



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.03.2009 Bulletin 2009/10

(51) Int Cl.:
F04C 18/16 ^(2006.01) **F04C 28/12** ^(2006.01)

(21) Application number: **08014771.3**

(22) Date of filing: **20.08.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(72) Inventors:
• **Yonemoto, Ryuichiro**
Shizuoka-shi
Shizuoka (JP)
• **Iizuka, Yasuaki**
Shizuoka-shi
Shizuoka (JP)
• **Urashin, Masayuki**
Shizuoka-shi
Shizuoka (JP)

(30) Priority: **30.08.2007 JP 2007223471**

(71) Applicant: **Hitachi Appliances, Inc.**
Minato-ku
Tokyo (JP)

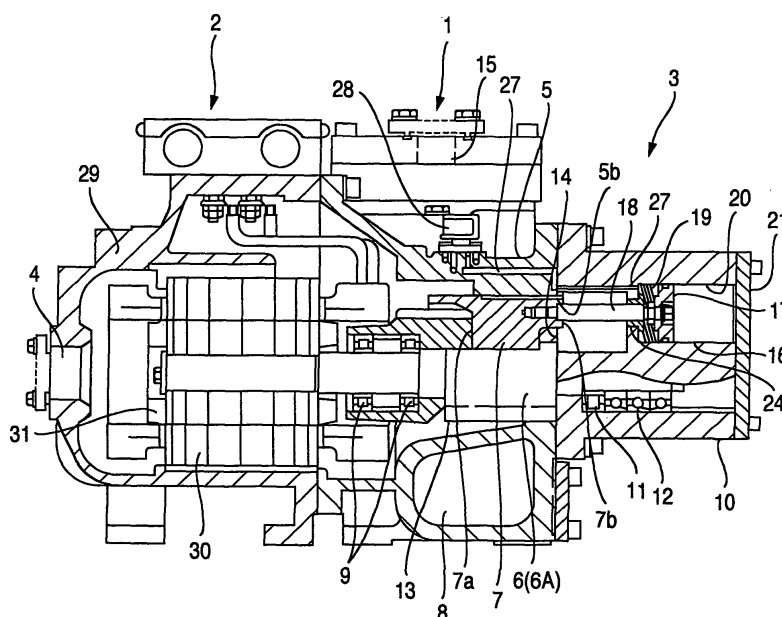
(74) Representative: **Beetz & Partner**
Patentanwälte
Steinsdorfstrasse 10
80538 München (DE)

(54) **Capacity control device for screw compressor**

(57) A capacity control device for a screw compressor comprising a capacity control valve (7), a piston rod (18) connected to the capacity control valve (7), a piston (17), and a cylinder (16) that guides the piston (17) slid-

ably, and wherein a guide body (24) for permitting and guiding inclined movements of the piston rod (18) is provided on that end wall (22) toward the piston rod (18), which forms the cylinder (16).

FIG.1



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a capacity control device for a screw compressor, and more particular, to a capacity control device for a screw compressor, in which capacity control is performed by a capacity control valve.

[0002] Conventional screw compressors include a capacity control device comprising a capacity control valve for controlling compressive capacity in response to a load. The capacity control device comprises a cylinder formed in a discharge casing, a piston provided in the cylinder and a piston rod extending through a rod hole formed in the discharge casing, which defines the cylinder, to be connected to a capacity control valve (see, for example, JP-A-62-58077).

[0003] In the above-described capacity control device for a screw compressor, in order to move the capacity control valve (slide valve) in response to a load on the screw compressor, pressure fluid is supplied to one side chamber or the other side chamber of the piston in the cylinder to operatively move the capacity control valve through a piston rod but a force toward a suction side from a discharge side and a force in a direction, in which the slide valve is rotated, act on the capacity control valve at all times in operation of the compressor. Due to such rotating force, the slide valve is inclined, and the piston rod connected to the slide valve and a rod hole for guiding the piston rod are brought into contact with each other.

[0004] Since movements of the piston rod become large in case of trying to enlarge the range of capacity control, a degree of contact of the piston rod with the rod hole is further increased.

[0005] As a result, when load-up and load-down are repeated in operation over a long term, abrasion goes on in the rod hole and so a gap between the rod hole and the piston rod becomes large. Therefore, there is caused a problem that pressure fluid supplied into the cylinder leaks from the gap, and so pressure in the cylinder cannot be maintained and cannot hold the capacity control valve in an appropriate position.

[0006] Also, in the case where internal pressure in the cylinder to operate the capacity control valve cannot be maintained as described above, it becomes necessary to exchange a compressor and exchange a discharge casing having a cylinder, thus causing a problem of an increase in the number of renewal parts and manhour for exchange.

SUMMARY OF THE INVENTION

[0007] The invention has been thought of in view of the matter described above and has its object to provide a capacity control device for a screw compressor, in which leakage of pressure fluid in a cylinder, which is resulted by inclination movement of a piston rod, can be

prevented.

[0008] In order to attain the object, according to a first aspect of the invention, there may be provided a capacity control device for a screw compressor comprising a capacity control valve, a piston rod connected to the capacity control valve, a piston and a cylinder that slidably guides the piston, and/or a guide body for permitting and guiding inclined movements of the piston rod is provided on an end wall of the cylinder, through which the piston rod extends.

[0009] In the capacity control device according to a first aspect of the invention, the guide body may comprise a tube portion having a hole for guiding the piston rod and threadedly fixed to a threaded hole in the cylinder end wall, and/or an O-ring is provided between an inner surface of the hole of the tube portion for guiding the piston rod and an outer peripheral surface of the piston rod.

[0010] Further, in the capacity control device according to a first aspect of the invention, the guide body may comprise a tube portion having a hole for guiding the piston rod and fitted into the hole of the cylinder end wall and a flange provided on one side of the tube portion and fixed to an inner surface side of the cylinder end wall, and/or an O-ring is provided between an inner surface of the hole of the tube portion for guiding the piston rod and an outer peripheral surface of the piston rod.

[0011] Also, in the capacity control device according to a first aspect of the invention, the guide body may comprise a tube portion having a hole for guiding the piston rod and press fitted into the hole of the cylinder end wall, and/or an O-ring is provided between an inner surface of the hole of the tube portion for guiding the piston rod and an outer peripheral surface of the piston rod.

[0012] Further, according to a second aspect of the invention, there is provided a capacity control device for a screw compressor comprising a capacity control valve, a piston rod connected to the capacity control valve, a piston, and a cylinder that slidably guides the piston, and/or a guide body for suppressing and guiding inclined movements of the piston rod is provided on an cylinder end wall of the cylinder, through which the piston rod extends.

[0013] Also, in the capacity control device according to a second aspect of the invention, the guide body may be formed from a material being high in hardness as compared with the cylinder end wall.

[0014] Further, in the capacity control device according to a second aspect of the invention, the guide body may be made high in hardness by means of heat treatment as compared with the cylinder end wall.

[0015] Also, in the capacity control device according to a second aspect of the invention, the guide body may comprise a tube portion having a hole for guiding the piston rod and threadedly fixed to a threaded hole of the cylinder end wall.

[0016] Further, in the capacity control device accord-

ing to a second aspect of the invention, the guide body may comprise a tube portion having a hole for guiding the piston rod and fitted into the hole of the cylinder end wall and a flange provided on one side of the tube portion and fixed to an inner surface side of the cylinder end wall.

[0017] Also, in the capacity control device according to a second aspect of the invention, the guide body may comprise a tube portion having a hole for guiding the piston rod and press fitted into the hole of the cylinder end wall.

[0018] According to the invention, since leakage of pressure fluid in a cylinder, which is caused by the inclined movement of the piston rod constituting a capacity control device, is restrained, pressure in the cylinder is surely maintained, so that the capacity control valve can be held in an appropriate position and heightened in control performance and is improved in reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a longitudinal, cross sectional, front view showing a screw compressor comprising an embodiment of a capacity control device, for a screw compressor, of the invention;

Fig. 2 is a longitudinal, cross sectional, front view showing, in enlarged view, the embodiment of the capacity control device, for a screw compressor, of the invention shown in Fig. 1;

Fig. 3 is a longitudinal, cross sectional, front view showing, in enlarged view, a guide body used in the embodiment of the capacity control device, for a screw compressor, of the invention shown in Fig. 1; Fig. 4 is a longitudinal, cross sectional, front view showing, in enlarged view, another embodiment of a capacity control device, for a screw compressor, of the invention; and

Fig. 5 is a longitudinal, cross sectional, front view showing, in enlarged view, a further embodiment of a capacity control device, for a screw compressor, of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Embodiments of a capacity control device, for a screw compressor, of the invention will be described hereinafter with reference to the drawings. Figs. 1 to 3 show an embodiment of a capacity control device, for a screw compressor, of the invention, Fig. 1 being a longitudinal, cross sectional, front view showing a screw compressor comprising an embodiment of a capacity control device, for a screw compressor, of the invention, Fig. 2 being a longitudinal, cross sectional, front view showing, in enlarged view, the embodiment of the capacity control device, for a screw compressor, of the invention shown in Fig. 1, and Fig. 3 is a longitudinal, cross sectional, front view showing, in enlarged view, a guide body used in the

embodiment of the capacity control device, for a screw compressor, of the invention shown in Fig. 1.

[0021] In addition, Fig. 1 shows an operation, in which a position of the capacity control valve is in a high load region and Fig. 2 shows an operation, in which a position of the capacity control valve is in a low load region.

[0022] In Fig. 1, a screw compressor generally comprises a compressor part 1, a motor part 2 provided on one side (on the left in Fig. 1) of the compressor part 1, and a discharge casing part 3 provided on the other side (on the right in Fig. 1) of the compressor part 1. Gas being compressed flows to the compressor part 1 through an interior of the motor part 2 from a suction inlet 4 provided on the motor part 2, is increased in pressure and then discharged outside the compressor through the discharge casing part 3.

[0023] The compressor part 1 includes a main casing 5, a screw rotor 6 received in the main casing 5, a capacity control valve (slide valve) 7 arranged above the screw rotor 6, an oil reservoir section 8 arranged below the screw rotor 6, and roller bearings 9 that support one side of the screw rotor 6. The discharge casing part 3 includes a discharge casing 10, a roller bearing 11 arranged in the discharge casing 10 to support the other side of the screw rotor 6, ball bearings 12, and a capacity control operating part (described later) that drives the capacity control valve 7 left and right in the figure.

[0024] The main casing 5 in the compressor part 1 is formed with a suction port 13, a discharge port 14, a discharge outlet 15, etc. The suction port 13 and the suction inlet 4 define a suction flow passage to the screw rotor 6. The discharge port 14 defines a discharge flow passage from the screw rotor 6.

[0025] The screw rotor 6 comprises a pair of a male rotor 6A and a female rotor (not shown), which mesh with each other, and is received in a pair of cylindrical-shaped bores (not shown). Spindle portions provided on both sides of the male rotor 6A are supported by the roller bearings 9 mounted in the main casing 5 and the roller bearing 11 and the ball bearings 12, which are mounted in the discharge casing 10.

[0026] The capacity control valve 7 serves to bypass a part of sucked refrigerant gas sucked into a meshing portion of the screw rotor 6 to perform capacity control and is received movably in a recess 5b provided in the main casing 5.

[0027] The capacity control operating part that drives the capacity control valve 7 left and right in the figure includes, as shown in Figs. 1 and 2, a cylinder 16, a piston 17 provided slidably in the cylinder 16, a piston rod 18 having one end thereof fixed to the piston 17 and having the other end thereof connected to the capacity control valve 7, and a coil spring 19 provided in a chamber of the cylinder 16 toward the piston rod 18 to generate a force for pushing the piston 17 rightward in Fig. 2. The cylinder 16 includes a cylinder hole 20 formed in the discharge casing 10, an end cover 21 that closes one side (on the right in Figs. 1 and 2) of the cylinder hole 20, and

a cylinder end wall 22 formed on the discharge casing 10 to close the other side (on the left in Figs. 1 and 2) of the cylinder hole 20.

[0028] That portion of the cylinder end wall 22, through which the piston rod 18 extends, is provided with a threaded hole 23. A guide body 24 of the piston rod 18 shown in Fig. 3 is threaded into and fixed to the threaded hole 23. The guide body 24 is provided with a tube portion 24B, which has a hole 24A for guiding the piston rod 18, a flange portion 24C provided on one side of the tube portion 24B and threads 24D provided on an outer periphery of the tube portion 24B and threaded into the threaded hole 23 of the cylinder end wall 22. Also, an engagement groove 24E for a screwing tool is provided on an outer peripheral surface of the flange portion 24C, and the guide body 24 includes an O-ring groove 24F provided on an inner surface of the hole 24A for guiding the piston rod 18 to receive an O-ring 25 that comes into sliding contact with an outer peripheral surface of the piston rod 18, and an O-ring groove 24G provided on an end surface of the flange portion 24C opposed to an inner surface of the cylinder end wall 22 to receive an O-ring 26 that abuts against the inner surface of the cylinder end wall 22.

[0029] Referring again to Fig. 1, a fluid supply passage 27 communicated with a piston-rod side chamber of the cylinder 16 is provided in the main casing 5 and the discharge casing 10. The fluid supply passage 27 permits a high-pressure fluid from the oil reservoir section 8 to flow into and out of the cylinder 16. An electromagnetic valve 28 is provided midway the fluid supply passage 27. The electromagnetic valve 28 opens and closes to control flow of oil to the cylinder 16 to move the piston 17 left and right in Fig. 1. Thereby, the capacity control valve 7 is positionally controlled and capacity control is performed.

[0030] The motor part 2 comprises a motor casing 29, a motor stator 30, a motor rotor 31, etc. The motor part 2 is structured to transmit its driving force to the male rotor 6A of the compressor part 1. The motor stator 30 and the motor rotor 31 constitute a driving motor. The motor stator 30 is mounted to the motor casing 29 and the motor rotor 31 is fixed to a spindle portion formed on one side of the male rotor 6A within the motor stator 30. With such construction, the driving force of the driving motor is transmitted to the male rotor 6A. In addition, the female rotor is driven by the male rotor 6A.

[0031] Subsequently, an embodiment of a capacity control device, for a screw compressor, of the invention will be described with reference to Figs. 1 to 3.

[0032] The capacity control valve 7 and the capacity control operating part constitute a capacity control mechanism, of which capacity control uses the electromagnetic valve 28 to control flow of high-pressure fluid supplied through the fluid supply passage 27 to the cylinder 16 from the oil reservoir section 8 to move the piston 17 left and right in Fig. 1. Thereby, the capacity control valve 7 is positionally controlled so as to enable operation under

an appropriate load in response to an operating state to perform capacity control.

[0033] In a low load region, since fluid pressure in a chamber of the cylinder 16 toward the end cover 21 (on the right in Fig. 1) is always low in pressure, the capacity control valve 7 is moved toward the end cover 21 (on the right in Fig. 1) by increasing fluid pressure in a chamber of the cylinder 16 toward the coil spring 19 (toward the piston rod 18) to move the piston 17 toward the end cover 21. Also, in a high load region, fluid pressure in the cylinder 16 toward the coil spring 19 (toward the piston rod 18) is reduced, so that a pressure difference between low pressure acting on an end wall 7a of the capacity control valve 7 toward the motor part 2 and high pressure acting on an end wall 7b toward the piston rod 18 causes the capacity control valve 7 to move toward the motor part 2 (on the left in Fig. 1).

[0034] In the capacity control described above, a force toward the suction side from the discharge side and a force in a direction, in which the capacity control valve 7 is rotated, act on the capacity control valve 7 at all times but the capacity control valve 7 repeats load-up and load-down in a state of being inclined due to the rotating force. Therefore, while the piston rod 18 connected to the capacity control valve 7 is inclined in the same manner, inclination of the piston rod 18 is allowed by the O-ring 25 provided inside the hole 24A of the guide body 24. Also, the O-ring 25 restricts leakage of pressure fluid supplied to the chamber of the cylinder 16 toward the piston rod.

[0035] As a result, pressure in the cylinder 16 is surely maintained, so that the capacity control valve 7 can be held in an appropriate position and heightened in control performance and is improved in reliability. Also, in the embodiment of the invention, in the case where the O-ring 25 undergoes aging, the guide body 24 is removed from the cylinder end wall 22 whereby exchange of the O-ring 25 is facilitated and a short period of time is sufficient for the work of exchange.

[0036] Also, in a try of making the range of capacity control large, a degree of contact of the piston rod with the rod hole is further increased since movements of the piston rod become large, but such disadvantage can be accommodated for, so that it is possible to enlarge the range of capacity control of the screw compressor, thus enabling making its use various.

[0037] Fig. 4 is a longitudinal, cross sectional, front view showing another embodiment of a capacity control device, for a screw compressor, of the invention, Fig. 4 showing a position of a capacity control valve in operation in a low load region in the same manner as in Fig. 2. Also, since the same reference numerals as those shown in Figs. 2 and 3 denote the same parts as those in the latter or parts corresponding to those in the latter, a detailed explanation therefor is omitted.

[0038] In this embodiment, a guide body 24 comprises a tube portion 24B having a hole 24A for guiding a piston rod 18 and a flange portion 24C provided on one side of

the tube portion 24B. The guide body 24 is provided detachably on an inner side of a cylinder end wall 22 by inserting the tube portion 24B into a hole 32 of the cylinder end wall 22 and fixing the flange portion 24C to the inner side of the cylinder end wall 22 by means of bolts 33.

[0039] In the same manner as the previous embodiment, an O-ring 25 that comes into sliding contact with an outer peripheral surface of the piston rod 18 is provided on an inner surface of the hole 24A for guiding the piston rod 18, and an O-ring 26 that abuts against an inner surface of the cylinder end wall 22 is provided on an end surface of a flange portion 24C opposed to an inner surface of the cylinder end wall 22.

[0040] According to the embodiment, pressure in a cylinder 16 is surely maintained, so that a capacity control valve 7 can be held in an appropriate position and heightened in control performance and is improved in reliability. Also, in the case where the O-ring 25 undergoes aging, exchange of the O-ring 25 is facilitated by removing the guide body 24 from the cylinder end wall 22 and a short period of time is sufficient for the work of exchange. Also, since movements of the piston rod become large in case of trying to enlarge the range of capacity control, a degree of contact of the piston rod with the rod hole is further increased but such disadvantage can be accommodated for, so that it is possible to enlarge the range of capacity control of the screw compressor, thus enabling making its use various.

[0041] Fig. 5 is a longitudinal, cross sectional, front view showing a further embodiment of a capacity control device, for a screw compressor, of the invention, Fig. 5 showing a position of a capacity control valve in operation in a low load region in the same manner as in Fig. 2. Also, since the same reference numerals as those shown in Figs. 2 and 3 denote the same parts as those in the latter or parts corresponding to those in the latter, a detailed explanation therefor is omitted.

[0042] In this embodiment, a guide body 24 comprises a tube portion 24B having a hole 24A for guiding a piston rod 18 and a flange portion 24C provided on one side of the tube portion 24B. The guide body 24 is provided on an inner surface of a cylinder end wall 22 with the tube portion 24B thereof press fitted into a hole 32 of the cylinder end wall 22.

[0043] An O-ring 25 that comes into sliding contact with an outer peripheral surface of the piston rod 18 is provided on an inner surface of the hole 24A of the guide body 24 for guiding the piston rod 18, and an O-ring 26 that abuts against an inner surface of the cylinder end wall 22 is provided on an end surface of a flange portion 24C opposed to an inner surface of the cylinder end wall 22.

[0044] According to the embodiment, pressure in a cylinder 16 is surely maintained in the same manner as in the previous embodiments, so that a capacity control valve 7 can be held in an appropriate position and heightened in control performance and is improved in reliability. Also, in the case where the O-ring 25 undergoes aging,

exchange of the O-ring 25 is facilitated by removing the guide body 24 from the cylinder end wall 22 and a short period of time is sufficient for the work of exchange. Further, parts, such as bolts, etc., to fix the guide body 24 to the cylinder end wall 22 are dispensed with, thus enabling reducing parts cost.

[0045] In addition, while the O-ring 25 that comes into sliding contact with the outer peripheral surface of the piston rod 18 is provided on the inner surface of the hole 24A of the guide body 24 for guiding the piston rod 18 in the embodiments, a construction, in which the O-ring 25 is omitted, is possible. That is, the guide body 24 can be formed from a material being higher in hardness than that of the discharge casing 10 and can be formed to be made higher in hardness than a material of the discharge casing 10 by means of heat treatment, and the guide body 24 thus formed can be also fixed to the cylinder end wall 22 by the same means as that in the embodiments described above.

[0046] In addition, in this case, by setting fit dimensions so as to make fitting of the hole 32 of the cylinder end wall 22 and the piston rod 18 close tight, leakage of pressure fluid can be made minimum and pressure in the cylinder 16 can be maintained.

[0047] According to the embodiment, a further simple construction makes it possible to heighten a screw compressor in abrasion resistance and in reliability and to limit the number of renewal parts and manhour for exchange to a minimum, thus enabling rapidly restoring the capacity control function.

Claims

1. A capacity control device for a screw compressor comprising a capacity control valve (7), a piston rod (18) connected to the capacity control valve (7), a piston (17), and a cylinder (16) that guides the piston (17) slidably, and wherein a guide body (24) for permitting and guiding inclined movements of the piston rod (18) is provided on an cylinder end wall (22) of the cylinder (16), through which the piston rod (18) extends.
2. The capacity control device, for a screw compressor, according to claim 1, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and threadedly fixed to a threaded hole (23) of the cylinder end wall (22), and an O-ring (25) is provided between an inner surface of the hole (24A) of the tube portion (24B) for guiding the piston rod (18) and an outer peripheral surface of the piston rod (18).
3. The capacity control device, for a screw compressor, according to claim 1 or 2, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and fitted into a

- hole of the cylinder end wall (22) and a flange (24C) provided on one side of the tube portion (24B) and fixed to an inner surface side of the cylinder end wall (22), and an O-ring (25) is provided between an inner surface of the hole (24A) of the tube portion (24B) for guiding the piston rod (18) and an outer peripheral surface of the piston rod (18).
4. The capacity control device, for a screw compressor, according to at least one of claims 1 to 3, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and press fitted into a hole of the cylinder end wall (22), and an O-ring (25) is provided between an inner surface of the hole (24A) of the tube portion (24B) for guiding the piston rod (18) and an outer peripheral surface of the piston rod (18).
 5. A capacity control device for a screw compressor comprising a capacity control valve (7), a piston rod (18) connected to the capacity control valve (7), a piston (17) therefor, and a cylinder (16) that guides the piston (17) slidably, and wherein a guide body (24) for suppressing and guiding inclined movements of the piston rod (18) is provided on an cylinder end wall (22) of the cylinder (16), through which the piston rod (18) extends.
 6. The capacity control device, for a screw compressor, according to claim 5, wherein the guide body (24) is formed from a material being high in hardness as compared with the cylinder end wall (22).
 7. The capacity control device, for a screw compressor, according to claim 5 or 6, wherein the guide body (24) is made high in hardness by means of heat treatment as compared with the cylinder end wall (22).
 8. The capacity control device, for a screw compressor, according to at least one of claims 5 to 7, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and threadedly fixed to a threaded hole (23) of the cylinder end wall (22).
 9. The capacity control device, for a screw compressor, according to at least one of claims 5 to 8, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and threadedly fixed to a threaded hole (23) of the cylinder end wall (22).
 10. The capacity control device, for a screw compressor, according to at least one of claims 5 to 9, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and fitted into a hole of the cylinder end wall (22) and a flange (24C) provided on one side of the tube portion (24B) and fixed to an inner surface side of the cylinder end wall (22).
 11. The capacity control device, for a screw compressor, according to at least one of claims 5 to 10, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and fitted into a hole of the cylinder end wall (22) and a flange (24C) provided on one side of the tube portion (24B) and fixed to an inner surface side of the cylinder end wall (22).
 12. The capacity control device, for a screw compressor, according to at least one of claims 5 to 11, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and press fitted into a hole of the cylinder end wall (22).
 13. The capacity control device, for a screw compressor, according to at least one of claims 5 to 12, wherein the guide body (24) comprises a tube portion (24B) having a hole (24A) for guiding the piston rod (18) and press fitted into a hole of the cylinder end wall (22).

FIG.1

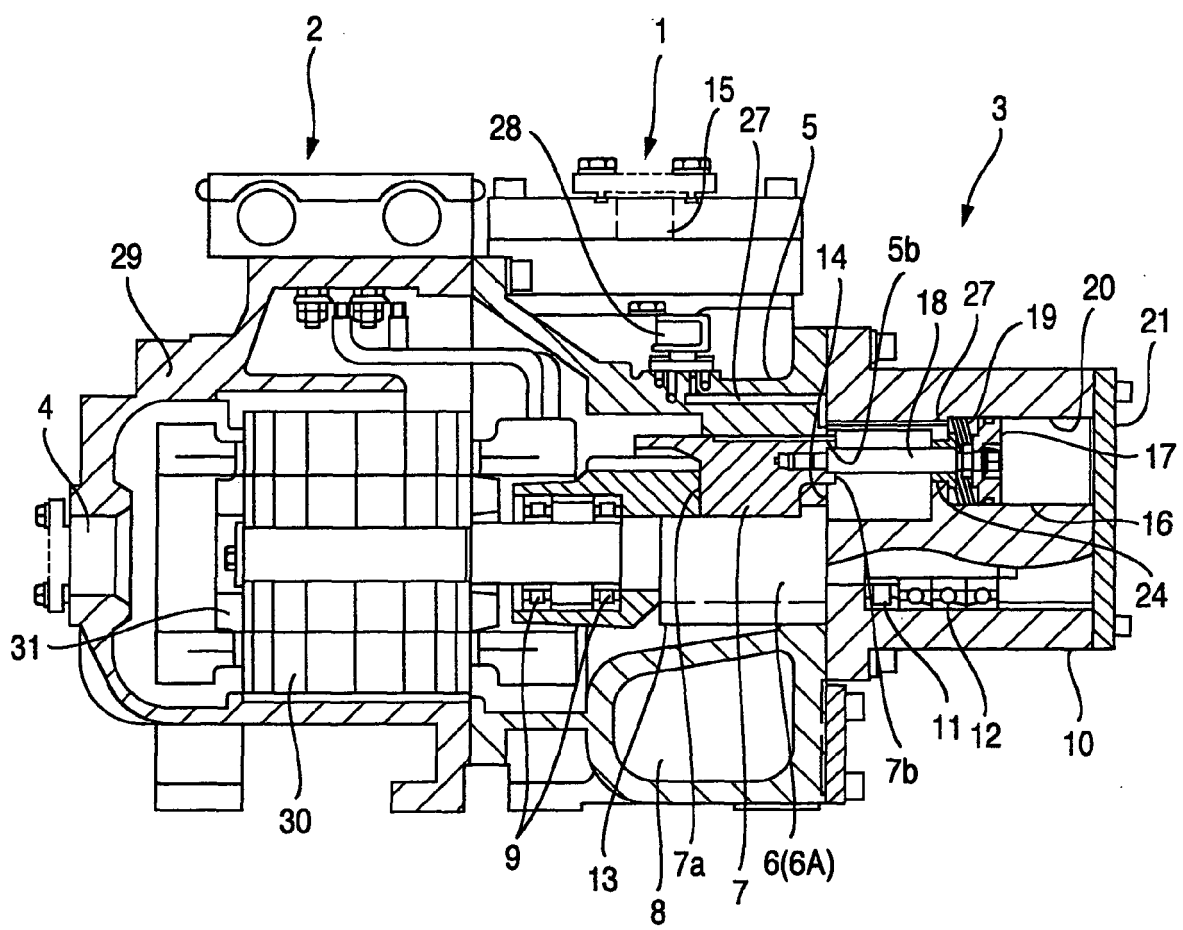


FIG.2

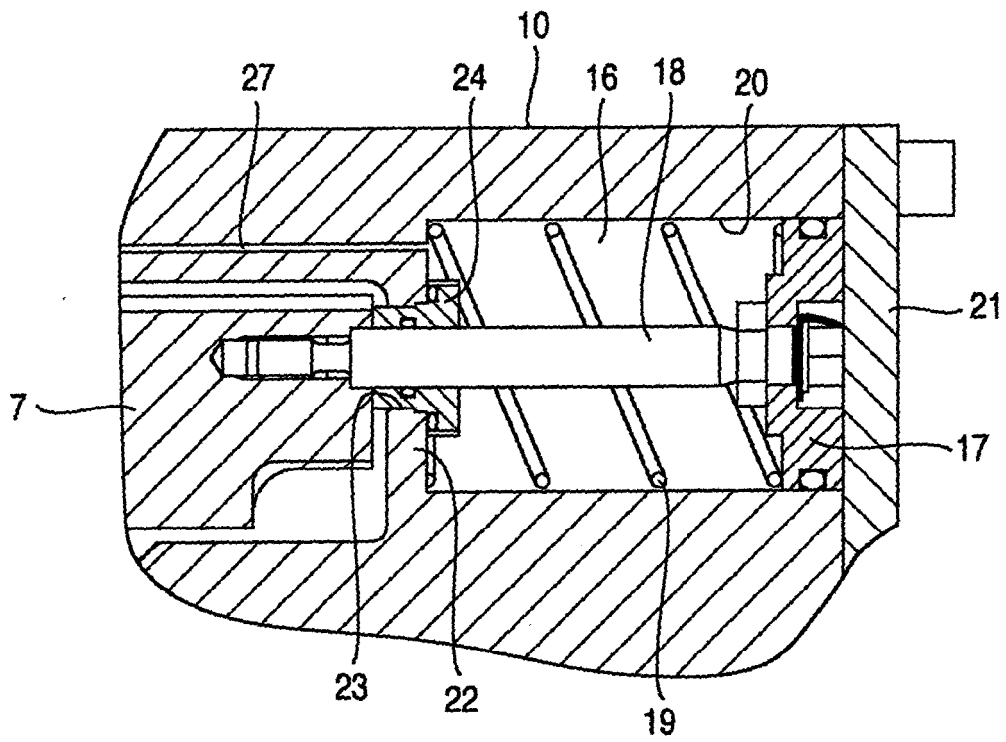


FIG.3

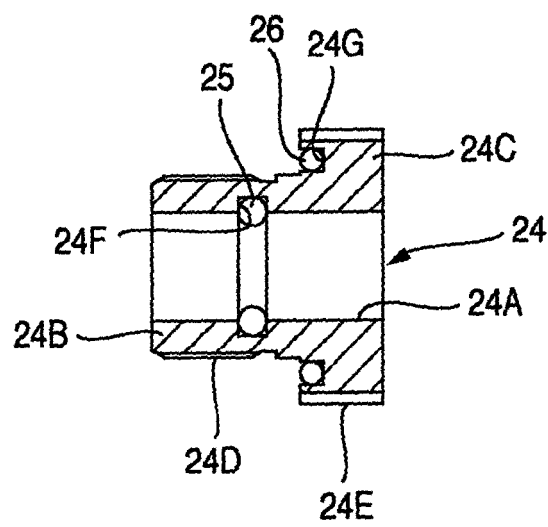


FIG.4

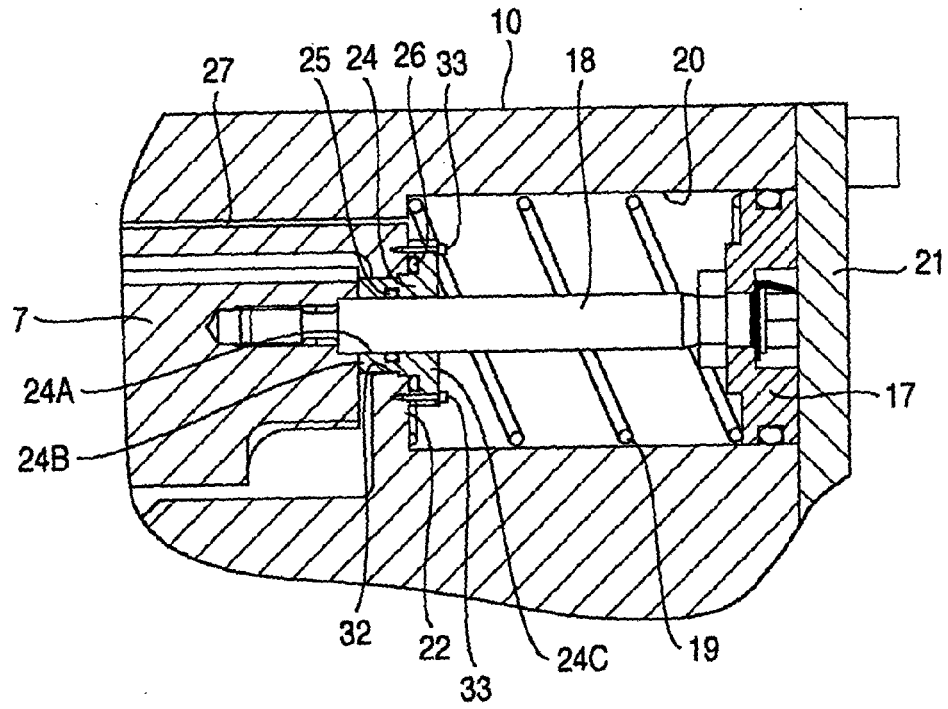
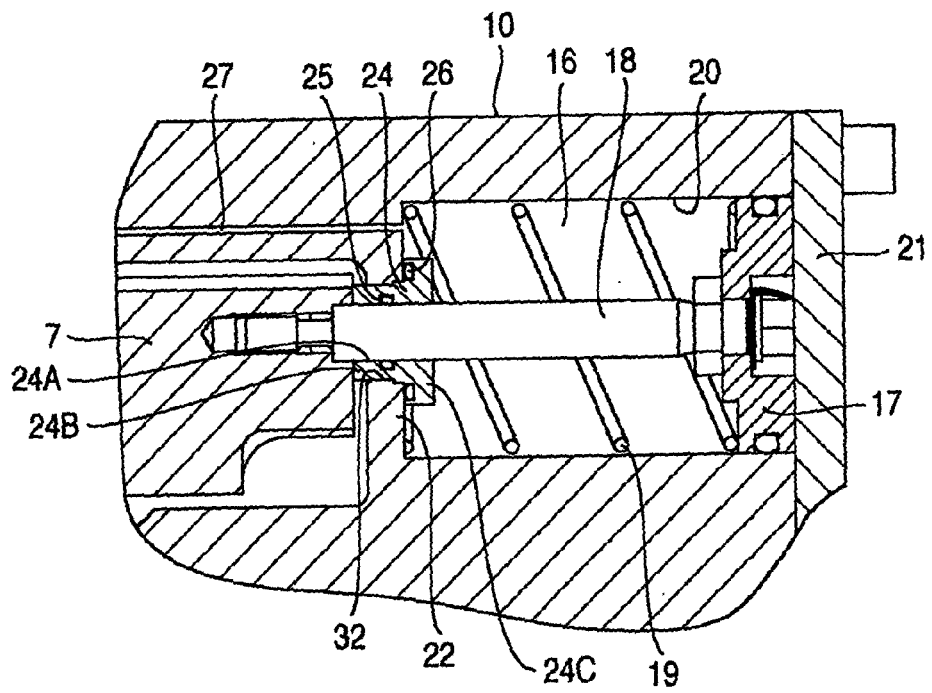


FIG.5



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 62058077 A [0002]