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(54) **Scroll expander**

(57) A scroll expander includes a housing, a main port, a high-pressure chamber, an operation chamber, a low-pressure chamber, a subport, a valve portion, an actuator, and a drive shaft. The high-pressure and low-pressure chambers are separated by a partition wall. The main port draws working fluid in the high-pressure chamber into the operation chamber. The subport introduces the working fluid from the high-pressure chamber to the operation chamber so that the volume of the working fluid in the operation chamber is variable. The valve portion selectively opens and closes the subport. The actuator is arranged in the low-pressure chamber. The drive shaft extends through the partition wall and connects the actuator and the valve portion with each other. When the drive shaft is actuated by the actuator, the subport is selectively opened and closed by the valve portion.

Fig.1

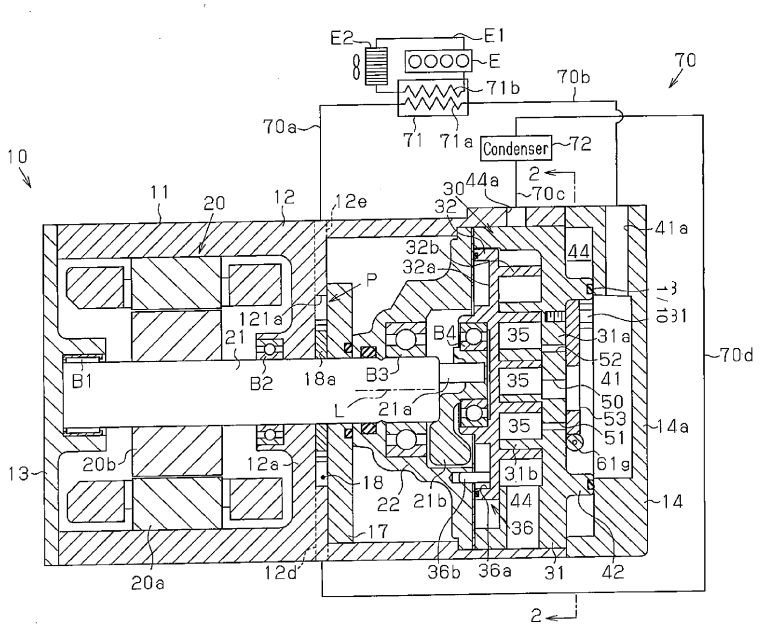

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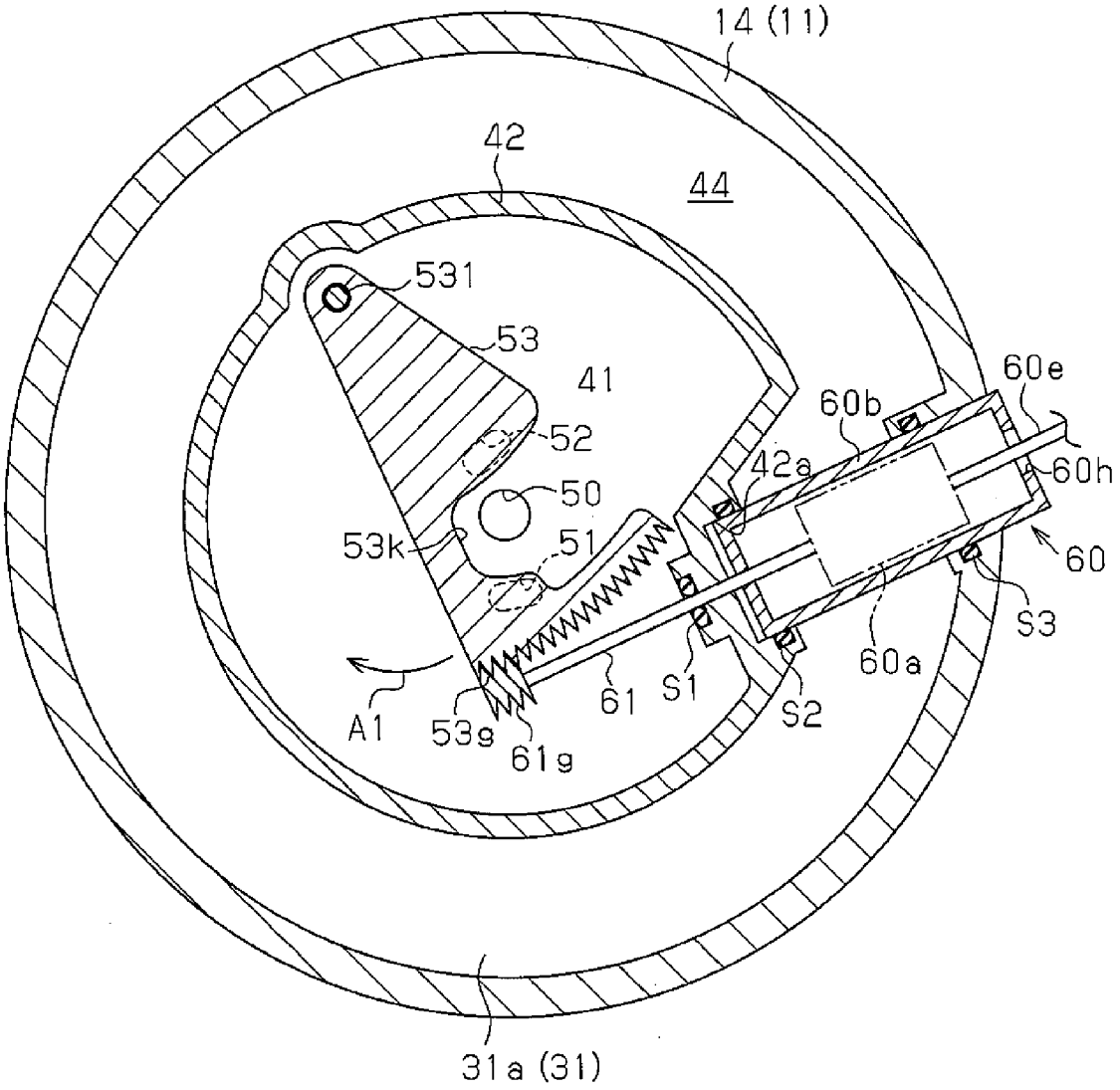
Fig.2


14 (11)
42
44
531
53
41
52
50
53k
51
60e
60b
42a
60h
60
S3
60a
S2
S1
61
A1
53g
61g
31a (31)

Description

BACKGROUND OF THE INVENTION

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

[0002] For example, Japanese Laid-Open Patent Publication No. 2005-30386 discloses a scroll expander of such a type. The scroll expander includes an expander portion configured by two spiral scrolls, namely, a fixed scroll and a moveable scroll engaged with each other. An operation chamber (expansion chamber) is defined between the moveable scroll and the fixed scroll. The volume of the operation chamber varies according to orbiting motion of the moveable scroll. A suction port (main port) is formed at a central portion of the housing of the expander portion.

[0003] Working fluid discharged to a heat exchanger by a pump portion obtains thermal energy in the heat exchanger to have a high temperature and a high pressure, and then is drawn by the operation chamber via the suction port to be expanded. The working fluid is transferred to an outer circumferential portion, while causing the moveable scroll to orbit by the expansion in the operation chamber, and is then discharged from the expander portion. Mechanical energy (drive force) is generated according to the orbiting motion of the moveable scroll.

[0004] The above publication also discloses a variable volume type expander portion with a variable volume of the working fluid in the operation chamber. As shown in Fig. 7A, a spool hole 92 is formed in an end plate of a housing 91. The open end of the spool hole 92 is sealed by a stop cock 93. A reciprocatable spool 94 and a spring 95 are accommodated in the spool hole 92. Also, a high-pressure connection passage 91a, which supplies the spool hole 92 with the working fluid that has obtained the thermal energy in the heat exchanger to have a high temperature and a high pressure, is formed in the end plate of the housing 91. A low-pressure communicating passage 91b, which connects a portion of the spool hole 92 opposite to the open end with the operation chamber 96, is formed in the housing 91. A control valve 97, which controls supply of the working fluid from the high pressure-connection passage 91a, is arranged in the expander portion 90. A pair of bypass holes 98 (subports), which connects the spool hole 92 and the operation chamber 96 with each other, are formed in the housing 91. A pair of valve portions 94a, which selectively open and close the pair of bypass holes 98, are formed in the spool 94.

[0005] When the working fluid is supplied from the control valve 97 through the high-pressure connection passage 91a, the difference between the pressure in a portion of the spool hole 92 closer to the open end than the spool 94 and the pressure in a portion of the spool hole 92 closer to the low-pressure communicating passage 91b than the spool 94 moves the spool 94 toward spring 95 against the spring force of the spring 95. Then, the pair of bypass holes 98 are closed by the valve portions 94a of spool 94 so that the introduction of the working fluid to operation chamber 96 through the pair of bypass holes 98 is no longer performed.

[0006] As shown in Fig. 7B, when the supply of the working fluid from the control valve 97 through the high-pressure connection passage 91a is stopped, the difference no longer exists between the pressure in the portion of the spool hole 92 closer to the open end than the spool 94 and the pressure in the portion of the spool hole 92 closer to the low-pressure communicating passage 91b than the spool 94 so that the spool 94 is moved toward the open end apart from the spring 95 by the spring force of the spring 95. Then, the valve portions 94a of the spool 94 come off the pair of bypass holes 98 so that the working fluid is introduced from the spool hole 92 into the operation chambers 96 through the pair of bypass holes 98 in addition to the suction of the working fluid to the operation chambers 96 through the suction port 91c. This increases the volume of the working fluid drawn into the operation chambers 96, while reducing the expansion ratio of the working fluid in the operation chambers 96. Accordingly, the working fluid drawn into the operation chamber 96 is prevented from being excessively expanded.

[0007] However, the actuator formed of the spool 94 and the spring 95 configured to move the valve portions 94a, which selectively open and close the pair of bypass holes 98, is arranged in the spool hole 92, to which the working fluid with a high temeprature and a high pressure is supplied. Accordingly, the spool 94 and the spring 95 as component parts forming the actuator are exposed to the working fluid with a high temperature and a high pressure so that the spool 94 and the spring 95 are likely to deteriorate due to the working fluid with a high temperature and a high pressure.

SUMMARY OF THE INVENTION

[0008] An object of the present invention is to provide a scroll expander that drives an actuator to move a valve portion, thereby selectively opening and closing a subport with the valve portion, while limiting deterioration of the component parts of the actuator.

[0009] To achieve the foregoing object and in accordance with one aspect of the present invention, a scroll expander including a housing having an inner circumferential surface, a fixed scroll, a moveable scroll, a high-pressure chamber, an operation chamber, a low-pressure chamber, a partition wall, a main port, a subport, a valve portion, and an actuator is provided. The fixed scroll is accommodated in the housing and fixed to the inner circumferential surface of the housing. The moveable scroll is accommodated in the housing and arranged to face the fixed scroll. The high-pressure chamber, to which high-pressure working fluid is supplied, is formed in the housing. The operation chamber, in which working fluid introduced from the high-pressure chamber is ex-

panded, is defined by the fixed scroll and the moveable scroll. The low-pressure chamber, to which working fluid that has been expanded and decompressed in the operation chamber is discharged, is formed in the housing. The partition wall separates a space in the housing into the high-pressure chamber and the low-pressure chamber. The main port draws the working fluid in the high-pressure chamber into the operation chamber. The subport introduces the working fluid from the high-pressure chamber to the operation chamber so that a volume of the working fluid in the operation chamber is variable. The valve portion selectively opens and closes the subport. The actuator applies drive force to move the valve portion. The actuator is arranged in the low-pressure chamber. The scroll expander includes a drive shaft that extends through the partition wall and connects the actuator and the valve portion with each other. When the drive shaft is actuated by the actuator, the valve portion is moved by the actuation of the drive shaft so that the subport is selectively opened and closed.

[0010] Other aspects and advantages of the present 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

[0011] 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 diagram illustrating a complex fluid machine and a Rankine cycle system according to one embodiment;

Fig. 2 is a cross-sectional view taken along line 2-2 of Fig. 1;

Fig. 3 is a cross-sectional view illustrating the state where a first subport of two subports is opened;

Fig. 4 is a cross-sectional view illustrating the state where both of the two subports are opened;

Fig. 5 is a partially enlarged cross-sectional view illustrating an electric motor and its surrounding according to another embodiment;

Fig. 6 is a partially enlarged cross-sectional view illustrating an electric motor and its surroundings according to yet another embodiment; and

Figs. 7A and 7B are cross-sectional views illustrating a part of a conventional scroll expander.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] Hereinafter, a complex fluid machine 10 to be installed in a Rankine cycle system 70 according to one embodiment of the present invention will be described with reference to Figs. 1 to 4.

[0013] As shown in Fig. 1, the complex fluid machine 10 includes a housing 11. The housing 11 is configured by a cylindrical center housing member 12, a plate-like front housing member 13, which is joined to one end of the center housing member 12, and a rear housing member 14, which is shaped as a tube with a closed end and joined to the other end of the center housing member 12. A partition wall 12a is formed on an inner circumferential surface of the center housing member 12. A motor generator 20 is accommodated in the space defined by the inner circumferential surface of the center housing member 12, the partition wall 12a, and the front housing member 13. The motor generator 20 includes a stator 20a fixed to the inner circumferential surface of the center housing member 12, and a rotor 20b arranged inside the stator 20a. The rotor 20b is firmly fixed to a rotary shaft 21 accommodated in the housing 11 to rotate integrally with the rotary shaft 21.

[0014] One end, namely, the left end of the rotary shaft 21 is rotationally supported by the front housing member 13 via a bearing B1, while a part at the other end, namely, the right part of the rotary shaft 21 extends through the partition wall 12a of the center housing member 12. A bearing B2 is located between the rotary shaft 21 and the partition wall 12a of the center housing member 12, and the rotary shaft 21 is rotationally supported by the partition wall 12a of the center housing member 12 via the bearing B2. Further, a shaft supporting member 22 is fixed inside the center housing member 12, and the right end of the rotary shaft 21 is rotationally supported by the shaft supporting member 22 via a bearing B3.

[0015] An oblong recess 121a is formed to surround the rotary shaft 21 in a surface of the partition wall 12a of the center housing member 12 facing the rear housing member 14. Also, a side plate 17, which closes the recess 121a, is fixed on the surface of the partition wall 12a of the center housing member 12 facing the rear housing member 14. A pump chamber 18 is defined by the recess 121a and the side plate 17. A pump portion P is accommodated in the pump chamber 18. The pump portion P includes a driven gear (not shown) rotationally supported by the pump chamber 18 and a primary drive gear 18a attached to the rotary shaft 21. The driven gear and the primary drive gear 18a are located in the state where they are engaged with each other.

[0016] A suction passage 12d is formed in the partition wall 12a of the center housing member 12. One end of the suction passage 12d is opened in the outer surface of the center housing member 12, while the other end is connected to the pump chamber 18. A discharge passage 12e is formed in the partition wall 12a of the center housing member 12. One end of the discharge passage 12e is connected to the pump chamber 18, while the other end of the discharge passage 12e is opened in the outer surface of the center housing member 12.

[0017] In the space defined by the inner circumferential surface of the center housing member 12, the partition

wall 12a, and the rear housing member 14, a scroll expander portion 30 is accommodated between the shaft supporting member 22 and a bottom wall 14a of the rear housing member 14. The expander portion 30 is configured by a fixed scroll 31, which is accommodated in the center housing member 12 and fixed on the inner circumferential surface of the center housing member 12, and a moveable scroll 32, which is accommodated in the center housing member 12, and arranged between the fixed scroll 31 and the shaft supporting member 22 to face the fixed scroll 31. The fixed scroll 31 includes a disc-shaped fixed base plate 31a, and a fixed volute portion 31b standing from the fixed base plate 31a. The moveable scroll 32 includes a disc-shaped moveable base plate 32a, and a moveable volute portion 32b standing from the moveable base plate 32a toward the fixed base plate 31a.

[0018] The fixed volute portion 31b and the moveable volute portion 32b are engaged with each other. The distal end surface of the fixed volute portion 31b contacts the moveable base plate 32a, and the distal end surface of the moveable volute portion 32b contacts the fixed base plate 31a. The fixed base plate 31a and the fixed volute portion 31b, and the moveable base plate 32a and the moveable volute portion 32b define operation chambers 35.

[0019] An eccentric shaft 21a is provided to protrude at a position displaced from the axis L of the rotary shaft 21 at the right end of the rotary shaft 21. A bushing 21b is fixed to the eccentric shaft 21a. On the bushing 21b, the moveable base plate 32a is supported via a bearing B4 in a rotational manner relative to the bushing 21b.

[0020] An anti-rotation mechanism 36 is provided between the moveable base plate 32a and the shaft supporting member 22. The anti-rotation mechanism 36 is configured by a plurality of annular holes 36a provided in a surface of the moveable base plate 32a facing the shaft supporting member 22, and pins 36b, which protrude from an outer circumferential portion of the shaft supporting member 22 facing the moveable base plate 32a and are fitted into the corresponding annular holes 36a with allowance therebetween.

[0021] In the housing 11, a suction chamber 41 is defined between the fixed base plate 31a and the rear housing member 14. That is, the suction chamber 41 is formed in the housing 11. A suction port 41a connected to the suction chamber 41 is formed in the bottom wall 14a of the rear housing member 14. A main port 50, which connects the suction chamber 41 to the operation chambers 35 prior to the expansion, is formed in a central portion of the fixed base plate 31a. The operation chambers 35 are formed in a radially central portion of the expander portion 30. Further, a first subport 51 and a second subport 52 are formed at positions radially outward of the main port 50 in the fixed base plate 31a. The first subport 51 connects the suction chamber 41 with one of the two operation chambers 35 that are located radially outward of the operation chambers 35 at the radially central portion. The second subport 52 connects the suction chamber 41 with the other one of the two operation chambers 35 that radially outward of the operation chambers 35 defined in the radially central portion.

[0022] An annular partition wall 42 protrudes on a surface of the fixed base plate 31a facing the bottom wall 14a of the rear housing member 14 at a position radially outward of the first and the second subports 51 and 52. A distal end of the partition wall 42 contacts an inner surface of the bottom wall 14a of the rear housing member 14. An annular sealing member 43 is located between the distal end of the partition wall 42 and the bottom wall 14a of the rear housing member 14. In the housing 11, the outermost circumferential surface of the moveable volute portion 32b, the outer circumferential surface of the partition wall 42, the center housing member 12, and the rear housing member 14 define a discharge chamber 44. That is, the discharge chamber 44 is formed in the housing 11. Accordingly, the partition wall 42 separates the inner space between the rear housing member 14 and the fixed scroll 31 into the suction chamber 41 and the discharge chamber 44. Also, a discharge port 44a connected to the discharge chamber 44 is formed in the center housing member 12.

[0023] As shown in Fig. 2, on the surface of the fixed base plate 31a facing the bottom wall 14a of the rear housing member 14, a substantially sectoral plate-shaped valve portion 53, which selectively opens and closes the first subport 51 and the second subport 52, is attached at a position radially inward of the partition wall 42. The valve portion 53 is fixed to the fixed base plate 31a by a screw member 531. A slight gap is formed between the valve portion 53 and the screw member 531 so that the valve portion 53 rotates about the screw member 531. A notch portion 53k is formed in the valve portion 53. The main port 50 is located inside the notch portion 53k so that it is not closed by the valve portion 53. A gear portion 53g is formed in the outer circumferential surface of the valve portion 53, which curves to be arcuate.

[0024] A fitting recess 42a is formed in the outer circumferential surface of the partition wall 42. An electric motor 60 is fixed to the fitting recess 42a. Accordingly, the electric motor 60 is arranged in the discharge chamber 44. The electric motor 60 has a motor portion 60a and a case 60b, which accommodates the motor portion 60a. The motor portion 60a is configured by a stator and a rotor, which are not shown. A drive shaft 61 is connected to the motor portion 60a. The drive shaft 61 extends through the partition wall 42. One end of the drive shaft 61 extends through the case 60b to be connected to the motor portion 60a, and the other end is connected to the valve portion 53. The drive shaft 61 is rotational by driving the motor portion 60a. A worm gear 61g is attached to the distal end of the drive shaft 61. The worm gear 61g is meshed and engaged with the gear portion 53g of the valve portion 53. Accordingly, the drive shaft 61 connects the motor portion 60a (electric motor 60) and the valve portion 53 with each other.

[0025] A part of the case 60b opposite to the fitting

recess 42a extends through the rear housing member 14 to be exposed to the outside of the housing 11. A through hole 60h is formed in the portion of the case 60b exposed to the outside of the housing 11. The through hole 60h faces outside the housing 11. A lead 60e extends from the motor portion 60a such that the lead 60e extends outside the housing 11 via the through hole 60h to be electrically connected to an external power supply, which is not shown. The electricity is supplied from the external power supply to the motor portion 60a via the lead 60e to drive the motor portion 60a. Further, the inside of the case 60b and the outside of the housing 11 communicate with each other via the through hole 60h.

[0026] An annular first sealing member S1 is located between the drive shaft 61 and the partition wall 42. The first sealing member S1 prevents the working fluid in the suction chamber 41 from flowing into the discharge chamber 44 via the space between the drive shaft 61 and the partition wall 42. Further, an annular second sealing member S2 as a sealing member is located between the case 60b and the fitting recess 42a. The second sealing member S2 prevents the working fluid in the discharge chamber 44 from flowing into the case 60b via the space between the case 60b and the fitting recess 42a, and the space between the case 60b and the drive shaft 61. Moreover, an annular third sealing member S3 is located between the case 60b and the rear housing member 14. The third sealing member S3 seals the interface between the discharge chamber 44 and the outside of the housing 11.

[0027] Next, the Rankine cycle system 70, in which the complex fluid machine 10 as above configured is installed will be described below.

[0028] As shown in Fig. 1, a heat absorber 71a of a heat exchanger 71 is connected to the discharge passage 12e via a first channel 70a. The heat exchanger 71 has a heat radiator 71b. The heat radiator 71b is provided on a cooling water circulation path E1 connected to an engine E as a source of exhaust heat. A radiator E2 is provided on the cooling water circulation path E1. The cooling water circulation path E1 is configured such that cooling water as fluid for cooling the engine E circulates therein.

[0029] The suction port 41a is connected to a discharge portion of the heat absorber 71a in the heat exchanger 71 via a second channel 70b. Further, a condenser 72 is connected to the discharge port 44a via a third channel 70c. The suction passage 12d is connected to a discharge portion of the condenser 72 via a fourth channel 70d. The Rankine cycle system 70 includes a circuit configured by connecting the pump portion P, the heat exchanger 71, the expander portion 30, and the condenser 72 in this order.

[0030] Next, operation of the present embodiment will be described.

[0031] When the motor generator 20, when serving as an electric motor, is driven to drive the pump portion P, the working fluid in the pump chamber 18 flows into the heat exchanger 71 by way of the discharge passage 12e and the first channel 70a. Then, in the heat exchanger 71, according to the heat exchange between the heat absorber 71a and the heat radiator 71b, the working fluid is heated by the exhaust heat from the engine E, and receives the thermal energy to have a high temperature and a high pressure.

[0032] The working fluid with a high temperature and a high pressure due to the heat exchange in the heat exchanger 71 is drawn into the operation chamber 35 by way of the second channel 70b, the suction port 41a, the suction chamber 41, and the main port 50, and expanded. Therefore, in the present embodiment, the suction chamber 41 corresponds to a high-pressure chamber to which the working fluid with a high temperature and a high pressure due to the heat exchange in the heat exchanger 71 is supplied.

[0033] According to the expansion of the working fluid in the operation chamber 35, the expander portion 30 generates, namely, outputs mechanical energy (drive force). According to the drive force, the moveable scroll 32 orbits about the axis of the fixed scroll 31 (the rotation axis L of the rotary shaft 21) via the eccentric shaft 21a. The moveable scroll 32 is prevented from rotating by the anti-rotation mechanism 36, but is only permitted to orbit. The volumes of the operation chambers 35 are changed by the orbiting motion of the moveable scroll 32. When the rotary shaft 21 is rotated by the orbiting motion of the moveable scroll 32, the motor generator 20 is rotated to function as a power generator. At this time, the drive force of the motor generator 20 is converted into electric power, and the electric power is charged to a battery (not shown).

[0034] The working fluid that has been expanded and decompressed in the operation chambers 35 is discharged to the discharge chamber 44. Therefore, in the present embodiment, the discharge chamber 44 corresponds to a low-pressure chamber to which the working fluid that has been expanded and decompressed in the operation chambers is supplied. The working fluid that has been discharged to the discharge chamber 44 passes through the condenser 72 by way of the discharge port 44a and the third channel 70c to be liquidized. Then, the working fluid that has been liquidized in the condenser 72 is returned to the pump chamber 18 by way of the fourth channel 70d and the suction passage 12d.

[0035] As shown in Fig. 2, when the motor portion 60a in the state where the first and the second subports 51 and 52 are closed by the valve portion 53 is rotated in one direction, the drive shaft 61 is driven, namely, rotated by the rotation force of the motor portion 60a, and the valve portion 53 is rotated in a direction of arrow A1 about the screw member 531 via the worm gear 61g and the gear portion 53g. Therefore, in the present embodiment, the electric motor 60 (motor portion 60a) functions as an actuator, which applies the drive force to the valve portion 53 to move the valve portion 53.

[0036] Then, as shown in Fig. 3, the valve portion 53 becomes out of the first subport 51 so that the first subport

51 connects the suction chamber 41 with one of the two operation chambers 35 that are located radially outward of the operation chambers 35 defined in the radially central portion of the expander portion 30. Thereby, the working fluid is introduced from the suction chamber 41 to the operation chambers 35 connected to the first subport 51 via the first subport 51 so that the volume of the working fluid in the operation chambers 35 is increased, while the expansion ratio of the working fluid in the operation chambers 35 is reduced.

[0037] As shown in Fig. 4, when the valve portion 53 is further rotated in the direction of arrow A1, the valve portion 53 becomes out of the second subport 52 so that the second subport 52 connects the suction chamber 41 with the other one of the two operation chambers 35 that are located radially outward of the operation chambers 35 defined in the radially central portion of the expander portion 30. Thereby, the working fluid is introduced from the suction chamber 41 to the operation chambers 35 connected to the second subport 52 via the second subport 52 so that the volume of the working fluid in the operation chambers 35 is increased, while the expansion ratio of the working fluid in the operation chambers 35 is reduced. Accordingly, the suction volume to the operation chambers 35 in the expander portion 30 is variable so that the suction volume to the operation chambers 35 is optimally adjusted to operate the expander portion 30 under the optimal conditions.

[0038] Since the electric motor 60 is arranged in the discharge chamber 44, it is prevented from being exposed to the working fluid with a high temperature and a high pressure in the suction chamber 41 in which the valve portion 53 is arranged. Therefore, deterioration of the component parts of the electric motor 60 by the working fluid with a high temperature and a high pressure is limited. Also, in comparison to the case where the electric motor 60 is exposed to the working fluid with a high temperature and a high pressure, the cooling performance of the electric motor 60 is improved.

[0039] The above described embodiment has the following advantages.

(1) The electric motor 60 is arranged in the discharge chamber 44. Further, the expander portion 30 is provided with the drive shaft 61, which extends through the partition wall 42, and connects the electric motor 60 and the valve portion 53 with each other. When the drive shaft 61 is driven by the electric motor 60, the valve portion 53 is moved by the driving of the drive shaft 61 so that the first and the second subports 51 and 52 are selectively opened and closed. Therefore, the electric motor 60 is prevented from being exposed to the working fluid with a high temperature and a high pressure. The valve portion 53 is moved by driving the electric motor 60 to drive the drive shaft 61. Therefore, the reduction of the quality of the component parts of the electric motor 60 is limited, while the first and the second subports 51 and 52 are selectively opened and closed by the valve portion 53 by driving the electric motor 60 to move the valve portion 53.

(2) According to the present embodiment, since the electric motor 60 is prevented from being exposed to the working fluid with a high temperature and a high pressure, in comparison to the case where the electric motor 60 is exposed to the working fluid with a high temperature and a high pressure, the cooling performance of the electric motor 60 is improved.

(3) A part of the case 60b of the electric motor 60 extends through the housing 11 to be exposed to the outside of the housing 11. The through hole 60h is formed at a position of the case 60b exposed to the outside of the housing 11 so that the through hole 60h connects the inside of the case 60b with the outside of the housing 11. Accordingly, the pressure inside the case 60b is the same as the pressure outside the housing 11 so that it is not necessary to provide a sealing member between the lead 60e and the through hole 60h to seal the interface between the inside of the case 60b and the outside of the housing 11. Therefore, the number of parts is reduced.

(4) The worm gear 61g g is attached to the distal end of the drive shaft 61. The worm gear 61g is meshed and engaged with the gear portion 53g of the valve portion 53. When the drive shaft 61 is rotated by the rotation force of the motor portion 60a, the valve portion 53 is moved via the worm gear 61g and the gear portion 53g. Accordingly, even if the valve portion 53 tends to vibrate, the position of the valve portion 53 is easily maintained by the engagement through meshing between the worm gear 61g and the gear portion 53g. Therefore, the vibration of the valve portion 53 is limited.

[0040] The above described embodiments may be modified as follows.

[0041] As shown in Fig. 5, the second sealing member S2 may be omitted, and an annular fourth sealing member S4 may be located between the through hole 60h and the lead 60e to prevent the inside of the case 60b and the outside of the housing 11 from being connected to each other. According to such a configuration, the working fluid in the discharge chamber 44 flows into the case 60b through the interface between the case 60b and the fitting recess 42a, and the interface between the case 60b and the drive shaft 61 so that the pressure inside the case 60b is the same as the pressure in the discharge chamber 44. This configuration eliminates the problem that a difference is generated between the pressure inside the case 60b and the pressure in the discharge chamber 44 to cause the case 60b to be deformed.

[0042] As shown in Fig. 6, the first sealing member S1 may be omitted, and an annular fourth sealing member S4 may be located between the through hole 60h and

the lead 60e to prevent the inside of the case 60b and the outside of the housing 11 from being connected to each other. According to such a configuration, the working fluid in the suction chamber 41 flows into the case 60b through the interface between the drive shaft 61 and the partition wall 42, and the interface between the case 60b and the drive shaft 61 so that the pressure inside the case 60b is the same as the pressure in the suction chamber 41. As a result, the inside of the case 60b is heated by the working fluid with a high temperature and a high pressure so that a difference is generated between the temperature inside the case 60b and the temperature of the working fluid in the discharge chamber 44. According to the difference in temperature, the heat inside the case 60b is likely to be dissipated to the working fluid in the discharge chamber 44 since the temperature of the fluid is lower than the temperature inside the case 60b. Accordingly, the cooling performance of the electric motor 60 is further improved. Further, since it is not necessary to provide the first sealing member S1 in the interface between the partition wall 42 and the drive shaft 61, sliding resistance between the drive shaft 61 and the first sealing member S1 to be caused when the first sealing member S1 is located between the partition wall 42 and the drive shaft 61 is prevented from being generated. Accordingly, the drive shaft 61 is smoothly driven so that the valve portion 53 is smoothly moved.

[0043] In the embodiment, the number of the subports is not particularly limited.

[0044] In the embodiment, as for the fluid from the source of exhaust heat, exhaust gas of the engine E may be used, for example.

[0045] In the embodiment, the electric motor 60 is adopted as an actuator. The configuration is not limited to this. For example, a fluid pressure cylinder that directly drives the drive shaft by fluid may be adopted. The valve portion, which selectively opens and closes the subports, may be moved by directly driving the drive shaft.

[0046] In the embodiment, the suction chamber 41 is used as a high-pressure chamber, and the discharge chamber 44 is used as a low-pressure chamber. However, a portion with a high pressure other than the suction chamber 41 may be used as a high-pressure chamber, and a portion with a low pressure other than the discharge chamber 44 may be used as a low-pressure chamber so that the valve portion 53 and the electric motor 60 may be provided therein, respectively.

[0047] Although the present invention is embodied by the complex fluid machine 10 installed in the Rankine cycle system 70, the configuration is not limited to this. The present invention may be embodied by a scroll expander that is used independently. The present invention may be embodied by a scroll expander in which a compressor and a clutch mechanism are provided integrally with each other to be installed on a refrigeration circuit.

[0048] 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 and equivalence of the appended claims.

Claims

1. A scroll expander comprising:

a housing (11) having an inner circumferential surface;
a fixed scroll (31), which is accommodated in the housing (11) and fixed to the inner circumferential surface of the housing (11);
a moveable scroll (32), which is accommodated in the housing (11) and arranged to face the fixed scroll (31);
a high-pressure chamber formed in the housing, to which high-pressure working fluid is supplied;
an operation chamber (35) defined by the fixed scroll and the moveable scroll, in which working fluid introduced from the high-pressure chamber (41) is expanded;
a low-pressure chamber (44) formed in the housing, to which working fluid that has been expanded and decompressed in the operation chamber (35) is discharged;
a partition wall (42) that separates a space in the housing (11) into the high-pressure chamber (41) and the low-pressure chamber (44);
a main port (50), which draws the working fluid in the high-pressure chamber (41) into the operation chamber (35);
a subport (51, 52), which introduces the working fluid from the high-pressure chamber (41) to the operation chamber (35) so that a volume of the working fluid in the operation chamber (35) is variable;
a valve portion (53), which selectively opens and closes the subport (51, 52); and
an actuator (60), which applies drive force to move the valve portion (53), wherein
the scroll expander being **characterized in that**
the actuator (60) is arranged in the low-pressure chamber (44),
the scroll expander includes a drive shaft (61) that extends through the partition wall (42) and connects the actuator (60) and the valve portion (53) with each other, and
when the drive shaft (61) is actuated by the actuator (60), the valve portion (53) is moved by the actuation of the drive shaft (61) so that the subport (51, 52) is selectively opened and closed.

2. The scroll expander according to claim 1, wherein the actuator includes an electric motor (60).

3. The scroll expander according to claim 2, wherein

the electric motor (60) includes a motor portion (60a) and a case (60b) that accommodates the motor portion (60a) therein,
a part of the case (60b) extends through the housing (11) to be exposed to an outside of the housing (11),
the case (60b) has a through hole (60h) in the portion exposed to the outside of the housing (11), and
the inside of the case (60b) and the outside of the housing (11) are connected with each other via the through hole (60h).

4. The scroll expander according to claim 2, wherein
the electric motor (60) includes a motor portion (60a) and a case (60b) that accommodates the motor portion (60a) therein,
the drive shaft (61) extends through the case (60b) to be connected to the motor portion (60a), and
the inside of the case (60b) and the low-pressure chamber (44) are connected with each other via an interface between the case (60b) and the drive shaft (61).

5. The scroll expander according to claim 2, wherein
the electric motor (60) includes a motor portion (60a) and a case (60b) that accommodates the motor portion (60a) therein,
the drive shaft (61) extends through the case (60b) to be connected to the motor portion (60a),
a sealing member (S2) is arranged between the case (60b) and the partition wall (42), and
the inside of the case (60b) and the high-pressure chamber (41) are connected with each other via an interface between the partition wall (42) and the drive shaft (61) and an interface between the case (60b) and the drive shaft (61).

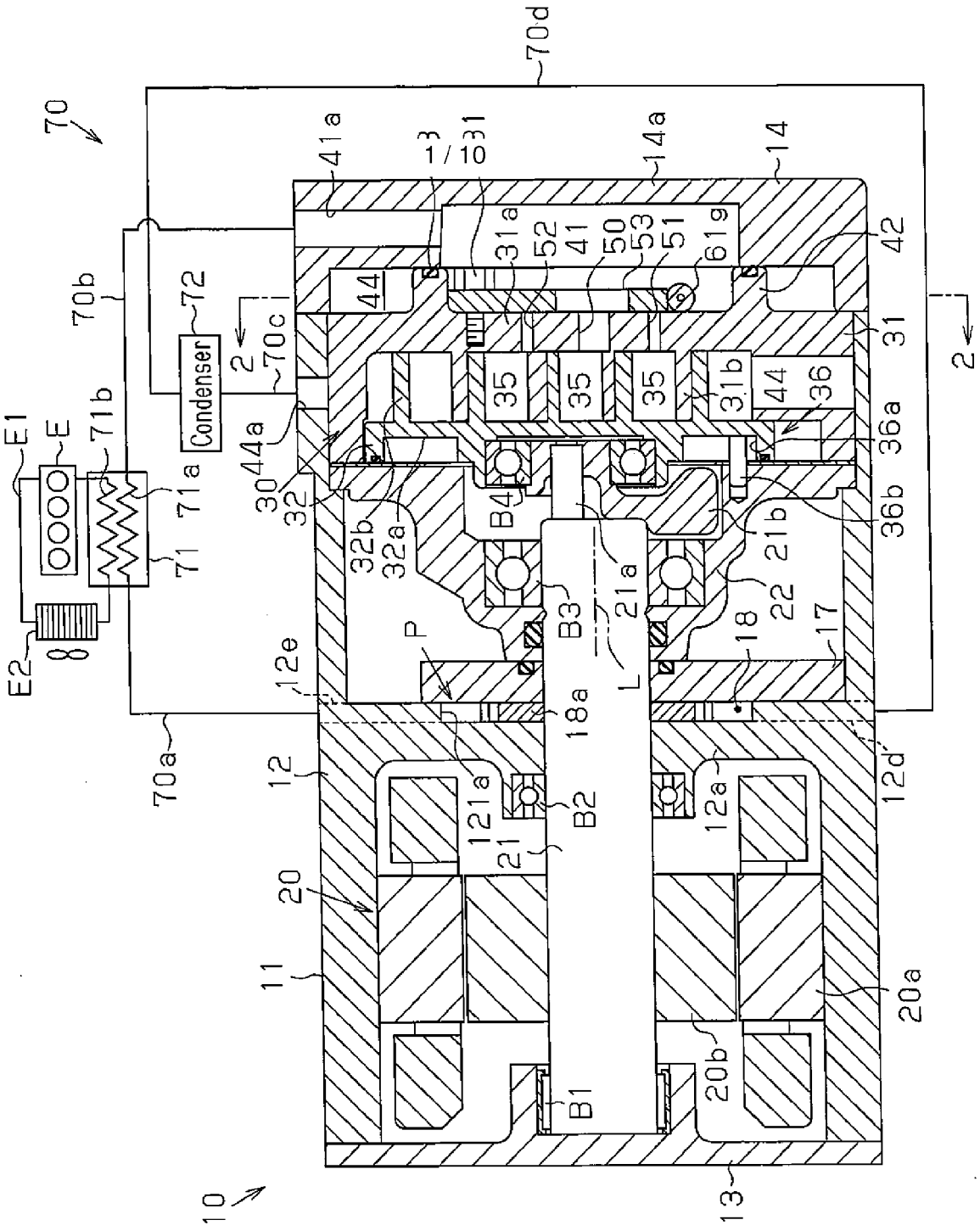

70
70d
41a
13
14a
14
31a
52
41
50
53
51
61g
42
44
70b
72
70c
2
31
35
35
35
31b
44
36
36a
Condenser
E1
E
71b
71a
71
44a
30
32
32b
32a
B4
36b
21b
21a
B3
22
17
18
E2
12e
P
18a
L
70a
12
121a
B2
12a
12d
21
20
11
20a
20b
B1
10

Fig.1

Fig.2

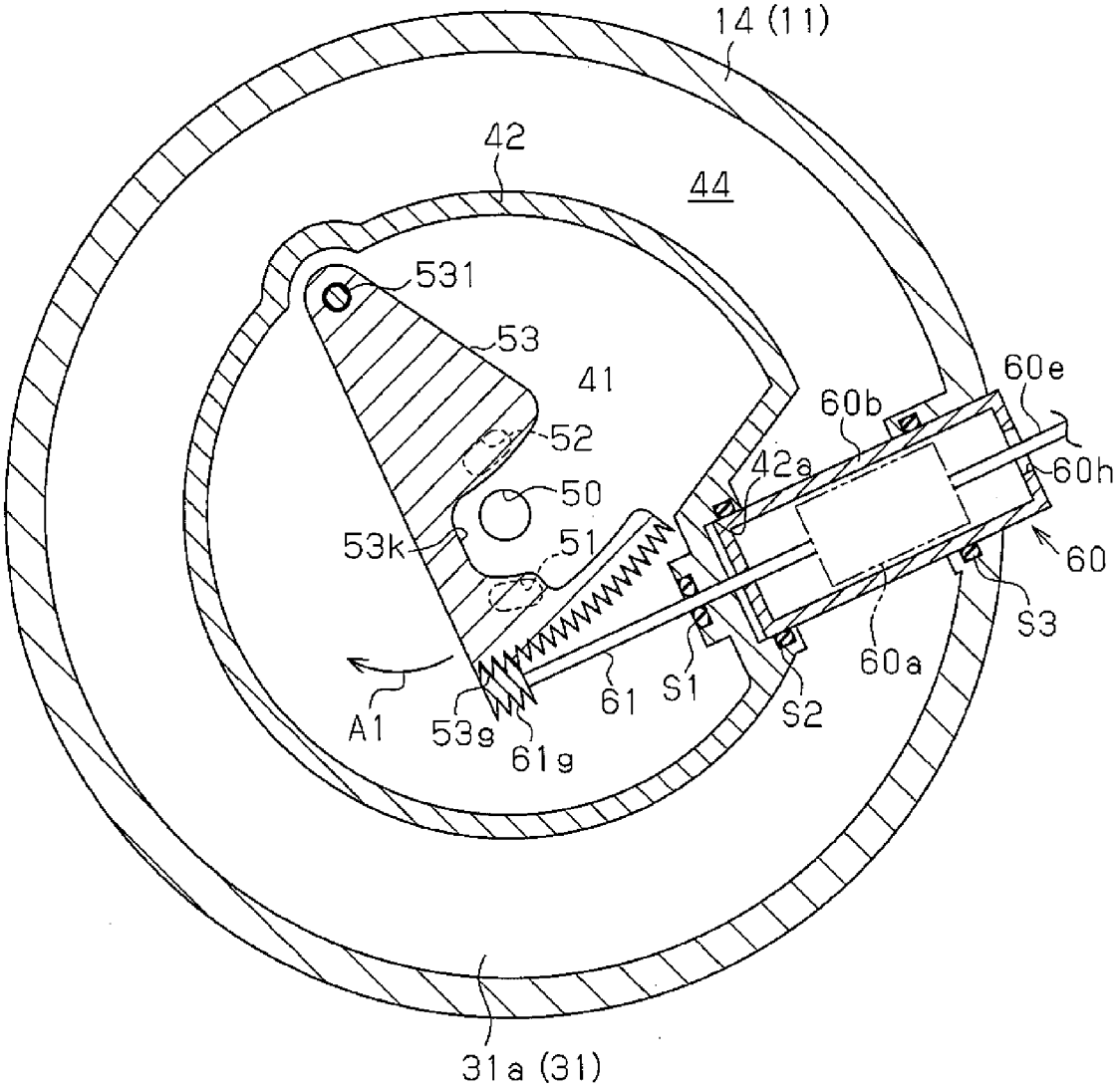

14 (11)
42
44
531
53
41
52
50
51
53k
60e
60b
42a
60h
60
S3
60a
S2
S1
61
A1
53g
61g
31a (31)

Fig.3

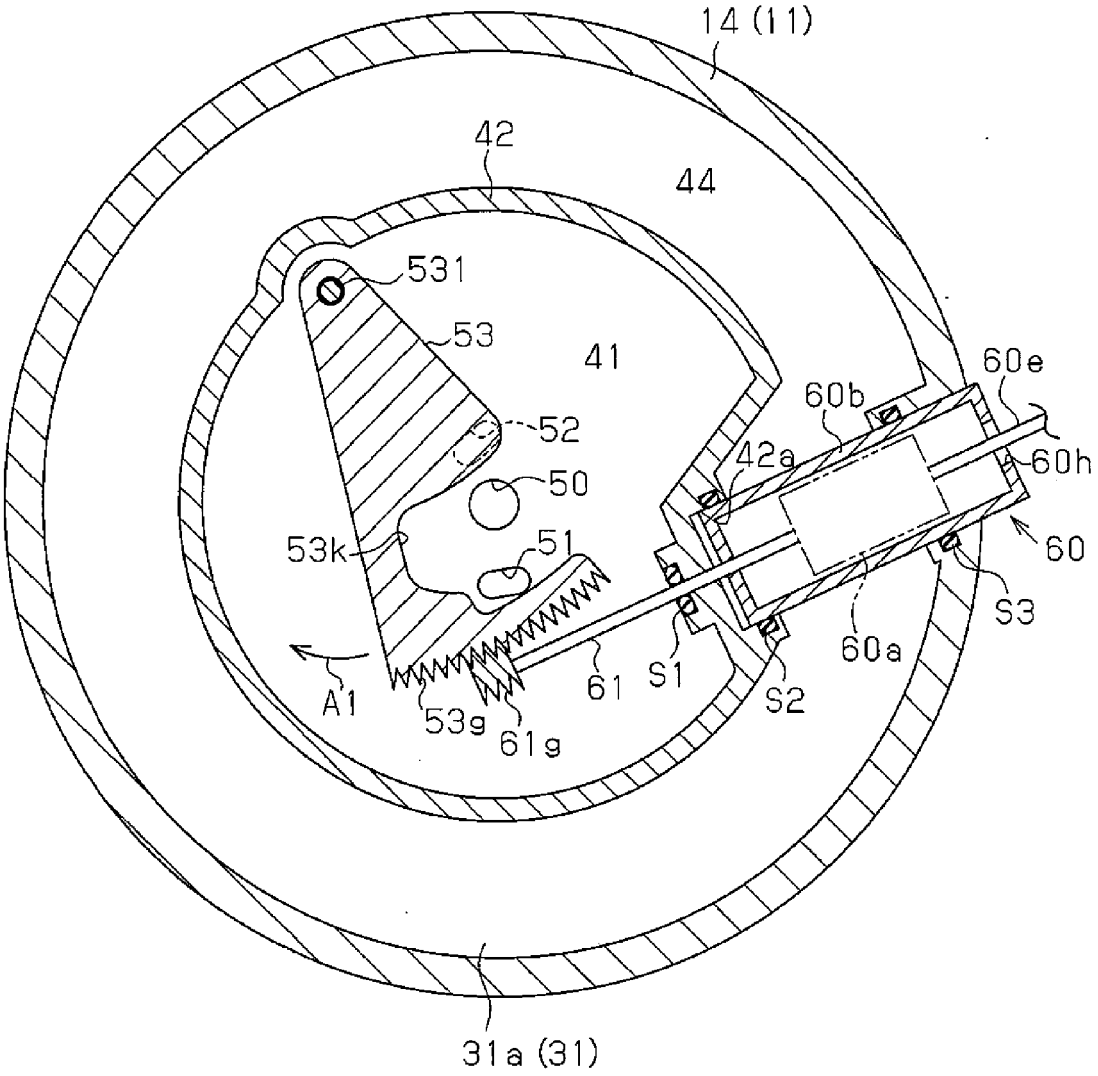

14 (11)
42
44
531
53
41
52
50
51
53k
A1
53g
61g
61
S1
S2
S3
60a
60b
60e
60h
42a
60
31a (31)

Fig.4

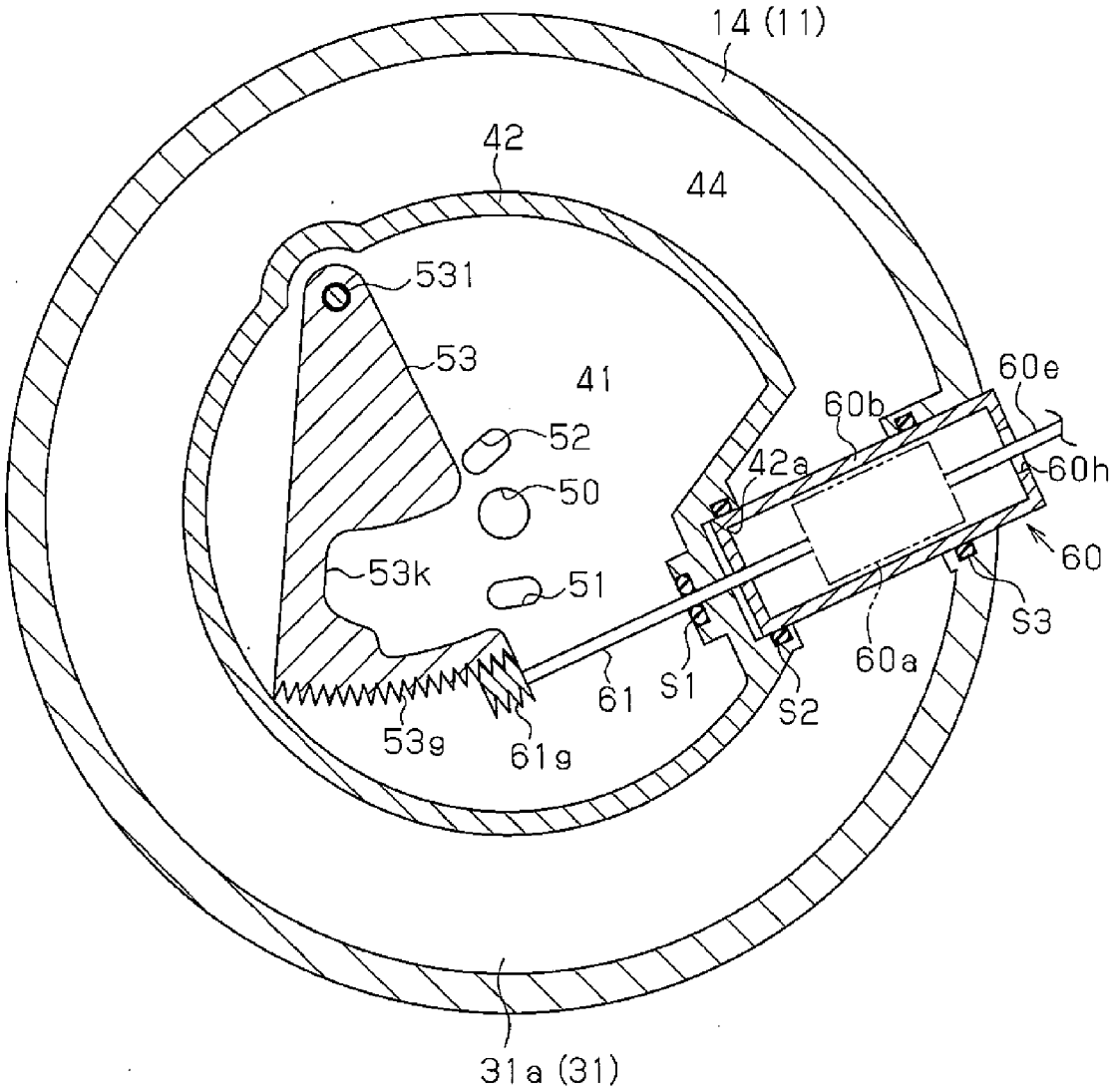
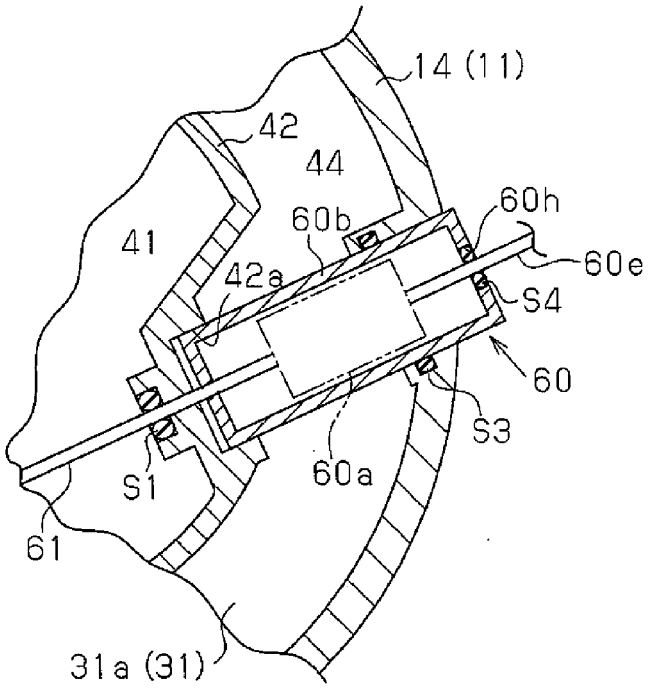

14 (11)
42
44
531
53
41
52
50
53k
51
60e
60b
42a
60h
60
S3
60a
S1
S2
61
53g
61g
31a (31)

Fig.5


14 (11)
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44
41
60b
60h
60e
42a
S4
60
S3
S1
60a
61
31a (31)

Fig.6

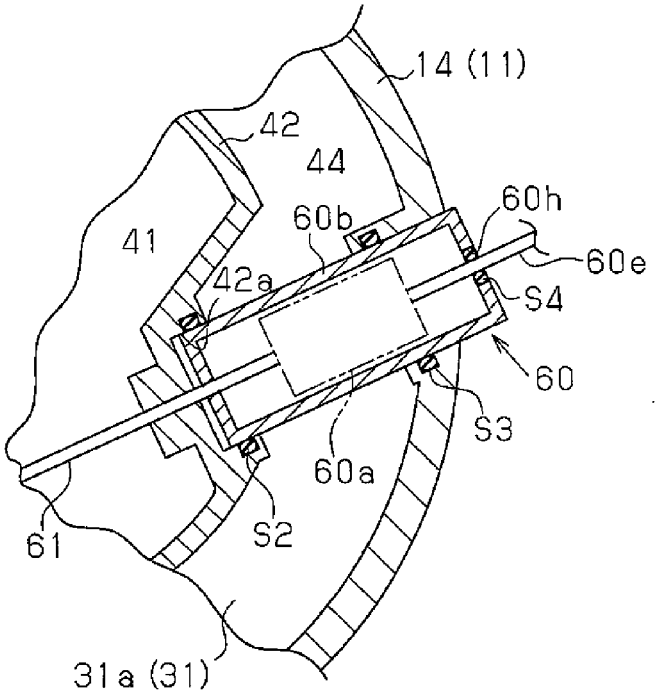
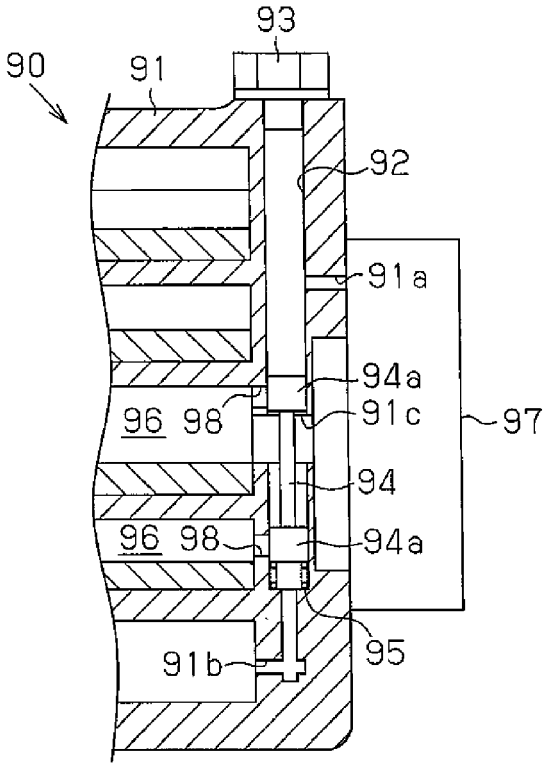

14 (11)
42
44
41
60b
60h
60e
42a
S4
60
S3
60a
S2
61
31a (31)

Fig.7A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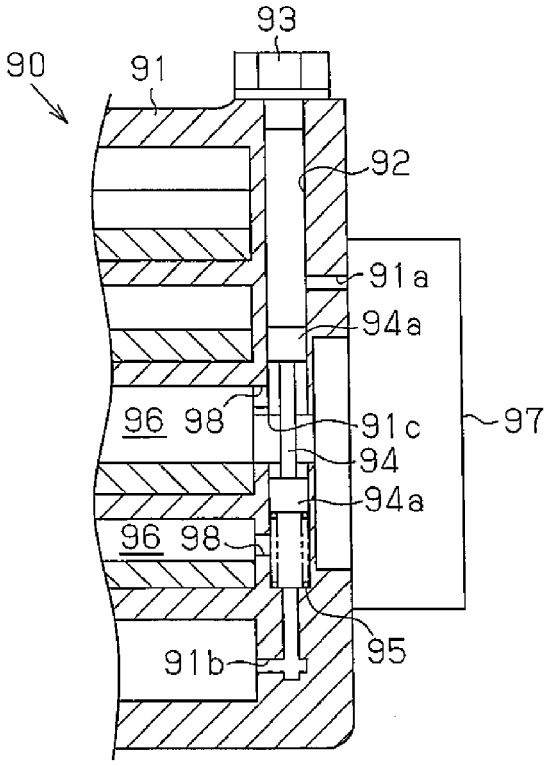
90
91
92
91a
94a
96 98
91c
97
94
96 98
94a
95
91b

Fig.7B


93
90
91
92
91a
94a
96 98
91c
97
94
94a
96 98
95
91b

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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