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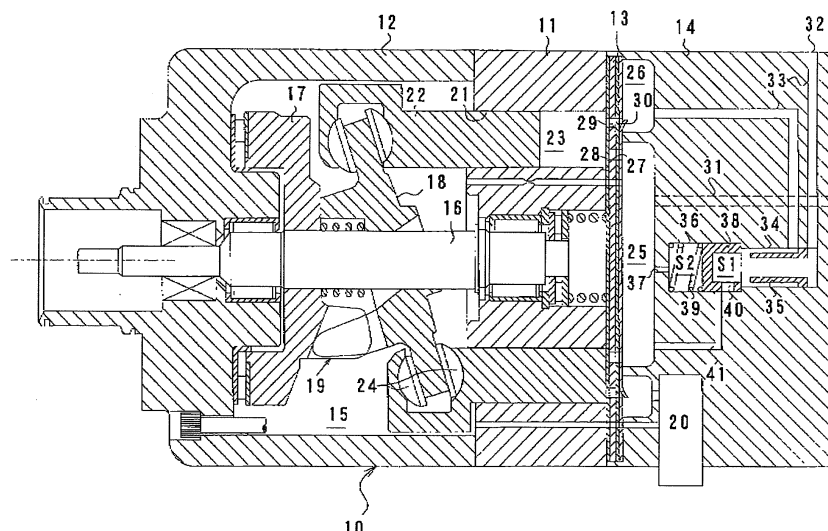
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(74) Representative: **TBK-Patent****Bavariaring 4-6****80336 München (DE)****(54) Compressor having a mechanism for separating and recovering lubrication oil**

(57) A compressor has a discharge passage, an oil separation mechanism, an oil supply passage, and a valve mechanism. The oil supply passage supplies the separated lubrication oil into an oil recovery region. The valve mechanism is formed in the oil supply passage and includes a valve chamber, a spool and an urging member. The spool separates the valve chamber into a first pressure sensing chamber and a second pressure sensing

chamber. The amount of the lubrication oil supplied to the oil recovery region is adjusted in such a manner that as the pressure differential between the first and the second pressure sensing chambers increases, the spool slides in the valve chamber and the opening degree of the oil supply passage increases to the maximum and then decreases, and that when the compressor is stopped, the opening degree of the oil supply passage is minimized by the urging force of the urging member.

FIG. 1

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a compressor used in an air conditioner for a vehicle, and more specifically to a compressor having a mechanism for separating lubrication oil from compressed refrigerant gas and recovering the lubrication oil.

[0002] In a compressor for use in an air conditioner for a vehicle, lubrication oil is mixed in the form of mist in refrigerant gas and lubricates movable sliding parts. When the lubrication oil mixed in the refrigerant gas flows out of the compressor together with the refrigerant gas and circulates in the external refrigerant circuit, the oil adheres to an inner wall of an evaporator and the like, and deteriorates the heat exchange efficiency.

[0003] Conventionally, an oil separator is formed outside a compressor and is located in the high-pressure piping connecting the compressor to a condenser. The separated lubrication oil is recovered into the compressor through an oil recovery passage. When the oil separator outside of the compressor is utilized, however, the construction of the whole refrigerant circuit becomes congested with equipments and additional piping. Furthermore, the oil recovery passage is elongated and has a small diameter so that problems such as clogging may occur. Therefore, an oil separator formed inside a compressor has been offered recently.

[0004] In the above-described compressor, the lubrication oil is separated in the oil separation mechanism and is supplied from the oil separation mechanism to a low pressure region through an oil supply passage. When the compressor is stopped, all the stored oil flows out to the low pressure region through the oil supply passage. Therefore, when the compressor restarts, highly-pressurized refrigerant gas may flow reversely through the oil supply passage, and the lubrication oil stored in the low pressure region may be compressed in liquid state. In order to avoid such problems, Unexamined Japanese Patent Publication No. 05-240158 discloses a compressor which includes an oil separation chamber, a primary oil storage chamber, a main oil storage chamber, an oil recovery hole, and a valve means. The oil separation chamber is formed in a high pressure region inside the compressor. The primary oil storage chamber for recovering lubrication oil is located below the oil separation chamber. The main oil storage chamber is connected to the primary oil storage chamber via a hole. The hole extends upward from a bottom portion of the primary oil storage chamber to the main oil storage chamber. The lubrication oil in the primary oil storage chamber flows upward through the hole and drops downward in the main storage chamber. The oil recovery hole is opened in a valve seat surface formed at the bottom of the main oil storage chamber and connects the main oil storage chamber to the low pressure region inside the compressor. The valve means adjusts the flow rate of the lubri-

cation oil to be recovered in accordance with the pressure differential between the high pressure region and the low pressure region. In accordance with the increase of the pressure differential between the high pressure region and the low pressure region, the valve means adjusts the flow rate of the lubrication oil to be gradually decreased. The valve means ensures an optimal amount of the lubrication oil based on the balance between the amount of the separated lubrication oil and the required amount of the lubrication oil to be recovered. On the other hand, after the compressor is stopped, the move of the separated lubrication oil between the primary oil storage chamber and the main oil storage chamber is stopped at the time when the pressure differential is balanced to the force due to the weight of the lubrication oil which is in the hole. When the pressure in the refrigerant circuit is balanced, the optimal amount of the lubrication oil is stored in the primary oil storage chamber. However, when the pressure differential is relatively small due to the small flow rate of the refrigerant gas, the opening degree of the oil recovery hole is fully opened and the amount of the separated lubrication oil is small in comparison to the amount of the recovered lubrication oil. Accordingly, all the stored oil flows out to the low pressure region. As described above, the refrigerant gas may flow reversely and the lubrication oil may be compressed in liquid state. Furthermore, the structure of the valve means is complicated, thereby needs many assembling processes and accuracy in manufacturing.

SUMMARY OF THE INVENTION

[0005] In accordance with the present invention, a compressor has an outlet, a discharge passage, an oil separation mechanism, an oil supply passage, and a valve mechanism. The outlet discharges refrigerant gas out from the compressor. The discharge passage is connected to the outlet, and the refrigerant gas is discharged through the discharge passage and the outlet from the compressor. The oil separation mechanism separates lubrication oil from the refrigerant gas. The oil supply passage supplies the separated lubrication oil into an oil recovery region. The valve mechanism is formed in the oil supply passage and includes a valve chamber, a spool and an urging member. The spool separates the valve chamber into a first pressure sensing chamber and a second pressure sensing chamber. The amount of the lubrication oil supplied to the oil recovery region is adjusted in such a manner that as the pressure differential between the first pressure sensing chamber and the second pressure sensing chamber increases, the spool slides in the valve chamber and the opening degree of the oil supply passage increases to the maximum and then decreases, and that when the compressor is stopped, the opening degree of the oil supply passage is minimized by the urging force of the urging member.

[0006] Other aspects and advantages of the invention will become apparent from the following description, tak-

en in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] 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 variable displacement swash plate compressor according to a first preferred embodiment of the present invention;

FIG. 2 is an enlarged schematic view of a valve mechanism in a state where the valve mechanism is fully opened;

FIG. 3 is an enlarged schematic view of the valve mechanism in a state where the compressor is at a maximum displacement operational mode according to the first preferred embodiment of the present invention;

FIG. 4 is an enlarged schematic view of the valve mechanism in a state where the compressor is stopped according to the first preferred embodiment of the present invention;

FIG. 5 is a graph showing a relation between the pressure differential acting on a spool of the valve mechanism and the opening degree of an oil supply passage according to the present invention;

FIG. 6 is a longitudinal cross-sectional view of a variable displacement swash plate compressor according to a second preferred embodiment of the present invention;

FIG. 7 is an enlarged schematic view of a valve mechanism in a state where the valve mechanism is fully opened according to the second preferred embodiment of the present invention;

FIG. 8 is an enlarged schematic view of the valve mechanism in a state where the compressor is at a maximum displacement operational mode according to the second preferred embodiment of the present invention;

FIG. 9 is an enlarged schematic view of the valve mechanism in a state where the compressor is stopped according to the second preferred embodiment of the present invention;

FIG. 10 is a longitudinal cross-sectional view of a variable displacement swash plate compressor according to a third preferred embodiment of the present invention;

FIG. 11 is a longitudinal cross-sectional view of a variable displacement swash plate compressor according to a fourth preferred embodiment of the present invention; and

FIG. 12 is a longitudinal cross-sectional view of a variable displacement swash plate compressor according to an alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0008] A first preferred embodiment of a variable displacement swash plate compressor 10 (hereinafter referred to as a "compressor") according to the present invention will now be described with reference to FIGS. 1 through 5.

[0009] Referring to FIG. 1, the compressor 10 includes a cylinder block 11, a front housing 12 and a rear housing 14. The left-hand side of the compressor 10 corresponds to the front side and the right-hand side of the compressor 10 corresponds to the rear side as viewed in Fig. 1. The front housing 12 is connected to the front end of the cylinder block 11. The rear housing 14 is connected to the rear end of the cylinder block 11 through a valve port plate assembly 13. The cylinder block 11, the front housing 12 and the rear housing 14 cooperate to form a housing of the compressor 10. A crank chamber 15 is defined by the cylinder block 11 and the front housing 12. A drive shaft 16 is rotatably disposed in the crank chamber 15. The front end portion of the drive shaft 16 protrudes from the crank chamber 15 and is coupled to a vehicle engine (not shown) to receive driving force so that the drive shaft 16 is rotated.

[0010] A lug plate 17 is disposed in the crank chamber 15 and fixed to the drive shaft 16 for rotation therewith. A swash plate 18 is disposed in the crank chamber 15. The swash plate 18 is supported by the drive shaft 16 so as to be slidable in the axial direction of the drive shaft 16 and also inclinable relative to the axis of the drive shaft 16. The swash plate 18 is connected to the lug plate 17 via a hinge mechanism 19. The hinge mechanism 19 is provided between the lug plate 17 and the swash plate 18. Through the hinge mechanism 19 the swash plate 18 is synchronously rotatable with the lug plate 17 and the drive shaft 16 and inclinable relative to the axial direction of the drive shaft 16 with sliding on the drive shaft 16. The inclination angle of the swash plate 18 is adjusted by a control valve 20.

[0011] A plurality of cylinder bores 21 (two of the cylinder bores are shown in FIG. 1) are formed in the cylinder block 11 for accommodating a reciprocable single-head-

ed piston 22 respectively. In each cylinder bore 21, a compression chamber 23 is defined by the piston 22 and the valve port plate assembly 13. Each piston 22 is engaged with the outer periphery of the swash plate 18 through a pair of shoes 24. The rotation of the swash plate 18 in accordance with the rotation of the drive shaft 16 is converted to the reciprocation of the pistons 22 through the pair of shoes 24 so that each piston 22 reciprocates in the respective cylinder bore 21.

[0012] A suction chamber 25 is defined in the rear housing 14 at the center thereof, and a discharge chamber 26 is defined around the suction chamber 25 in the rear housing 14. Suction ports 27 and suction valves 28 are formed in the valve port plate assembly 13. Discharge ports 29 and discharge valves 30 are formed in the valve port plate assembly 13. Refrigerant gas in the suction chamber 25 is introduced into the compression chamber 23 through the respective suction port 27 by pushing away the respective suction valve 28 as the piston 22 moves from its top dead center position to its bottom dead center position. The refrigerant gas is compressed in the compression chamber 23 to a predetermined pressure level, and is discharged into the discharge chamber 26 through the discharge port 29 while pushing away the discharge valve 30 as the piston 28 moves from its bottom dead center position to its top dead center position.

[0013] The rear housing 14 has an inlet 31 and an outlet 32. The inlet 31 is connected to an external refrigerant circuit (not shown) and the refrigerant gas is introduced into the suction chamber 25 through the inlet 31. The outlet 32 is connected to the external refrigerant circuit. A discharge passage 33 is formed to connect the outlet 32 and the discharge chamber 26. The refrigerant gas in the discharge chamber 26 is discharged out from the compressor 10 through the discharge passage 33 and the outlet 32. An oil separation mechanism is formed in the discharge passage 33. The oil separation mechanism includes an oil separation chamber 34 and an oil separation cylinder 35. The oil separation chamber 34 is formed with a cylindrical shape with a bottom surface at the rear end thereof. The oil separation cylinder 35 is received in the oil separation chamber 34. A valve mechanism is integrally formed with the oil separation mechanism. As shown in FIG. 1, the valve mechanism is formed adjacent to the oil separation mechanism so that the front end of the oil separation mechanism is shared by the rear end of the valve mechanism. The valve mechanism includes a valve chamber 36, a spool 38, and a spring 39 as an urging member. The valve chamber 36 is formed in the rear housing 14 and has a cylindrical shape with a bottom surface. The diameter of the valve chamber 36 is greater than that of the oil separation chamber 34. The spool 38 separates the valve chamber 36 into a first pressure sensing chamber S1 and a second pressure sensing chamber S2. The first pressure sensing chamber S1 is in communication with the discharge chamber 26 and the discharge passage 33 as a high pressure region through the oil separation chamber 34.

The second pressure sensing chamber S2 is in communication with the suction chamber 25 as a low pressure region through a pressure introduction passage 37. The spring 39 is disposed in the second pressure sensing chamber S2 and urges the spool 38 in the direction toward the rear end of the valve mechanism, or toward the oil separation mechanism. In a side surface of the spool 38 which faces the first pressure sensing chamber S1, an oil introduction hole 40 is formed so as to face a circumferential surface of the valve chamber 36. An oil passage 41 supplies the lubrication oil to the suction chamber 25, and is formed in such a manner that one end of the oil passage 41 opens to the suction chamber 25 and the other end of the oil passage 41 opens to the circumferential surface of the valve chamber 36. The opening end of the oil passage 41 opened to the valve chamber 36 is formed at a position where the oil introduction hole 40 overlaps the opening end of the oil passage 41 when the spool 38 slides. In the first preferred embodiment, an oil supply passage includes the oil separation chamber 34, the valve chamber 36, the oil introduction hole 40, and the oil passage 41. The valve mechanism is formed in the oil supply passage to adjust the opening degree of the oil supply passage.

[0014] The following will describe the operation of the compressor 10 of the first embodiment. As the drive shaft 16 is rotated, the swash plate 18 is rotated therewith and the piston 22 engaged with the swash plate 18 reciprocates in the cylinder bore 21, accordingly. As the piston 22 reciprocates, the refrigerant gas is introduced into the compression chamber 23 from the suction chamber 25, and is compressed in the compression chamber 23, and then discharged to the discharge chamber 26. The highly-pressurized refrigerant gas is introduced into the oil separation chamber 34 from the discharge chamber 26 through the discharge passage 33. The refrigerant gas introduced into the oil separation chamber 34 flows through the opening of the oil separation cylinder 35 to the inside of the oil separation cylinder 35 while swirling along the inner cylindrical wall of the oil separation chamber 34. The refrigerant gas is sent to the external refrigerant circuit (not shown) through the outlet 32. In the meantime, the oil mixed in the refrigerant gas is separated from the refrigerant gas by the centrifugal force generated by the swirling flow.

[0015] When the compressor 10 is not operated, the opening degree of the oil supply passage is minimum. When the compressor 10 starts, pressure differential is generated between the pressure in the first pressure sensing chamber S1 which acts on the rear side of the spool 38 and the pressure in the second pressure sensing chamber S2 which acts on the front side of the spool 38. The pressure in the first pressure sensing chamber S1 is based on the refrigerant gas introduced from the discharge chamber 26 through the discharge passage 33. The pressure in the second pressure sensing chamber S2 is based on the refrigerant gas introduced from the suction chamber 25 through the pressure introduction

passage 37. Accordingly, the pressure differential between the first pressure sensing chamber S1 and the second pressure sensing chamber S2, that is, the pressure differential which acts on the spool 38, overcomes the urging force of the spring 39, and the spool 38 slides frontward, or in the direction away from the oil separation mechanism to some extent in such a manner that the volume of the second pressure sensing chamber S2 is decreased and the oil introduction hole 40 begins to overlap with the opening end of the oil passage 41. As shown in Fig. 2, when the oil passage 41 is fully opened, the opening degree of the oil supply passage increases to the maximum. The oil separation chamber 34 is in communication with the oil passage 41 through the oil introduction hole 40. The lubrication oil separated in the oil separation chamber 34 is temporarily stored in the oil separation chamber 34, and introduced into the oil passage 41 through the oil introduction hole 40. Then the lubrication oil is recovered to the suction chamber 25.

[0016] As the pressure differential which acts on the spool 38 increases, the amount of the lubrication oil supplied to the suction chamber 25 increases until the opening degree of the oil supply passage increases to the maximum. Then, the spool 38 slides further, and the oil introduction hole 40 begins to pass through the opening end of the oil passage 41. When the spool 38 slides and moves to a position to partially close the opening of the oil passage 41, as shown in Fig. 3, the opening degree of the oil supply passage becomes decreasing. As a result, small amount of the lubrication oil is recovered to such an extent that the lubrication oil in the oil separation chamber 34 does not flow out completely. Thereby, the circulation of lubrication oil in the compressor 10 is maintained.

[0017] When the operation of the compressor 10 is stopped, the pressure in the first pressure sensing chamber S1 decreases to substantially the same level as the pressure in the second pressure sensing chamber S2. The urging force of the spring 39 overcomes the pressure differential which acts on the spool 38 so that the spool 38 is pushed rearward, or in the direction toward the oil separation mechanism to make contact with the rear end surface of the first pressure sensing chamber S1. The opening end of the oil passage 41 is closed by the spool 38, and the communication between the valve chamber 36 and the oil passage 41 is shut. In other words, the opening degree of the oil supply passage is minimized by the urging force of the spring 39. Thus, when the compressor 10 is stopped, the circulation of the lubrication oil inside the compressor 10 is stopped, and accordingly the recovery of the lubrication oil to the suction chamber 25 is stopped.

[0018] According to the first preferred embodiment of the present invention, the following advantageous effects are obtained.

- (1) The compressor 10 has the valve mechanism which has the valve chamber 36, the spool 38, and

the spring 39. The valve chamber 36 is formed with the cylindrical shape with the bottom surface in the rear housing 14. The spool 38 separates the valve chamber 36 into the first pressure sensing chamber S1 and the second pressure sensing chamber S2. The first pressure sensing chamber S1 is in communication with the discharge chamber 26 and the discharge passage 33. The second pressure sensing chamber S2 is in communication with the suction chamber 25. The spring 39 is disposed in the second pressure sensing chamber S2 and urges the spool 38 in the direction rearward, or toward the oil separation mechanism. The oil introduction hole 40 is formed in the side surface of the spool 38 which faces the first pressure sensing chamber S1 so as to face the circumferential surface of the valve chamber 36. The oil passage 41 has a opening end in the circumferential surface of the valve chamber 36 at a position where the opening end of the oil passage 41 overlaps the oil introduction hole 40 when the spool 38 slides. Accordingly, when the compressor 10 starts, the pressure differential which acts on the spool 38 overcomes the urging force of the spring 39 to move the spool 38 frontward, or in the direction so as to decrease the volume of the second pressure sensing chamber S2. The oil separation chamber 34 and the oil passage 41 communicate through the oil introduction hole 40, and the lubrication oil separated in the oil separation chamber 34 is introduced into the oil passage 41 through the oil introduction hole 40, and then is recovered to the suction chamber 25. As the pressure differential acting on the spool 38 increases further, the spool 38 slides to a position where the oil introduction hole 40 partially faces the opening end of the oil passage 41 and the spool 38 partially closes the opening end of the oil passage 41, that is, the front end of the oil introduction hole 40 passes through the front end of the oil passage 41, so that the opening degree of the oil supply passage is decreased accordingly. Thus, the opening degree of the oil supply passage becomes maximum from minimum and then becomes smaller than the maximum in accordance with the pressure differential acting on the spool 38. The opening degree of the oil supply passage is set at an optimal value in accordance with the pressure differential acting on the spool 38 as shown in the graph in Fig. 5, and that can ensure the optimal amount of the recovered lubrication oil, without excess nor deficiency, at any operational mode.

Further, the oil introduction hole 40 is formed in the side surface of the spool 38, and the relation with the opening end of the oil passage 41 is changed in accordance with the sliding movement of the spool 38. The communicating area where the oil introduction hole 40 and the opening end of the oil passage 41 overlaps increases in accordance with the increase of the pressure differential acting on the spool

38, and after the communicating area becomes the maximum, the communicating area decreases. Accordingly, the opening degree of the oil supply passage is adjusted with the simple structure manufactured by simple processes.

(2) The oil separation chamber 34 and the valve chamber 36 are adjacent to each other, and the front end of the oil separation chamber 34 is shared by the rear end of the valve chamber 36. As the pressure differential acting on the spool 38 increases, the spool 38 slides frontward, or in the direction away from the oil separation mechanism so as to decrease the volume of the second pressure sensing chamber S2. Accordingly, the first pressure sensing chamber S1 which is on the rear side of the spool 38 can be used as an additional oil separation space. Therefore the whole space used for storing lubrication oil is increased. In general, when pressure differential between a high pressure region and a low pressure region in the compressor 10 is large, the flow rate in the compressor 10 is large. Thus, the volume of the whole space can be enlarged in accordance with the amount of the separated lubrication oil, which increases in accordance with the increase of the flow rate of the refrigerant gas. Further, the front end of the oil separation chamber 34 is applicable as a valve seat of the spool 38, so the compressor 10 can be manufactured by simple structure.

A second preferred embodiment of the present invention will now be described with reference to FIG. 6. The compressor of the second embodiment differs from that of the first embodiment in that the structure of the valve mechanism is modified, and the rest of the structure of the compressor of the second embodiment is substantially the same as the first embodiment. For the sake of convenience of explanation, therefore, like or same parts or elements will be referred to by the same reference numerals as those which have been used in the first embodiment, and the description thereof will be omitted.

As shown in Fig. 6, a valve mechanism of the second embodiment has the valve chamber 36, the spool 38, and the spring 39 as the urging member. The valve chamber 36 is formed in the rear housing 14 and has the cylindrical shape with the bottom surface. The spool 38 separates the valve chamber 36 into the first pressure sensing chamber S1 and the second pressure sensing chamber S2. The first pressure sensing chamber S1 is in communication with the discharge chamber 26 and the discharge passage 33 as a high pressure region through the oil separation chamber 34. The second pressure sensing chamber S2 is in communication with the suction chamber 25 as a low pressure region through the oil passage 41. The spring 39 is disposed in the second pressure sensing chamber S2 of the valve chamber 36 and urges the spool 38 rearward, or in the direc-

tion toward the oil separation mechanism. A groove 42 is formed in the circumferential surface of the valve chamber 36. The groove 42 is formed at a position where the groove 42 is partially covered by the spool 38 and formed so that the communication between the groove 42 and the first pressure sensing chamber S1 is shut, when the compressor 10 is stopped. In addition, the position of the groove 42 is set so that the first pressure sensing chamber S1 and the second pressure sensing chamber S2 communicate through the groove 42 to open the oil supply passage, when the spool 38 slides frontward from the rear end of the valve mechanism. In the second embodiment, specifically, the groove 42 is formed along the sliding direction of the spool 38, as shown in FIG. 7 through FIG. 9. The oil supply passage of the second embodiment includes the oil separation chamber 34, the valve chamber 36, the oil passage 41 and the groove 42. The valve mechanism is formed in the oil supply passage to adjust the opening degree of the oil supply passage.

When the compressor 10 starts, the pressure differential acting on the spool 38 overcomes the urging force of the spring 39, and the spool 38 slides to some extent in the direction away from the oil separation mechanism, as shown in Fig. 7. Accordingly, the first pressure sensing chamber S1 and the second pressure sensing chamber S2 communicate through the groove 42 as shown in Fig. 7, and the separated lubrication oil in the oil separation chamber 34 is introduced into the oil passage 41 through the groove 42, and then is recovered to the suction chamber 25.

As the pressure in the first pressure sensing chamber S1 increases, the pressure differential acting on the spool 38 increases, and the amount of the lubrication oil supplied to the suction chamber 25 increases until the opening degree of the oil supply passage is maximum. Then, the spool 38 slides to a position where the area of the groove 42 communicating with the first pressure sensing chamber S1 becomes larger than the area of the groove 42 communicating with the second pressure sensing chamber S2, as shown in Fig. 8. Accordingly, the opening degree of the oil supply passage is decreased. As a result, small amount of the lubrication oil is recovered to such an extent that the stored lubrication oil does not flow out completely, thereby the circulation of the lubrication oil is maintained.

When the compressor 10 is stopped, the pressure in the first pressure sensing chamber S1 decreases to substantially the same level as that of the second pressure sensing chamber S2. The urging force of the spring 39 overcomes the pressure differential acting on the spool 38 so that the spool 38 is pushed toward the end surface of the first pressure sensing chamber S1 so as to make contact with the end surface of the first pressure sensing chamber S1, and

then the communication between the first pressure sensing chamber S1 and the groove 42 is shut. Thus, when the compressor 10 is stopped, the circulation of the lubrication oil inside the compressor 10 is stopped, and accordingly the recovery of the lubrication oil to the suction chamber 25 is stopped.

According to the second embodiment of the present invention, the similar effect as (2) of the first embodiment is obtained, and further, the following advantageous effect (3) instead of (1) of the first embodiment is obtained.

(3) The compressor 10 includes the valve mechanism which has the valve chamber 36, the spool 38, and the spring 39. The valve chamber 36 is formed with the cylindrical shape with the bottom surface in the rear housing 14. The spool 38 separates the valve chamber 36 into the first pressure sensing chamber S1 and the second pressure sensing chamber S2. The first pressure sensing chamber S1 is in communication with the discharge chamber 26 and the discharge passage 33. The second pressure sensing chamber S2 is in communication with the suction chamber 25. The spring 39 is disposed in the second pressure sensing chamber S2 and urges the spool 38 in the direction toward the oil separation mechanism so as to increase the volume of the second pressure sensing chamber S2. The groove 42 is formed in the circumferential surface of the valve chamber 36 at a position where the communication between the groove 42 and the first pressure sensing chamber S1 is shut by the spool 38 when the compressor 10 is stopped. In addition, the position of the groove 42 is set so that the first pressure sensing chamber S1 and the second pressure sensing chamber S2 communicate through the groove 42 to open the oil supply passage, when the spool 38 slides frontward from the rear end of the valve mechanism. Accordingly, when the compressor 10 starts, the pressure differential acting on the spool 38 overcomes the urging force of the spring 39 to move the spool 38 in the direction away from the oil separation mechanism. Thus, the first pressure sensing chamber S1 and the second pressure sensing chamber S2 communicate through the groove 42, and the lubrication oil separated in the oil separation chamber 34 is introduced into the oil passage 41 through the groove 42, and is recovered to the suction chamber 25. As the pressure differential acting on the spool 38 increases further, the spool 38 slides to a position where the area of the groove 42 communicating with the first pressure sensing chamber S1 becomes larger than the area of the groove 42 communicating with the second pressure sensing chamber S2, and accordingly the opening degree of the oil supply passage is decreased. As a result, an optimal amount of the lubrication oil can be ensured, without excess nor deficiency at any operational mode. Further, the

opening degree of the oil supply passage is adjusted with the simple structure manufactured by simple processes.

A third preferred embodiment of the present invention will now be described with reference to FIG. 10. The compressor of the third embodiment differs from that of the first embodiment in that the method for adjusting the valve mechanism is modified, and the rest of the compressor of the third embodiment is substantially the same as the first embodiment. For the sake of convenience of explanation, therefore, like or same parts or elements will be referred to by the same reference numerals as those which have been used in the first embodiment, and the description thereof will be omitted.

As shown in Fig. 10, a valve mechanism of the third embodiment has a second pressure sensing chamber S2 which is in communication with the downstream of the oil separation mechanism in the discharge passage 33, instead that the second pressure sensing chamber S2 of the first embodiment is in communication with the suction chamber 25. Thereby, during the operation of the compressor 10, the pressure in the second pressure sensing chamber S2 is substantially equal to the pressure in the downstream of the oil separation mechanism in the discharge passage 33.

A check valve 43 is formed in the discharge passage 33. In detail, the check valve 43 is formed between the oil separation mechanism and a branching point connecting to the second pressure sensing chamber S2. Thereby, when the compressor is stopped, only the pressure in the second pressure sensing chamber S2 is substantially equal to the pressure in the external refrigerant circuit. In the third embodiment, the oil supply passage includes the oil separation chamber 34, the valve chamber 36, the oil introduction hole 40, and the oil passage 41.

When the compressor 10 starts, pressure differential is generated between the upstream and the downstream of the oil separation mechanism in the discharge passage 33, and thereby pressure differential is generated between the first pressure sensing chamber S1 and the second pressure sensing chamber S2. The pressure differential acting on the spool 38 overcomes the urging force of the spring 39 to move the spool 38 frontward, or in the direction away from the oil separation mechanism to some extent. Thereby the oil separation chamber 34 and the oil passage 41 communicate through the oil introduction hole 40, and the lubrication oil separated in the oil separation chamber 34 is introduced into the oil passage 41 through the oil introduction hole 40, and then is recovered to the suction chamber 25.

As the flow rate in the compressor 10 increases, the pressure differential between the upstream and the downstream of the oil separation mechanism increases, and as a result the pressure differential act-

ing on the spool 38 increases. In accordance with the increase in the pressure differential acting on the spool 38, the spool 38 slides to a position where the opening degree of the oil supply passage is maximum, and then to a position where the oil introduction hole 40 is moved past the opening end of the oil passage 41 and the spool 38 partially covers the oil passage 41 so that the opening degree of the oil supply passage is decreased.

When the operation of the compressor 10 is stopped, the pressure in the discharge passage 33 decreases gradually, and approaches the pressure in the external refrigerant circuit. Thereby, when the compressor 10 is stopped, the pressure in the second pressure sensing chamber S2 is substantially equal to the pressure in the external refrigerant circuit. On the other hand, the check valve 43 is closed, and the pressure in the first pressure sensing chamber S1 is substantially equal to the pressure in the discharge chamber 26. Thereby the pressure in the second pressure sensing chamber S2 becomes larger than the pressure in the first pressure sensing chamber S1, and the spool 38 slides to the end surface of the first pressure sensing chamber S1 by the pressure differential and the urging force of the spring 39 so as to shut the communication between the valve chamber 36 and the oil passage 41. Thus, when the compressor 10 is stopped, the circulation of the lubrication oil in the compressor 10 and the recovery to the suction chamber 25 is accordingly stopped. According to the third embodiment of the present invention, the similar effect as (2) of the first embodiment is obtained, and further, the following advantageous effects (4) through (6) instead of (1) of the first embodiment are obtained.

(4) The compressor 10 includes the valve mechanism which has the valve chamber 36, the spool 38, and the spring 39. The valve chamber 36 is formed with the cylindrical shape with the bottom surface in the rear housing 14. The spool 38 separates the valve chamber 36 into the first pressure sensing chamber S1 and the second pressure sensing chamber S2. The first pressure sensing chamber S1 is in communication with the discharge chamber 26 and the discharge passage 33. The second pressure sensing chamber S2 is in communication with the downstream of the oil separation mechanism. The spring 39 is disposed in the second pressure sensing chamber S2 and urges the spool 38 in the direction toward the oil separation mechanism so as to increase the volume of the second pressure sensing chamber S2. When the compressor 10 starts, the pressure differential is generated between the upstream and the downstream of the oil separation mechanism in the discharge passage 33, and thereby the pressure differential acts on the spool 38. Due to the pressure differential, the spool 38 slides in the

direction away from the oil separation mechanism to some extent. Thereby the oil separation chamber 34 and the oil passage 41 communicate through the oil introduction hole 40. Thus, the lubrication oil separated in the oil separation chamber 34 is introduced into the oil passage 41 through the oil introduction hole 40, and is recovered to the suction chamber 25. As the flow rate of the refrigerant gas in the compressor 10 increases, the pressure differential between the upstream and the downstream of the oil separation mechanism increases accordingly, and as a result, the pressure differential acting on the spool 38 increases. Due to the increase in the pressure differential after the opening degree of the oil supply passage is maximum, the spool 38 slides to a position where the oil introduction hole 40 is moved past the opening of the oil passage 41 and the spool 38 partially covers the oil passage 41 to decrease the opening degree of the oil supply passage. Thus, an optimal amount of the lubrication oil can be ensured, without excess nor deficiency at any operational mode.

(5) The pressure differential acting on the spool 38 is substantially equal to the pressure differential between the upstream and the downstream of the oil separation mechanism. The pressure differential varies in accordance with the flow rate of the refrigerant gas in the compressor 10. Thereby the opening degree of the oil supply passage can be adjusted in accordance with the change in the flow rate of the refrigerant gas.

(6) The check valve 43 is formed between the branching point to the second pressure sensing chamber S2 and the oil separation mechanism in the discharge passage 33. Accordingly, when the compressor 10 is stopped, the spool 38 is urged toward the rear end surface of the valve chamber 36 by the pressure in the external refrigerant circuit in addition to the urging force. The oil supply passage can be reliably shut.

A fourth preferred embodiment of the present invention will now be described with reference to FIG. 11. The compressor of the fourth embodiment differs from that of the first embodiment in that the structure of the valve mechanism is modified, and the rest of the structure of the compressor of the fourth embodiment is substantially the same as the first embodiment. For the sake of convenience of explanation, therefore, like or same parts or elements will be referred to by the same reference numerals as those which have been used in the first embodiment, and the description thereof will be omitted.

As shown in Fig. 11, a valve mechanism of the fourth embodiment has a pair of magnets 44 as an urging member. The pair of magnets 44 are disposed in the valve chamber 36 to generate a repelling force with

each other. The magnets 44 urge the spool 38 rearward, or in the direction toward the oil separation mechanism. The oil supply passage of the fourth embodiment includes the oil separation chamber 34, the valve chamber 36, the oil introduction hole 40, and the oil passage 41.

When the compressor 10 starts, the pressure differential acting on the spool 38 overcomes the urging force generated by the magnets 44, and the spool 38 slides in the direction away from the oil separation mechanism to some extent. Accordingly, the oil separation chamber 34 and the oil passage 41 communicate through the oil introduction hole 40. The lubrication oil separated in the oil separation chamber 34 is introduced into the oil passage 41, and is recovered to the suction chamber 25.

As the pressure differential between the upstream and the downstream of the oil separation mechanism increases, the pressure differential acting on the spool 38 increases. Accordingly, after the opening degree of the oil supply passage is maximum, the spool 38 slides to a position where the oil introduction hole 40 is moved past the opening end of the oil passage 41 and the spool 38 partially covers the oil passage 41 to decrease the opening degree of the oil supply passage.

When the compressor 10 is stopped, the pressure in the first pressure sensing chamber S1 decreases to substantially the same level as the pressure in the second pressure sensing chamber S2, and the urging force generated by the magnets 44 overcomes the pressure differential acting on the spool 38. The spool 38 is moved in the direction toward the end surface of the first pressure sensing chamber S1, and the communication between the valve chamber 36 and the oil passage 41 is shut. Thus, when the compressor 10 is stopped, the circulation of the lubrication oil inside the compressor 10 is stopped, and the recovery of the lubrication oil to the suction chamber 25 is stopped.

According to the fourth embodiment of the present invention, the similar effects as (1) and (2) of the first embodiment are obtained, and further, the following advantageous effect (7) is obtained.

(7) A pair of magnets 44 as an urging member are disposed in the valve chamber 36 so as to repel each other. The magnets 44 urge the spool 38 in the direction toward the oil separation mechanism. Accordingly, utilizing the characteristics of the variation of the magnetic force in accordance with the temperature of the magnets 44, the characteristics of the relation between the pressure differential acting on the spool 38 and the opening degree of the oil passage 41 can be changed in accordance with the temperature of the refrigerant gas.

bodiments described above but may be modified into the following alternative embodiments.

[0020] In the first through fourth embodiments, the oil separation chamber 34 and the valve chamber 36 are integrally formed. In an alternative embodiment, the oil separation chamber 34 and the valve chamber 36 may be formed separately and an oil storage chamber 45 is formed therebetween, as shown in FIG. 12.

[0021] In addition to the above alternative embodiment having the oil storage chamber 45 between the oil separation chamber 34 and the valve chamber 36, the separated lubrication oil may be supplied to the second pressure sensing chamber S2, instead of supplying to the first pressure chamber S1. When the above alternative structure is applied to the first, third, and the fourth embodiments, the oil introduction hole 40 may be formed in the side of the second pressure sensing chamber S2 so as to face the second pressure sensing chamber S2. When the above alternative structure is applied to the second embodiment, the oil passage 41 may be formed in the side of the first pressure sensing chamber S1 so as to face the first pressure sensing chamber S1.

[0022] In the first through third embodiments, the spring 39 is disposed in the valve chamber 36 to urge the spool 38 in the direction toward the end surface of the valve chamber 36. Instead, the spool 38 and an end surface of the valve chamber 36 may be connected by a bellows. In this case, considering the characteristic of bellows, the bellows may be disposed in the first pressure sensing chamber S1, and not in the second pressure sensing chamber S2.

[0023] In the first through fourth embodiments, the oil passage 41 is connected to the suction chamber 25 as an oil recovery region where the separated lubrication oil is supplied. As an alternative, the oil passage 41 may be connected to the crank chamber 15.

[0024] 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.

[0025] A compressor has a discharge passage, an oil separation mechanism, an oil supply passage, and a valve mechanism. The oil supply passage supplies the separated lubrication oil into an oil recovery region. The valve mechanism is formed in the oil supply passage and includes a valve chamber, a spool and an urging member. The spool separates the valve chamber into a first pressure sensing chamber and a second pressure sensing chamber. The amount of the lubrication oil supplied to the oil recovery region is adjusted in such a manner that as the pressure differential between the first and the second pressure sensing chambers increases, the spool slides in the valve chamber and the opening degree of the oil supply passage increases to the maximum and then decreases, and that when the compressor is stopped, the opening degree of the oil supply passage is minimized by the urging force of the urging member.

[0019] The present invention is not limited to the em-

Claims

1. A compressor (10) comprising:

an outlet (32) for discharging refrigerant gas out from the compressor (10);
a discharge passage (33) connected to the outlet (32), wherein the refrigerant gas is discharged through the discharge passage (33) and the outlet (32);

characterized in that

an oil separation mechanism (34, 35) for separating lubrication oil from the refrigerant gas;
an oil supply passage (34, 36, 40, 41) supplying the separated lubrication oil into an oil recovery region (15, 25),
a valve mechanism (36, 38, 39) formed in the oil supply passage (34, 36, 40, 41), wherein the valve mechanism includes a valve chamber (36), a spool (38) and an urging member (39, 44), wherein the spool (38) separates the valve chamber (36) into a first pressure sensing chamber (S1) and a second pressure sensing chamber (S2);
wherein the amount of the lubrication oil supplied to the oil recovery region (15, 25) is adjusted in such a manner that as the pressure differential between the first pressure sensing chamber (S1) and the second pressure sensing chamber (S2) increases, the spool (38) slides in the valve chamber (36) and the opening degree of the oil supply passage (34, 36, 40, 41) increases to the maximum and then decreases, and that when the compressor (10) is stopped, the opening degree of the oil supply passage (34, 36, 40, 41) is minimized by the urging force of the urging member (39, 44).

2. The compressor according to claim 1, wherein the first pressure sensing chamber (S1) is connected to a high pressure region and the second pressure sensing chamber (S2) is connected to a low pressure region.
3. The compressor according to claim 2, wherein the high pressure region includes a discharge passage (26), and the low pressure region includes a suction chamber (25).
4. The compressor (10) according to any one of claims 1 through 3, wherein the oil recovery region includes a suction chamber (25).
5. The compressor (10) according to any one of claims 1 through 3, wherein the oil supply passage includes an oil passage (41) which communicates the valve chamber to the oil recovery region, wherein an oil introduction hole (40) is formed in the spool (38) facing the first pressure sensing chamber (S1) so as to

face a circumferential surface of the valve chamber (36) at a side surface thereof, wherein the oil introduction hole (40) overlaps an opening end of the oil passage (41) formed in a circumferential surface of the valve chamber (36) when the spool (38) slides, so as to open the oil supply passage (34, 36, 40, 41), wherein the opening degree of the oil supply passage (34, 36, 40, 41) is adjusted in accordance with an area where the oil introduction hole (40) and the opening degree of the oil passage (41) overlap.

6. The compressor (10) according to any one of claims 1 through 4, wherein a groove (42) is formed on the valve chamber to be positioned so that the first pressure sensing chamber (S1) and the second pressure sensing chamber (S2) communicate through the groove (42) when the spool (38) slides so as to open the oil supply passage (34, 36, 40, 41).
7. The compressor (10) according to any one of claims 1 through 6, wherein the first pressure sensing chamber (S1) is connected to an upstream of the oil separation mechanism (34, 36) and the second pressure sensing chamber (S2) is connected to a downstream of the oil separation mechanism (34, 36), wherein the spool (38) is moved by the pressure differential between the upstream and the downstream of the oil separation mechanism (34, 36).
8. The compressor (10) according to claim 7, wherein the discharge passage (33) has a branching point connecting to the second pressure sensing chamber (S2), and a check valve (43) is formed between the branching point and the oil separation mechanism (34, 36) in the discharge passage (33).
9. The compressor (10) according to any one of claims 1 through 8, wherein the oil separation chamber (34) is integrally formed with the valve chamber (36).
10. The compressor (10) according to any one of claims 1 through 9, wherein the urging member (38) is a spring (38).
11. The compressor (10) according to any one of claims 1 through 9, wherein the urging member (44) is a pair of magnets (44) to be formed to generate repelling force.

FIG. 1

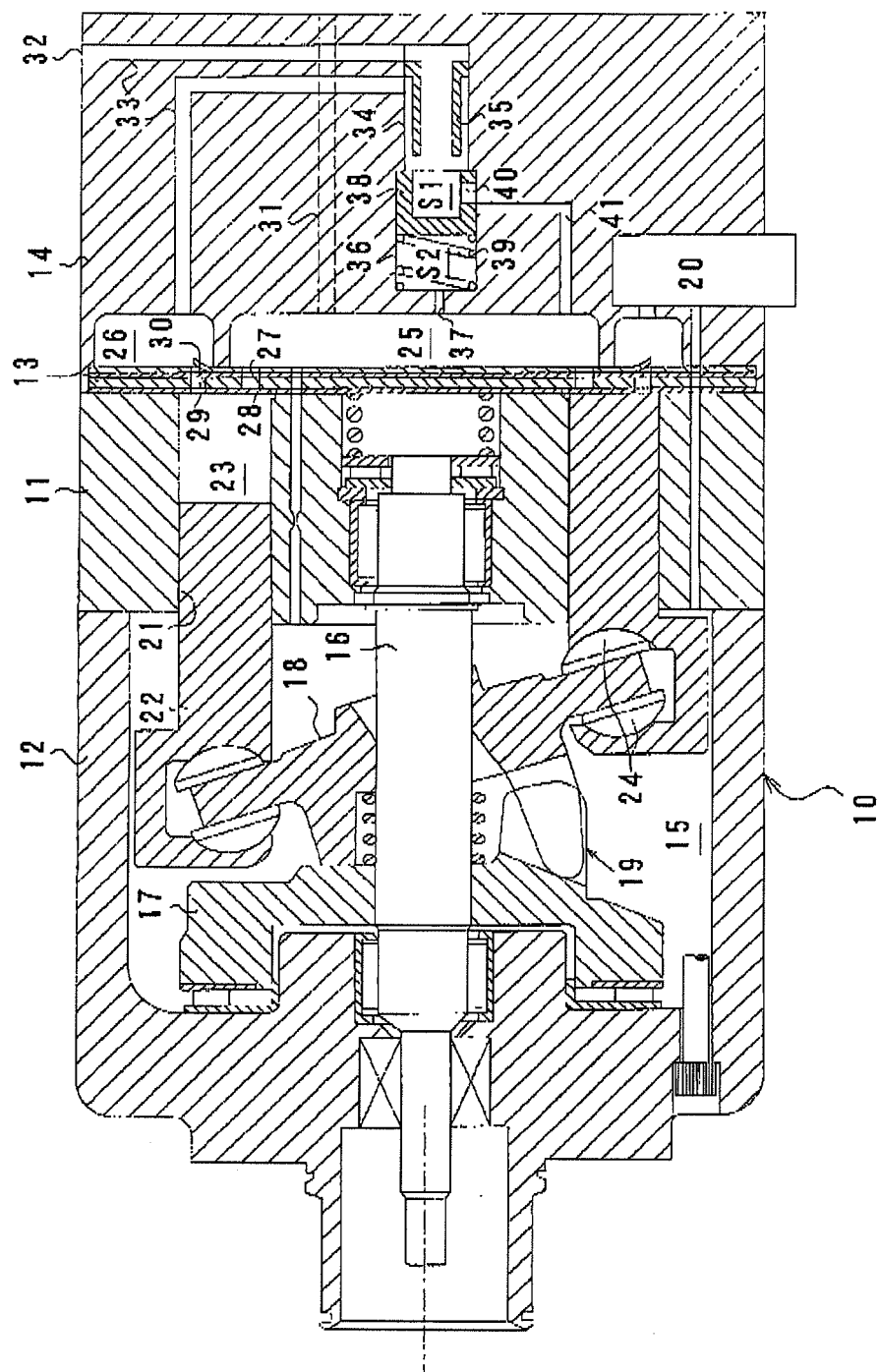


FIG. 2

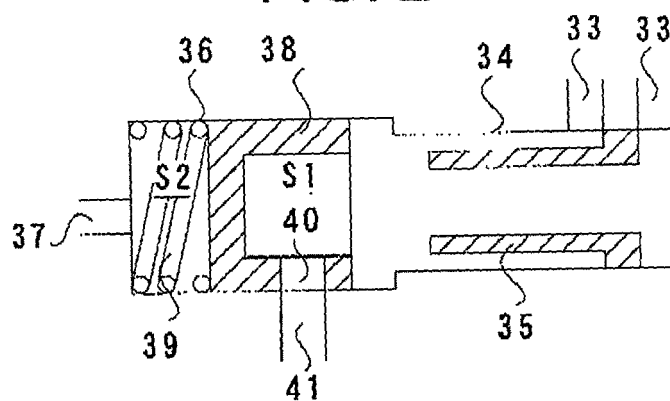


FIG. 3

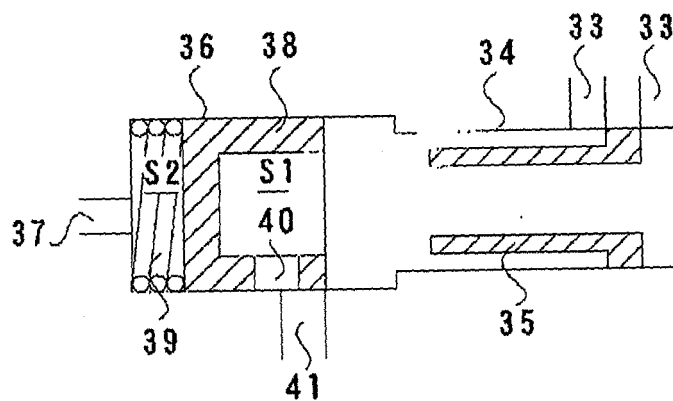


FIG. 4

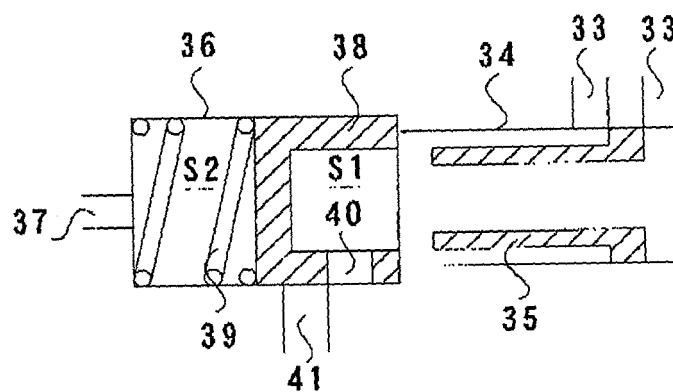


FIG. 5

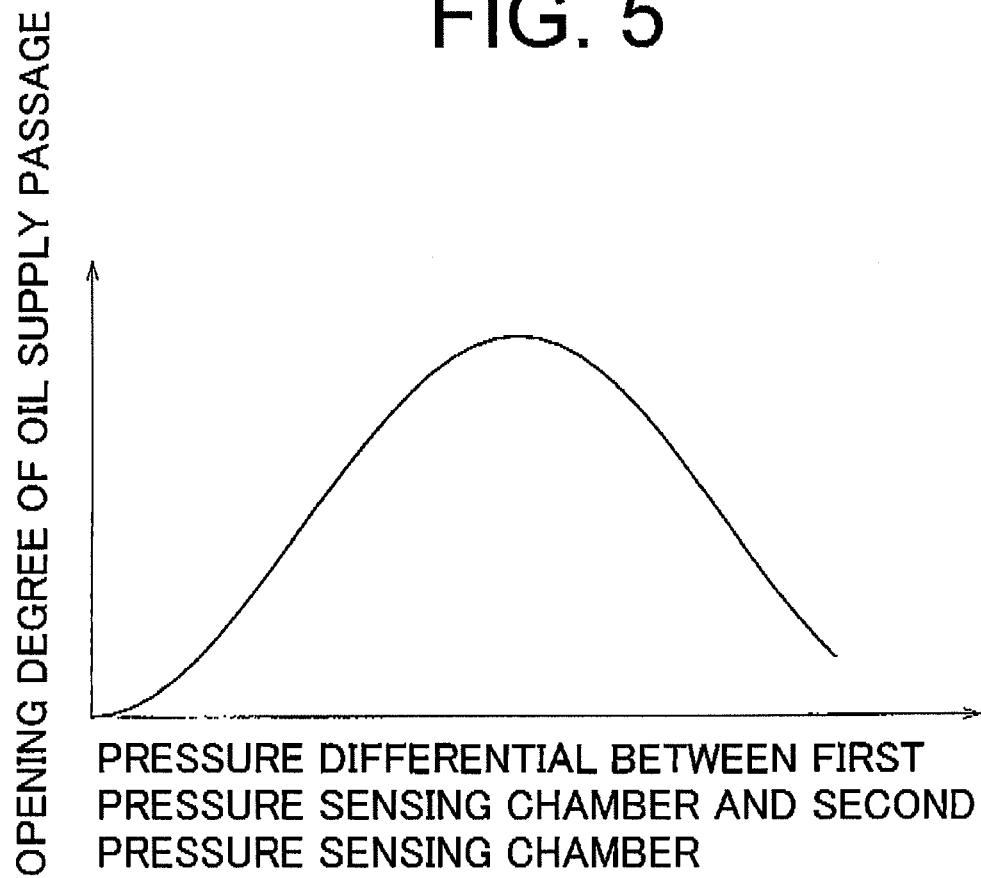


FIG. 6

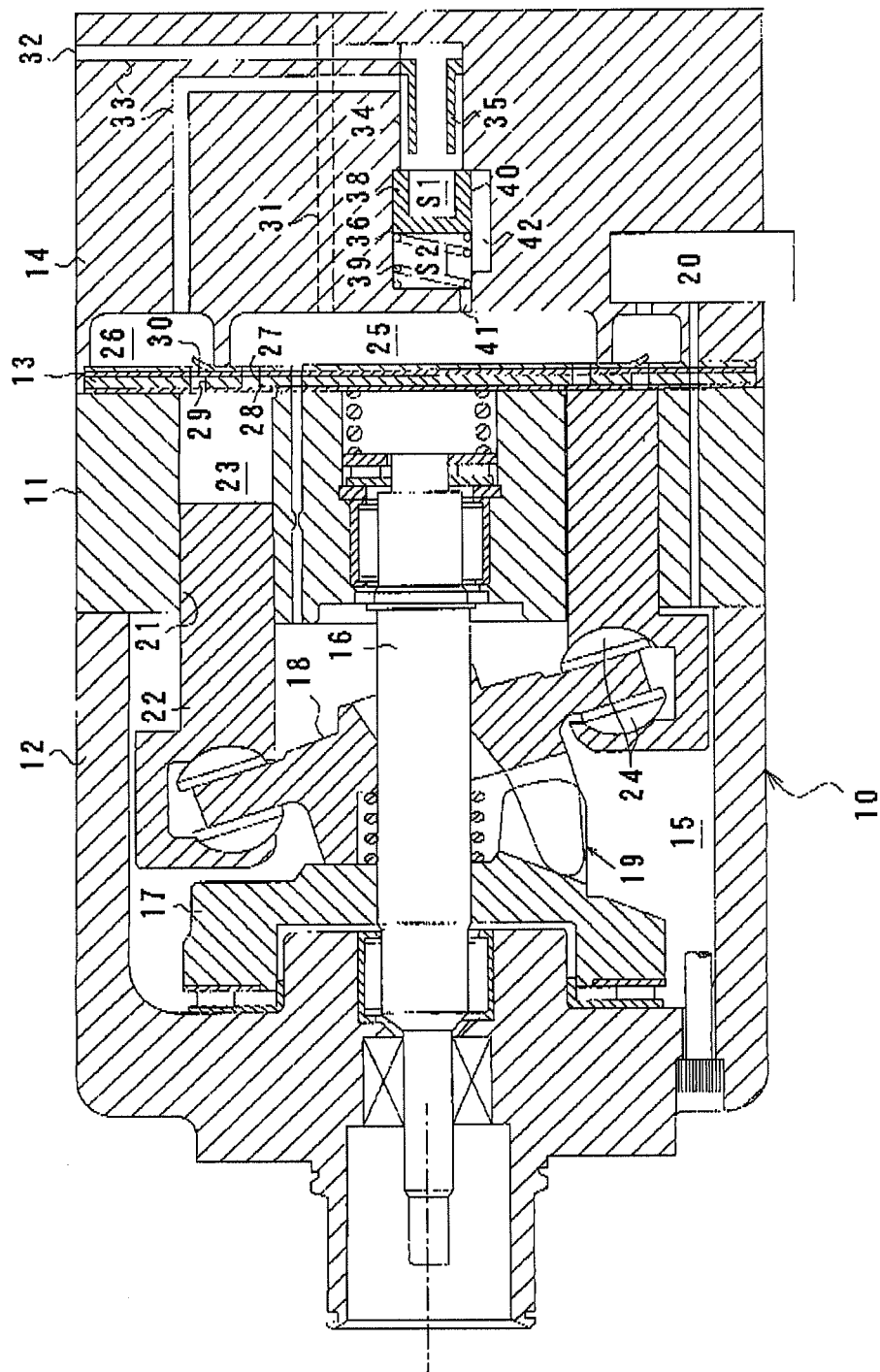


FIG. 7

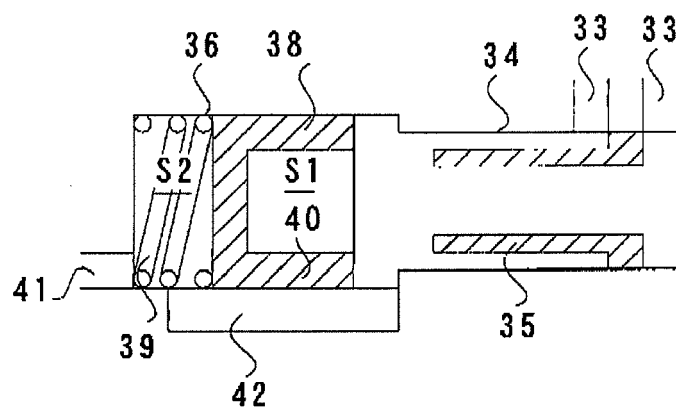


FIG. 8

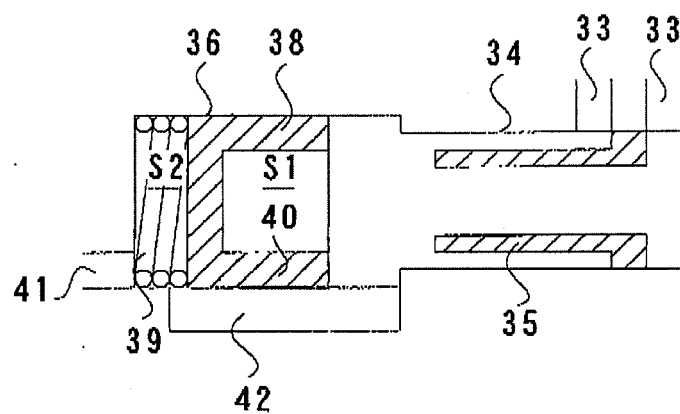


FIG. 9

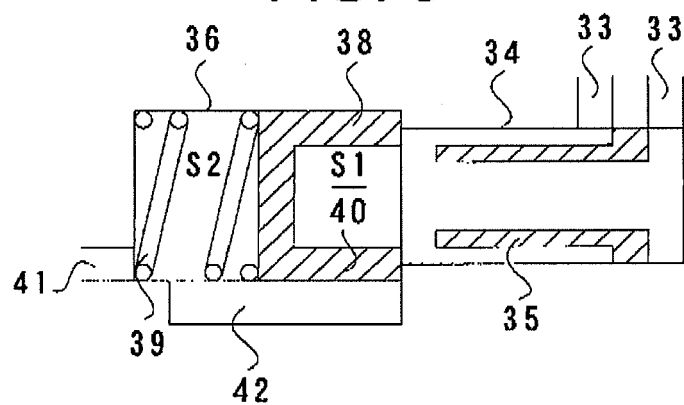


FIG. 10

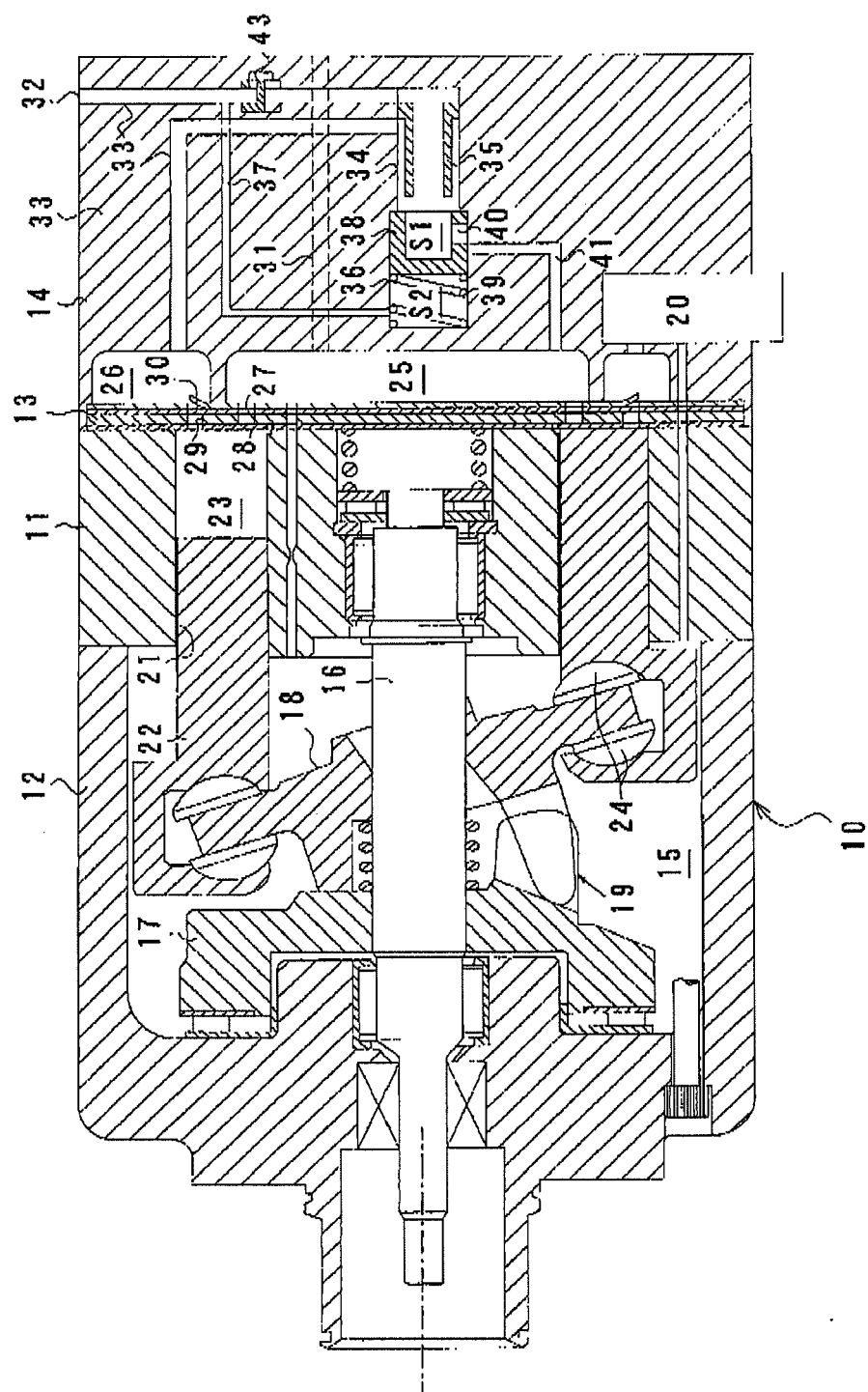


FIG. 11

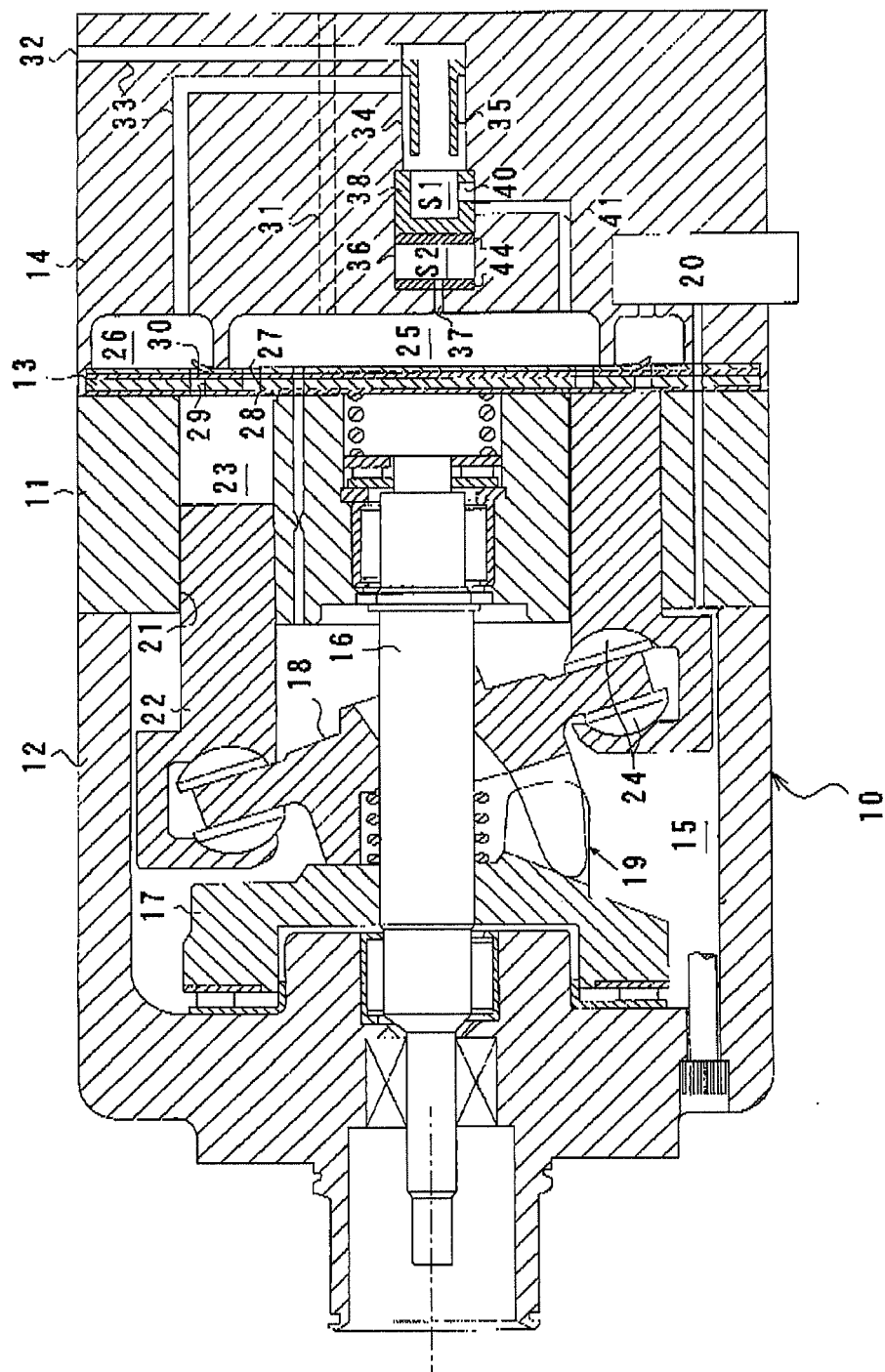
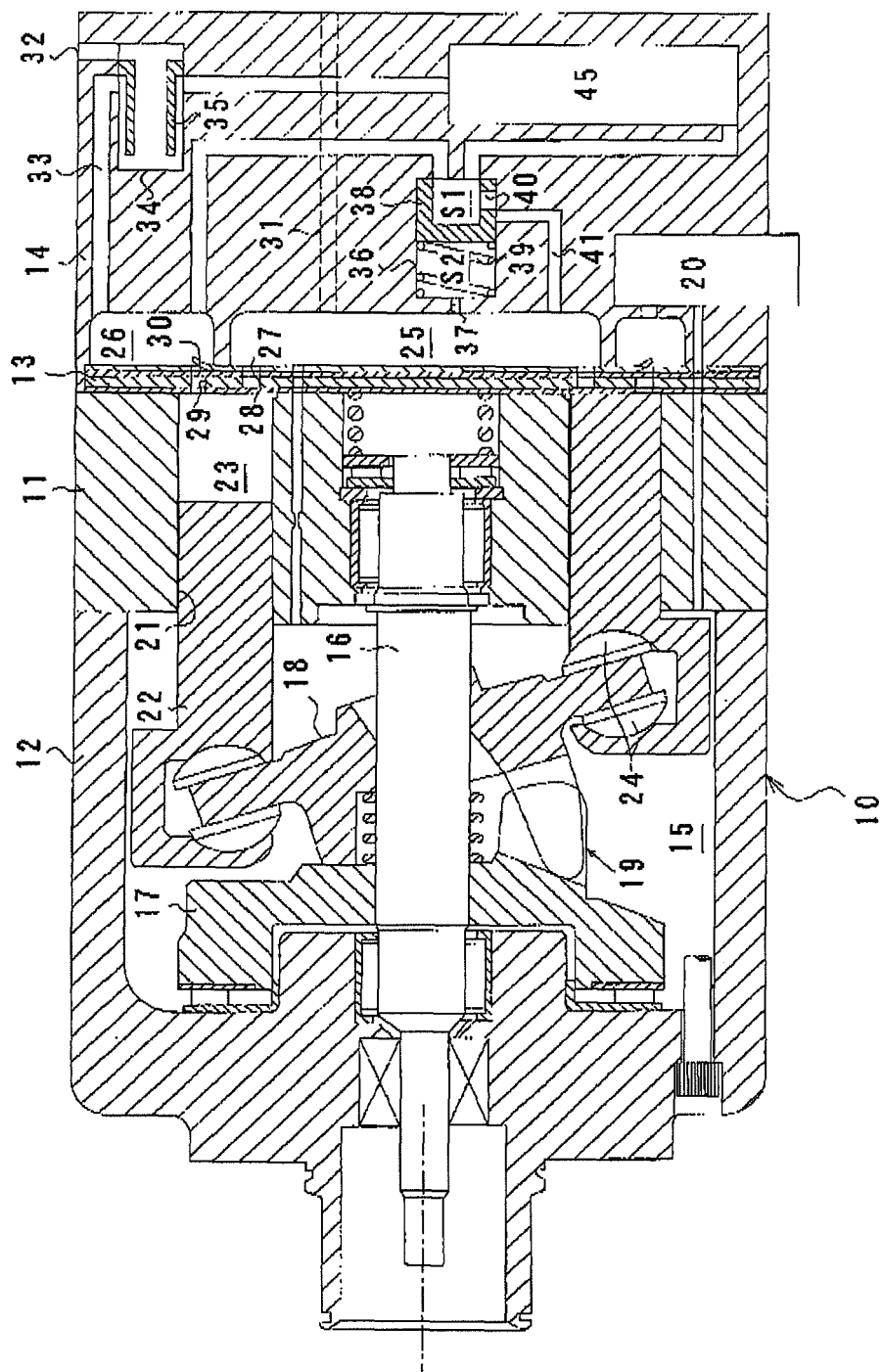


FIG. 12



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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