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(54) Air conditioning systems

(57) The air conditioning system 100 may include a compressor 101, a heating circuit 152, and a refrigerant releaser 181. The compressor 101 may have a suction port 115 for drawing refrigerant and a discharge port for 120 discharging compressed refrigerant. The heating circuit 152 has a passage 152a that extends from the discharge port 120 to the suction port 115 though a heat exchanger 159.

The refrigerant releaser 181 may release the refrigerant from the discharge port 120 to the suction port 115 when the discharge pressure Pd of the refrigerant results a predetermined high-pressure state during the operation of the heating circuit 152.

The air conditioning system 100 can solve a problem of insufficient heating performance due to releasing the refrigerant in the heating circuit into the cooling circuit to alleviate the abnormally high-pressure state during operation of the heating circuit.

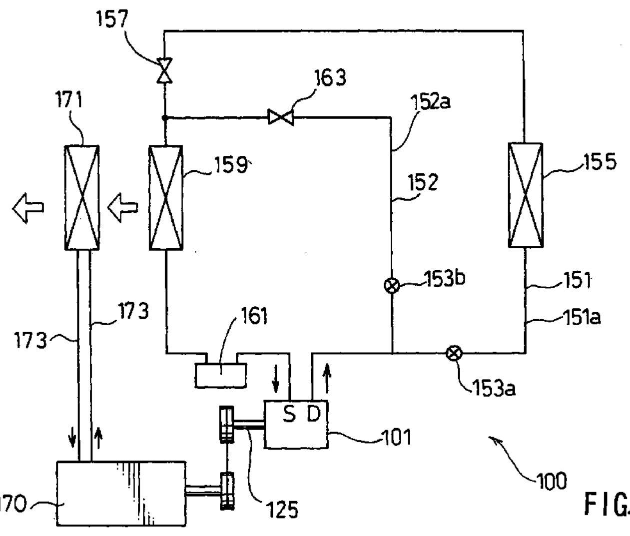


FIG. 2

EP 1 001 230 A2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to air conditioning systems that utilize refrigerants and a compressor, and particularly to air conditioning systems capable of alleviating excessive increases in refrigerant discharge pressure within a heating circuit.

Description of the Related Art

[0002] A known air conditioning system is disclosed in Japanese Patent Application No. 7-19630 and includes a compressor 1, a cooling circuit 51, a heating circuit 52 and a controller 83, as shown in FIG. 1. The cooling circuit 51 includes a condenser 55, a first expansion valve 57 and a heat exchanger 59 provided on a passage extending from a discharge port D to a suction port S of the compressor 1. High pressure refrigerant discharged from the discharge port D of the compressor 1 is drawn through the above respective devices and back to the compressor 1.

[0003] The heating circuit 52 includes a bypass passage 52a that extends from the discharge port D of the compressor 1 to the heat exchanger 59. A second expansion valve 63 provided within the bypass passage 52a between the discharge port D and the heat exchanger 59. The high pressure refrigerant discharged from the compressor 1 is not directed to the condenser 55, but rather is drawn by the compressor 1 through the second expansion valve 63 and the heat exchanger 59. Such a heating circuit 52 is generally known as a hot gas bypass heater.

[0004] The operation of the cooling circuit 51 and the heating circuit 52 is changeably selected by opening and closing selector valves 53a and 53b, which opening and closing operations are performed by the controller 83.

[0005] Because the refrigerant discharge pressure is higher when the heating circuit 52 is used than when the cooling circuit 51 is used, the air conditioning system must operate in a high pressure state when the heating circuit 52 is utilized. An abnormally high-pressure state may be created if the output discharge capacity of the compressor 1 temporarily increases during the operation of the heating circuit 52. A refrigerant releasing passage 91 having a pressure relief valve 93 is provided in order to release excess pressure from the heating circuit 52, if an abnormally high pressure state is reached. The refrigerant releasing passage 91 is connected to the heating circuit 52 and the cooling circuit 51 and the pressure relief valve 93 can be opened to release the refrigerant from the heating circuit 52 into the cooling circuit 51 when the refrigerant discharge pressure abnormally increases during the operation of the heating circuit 52.

[0006] Because the cooling circuit 51 and the heating circuit 52 are alternatively selected by the selector valves 53a and 53b, the refrigerant is released into the cooling circuit 51 which is not used in operation of the heating circuit 52, thereby preventing the discharge pressure at the heating circuit 52 from increasing abnormally.

[0007] However, because the refrigerant in the heating circuit 52 is released into the cooling circuit 51 whenever the discharge pressure abnormally increases, the amount of the refrigerant in the heating circuit 52 is reduced and heating performance may be reduced.

SUMMARY OF THE INVENTION

[0008] It is, therefore, an object of the present invention to quickly and effectively alleviate an abnormally high discharge pressure in an air conditioning system driven by utilizing refrigerant compressed by a compressor, and particularly in an air conditioning system having a hot gas bypass heater as a heating circuit.

[0009] The air conditioning system may include a compressor, a heating circuit, and a refrigerant releaser. The compressor has a suction port for drawing refrigerant and a discharge port for discharging compressed refrigerant. The heating circuit has a passage that extends from the discharge port to the suction port through a heat exchanger.

[0010] The refrigerant releaser may release the refrigerant from the discharge port to the suction port when the discharge pressure of the refrigerant results a predetermined high-pressure state during the operation of the heating circuit.

[0011] According to the air conditioning system, because the refrigerant releaser is employed for releasing the compressed refrigerant from the discharge port to the suction port when the discharge pressure is in the abnormally high-pressure state, the air conditioning system can solve a problem of insufficient heating performance due to releasing the refrigerant in the heating circuit into the cooling circuit to alleviate the abnormally high-pressure state during operation of the heating circuit.

[0012] Other objects, features and advantages of the present invention will be readily understood after reading the following detailed description together with the accompanying drawings and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 shows a known air conditioning system.
FIG. 2 shows an air conditioning system according to a first representative embodiment.
FIG. 3 shows a compressor and a refrigerant

releaser in the air conditioning system according to the first representative embodiment.

FIGS. 4 is a sectional view taken along line A-A in FIG. 3 and shows the refrigerant releaser of the first representative embodiment in detail.

FIG. 5 shows a refrigerant releaser in detail of an air conditioning system according to a second representative embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Preferably, an air conditioning system includes a compressor, a heating circuit and a refrigerant releaser. The compressor may have a suction port for drawing refrigerant into the compressor and a discharge port for discharging high pressure refrigerant from the compressor. The heating circuit may have a passage that extends from the discharge port to the suction port through the heat exchanger. The refrigerant releaser may release the refrigerant from the discharge port to the suction port when the refrigerant discharge pressure results a predetermined high-pressure state.

[0015] The refrigerant releaser may release the refrigerant from the discharge port to the suction port to decrease the discharge pressure when the discharge pressure of the refrigerant results the predetermined high-pressure state. The compressor discharge pressure is decreased as a direct effect of releasing the refrigerant from the discharge port to the suction port.

[0016] Preferably, the predetermined high-pressure state of the discharge pressure may be detected based on the difference between the discharge pressure and pressure on the low-pressure side of the air conditioning system. The suction pressure of the refrigerant may preferably be utilized as pressure on the low-pressure side for detecting the high pressure state based on the differential pressure. According to this example, because only pressures detected within the air conditioning system are utilized to determine whether abnormally high discharge pressure will be released into the suction port. Therefore, an air-tight air conditioning system can be constructed with a relatively simple design. Otherwise, the predetermined high-pressure state of the discharge pressure may be detected based on the absolute value of the discharge pressure.

[0017] When the discharge pressure results an abnormal high-pressure state during operation of the heating circuit, the heating circuit will be damaged because high pressure is utilized in operating the heating circuit to attain sufficient heating performance. Therefore, an upper limit tolerance level for the discharge pressure becomes closer in the heating circuit.

[0018] Particularly, such abnormal high discharge pressure will seriously damage the hot gas bypass heater circuit because the circuit capacity for flowing the refrigerant in the hot gas bypass heater is smaller than a general type of heating circuit such as a heat pump.

[0019] When the above pressure difference is increased, the system determines that the refrigerant discharge pressure has reached a predetermined high-pressure state and the refrigerant releaser releases the refrigerant from the discharge port to the suction port. Because supply of the high-pressure refrigerant from the discharge port to the heating circuit is immediately cut by the release of the compressed refrigerant, the abnormally high-pressure state of the discharge pressure is quickly alleviated during operation of the heating circuit. The refrigerant released from the discharge port to the suction port by the refrigerant releaser is drawn into the compressor again through the suction port and is compressed and discharged.

[0020] The refrigerant releaser also may have a refrigerant release passage that extends from the discharge port to the suction port and a refrigerant release valve provided on the refrigerant release passage. The refrigerant release valve may be opened by an increased pressure difference between the refrigerant discharge pressure and the refrigerant suction pressure. As a result, the refrigerant release passage is opened to connect the discharge port into the suction port and the refrigerant is released from the discharge port to the suction port. The refrigerant release passage and the refrigerant release valve are the features that correspond to the refrigerant releaser or the refrigerant releasing means from the discharge port to the suction port, although the interpretation of the refrigerant releaser or the refrigerant releasing means is not limited within such refrigerant release passage and refrigerant release valve.

[0021] Preferably, a variable displacement compressor may be employed to the air conditioning system. The variable displacement compressor may have a driving chamber, a suction port for drawing the refrigerant, a discharge port for discharging compressed refrigerant and a driving means such like a swash plate connected to a piston. The variable displacement compressor can change the output discharge capacity by changing driving chamber pressure.

[0022] The variable displacement compressor can decrease the discharge pressure by releasing the refrigerant from the discharge port into the driving chamber thereby decreasing the output discharge capacity. However, considerable time is required in the variable displacement compressor to decrease the discharge pressure, because it is necessary to release the compressed refrigerant from the discharge port to the driving chamber in order to increase the driving chamber pressure and in order to decrease the compressor output discharge capacity. Therefore, the refrigerant releaser that releases the refrigerant directly from the discharge port to the suction port may preferably be employed to the air conditioning system that utilizes the variable displacement compressor.

[0023] Each of the additional features and method steps disclosed above and below may be utilized separately or in conjunction with other features and method steps to provide improved air conditioning systems and methods for designing and using such air conditioning systems.

[0024] Representative examples of the present invention, which examples utilize many of these additional features and method steps in conjunction, will now be described in detail with reference to the drawings. This detailed description is merely intended to teach a person of skilled in the art further details for practicing preferred aspects of the present teachings and is not intended to limit the scope of the invention. Only the claims define the scope of the claimed invention. Therefore, combinations of features and steps disclosed in the following detail description may not be necessary to practice the invention in the broadest sense, and are instead taught merely to particularly described some representative examples of the invention, which detailed description will now be given with reference to the accompanying drawings.

DETAILED REPRESENTATIVE EMBODIMENTS

First Detailed Representative Embodiment

[0025] Referring to FIG. 2, the air conditioning system 100 may include a cooling circuit 151, a heating circuit 152 and a variable displacement compressor 101 as a driving source of both the circuits. A refrigerant releaser is shown in FIGS. 3 and 4 but not in FIG. 2 that shows the general structure of the air conditioning system 100. The structure and operation of the refrigerant releaser will be described later in detail. Such an air conditioning system 100 may be utilized in a vehicle-mounted air conditioning system. In such case, a compressor driving shaft 125 may be coupled to and driven by an automobile engine 170, though it is not particularly shown in the drawings.

[0026] The cooling circuit 151 may be driven by high-pressure refrigerant, which is compressed by the compressor 101, and may include a condenser 155, a first expansion valve 157, a heat exchanger 159 and an accumulator 161. These devices may be disposed within a path 151a that extends from a discharge port D to a suction port S of the compressor 101. The heat exchanger 159 is generally known as an evaporator. The heat exchanger 159 may be arranged side by side with a hot-water heater 171, which circulates hot water from the engine 170 through a pipe 173.

[0027] The heating circuit 152 is driven by high-temperature and high-pressure refrigerant, which is also compressed by the compressor 101, and may include a second expansion valve 163, the heat exchanger 159 and the accumulator 161. These devices may be disposed on a bypass passage 152a for introducing the refrigerant discharged from the discharge port D to the heat exchanger 159. In other words, the heating circuit 152 partially overlaps with the cooling circuit 151. Such a heating circuit 152 is generally known as a hot-gas bypass heater.

[0028] In FIG. 2, a first open/close valve 153a and a second open/close valve 153b may be utilized as switch valves for alternatively actuating the cooling circuit 151 and the heating circuit 152.

[0029] During operation of the cooling circuit 151, the refrigerant is compressed by the compressor 101 to attain a high temperature and high pressure state. This compressed refrigerant is sent to the condenser 155, where heat from the high-temperature refrigerant is dissipated to the outside environment and the refrigerant is liquefied. The refrigerant is decompressed by the first expansion valve 157 and sent to the heat exchanger 159 where the refrigerant absorbs outside heat and is gasified. The gasified refrigerant is returned to the compressor 101 again through the accumulator 161 for recirculation throughout the system 100.

[0030] During operation of the heating circuit 152, the refrigerant is compressed by the compressor 101 to attain a high temperature and high pressure state. The compressed refrigerant is then decompressed by the second expansion valve 163 and sent to the heat exchanger 159, where heat from the compressed refrigerant is dissipated to the outside environment. In the heating circuit cycle, the refrigerant is constantly in a gaseous state while circulating through the heating circuit 152.

[0031] The heating circuit 152 may be used as an auxiliary heater. Heat generated by the heat exchanger 159 during operation of the heating circuit 152 may be used as an auxiliary heating source for the hot water heater described above. The heating circuit 152 also may be used to assist the coolant from the engine when the coolant can not provide sufficient heat to start the engine in a low-temperature environment, such as an outside air temperature of -20 °C or so.

[0032] Referring to FIG. 3, a representative compressor 101 is shown that may include a driving chamber 110 defined within a housing 101a of the compressor 101 and a swash plate that is rotatably supported by the driving shaft 125 in the driving chamber 110. The swash plate 130 may be supported by the driving shaft 125 and may rotate together with the driving shaft 125. The swash plate 130 is inclined with respect to the driving shaft 125 when the driving shaft 125 rotates and the inclination angle of the swash plate 130 with respect to a plane perpendicular to the axis of rotation of the driving shaft 125 is changeable.

[0033] The peripheral edge portion of the swash plate 130 may be connected to the base portions of pistons 135 by means of movable shoes 131. Six pistons 135 in total may be disposed around the driving shaft 125 (however, only one piston is shown in FIG.1 for the sake of convenience) and may be laterally slide within six cylinder bores 109. The circumferential positions of the six cylinder bores 109 are fixed by the compressor housing 101a.

[0034] When the swash plate 130 rotates together with the driving shaft 125 while being inclined as shown in FIG. 1, the peripheral edge of the swash plate 130 slides with respect to the piston 135 fixed in the circumferential direction. When the peripheral edge of the swash plate 130 being inclined to a position closest to the cylinder bores 109 (as shown in FIG. 3), the piston 135 reaches its deepest insertion into the cylinder bores 109. When the peripheral edge of the swash plate 130 (the peripheral edge shown in a lower part of FIG. 3) being inclined to a position furthest away from the cylinder bores, the piston 135 is substantially withdrawn from the cylinder bore 109. Each 360° rotation of the driving shaft 125 results in each piston 135 laterally reciprocating one time.

[0035] A suction port 118a and a discharge port 123a are defined in a bottom portion of each the cylinder bore 109. A suction valve 118 is positioned to correspond to the suction port 118a and a discharge valve 123 is positioned to correspond to the discharge port 123a. Each suction port 118a communicates with a suction chamber 115 and each discharge port 123a communicates with a discharge chamber 120.

[0036] When the piston 135 moves to the left in FIG. 3, as a result of rotation of the swash plate 130, refrigerant is introduced from a suction opening 116 through the suction chamber 115, suction port 118a and suction valve 118 into the cylinder bore 109. When the piston 135 moves to the right in FIG. 3, as a result of further rotation of the swash plate 130, the refrigerant is compressed into a high-pressure state and discharged from a discharge opening 121 through the discharge port 123a, discharge valve 123 and discharge chamber 120.

[0037] The output discharge capacity of the compressor 101 is determined by the stroke length of the piston 135, which is determined by the degree of change in inclination angle of the swash plate 130 during each cycle. That is, the further the swash plate 130 is withdrawn from the cylinder bore 123 during each cycle, the longer the stroke length of the piston 135 will be. As the stroke length increases, the output discharge capacity of the compressor 101 also increases.

[0038] As shown in FIG. 3, the suction chamber 115 and the driving chamber 110 may be connected by a bleeding passage 105. The discharge chamber 120 and the driving chamber 110 may be connected by a capacity control passage 107. A capacity control valve 141 is provided within the capacity control passage 107. The capacity control valve 141 is a solenoid valve that includes a valve body 211 and a solenoid 213 and may open or close the refrigerant release passage 107 by exciting or not exciting the solenoid 213. Opening and closing of the capacity control valve 141 are controlled by the controller that is not particularly shown in the drawings.

[0039] The inclination angle of the swash plate 130 is determined, in part, by the difference in pressure on the opposite sides of the piston 135, i.e., the pressure difference between driving chamber pressure and the cylinder bore pressure. The above-described opening and closing operation of the capacity control valve 141 can adjust this pressure difference by releasing the high pressure refrigerant from the discharge chamber 120 to the driving chamber 110.

[0040] Thus, in order to decrease the output discharge capacity, the capacity control valve 141 is opened to release the high pressure refrigerant in the discharge chamber 121 into the driving chamber 110. Due to resulting increasing in the driving chamber pressure, the swash plate 130 stands and the stroke length of the piston 135 decreases. Therefore, the output discharge capacity also will decrease. On the other hand, in order to increase the output discharge capacity, the capacity control valve 141 is closed so that the refrigerant in the discharge chamber 120 is prevented from being released into the driving chamber 110. As a result, the driving chamber pressure will gradually decrease, the swash plate 130 will move further in the lateral direction and the stroke length of the piston 135 will increase. In this case, the output discharge capacity will increase.

[0041] When the discharge pressure of the refrigerant results high-pressure state during operation of the heating circuit, the capacity control valve 141 is opened. The refrigerant is released from the discharge chamber 120 into the driving chamber 110 through the capacity control passage 107. The pressure in the driving chamber 110 is increased and the output discharge capacity of the compressor 101 is decreased. Thus, the compressor discharge pressure is decreased and the heating circuit 152 is prevented from being damaged.

[0042] When the suction pressure of the refrigerant results excessively low-pressure state during operation of the cooling circuit 151, the capacity control valve 141 is opened. The refrigerant is released from the discharge chamber 120 into the driving chamber 110 through the capacity control passage 107. The pressure in the driving chamber 110 is increased and the output discharge capacity of the compressor 101 is decreased. Thus, the compressor suction pressure is increased and the heat exchanger of the cooling circuit 151 is prevented from being frosted. Thus, the capacity control valve 141 has functions of both the discharge pressure control valve for the heating circuit and the suction pressure control valve for the cooling circuit.

[0043] As shown in FIG. 3 and FIG. 4, the refrigerant releaser 190 is provided and has a refrigerant release valve 181, a first refrigerant release passage 191a, a second refrigerant release passage 191b. The first refrigerant release passage 191a extends from the discharge opening 121 to the refrigerant release valve 181 and the second refrigerant release passage 191b extends from the refrigerant release valve 181 to the suction opening 116.

[0044] As shown in FIG. 4, the discharge opening 121 communicates with a first section chamber 192 in the release valve 181 through the first refrigerant release passage 191a. Therefore, the pressure in the first section chamber 192 is equal to the discharge pressure Pd of the refrigerant. The suction opening 116 communicates with a second section chamber 193 in the refrigerant release valve 181 through the refrigerant release passage 191b. Therefore, the pressure in the second section chamber 193 is equal to the suction pressure Ps of the refrigerant. The first section chamber 192 and the second section chamber 193 are connected by a connecting passage 194 and the connecting passage 194 can be opened or closed by the valve body 196. The valve body 196 may be biased toward the first section chamber 192 (to the left in FIG. 4) by a spring 197.

[0045] During normal operation of the heating circuit, i.e. the discharge pressure Pd of the refrigerant is not in the abnormally high-pressure state during the operation of the heating circuit, a resultant of the suction pressure Ps in the second section chamber 193 and the biasing force of the spring 197 counteracts the rightward movement of the valve body 196. Therefore, the valve body 196 is pushed towards a valve seat 196a to close the connecting passage 194.

[0046] On the other hand, when the discharge pressure Pd of the refrigerant becomes abnormally high during the operation of the heating circuit, the discharge pressure force exceeds the resultant of pressure in the second section chamber 193, i.e., the suction pressure Ps and the biasing force of the spring 197. Therefore, the valve body 196 will move to the right in FIG. 4. The valve body 196 no longer contacts the valve seat 196a and the connecting passage 194 is opened to connect the first section chamber 192 and the second section chamber 193. Therefore, when the discharge pressure Pd of the refrigerant reaches an abnormally high-pressure state, refrigerant is released from the discharge opening 121 to the suction opening 116 and to the suction chamber 115. As the result, the compressor discharge pressure decreases in response to such releasing of the refrigerant to the suction opening 116. The biasing force of the spring 197 may be properly determined based on an evaluation as to at which difference between the discharge pressure Pd and the suction pressure Ps the connecting passage 194 should be opened, i.e., which difference between the discharge pressure Pd and the suction pressure Ps reflects the abnormally high-pressure state of the discharge pressure Pd.

[0047] Thus, by utilizing the refrigerant releaser 190 that includes the release valve 181, the first refrigerant release passage 191a and the second refrigerant release passage 191b, the refrigerant is immediately released from the discharge side to the suction side based on the difference between the discharge pressure Pd and the suction pressure Ps when the discharge pressure Pd reaches the abnormally high-pressure state.

[0048] In this air conditioning system, the variable displacement compressor is utilized. When the discharge pressure increases relatively slowly, discharge pressure may be alleviated by opening the capacity control valve 141 shown in FIG. 3 thereby releasing the refrigerant from the discharge chamber 120 into the driving chamber 110 to increase the pressure in the driving chamber 110. The swash plate 130 stands to decrease the stroke length of the piston 135, thereby decreasing the output discharge capacity and decreasing the discharge pressure. On the contrary, when the discharge pressure increases sharply such that the alleviation by utilizing the decreasing of the compressor output discharge capacity can not catch up with the increasing speed of the discharge pressure, the refrigerant is released immediately from the discharge side to the suction side by utilizing the refrigerant releaser 190 to alleviate the high-pressure state of the discharged refrigerant as a direct effect of the release.

[0049] As shown in FIG. 4, the discharge pressure Pd is released based on the difference between the discharge pressure Pd and the suction pressure Ps and it is unnecessary to employ atmospheric pressure or vacuum pressure as a reference value. Therefore, it is possible to improve airtightness of the air conditioning system.

[0050] During operation of the cooling circuit, the cooling circuit is not necessarily driven by utilizing the refrigerant at high-pressure in comparison with the heating circuit that requires the refrigerant at high-pressure to attain the high heat performance. Therefore, the alleviation of the abnormally high discharge pressure is not required during the operation of the cooling circuit. Thus, condition for opening the refrigerant release valve 181 is arranged based on the operating pressure of the heating circuit that utilizes the relatively high pressure. As the result, the release valve 181 is closed during operation of the cooling circuit that utilizes the relatively low discharge pressure.

Second Detailed Representative Embodiment

[0051] In a second representative embodiment, as shown in FIG. 5, a refrigerant release valve 281 is provided that is opened by utilizing a difference between the discharge pressure Pd and the pressure Pc in the driving chamber 110. In other words, the discharge pressure is utilized as pressure on the high-pressure side and the pressure in the driving chamber 110 is utilized as pressure on the low-pressure side.

[0052] The refrigerant release valve 281 includes a first section chamber 292, a second section chamber 293, and a third section chamber 295. The first section chamber 292 communicates with the discharge opening 121 through a first refrigerant release passage 291a. Therefore, pressure in the first section chamber 292 is equal to the discharge pressure Pd. The second section chamber 293 communicates with the suction opening

116 through the second refrigerant release passage 291b. Therefore, pressure in the second section chamber 293 is equal to the suction pressure Ps. The third section chamber 295 communicates with the driving chamber 110 shown in FIG. 3 through a driving chamber pressure introducing passage 291c. Therefore, pressure in the third section chamber 295 is equal to the pressure Pc in the driving chamber 110.

[0053] In the refrigerant release valve 281, a valve body 296, a differential pressure actuated member 299, and a connecting bar 298 for connecting the valve body 296 and the differential pressure actuated member 299 are formed integrally.

[0054] During normal operation of the heating circuit, i.e. the discharge pressure Pd is not in the abnormally high-pressure state during the operation of the heating circuit, a resultant of the pressure Pc in the third section chamber 295 and the biasing force of the spring 297 counteracts the rightward movement of the differential pressure actuated member 299 and the valve body 296. Therefore, the valve body 296 is pushed towards a valve seat 296a to close the connecting passage 294.

[0055] On the other hand, when the discharge pressure Pd becomes abnormally high during operation of the heating circuit, the discharge pressure force exceeds the resultant of pressure in the third section chamber 295, i.e., the pressure Pc and the biasing force of the spring 297. Therefore, the valve body 296 will move to the right in FIG. 5. The valve body 296 no longer contacts the valve seat 296a and the connecting passage 294 is opened to connect the first section chamber 292 and the second section chamber 293. Therefore, when the discharge pressure Pd of the refrigerant reaches an abnormally high-pressure state, refrigerant is released from the discharge opening 121 to the suction opening 116. As the result, the compressor discharge pressure decreases in response to such releasing of the refrigerant from the discharge opening 121 to the suction opening 116. The biasing force of the spring 297 may be properly determined based on an evaluation as to at which difference between the discharge pressure Pd and the pressure Pc the connecting passage 194 should be opened, i.e., which difference between the discharge pressure Pd and the pressure Pc reflects the abnormally high-pressure state of the discharge pressure Pd.

[0056] Although the variable displacement compressor is used in the above first and second embodiments, a fixed displacement compressor with a constant discharge capacity of the refrigerant can be utilized in stead of the variable displacement compressor. As pistons for compressing the refrigerant, double-ended pistons connected to opposite sides of the swash plate 130 for reciprocation in the compressor can be utilized.

[0057] Although the refrigerant releaser 190 is provided inside the compressor (within the housing) , the refrigerant releaser 190 can be entirely or partially provided outside the compressor.

[0058] Although the air conditioning system has the heating circuit and the cooling circuit in the embodiments, the cooling circuit can be omitted, because it is especially during operation of the heating circuit that the high-pressure state of the discharge pressure of the refrigerant becomes a problem.

Claims

1. An air conditioning system comprising;

a compressor having a suction port and a discharge port,
a heating circuit having a passage extending from the discharge port to the suction port through the heat exchanger,
characterized by
a refrigerant releaser that releases the refrigerant from the discharge port to the suction port when the discharge pressure of the refrigerant results a predetermined high-pressure state during the operation of the heating circuit.

2. An air conditioning system according to claim 1, the system further comprising;

a cooling circuit having a condenser disposed on a passage extending from the discharge port to the suction port and the heat exchanger disposed downstream from the condenser.

3. An air conditioning system according to claim 1 or 2, wherein the compressor has a driving unit provided in a compressor driving chamber, the driving unit being capable of decreasing the compressor output discharge capacity by releasing the compressed refrigerant from the discharge port into the driving chamber.

4. An air conditioning system according to claim 3, wherein the driving unit has a swash plate connected to a driving shaft disposed within the driving chamber, the swash plate rotating together with the driving shaft at an inclination angle with respect to a plane perpendicular to the driving shaft and

a piston disposed in a cylinder bore, an end portion of the piston connected to a peripheral edge of the swash plate by means of a shoe, the piston reciprocating in the cylinder bore to compress the refrigerant in response to rotation of the swash plate in the driving chamber.

5. An air conditioning system according to claim 3 or 4, wherein the compressor has a capacity control valve that releases the compressed refrigerant from the discharge port into the driving chamber to decrease the compressor output discharge capacity.

6. An air conditioning system according to any one of claims 1 to 5, wherein the refrigerant releaser has a refrigerant release passage extending from the discharge port to the suction port and a refrigerant release valve provided on the refrigerant release passage.

7. An air conditioning system according to claim 6, wherein the refrigerant release valve is opened by a difference between the suction pressure and the discharge pressure of the refrigerant.

8. An air conditioning system according to claim 6 or 7, wherein the refrigerant release passage and the refrigerant release valve are provided within a housing of the compressor.

9. An air conditioning system comprising;

a compressor having a suction port and a discharge port,
a heating circuit having a passage extending from the discharge port to the suction port through the heat exchanger,
characterized by
means for releasing a compressed refrigerant from the discharge port to the suction port when the discharge pressure of the refrigerant results a predetermined high-pressure state during the operation of the heating circuit.

10. A method of using the air conditioning system according to any one of claims 1 to claim 6,
characterized by the step of

releasing the refrigerant from the discharge port to the suction port when the discharge pressure of the refrigerant results a predetermined high-pressure state during the operation of the heating circuit.

11. A method of controlling discharge pressure of the refrigerant in an air conditioning system,
characterized by the step of

releasing the refrigerant from the compressor discharge port to the compressor suction port when the discharge pressure of the refrigerant results a predetermined high-pressure state during the operation of the heating circuit.

12. A method according to claim 10 or 11, wherein the air conditioning system further comprising;

a cooling circuit having a condenser disposed on a passage extending from the discharge port to the suction port and the heat exchanger disposed downstream from the condenser.

13. A method according to any one of claims 10 to 12, wherein the compressor has a driving unit provided in a compressor driving chamber, the driving unit being capable of decreasing the compressor output discharge capacity by releasing the compressed refrigerant from the discharge port into the driving chamber.

14. A method according to claim 13, wherein the driving unit has a swash plate connected to a driving shaft disposed within the driving chamber, the swash plate rotating together with the driving shaft at an inclination angle with respect to a plane perpendicular to the driving shaft and

a piston disposed in a cylinder bore, an end portion of the piston connected to a peripheral edge of the swash plate by means of a shoe, the piston reciprocating in the cylinder bore to compress the refrigerant in response to rotation of the swash plate in the driving chamber.

15. A method according to claim 13 or 14, wherein the compressor has a capacity control valve that releases the compressed refrigerant from the discharge port into the driving chamber to decrease the compressor output discharge capacity.

16. A method according to any one of claims 10 to 15, wherein the refrigerant is released from the discharge port to the suction port by opening a refrigerant release valve provided on a refrigerant release passage extending from the discharge port to the suction port.

17. A method according to claim 16, wherein the refrigerant release valve is opened by a difference between the suction pressure and the discharge pressure of the refrigerant.

18. A vehicle comprising an air conditioning system according to any one of claims 1 to 9 and an engine for driving the compressor.

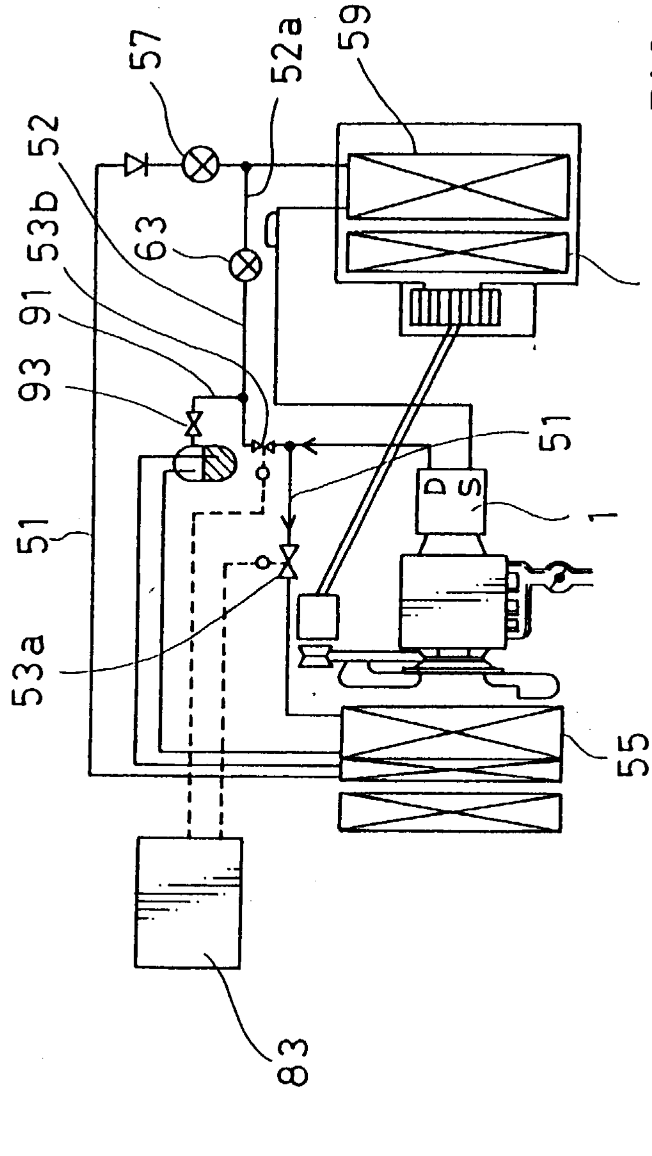


FIG. 1

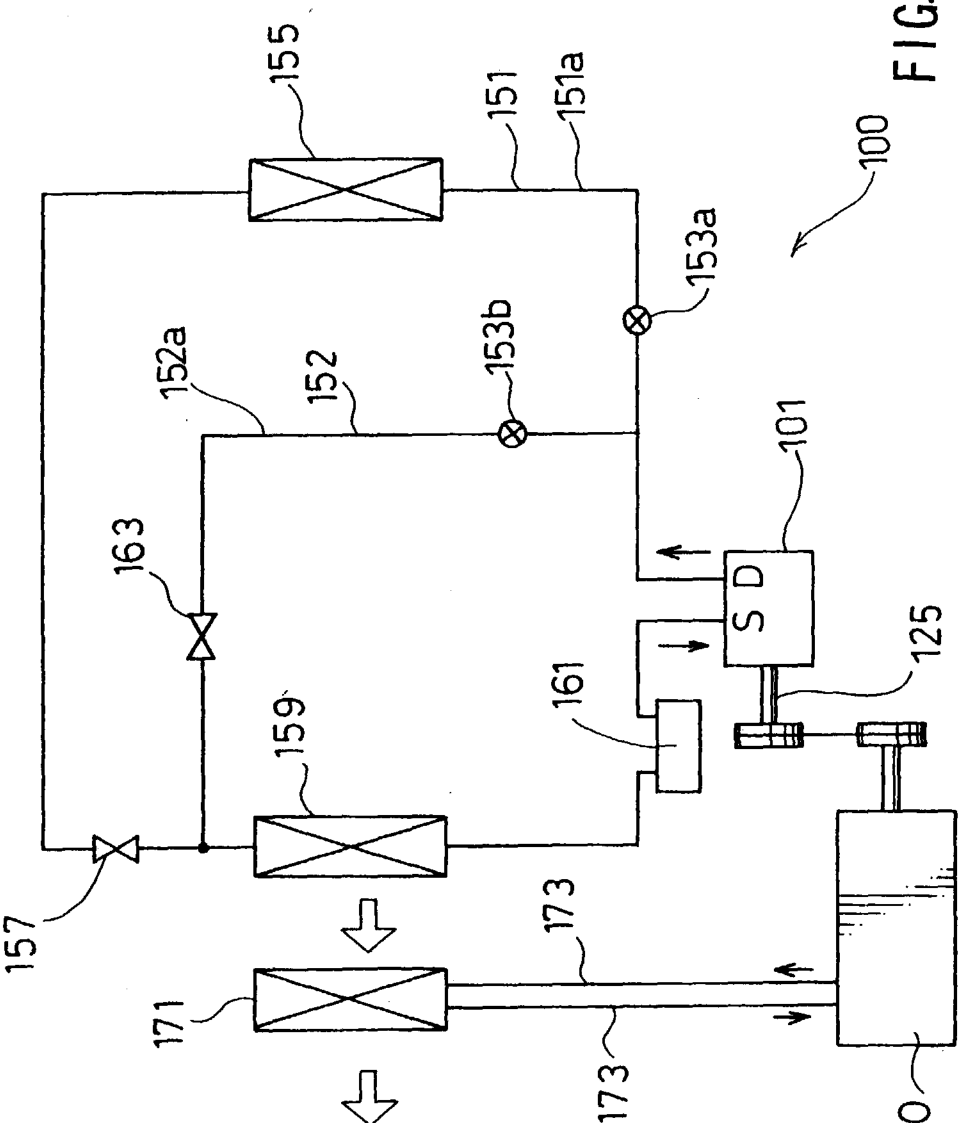

155
151
151a
153a
153b
152a
152
101
S
D
163
125
161
159
157
173
173
171
170
100

FIG. 2

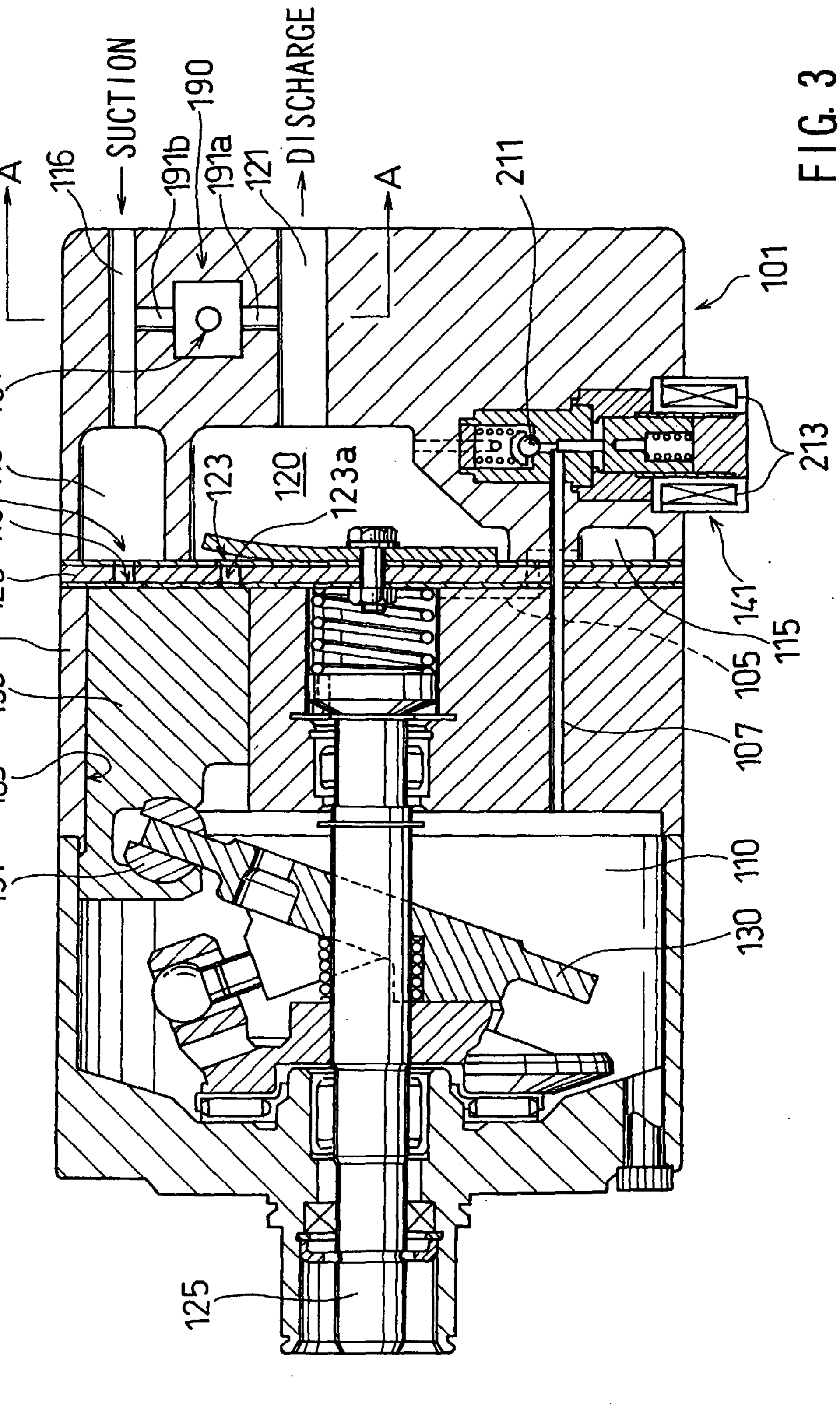

A
116
SUCTION
191b
190
191a
121
DISCHARGE
A
211
101
181
118a
115
118
126
101a
135
109
131
123
120
123a
213
141
115
105
107
110
130
125

FIG. 3

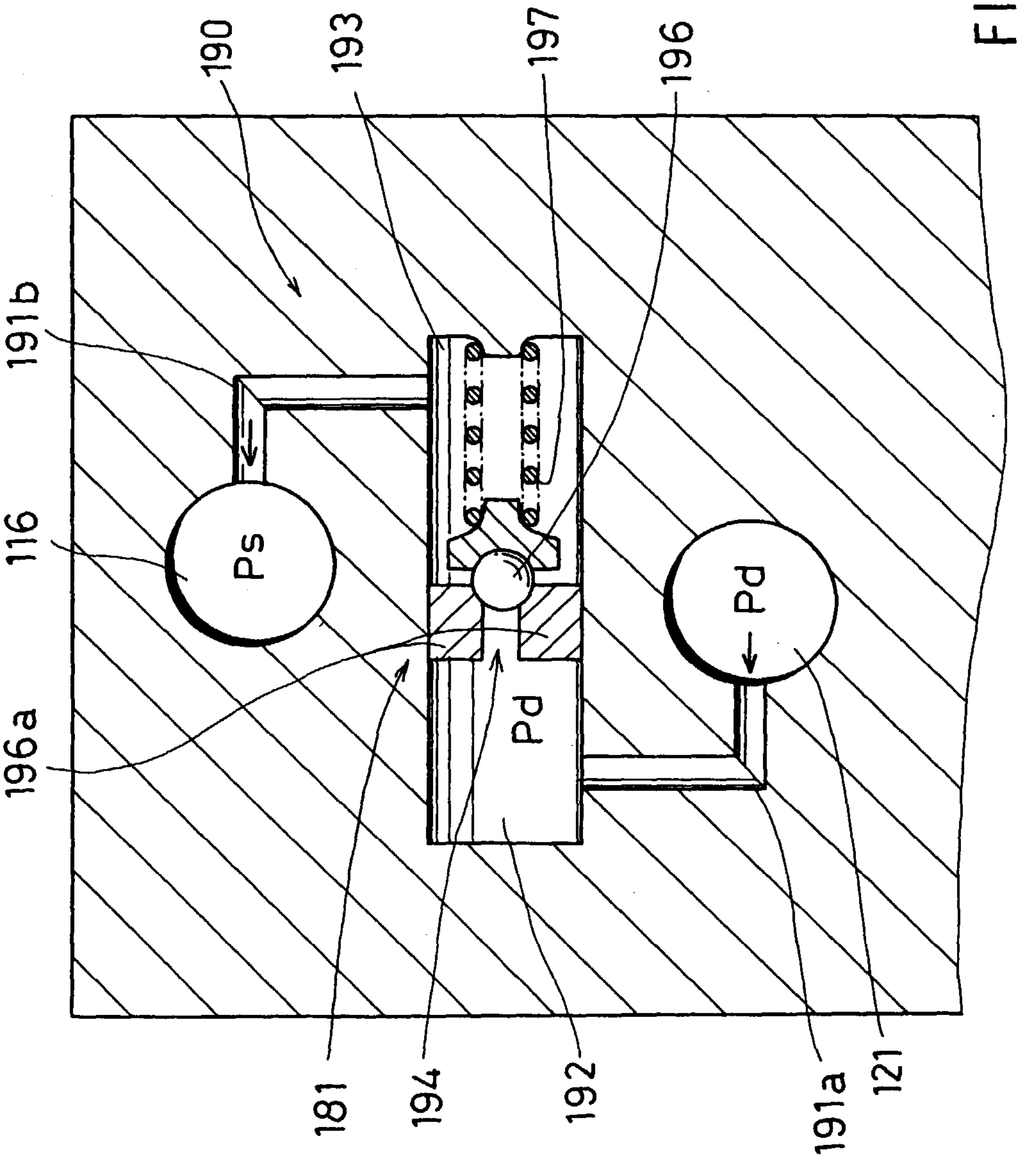
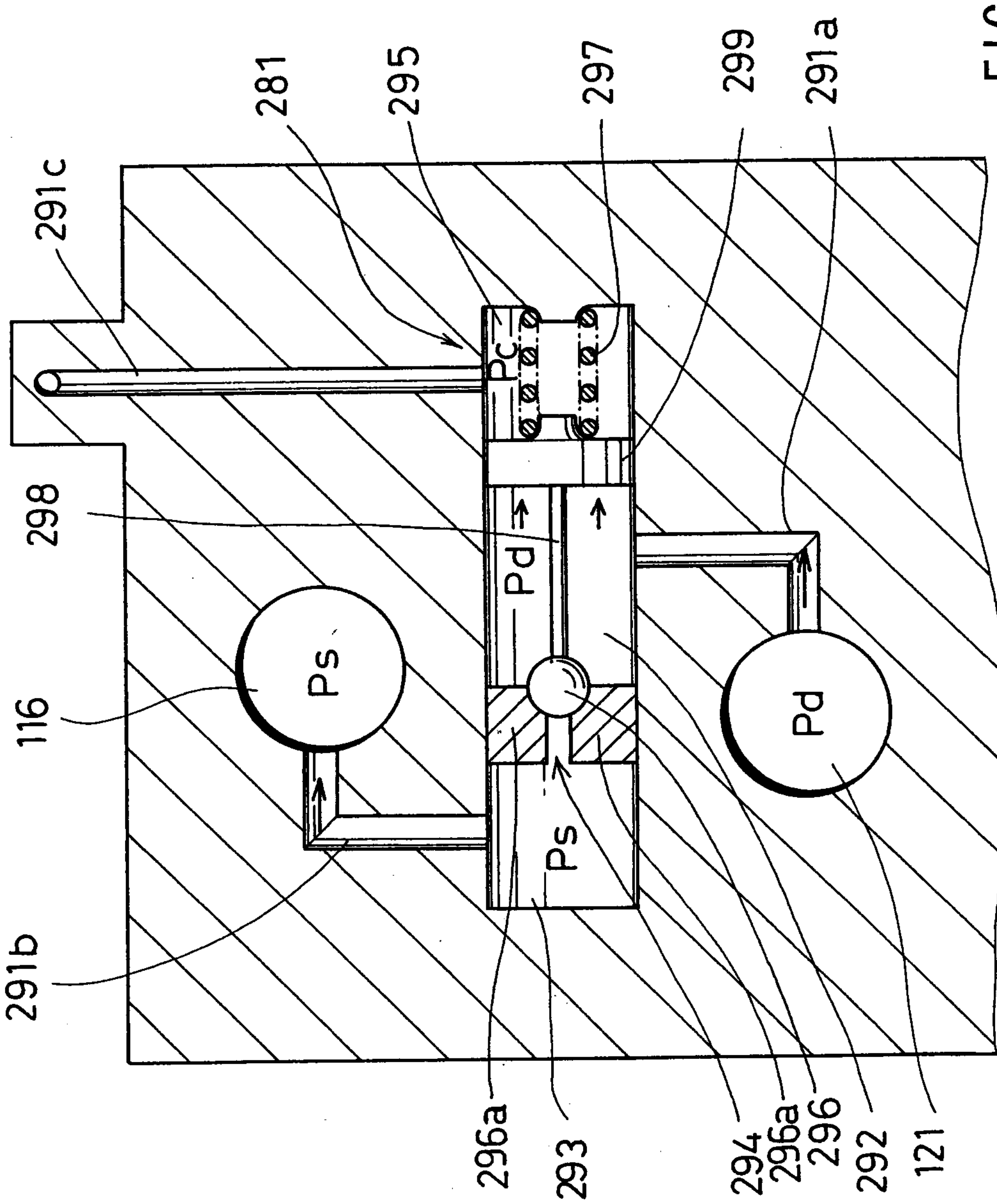


FIG. 4



291c
281
295
297
299
291a
298
116
291b
Pc
Pd
Ps
Pd
Ps
296a
293
294
296a
296
292
121

FIG. 5