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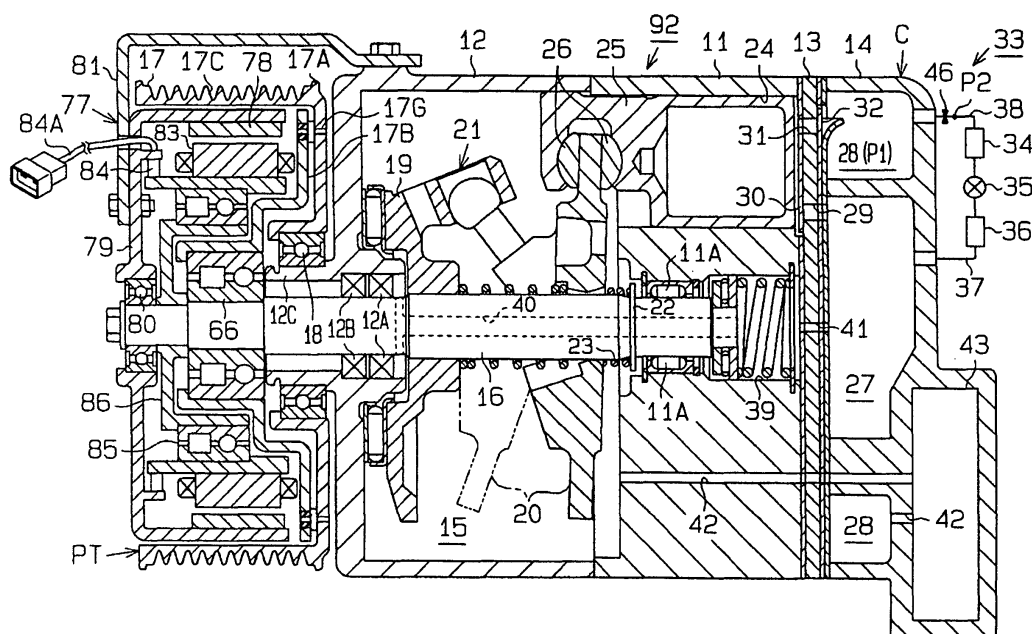
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(54) **Rotary machine for vehicle**

(57) A rotary machine for a vehicle has a housing, a pressure exerting mechanism, a rotary shaft, a rotary body, a power transmission clutch assembly and an electric motor. The rotary machine is selectively driven by the electric motor and an external drive source. The mechanism is located in the housing. The rotary shaft is rotatably supported by the housing, and one end of the rotary shaft protrudes from the housing. The rotary

body is coaxially located on the rotary shaft on the protrusion side and is operatively connected to the rotary shaft. The rotary body forms a cylinder having an open end at one end and a closed surface at the other end, and the closed surface is adjacent to the housing. The power transmission clutch assembly is placed between the rotary body and the rotary shaft. The electric motor is at least partially located in the cylinder.

FIG. 2



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a rotary machine for a vehicle and particularly relates to the rotary machine including an electric motor and a rotary body that transmit power to a rotary shaft for driving an internal mechanism.

[0002] Unexamined Japanese Patent Publication No. 2001-140757 and Unexamined Japanese Utility Model Publication No. 6-87678 disclose a conventional compressor or a rotary machine for a vehicle. The compressor drives a compression mechanism. The compressor is selectively driven by an external drive source or an electric motor for compressing refrigerant.

[0003] A compressor main body generally includes a housing, a compression mechanism and a rotary shaft or a drive shaft supported therein for driving the compression mechanism. A pulley or a rotary body is placed on the shaft for transmitting power from the external drive source to the rotary shaft. The electric motor is also placed in the main body for driving the rotary shaft. A power transmission clutch assembly such as an electromagnetic clutch assembly and a one-way clutch assembly is located in a power transmission path between the pulley and the rotary shaft. As the power transmission clutch assembly is activated and de-activated, the compression mechanism is selectively driven by the external drive source or the electric motor.

[0004] In the attempt to access the electric motor that is at least partially inside the pulley when the electric motor needs to be repaired or checked, the structure in the above publications does not allow access to the inside of the pulley while the pulley and the power transmission clutch assembly are still in the respective assembled position in the main body. Namely, while the pulley and the power transmission clutch assembly are being at the respective designated placement on the main body, the pulley and the power transmission clutch assembly must be initially detached from the main body before the electric motor is detached. Additionally, when the electric motor is reassembled to the main body after repairing or checking, the pulley and the power transmission clutch assembly must be assembled to the main body after the electric motor is initially assembled to the main body. Thus, it is complicated to assemble and detach the electric motor in the above disclosed structures.

[0005] Meanwhile, the above Unexamined Japanese Utility Model Publication No. 6-87678 discloses another structure that includes a closed casing or a housing, a pulley and an electric motor. Then, the electric motor is located on an opposite side of the pulley relative to the housing. In the above structure, while the pulley and the power transmission clutch assembly are being at the respective designated placement on the compressor main body, the above structure allows access to the electric motor. However, an unwanted feature in the above

structure is that the entire electric motor is located outside the housing. The width of the rotary machine is relatively large in an axial direction of the rotary shaft. For the above reasons, there is a need for easily assembling and detaching an electric motor to a main body of a rotary machine to cut manufacturing costs and for reducing the size of the rotary machine in an axial direction of its rotary shaft.

SUMMARY OF THE INVENTION

[0006] In accordance with the present invention, a rotary machine for a vehicle having an external drive source to drive the rotary machine has a housing, a pressure exerting mechanism, a rotary shaft, a rotary body, a first power transmission clutch assembly and an electric motor. The pressure exerting mechanism is located in the housing. The rotary shaft is rotatably supported by the housing to drive the mechanism, and one end of the rotary shaft protrudes from the housing on a protrusion side. The rotary body is coaxially located on the rotary shaft on the protrusion side and is operatively connected to the rotary shaft to form a first power transmission path between the rotary body and the rotary shaft. The rotary body forms a cylinder having an open end at one end and a closed surface at the other end, and the closed surface is adjacent to the housing. The first power transmission clutch assembly is located in the first power transmission path for selectively transmitting power between the rotary body and the rotary shaft. The electric motor is at least partially located in the cylinder for selectively driving the rotary shaft.

[0007] The present invention also provides a method of providing a rotary body and an electric motor to a main body of a rotary machine. The main body includes a pressure exerting mechanism and a rotary shaft for driving the pressure exerting mechanism. The method includes providing the rotary body with an inner space with an open end, attaching the rotary body to the rotary shaft in such a manner to face the open end away from the housing, and placing a substantial portion of the electric motor in the inner space after the attaching step.

[0008] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. 1 is a schematic end view of an engine of a vehicle with auxiliary machines according to a preferred embodiment of the present invention;

FIG. 2 is a schematic cross-sectional view of a compressor and a refrigerant circuit according to the preferred embodiment of the present invention;

FIG. 3 is a schematic cross-sectional view of a control valve in the compressor according to the preferred embodiment of the present invention;

FIG. 4 is an enlarged schematic cross-sectional view of a power transmitting mechanism according to the preferred embodiment of the present invention;

FIG. 5A is an enlarged schematic cross-sectional view of a one-way clutch mechanism in a state when power transmits according to the preferred embodiment of the present invention;

FIG. 5B is an enlarged schematic cross-sectional view of the one-way clutch mechanism in a state when power transmission is blocked according to the preferred embodiment of the present invention; and

FIG. 6 is a perspective view of a housing side support member according to the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] A preferred embodiment of the present invention will now be described in reference to FIGs. 1 through 6.

[0011] Referring to FIG. 1, a diagram illustrates a schematic side view of an engine of a vehicle or an external drive source E and auxiliary rotary machines 90, 91, 92 fixedly connected to both sides of the engine E. The engine E has a crankshaft and a crank pulley 93 that is secured to the crankshaft, and the crank pulley 93 rotates integrally with the crankshaft. The auxiliary machines are a power steering pump 90, an alternator 91 and a compressor 92. These auxiliary machines 90, 91 and 92 each have respective pulleys 90A, 91A and 17. A belt B1 couples the pulley 90A of the power steering pump 90 to the crank pulley 93 and transmits power of the engine E to the power steering pump 90. A belt B2 couples the pulleys 91A, 17 to the crank pulley 93 and transmits the power of the engine E respectively to the alternator 91 and the compressor 92. Namely, both the pulleys 91A and 17 are coupled to the crank pulley 93 through the shared belt B2. Thus, the auxiliary machines 90, 91 and 92 are driven by the engine E. In addition, a tension device 94 is arranged for appropriately

tensioning the belt B2. The belt B2 winds on the pulley 17 on a side that is opposite from the engine E.

[0012] Now referring to FIG. 2, a diagram illustrates a schematic cross-sectional view that is taken along the line I-I in FIG. 1. The left side and the right side in FIG. 2 respectively correspond to the front side and the rear side of the compressor or the rotary machine 92. The compressor 92 includes a power transmitting mechanism PT and a compressor main body or a rotary machine main body C. The compressor main body C provides a part of an air-conditioning system for a vehicle. The power transmitting mechanism PT is connected to the compressor main body C. The power transmitting mechanism PT includes the pulley or a rotary body 17, a bearing 18, first and second one-way clutch assemblies or first and second power transmission clutch assemblies 66 and 85, an electric motor 77 and a connecting member 86.

[0013] The compressor main body C has a housing that includes a cylinder block 11, a front housing 12, a valve plate assembly 13 and a rear housing 14. The front housing 12 is connected to the front end of the cylinder block 11. The rear housing 14 is connected to the rear end of the cylinder block 11 through the valve plate assembly 13.

[0014] A crank chamber or a pressure control region 15 is defined between the cylinder block 11 and the front housing 12. A rotary shaft 16 extends through the crank chamber 15 and is rotatably supported by the housing. The front end of the rotary shaft 16 is supported by a radial bearing 12A that is fixedly connected to the front end wall of the front housing 12. The rear end of the rotary shaft 16 is supported by a radial bearing 11A that is fixedly connected to the cylinder block 11. The front end of the rotary shaft 16 extends through the front end wall of the front housing 12 and protrudes from the housing. The protruded front end of the rotary shaft 16 is operatively connected to the power transmitting mechanism PT. The front end of the rotary shaft 16 and the front end wall of the front housing 12 interpose a seal member 12B that is located near the front side of the radial bearing 12A. The seal member 12B isolates the inside of the housing from the outside of the housing.

[0015] A variable displacement piston type compression mechanism includes a cylinder bore 24 of the cylinder block 11, a rotary shaft 16, a lug plate 19, a swash plate or a cam plate 20, a hinge mechanism 21, a piston 25 and a shoe 26. The lug plate 19 is secured to the rotary shaft 16 in the crank chamber 15 so as to rotate integrally. The swash plate 20 is movably connected to the lug plate 19 through the hinge mechanism 21 in the crank chamber 15 and is supported by the rotary shaft 16. The hinge mechanism 21 allows the swash plate 20 to slide and tilt relative to the rotary shaft 16. Due to the above movable connection and the support by the rotary shaft 16, the swash plate 20 rotates synchronously with the lug plate 19 and the rotary shaft 16 and is tiltable with respect to the rotary shaft 16 in accordance with a

slide along the axial direction of the rotary shaft 16.

[0016] An engaging ring 22 is connected to the rotary shaft 16. A spring 23 is placed between the engaging ring 22 and the swash plate 20. The minimum inclination angle of the swash plate 20 is regulated by the engaging ring 22 and the spring 23. The minimum inclination angle of the swash plate 20 is an inclination angle which is the closest to 90° with respect to the axial direction of the rotary shaft 16.

[0017] The cylinder block 11 includes the plurality of cylinder bores 24. Only one of the cylinder bores 24 is illustrated in FIG. 2. The cylinder bore 24 extends in the axial direction of the rotary shaft 16. Each of the cylinder bores 24 accommodates the single-headed piston 25 that reciprocates therein. The front opening and the rear opening of the cylinder bore 24 are respectively shut by the piston 25 and the valve plate assembly 13. A compression chamber is defined by the cylinder bore 24, the piston 25 and the valve plate assembly 13. The piston 25 engages the outer periphery of the swash plate 20 through the pair of shoes 26. Due to the above engagement, the rotation of the tilted swash plate 20 is converted to the reciprocation of the piston 25. The compression chamber varies its volume as the piston 25 reciprocates.

[0018] A suction chamber or a suction pressure region 27 and a discharge chamber or a discharge pressure region 28 are defined in the rear housing 14. Each front end of the suction chamber 27 and the discharge chamber 28 is shut by the valve plate assembly 13. As the piston 25 moves from a top dead center to a bottom dead center, refrigerant in the suction chamber 27 is introduced into the compression chamber through a suction port 29 by opening a suction valve 30. On the other hand, as the piston 25 moves from the bottom dead center to the top dead center, the introduced refrigerant in the compression chamber is compressed to a predetermined pressure value and is discharged to the discharge chamber 28 through a discharge port 31 by opening a discharge valve 32.

[0019] The compressor main body C and an external refrigerant circuit 33 constitute a refrigerant circuit of the air-conditioning system for a vehicle. The suction chamber 27 and the discharge chamber 28 are each connected to the external refrigerant circuit 33. The external refrigerant circuit 33 includes a condenser 34, a thermostatic expansion valve or a decompressor 35 and an evaporator 36. The opening degree of the expansion valve 35 is adjusted by a feedback control based on a temperature detected by a temperature sensitive cylinder and a vaporization pressure or a pressure at the outlet of the evaporator 36. The temperature sensitive cylinder is not shown in the drawing and is located near the outlet of the evaporator 36 or downstream of the expansion valve 36. The expansion valve 35 supplies the evaporator 36 with liquid refrigerant that complies with cooling load and regulates the flow rate of refrigerant in the external refrigerant circuit 33.

[0020] A conduit 37 is placed at the downstream region of the external refrigerant circuit 33. The refrigerant flows from the evaporator 36 to the suction chamber 27 through the conduit 37. Another conduit 38 is placed at the upstream region of the external refrigerant circuit 33. The refrigerant flows from the discharge chamber 28 to the condenser 34 through the conduit 38. As the refrigerant is introduced from the downstream region of the external refrigerant circuit 33 to the suction chamber 27, the compressor main body C compresses the refrigerant. Subsequently, the compressor main body C discharges the refrigerant to the discharge chamber 28 that is connected to the upstream region of the external refrigerant circuit 33.

[0021] The cylinder block 11 includes a shaft hole 39, and the rear end of the rotary shaft 16 extends through the shaft hole 39. The shaft hole 39 communicates with the crank chamber 15 through an axial passage 40 that is formed in the rotary shaft 16. The shaft hole 39 also communicates with the suction chamber 27 through a communication hole 41 that is formed in the valve plate assembly 13. As a result, the crank chamber 15 communicates with the suction chamber 27. The shaft hole 39, the axial passage 40 and the communication hole 41 constitute a bleed passage.

[0022] The housing includes a supply passage 42 that interconnects the discharge chamber 28 and the crank chamber 15. A control valve 43 is located in the supply passage 42 and regulates the opening degree of the supply passage 42. The regulation adjusts the balance of the amount of refrigerant flowing into and out of the crank chamber 15. Thus, the control valve 43 determines a crank chamber pressure P_c or a pressure in the crank chamber 15. A pressure differential between the crank chamber 15 and the compression chamber varies according to variation of the crank chamber pressure P_c . Due to the differential pressure change, the swash plate 20 varies its inclination angle. As a result, a stroke distance of the piston 25 is also adjusted. In other words, the displacement in the compressor main body C is adjusted per unit rotation of the rotary shaft 16. In the preferred embodiment, the above displacement per unit rotation of the rotary shaft 16 becomes substantially zero when the swash plate 20 is at the minimum inclination angle.

[0023] Still referring to FIG. 2, as the refrigerant flow rate Q increases in the refrigerant circuit, pressure loss increases per unit length of the refrigerant circuit or the conduit. Namely, the flow rate Q positively correlates to pressure loss or a pressure differential between pressure monitoring points P_1 and P_2 in the refrigerant circuit. Based upon the above relation, the flow rate Q is calculated by the pressure differential between the pressure monitoring points P_1 and P_2 . Where P_{dH} and P_{dL} respectively denote pressure at the pressure monitoring points P_1 and P_2 , the pressure differential ΔP_X is expressed as follows.

$$\Delta PX = PdH - PdL$$

[0024] The pressure monitoring point P1 is located in the discharge chamber 28 that corresponds to the most upstream region of the conduit 38 where a pressure is relatively high. The pressure monitoring point P2 is located at a predetermined distance from the location of the pressure monitoring point P1 in the conduit 38 in the downstream region where a pressure is relatively low.

[0025] Still referring to FIG. 2, a fixed throttle or a pressure differential increasing means 46 is placed in the conduit 38 between the pressure monitoring points P1 and P2. Even if a distance between the pressure monitoring points P1 and P2 is relatively short, the fixed throttle 46 increases the pressure differential ΔPX between the points P1 and P2 by lowering the pressure PdL below the pressure PdH. For the above reason, the pressure monitoring point P2 is placed near the compressor main body C. Although the pressure PdL is lowered below the pressure PdH due to the fixed throttle 46, the pressure PdL is still sufficiently higher than the crank chamber pressure Pc.

[0026] Now referring to FIG. 3, a diagram illustrates a schematic cross-sectional view of the control valve 43. A valve chamber 48, a communication passage 49 and a pressure sensing chamber 50 are defined in a valve housing 47 of the control valve 43. A rod 51 is movably placed in the valve chamber 48 and the communication passage 49 in an axial direction of the rod 51, that is, a vertical direction in the drawing. The communication passage 49 is separated from the pressure sensing chamber 50 by the upper end of the rod 51. The valve chamber 48 communicates with the discharge chamber 28 through an upstream region of the supply passage 42. The communication passage 49 communicates with the crank chamber 15 through a downstream region of the supply passage 42. The valve chamber 48 and the communication passage 49 constitute a portion of the supply passage 42.

[0027] The rod 51 includes a valve body portion 52 in its middle portion, and the valve body portion 52 is placed in the valve chamber 48. A step or a valve seat 53 is formed at a boundary between the valve chamber 48 and the communication passage 49. The communication passage 49 functions as a valve hole. The valve body portion 52 adjusts an opening degree of the supply passage 42. In other words, as the rod 51 moves from a lowest position shown in the drawing to a highest position where the valve body portion 52 contacts the valve seat 53, the communication passage 49 is shut.

[0028] A pressure sensing mechanism includes the pressure sensing chamber 50 and a pressure sensing member 54. The pressure sensing member or a bellows 54 is located in the pressure sensing chamber 50. The pressure sensing member 54 is substantially cylindrical in shape and has an opening at one end. The upper end of the pressure sensing member 54 is fixed to the valve

housing 47. The lower end of the pressure sensing member 54 is fitted to the upper end of the rod 51. The pressure sensing chamber 50 is divided into a first pressure chamber 55, and a second pressure chamber 56 by the pressure sensing member 54. The first and second pressure chambers 55 and 56 are respectively inside and outside the pressure sensing member 54. A first pressure introducing passage 44 interconnects the pressure monitoring point P1 and the first pressure chamber 55. The pressure PdH at the pressure monitoring point P1 is applied to the first pressure chamber 55 through the first pressure introducing passage 44. Similarly, a second pressure introducing passage 45 interconnects the pressure monitoring point P2 and the second pressure chamber 56. The pressure PdL at the pressure monitoring point P2 is applied to the second pressure chamber 56 through the second pressure introducing passage 45. In addition, the pressure monitoring point P2 is located near the compressor main body C. In the preferred embodiment, because of the location of the pressure monitoring point P2, the second pressure introducing passage 45 is relatively short.

[0029] An electromagnetic actuator or a pressure differential value changing means 57 is located at the lower side of the valve housing 47. The electromagnetic actuator 57 includes a cylindrical plunger housing 58 having an opening at one end, and the plunger housing 58 is coaxially located at the lower side of the valve housing 47. A center post 59 is fixedly inserted from the upper end opening of the plunger housing 58. Due to the insertion of the center post 59, a plunger chamber 60 is defined in the lower end of the plunger housing 58.

[0030] A plunger 61 is placed in the plunger chamber 60 and is movable in the axial direction of the rod 51. A guide hole 62 is centrally formed in the center post 59 and extends in the axial direction of the rod 51. The lower end of the rod 51 is placed in the guide hole 62 and is movable in the axial direction of the rod 51. The lower end of the rod 51 contacts the upper end of the plunger 61 in the plunger chamber 60. In the plunger chamber 60, a coil spring 63 is placed between the lower end of the plunger housing 58 and the plunger 61 for urging the plunger 61 toward the rod 51. Meanwhile, the rod 51 is urged toward the plunger 61 by spring or bellows force of the pressure sensing member 54. Namely, the plunger 61 accompanies the rod 51 when the plunger 61 and the rod 51 together move vertically. The bellows spring force is greater than the urging force of the coil spring 63.

[0031] A coil 64 is located outside the plunger housing 58 and extends between the center post 59 and the plunger 61. The coil 64 is supplied with electric current from a battery via a drive circuit in such a manner that a controller sends an external command to the drive circuit. The controller, the drive circuit and the battery are not shown in the drawing. Due to the above power supply to the coil 64, electromagnetic attraction is generated in proportion to the magnitude of the supplied electric current between the plunger 61 and the center post 59.

Based upon the above electromagnetic attraction, urging force is upwardly applied to the plunger 61, and the plunger 61 pushes the rod 51. The electric current to the coil 64 is adjusted by an applied voltage by means of pulse width modulation (PWM) control or duty control.

[0032] A position of the valve body portion 52 or an opening degree of the control valve 43 is externally determined as follows. When the coil 64 is supplied with no electric current (duty ratio = 0%), the bellows spring force dominates to urge the rod 51 to the lowest position to fully open the communication passage 49. Under the above condition, as described in FIG. 2, as the crank chamber pressure P_c reaches a maximum value, the pressure differential also increases between the crank chamber pressure P_c and the compression chamber pressure. Namely, the pressure differential increases between the pressures applied to both sides of the pistons 25. As a result, the inclination angle of the swash plate 20 becomes minimum, and the displacement of the compressor main body C becomes minimum per unit rotation of the rotary shaft 16.

[0033] Still referring to FIG. 3, when the coil 64 is supplied with the electric current, the duty ratio is equal to or greater than a minimum duty ratio in its adjustable range (duty ratio > 0%). The sum of the electromagnetic force and the upward urging force of the coil spring 63 becomes greater than the downward urging force of the bellows spring force so that the rod 51 moves upwardly. Under the above condition, the electromagnetic force and the additional upward urging force of the coil spring 63 counter the downward force based on the pressure differential ΔPX and the additional downward urging force of the bellows spring force. Consequently, the position of the valve body portion 52 is determined relative to the valve seat 53 based on the balance resulting from the above described upward and downward forces.

[0034] When the duty ratio of the coil 64 is increased to further strengthen the electromagnetic attraction, the valve body portion 52 moves upwardly, and the opening degree of the communication passage 49 reduces. Due to the above reduced opening, the displacement of the compressor main body C increases. As a result, the refrigerant flow rate increases in the refrigerant circuit, and the pressure differential ΔPX also increases. On the contrary, when the duty ratio of the coil 64 is reduced to weaken the electromagnetic attraction, the valve body portion 52 of the rod 51 moves downwardly, and the opening degree of the communication passage 49 increases. Due to the above increase of the opening degree, the displacement of the compressor main body C reduces. As a result, the refrigerant flow rate reduces in the refrigerant circuit, and the pressure differential ΔPX also reduces.

[0035] On the other hand, a position of the valve body portion 52 or an opening degree of the control valve 43 is internally determined as follows. When the refrigerant flow rate reduces in the refrigerant circuit, the downward force to the rod 51 also reduces based upon the pres-

sure differential ΔPX . Due to the above reduction of the downward force, the rod 51 initiates to move upwardly. As a result, the opening degree of the communication passage 49 reduces, the crank chamber pressure P_c tends to reduce, as described in FIG. 2. Due to the above reduction of the crank chamber pressure P_c , the swash plate 20 initiates to increase its inclination angle, and the displacement of the compressor main body C increases. As the displacement of the compressor main body C increases, the refrigerant flow rate also increases in the refrigerant circuit. Thus, the pressure differential ΔPX increases.

[0036] Still referring to FIG. 3, when the refrigerant flow rate increases in the refrigerant circuit, the downward force to the rod 51 increases based upon the pressure differential ΔPX . Then, the valve body portion 52 initiates to move downwardly, and the opening degree of the communication passage 49 increases. Due to the above increase of the opening degree, as described in FIG. 2, the crank chamber pressure P_c tends to increase, and the swash plate 20 initiates to reduce its inclination angle. As a result, the displacement of the compressor main body C reduces, and the refrigerant flow rate also reduces in the refrigerant circuit. Thus, the pressure differential ΔPX reduces.

[0037] Thereby, a target pressure differential or a set pressure differential is externally controlled by adjusting the duty ratio. The control valve 43 mechanically determines the position of the valve body portion 52 in accordance with variation of the pressure differential ΔPX so as to be close to the target pressure differential.

[0038] Now referring to FIG. 4, the pulley 17 includes an upstream pulley member 17A, a downstream pulley member 17B, power transmitting pins or power transmission cutting means or breaking members 17G and damping members 17N. The upstream pulley member 17A includes an outer cylindrical portion 17D, an inner cylindrical portion 17E and a disc-shaped portion 17F. The outer cylindrical portion 17D includes a power transmitting portion 17C on its outer circumference, and the above described belt B2 winds around the power transmitting portion 17C. The disc-shaped portion 17F interconnects the rear end of the outer cylindrical portion 17D and the rear end of the inner cylindrical portion 17E, and the outer cylindrical portion 17D, the inner cylindrical portion 17E and the disc-shaped portion 17F are integrated into a single component. Thus, the pulley 17 has an open end at one end and a closed surface or the disc-shaped portion 17F at the other end. The closed surface or the disc-shaped portion 17F is adjacent to the front housing 12.

[0039] Still referring to FIG. 4, a cylindrical support portion 12C extends from the front end wall of the front housing 12 to surround the front end of the rotary shaft 16. The inner cylindrical portion 17E and the cylindrical support portion 12C interpose the bearing 18. Namely, the upstream pulley member 17A is rotatably supported by the cylindrical support portion 12C.

[0040] The plurality of power transmitting pins, power transmission cutting means or breaking members 17G is fixed to the radially outer portion of the disc-shaped portion 17F on the front side. Although only two power transmitting pins 17G are illustrated in the drawing, the plurality of power transmitting pins 17G is located at equiangular positions on the disc-shaped portion 17F. The power transmitting pins 17G includes a cylindrical portion and a collar portion that is integrally formed on the axially middle portion of the cylindrical portion. The rear end of the power transmitting pin 17G is fixedly inserted into a through hole formed in the disc-shaped portion 17F while the front end of the power transmitting pin 17G protrudes in the axial direction of the rotary shaft 16. In the preferred embodiment, the power transmitting pins 17G are made of sintered metal. The sintered metal has a fatigue limit ratio σ_W/σ_B of approximately 0.5 where σ_W and σ_B respectively denote fatigue strength and tensile strength.

[0041] The downstream pulley member 17B is located in front of the disc-shaped portion 17F. The downstream pulley member 17B includes an inner cylindrical portion 17L and a flange 17M. The flange 17M extends radially from the rear end of the inner cylindrical portion 17L. The inner cylindrical portion 17L and the flange 17M are integrated into a single component.

[0042] The damping members 17N are cylindrical rubbers and are fixedly placed in through holes in the radially outer portion of the flange 17M so that the damping members receive the corresponding power transmitting pins 17G. Accordingly, in the pulley 17 of the preferred embodiment, as the power is transmitted to the upstream pulley member 17A through the above described belt B2, the power is subsequently transmitted to the downstream pulley member 17B through the power transmitting pins 17G and the damping members 17N. In other words, the power transmitting pins 17G and the damping members 17N are placed in a power transmission path between the upstream pulley member 17A and the downstream pulley member 17B.

[0043] The first one-way clutch assembly 66 is located between the rotary shaft 16 and the inner cylindrical portion 17L. In other words, the first one-way clutch assembly 66 is located in the power transmission path between the pulley 17 and the rotary shaft 16. The bearing mechanism 68 includes a plurality of balls or rolling components 71. The first one-way clutch assembly 66 further includes a one-way clutch mechanism or a clutch mechanism 67 and a bearing mechanism 68. The one-way clutch mechanism 67 and the bearing mechanism 68 are integrated in the first one-way clutch assembly 66 and are aligned in the axial direction of the rotary shaft 16. The first one-way clutch assembly 66 further includes an outer ring 69 and an inner ring 70. The outer ring 69 is fixedly connected to the inner circumferential surface of the inner cylindrical portion 17L. The inner ring 70 is fixedly connected to the outer circumferential surface of the rotary shaft 16 and is surrounded by the

outer ring 69. The balls 71 are circumferentially arranged between the outer ring 69 and the inner ring 70 so that the outer ring 69 rotates relative to the inner ring 70.

[0044] Now referring to FIGs. 5A and 5B, in the one-way clutch mechanism 67, a plurality of recesses 72 is formed in the inner circumferential wall of the outer ring 69 at equiangular positions around the rotary shaft 16. Each recess 72 accommodates a roller 74 that is placed in parallel with the rotary shaft 16. A depth of the clockwise or right end of each recess 72 is smaller than that of the middle so that a power transmitting surface 73 is formed at the right end of each recess 72. As illustrated in FIG. 5A, the roller 74 is movable in the recess 72 and is in contact with the power transmitting surface 73 at a contact position. The roller 74 leaves the power transmitting surface 73 at a non-contact position as illustrated in FIG. 5B. The roller 74 travels between the contact position and the non-contact position. A spring seat member 75 is located at an opposite end relative to the power transmitting surface 73 in each recess 72. A spring 76 is placed between the spring seat member 75 and the roller 74 for urging the roller 74 toward the power transmitting surface 73.

[0045] Referring to FIG. 5A, as the power is transmitted from the engine E to the pulley 17, the outer ring 69 rotates in the direction indicated by an arrow. Due to the above rotation, the roller 74 travels to the contact position to contact the power transmitting surface 73 by urging force of the spring 76. The power transmitting surface 73 and the outer circumferential surface of the inner ring 70 engage the roller 74 due to the shape of the recess 72 or a wedge function. As a result, the inner ring 70 is rotated in the same direction as the outer ring 69. As described with respect to FIG. 4, the power of the engine E is transmitted to the rotary shaft 16 through the pulley 17 and the one-way clutch mechanism 67, and the rotary shaft 16 is regularly rotated.

[0046] Referring to FIG. 5B, on the other hand, as the inner ring 70 initiates to rotate in the direction indicated by an arrow after the engine E and the pulley 17 stop their rotation, the roller 74 is disengaged from the contact position against the urging force of the spring 76. As a result, the inner ring 70 idles relative to the outer ring 69 and fails to transmit its rotation.

[0047] Referring back to FIG. 4, the electric motor 77 is located substantially located in a donut-shaped space defined by the outer cylindrical portion 17D and the downstream pulley member 17B. A stator 78 of the electric motor 77 is secured to the inner circumferential surface of a cylindrical portion 79A of a cylindrical stator side support member 79. The stator 78 includes a permanent magnet.

[0048] The substantially cylindrical stator side support member 79 and a housing side support member 81 constitute a support member. In other words, the stator 78 not only is fixed to the front housing 12 but also is supported by the rotary shaft 16 through the bearing 80. The

cylindrical stator side support member 79 includes the cylindrical portion 79A, a disc-shaped portion 79B and a protruding portion 79D. The disc-shaped portion 79B extends radially and inwardly from the front end of the cylindrical portion 79A. The protruding portion 79D extends in the axial direction of the rotary shaft 16 from the rear end surface of the disc-shaped portion 79B. The cylindrical portion 79A, the disc-shaped portion 79B and the protruding portion 79D are integrated into a single component. The disc-shaped portion 79B forms a through hole 79C at its center, and a bearing 80 is placed between the inner circumferential surface of the through hole 79C and the outer circumferential surface of the rotary shaft 16. In other words, the stator side support member 79 is supported by the rotary shaft 16 through the bearing 80.

[0049] The stator side support member 79 is also anchored to the front housing 12 by the housing side support member 81. The substantially L-shaped housing side support member 81 includes a proximal portion 81A, a fixing portion 81B and a connecting portion 81C. The proximal portion 81A is detachably connected to the front housing 12 via a bolt 12D. The fixing portion 81B is detachably connected to the stator side support member 79 via a bolt 82A and a nut 82B. The connecting portion 81C interconnects the proximal portion 81A and the fixing portion 81B. The connecting portion 81C extends in the axial direction of the rotary shaft 16 over the outer cylindrical portion 17D in such a manner that the above described belt B2 does not contact the connecting portion 81C.

[0050] Now referring to FIG. 6, a diagram illustrates a perspective view of the housing side support member 81. Through holes 81D are formed in the proximal portion 81A for inserting a bolt in an oblong shape that extends in the direction indicated by an arrow in the drawing. Namely, a fixing position of the housing side support member 81 is adjustable in the above direction. Additionally, through holes 81E are formed in the lower end of the fixing portion 81B for inserting a bolt.

[0051] Referring back to FIG. 4, the electric motor 77 includes the stator 78, the stator side support member 79, the bearing 80, the housing side support member 81, the bolts 82A, the nuts 82B, a rotor 83, a brush 84 and a power cable 84A. The electric motor 77 is substantially located in the donut-shaped space that is exposed to an opposite side relative to the front housing 12. The rotor 83 is located inside the cylindrical portion 79A to face the stator 78. The rotor 83 includes an annular proximal portion 83A, a rotor iron core 83B and a coil 83C. The coil 83C winds around the rotor iron core 83B to receive electric current through the brush 84 that is secured to the protruding portion 79D. The electric motor 77 drives the rotor 83 by an interaction of magnetic force from the stator 78 and the rotor 83. The stator side support member 79, the bearing 80, the stator 78, the rotor 83 and the brush 84 are substantially located in the space which is partially defined by the outer cy-

lindrical portion 17D.

[0052] The brush 84 is electrically connected to a battery through the power cable 84A and a drive circuit. The drive circuit and the battery are not shown in the drawing. The power cable 84A constitutes a power supply path between the battery and the electric motor 77. The power cable 84A extends from the brush 84 and exits through a hole that extends through the disc-shaped portion 79B and the fixing portion 81B. The power cable 84A protrudes toward the front side of the power transmitting mechanism PT. The drive circuit controls electric current from the battery to the brush 84 in response to a command from a controller, which is not shown in the drawing.

[0053] The second one-way clutch assembly 85 is placed in a power transmission path between the rotor 83 and the rotary shaft 16. The second one-way clutch assembly 85 has substantially the same structure as that of the first one-way clutch assembly 66. For the above reason, the same reference numerals are assigned to substantially the identical components of the first one-way clutch assembly 66, and the description of the substantially identical components is omitted. In the second one-way clutch assembly 85, the outer ring 69 is fixedly connected to the inner circumferential surface of the annular proximal portion 83A, and the inner ring 70 is fixedly connected to the connecting member 86 that is secured to the outer circumferential surface of the rotary shaft 16. In details, the connecting member 86 includes an annular proximal portion 86A, a cylindrical portion 86B and a disc-shaped portion 86C. The proximal portion 86A is secured to the outer circumferential surface of the rotary shaft 16 at the front side of the first one-way clutch assembly 66. The inner ring 70 of the second one-way clutch assembly 85 is secured to the cylindrical portion 86B. The proximal portion 86A and the cylindrical portion 86B are interconnected by the disc-shaped portion 86C that is located at the front side of the downstream pulley member 17B.

[0054] In the preferred embodiment, the electric motor 77 is detachable from the compressor main body C while the pulley 17 and the first one-way clutch assembly 66 are connected to the compressor main body C. Namely, the electric motor 77 is detachable from the compressor main body C through the front side of the pulley 17 and the first one-way clutch assembly 66 without detaching the pulley 17 and the first one-way clutch assembly 66.

[0055] In the preferred embodiment, upon operation of the engine E, the power of the engine E is regularly transmitted to the rotary shaft 16 through the pulley 17 and the first one-way clutch assembly 66. Meanwhile, if air-conditioning is required while the engine E is not running, the electric motor 77 is actuated to rotate the rotary shaft 16 through the second one-way clutch assembly 85.

[0056] The controller controls the drive circuit of the electric motor 77 to disrupt the electric current to the

brush 84 during the engine E operation. The power of the engine E is transmitted from the outer ring 69 to the inner ring 70 in the first one-way clutch assembly 66 so as to rotate the rotary shaft 16. Namely, the first one-way clutch assembly 66 is in a connected state for the power transmission during the engine E operation. Meanwhile, the inner ring 70 of the second one-way clutch assembly 85 integrally rotates with the rotary shaft 16. However, the inner ring 70 of the second one-way clutch assembly 85 idles relative to the outer ring 69 of the second one-way clutch assembly 85 and fails to transmit the power to the rotor 83. Namely, the second power transmission clutch assembly 85 is in a disconnected state during the engine E operation.

[0057] A cogging torque is a minimum load for rotating the rotor 83 based upon magnetic force of the stator 78. Sufficient torque from the rotary shaft 16 is needed to overcome the cogging torque to initiate the rotation of the rotor 83. In the preferred embodiment, since torque transmitted from the inner ring 70 to the outer ring 69 in the second one-way clutch assembly 85 is smaller than the above cogging torque, the second one-way clutch assembly 85 fails to transmit the power. Namely, when the brush 84 is not supplied with electric current, even if the rotary shaft 16 rotates, the rotor 83 substantially fails to rotate.

[0058] If air-conditioning is required for cooling after the engine E is stopped, the controller sends a command to the drive circuit so that the drive circuit supplies the brush 84 with electric current to actuate the electric motor 77. Then, the rotor 83 of the electric motor 77 generates the rotational power that is transmitted to the rotary shaft 16 through the outer ring 69 to the inner ring 70 in the second one-way clutch assembly 85. In summary, the second one-way clutch assembly 85 is in a connected state for the power transmission during the electric motor 77 operation so as to activate air-conditioning in a passenger compartment after the engine E has stopped.

[0059] Meanwhile, the inner ring 70 of the first one-way clutch assembly 66 integrally rotates with the rotary shaft 16. However, the inner ring 70 of the first one-way clutch assembly 66 idles relative to the outer ring 69, and almost no power of the electric motor 77 is transmitted to the pulley 17. Namely, the first power transmission clutch assembly 66 is in a disconnected state during the electric motor 77 operation.

[0060] In the preferred embodiment, the power is initially transmitted from the engine E to the upstream pulley member 17A. An offset between the pulley members 17A and 17B causes stress on bearing members such as the radial bearing 12A, the bearing mechanism 68 of the first one-way clutch assembly 66 and the bearing 18. The power is transmitted from the upstream pulley member 17A to the downstream pulley member 17B through the damping members 17N and the power transmitting pins 17G. Since the damping members 17N are placed in a power transmission path between the

upstream pulley member 17A and the downstream pulley member 17B, the offset between central axes of the pulley members 17A and 17B is absorbed. That is, the damping member 17N elastically deforms and reduces the above stress. In addition, vibration of the rotary shaft 16 or torque variation due to compression reactive force is generated in the compression mechanism. That is, the damping member 17N restricts the above vibration to transmit from the downstream pulley member 17B to the upstream pulley member 17A by its damping function. In addition, the above vibration includes mainly two rotational components. In the preferred embodiment, the first one-way clutch assembly 66 including the one-way clutch mechanism 67 is placed between the pulley 17 and the rotary shaft 16. The one-way clutch mechanism 67 substantially does not transmit one of the above components from the rotary shaft 16 to the pulley 17.

[0061] In the preferred embodiment, when torque transmitted in a predetermined normal range between the upstream pulley member 17A and the downstream pulley member 17B does not damage the engine E, the power is continuously transmitted from the engine E to the rotary shaft 16. On the other hand, when abnormality such as a deadlock occurs in the compressor main body C and the transmission torque exceeds a predetermined value, the power transmitting pins 17G break due to the above excessive load. Due to the above break, power transmission is blocked between the upstream pulley member 17A and the downstream pulley member 17B. Thus, the engine E is prevented from being damaged by the excessive transmission torque.

[0062] According to the preferred embodiment, the following advantageous effects are obtained.

(1) In the compressor 92, the electric motor 77 is connected to the compressor main body C while the pulley 17 and the first one-way clutch assembly 66 are being assembled to the compressor main body C. In comparison to a structure that restricts to connect an electric motor to a compressor main body while a pulley and a first one-way clutch assembly are being assembled to the compressor main body, the electric motor 77 is easily assembled to the compressor main body C in the preferred embodiment.

In addition, a compressor with an electric motor and a compressor without an electric motor optionally have common components. For example, the pulley 17, the bearing 18 and the first one-way clutch assembly 66 can be the common components. A compressor driven by an engine is an engine-driven compressor, while a compressor selectively driven by an engine and an electric motor is a hybrid compressor. If the above common components are applied to the above compressors, the engine-driven compressor is easily modified into the hybrid compressor. Furthermore, since the identical components are used, the above modification costs

are relatively low.

(2) The electric motor 77 is connected from the front side of the pulley 17 and the first one-way clutch assembly 66. Due to the above structure, since the housing does not interfere with assembling the electric motor 77, the electric motor 77 is easily assembled to the compressor main body C.

(3) The stator 78 is supported by the stator side support member 79 that is connected to the housing side support member 81. The housing side support member 81 is connected to the housing and extends over the outer circumference of the pulley 17 to the stator side. Due to the above support, the stator 78 is located at the front side of the pulley 17.

(4) In the preferred embodiment, the stator 78 is supported by the support member that includes the stator side support member 79 and the housing side support member 81. One end of the support member near the through hole 79C is supported by the rotary shaft 16 through the bearing 80, and the other end of the support member is supported by the front housing 12. In comparison to a structure that includes a support member that is supported only at its one end, the support member and the rotary shaft 16 improve their relative stability in the preferred embodiment. Due to the improved stability, a narrow clearance is accurately maintained between the stator 78 and the rotor 83. The narrow clearance facilitates a sufficient output power from the electric motor 77.

(5) The support member includes the housing side support member 81 and the stator side support member 79, and the stator side support member 79 is located on the stator side and is fixedly connected to the housing side support member 81. Due to the above structure, for example, when the pulley 17 needs to be enlarged in its diameter, the housing side support member 81 is replaced to avoid the interference with the pulley 17. In other words, the enlargement of the pulley 17 is permitted only by replacing the housing side support member 81. Accordingly, in comparison to a support member that integrates a housing side support member and a stator side support member, costs are reduced for enlarging the diameter of the pulley 17 in the preferred embodiment.

(6) The through holes 81 D are oblong-shaped and extend in the axial direction of the rotary shaft 16. Due to the above structure, a position of the support member 79, 81 is adjustable in the axial direction. For example, without changing the size of the support member in the axial direction, the stator 78 can be moved or resized in the axial direction.

(7) The power cable 84A exits from the front side of the pulley 17. Due to the above structure, the power cable 84A is wired inside the pulley 17 in such a manner that it does not need to cross any significant width of the pulley 17. For the above reason, the power cable 84 will easily be assembled.

(8) The entire electric motor 77 is substantially located in the donut-shaped space defined by the outer cylindrical portion 17D and the downstream pulley member 17B. In comparison to a structure that an electric motor is not located in the donut-shaped space, the size of the compressor 92 is reduced in the axial direction of the rotary shaft 16 in the preferred embodiment.

(9) The first one-way clutch assembly or the first power transmission clutch assembly 66 is placed in the first power transmission path between the pulley 17 and the rotary shaft 16, and the second one-way clutch assembly or the second power transmission clutch assembly 85 is placed in the second power transmission path between the electric motor 77 and the rotary shaft 16. Namely, the first and second power transmission paths independently include the respective first and second power transmission clutch assemblies 66 and 85. The independently located first and second power transmission clutch assemblies 66 and 85 permit one of the power transmission paths to be connected while they leave the other disconnected. For example, when the electric motor 77 is inactive, the first and second power transmission clutch assemblies 66 and 85 enable the rotary shaft 16 to be driven by the power transmitted from the engine E.

Meanwhile, when the rotary shaft 16 is required to drive the rotor 83, the rotary shaft 16 needs to overcome the cogging torque due to the stator or the permanent magnet 78. The torque overcoming the cogging torque corresponds to rotational load of the rotary shaft 16. In the preferred embodiment, when the first one-way clutch assembly 66 is connected and the second one-way clutch assembly 85 is disconnected, the second one-way clutch assembly 85 blocks the cogging torque from being applied to the rotary shaft 16 while the first one-way clutch assembly 66 enables the rotary shaft 16 to be driven by the engine E. As a result, the above rotational load is efficiently blocked from being transmitted.

Incidentally, when the size of the electric motor 77 is reduced and is configured to drive the rotary shaft 16 at a relatively low speed. Even if the rotary shaft 16 is being rotated at a relatively high speed by the pulley 17, since the second one-way clutch assembly 85 is disconnected, the rotor 83 cannot be rotated. In other words, excessive induced electromotive force is prevented from being generated at the coil 83C due to the forced rotation. Due to the

above prevention, heating due to the excessive induced electromotive force upon the electric motor 77 will also be prevented. In the preferred embodiment, the first and second power transmission clutch assemblies 66 and 85 are respectively placed in the power transmission paths between the pulley 17 and the rotary shaft 16 and between the electric motor 77 and the rotary shaft 16. The structure of the preferred embodiment is particularly effective to prevent the electric motor 77 from being rotated at a relatively high speed when the electric motor 77 is used in the range of a relatively low speed.

(10) In the preferred embodiment, both clutch mechanisms of the first and second power transmission clutch assemblies 66 and 85 are one-way clutch mechanisms, and no controller is needed for the first and second one-way clutch assemblies 66 and 85. The structure of the compressor 92 will be simpler than power transmission clutch assemblies that include at least one electromagnetic clutch assembly.

(11) Each of the first and second one-way clutch assemblies 66 and 85 includes the one-way clutch mechanism 67 and the bearing mechanism 68, and the above two mechanisms 67, 68 are integrated. In comparison to a one-way clutch mechanism that is independent from a bearing mechanism, the one-way clutch assembly has a reduced number of independent components in the preferred embodiment.

(12) The power transmission cutting means or the power transmitting pin 17G is placed in the power transmission path between the pulley 17 and the rotary shaft 16. Due to the above structure, if abnormality such as a deadlock occurs in the compressor main body C, the power transmission cutting means 17G prevents excessive load from damaging the engine E.

(13) The power transmitting pin 17G is made of sintered metal. Since the sintered metal has a relatively low ductility, when excessive transmission torque is applied to the power transmitting pin 17G, it is easy to set a threshold value to break the power transmitting pin 17G. In addition, the sintered metal ensures a relatively high fatigue limit ratio σ_W/σ_B . For the above reason, the power transmitting pin 17G has high durability despite repeated stress on the power transmitting pin 17G during normal power transmission state and has an effective balance between the durability and breakage. In summary, the power transmitting pin 17G made of sintered metal ensures a relatively high durability for the normal power transmission and prevents excessive trans-

mission torque.

(14) The damping member 17N is placed in the power transmission path between the upstream pulley member 17A and the downstream pulley member 17B. Due to the above structure, the damping member 17N absorbs rotational vibration that is caused by the offset due to a dimensional tolerance between the rotational axes of the upstream and downstream pulley members 17A and 17B. Namely, the damping member 17N deforms itself to reduce stress due to the above offset on the bearing members such as the radial bearing 12A, the bearing mechanism 68 and the bearing 18. As a result, durability of the compressor 92 improves.

(15) The damping member 17N damps the rotational vibration or the transmission torque variation that is transmitted from the downstream pulley member 17B to the upstream pulley member 17A. As a result, resonance due to the above transmission torque variation is also restricted between the engine E and the rotary shaft 16.

(16) In the preferred embodiment, the compression mechanism is designed to reduce its displacement per unit rotation of the rotary shaft 16 to approximately zero. Furthermore, the above displacement is optionally adjusted to approximately zero while the rotary shaft 16 is being driven. Namely, when air-conditioning is not required, load is reduced for driving the rotary shaft 16 to approximately zero.

(17) The displacement or the refrigerant flow rate per unit time in the compressor main body C mainly correlates with the load torque of the compressor main body C. In the preferred embodiment, the controller sends an external command to the control valve 43 and directly controls the above displacement. For example, the refrigerant flow rate is accurately and responsively maintained below a predetermined value without a sensor for detecting the refrigerant flow rate.

[0063] The present invention is not limited to the above-described preferred embodiment, but is modified into the following alternative embodiments.

[0064] In alternative embodiments to the preferred embodiment, the rotor 83 and the connecting member 86 are directly connected without the second one-way clutch assembly 85.

[0065] In alternative embodiments to the preferred embodiment, the power cable 84A exits on the housing side from the pulley 17.

[0066] In alternative embodiments to the preferred embodiment, the housing side support member 81 includes a cutout portion that extends from the rear edge of the proximal portion 81A in predetermined length in

the axial direction of the rotary shaft 16, instead of the oblong through hole 81D. The location of the housing side support member 81 is adjustable in the axial direction of the rotary shaft 16.

[0067] In alternative embodiments to the preferred embodiment, the location of the housing side support member 81 is not adjustable in the axial direction of the rotary shaft 16.

[0068] In alternative embodiments to the preferred embodiment, the stator side support member 79 and the housing side support member 81 are not detachable with each other. For example, the housing side support member 81 is welded to the stator side support member 79. Also, for example, the housing side support member 81 and the stator side support member 79 are integrated into a single component.

[0069] In alternative embodiments to the preferred embodiment, the support member is supported only by the front housing 12 without the rotary shaft 16.

[0070] In alternative embodiments to the preferred embodiment, the one-way clutch mechanism 67 and the bearing mechanism 68 of each of the first and second one-way clutch assemblies 66 and 85 are independently provided from each other.

[0071] In alternative embodiments to the preferred embodiment, one of the first and second power transmission clutch assemblies is a one-way clutch assembly, while the other is an electromagnetic clutch assembly. In another alternative embodiment, both of the first and second power transmission clutch assemblies are electromagnetic clutch assemblies.

[0072] In alternative embodiments to the preferred embodiment, the fatigue limit ratio σ_W/σ_B of the sintered metal for the breaking member is not limited to approximately 0.5 as far as the threshold value for breaking the breaking member is set in an adequate range, when transmission torque exceeds the threshold value on the breaking member.

[0073] In alternative embodiments to the preferred embodiment, the breaking member is made of low-carbon steel instead of sintered metal. The low-carbon steel ensures the fatigue limit ratio σ_W/σ_B of approximately 0.5. Due to the above property, the low-steel carbon ensures relatively high durability against repeated stress that acts on the breaking member in a normal power transmission state, and effectively balances the above durability and the transmission torque that breaks the breaking member. Accordingly, the breaking member has high durability for transmitting the power transmission in a normal power transmission state, while it cuts the power transmission when the transmission torque exceeds a threshold value.

[0074] In alternative embodiments to the preferred embodiment, the breaking member is made of a material other than metal. As far as the material breaks when it experiences transmission torque that exceeds a threshold value, any material such as resin and ceramic is applicable.

[0075] In alternative embodiments to the preferred embodiment, the power transmission cutting means includes an engaging member instead of the breaking member. For example, the engaging member is placed in a power transmission path between the upstream rotary body and the downstream rotary body. The engaging member differs from the breaking member in that it selectively disengages at least one of the above rotary bodies without breaking itself in order to operatively disconnect the other one of the above rotary bodies.

[0076] In alternative embodiments to the preferred embodiment, the power transmission cutting means or the power transmitting pin 17G is omitted.

[0077] In alternative embodiments to the preferred embodiment, the damping member 17N is made of elastomer instead of rubber.

[0078] In alternative embodiments to the preferred embodiment, the damping member 17N is omitted.

[0079] In alternative embodiments to the preferred embodiment, a one-way clutch mechanism does not include the wedge function as mentioned above. For example, as far as power is transmitted from the pulley 17 or the electric motor 77 to the rotary shaft 16 while the power transmission is being blocked from the rotary shaft 16 to the pulley 17 or the electric motor 77, any one-way clutch mechanisms are applicable.

[0080] In alternative embodiments to the preferred embodiment, the bearing mechanism 68 includes a plurality of in-line balls that is aligned in the axial direction of the rotary shaft 16.

[0081] In alternative embodiments to the preferred embodiment, a single pressure monitoring point is located in a refrigerant circuit, instead of two monitoring points. The control valve 43 adjusts a position of the valve body portion 52 in response to detected pressure at the single pressure monitoring point. Incidentally, the control valve 43 is designed to vary a position of the valve body portion 52 only by an external command.

[0082] In alternative embodiments to the preferred embodiment, the control valve 43 is designed to mechanically vary a position of the valve body portion 52, instead of the control valve 43 that is designed to externally vary a normal position of the valve body portion 52.

[0083] In alternative embodiments to the preferred embodiment, the power transmitting mechanism PT is employed to a double-headed piston type compressor that includes a double-headed piston for exerting pressure on fluid in a cylinder bore formed on both sides of a crank chamber.

[0084] In alternative embodiments to the preferred embodiment, instead of the compressor main body C having the swash plate or the cam plate 20 that rotates integrally with the rotary shaft 16, the compressor main body C has a cam plate that is supported by a rotary shaft, and the cam plate oscillates relative to the rotary shaft. For example, the compressor main body C is a wobble type compressor.

[0085] In alternative embodiments to the preferred

embodiment, the compressor main body C is not configured to vary its displacement to substantially zero.

[0086] In alternative embodiments to the preferred embodiment, the compressor main body C is a fixed displacement compressor. Due to the above structure, the piston 25 reciprocates over a constant stroke distance.

[0087] In alternative embodiments to the preferred embodiment, the compressor main body C is a rotary type compressor such as a scroll type compressor. In other alternative embodiments to the preferred embodiment, the rotary body is replaced by a sprocket or a gear.

[0088] In alternative embodiments to the preferred embodiment, a rotary machine is not a compressor but a power steering pump. The rotary machine for a vehicle includes an electric motor, and a rotary shaft of the rotary machine is selectively driven by the electric motor and an external drive source.

[0089] In alternative embodiments to the preferred embodiment, a rotary machine does not include an electric motor and is driven only by an external drive source, and a first power transmission clutch assembly in the power transmission path between a rotary body and a rotary shaft is replaced by an annular spacer. For example, in a state where the electric motor 77, the second one-way clutch assembly 85 and the connecting member 86 are removed from the compressor 92, the first one-way clutch assembly 66 is replaced by the above spacer. Thus, a power transmitting mechanism PT of the alternative embodiment is simpler than that of the preferred embodiment. In this case, the components of the rotary body such as the pulley 17 and the bearing 18 are common between the rotary machine with the electric motor and the rotary machine without the electric motor.

[0090] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.

Claims

1. A rotary machine for a vehicle having an external drive source to drive the rotary machine, the rotary machine comprising:
 - a housing;
 - a pressure exerting mechanism located in the housing;
 - a rotary shaft rotatably supported by the housing to drive the mechanism, one end of the rotary shaft protruding from the housing on a protrusion side;
 - a rotary body coaxially located on the rotary shaft on the protrusion side, the rotary body being operatively connected to the rotary shaft to

form a first power transmission path between the rotary body and the rotary shaft, the rotary body forming a cylinder having an open end at one end and a closed surface at the other end, the closed surface being adjacent to the housing;

a first power transmission clutch assembly located in the first power transmission path for selectively transmitting power between the rotary body and the rotary shaft; and
an electric motor at least partially located in the cylinder for selectively driving the rotary shaft, the electric motor including a rotor and a stator.

2. The rotary machine according to claim 1, wherein the rotary body including:

a connecting portion extending substantially in a radial direction of the rotary shaft to a peripheral end of the rotary body; and

an outer cylindrical portion connected near the peripheral end of the connecting portion and extending substantially parallel to the axis of the rotary shaft away from the housing, the outer cylindrical portion being operatively connected to the external drive source for transmitting power from the external drive source to the first power transmission path, an inner space being defined by the connecting portion and the outer cylindrical portion.

3. The rotary machine according to claim 1 further comprising:

a power transmission cutting means located in the first power transmission path for cutting the first power transmission path when torque transmission exceeds a predetermined value between the rotary body and the rotary shaft.

4. The rotary machine according to claim 1 further comprising:

a damping member located in the first power transmission path.

5. The rotary machine according to claim 1, wherein the electric motor is detachable from the open end of the rotary body.

6. The rotary machine according to claim 5, wherein the electric motor includes a power cable for supplying the electric motor with electric power, and the power cable exits from the open end of the rotary body.

7. The rotary machine according to claim 5 further comprising:

a support member fixed to the housing and extending over an outer circumference of the cylinder to the electric motor, the stator being supported by the support member.

8. The rotary machine according to claim 7, wherein a position of the support member is adjustable with respect to the electric motor in the direction of the axis of the rotary shaft.

9. The rotary machine according to claim 7 further comprising:

a bearing supporting the rotary shaft and one end of the support member.

10. The rotary machine according to claim 7, wherein the support member includes:

a housing side support member detachably fixed to the housing, the housing side support member extending over the outer circumference of the cylinder; and

a stator side support member detachably fixed to the housing side support member, the stator side support member being located near the stator.

11. The rotary machine according to claim 7, wherein the support member includes a through hole in an oblong shape that extends in a direction of an axis of the rotary shaft.

12. The rotary machine according to claim 1 further comprising:

a second power transmission clutch assembly located in a second power transmission path between the electric motor and the rotary shaft.

13. The rotary machine according to claim 12, wherein at least one of the first and second power transmission clutch assemblies is a one-way clutch assembly.

14. The rotary machine according to claim 12, wherein the first and second power transmission clutch assemblies are one-way clutch assemblies, and the first and second power transmission clutch assemblies are located in the cylinder.

15. The rotary machine according to claim 1, wherein the pressure exerting mechanism includes a compressor for exerting pressure on fluid.

16. The rotary machine according to claim 15, wherein the compressor further includes a variable displacement unit for varying its displacement per rotation

of the rotary shaft, and the displacement of the compressor is controllably decreased to zero.

17. A rotary body for transmitting power from an external drive source to a pressure exerting mechanism, a protrusion side of a rotary shaft protruding from a housing, the rotary body and an electric motor being coaxially located on the rotary shaft on the protrusion side for selectively driving the rotary shaft, the rotary body comprising:

a connecting portion connected to the rotary shaft and extending substantially in a radial direction of the rotary shaft to an peripheral end, the connecting portion being located between the electric motor and the housing; and an outer cylindrical portion connected to the peripheral end and extending substantially parallel to the axis of the rotary shaft away from the housing, whereby an inner space is defined by the connecting portion and the outer cylindrical portion, the inner space accommodating a substantial portion of the electric motor.

18. The rotary body according to claim 17 further comprising:

a power transmission clutch assembly placed between the rotary body and the rotary shaft for selectively enabling power transmission between the rotary body and the rotary shaft.

19. The rotary body according to claim 18, wherein the power transmission clutch assembly is a one-way clutch assembly.

20. A method of providing a rotary body and an electric motor to a main body of a rotary machine, the main body including a pressure exerting mechanism and a rotary shaft for driving the pressure exerting mechanism, the method comprising the steps of:

providing the rotary body with an inner space with an open end;
attaching the rotary body to the rotary shaft in such a manner to face the open end away from the housing; and
placing a substantial portion of the electric motor in the inner space after the attaching step.

21. The method of providing the rotary body and the electric motor to the main body of the rotary machine according to claim 20, wherein the placing step includes the steps of:

providing a support member for supporting the electric motor, the support member having an oblong hole for adjusting the support member

in an axial direction of the rotary shaft;
attaching the support member to the housing
via bolts through the oblong holes; and
adjusting a relative location of the support
member with respect to the electric motor and
the housing. 5

- 22.** The method of providing the rotary body and the
electric motor to the main body of the rotary ma-
chine according to claim 20 further comprising the
steps of; 10

removing the electric motor from the inner
space of the rotary body while the rotary body
is being attached to the main body; and 15
placing the electric motor in the inner space
while the rotary body is being attached to the
main body.

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FIG. 1

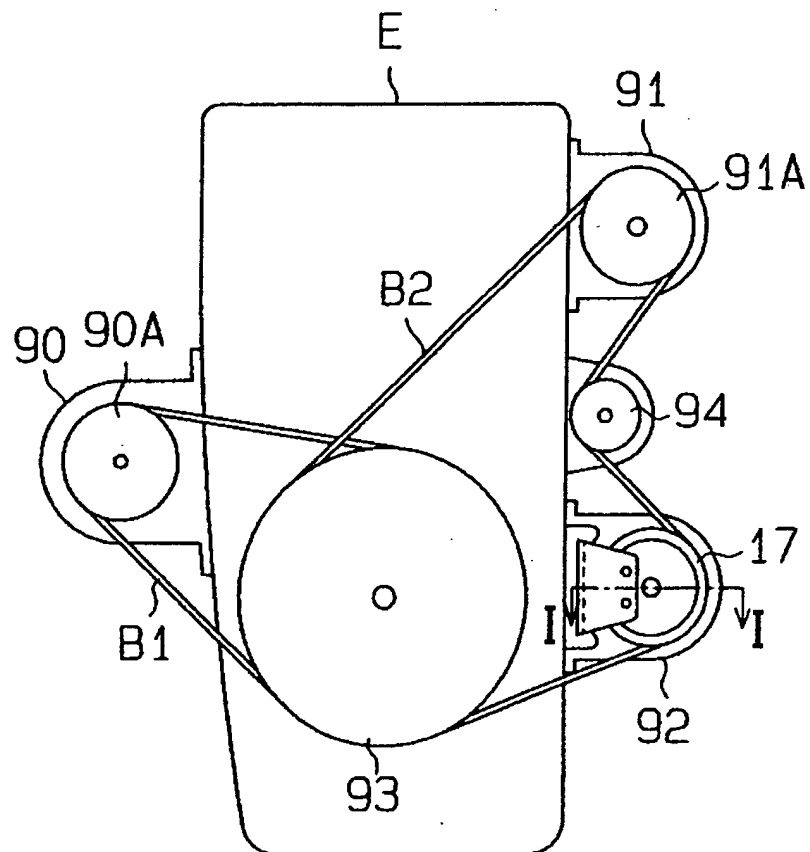


FIG. 2

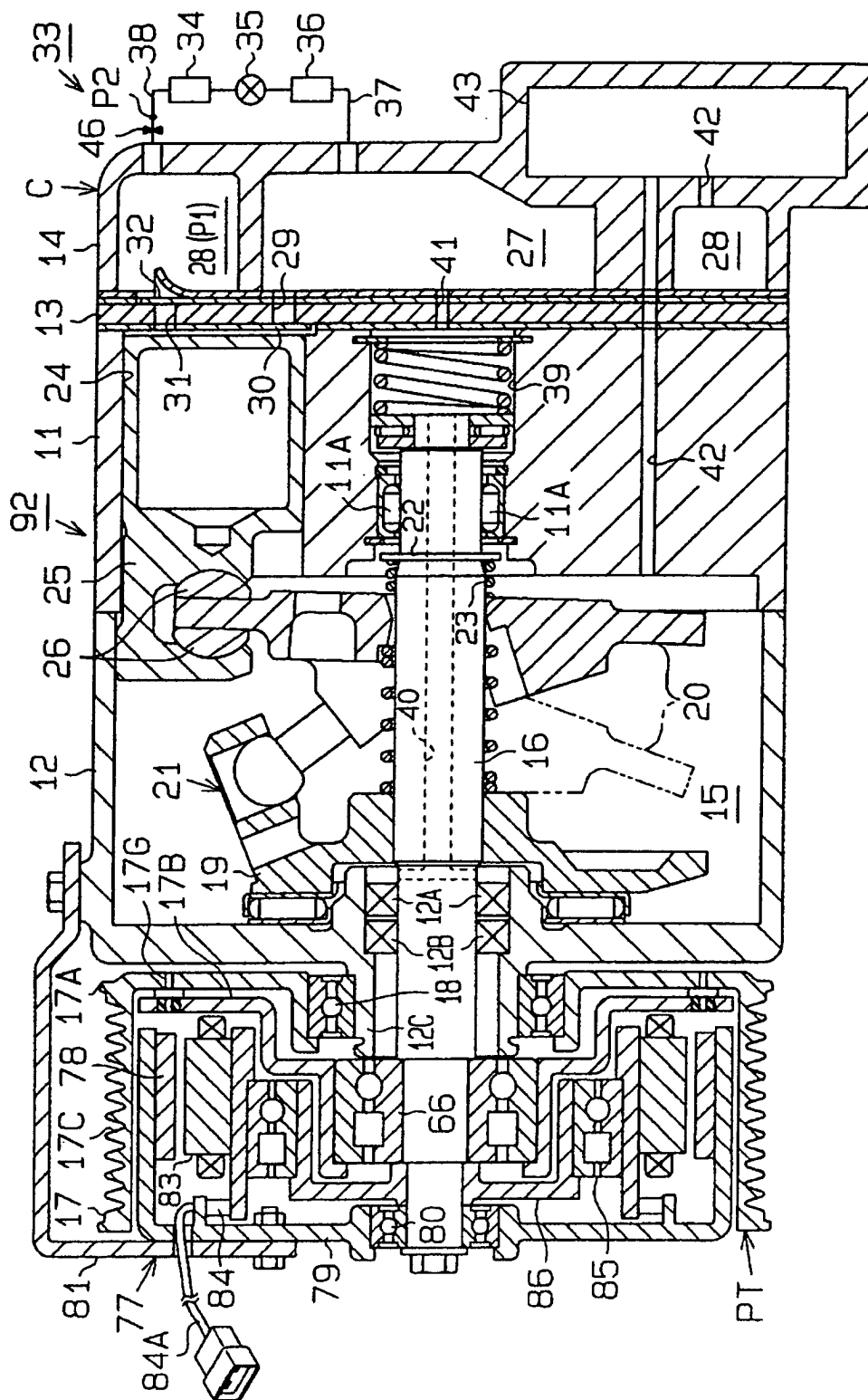


FIG. 3

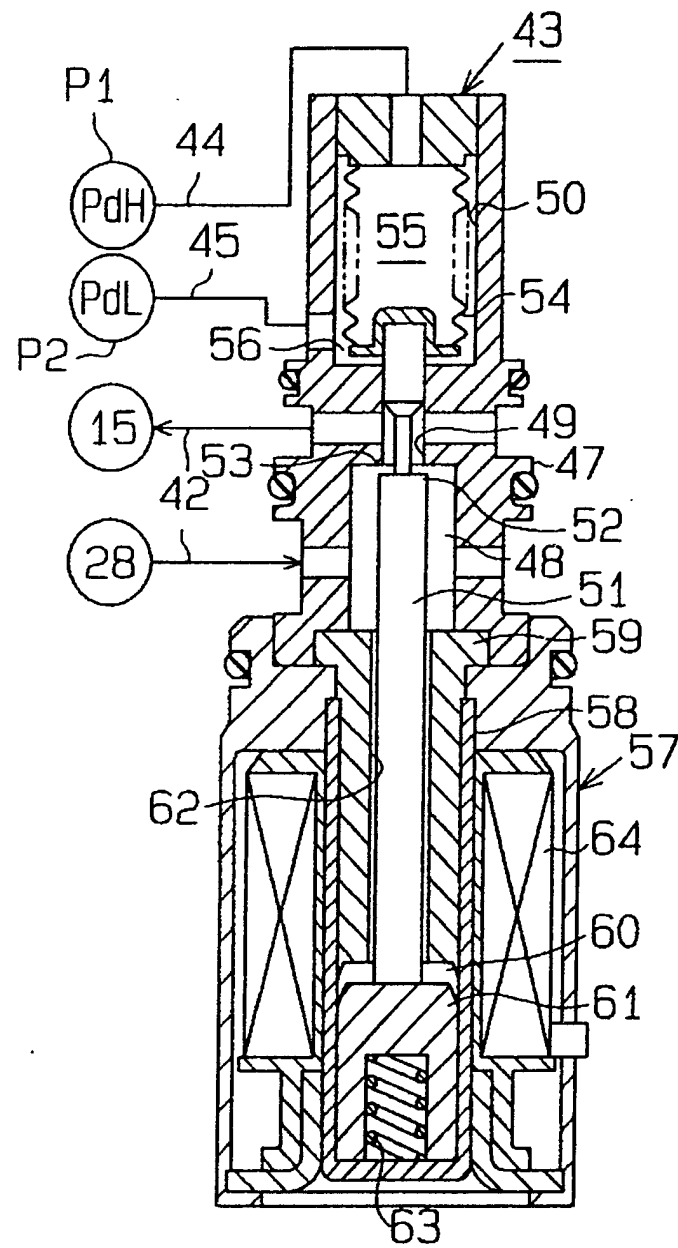


FIG. 4

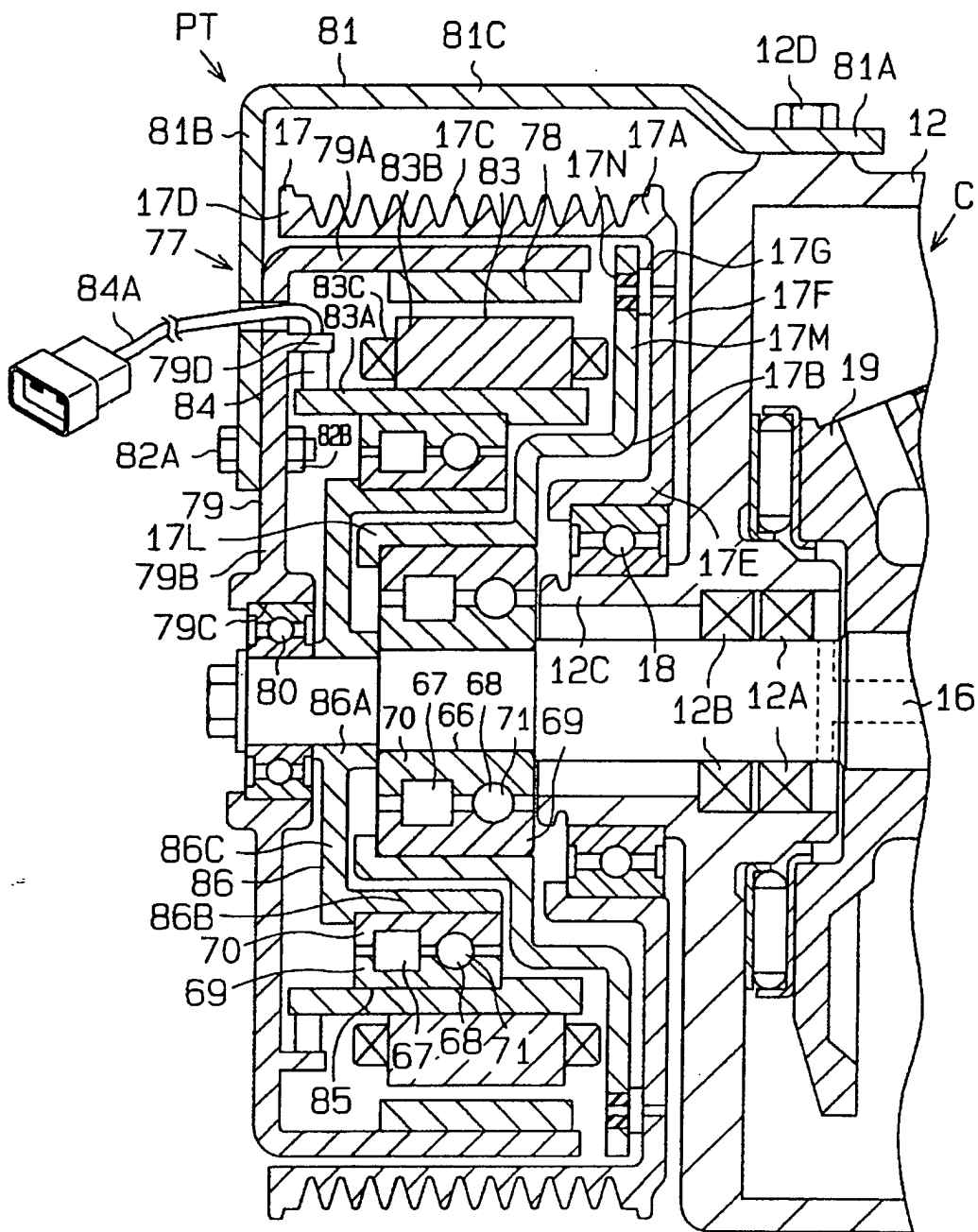


FIG. 5A

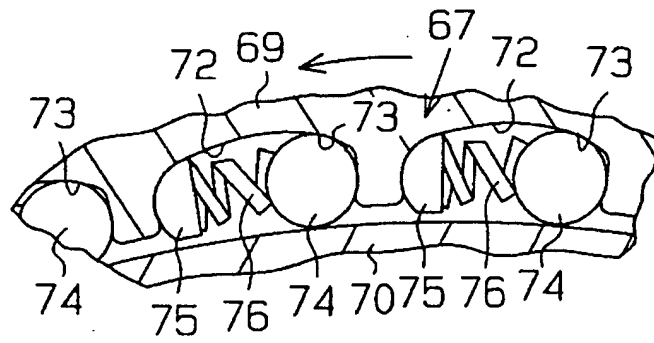


FIG. 5B

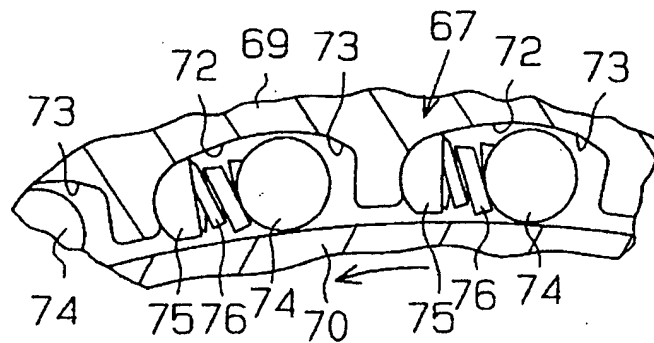


FIG. 6

