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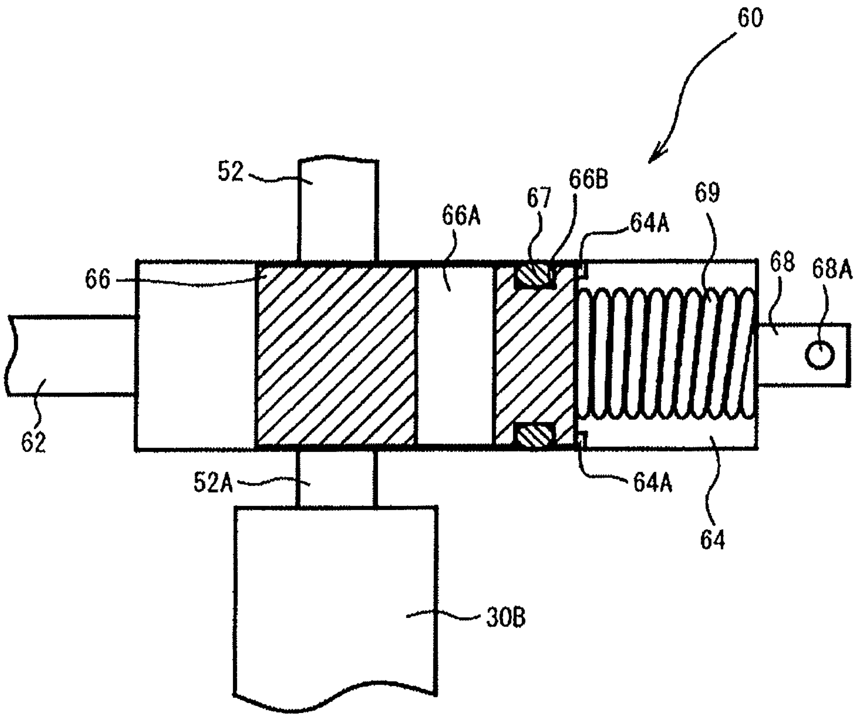
(54) **Scroll compressor**

(57) A scroll compressor includes a housing (10), a fixed scroll (26), a movable scroll (28) both disposed in the housing (10), and an injection passage (52) through which medium-pressure refrigerant is introduced into a compression chamber (30B). The scroll compressor further includes a selector device (60) connecting the compression chamber (30B) to the injection passage (52) or disconnecting the compression chamber (30B) from the injection passage (52) with the change of the pressure or the temperature of the refrigerant in the suction chamber (38).

FIG. 3



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a scroll compressor.

[0002] There is known a method of increasing operating efficiency of a scroll compressor by injection of medium-pressure refrigerant into a compression chamber formed between fixed and movable scrolls of the compressor. Such injection is performed depending on the operating condition of the compressor.

[0003] Japanese Unexamined Patent Application Publication No. 11-107968 discloses a scroll compressor that is provided with an injection pipe for injection of refrigerant gas into the compression chamber. The injection pipe is connected to a refrigerant gas supply passage connected to a separator and provided with a three-way solenoid valve. During high load operation such as heating operation, the valve opens the injection passage, so that the refrigeration cycle of the scroll compressor is operated at high efficiency with the help of the injection of refrigerant. During low load operation such as cooling operation, the valve closes the injection passage to cause the refrigerant to be flown from the refrigerant gas supply passage into the suction passage, so that the refrigeration cycle of the scroll compressor is operated at high efficiency also during the low load operation.

[0004] Japanese Unexamined Patent Application Publication No. 2008-303858 discloses another scroll compressor in which a cylindrical chamber communicating with an injection passage is provided. A piston is slidingly movable in the cylindrical chamber to define a first space and a second space therein. The first space is in communication with a high pressure space, while the second space is in communication with a low pressure space. The piston is moved depending on the pressure difference between the first and second spaces, so that the injection passage is connected to or disconnected from the compression chamber, thereby allowing increased operating efficiency of the scroll compressor.

[0005] The compressor disclosed in the publication No. 11-107968 in which the three-way valve is provided in the refrigerant gas supply passage outside the compressor increases the entire size of the cycle. The compressor also requires an electric signal line to operate the valve and hence increases the entire size of the cycle further, resulting in an increased cost. The compressor disclosed in the publication No. 2008-303858 in which the cylindrical chamber and its related piston for the injection are incorporated in the fixed scroll, on the other hand, allows compact configuration, but the operating efficiency of the compressor during heating operation tends to be reduced as compared to the case of cooling operation if the compressor is used in both cooling and heating. This is because the suction pressure and the suction refrigerant density in the compressor are low due to the low air temperature in an evaporator, which decreases the flow rate of the refrigerant to be introduced into the compressor. To prevent the reduction of the efficiency of the compressor, the injection should preferably be performed during heating operation to increase the refrigerant flow rate. However, in the compressor disclosed in the publication No. 2008-303858 wherein the pressure difference between the high pressure space and the low pressure space is used to move the piston, the injection may not necessarily be controlled appropriately with the switching between the cooling and the heating operations of the compressor.

[0006] The present invention is directed to providing a scroll compressor having a selector device that allows the injection to be controlled appropriately with the switching between the cooling and the heating operations of the compressor.

SUMMARY OF THE INVENTION

[0007] In accordance with an aspect of the present invention, a scroll compressor includes a housing having therein a suction chamber and a discharge chamber, a fixed scroll fixed in the housing, a movable scroll disposed in the housing in engagement with the fixed scroll to form therebetween a compression chamber into which low pressure refrigerant is introduced from the suction chamber and from which high pressure refrigerant is discharged into the discharge chamber, the movable scroll orbiting relative to the fixed scroll to vary the volume of the compression chamber, and an injection passage through which medium-pressure refrigerant is introduced into the compression chamber. The scroll compressor further includes a selector device connecting the compression chamber to the injection passage or disconnecting the compression chamber from the injection passage with the change of the pressure or the temperature of the refrigerant in the suction chamber.

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

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a longitudinal sectional view of a scroll compressor according to a first embodiment of the present invention;

Fig. 2 is an enlarged fragmentary view of the compressor of Fig. 1, showing a selector device and its related components;

Fig. 3 is an enlarged view of the selector device of Fig. 2;

Figs. 4A and 4B are schematic diagrams of a refrigerant circuit including the compressor of Fig. 1;

Fig. 5 is a view explaining the operation of the selector device of Fig. 3;

Fig. 6 is a fragmentary sectional view of a second embodiment of the scroll compressor according to the present invention, showing a selector device and its related components;

Fig. 7 is an enlarged view of the selector device of Fig. 6;

Fig. 8 is a view explaining the operation of the selector device of Fig. 7;

Fig. 9 is an enlarged view of a third embodiment of the selector device of the compressor according to the present invention;

Fig. 10 is a view explaining the operation of the selector device of Fig. 9;

Fig. 11 is a fragmentary sectional view of a fourth embodiment of the scroll compressor according to the present invention, showing a selector device and its related components;

Fig. 12 is an enlarged view of the selector device of Fig. 11;

Fig. 13 is a view explaining the operation of the selector device of Fig. 12;

Fig. 14 is an enlarged view of a fifth embodiment of the selector device of the compressor according to the present invention; and

Fig. 15 is a view explaining the operation of the selector device of Fig. 14.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0010] The following will describe the embodiments of the scroll compressor in accordance with the present invention with reference to the accompanying drawings. Referring to Fig. 1, the electric scroll compressor of the first embodiment designated generally by 1 has a housing 10 formed of a cylindrical front housing 11 having an opening at the rear end on the left side in Fig. 1 and a rear housing 12 fastened by plural bolts 13 to the rear end of the front housing 11 to close the opening with a seal (not shown) interposed therebetween. The front housing 11 has an inlet port 15 at a position adjacent to the front end thereof for connection to an external refrigerant circuit. The front housing 11 accommodates a drive shaft 18 extending in longitudinal direction of the front housing 11, a stator 20 fixed to the inner surface of the front housing 11, and a rotor 22 fixed on the drive shaft 18 inside the stator 20. The drive shaft 18 is rotatably supported at one end thereof by a bearing 16 mounted in the front housing 11 and at the other end thereof by a bearing 25 mounted in the middle of a shaft support 24 that is provided in the front housing 11.

[0011] The front housing 11 accommodates a fixed scroll 26 on the side of the shaft support 24 facing the rear housing 12 and a movable scroll 28 between the fixed scroll 26 and the shaft support 24. The movable scroll 28 is disposed in engagement with the fixed scroll 26 to form therebetween plural compression chambers 30, 30A, 30B. To prevent the rotation of the movable scroll 28 on its own axis, plural rings 32 (only one being shown) are fixed on the side of the shaft support 24 facing the rear housing 12, and plural pins 33 (only one being shown) to be guided in the respective rings 32 are fixed on the side of the movable scroll 28 facing the shaft support 24. The movable scroll 28 has in the center thereof on the side facing the shaft support 24 a bearing 34 that is connected to a bush 35 in which a cylindrical eccentric pin 36 formed at the end of the drive shaft 18 is inserted. Such configuration allows the movable scroll 28 to orbit relative to the fixed scroll 26 thereby to vary the volume of the compression chambers 30, 30A, 30B for compression of refrigerant gas.

[0012] In the front housing 11, a suction chamber 38 for admitting low-pressure refrigerant gas is formed in the region forward of the shaft support 24. Refrigerant gas in the suction chamber 38 is introduced into a compression chamber 30 through a suction port 40 that is formed in the inner surface of the front housing 11 at a position adjacent to the fixed scroll 26 in communication with the compression chamber 30. The fixed scroll 26 and the rear housing 12 cooperate to form therebetween a discharge chamber 44 for admitting high-pressure refrigerant gas. The discharge chamber 44 is communicable with the compression chamber 30A through a discharge port 42 that is formed through the fixed scroll 26 at the center thereof. The fixed scroll 26 is provided with a reed valve 46 to close and open the discharge port 42. The opening of the reed valve 46 is restricted by a retainer 48 disposed on the rear side of the reed valve 46. The rear housing 12 has an outlet port 50 formed therethrough in communication with the discharge chamber 44. The rear housing 12 is provided with an injection passage 52 of a round cross section that extends through the wall of the rear housing 12 and the discharge chamber 44 and to the fixed scroll 26. The injection passage 52 is connected to the compression chamber 30B through a selector device 60.

[0013] Referring to Fig. 2, the selector device 60 includes a suction pressure passage 62, a cylindrical chamber 64, a spool valve 66 and an outside air chamber 68. The suction pressure passage 62 is in communication at one end thereof with the suction port 40 and at the other end thereof with the cylindrical chamber 64. That is, the cylindrical chamber 64 is in communication through the suction pressure passage 62 with the suction chamber 38. The injection passage 52 is connected to the cylindrical chamber 64 at a position in the periphery thereof. The cylindrical chamber 64 is in communication with the outside air chamber 68. The outside air chamber 68 is disposed on the side of the cylindrical chamber 64 opposite from the suction pressure passage 62. The outside air chamber 68 has a communication port 68A (see Fig. 3) that is in communication through a passage (not shown) with the air outside the compressor 1, or the outside air. The cylindrical chamber 64 is in communication through the outside air chamber 68 with the outside air. The cylindrical chamber 64 is communicable with a connecting passage 52A which is formed in the fixed scroll 26 and has a round cross section with a diameter that is substantially equal to the diameter of the injection passage 52. The connecting passage 52A is communicable at one end thereof with the cylindrical chamber 64 and at the other end thereof with the compression chamber 30B. The connecting passage 52A is disposed on the side of the cylindrical chamber 64 opposite from the injection passage 52. The connecting passage 52A and the injection passage 52 are arranged linearly and coaxially.

[0014] The cylindrical chamber 64 accommodates the cylindrical spool valve 66. The spool valve 66 is slidingly movable in the cylindrical chamber 64. The suction pressure passage 62 is in communication with the cylindrical chamber 64 so that the pressure in the suction chamber 38 is applied to one end of the spool valve 66. The outside air chamber 68 is in communication with the cylindrical chamber 64 so that the outside air pressure in the outside air chamber 68 is applied to the other end of the spool valve 66. The spool valve 66 has a diameter that is slightly smaller than the diameter of the cylindrical chamber 64. In the cylindrical chamber 64, the spool valve 66 can block fluid flow from the suction port 40 or the suction chamber 38, the outside air chamber 68, the injection passage 52, and the connecting passage 52A or the compression chamber 30B. The spool valve 66 has a communication hole 66A extending therethrough perpendicularly to the direction of the sliding movement of the spool valve 66. The communication hole 66A has a diameter that is substantially equal to the diameters of the injection passage 52 and the connecting passage 52A. The communication hole 66A connects between the injection passage 52 and the connecting passage 52A when the spool valve 66 is positioned at the end of the cylindrical chamber 64 adjacent to the suction pressure passage 62 (see Fig. 5). The spool valve 66 has an annular groove 66B formed in the periphery thereof adjacent to the outside air chamber 68. The annular groove 66B receives an O ring 67 that prevents the outside air in the outside air chamber 68 from flowing through the cylindrical chamber 64 into the suction pressure passage 62 and also prevents refrigerant gas in the suction pressure passage 62 from flowing through the cylindrical chamber 64 into the outside air chamber 68. The cylindrical chamber 64 accommodates a coil spring 69 or an urging member on the side of the spool valve 66 facing the outside air chamber 68. The coil spring 69 urges the spool valve 66 toward one end of the cylindrical chamber 64, that is, toward the suction pressure passage 62 so that the compression chamber 30B is connected to the injection passage 52. The cylindrical chamber 64 has two projections 64A at positions that are radially outside the coil spring 69. The projections 64A restrict the sliding movement of the spool valve 66 toward the outside air chamber 68 in the cylindrical chamber 64.

[0015] Referring to Figs. 4A and 4B, the above-described scroll compressor 1 forms part of the cooling and heating circuit of a vehicular air conditioner through which refrigerant circulates. The circuit further includes a four-way valve 70 with four ports 82, 83, 87 and 88, a first heat exchanger 71, an expansion valve 72, a receiver 73, a second heat exchanger 74, a blower 75, and an expansion valve 76. The outlet port 50 (see Fig. 1) of the scroll compressor 1 is connected through a tube 81 to the first port 82 of the valve 70. The second port 83 of the valve 70 is connected through a tube 84 to the first heat exchanger 71, The first heat exchanger 71 for heat exchange with the outside air is connected through a tube to the expansion valve 72 that is in turn connected to the receiver 73. The receiver 73 is connected through a tube 85 to the expansion valve 76 that is in turn connected to the second heat exchanger 74. The second heat exchanger 74 provides heat exchange with the air inside a passenger compartment of the vehicle with the help of the blower 75 disposed adjacent to the second heat exchanger 74. The second heat exchanger 74 is connected through a tube 86 to the third port 87 of the valve 70. The fourth port 88 of the valve 70 is connected through a tube 89 to the inlet port 15 (see Fig. 1) of the scroll compressor 1.

[0016] The valve 70 is operated between a first position in which the first port 82 is connected to the second port 83 and the third port 87 is connected to the fourth port 88 as shown in Fig. 4A and a second position in which the first port 82 is connected to the third port 87 and the second port 83 is connected to the fourth port 88 as shown in Fig. 4B. The receiver 73 is connected to a refrigerant gas supply passage 90 that is in turn connected to the injection passage 52 of the scroll compressor 1. The refrigerant gas supply passage 90 is provided with a check valve (not shown).

[0017] The following will describe the operation of the scroll compressor 1 of the present embodiment. During the cooling operation of the scroll compressor 1 of the air conditioner, refrigerant is circulated through the cooling and heating circuit so that the second heat exchanger 74 functions as an evaporator. The first heat exchanger 71 functions as a condenser to release the heat of refrigerant to the outside air. In the valve 70, the first port 82 is connected to the second port 83 while the third port 87 is connected to the fourth port 88, as shown in Fig. 4A. In the scroll compressor 1, the drive shaft 18 is rotated with the rotor 22, so that the movable scroll 28 connected through the bush 35 and the bearing 34 to the eccentric pin 36 of the drive shaft 18 is driven to make an orbital motion with respect to the fixed scroll 26. With the orbital motion of the movable scroll 28, refrigerant is introduced from the inlet port 15 into the suction chamber 38 and then through the suction port 40 into the compression chamber 30. The volume of the compression chambers 30, 30A, 30B trapping the refrigerant is reduced thereby to compress the refrigerant. The compressed refrigerant is discharged out of the compression chamber 30A through the discharge port 42 into the discharge chamber 44, and then discharged through the outlet port 50 into the tube 81 of the cooling and heating circuit.

[0018] During the cooling operation of the compressor 1, the selector device 60 is in the state shown in Fig. 3. The cylindrical chamber 64 is supplied with suction refrigerant, or refrigerant of suction pressure, from the suction port 40 through the suction pressure passage 62. The cylindrical chamber 64 is also supplied with the outside air from the communication port 68A through the outside air chamber 68. In the cylindrical chamber 64, the pressure of suction refrigerant is applied to the spool valve 66 from the left side as seen in Fig. 3, while the urging force of the coil spring 69 and the outside air pressure are applied to the spool valve 66 from the right side. Since the suction refrigerant has a high temperature and pressure during the cooling operation, the force due to the pressure of suction refrigerant is larger than the sum of the urging force of the coil spring 69 and the force due to the outside air pressure. Accordingly, the spool valve 66 is moved rightward as seen in Fig. 3, or toward the outside air chamber 68 in the cylindrical chamber 64 until the spool valve 66 is brought into contact with the projections 64A, so that the injection passage 52 is disconnected from the communication hole 66A of the spool valve 66 and hence from the connecting passage 52A and the compression chamber 30B. Thus, while the vehicle passenger compartment is being cooled, refrigerant of a medium pressure supplied from the receiver 73 through the refrigerant gas supply passage 90 to the injection passage 52 is not introduced into the compression chamber 30B.

[0019] On the other hand, when the first port 82 is connected to the third port 87 while the second port 83 is connected to the fourth port 88 in the valve 70 as shown in Fig. 4B, the second heat exchanger 74 functions as a condenser, so that the passenger compartment is heated. The first heat exchanger 71 then functions as evaporator to release the heat of refrigerant to the outside air. In this case, the selector device 60 is in the state shown in Fig. 5. Since the suction refrigerant has a low temperature and pressure during the heating operation, the sum of the urging force of the coil spring 69 and the outside air pressure is larger than the pressure of suction refrigerant. The spool valve 66 is moved leftward, as seen in Fig. 5, or toward the suction pressure passage 62 in the cylindrical chamber 64 until the spool valve 66 is brought into contact with the end of the cylindrical chamber 64, so that the communication hole 66A of the spool valve 66 is connected to the injection passage 52 and also to the connecting passage 52A and the compression chamber 30B. Thus, while the vehicle passenger compartment is being heated, refrigerant of a medium pressure supplied from the receiver 73 through the refrigerant gas supply passage 90 to the injection passage 52 is introduced into the compression chamber 30B through the connecting passage 52A. The medium-pressure refrigerant is further compressed in the compression chamber 30B together with the refrigerant supplied through the suction port 40, resulting in increased operating efficiency of the cooling and heating circuit.

[0020] The scroll compressor 1 of the present embodiment offers the following advantages.

(1) In the selector device 60, the spool valve 66 is moved according to the relation of the suction refrigerant pressure supplied from the suction pressure passage 62, the urging force of the coil spring 69 and the outside air pressure, so that the injection passage 52 is connected to or disconnected from the compression chamber 30B. Thus, the injection of medium-pressure refrigerant from the injection passage 52 into the compression chamber 30B can be controlled automatically according to the change of the suction refrigerant pressure due to the switching between the cooling and the heating operations of the compressor. That is, the injection can be done or stopped appropriately with the switching between the cooling and the heating operations of the compressor.

(2) The selector device 60 for injection of medium-pressure refrigerant is provided not in the cooling and heating circuit outside the compressor 1, but in the fixed scroll 26 of the scroll compressor 1. This prevents an increase of the size of the cooling and heating circuit.

(3) Since the suction refrigerant pressure, the urging force of the coil spring 69 and the outside air pressure are used to move directly the spool valve 66, there is no need to provide any electric actuator and its associated electric signal line for moving the spool valve 66, resulting in a simple structure and reduced cost of the selector device 60.

(4) In the selector device 60, the outside air pressure is applied to the spool valve 66. The outside air used to move the spool valve 66 is less changed in state and hence stable and also provides a good pressure difference against the suction refrigerant, resulting in reliable operation of the selector device 60.

[0021] Figs. 6, 7 and 8 show the second embodiment of the scroll compressor according to the present invention. The second embodiment differs from the first embodiment in the structure of the selector device. In the drawings, same reference numerals are used for the common elements or components in the first and second embodiments, and the description of such elements or components of the second embodiment will be omitted. As shown in Fig. 6, the selector device designated generally by 100 includes a suction pressure passage 162, a discharge pressure passage 144, a first cylindrical chamber 164 and a second cylindrical chamber 102. The suction pressure passage 162 is in communication at one end thereof with the suction port 40 and at the other end thereof with the first cylindrical chamber 164. That is, the first cylindrical chamber 164 is in communication through the suction pressure passage 162 and the suction port 40 with the suction chamber 38 (Fig. 1). The discharge pressure passage 144 is connected at one end thereof to the discharge chamber 44 and at the other end thereof to the first cylindrical chamber 164 at a position in the periphery thereof. The first cylindrical chamber 164 is in communication with the outside air chamber 68. The outside air chamber 68 is disposed on the side of the first cylindrical chamber 164 that is opposite from the suction pressure passage 162. The outside air chamber 68 has the communication port 68A (see Fig. 7) that is in communication with the outside air. The first cylindrical chamber 164 is in communication through the outside air chamber 68 with the outside air.

[0022] The first cylindrical chamber 164 is in communication also with a connecting passage 152A which is of a round cross section having a diameter that is substantially equal to the diameter of the discharge pressure passage 144. The connecting passage 152A is in communication at one end thereof with the first cylindrical chamber 164 and at the other end thereof with the second cylindrical chamber 102. The connecting passage 152A is disposed on the side of the first cylindrical chamber 164 that is opposite from the discharge pressure passage 144. The connecting passage 152A and the discharge pressure passage 144 are arranged linearly and coaxially. The injection passage 152 is connected to the second cylindrical chamber 102 at a position in the periphery thereof, The second cylindrical chamber 102 is also in communication with a connecting passage 152B. The connecting passage 152B is in communication at one end thereof with the second cylindrical chamber 102 and at the other end thereof with the compression chamber 30B. The connecting passage 152B is disposed on the side of the second cylindrical chamber 102 that is opposite from the connecting passage 152A. The connecting passage 152A and the connecting passage 152B are arranged linearly and coaxially.

[0023] The first cylindrical chamber 164 accommodates a cylindrical first spool valve 166. The first spool valve 166 is slidingly movable in the first cylindrical chamber 164. The suction pressure passage 162 is in communication with the first cylindrical chamber 164 so that the pressure in the suction chamber 38 is applied to one end of the first spool valve 166. The outside air chamber 68 is in communication with the first cylindrical chamber 164 so that the outside air pressure in the outside air chamber 68 is applied to the other end of the first spool valve 166. The first spool valve 166 has a diameter that is slightly smaller than the diameter of the first cylindrical chamber 164. In the first cylindrical chamber 164, the first spool valve 166 can block fluid flow from the suction port 40 or the suction chamber 38, the outside air chamber 68, the discharge pressure passage 144, and the connecting passage 152A or the second cylindrical chamber 102. The first spool valve 166 has in the periphery thereof a first communication passage 166A in the form of an annular groove. The first communication passage 166A connects between the discharge pressure passage 144 and the connecting passage 152A when the first spool valve 166 is moved toward the outside air chamber 68 and brought into contact with the projections 164A (see Fig. 7). The first spool valve 166 has an annular groove 166B formed in the periphery thereof adjacent to the outside air chamber 68 to receive the O ring 67. The first cylindrical chamber 164 accommodates the coil spring 69 that urges the first spool valve 166 toward one end of the first cylindrical chamber 164, that is, toward the suction pressure passage 162 so that the suction chamber 38 is connected to the second cylindrical chamber 102.

[0024] The first spool valve 166 has a second communication passage 166C formed therethrough in the form of an L shape. One end of the second communication passage 166C is opened to the suction pressure passage 162, while the other end of the second communication passage 166C is opened to the connecting passage 152A. The second communication passage 166C is connected to the connecting passage 152A when the first spool valve 166 is positioned at the end of the first cylindrical chamber 164, as shown in Fig. 8. The second cylindrical chamber 102 accommodates a cylindrical second spool valve 104. The second spool valve 104 is slidingly movable in the second cylindrical chamber 102. The first cylindrical chamber 164 is connected to the second cylindrical chamber 102 so that the pressure in the suction chamber 38 or in the discharge chamber 44 is applied to one end of the second spool valve 104. The compression chamber 30B is in communication with the second cylindrical chamber 102 so that the pressure in the compression chamber 30B is applied to the other end of the second spool valve 104. The second spool valve 104 has a diameter that is slightly smaller than the diameter of the second cylindrical chamber 102. In the second cylindrical chamber 102, the second spool valve 104 can block fluid flow from the connecting passage 152A or the first cylindrical chamber 164, the injection passage 152, and the connecting passage 152B or the compression chamber 30B. The scroll compressor 1 equipped with the above-described selector device 100 forms a part of the cooling and heating circuit of the vehicular air conditioner shown in Figs. 4A and 4B, as in the case of the first embodiment.

[0025] The following will describe the operation of the selector device 100. During the cooling operation of the compressor 1, the selector device 100 is in the state shown in Fig. 7. The first cylindrical chamber 164 is supplied with suction refrigerant, or refrigerant of suction pressure, from the suction port 40 through the suction pressure passage 162. The first cylindrical chamber 164 is also supplied with the outside air from the communication port 68A through the outside air chamber 68. In the first cylindrical chamber 164, the pressure of suction refrigerant is applied to the first spool valve 166 from the left side as seen in Fig. 7, while the urging force of the coil spring 69 and the outside air pressure are applied to the first spool valve 166 from the right side. Since the suction refrigerant has a high temperature and pressure during the cooling operation, the pressure of suction refrigerant is larger than the sum of the urging force of the coil spring 69 and the outside air pressure. The first spool valve 166 is moved rightward toward the outside air chamber 68 in the first cylindrical chamber 164, so that the discharge pressure passage 144 is connected to the connecting passage 152A through the first communication passage 166A of the first spool valve 166. Then high pressure refrigerant in the discharge chamber 44 is introduced through the discharge pressure passage 144 into second cylindrical chamber 102. In the second cylindrical chamber 102, the pressure of refrigerant in the discharge chamber 44 is applied to the side of the second spool valve 104 facing the connecting passage 152A, while the pressure of refrigerant in the compression chamber 30B and the injection passage 152 is applied to the side of the second spool valve 104 facing the connecting passage 152B. Since the pressure of refrigerant in the discharge chamber 44 is larger than the pressure of refrigerant in the compression chamber 30B and the injection passage 152, the second spool valve 104 is moved downward as seen in Fig. 7 in the second cylindrical chamber 102, so that the injection passage 152 is disconnected from the connecting passage 152B and hence from the compression chamber 30B by the second spool valve 104. Thus, while the vehicle passenger compartment is being cooled, refrigerant of a medium pressure that is supplied from the receiver 73 through the refrigerant gas supply passage 90 to the injection passage 152 is not introduced into the compression chamber 30B.

[0026] During the heating operation of the compressor 1, the selector device 100 is in the state shown in Fig. 8. Since the suction refrigerant has a low temperature and pressure during the heating operation, the sum of the urging force of the coil spring 69 and the outside air pressure is larger than the pressure of suction refrigerant. The first spool valve 166 is moved leftward as seen in Fig. 8 or toward the suction pressure passage 162 in the first cylindrical chamber 164, so that the first communication passage 166A of the first spool valve 166 is disconnected from the discharge pressure passage 144 and the connecting passage 152A and, therefore, the discharge pressure passage 144 is disconnected from the connecting passage 152A by the first spool valve 166, as shown in Fig. 8. The second communication passage 166C is connected to the suction pressure passage 162 and the connecting passage 152A and also to the second cylindrical chamber 102. In the second cylindrical chamber 102, the pressure of refrigerant in the suction chamber 38 is applied to the side of the second spool valve 104 facing the connecting passage 152A, while the pressure of refrigerant in the compression chamber 30B and the injection passage 152 is applied to the side of the second spool valve 104 facing the connecting passage 152B. Since the pressure of refrigerant in the suction chamber 38 is smaller than the pressure of refrigerant in the compression chamber 30B and the injection passage 152, the second spool valve 104 is moved upward as seen in Fig. 8 in the second cylindrical chamber 102, so that the injection passage 152 is connected to the connecting passage 152B and hence to the compression chamber 30B. Thus, while the vehicle passenger compartment is being heated, refrigerant of a medium pressure that is supplied from the receiver 73 through the refrigerant gas supply passage 90 to the injection passage 152 is introduced into the compression chamber 30B.

[0027] The second embodiment offers the following advantages.

(5) In the selector device 100, the first spool valve 166 is moved according to the relation of the suction refrigerant pressure supplied from the suction pressure passage 162, the urging force of the coil spring 69 and the outside air pressure, so that the discharge pressure passage 144 or the suction pressure passage 162 is selectively connected to or disconnected from the second cylindrical chamber 102. In the second cylindrical chamber 102, the second spool valve 104 is moved according to the relation of the discharge refrigerant pressure in the discharge chamber 44 supplied through the discharge pressure passage 144 or the suction refrigerant pressure in the suction chamber 38 supplied through the suction pressure passage 162, the pressure of refrigerant in the injection passage 152 and the compression chamber 30B, so that the injection passage 152 is connected to or disconnected from the compression chamber 30B. Thus, the injection of medium-pressure refrigerant from the injection passage 152 into the compression chamber 30B can be controlled automatically with the switching between the cooling and the heating operations of the compressor. That is, the injection can be done or stopped appropriately with the switching between the cooling and the heating operations of the compressor.

(6) The selector device 100 for injection of medium-pressure refrigerant is provided not in the cooling

and heating circuit outside the compressor 1, but in the fixed scroll 26 of the scroll compressor 1. This prevents an increase of the size of the cooling and heating circuit.

(7) In the selector device 100, the first cylindrical chamber 164 and the second cylindrical chamber 102 are connected by the connecting passage 152A. This allows flexible arrangement of the first cylindrical chamber 164, thereby allowing the injection passage 152 to be located closer to the compression chamber 30B.

[0028] Figs. 9 and 10 show the third embodiment of the scroll compressor according to the present invention. The third embodiment differs from the second embodiment in the structure of the second spool valve of the selector device. In the drawings, same reference numerals are used for the common elements or components in the second and third embodiments, and the description of such elements or components of the third embodiment will be omitted. As shown in Fig. 9, the selector device designated generally by 110 includes a second spool valve 106 accommodated in the second cylindrical chamber 102. The second spool valve 106 has two cylindrical portions of different diameters, namely a small-diameter portion on the side facing the connecting passage 152A and a large-diameter portion on the side facing the connecting passage 152B. The diameter of the small-diameter portion of the second spool valve 106 is larger than the diameter of the connecting passage 152A. The following will describe the operation of the selector device 110. During the cooling operation, the selector device 110 is in the state shown in Fig. 9. In the first cylindrical chamber 164, the pressure of suction refrigerant is applied to the first spool valve 166 from the left side as seen in Fig. 9, while the urging force of the coil spring 69 and the outside air pressure are applied to the first spool valve 166 from the right side. Since the suction refrigerant has a high temperature and pressure during the cooling operation, the first spool valve 166 is moved rightward or toward the outside air chamber 68 in the first cylindrical chamber 164.

[0029] Then the discharge pressure passage 144 is connected to the connecting passage 152A through the first communication passage 166A of the first spool valve 166. High pressure refrigerant in the discharge chamber 44 is introduced through the discharge pressure passage 144 into the second cylindrical chamber 102. In the second cylindrical chamber 102, the pressure of refrigerant in the discharge chamber 44 is applied to the side of the second spool valve 106 facing the connecting passage 152A, while the pressure of refrigerant in the compression chamber 30B is applied to the side of the second spool valve 106 facing the connecting passage 152B. Since the pressure in the discharge chamber 44 is larger than the pressure of refrigerant in the compression chamber 30B, the second spool valve 106 is moved downward, or toward the connecting passage 152B in the second cylindrical chamber 102, so that the injection passage 152 is disconnected from the connecting passage 152B and hence from the compression chamber 30B by the second spool valve 106. Thus, while the vehicle passenger compartment is being cooled, refrigerant of a medium pressure supplied from the receiver 73 through the refrigerant gas supply passage 90 to the injection passage 152 is not introduced into the compression chamber 30B. In this case where the injection passage 152 is connected through the discharge pressure passage 144 to the discharge chamber 44, the pressure in the discharge chamber 44 is supplied to the injection passage 152 and also to the check valve provided in the refrigerant gas supply passage 90.

[0030] During the heating operation of the compressor 1, the selector device 110 is in the state shown in Fig. 10. During the heating operation when the suction refrigerant has a low temperature and pressure, the first spool valve 166 is moved leftward as seen in Fig. 10, or toward the suction pressure passage 162 in the first cylindrical chamber 164, so that the discharge pressure passage 144 is disconnected from the connecting passage 152A by the first spool valve 166. The suction pressure passage 162 is connected to the second cylindrical chamber 102 through the second communication passage 166C of the first spool valve 166. The refrigerant in the injection passage 152 which has substantially the same pressure as the refrigerant in the discharge chamber 44 is flown through the second cylindrical chamber 102 and the suction pressure passage 162 into the suction chamber 38 of lower pressure, so that the refrigerant present in the injection passage 152 and the refrigerant applied to the upper surface of the second spool valve 106 have substantially the same pressure as the refrigerant in the suction chamber 38. On the other hand, the pressure of refrigerant in the compression chamber 30B is applied to the lower surface of the second spool valve 106. Since the pressure of refrigerant in the compression chamber 30B is larger than the pressure of refrigerant in the suction chamber 38, the second spool valve 106 is moved upward in the second cylindrical chamber 102, so that the injection passage 152 is connected to the connecting passage 152B and hence to the compression chamber 30B. Thus, while the vehicle passenger compartment is being heated, refrigerant of a medium pressure supplied from the receiver 73 through the refrigerant gas supply passage 90 to the injection passage 152 is introduced into the compression chamber 30B.

[0031] The third embodiment offers the advantages similar to those of the second embodiment and also offers the following advantage.

(8) During the cooling operation, the injection passage 152 is connected to the discharge chamber 44 through the second cylindrical chamber 102, the connecting passage 152A, the first cylindrical chamber 164 and the discharge pressure passage 144. This

allows the injection passage 152 to be used as a muffler chamber.

[0032] Figs. 11, 12 and 13 show the fourth embodiment of the scroll compressor according to the present invention. The fourth embodiment differs from the first embodiment in the structure of the selector device. In the drawings, same reference numerals are used for the common elements or components in the first and fourth embodiments, and the description of such elements or components of the fourth embodiment will be omitted. As shown in Figs. 11 and 12, the selector device designated generally by 121 includes a bimetal strip 124, a connecting member 126, a cylindrical spool valve 266 and the aforementioned cylindrical chamber 64. The spool valve 266 is slidingly movable in the cylindrical chamber 64 with a variation of the temperature in the suction chamber 38. The compression chamber 30B is connected to or disconnected from the injection passage 52 with the movement of the spool valve 266. The selector device 121 further includes a bracket 122 projecting from the movable scroll 28 into the suction port 40 to support one end of the bimetal strip 124. The other end of the bimetal strip 124 is connected to one end of the connecting member 126. The other end of the connecting member 126 is connected to the spool valve 266. The bimetal strip 124 is connected through the connecting member 126 to the spool valve 266. The bimetal strip 124 is composed of two metal plates 124A, 124B joined together and having different coefficients of thermal expansion. In the present embodiment, the bimetal strip 124 is disposed such that the metal plate 124B of a lower coefficient of thermal expansion is located closer to the suction pressure passage 62 than the other metal plate 123A (see Fig. 12). The bimetal strip 124 is formed such that there is little difference in length between the two metal plates 124A, 124B and no deformation occurs in the bimetal strip 124 when the bimetal strip 124 is exposed to the temperature of refrigerant in the suction chamber 38 during the cooling operation. The connecting member 126 is made of a metal having an elasticity and a low coefficient of thermal expansion. It is noted that in the fourth embodiment the spool valve 266 has no annular groove such as 66B and no O ring such as 67 and also that no coil spring such as 69 is provided in the cylindrical chamber 64 and no outside air chamber such as 68 is provided (see Figs. 3, 12 and 13).

[0033] The following will describe the operation of the selector device 121. During the cooling operation of the compressor 1, the selector device 121 is in the state shown in Fig. 12. The cylindrical chamber 64 is supplied with suction refrigerant from the suction port 40 through the suction pressure passage 62. During the cooling operation when the suction refrigerant has a higher temperature, as compared to the case of heating operation, there is little difference in length between the metal plates 124A, 124B due to thermal expansion and no deformation occurs in the bimetal strip 124. In this case, the connecting member 126 connected to the bimetal strip 124 positions the spool valve 266 in contact with the projections 64A in the cylindrical chamber 64. The communication hole 266A of the spool valve 266 is disconnected from the injection passage 52 and the connecting passage 52A, so that the injection passage 52 is disconnected from the compression chamber 30B by the spool valve 266. Thus, while the vehicle passenger compartment is being cooled, refrigerant of a medium pressure supplied from the receiver 73 through the refrigerant gas supply passage 90 to the injection passage 52 is not introduced into the compression chamber 30B.

[0034] During the heating operation of the compressor 1, the selector device 121 is in the state shown in Fig. 13. The cylindrical chamber 64 is supplied with suction refrigerant from the suction port 40 through the suction pressure passage 62. During the heating operation when the suction refrigerant has a lower temperature, as compared to the case of cooling operation, there occurs a noticeable difference in length between the metal plates 124A, 124B due to thermal expansion; which causes deformation of the bimetal strip 124, so that the end of the bimetal strip 124 connected to the connecting member 126 is moved away from the suction pressure passage 62 and, therefore, the spool valve 266 connected to the connecting member 126 is moved leftward in the cylindrical chamber 64 as seen in Fig. 13. Then the communication hole 266A of the spool valve 266 is connected to the injection passage 52 and the connecting passage 52A, so that the injection passage 52 is connected to the compression chamber 30B. Thus, refrigerant of a medium pressure is introduced from the injection passage 52 into the compression chamber 30B.

[0035] The fourth embodiment offers the following advantages.

(9) In the selector device 121, the operation of the bimetal strip 124 occurring depending on the temperature of the suction refrigerant causes movement of the spool valve 266 in the cylindrical chamber 64 through the connecting member 126, thereby causing the injection passage 52 to be connected to or disconnected from the compression chamber 30B. Thus, the injection of medium-pressure refrigerant from the injection passage 52 into the compression chamber 30B can be controlled automatically with the switching between the cooling and the heating operations of the compressor. That is, the injection can be done or stopped appropriately with the switching between the cooling and the heating operations of the compressor.

(10) The selector device 121 for injection of medium-pressure refrigerant is provided not in the cooling and heating circuit outside the compressor 1, but in the fixed scroll 26 of the scroll compressor 1.

(11) The use of the bimetal strip 124 in the selector

device 121 allows the selector device 121 to operate depending on the suction refrigerant temperature and also results in a simple structure.

[0036] Figs. 14 and 15 show the fifth embodiment of the scroll compressor according to the present invention. The fifth embodiment differs from the fourth embodiment in the structure of the selector device. In the drawings, same reference numerals are used for the common elements or components in the fourth and fifth embodiments, and the description of such elements or components of the fifth embodiment will be omitted. As shown in Fig. 14, the selector device designated generally by 130 includes a cylindrical temperature-sensing member 131, an extendable member 132, a connecting member 133 and the aforementioned cylindrical chamber 64 and cylindrical spool valve 266. The selector device 130 includes no bracket such as 122 and no bimetal strip such as 124 as in the fourth embodiment. The temperature-sensing member 131 is provided in the suction port 40 so as to close the opening of the suction pressure passage 62, serving to detect the variation of refrigerant temperature in the suction chamber 38. In the present embodiment, the temperature-sensing member 131 is made of a metal plate having a high thermal conductivity such as a stainless steel plate or copper plate. The interior of the temperature-sensing member 131 is in communication with the interior of the extendable member 132 that is provided in the suction pressure passage 62. The temperature-sensing member 131 and the extendable member 132 are filled with a thermally expandable medium that is expandable and shrinkable with the variation of its temperature. The extendable member 132 is connected to one end of the connecting member 133. The other end of the connecting member 133 is connected to the spool valve 266. The extendable member 132 is connected through the connecting member 133 to the spool valve 266.

[0037] The following will describe the operation of the selector device 130. During the cooling operation of the compressor 1, the selector device 130 is in the state shown in Fig. 14. The temperature-sensing member 131 is exposed to the suction refrigerant in the suction port 40. During the cooling operation when the suction refrigerant has a higher temperature, as compared to the case of heating operation, the thermally expandable medium exposed through the temperature-sensing member 131 to such suction refrigerant is expanded thereby to extend the extendable member 132. The spool valve 266 connected through the connecting member 133 to the extendable member 132 is moved rightward as seen in Fig. 14 in the cylindrical chamber 64, so that the communication hole 266A of the spool valve 266 is disconnected from the injection passage 52 and the connecting passage 52A and, therefore, the injection passage 52 is disconnected from the compression chamber 30B by the spool valve 266. Thus, while the passenger compartment is being cooled, medium-pressure refrigerant supplied from the receiver 73 through the refrigerant gas supply passage 90 to the injection passage 52 is not introduced into the compression chamber 30B.

[0038] During the heating operation of the compressor 1, the selector device 130 is in the state shown in Fig. 15. The temperature-sensing member 131 is exposed to the suction refrigerant in the suction port 40. During the heating operation when the suction refrigerant has a lower temperature, as compared to the case of cooling operation, the thermally expandable medium exposed through the temperature-sensing member 131 to such suction refrigerant is shrunk thereby to retract the extendable member 132. The spool valve 266 connected through the connecting member 133 to the extendable member 132 is moved leftward as seen in Fig. 15 in the cylindrical chamber 64, so that the communication hole 266A of the spool valve 266 is connected to the injection passage 52 and the connecting passage 52A and, therefore, the injection passage 52 is connected to the compression chamber 30B. Thus, medium-pressure refrigerant is introduced from the injection passage 52 into the compression chamber 30B.

[0039] The fifth embodiment offers the following advantages.

(12) The selector device 130 has the temperature-sensing member 131 and the extendable member 132 which are filled with the thermally expandable medium. The thermally expandable medium is expanded or shrunk with the variation of the suction refrigerant temperature thereby to extend or retract the extendable member 132, so that the spool valve 266 connected to the extendable member 132 is moved in the cylindrical chamber 64 and, therefore, the injection passage 52 is connected to or disconnected from the compression chamber 30B. Thus, the injection of medium-pressure refrigerant from the injection passage 52 into the compression chamber 30B can be controlled automatically with the switching between the cooling and the heating operations of the compressor. That is, the injection can be done or stopped appropriately with the switching between the cooling and the heating operations of the compressor.

(13) The selector device 130 for injection of medium-pressure refrigerant is provided not in the cooling and heating circuit outside the compressor 1, but in the fixed scroll 26 of the scroll compressor 1.

(14) The use of the temperature-sensing member 131, the extendable member 132 and the thermally expandable medium in the selector device 130 allows the selector device 130 to operate depending on the variation of suction refrigerant temperature and also to simplify the structure.

[0040] It is to be understood that the present invention is not limited to the above-described embodiments, but it may be modified in various ways as exemplified below.

[0041] The injection passages 52, 152 may be connected to the compression chamber 30 other than the compression chamber 30B. Plural injection passages such as 52, 152 may be provided for injection of medium-pressure refrigerant into the plural compression chambers 30.

[0042] The urging member may be provided not only by the coil spring 69 but also by any other elastic member such as leaf spring. In addition, for example in the first embodiment, the urging member such as 69 disposed not only on the side of the spool valve 66 facing the outside air chamber 68 but also on the side of the spool valve 66 facing the suction pressure passage 62 may urge the spool valve 66 toward the suction pressure passage 62.

[0043] In the second embodiment, the length or shape of the connecting passage 152A may be changed. Locating the first cylindrical chamber 164 on the side of the second cylindrical chamber 102 closer to the suction port 40, the distance between the compression chamber 30 and the discharge chamber 44 can be reduced further.

[0044] The first and second spool valves 166, 104 in the second embodiment are applicable to the fourth and fifth embodiments.

[0045] In the third embodiment, the discharge pressure supplied to the check valve in the refrigerant gas supply passage 90 may be used to operate the four-way valve 70 in switching between the cooling and the heating operations.

[0046] In the fourth embodiment, the bimetal strip 124 may be replaced by a shape-memory alloy or any other suitable means that allows the spool valve 266 to be moved with the variation of suction refrigerant temperature.

[0047] A scroll compressor includes a housing having therein a suction chamber and a discharge chamber, a fixed scroll fixed in the housing, a movable scroll disposed in the housing in engagement with the fixed scroll to form therebetween a compression chamber into which low pressure refrigerant is introduced from the suction chamber and from which high pressure refrigerant is discharged into the discharge chamber, the movable scroll orbiting relative to the fixed scroll to vary the volume of the compression chamber, and an injection passage through which medium-pressure refrigerant is introduced into the compression chamber. The scroll compressor further includes a selector device connecting the compression chamber to the injection passage or disconnecting the compression chamber from the injection passage with the change of the pressure or the temperature of the refrigerant in the suction chamber.

Claims

1. A scroll compressor, comprising:

a housing (10) having therein a suction chamber (38) and a discharge chamber (44);

a fixed scroll (26) fixed in the housing (10);

a movable scroll (28) disposed in the housing (10) in engagement with the fixed scroll (26) to form therebetween a compression chamber (30, 30A, 30B) into which low pressure refrigerant is introduced from the suction chamber (38) and from which high pressure refrigerant is discharged into the discharge chamber (44), the movable scroll (28) orbiting relative to the fixed scroll (26) to vary the volume of the compression chamber (30, 30A, 30B); and

an injection passage (52, 152) through which medium-pressure refrigerant is introduced into the compression chamber (30B),

characterized by

a selector device (60, 100, 110, 121, 130) connecting the compression chamber (30B) to the injection passage (52, 152) or disconnecting the compression chamber (30B) from the injection passage (52, 152) with the change of the pressure or the temperature of the refrigerant in the suction chamber (38).

2. The scroll compressor of claim 1, wherein the selector device (60) includes

a cylindrical chamber (64) connected to the suction chamber (38) , outside air, the injection passage (52) and the compression chamber (30B) ;

a spool valve (66) slidingly movable in the cylindrical chamber (64) with the change of the pressure of the refrigerant in the suction chamber (38) so that the compression chamber (30B) is connected to or disconnected from the injection passage (52) ; and

an urging member (69) urging the spool valve (66) so that the compression chamber (30B) is connected to the injection passage (52) ,

wherein the cylindrical chamber (64) is connected to the suction chamber (38) so that the pressure in the suction chamber (38) is applied to one end of the spool valve (66) , and

the cylindrical chamber (64) is connected to the outside air so that the pressure of the outside air is applied to the other end of the spool valve (66) .

3. The scroll compressor of claim 1, wherein the selector device (100, 110) includes

a first cylindrical chamber (164) connected to the suction chamber (38) , outside air and the discharge chamber (44) ;

a second cylindrical chamber (102) connected to the first cylindrical chamber (164) , the injection passage (152) and the compression chamber (30B) ;

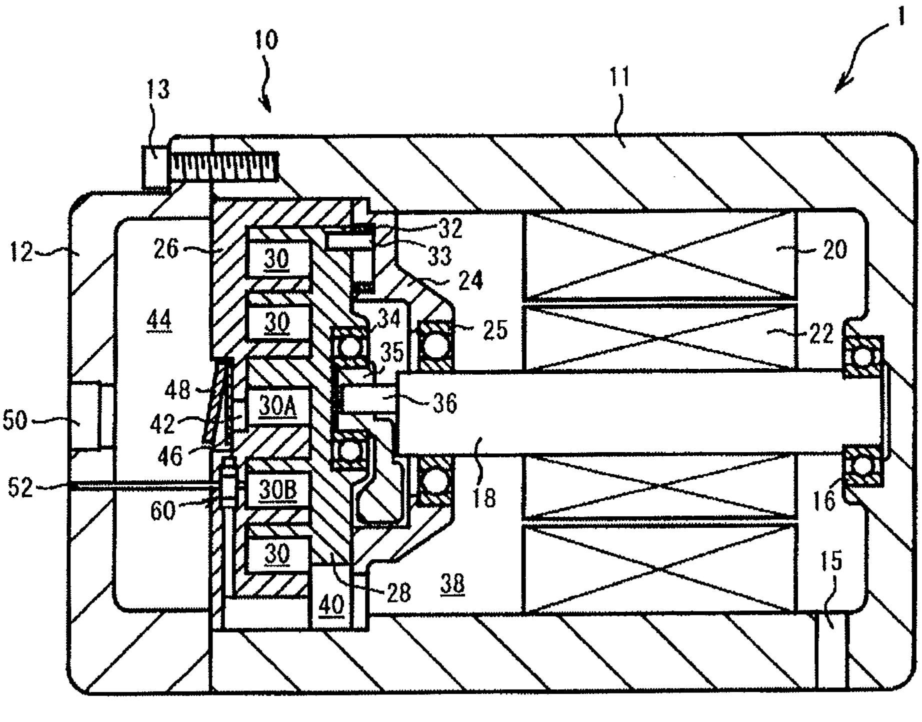
a first spool valve (166) slidingly movable in the first cylindrical chamber (164) with the change of the pressure of the refrigerant in the suction chamber (38) so that the discharge chamber (44) is connected

to or disconnected from the second cylindrical chamber (102) , the first spool valve (166) disconnecting the suction chamber (38) from the second cylindrical chamber (102) when the discharge chamber (44) is connected to the second cylindrical chamber (102) , the first spool valve (166) connecting the suction chamber (38) to the second cylindrical chamber (102) when the discharge chamber (44) is disconnected from the second cylindrical chamber (102) ;
a second spool valve (104, 106) slidingly movable in the second cylindrical chamber (102) , the second spool valve (104, 106) disconnecting the compression chamber (30B) from the injection passage (152) when the second cylindrical chamber (102) is connected to the discharge chamber (44) , the second spool valve (104, 106) connecting the compression chamber (30B) to the injection passage (152) when the second cylindrical chamber (102) is connected to suction chamber (38) ; and
an urging member (69) urging the first spool valve (166) so that the suction chamber (38) is connected to the second cylindrical chamber (102) ,
wherein the first cylindrical chamber (164) is connected to the suction chamber (38) so that the pressure in the suction chamber (38) is applied to one end of the first spool valve (166) ,
the first cylindrical chamber (164) is connected to the outside air so that the pressure of the outside air is applied to the other end of the first spool valve (166) ,
the second cylindrical chamber (102) is connected to the first cylindrical chamber (164) so that the pressure in the suction chamber (38) or in the discharge chamber (44) is applied to one end of the second spool valve (104, 106) , and
the second cylindrical chamber (102) is connected to the compression chamber (30B) so that the pressure in the compression chamber (30B) is applied to the other end of the second spool valve (104, 106) .

4. The scroll compressor of claim 1, wherein the selector device (121) includes
a cylindrical chamber (64) connected to the injection passage (52) and the compression chamber (30B);
a spool valve (266) slidingly movable in the cylindrical chamber (64) with the change of the temperature of the refrigerant in the suction chamber (38) so that the compression chamber (30B) is connected to or disconnected from the injection passage (52); and
a bimetal strip (124) connected to the spool valve (266), wherein deformation of the bimetal strip (124) with the change of the temperature of the refrigerant in the suction chamber (38) causes movement of the spool valve (266).

5. The scroll compressor of claim 1, wherein the selector device (130) includes
a cylindrical chamber (64) connected to the injection passage (52) and the compression chamber (30B);
a spool valve (266) slidingly movable in the cylindrical chamber (64) with the change of the temperature of the refrigerant in the suction chamber (38) so that the compression chamber (30B) is connected to or disconnected from the injection passage (52);
a temperature-sensing member (131) detecting the temperature of the refrigerant in the suction chamber (38); and
an extendable member (132) filled with a thermally expandable medium that is expanded or shrunk depending on the temperature detected by the temperature-sensing member (131), wherein the extendable member (132) is extended by the expansion of the thermally expandable medium to cause movement of the spool valve (266).

FIG. 1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30A
36
50
42
46
52
30B
18
60
16
30
15
28
38
40

FIG. 2

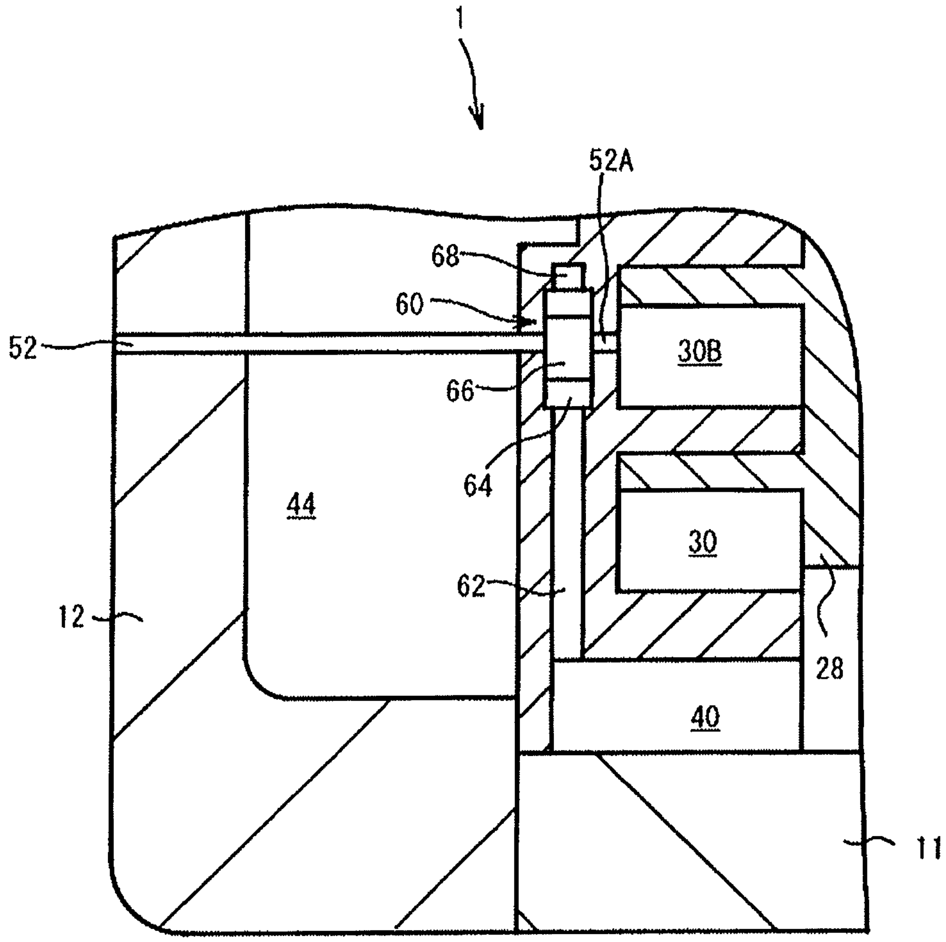


FIG. 3

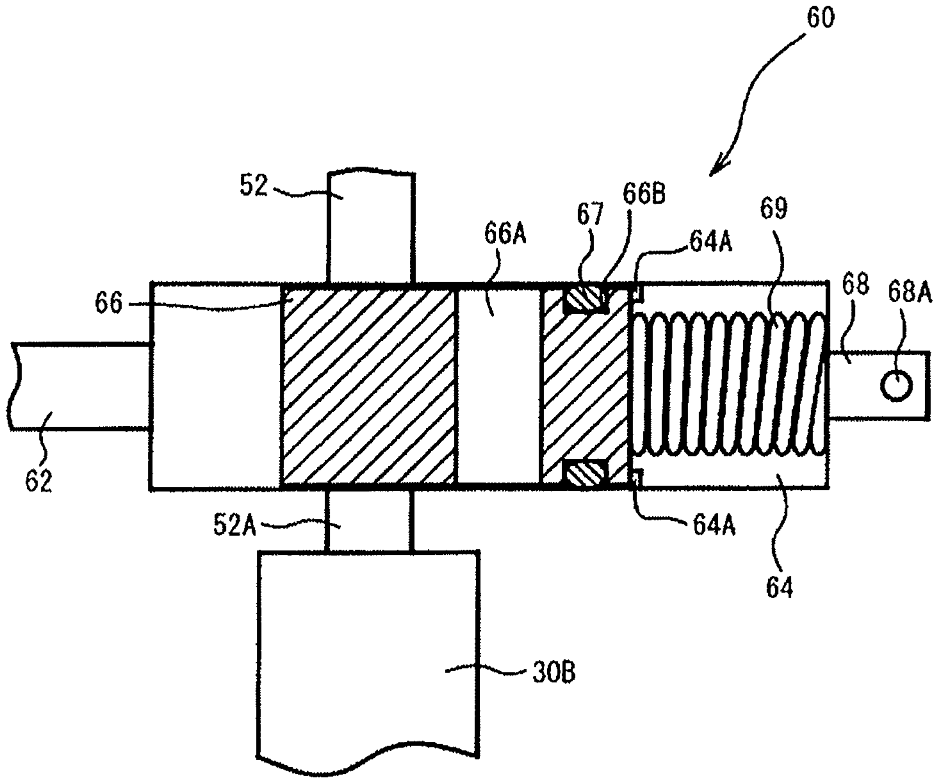
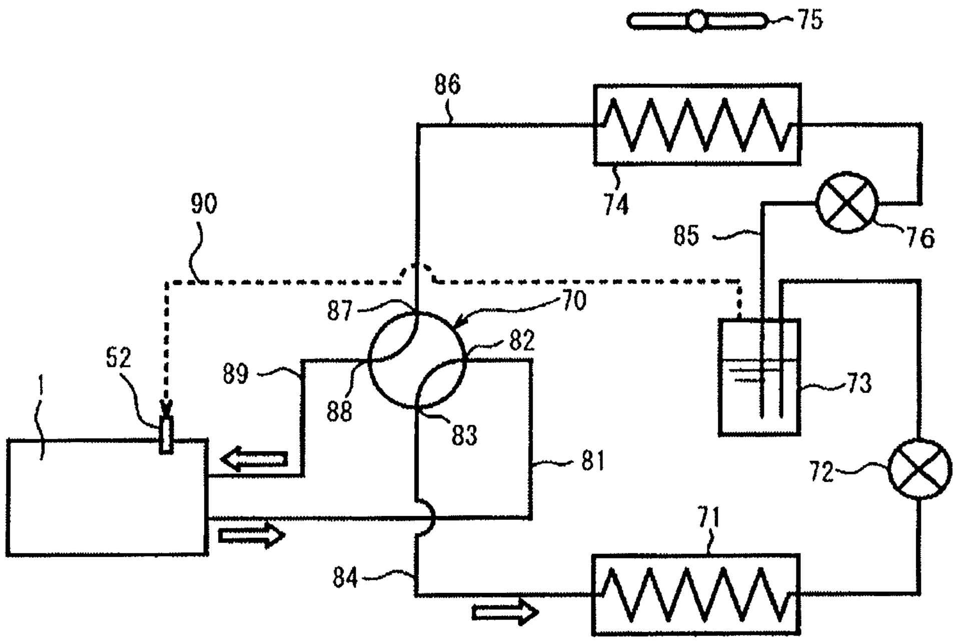


FIG. 4A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84

FIG. 4B

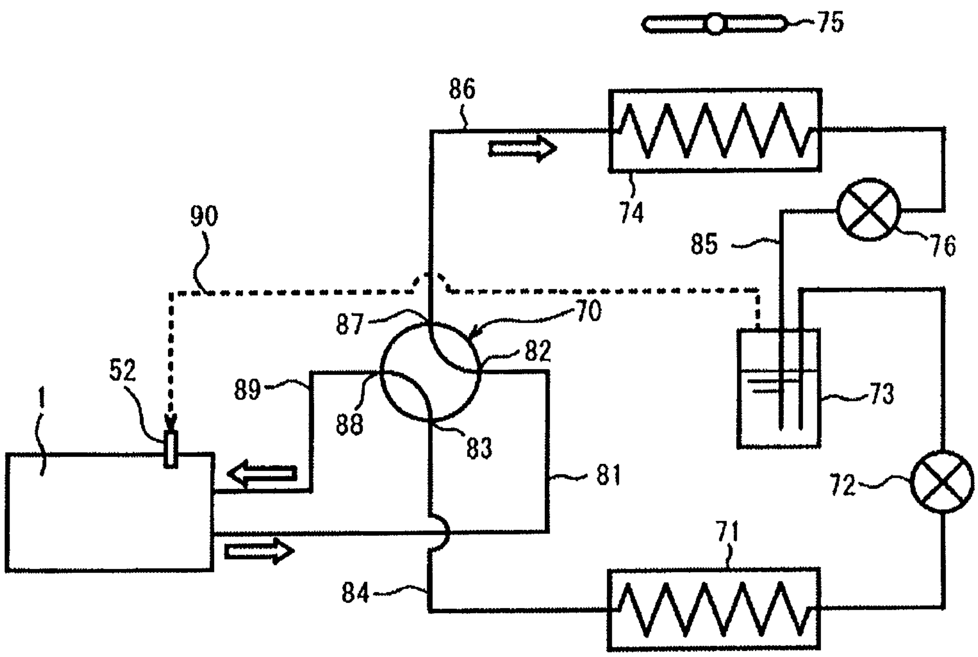
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FIG. 5

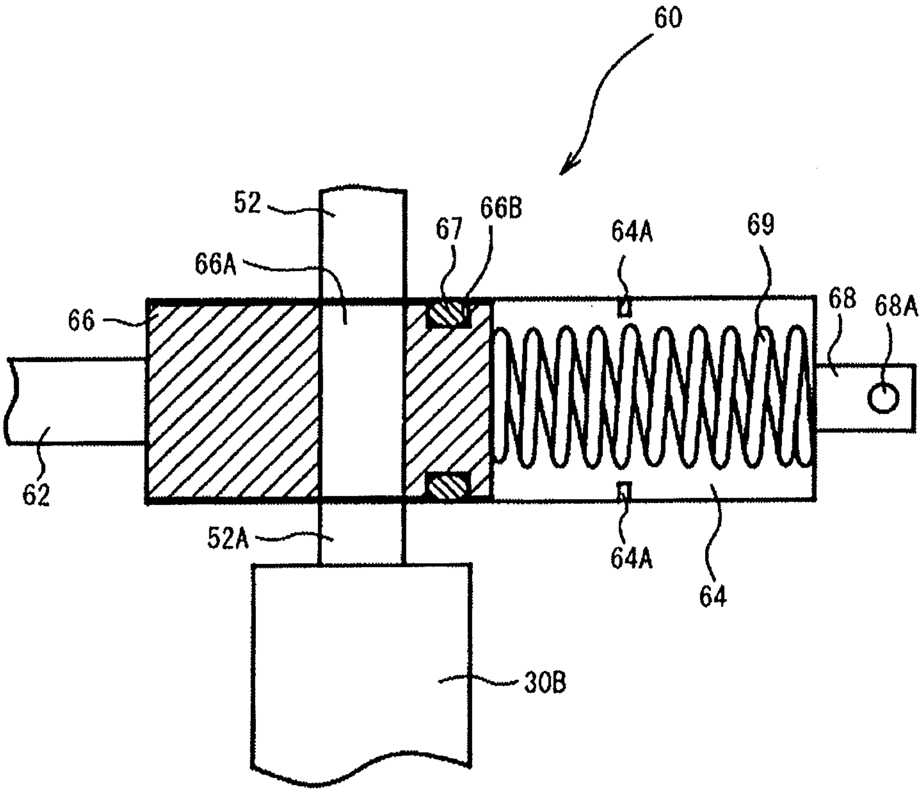
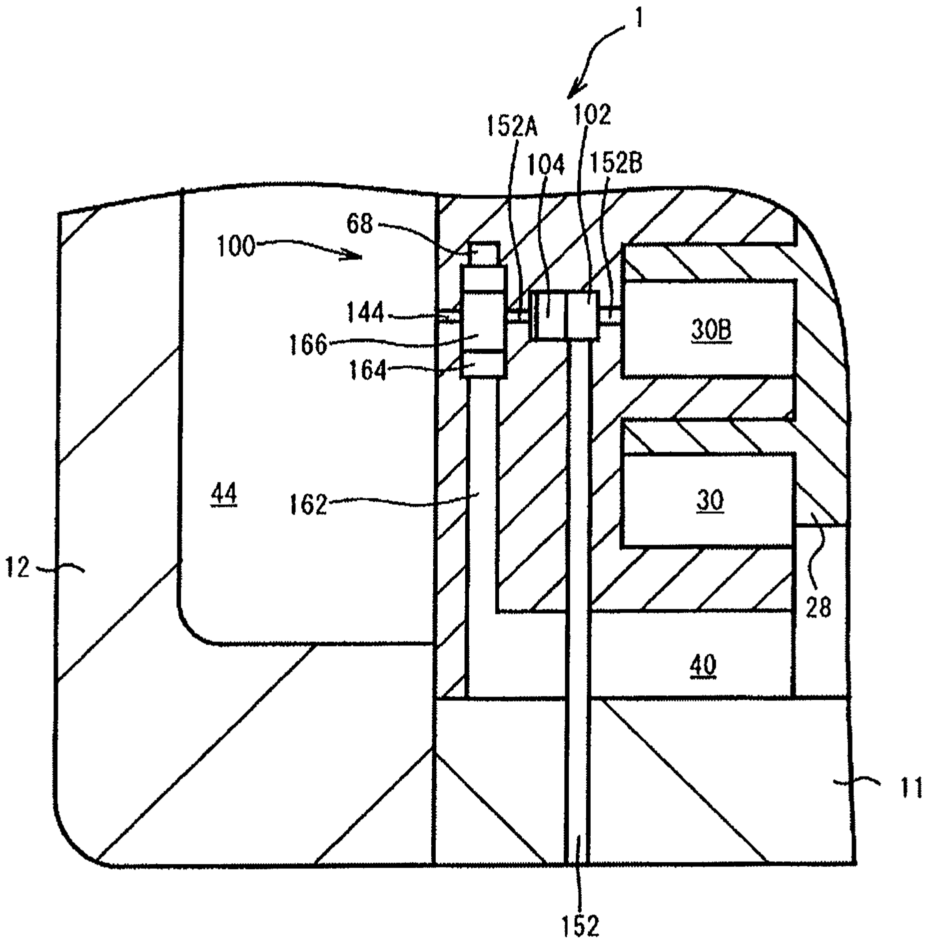


FIG. 6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152A
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152B
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164
30B
44
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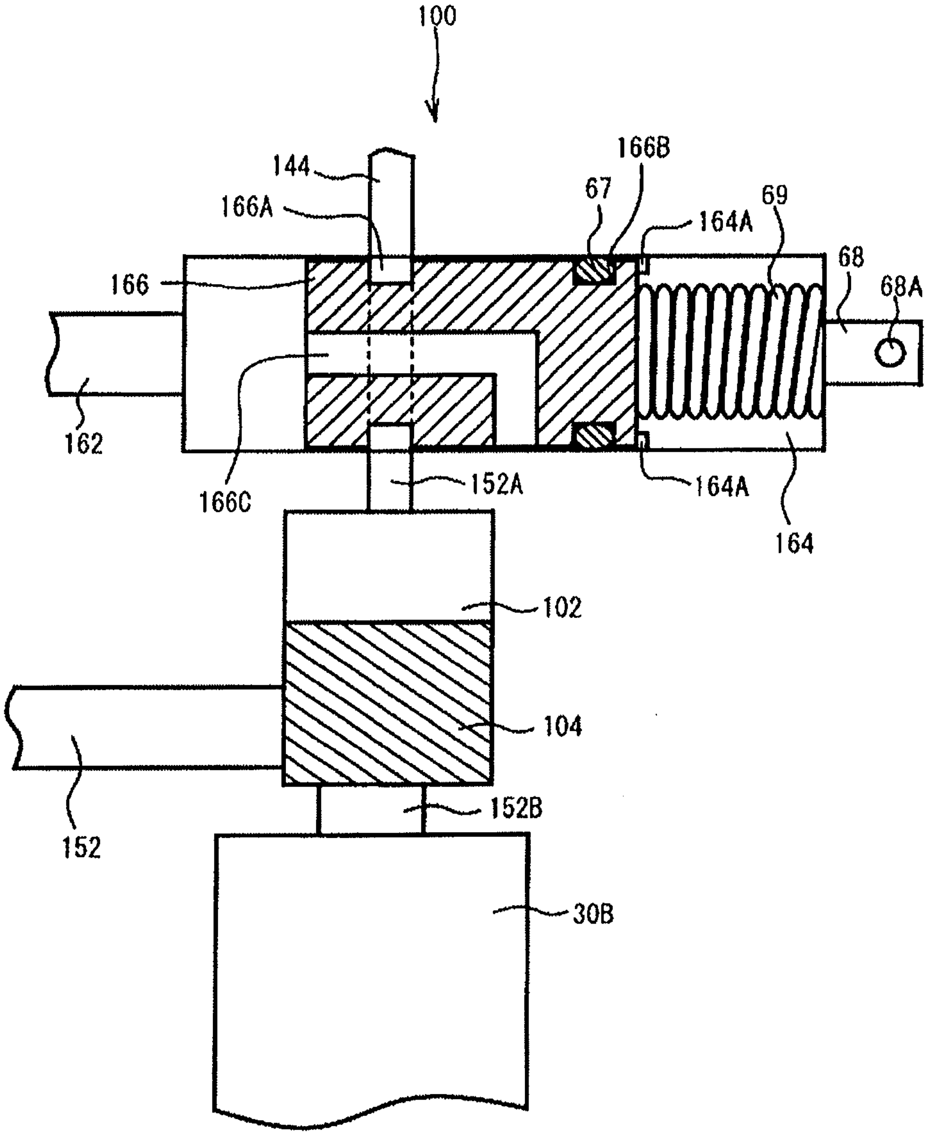
40
11
152

FIG. 7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166A
166B
67
164A
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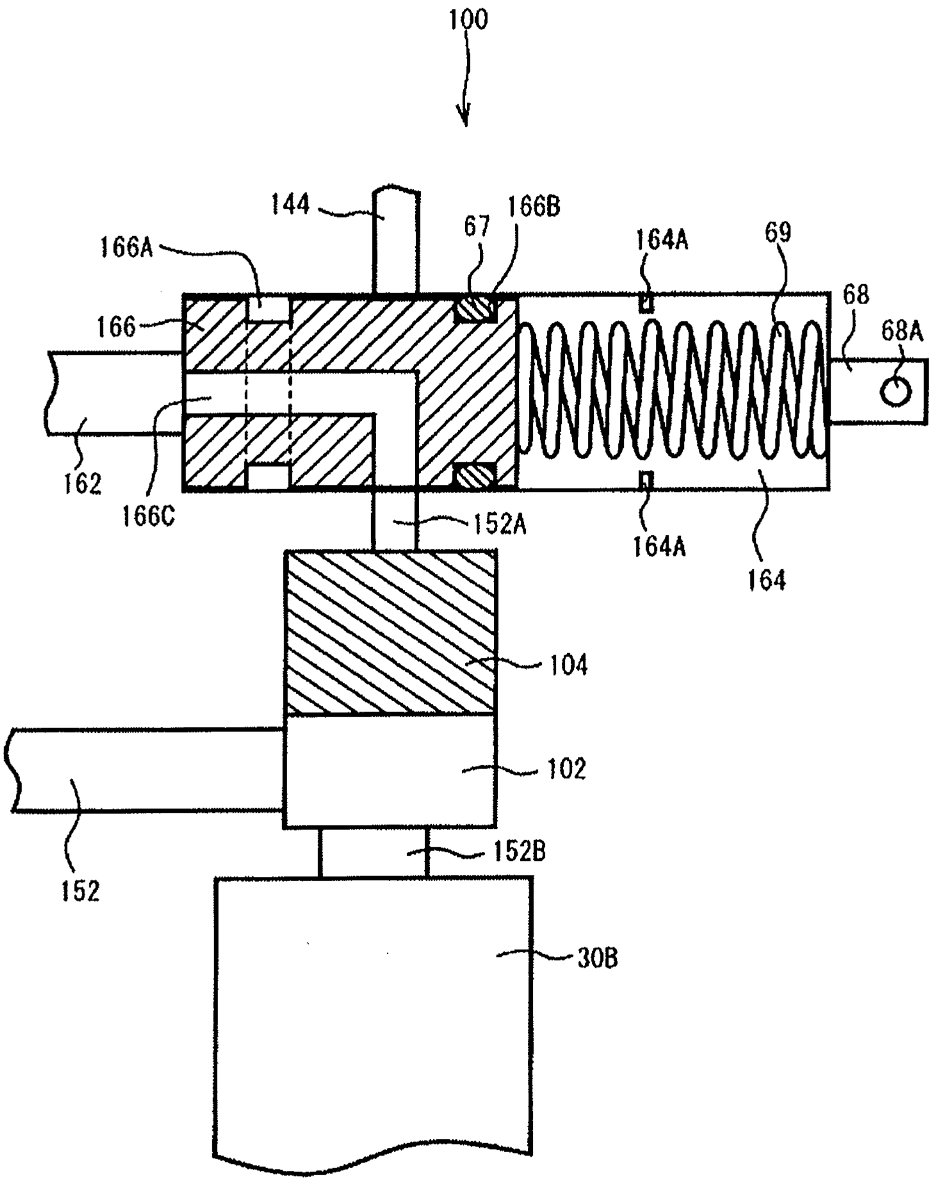
68
68A
166
162
166C
152A
164A
164
102
104
152
152B
30B

FIG. 8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68A
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166C
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164A
164
104
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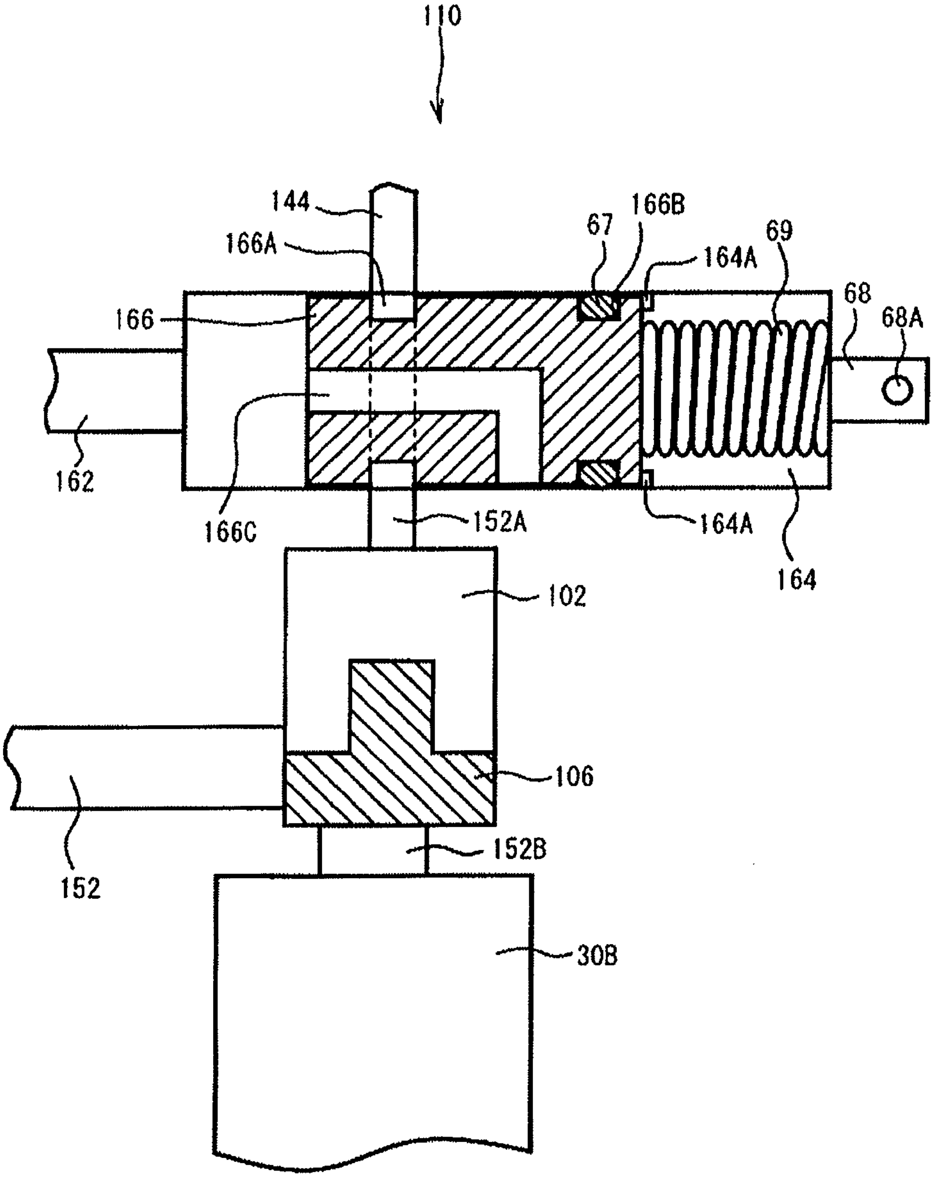
152B
152
30B

FIG. 9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106
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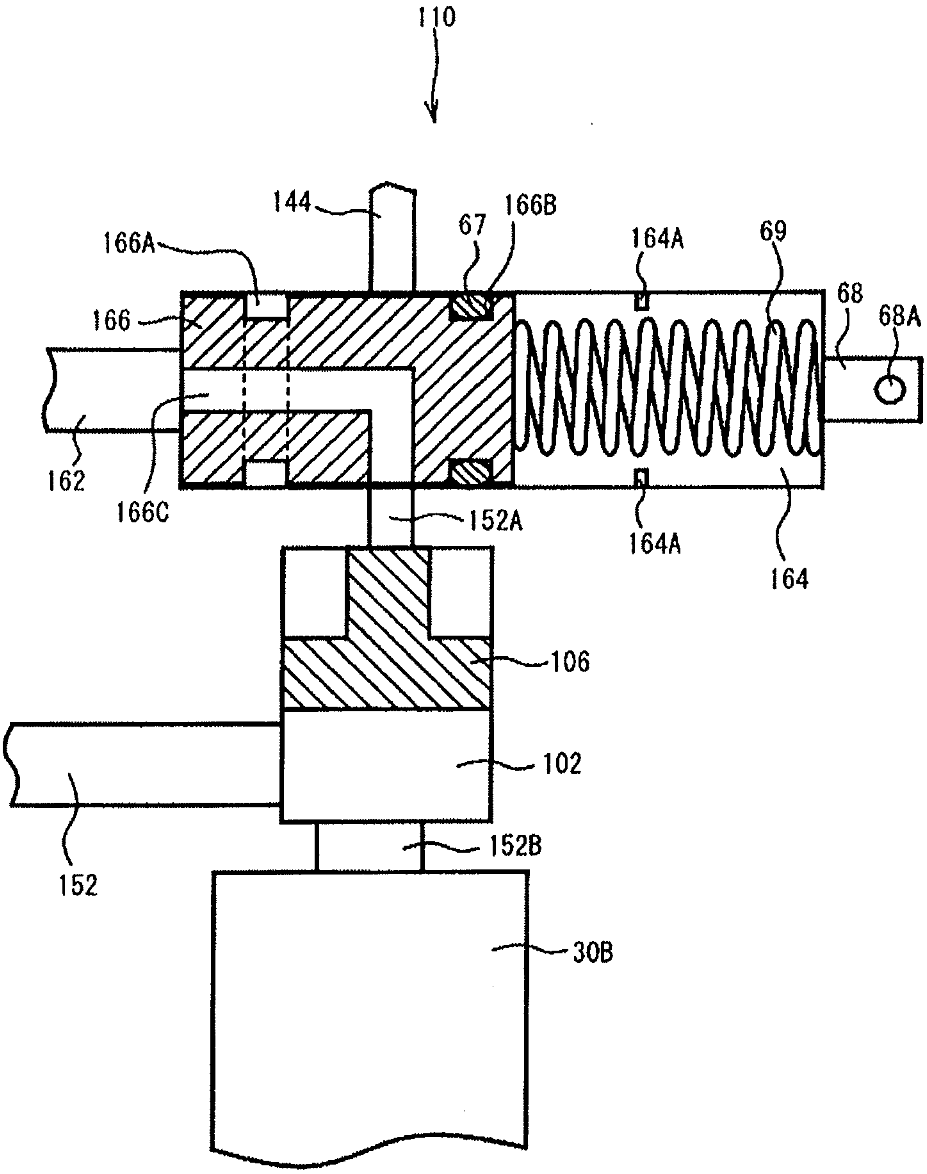
152B
30B

FIG. 10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102
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152B
30B

FIG. 11

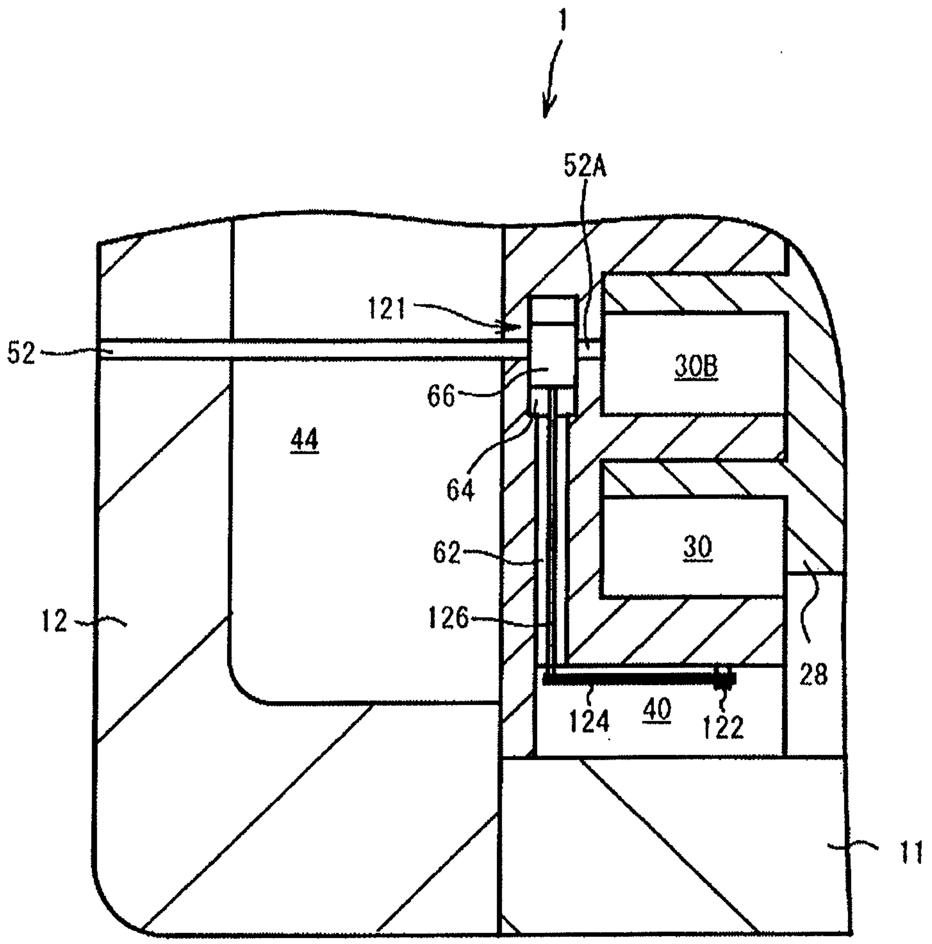
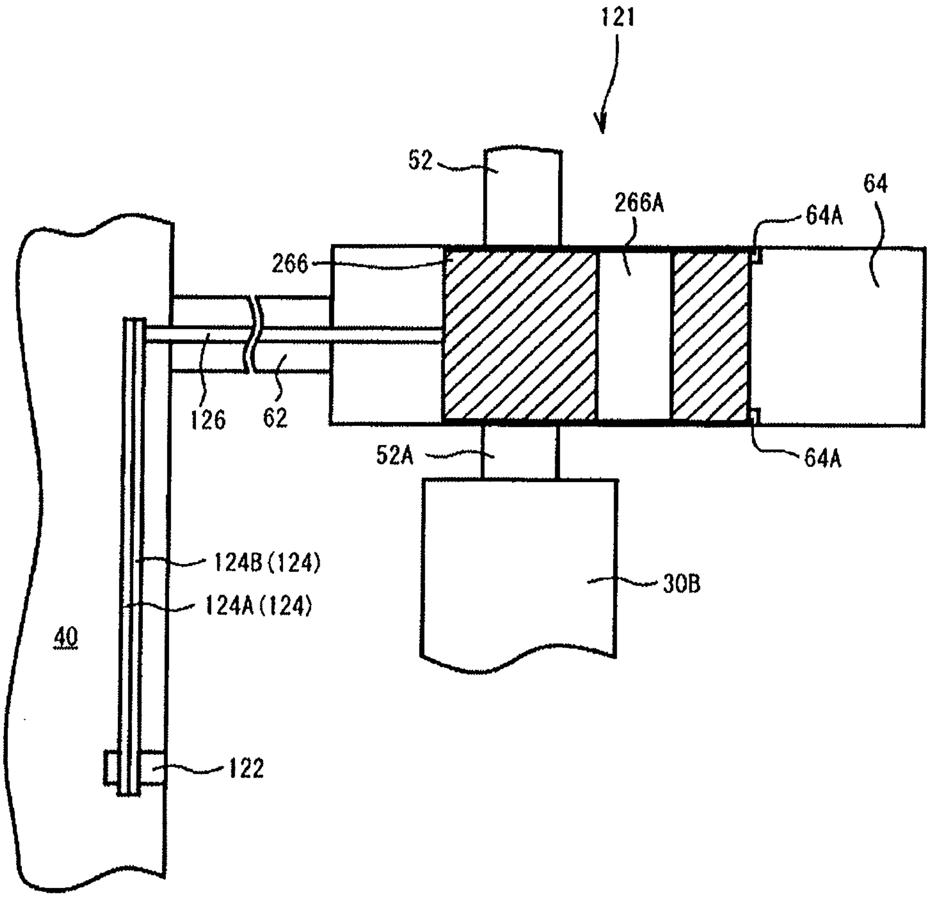


FIG. 12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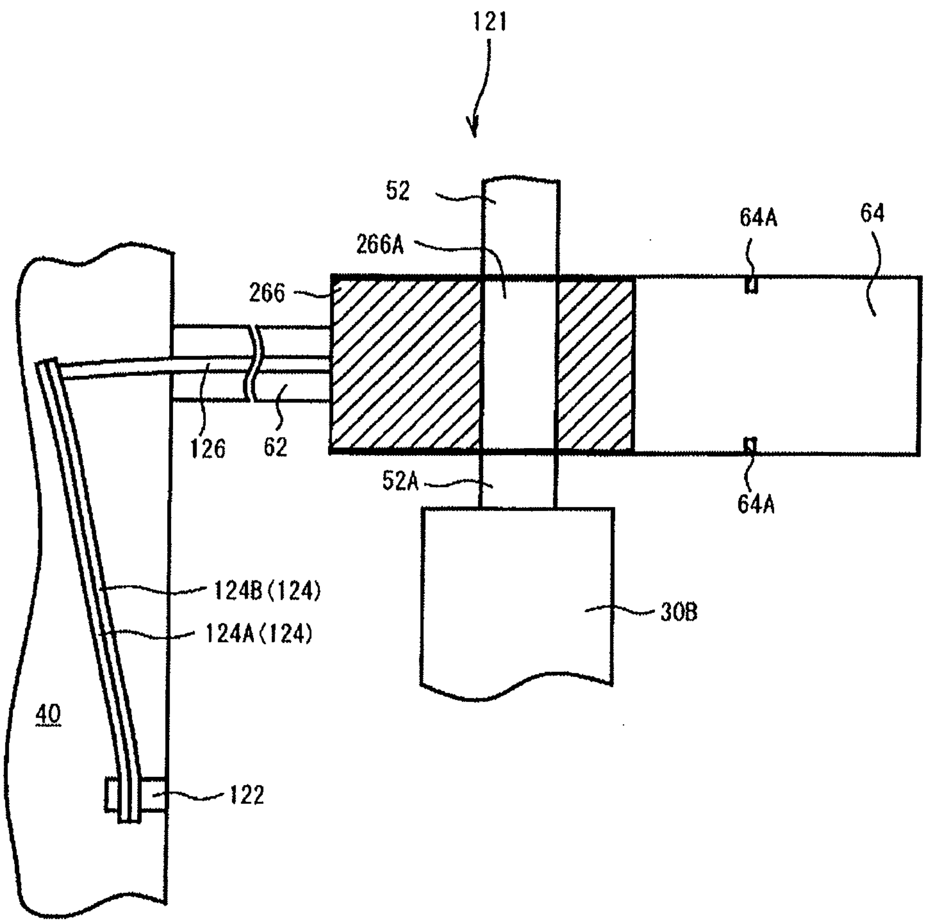
52
266A
64A
64
266
126
62
52A
64A
124B (124)
124A (124)
30B
40
122

FIG. 13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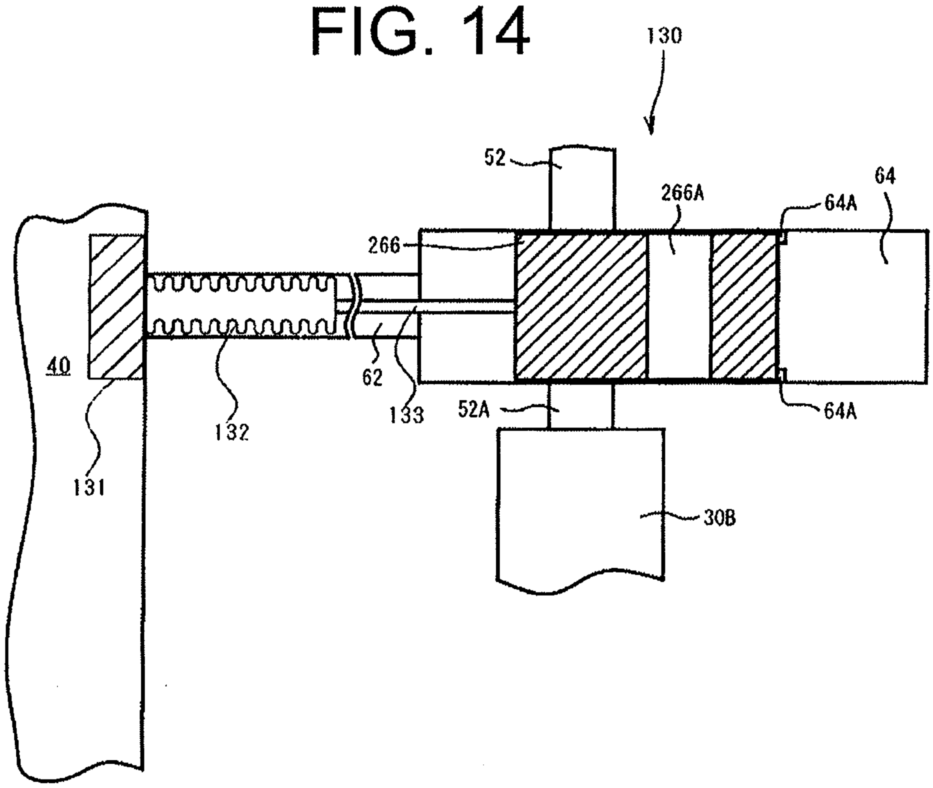
30B
40
122

FIG. 14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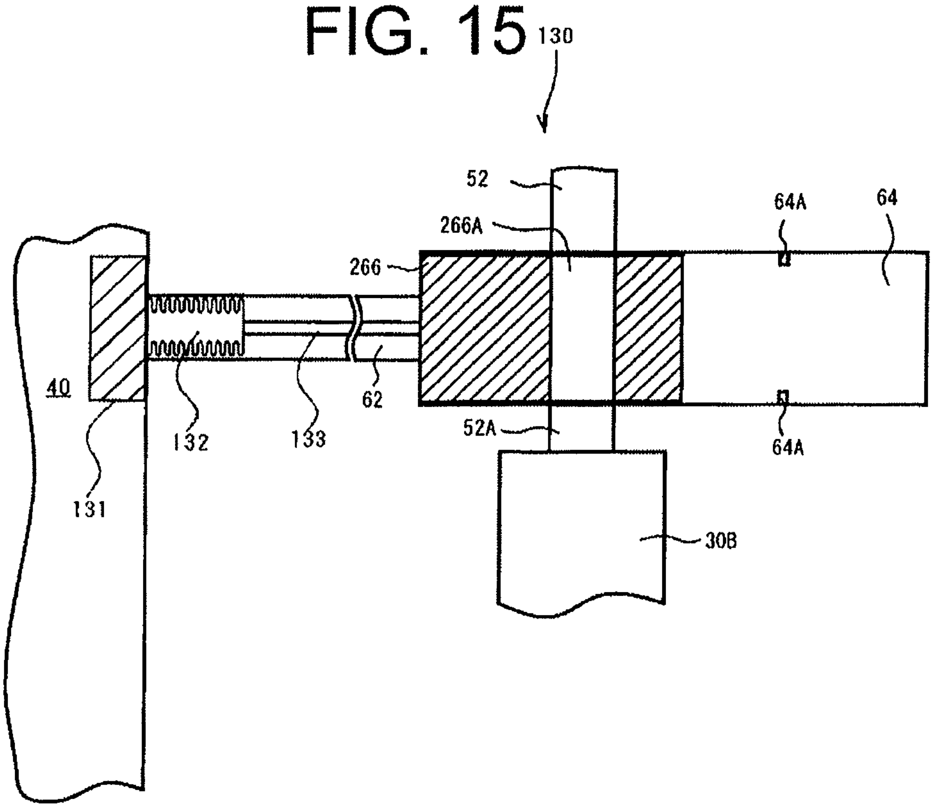
64A
131
30B

FIG. 15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64
266A
266
40
133
62
132
52A
64A
131
30B

REFERENCES CITED IN THE DESCRIPTION

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