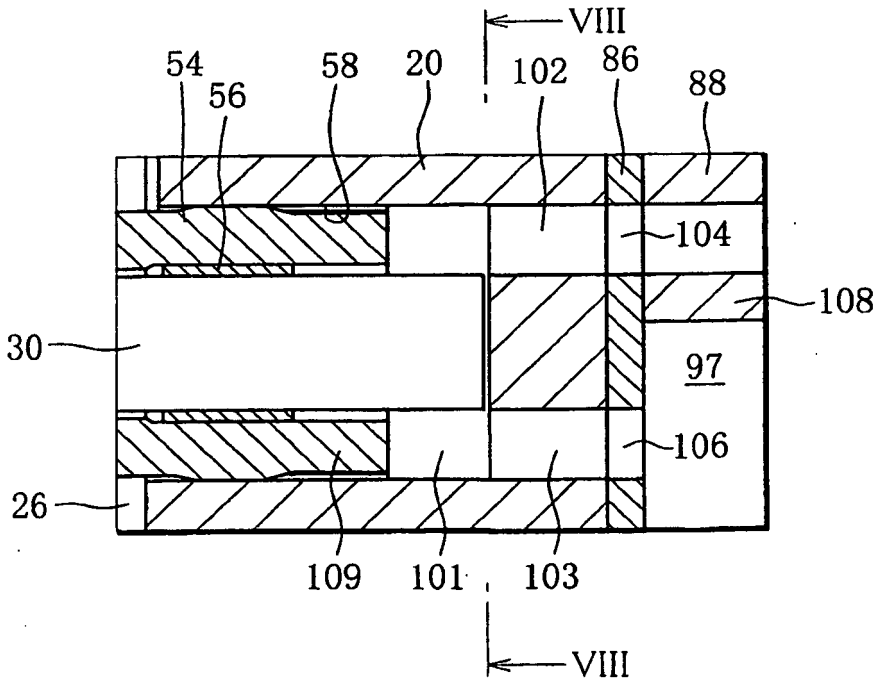

VIII
54
56
58
20
102
86
88
104
108
30
97
106
26
109
101
103
VIII

FIG. 5

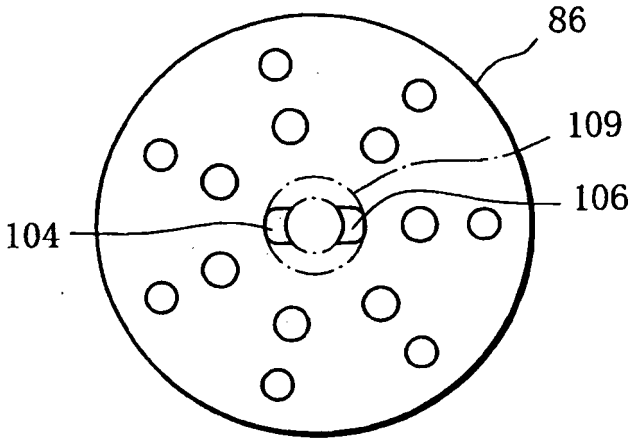


FIG. 6

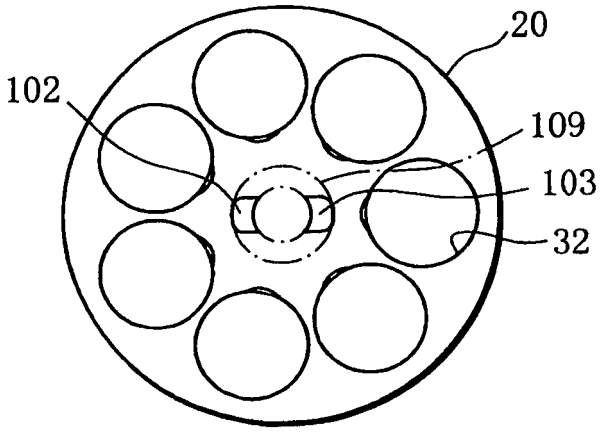


FIG. 7

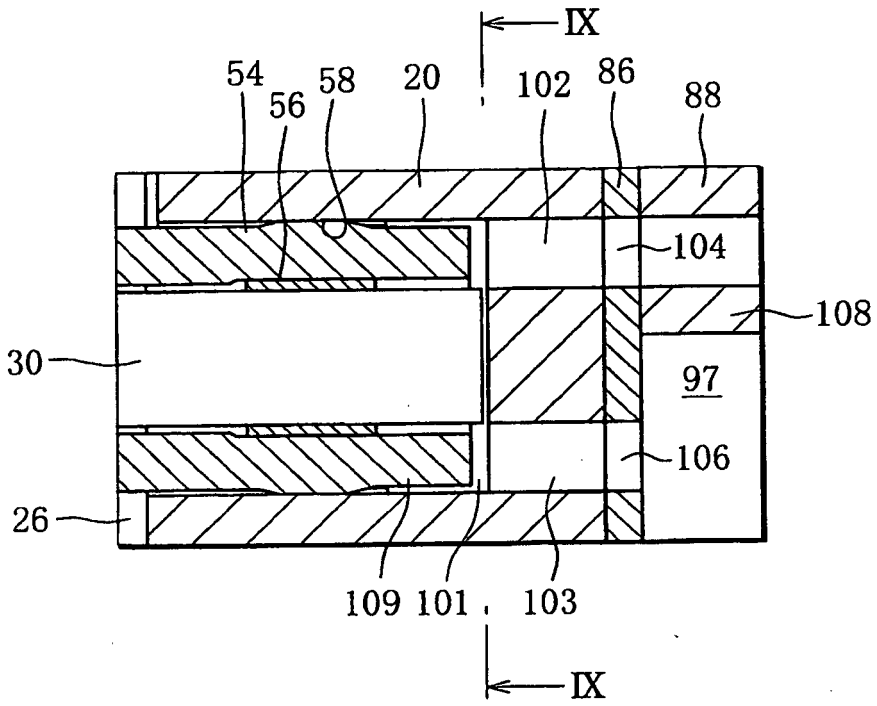


FIG. 8

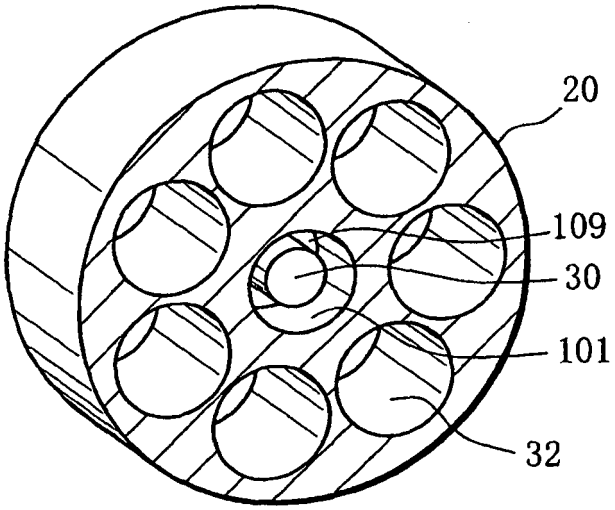


FIG. 9

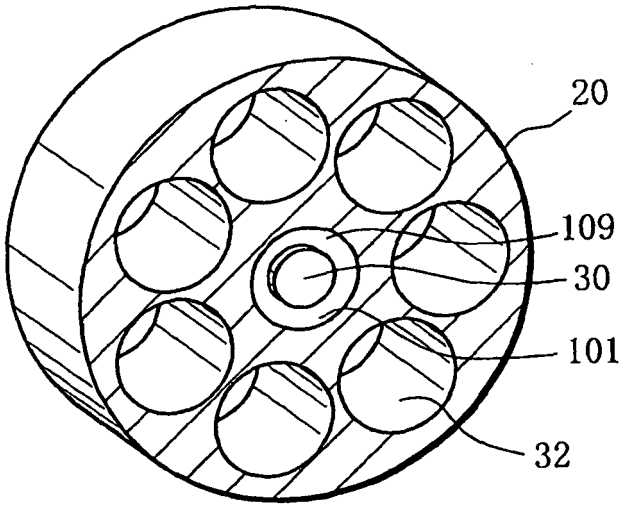


FIG. 10

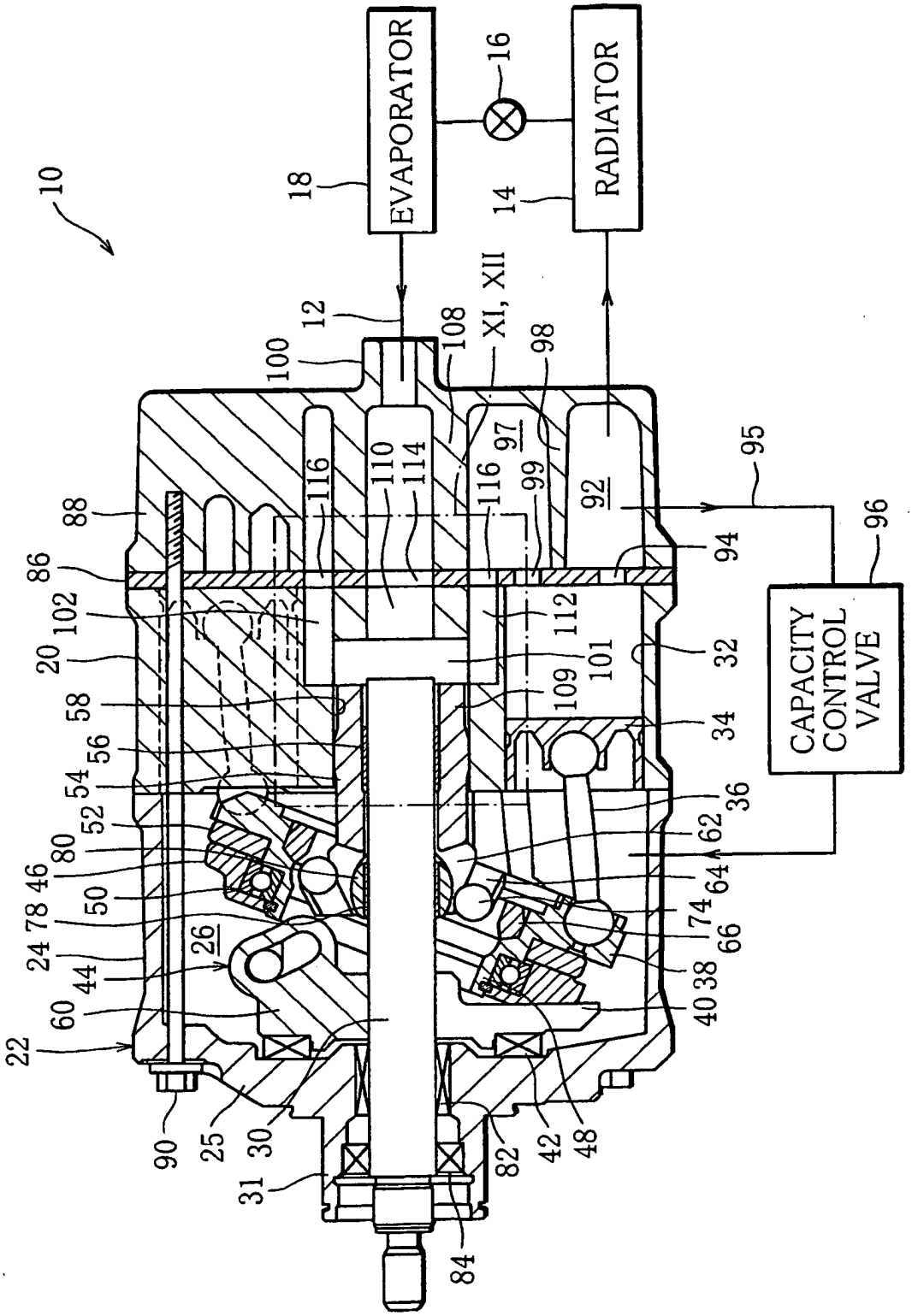

10
EVAPORATOR
16
RADIATOR
18
14
12
100
108
XI, XII
98
97
95
96
CAPACITY CONTROL VALVE
88
86
102
20
58
56
54
52
80
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50
78
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44
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84
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48
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32
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92
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110
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112
101
109

FIG. 11

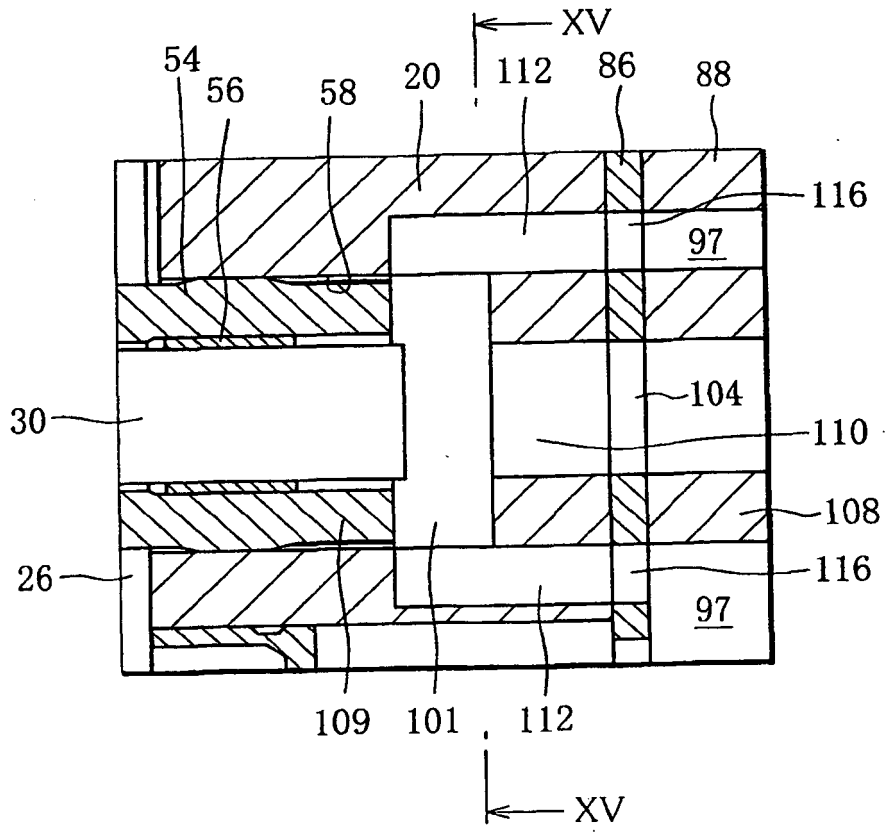

XV
54
56
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97
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101
112
XV

FIG. 12

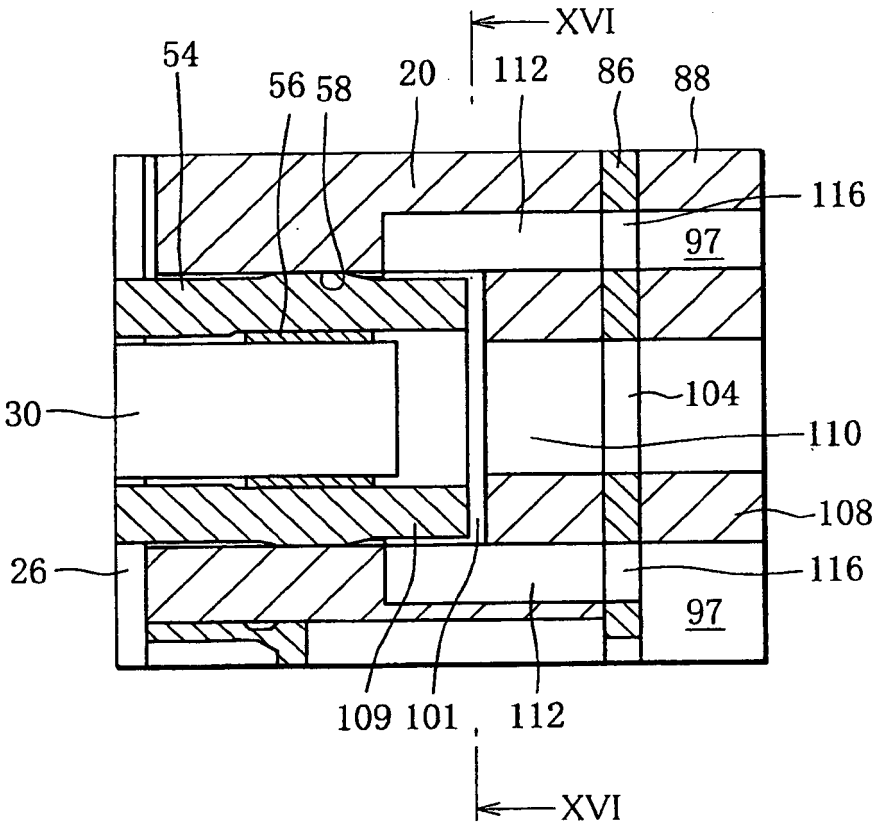

XVI
54
56
58
20
112
86
88
116
97
30
104
110
108
26
116
97
109
101
112
XVI

FIG. 13

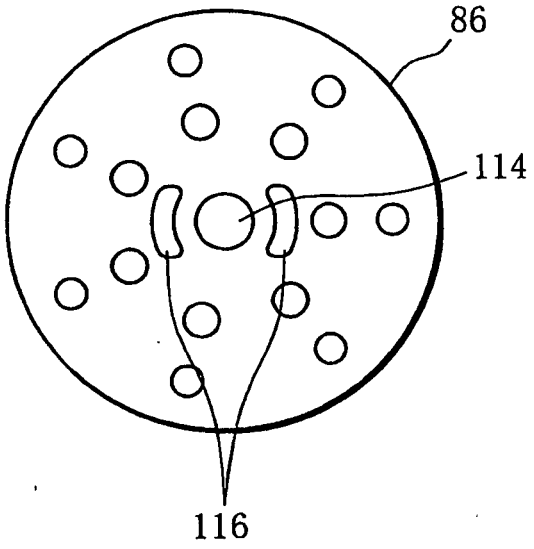


FIG. 14

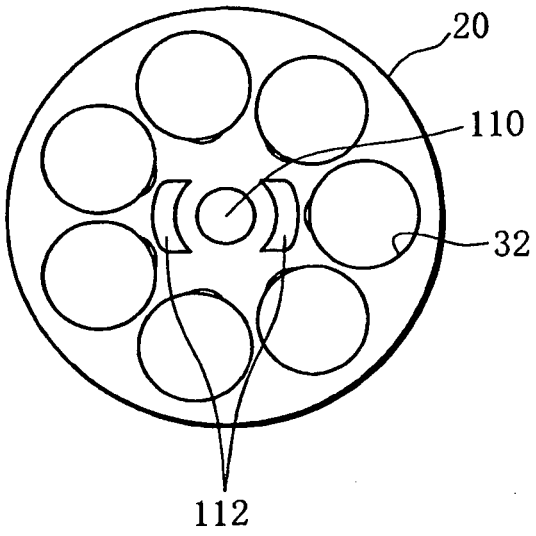


FIG. 15

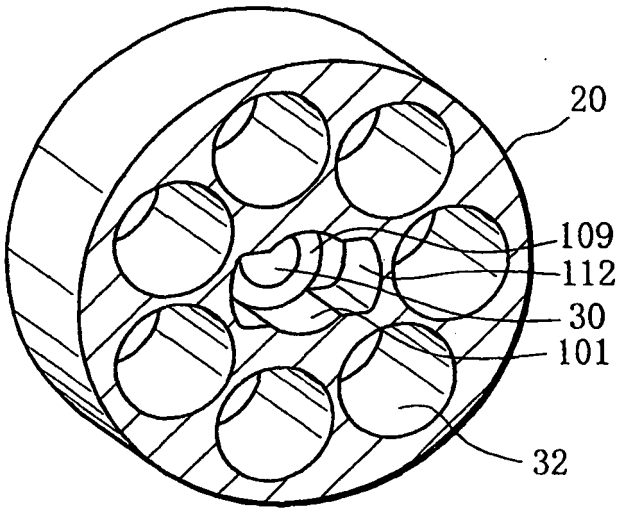
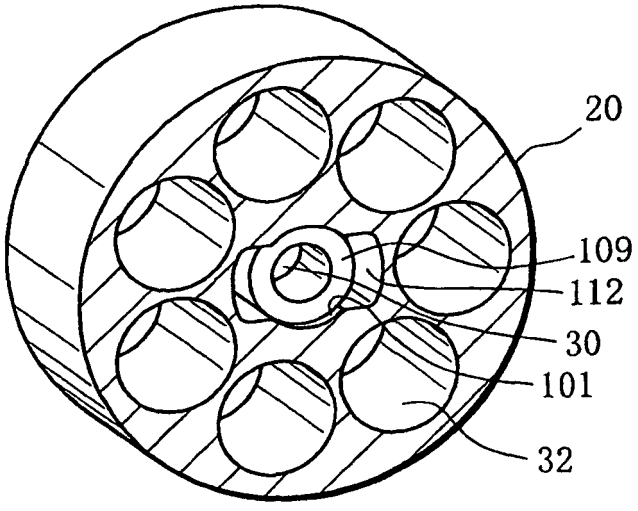


FIG. 16



REFERENCES CITED IN THE DESCRIPTION

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