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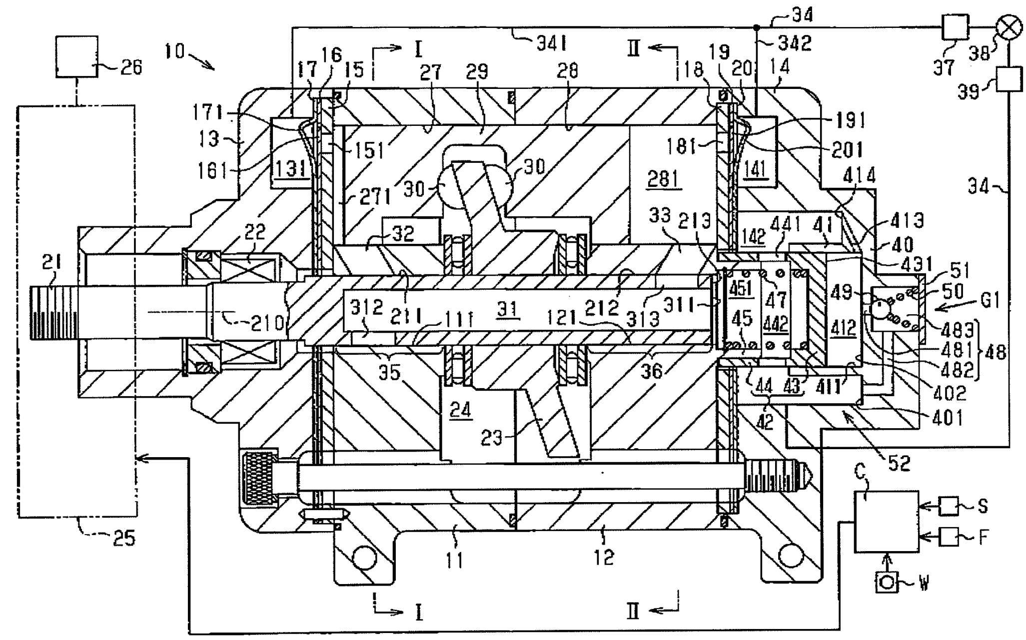
(54) **Suction structure in piston type compressor**

(57) A suction structure allows refrigerant from a suction pressure region in a piston type compressor. The suction structure includes a shifting device, a bleed passage, and a check valve. The shifting device has a valve body, a return spring, a backpressure chamber, and a backpressure passage. The valve body is movable between a connecting position and a disconnecting position. The return spring urges the valve body from the connecting position toward the disconnecting position. The backpressure chamber is defined by the valve body. The backpressure passage communicates with the suction pressure region and the backpressure chamber. The bleed passage communicates with the suction pressure region and the backpressure chamber. The check valve allows a fluid to flow from the backpressure chamber into the bleed passage.

FIG. 1



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## Description

BACKGROUND OF THE INVENTION

**[0001]** The present invention relates to a suction structure for allowing refrigerant from a suction pressure region in a piston type compressor. More specifically, the compressor has a rotary valve integrally rotated with a rotary shaft and having a supply passage for introducing refrigerant from the suction pressure region into a compression chamber defined in a cylinder bore by a piston.

**[0002]** In piston type compressors, there are two types of suction valves. One is a rotary valve as disclosed in Unexamined Japanese Patent Publications No. 7-119631 and No. 2006-083835. The other is a reed valve as disclosed in Unexamined Japanese Patent Publications No. 64-088064 and No. 2000-145629. The piston type compressor with the rotary valve has lower suction resistance in introducing refrigerant into cylinder bores, and has superior energy efficiency, compared to the piston type compressor with the reed valve.

**[0003]** As disclosed in the above reference No. 7-119631, when a conventional compressor is started, compressor torque is rapidly increased with the compression of refrigerant, and the increased torque is applied as a load to a vehicle engine (an internal combustion engine). As a result, the vehicle speed is temporarily decreased at the start of the compressor, which causes passengers of the vehicle to feel shock.

**[0004]** In a compressor disclosed in the above reference No. 7-119631, the rotary valve rotating with a rotary shaft is provided so as to be movable in axial direction of the rotary shaft. The rotary valve is moved in the axial direction of the rotary shaft depending on the pressure applied to a control pressure chamber. The rotary valve is formed with a bypass groove that allows almost all cylinder bores to communicate with a suction port provided in the center of a cylinder block. The rotary valve is placed in the axial direction of the rotary shaft so that almost all the cylinder bores communicate with the suction port through the bypass groove when the compressor is started and stopped. Therefore, even when a piston is moved to compress refrigerant in the cylinder bore at the start of the compressor, the refrigerant in the cylinder bore is returned to the suction port through the bypass groove. The shock at the start of the compressor does not occur, accordingly.

**[0005]** In order to prevent leakage of refrigerant along the periphery of the rotary valve, and also to allow the rotation of the rotary valve, the rotary valve requires minimum clearance around the periphery thereof. Additionally, the rotary valve movable in the axial direction of the rotary shaft requires the clearance that also allows the movement of the rotary valve in the axial direction of the rotary shaft. Such clearance is difficult to set appropriately.

**[0006]** A compressor disclosed in Unexamined Japanese Patent Publication No. 2000-145629 includes a pressure-differential detecting valve. The valve is opened and closed depending on the pressure differential between discharge pressure and suction pressure. The valve is located between a suction chamber in the compressor and a low-pressure refrigerant passage that introduces refrigerant from the outside of the compressor. When the compressor is started with the pressure in the compressor balanced, the pressure-differential detecting valve is closed, so that no refrigerant flows into the suction chamber from the outside of the compressor. As a result, the shock at the start of the compressor is suppressed.

**[0007]** A compressor disclosed in Unexamined Japanese Patent Publication No. 7-139474 includes a starting-load reducing device. The device is located in a suction passage connected to a suction chamber. The device includes a spool valve that constitutes an oil damper. Clearance is provided between a damper portion of the spool valve and a housing. When the spool valve is moved in such a direction that the suction passage is opened, oil in a damper chamber is gradually leaked to an intermediate chamber through the clearance. Therefore, the spool valve is gradually moved, and the suction passage is gradually opened. As a result, the shock at the start of the compressor is suppressed.

**[0008]** However, in the compressor disclosed in the reference No.7-139474, refrigerant remains in the suction chamber even when the suction passage is closed by the spool valve. The residual refrigerant is introduced into cylinder bores and compressed therein. Also in the compressor disclosed in the reference No. 2000-145629, refrigerant remains in the suction chamber even when the pressure-differential detecting valve is closed. The residual refrigerant is introduced into cylinder bores and compressed therein. Since the suction chamber generally has large volume to suppress the suction pulsation, large amount of refrigerant is introduced into the cylinder bores even when the pressure-differential detecting valve or the suction passage is closed. Therefore, the shock at the start of the compressor is not sufficiently suppressed.

**[0009]** The present invention is directed to further suppression of the shock at the start of the compressor.

SUMMARY OF THE INVENTION

**[0010]** In accordance with an aspect of the present invention, a suction structure allows refrigerant from a suction pressure region in a piston type compressor. Cylinder bores for accommodating a respective piston are arranged around a rotary shaft. The piston is coupled to the rotary shaft through a cam body so that the rotation of the rotary shaft is transmitted to the piston. A compression chamber is defined by the piston in the respective cylinder bore. A rotary valve has a supply passage for introducing the refrigerant from the suction pressure region to the compression chamber. The rotary valve is rotated integrally with the rotary shaft. The supply passage has an outlet and an inlet. The suction structure includes a shifting device for shifting between a connecting state and a disconnecting state. In the connecting state the suction pressure region is connected to the outlet of the supply passage, and in the disconnecting state the suction pressure region is disconnected from the outlet of the supply passage. The shifting device includes a valve body, a return spring, a backpressure chamber, and a backpressure passage. The valve body is movable between a connecting position and a disconnecting position. The connecting position corresponds to the connecting state and the disconnecting position corresponds to the disconnecting state. The return spring urges the valve body from the connecting position toward the disconnecting position. The backcpressure chamber is defined by the valve body. The backpressure passage communicates with the suction pressure region and the backpressure chamber. The suction structure further includes a bleed passage and a check valve. The bleed passage communicates with the suction pressure region and the backpressure chamber. The check valve allows a fluid to flow from the backpressure chamber into the bleed passage.

**[0011]** 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 THF DRAWING

**[0012]** 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 longitudinal cross-sectional view of a compressor according to a first embodiment of the present invention;

Fig. 2A is a cross-sectional view taken along the line I-I in Fig.1;

Fig. 2B is a cross-sectional view taken along the line II-II in Fig. 1;

Fig. 3 is a partially enlarged crass-sectional view of the compressor in a disconnecting state according to the first embodiment of the present invention;

Fig. 4 is a partially enlarged cross-sectional view of the compressor in a connecting state according to the first embodiment of the present invention;

Fig. 5A is a partially enlarged cross-sectional view of a compressor in a disconnecting state according to a second embodiment of the present invention;

Fig. 5B is a partially enlarged cross-sectional view of the compressor in a connecting state according to the second embodiment of the present invention;

Fig. 6A is a partially enlarged cross-sectional view of a compressor in a connecting state according to a third embodiment of the present invention;

Fig. 6B is a partially enlarged cross-sectional view of the compressor in a disconnecting state according to the third embodiment of the present invention;

Fig. 7A is a partially enlarged cross-sectional view of a compressor in a disconnecting state according to a fourth embodiment of the present invention;

Fig. 7B is a partially enlarged cross-sectional view of the compressor in a connecting state according to the fourth embodiment of the present invention; and

Fig. 8 is a longitudinal cross-sectional view of a compressor according to a fifth embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0013]** The following will describe a first embodiment of the present invention with reference to Figs. 1 through 4. Fig. 1 shows a piston type compressor 10 according to the first embodiment. The compressor 10 is of a fixed displacement type. It is noted that the left side and right side of the compressor 10 as viewed in Fig. 1 are the front and rear sides thereof, respectively. Referring to Fig. 1, the compressor 10 has a pair of cylinder blocks 11, 12. A front housing 13 is connected to the cylinder block 11. A rear housing 14 is connected to the cylinder block 12. The cylinder blocks 11, 12, the front housing 13, and the rear housing 14 constitute a housing assembly of the compressor 10. A discharge chamber 131 as a discharge pressure region in the compressor 10 is defined in the front housing 13. A discharge chamber 141 as the discharge pressure region in the compressor 10 is defined in the rear housing 14. A suction chamber 142 as a suction pressure region in the compressor 10 is defined in the rear housing 14. It is noted that "in the compressor" used hereinafter is the inside of the housing assembly, and that "out of the compressor" is the outside of the housing assembly.

**[0014]** A valve port plate 15, a valve plate 16, and a retainer plate 17 are interposed between the cylinder block 11 and the front housing 13. A valve port plate 18, a valve plate 19, and a retainer plate 20 are Interposed between the cylinder block 12 and the rear housing 14. The valve port plates 15, 18 are formed with discharge ports 151, 181, respectively. The valve plates 16, 19 are formed with discharge valves 161, 191 opening and closing the discharge ports 151,181, respectively. The retainer plates 17, 20 are formed with retainers 171, 201 regulating the opening degrees of the discharge valves 161, 191, respectively.

**[0015]** The cylinder blocks 11, 12 rotatably support a rotary shaft 21. The cylinder blocks 11, 12 are formed with shaft holes 111, 121 extending therethrough, respectively The rotary shaft 21 is inserted into the shaft holes 111, 121. The outer peripheral surface of the rotary shaft 21 is in contact with the inner peripheral surfaces of the shaft holes 111, 121. The cylinder blocks 11, 12 support directly the rotary shaft 21 through the inner peripheral surfaces of the shaft holes 111, 121, respectively. The outer peripheral surface of the rotary shaft 21 has a sealing surface 211 in contact with the shaft hole 111 and has a sealing surface 212 in contact with the shaft hole 121.

**[0016]** The compressor 10 has a swash plate 23 serving as a cam body and fixed to the rotary shaft 21. The swash plate 23 is accommodated in a crank chamber 24 defined between the cylinder blocks 11, 12. A lip-type seal member 22 is interposed between the front housing 13 and the rotary shaft 21. The seal member 22 prevents leakage of refrigerant between the front housing 13 and the rotary shaft 21. The front end of the rotary shaft 21 protruding out of the front housing 13 is connected to a vehicle engine 26 as an external drive source through an electromagnetic clutch 25. The rotary shaft 21 receives driving force from the vehicle engine 26 through the electromagnetic clutch 25.

**[0017]** As shown in Fig. 2A, the cylinder block 11 is formed with a plurality of cylinder bores 27 arranged around the rotary shaft 21. As shown in Fig. 2B, the cylinder block 12 is formed with a plurality of cylinder bores 28 arranged around the rotary shaft 21. Each cylinder bore 28 of the cylinder block 12 is paired with the opposite cylinder bore 27 of the cylinder block 11. Each pair of cylinder bores 27,28 accommodates therein a double-headed piston 29.

**[0018]** As shown in Fig. 1, the double-headed piston 29 is coupled to the swash plate 23 through a pair of shoes 30. The swash plate 23 rotates integrally with the rotary shaft 21. The rotary motion of the swash plate 23 is transmitted to the double-headed piston 29 through the shoes 30, so that the double-headed piston 29 reciprocates in the pair of cylinder bores 27, 28. The double-headed piston 29 defines compression chambers 271, 281 in the respective cylinder bores 27, 28.

**[0019]** The rotary shaft 21 is formed therein with an in-shaft passage 31. The in-shaft passage 31 extends along a rotational axis 210 of the rotary shaft 21. The in-shaft passage 31 has an inlet 311 and outlets 312, 313. The inlet 311 is formed at an end surface 213 of the rotary shaft 21 in the cylinder block 12. The inlet 311 is open to the suction chamber 142 in the rear housing 14. The outlet 312 is open at the sealing surface 211 of the rotary shaft 21 in the shaft hole 111. The outlet 313 is open at the sealing surface 212 of the rotary shaft 21 in the shaft hole 121.

**[0020]** As shown in Fig. 2A, the cylinder block 11 is formed with a plurality of communication passages 32. Each communication passage 32 communicates with the cylinder bore 27 and the shaft hole 111. As shown in Fig. 2B, the cylinder block 12 is formed with a plurality of communication passages 33. Each communication passage 33 communicates with the cylinder bore 28 and the shaft hole 121. As the rotary shaft 21 rotates, the outlets 312, 313 of the in-shaft passage 31 intermittently communicate with the communication passages 32, 33, respectively.

**[0021]** When the cylinder bore 27 is in a suction process, that is, the process moving the double-headed piston 29 rightward in Fig. 1, the outlet 312 is connected to the communication passage 32. Refrigerant in the in-shaft passage 31 of the rotary shaft 21 is introduced into the compression chamber 271 in the cylinder bore 27 through the outlet 312 and the communication passage 32.

**[0022]** When the cylinder bore 27 is in a discharge process, that is, the process moving the double-headed piston 29 leftward in Fig. 1, the outlet 312 is disconnected from the communication passage 32. Refrigerant in the compression chamber 271 is discharged into the discharge chamber 131 thorough the discharge port 151 while pushing open the discharge valve 181. Refrigerant discharged into the discharge chamber 131 then flows into an external refrigerant circuit 34 through a passage 341.

**[0023]** When the cylinder bore 28 is in a suction process, that is, the process moving the double-headed piston 29 leftward in Fig. 1, the outlet 313 is connected to the communication passage 33. Refrigerant in the in-shaft passage 31 of the rotary shaft 21 is introduced into the compression chamber 281 in the cylinder bore 28 through the outlet 313 and the communication passage 33.

**[0024]** When the cylinder bore 28 is in a discharge process, that is, the process moving the double-headed piston 29 rightward in Fig. 1, the outlet 313 is disconnected from the communication passage 33. Refrigerant in the compression chamber 281 is discharged into the discharge chamber 141 through the discharge port 181 while pushing open the discharge valve 191.Refrigerant discharged into the discharge chamber 141 then flows into the external refrigerant circuit 34 through a passage 342.

**[0025]** Oil is contained in the compressor 10 and the external refrigerant circuit 34. The oil flows with refrigerant and lubricates various parts requiring lubrication in the compressor 10. The external refrigerant circuit 34 is provided with a heat exchanger 37 for removing heat from refrigerant, an expansion valve 38, and a heat exchanger 39 for evaporating refrigerant with heat. The expansion valve 38 controls the flow rate of refrigerant depending on the change of refrigerant temperature at the outlet of the heat exchanger 39. The refrigerant flowing into the external refrigerant circuit 34 then returns to the suction chamber 142 of the compressor 14.

**[0026]** The sealing surface 211 of the rotary shaft 21 forms a first rotary valve 35 and the sealing surface 212 of the rotary shaft 21 forms a second rotary valve 36. That is, the rotary shaft 21 serves as a rotary valve in the present invention. The rotational axis 210 of the rotary shaft 21 serves as the rotational axis of the rotary valve. The end surface 213 of the rotary shaft 21, that is, the end surface of the rotary valve, intersects with the rotational axis 210 of the rotary valve. The rotary valve 35, 36 serve as a valve mechanism in the present invention disposed adjacent to the compression chambers 271, 281, respectively. The in-shaft passage 31 and the outlets 312, 313 constitute a supply passage of the rotary valve in this embodiment. The shaft hole 111 serves as a valve chamber accommodating therein the first rotary valve 35, and the shaft hole 121 serves as a valve chamber accommodating therein the second rotary valve 36.

**[0027]** As shown in Figs. 3 and 4, the rear housing 14 defining therein the suction chamber 142 is formed at the rear end thereof with a base 40 integral with the rear housing 14. The base 40 is formed at an inner surface 401 thereof with a cylinder 41 integral with the base 40. The inner surface 401 of the base 40 intersects perpendicularly with the rotational axis 210 of the rotary shaft 21.

**[0028]** The cylinder 41 has an inner space 411 receiving therein a slidable spool-shaped valve body 42. The valve body 42 includes a disk-shaped piston portion 43 and a cylindrical portion 44. The cylindrical portion 44 is formed with an introduction port 441. The introduction port 441 is open at the outer peripheral surface of the cylindrical portion 44 and communicates with an inner space 442 of the cylindrical portion 44. The inner space 442 serves as an internal passage of the valve body 42. The piston portion 43 defines a backpressure chamber 412 in the inner space 411 of the cylinder 41. The backpressure chamber 412 communicates with the suction chamber 142 through a backpressure passage 413. The backpressure passage 413 has an inlet 414 that is disposed above the backpressure chamber 412. A flat bottom surface 402 of the backpressure chamber 412 forms a part of the inner surface 401 of the base 40.

**[0029]** The cylinder block 12 is formed at the rear end thereof with a guide 45 having a cylindrical shape and facing to the cylinder 41. The guide 45 has an inner space 451 communicating with the in-shaft passage 31 through the inlet 311. The rear end of the guide 45 is spaced away from the front end of the cylinder 41. The cylindrical portion 44 of the valve body 42 is slidably fitted to the guide 45. A circular clip 46 is installed in the inner surface of the guide 45. A return spring 47 is interposed between the circular clip 46 and the piston portion 43. The return spring 47 urges the valve body 42 in such a direction that the valve body 42 approaches the bottom surface 402. When the valve body 42 approaches the bottom surface 402, the volume of the backpressure chamber 412 decreases.

**[0030]** The piston portion 43 of the valve body 42 has a pressure-receiving surface 431 receiving the pressure in the backpressure chamber 412. The pressure-receiving surface 431 is a flat surface and is parallel to the bottom surface 402. The pressure-receiving surface 431 and the bottom surface 402 are perpendicular to the rotational axis 210. The pressure-receiving surface 431 is contactable with the bottom surface 402.

**[0031]** The base 40 as a rear housing wall is formed with a bleed passage 48. The bleed passage 48 is formed inside the base 40 and extends through the base 40. The bleed passage 48 includes a valve port 481, an outlet passage 482, and a valve chamber 483. The valve port 481 is open to the backpressure chamber 412. The outlet passage 482 is open to the suction chamber 142 at the outlet thereof. The valve chamber 483 communicates with the valve port 481 and the outlet passage 482. The valve port 481 serves as the inlet of the bleed passage 48.

**[0032]** The valve chamber 483 accommodates therein a ball-shaped valve body 49 that is operable to open and close the valve port 481. The valve chamber 483 is closed by a cover 51 so as to be separated from the outside of the compressor 10. A compression spring 50 is disposed between the valve body 49 and the cover 51 for urging the valve body 49 in such a direction that the valve body 49 closes the valve port 481. The valve port 481, the valve chamber 483, the valve body 49, and the compression spring 50 constitute a check valve G1 allowing the fluid to flow from the backpressure chamber 412 into the bleed passage 48.

**[0033]** In Fig. 4, the whole introduction port 441 faces the suction chamber 142, so that the in-shaft passage 31 is connected to the suction chamber 142 through the inner space 451, the inner space 442, and the introduction port 441. The valve body 42 is then placed apart from the bottom surface 402. Fig. 4 shows a state where the valve body 42 is placed at a connecting position to connect the in-shaft passage 31 to the suction chamber 142. In Fig. 3, on the other hand, the introduction port 441 is in the inner space 411 and closed by the cylinder 41 of the base 40. Therefore, the in-shaft passage 31 is disconnected from the suction chamber 142. The pressure-receiving surface 431 of the piston portion 43 of the valve body 42 is in surface contact with the bottom surface 402. Fig. 3 shows a state where the valve body 42 is placed at a disconnecting position to disconnect the in-shaft passage 31 from the suction chamber 142. The oil in the compressor 10 flows with refrigerant and collected at the bottom in the backpressure chamber 412 and in the suction chamber 142 as indicated by X and Y in Figs. 3 and 4. Some of the oil flowing with refrigerant in the compressor 10 is attached to the pressure-receiving surface 431 and the bottom surface 402. In Fig. 3 wherein the pressure-receiving surface 431 is in contact with the bottom surface 402, an oil film due to the oil X is formed between these two surfaces. Such a contact with an oil film is also referred to as "surface contact."

**[0034]** Referring to Fig. 1, the electromagnetic clutch 25 is controlled by a computer C. The computer C is in electrical communication with an operating switch W for an air conditioner, a temperature setting device S for setting a target room temperature, and a temperature detecting device F for detecting a room temperature. When the operating switch W is turned on, the computer C controls the electric supply to the electromagnetic clutch 25 depending on the temperature difference between the target room temperature and the detected room temperature.

**[0035]** The computer C stops the electric supply to the electromagnetic clutch 25 when the detected temperature is below the target temperature, or when the detected temperature is above the target temperature but the temperature difference therebetween is within an allowable range. In this case, the electromagnetic clutch 25 is disengaged, so that the driving force of the vehicle engine 26 is not transmitted to the rotary shaft 21. The computer C allows the electric supply to the electromagnetic clutch 25 when the detected temperature is above the target temperature and the temperature difference is beyond the allowable range. In this case, the electromagnetic clutch 25 is engaged, so that the driving force of the vehicle engine 26 is transmitted to the rotary shaft 21.

**[0036]** When the piston type compressor 10 is in a stopped state (or the electromagnetic clutch 25 is disengaged), the pressure in the compressor 10 is balanced. That is, the valve body 42 is maintained at the disconnecting position by spring force of the return spring 47, as shown in Fig. 3. The pressure-receiving surface 431 of the valve body 42 is kept in surface contact with the bottom surface 402 via the above-described oil film.

**[0037]** When the compressor 10 is started, refrigerant in the in-shaft passage 31 and the inner spaces 451, 442 is introduced into the compression chamber 271 (see Fig. 1) and the compression chamber 281. Therefore, the pressure in the in-shaft passage 31 and the inner spaces 451, 442 is relatively decreased. That is, the pressure in the in-shaft passage 31 and the inner spaces 451, 442 becomes lower than the pressure in the suction chamber 142. The pressure in the suction chamber 142 is applied to the backpressure chamber 412 and, therefore, the pressure in the backpressure chamber 412 is equivalent to the pressure in the suction chamber 142. The pressure in the backpressure chamber 412 acts in opposition to the pressure in the inner spaces 451, 442 and the spring force of the return spring 47 through the valve body 42.

**[0038]** The piston portion 43 of the valve body 42 is attached to the bottom surface 402 by adhesive force of the oil film applied between the pressure-receiving surface 431 and the bottom surface 402. It is so set that the sum of the spring force of the return spring 47 and the adhesive force is smaller than the pressure difference between the backpressure chamber 412 and the inner spaces 451, 442 created when the compressor 10 is started. Accordingly, the valve body 42 is moved from the disconnecting position of Fig. 3 to the connecting position of Fig. 4 when the compressor 10 is started. When the valve body 42 is at the connecting position, refrigerant in the suction chamber 142 is introduced into the in-shaft passage 31 through the introduction port 441 and the inner spaces 442, 451. Then the refrigerant is further introduced into the compression chambers 271, 281 through the communication passages 32, 33.

**[0039]** When the compressor 10 is stopped, refrigerant in the in-shaft passage 31 and the inner spaces 451, 442 is not introduced any more into the compression chambers 271, 281. Therefore, the pressure in the in-shaft passage 31 and the inner spaces 451, 442 is increased and then becomes balanced with the pressure In the backpressure chamber 412. The valve body 42 is moved from the connecting position of Fig. 4 to the disconnecting position of Fig. 3 by the spring force of the return spring 47.

**[0040]** While the valve body 42 is moving from the disconnecting position toward the connecting position, the oil in the suction chamber 142 is introduced into the backpressure chamber 412 through the backpressure passage 413. When the valve body 42 is at the connecting position, as shown in Fig. 4, the oil in the suction chamber 142 is also introduced into the backpressure chamber 412 through the backpressure passage 413. As a result, the oil X is collected in the backpressure chamber 412. Since the pressure in the backpressure chamber 412 is equivalent to the pressure in the outlet passage 482 of the bleed passage 48, the valve port 481 is kept closed by the valve body 49 receiving the spring force of the compression spring 50. Accordingly, the oil Y in the suction chamber 142 does not flow into the backpressure chamber 412 through the bleed passage 48. When the compressor 10 is stopped and the valve body 42 is returned from the connecting position to the disconnecting position, the oil X in the backpressure chamber 412 flows out to the suction chamber 142 through the backpressure passage 413. The oil X in the backpressure chamber 412 also flows out to the suction chamber 142 through the bleed passage 48 while pushing away the valve body 49 from the valve port 481.

**[0041]** The valve body 42 is movable between the connecting position and the disconnecting position depending on pressure variation in the in-shaft passage 31 as the compressor 10 is started and stopped. The valve body 42 placed at the connecting position connects the suction chamber 142 to the outlets 312, 313 of the in-shaft passage 31. The valve body 42 placed at the disconnecting position disconnects the suction chamber 142 from the outlets 312, 313. The valve body 42, the return spring 47, the backpressure chamber 412, and the backpressure passage 413 constitute a shifting device 52. The shifting device 52 shifts between a connecting state and a disconnecting state.

**[0042]** In Fig. 3, the shifting device 52 is in the disconnecting state where the outlet 312 (see Fig. 1) and the outlet 313 of the in-shaft passage 31 are disconnected from the suction chamber 142. In other words, the compression chamber 271 (see Fig. 1) and the compression chamber 281 are disconnected from the suction chamber 142 upstream the shifting device 52 through the rotary valves 35, 36. In Fig. 4, the shifting device 52 is in the connecting state where the outlets 312, 313 are connected to the suction chamber 142. In other words, the compression chambers 271, 281 are connected to the suction chamber 142 upstream the shifting device 52 through the rotary valves 35, 36. The connecting and disconnecting states of the shifting device 52 corresponds to the connecting and disconnecting positions of the valve body 42, respectively.

**[0043]** The piston type compressor 10 according to the first embodiment offers the following advantages.

(1) The amount of refrigerant compressed while the shifting device 52 is in the disconnecting state is less than that of the background arts. Therefore, a rapid increase in the compressor torque, that is a shock, at the start of the compressor 10 is further suppressed, as compared to the background arts.

(2) If the valve body 42 takes a long time to move from the disconnecting position to the connecting position, the shock at the start of the compressor 10 is effectively suppressed. As described above, the oil film is formed between the pressure-receiving surface 431 of the valve body 42 and the bottom surface 402 of the backpressure chamber 412 when the valve body 42 is at the disconnecting position. Therefore, in starting the compressor 10, the time when the valve body 42 at the disconnecting position starts to move toward the connecting position is delayed because of the adhesive force of the oil film. As a result, the shock at the start of the compressor 10 is effectively suppressed.

(3) If the oil X in the backpressure chamber 412 does not flow out of the backpressure chamber 412, the valve body 42 cannot be returned to the disconnecting position. If the valve body 42 is not at the disconnecting position when the compressor 10 is started, the amount of refrigerant compressed at the start of the compressor 10 is increased, as compared to a case wherein the valve body 42 is at the disconnecting position. As a result, the shock at the start of the compressor 10 may not be sufficiently suppressed. According to the embodiment, however, when the compressor 10 is stopped, the oil X in the backpressure chamber 412 flows out to the suction chamber 142 through the backpressure passage 413 and the bleed passage 48 as the valve body 42 is moved. Thus, the valve body 42 is reliably returned to the disconnecting position by the spring force of the return spring 47.

(4) The pressure-receiving surface 431 and bottom surface 402 are flat surfaces and are parallel to each other. The pressure-receiving surface 431 comes into surface contact with the bottom surface 402. According to such structure, an oil film is formed on the whole bottom surface 402 except the valve port 481 facing the backpressure chamber 412 when the valve body 42 is at the disconnecting position. Obviously, such structure maximizes the adhesive force of the oil film. Therefore, the time when the valve body 42 starts to move from the disconnecting position toward the connecting position is further delayed, and the shock at the start of the compressor 10 is effectively suppressed.

(5) The oil X collected in the backpressure chamber 412 flows out to the suction chamber 142 through the bleed passage 48 as well as through the backpressure passage 413. Accordingly, the cross sectional area of the backpressure passage 413 can be minimized in such a range that the pressure in the suction chamber 142 is applied to the backpressure chamber 412. Such structure effectively prevents the oil in the suction chamber 142 from flowing easily into the backpressure passage 413.

(6) When the compressor 10 is stopped, the valve body 42 is returned to the disconnecting position by the spring force of the return spring 47. The use of the return spring 47 helps to simplify the structure for returning the valve body 42 to the disconnecting position.

(7) The oil flowing with the refrigerant tends to be collected at the bottom of the suction chamber 142. According to the embodiment wherein the inlet 414 of the backpressure passage 413 is disposed above the backpressure chamber 412, the amount of oil flowing into the backpressure passage 413 or into the backpressure chamber 412 is reduced.

(8) The introduction port 441 serves as an inlet of the inner space 442 of the valve body 42. When the valve body 42 is at the disconnecting position, the introduction port 441 of the valve body 42 is positioned in the inner space 411 of the cylinder 41, so that the in-shaft passage 31 is closed. When the valve body 42 is at the connecting position, the introduction port 441 is positioned out of the inner space 411 and faces the suction chamber 142, so that the in-shaft passage 31 is open. Such structure permits the introduction port 441 to be enlarged in size, thereby enabling the in-shaft passage 31 to have an adequate cross sectional area.

**[0044]** The following will describe a second embodiment of the present invention with reference to Figs. 5A and 5B. The same reference numerals denote the identical components to those in the first embodiment.

**[0045]** The rear housing 14 is formed with a communication chamber 53 and a valve port 541. The communication chamber 53 accommodates therein a plate 55 made of a magnetic material and operable to open and close the valve port 541. The valve port 541 is formed through a partition wall 54 separating the communication chamber 53 from the suction chamber 142. The inlet 311 of the in-shaft passage 31 is formed at the end surface 213 of the rotary shaft 21 in the cylinder block 12 and is open to the communication chamber 53 in the rear housing 14.

**[0046]** A piston portion 56 is slidably fitted in the inner space 411. The piston portion 56 has a pressure-receiving surface 561 for receiving the pressure in the backpressure chamber 412. The piston portion 56 is formed integrally with a rod 67, The rod 57 is fixed at the end thereof to the plate 55. The plate 55 is contactable at a sealing surface 551 thereof with a valve seat 542 thereby to close the valve port 541 and separable from the valve seat 542 thereby to open the valve port 541. The sealing surface 551 is a flat surface. That is, when the plate 55 closes the valve port 541, the sealing surface 551 of the plate 55 is in surface contact with the valve seat 542. The piston portion 56, the rod 57, and the plate 55 constitute a valve body 59 opening and closing the valve port 541. The valve body 59 defines the backpressure chamber 412 in the inner space 411.

**[0047]** The inner surface 401 around the cylinder 41 is formed with a protrusion 58 having a circular shape in the radial direction of the compressor 10. The inlet 414 of the backpressure passage 413 is open at the end surface of the protrusion 58. The outer periphery of the protrusion 58 serves as a stepped portion 581 surrounding circumferentially the inlet 414.

**[0048]** A return spring 60 is interposed between the piston portion 56 and the partition wall 54 for urging the piston portion 56 into the inner space 411. In Fig. 5B, the valve body 59 opens the valve port 541 and is at the connecting position to connect the communication chamber 53 to the suction chamber 142. In Fig. 5A, the valve body 59 closes the valve port 541 and is at the disconnecting position to disconnect the communication chamber 53 from the suction chamber 142. The return spring 60 urges the valve body 59 toward the disconnecting position.

**[0049]** The plate 55 is formed with restricting members 552 at the front surface thereof facing the end surface 213 of the rotary shaft 21. The restricting members 552 protrude from the front surface of the plate 55. As shown in Figs. 5A and 5B, the cylinder block 12 is formed at an end surface 122 with a cylindrical portion 123 protruding therefrom. The restricting members 552 are contactable with and separable from the end of the cylindrical portion 123. When the valve body 59 is at the connecting position of Fig. 5B, the restricting members 552 are in contact with the end of the cylindrical portion 123. When the valve body 59 is at the disconnecting position of Fig. 5A, the restricting members 552 are placed apart from the end of the cylindrical portion 123.

**[0050]** When the piston type compressor 10 is in a stopped state, the valve body 59 is maintained at the disconnecting position of Fig. 5A by spring force of the return spring 60. Refrigerant in the suction chamber 142 is not introduced into the communication chamber 53. The pressure-receiving surface 561 of the piston portion 56 is in surface contact with the bottom surface 402.

**[0051]** When the compressor 10 is started, refrigerant in the in-shaft passage 31 and the communication chamber 53 is introduced into the compression chamber 271 (see Fig. 1) and the compression chamber 281. As a result, the pressure in the in-shaft passage 31 and the communication chamber 53 decreases. That is, the pressure in the in-shaft passage 31 and the communication chamber 53 becomes lower than the pressure in the suction chamber 142. Accordingly, the valve body 59 is moved to the connecting position of Fig. 5B and the refrigerant in the suction chamber 142 flows into the compression chambers 271, 281 through the valve port 541, the communication chamber 53, and the in-shaft passage 31.

**[0052]** The valve body 59, the return spring 60, the backpressure chamber 412, and the backpressure passage 413 constitute a shifting device 52A. The shifting device 52A shifts between the connecting state and the disconnecting state. In the connecting state, the suction chamber 142 is connected to the outlet 312 (see Fig. 1) and the outlet 313 of the in-shaft passage 31. In the disconnecting state, the suction chamber 142 is disconnected from the outlets 312, 313.

**[0053]** In the second embodiment, the volume of the communication chamber 53 accommodating therein the plate 55 is reduced. That is, the amount of refrigerant compressed in the compression chambers 271, 281 during the disconnecting state may be reduced such as the first embodiment. Therefore, the shock at the start of the compressor 10 is suppressed similar to the first embodiment. Additionally, since the stepped portion 581 is provided around the inlet 414 of the backpressure passage 413, the oil attached to the inner surface 401 around the cylinder 41 hardly enters into the backpressure passage 413. That is, such structure prevents the oil in the suction chamber 142 from flowing easily into the backpressure chamber 412, thereby allowing the valve body 59 to be returned reliably to the disconnecting position.

**[0054]** The following will describe a third embodiment of the present invention with reference to Figs. 6A and 6B. The same reference numerals denote the identical components to those in the first embodiment.

**[0055]** A piston portion 61 is slidably fitted in the cylinder 41. The piston portion 61 defines the backpressure chamber 412 in the inner space 411. The piston portion 61 has a pressure-receiving surface 611 for receiving the pressure in the backpressure chamber 412. The piston portion 61 is connected to a rod 62 that is inserted in an in-shaft passage 31A of the rotary shaft 21. The in-shaft passage 31 A as the supply passage of the rotary valve includes a small-diameter passage 314 and a large-diameter passage 315. A disk 63 is fixed to the end of the rod 62 in the small-diameter passage 314. A cylindrical member 64 is fixed to the rod 62 in the large-diameter passage 315.

**[0056]** The disk 63 is fitted in the small-diameter passage 314 so as to be slidable in the direction of the rotational axis 210 of the rotary shaft 21. The cylindrical member 64 is fitted in the large-diameter passage 315 so as to be slidable in the direction of the rotational axis 210 thereby to open and close the outlet 313 in the large-diameter passage 315. A region of the in-shaft passage 31A between the disk 63 and the cylindrical member 64 communicates with a region of the in-shaft passage 31A between the inlet 311 and the cylindrical member 64 through the inner space of the cylindrical member 64.

**[0057]** As shown in Fig. 6B, when the cylindrical member 64 closes the outlet 313, the disk 63 is placed rearward of the outlet 312 in the in-shaft passage 31A. As a result, refrigerant in the in-shaft passage 31A is not introduced into the compression chamber 271 (see Fig. 1) through the outlet 312. As shown in Fig. 6A, when the cylindrical member 64 opens the outlet 313, the disk 63 is placed forward of the outlet 312 in the in-shaft passage 31A. As a result, refrigerant in the in-shaft passage 31A is introduced into the compression chamber 271 through the outlet 312.

**[0058]** The in-shaft passage 31A is formed with a step 316 between the small-diameter passage 314 and the large-diameter passage 315. A return spring 65 is interposed between the step 316 and the cylindrical member 64. The return spring 65 urges the disk 63, the cylindrical member 64, the rod 62, and the piston portion 61 together toward the backpressure chamber 412, that is, in the direction that causes the piston portion 61 to be pushed into the inner space 411.

**[0059]** The ball-shaped valve body 49 is accommodated in a valve chamber 483A. The valve chamber 483A constitutes a bleed passage 48A. The valve body 49 closes a valve port 481A by own weight thereof. The valve port 481A, the valve chamber 483A, and the valve body 49 constitute a check valve G2. The check valve G2 allows the fluid to flow from the backpressure chamber 412 into the bleed passage 48A.

**[0060]** The inlet 414 of the backpressure passage 413 is open at the inner surface 401 around the cylinder 41. The inner surface 401 is formed with an annular groove 66 surrounding circumferentially the inlet 414. The inner periphery of the groove 66 serves as a stepped portion 661.

**[0061]** When the compressor 10 is in a stopped state, the disk 63 and the cylindrical member 64 are maintained at the disconnecting position shown in Fig. 6B by spring force of the return spring 65. The pressure-receiving surface 611 of the piston portion 61 is then in surface contact with the bottom surface 402.

**[0062]** When the compressor 10 is started, refrigerant in a space 317 (a part of the in-shaft passage 31A) formed between the disk 63 and the front end of the in-shaft passage 31A is introduced into the compression chamber 271 (see Fig. 1). Accordingly, the pressure in the space 317 decreases, and the disk 63 and the cylindrical member 64 are moved from the disconnecting position of Fig. 6B to the connecting position of Fig. 6A against the spring force of the return spring 65.

**[0063]** When the compressor 10 is stopped, the disk 63 and the cylindrical member 64 are returned to the disconnecting position of Fig. 6B by the spring force of the return spring 65. The oil collected in the backpressure chamber 412 flows out to the suction chamber 142 through the bleed passage 48A while pushing away the valve body 49 from the valve port 481A.

**[0064]** The disk 63, the cylindrical member 64, the rod 62, and the piston portion 61 constitute a valve body 100 defining the backpressure chamber 412 in the inner space 411. The valve body 100 is movable between the connecting position and the disconnecting position depending on pressure variation in the space 317 as the compressor 10 is started and stopped. The valve body 100 at the connecting position connects the outlets 312, 313 of the in-shaft passage 31A to the suction chamber 142 in the compressor 10. The valve body 100 at the disconnecting position disconnects the outlets 312, 313 from the suction chamber 142. The valve body 100, the return spring 65, the backpressure chamber 412, and the backpressure passage 413 constitute a shifting device 52B. The shifting device 52B shifts between the connecting state and the disconnecting state. In the connecting state, the outlets 312, 313 of the in-shaft passage 31A are connected to the suction chamber 142 in the compressor 10. In the disconnecting state, the outlets 312, 313 are disconnected from the suction chamber 142.

**[0065]** The third embodiment offers further advantages in addition to the aforementioned advantages of the first and the second embodiments. Specifically, the third embodiment is more complicated in structure, but the shock at the start of the compressor 10 is suppressed, as compared to the first and the second embodiments. This is because only the refrigerant in the space 317, the outlets 312, 313, and the communication passages 32, 33 is introduced into compression chambers 271, 281 when the disk 63 and the cylindrical member 64 are placed at the disconnecting position.

**[0066]** Further, the structure of the check valve G2 is simplified, as compared to that of the check valve G1 in the first and second embodiments, because the valve body 49 closes the valve port 481A by own weight thereof. Additionally, the oil attached to the inner surface 401 around the cylinder 41 hardly enters into the backpressure passage 413 because the stepped portion 661 is provided around the inlet 414 of the backpressure passage 413. That is, such structure prevents the oil in the suction chamber 142 from flowing easily into the backpressure chamber 412.

**[0067]** The following will describe a fourth embodiment of the present invention with reference to Figs. 7A and 7B. The same reference numerals denote the identical components to those in the first embodiment.

**[0068]** The piston portion 43 has a cylindrical portion 67 on the back of the pressure-receiving surface 431. The cylindrical portion 67 defines therein a valve chamber 671. The ball-shaped valve body 49 is accommodated in the valve chamber 671. The piston portion 43 is formed with a valve port 432 that is open at the pressure-receiving surface 431. A circular clip 68 is installed in the inner surface of the cylindrical portion 67. The compression spring 50 is disposed in the valve chamber 671 between the circular clip 68 and the valve body 49. The valve body 49 is operable to open and close the valve port 432. The compression spring 50 urges the valve body 49 in such a direction that the valve body 49 closes the valve port 432. The valve chamber 671 communicates with the inner space 442 of the cylindrical portion 44. The valve chamber 671 and the valve port 432 constitute a bleed passage 69. The valve port 432, the valve chamber 671, the valve body 49, and the compression spring 50 constitute a check valve G3 allowing the fluid to flow from the backpressure chamber 412 into the bleed passage 69.

**[0069]** When the compressor 10 is in a stopped state, the valve body 42 is maintained at the disconnecting position shown in Fig. 7A by spring force of the return spring 47. The pressure-receiving surface 431 is in surface contact with the bottom surface 402, and the oil film is formed between the pressure-receiving surface 431 and the bottom surface 402.

**[0070]** When the compressor 10 is started, the valve body 42 is moved from the disconnecting position of Fig. 7A to the connecting position shown in Fig. 7B against the sum of the spring force of the return spring 47 and the adhesive force of the oil film.

**[0071]** When the compressor 10 is stopped, the valve body 42 is returned to the disconnecting position of Fig. 7A by the spring force of the return spring 47. The oil collected in the backpressure chamber 412 flows out through the bleed passage 69 into the inner space 442 while pushing the valve body 49 away from the valve port 432.

**[0072]** The fourth embodiment offers the advantages similar to those of the first embodiment.

**[0073]** The following will describe a fifth embodiment of the present invention with reference to Fig. 8. The same reference numerals denote the identical components to those in the first embodiment.

**[0074]** A housing assembly of a piston type compressor 10A includes the cylinder block 12, the front housing 13, and the rear housing 14. The compressor 10A is of a fixed displacement type. The crank chamber 24 is defined between the cylinder block 12 and the front housing 13 and accommodates therein the swash plate 23. A single-headed piston 70 is coupled to the swash plate 23 and reciprocates in the cylinder bore 28 with the rotation of the swash plate 23. The rotary shaft 21 is formed with the rotary valve 36 adjacent to the cylinder block 12. The rear housing 14 is formed with the bleed passage 48 and the check valve G1. The valve body 42 is received in the rear housing 14.

**[0075]** The fifth embodiment offers the advantages similar to those of the first embodiment.

**[0076]** The above embodiment may be modified in various ways as exemplified below.

**[0077]** The rotary valves 35, 36 may be formed independently of the rotary shaft 21.

**[0078]** An inlet of the bleed passage may be open at the bottom portion of the backpressure chamber 412.

**[0079]** In the first embodiment, the pressure-receiving surface 431 may be formed with a concave conical surface, and the bottom surface 402 may be formed with a convex conical surface. In this case, the convex conical surface of the bottom surface 402 is complementary to the concave conical surface of the pressure-receiving surface 431 so that the two surfaces 431, 402 are in surface contact with each other. Such structure allows the pressure-receiving surface 431 to be in surface contact with the bottom surface 402 over a larger contact area, with the result that the adhesive force of the oil film therebetween is further increased.

**[0080]** 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.

**[0081]** A suction structure allows refrigerant from a suction pressure region in a piston type compressor. The suction structure includes a shifting device, a bleed passage, and a check valve. The shifting device has a valve body, a return spring, a backpressure chamber, and a backpressure passage. The valve body is movable between a connecting position and a disconnecting position. The return spring urges the valve body from the connecting position toward the disconnecting position. The backpressure chamber is defined by the valve body. The backpressure passage communicates with the suction pressure region and the backpressure chamber. The bleed passage communicates with the suction pressure region and the backpressure chamber. The check valve allows a fluid to flow from the backpressure chamber into the bleed passage.

## Claims

1. A suction structure for allowing refrigerant from a suction pressure region (142) in a piston type compressor (10), wherein cylinder bores (27, 28) for accommodating a respective piston (29) are arranged around a rotary shaft (21), wherein the piston (29) is coupled to the rotary shaft (21) through a cam body (23) so that the rotation of the rotary shaft (21) is transmitted to the piston (29), wherein a compression chamber (271, 281) is defined by the piston (29)

in the respective cylinder bore (27, 28), wherein a valve mechanism (35, 36) is disposed adjacent to the compression chamber (271, 281),
**characterized by** the suction structure further comprising:

a shifting device (52) for shifting between a connecting state and a disconnecting state, wherein in the connecting state the compression chamber (271, 281) is connected to the suction pressure region (142) upstream the shifting device (52) through the valve mechanism (35, 36), and in the disconnecting state the compression chamber (271, 281) is disconnected from the suction pressure region (142) upstream the shifting device (52) through the valve mechanism (35, 36), the shifting device (52) including;
a valve body (42) movable between a connecting position and a disconnecting position, wherein the connecting position corresponds to the connecting state and the disconnecting position corresponds to the disconnecting state;
a return spring (47) urging the valve body (42) from the connecting position toward the disconnecting position;
a backpressure chamber (412) defined by the valve body (42); and
a backpressure passage (413) communicating with the suction pressure region (142) and the backpressure chamber (412),
a bleed passage (48) communicating with the suction pressure region (142) and the backpressure chamber (412); and
a check valve (G1) allowing a fluid to flow from the backpressure chamber (412) into the bleed passage (48).

**2.** The suction structure according to claim 1, wherein the valve mechanism (35, 36) is a rotary valve (35, 36) rotated integrally with the rotary shaft (21), wherein the rotary valve (35, 36) has a supply passage (31) for introducing the refrigerant from the suction pressure region (142) to the compression chamber (271,281), wherein the supply passage (31) has an outlet (312, 313) and an inlet (311), wherein in the connecting state the suction pressure region (142) is connected to the outlet (312, 313) of the supply passage (31), and in the disconnecting state the suction pressure region (142) is disconnected from the outlet (312, 313) of the supply passage (31).

**3.** The suction structure according to claim 2, wherein the valve body (42) includes a piston portion (43) defining the backpressure chamber (412), the backpressure chamber (412) has a bottom surface (402), and the piston portion (43) has a pressure-receiving surface (431) receiving a pressure in the backpressure chamber (412) and coming into surface contact with the bottom surface (402) of the backpressure chamber (412).

**4.** The suction structure according to claim 3, wherein the pressure-receiving surface (431) and the bottom surface (402) are flat and parallel to each other.

**5.** The suction structure according to claim 3 or claim 4, wherein the bleed passage (48) has an inlet (481) that is open at the bottom surface (402) of the backpressure chamber (492).

**6.** The suction structure according to claim 5, wherein the valve body (42) is moved in axial direction of the rotary shaft (21) between the connecting position and the disconnecting position.

**7.** The suction structure according to any one of claims 1 through 6, wherein the compressor (10) includes a rear housing (14) defining the suction pressure region (142) and having a rear housing wall (40), and the bleed passage (48) is formed inside the rear housing wall (40) so as to communicate with the suction pressure region (142).

**8.** The suction structure according to any one of claims 1 through 7, wherein the backpressure passage (413) has an inlet (414) disposed above the backpressure chamber (412).

**9.** The suction structure according to any one of claims 1 through 8, wherein the backpressure passage (413) has an inlet (414) surrounded circumferentially by a stepped portion (581) in the suction pressure region (142).

**10.** The suction structure according to any one of claims 1 through 9, wherein the valve body (42) is placed so that the inlet (311) of the supply passage (31) is disconnected from the suction pressure region (142) when the shifting device (52) is in the disconnecting state.

**11.** The suction structure according to any one of claims 1 through 10, wherein the compressor (10) includes a cylinder block (12) and a rear housing (14), the cylinder block (12) is formed with the cylinder bores (28), the rear housing (14) is connected to the cylinder block (12) and formed with a suction chamber (142) as the suction pressure region, and the valve body (42) is provided in the rear housing (14).

**12.** The suction structure according to any one of claims 1 through 11, wherein the supply passage has an in-shaft passage (31) formed inside the rotary shaft (21) and extending in axial direction of the rotary shaft (21), the inlet (311) of the supply passage is open at an end surface (213) of the rotary valve (21) and communicating with the in-shaft passage (31), the outlet (312, 313) of the supply passage is open at an outer periphery (211, 212) of the rotary valve (35, 36) and communicating with the in-shaft passage (31), the valve body (100) is disposed in the in-shaft passage (31), the valve body (100) is movable in the axial direction of the rotary shaft (21) between the connecting position and the disconnecting position in the in-shaft passage (31), and the valve body (100) at the disconnecting position disconnects the outlet (312, 313) of supply passage from the in-shaft passage (31).

**13.** The suction structure according to any one of claims 1 through 12, wherein the rotary shaft (21) is coupled to an external drive source (26) through a clutch (25).

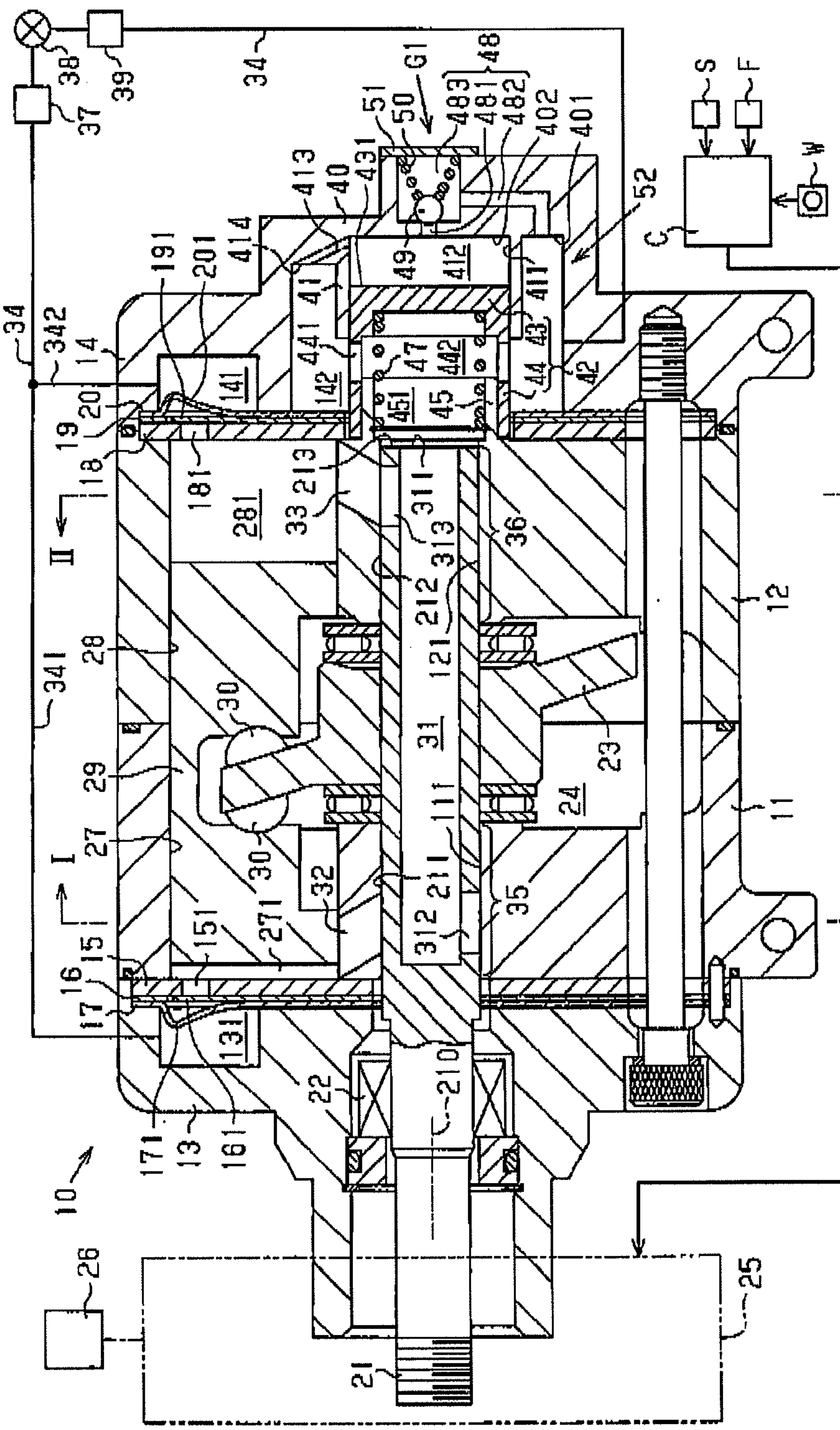

FIG. 1

FIG. 2A

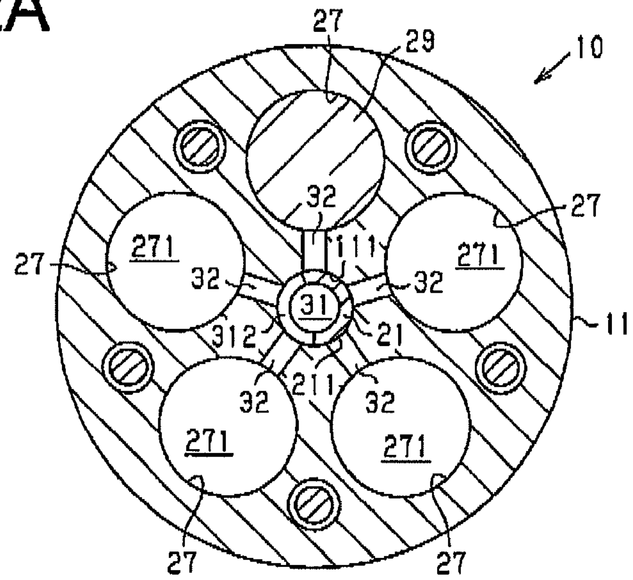
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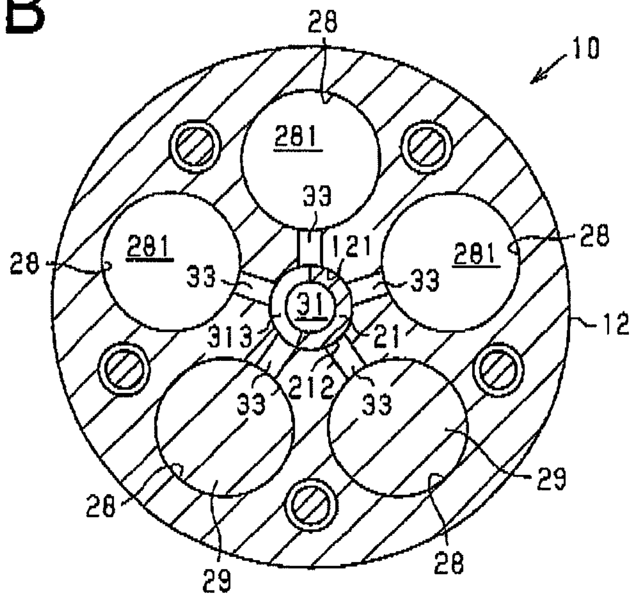
FIG. 2B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# FIG. 3

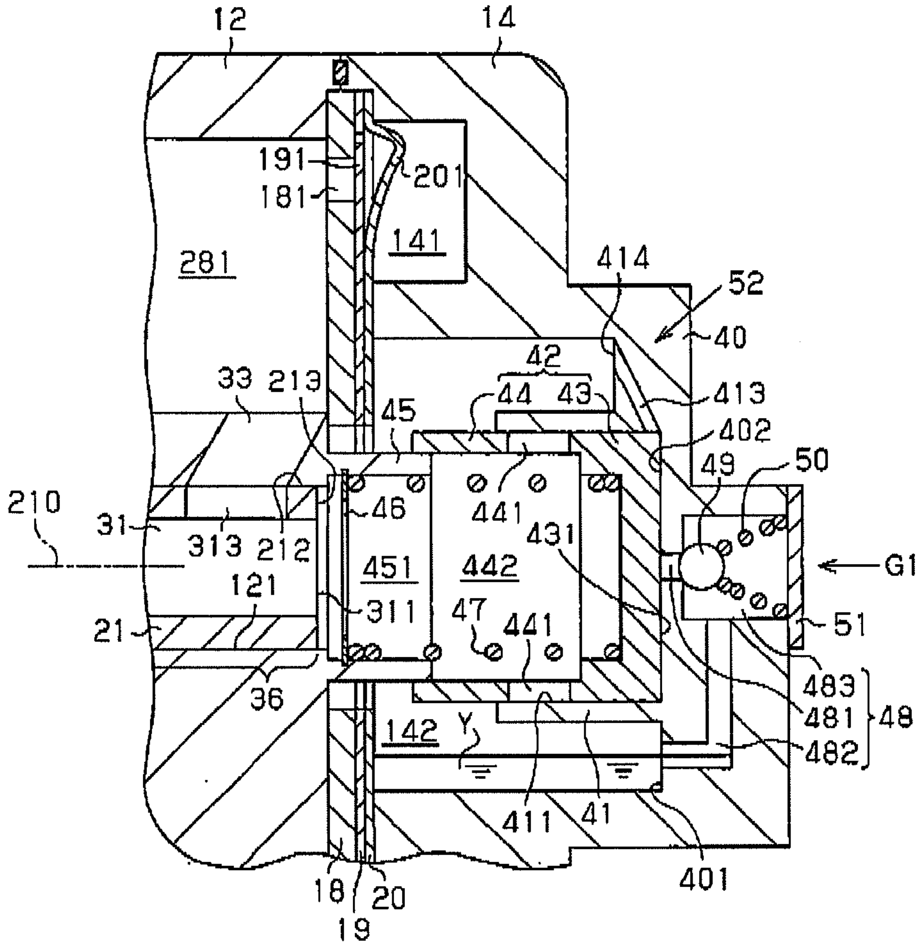
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FIG. 4

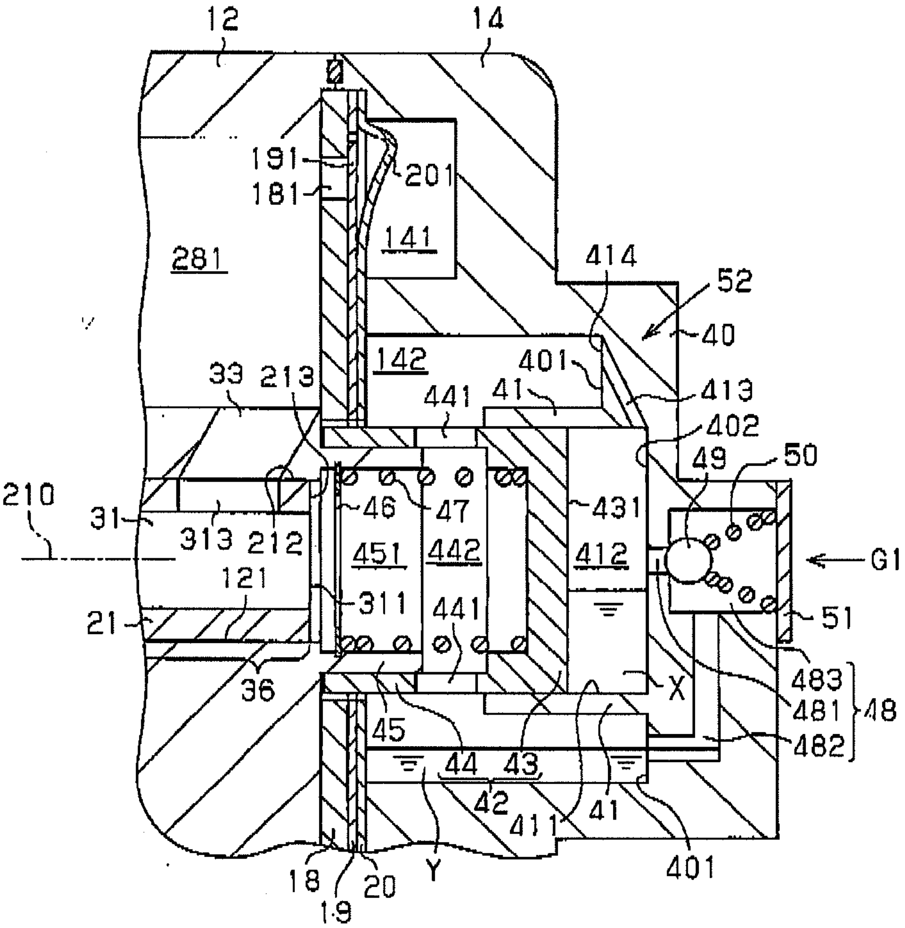
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FIG. 5B

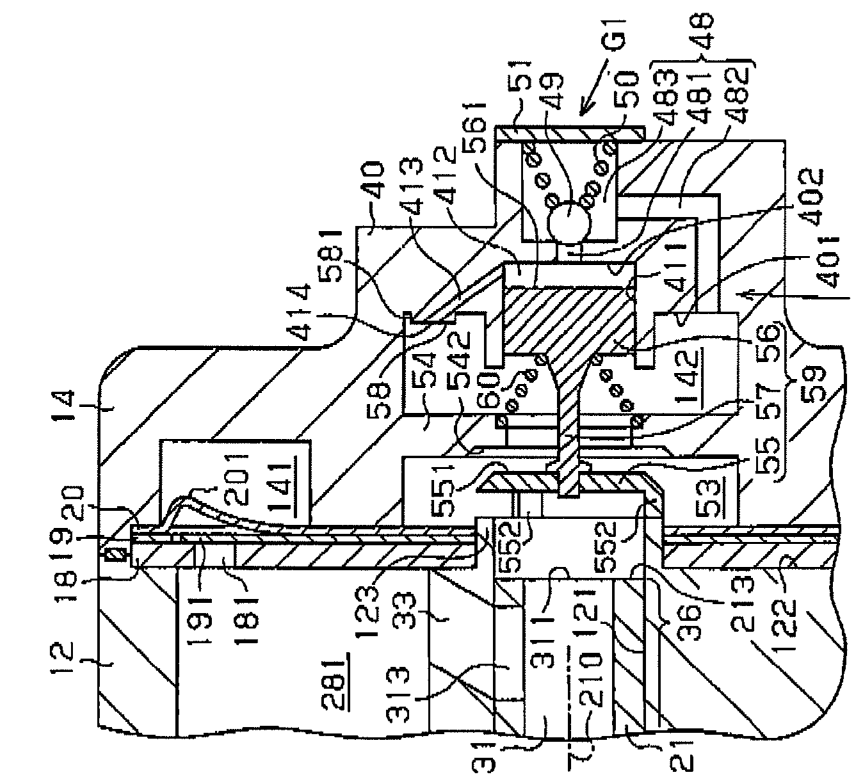
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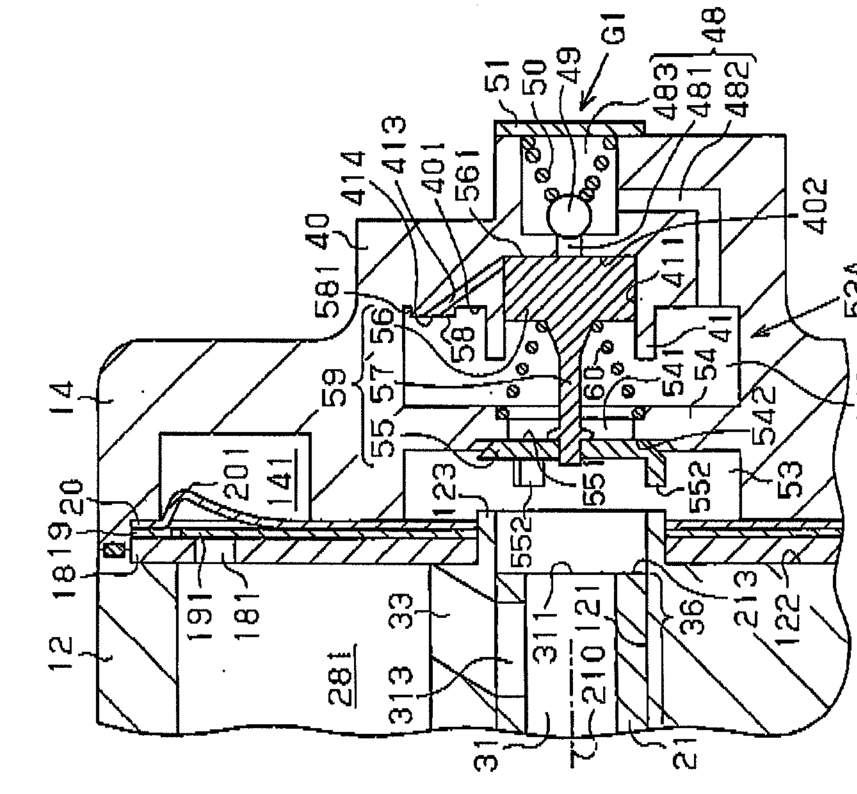
FIG. 5A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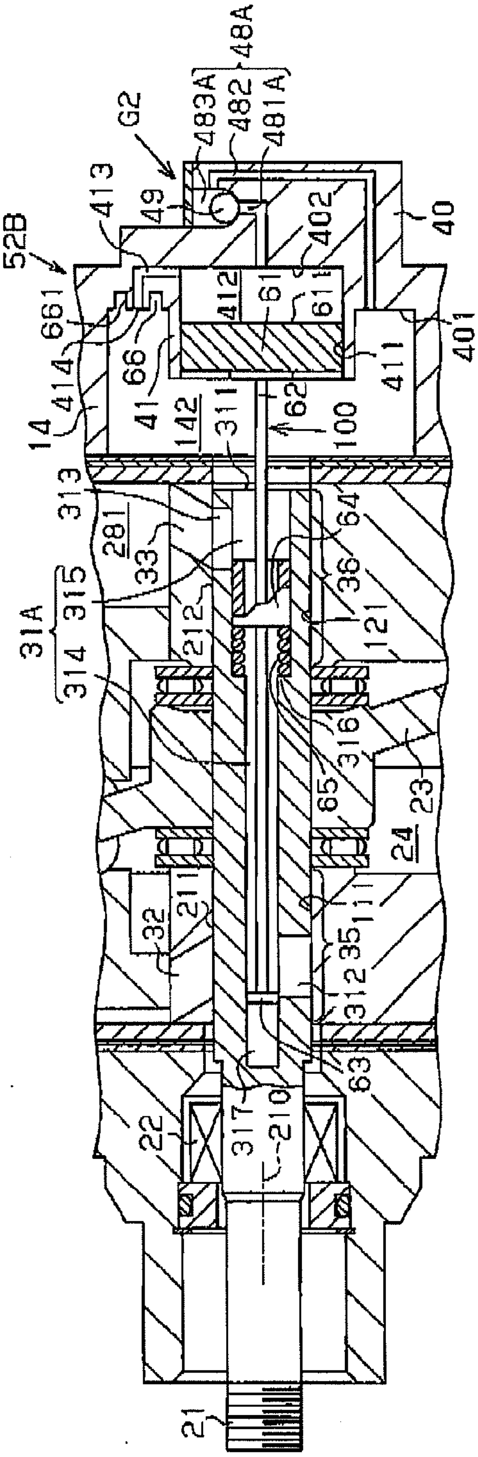
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FIG. 6A

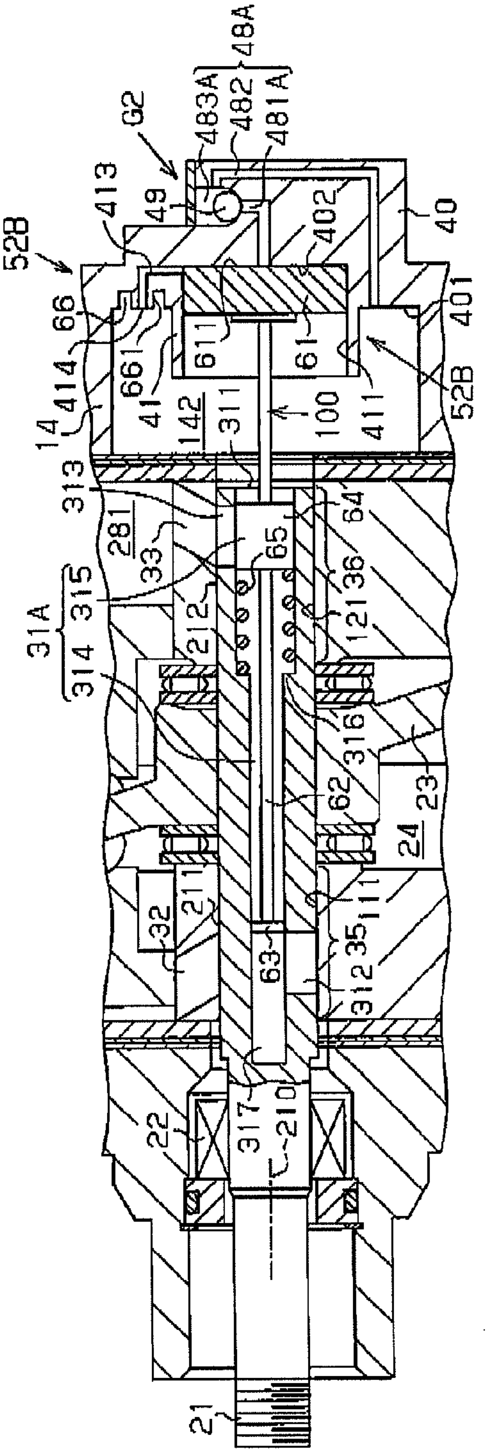
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FIG. 6B

FIG. 7B

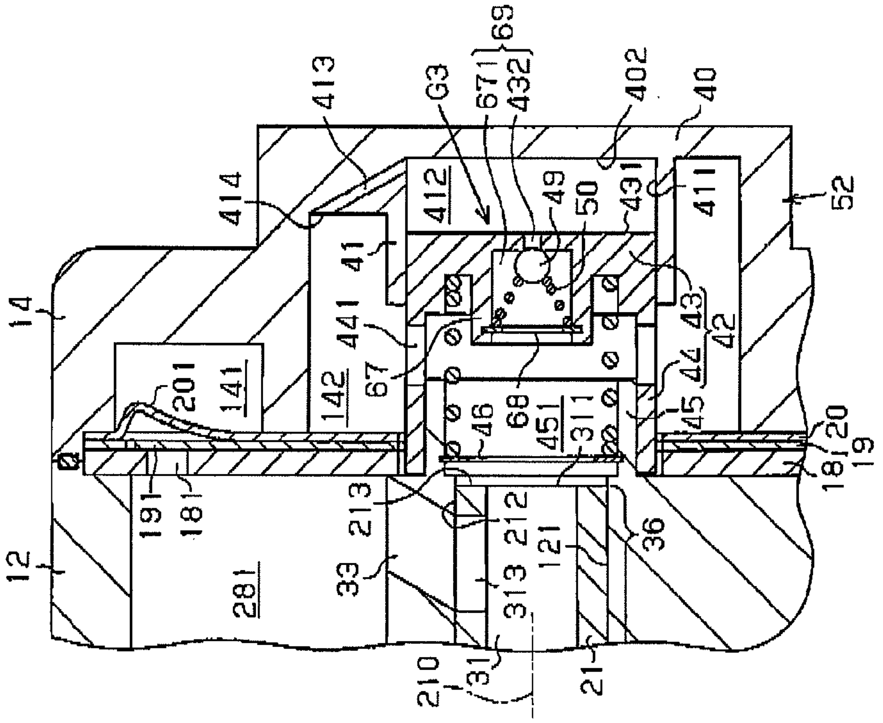
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FIG. 7A

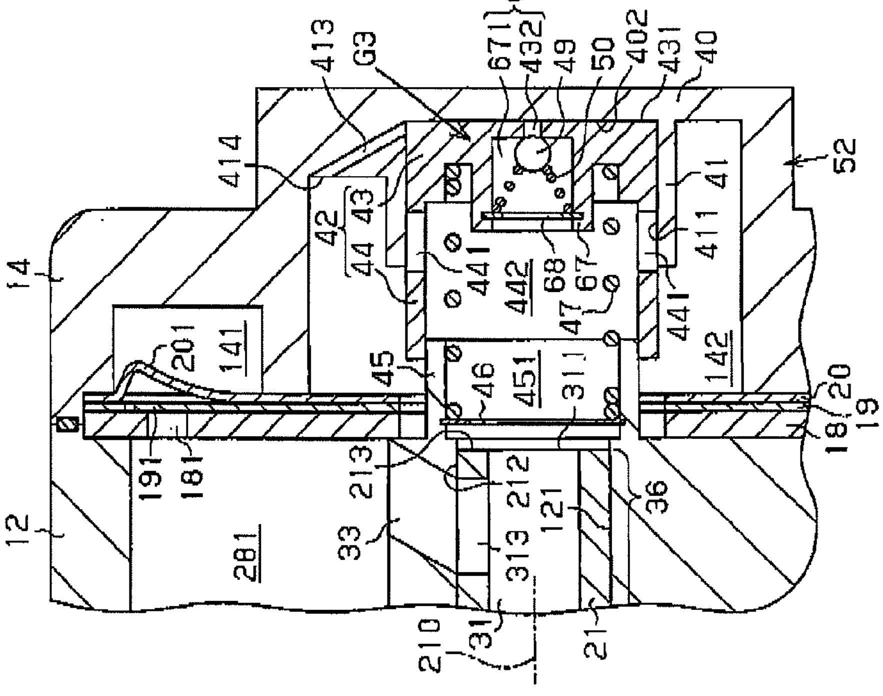
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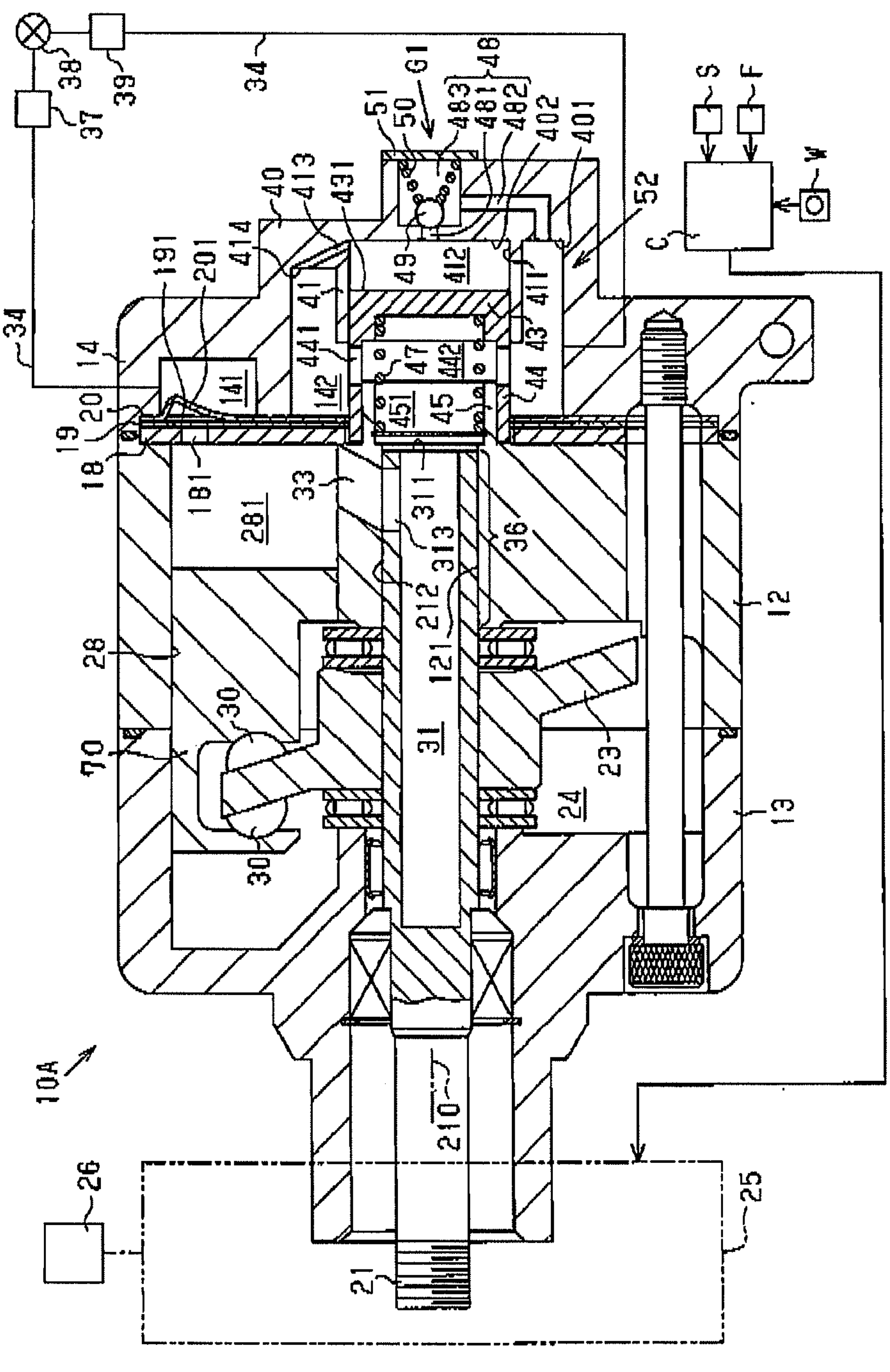
FIG. 8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## REFERENCES CITED IN THE DESCRIPTION

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- JP 64088064 B **[0002]**
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- WO 7119631 A **[0004]**
- JP 7139474 A **[0007]**