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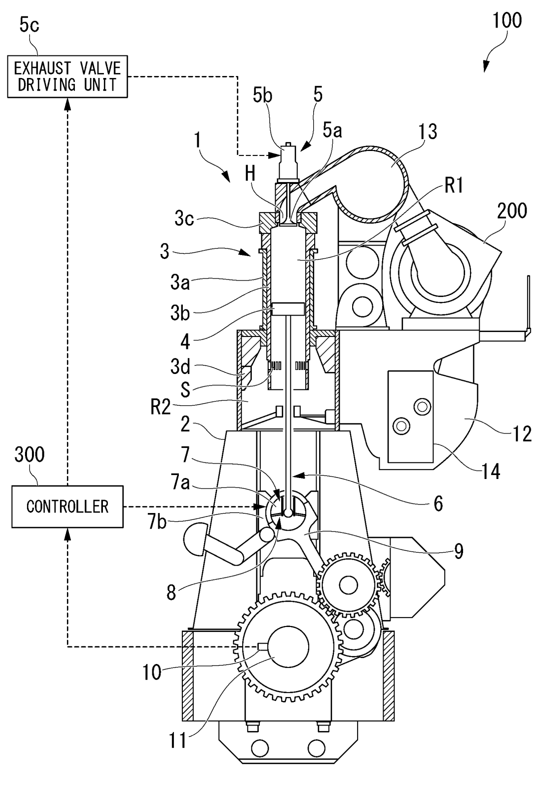
(54) VARIABLE COMPRESSION DEVICE AND ENGINE SYSTEM

(57) A variable compression device includes a piston rod (6), a connection member (7a) which is connected to the piston rod, a fluid chamber (R3) which is provided between the connection member and the piston rod and is configured to move the piston rod, in a direction in which a compression ratio is increased, with respect to the connection member by supplying a boosted working fluid thereto, and a regulation member (15) which is capable of abutting and being separated from the piston rod, and when the piston rod is moved in a direction in which a compression ratio is increased, abuts the piston rod to regulate movement of the piston rod such that a compression ratio is maintained

FIG. 1



EP 3 674 528 A1

Description

Technical Field

[0001] The present disclosure relates to a variable compression device and an engine system.

[0002] Priority is claimed on Japanese Patent Application No. 2017-159610, filed on August 22, 2017, the content of which is incorporated herein by reference.

Background Art

[0003] For example, Patent Document 1 discloses a large reciprocating piston combustion engine including a crosshead. The large reciprocating piston combustion engine disclosed in Patent Document 1 is a dual fuel engine that can be operated using both a liquid fuel such as heavy oil and a gaseous fuel such as natural gas. In the large reciprocating piston combustion engine disclosed in Patent Document 1, in order to cope with both a compression ratio suitable for operation using the liquid fuel and a compression ratio suitable for operation using the gaseous fuel, an adjustment mechanism capable of changing a compression ratio is provided in a crosshead portion.

Document of Related Art

Patent Document

[0004] [Patent Document 1] Japanese Unexamined Patent Application, First Publication No. 2014-20375

Summary of Invention

Technical Problem

[0005] The adjustment mechanism disclosed in Patent Document 1 increases a compression ratio by lifting a piston rod in a direction in which a compression ratio is increased by a hydraulic chamber provided in a crosshead. However, when the piston rod is lifted using oil pressure, a combustion pressure transmitted from a combustion chamber is applied to hydraulic oil, and thus the hydraulic oil is elastically compressed, which results in an instantaneous decrease in a compression ratio for each cycle. In addition, when a pressure in the combustion chamber does not increase at the time of lowering the piston rod in a direction in which a compression ratio is decreased, there is a possibility that a compression ratio will increase unintentionally due to an inertia force of the piston rod. Due to such unintended fluctuations in a compression ratio during a high compression operation, there is a possibility that the engine performance may deteriorate or the performance of a sealing member in the piston rod may deteriorate.

[0006] The present disclosure is made in consideration of the above-described circumstances, and an object thereof is to prevent an unintended change in compression ratio and maintain a compression ratio.

Solution to Problem

[0007] A variable compression device according to an aspect of the present disclosure is configured to change a compression ratio in a combustion chamber of an engine, and includes: a piston rod; a connection member which is connected to the piston rod; a fluid chamber which is provided between the connection member and the piston rod and is configured to move the piston rod, in a direction in which a compression ratio is increased, with respect to the connection member by supplying a boosted working fluid thereto; and a regulation member which is capable of abutting and being separated from the piston rod, and when the piston rod is moved in a direction in which a compression ratio is increased, abuts the piston rod to regulate movement of the piston rod such that a compression ratio is maintained.

[0008] In the variable compression device according to the aspect, the regulation member may include a regulation pin which is capable of being moved, toward the piston rod, in an intersection direction intersecting an extension direction of the piston rod, and the piston rod may include a concave portion into which the regulation pin is capable of being inserted.

[0009] In the variable compression device according to the aspect, the regulation member may include a supporting portion which is capable of being moved in an extension direction of the piston rod and is configured to support the piston rod from below.

[0010] In the variable compression device according to the aspect, the piston rod may include an opening into which the regulation member is capable of being inserted, and the regulation member may include a supporting portion which is inserted into the opening of the piston rod and is configured to hang and support the piston rod from above.

[0011] An engine system according to another aspect of the present disclosure includes the variable compression device according to the aspect of the present disclosure.

Effects of Invention

[0012] According to the present disclosure, when the piston rod is moved in a direction in which a compression ratio is increased, a regulation member regulates the movement of a piston rod while abutting the piston rod. Thereby, when a working fluid in a fluid chamber is elastically compressed due to a combustion pressure or in a case where a pressure in a combustion chamber does not increase, it is possible to regulate the movement of the piston rod, prevent a decrease or increase in a compression ratio, and maintain a compression ratio.

Brief Description of Drawings

[0013]

Fig. 1 is a cross-sectional view of an engine system in an embodiment of the present disclosure.
Fig. 2 is a partial cross-sectional view of the engine system in the embodiment of the present disclosure.
Fig. 3 is a partial cross-sectional view showing a portion of a variable compression device in the embodiment of the present disclosure.
Fig. 4 is a partial cross-sectional view showing a modification example of the variable compression device in the embodiment of the present disclosure.
Fig. 5 is a partial cross-sectional view showing a modification example of the variable compression device in the embodiment of the present disclosure.
Fig. 6 is a partial cross-sectional view showing a modification example of the variable compression device in the embodiment of the present disclosure.

Description of Embodiments

[0014] Hereinafter, an embodiment of an engine system 100 in the present disclosure will be described with reference to the accompanying drawings.

[0015] The engine system 100 of the present embodiment is mounted in a ship such as a large tanker, and includes an engine 1, a supercharger 200, and a controller 300 as shown in Fig. 1. Meanwhile, in the present embodiment, description will be given by regarding the supercharger 200 as an auxiliary device and providing the supercharger 200 as a separate body from the engine 1 (main device). However, the supercharger 200 may be configured as a part of the engine 1.

[0016] The engine 1 is a multi-cylinder uniflow scavenging diesel engine. The engine 1 has a gas operation mode in which a gaseous fuel such as natural gas is burned together with a liquid fuel such as heavy oil, and a diesel operation mode in which a liquid fuel such as heavy oil is burned. Meanwhile, in the gas operation mode, only a gaseous fuel may be burned. The engine 1 includes a frame 2, a cylinder portion 3, a piston 4, an exhaust valve unit 5, a piston rod 6, a crosshead 7, a hydraulic portion 8, a connecting rod 9, a crank angle sensor 10, a crank shaft 11, a scavenging reservoir 12, an exhaust reservoir 13, an air cooler 14, and a movement regulation unit 15 (regulation member) as shown in Figs. 1 and 2. In addition, a cylinder is constituted by the cylinder portion 3, the piston 4, the exhaust valve unit 5, and the piston rod 6.

[0017] The frame 2 is a strength member that supports the entire engine 1, and accommodates the crosshead 7, the hydraulic portion 8, and the connecting rod 9 therein. In addition, a crosshead pin 7a to be described later of the crosshead 7 can be reciprocated inside the frame 2.

[0018] The cylinder portion 3 includes a cylindrical cylinder cover 3a, a cylinder liner 3b, a cylinder head 3c, and a cylinder jacket 3d. The cylinder liner 3b is a cylindrical member which is accommodated in the cylinder cover 3a. A sliding surface with respect to the piston 4 is formed on the inner side (inner circumferential surface) of the cylinder liner 3b. A space surrounded by the inner circumferential surface of the cylinder liner 3b and the piston 4 serves as a combustion chamber R1. In addition, a plurality of scavenging ports S are formed in a lower portion of the cylinder liner 3b. The scavenging ports S are openings which are arranged along the circumferential surface of the cylinder liner 3b and make a scavenging chamber R2 inside the cylinder jacket 3d and the inner side of the cylinder liner 3b communicate with each other. The cylinder head 3c is a lid member provided in an upper end portion of the cylinder cover 3a. An exhaust port H is formed in the central portion of the cylinder head 3c when seen in a plan view, and is connected to the exhaust reservoir 13. In addition, a fuel injection valve (not shown) is provided in the cylinder head 3c. The cylinder jacket 3d is a cylindrical member which is provided between the frame 2 and the cylinder cover 3a and into which a lower end portion of the cylinder liner 3b is inserted. The scavenging chamber R2 is formed inside the cylinder jacket 3d. In addition, the scavenging chamber R2 of the cylinder jacket 3d is connected to the scavenging reservoir 12.

[0019] The piston 4 having a substantially columnar shape is connected to the piston rod 6 to be described later and is disposed on the inner side of the cylinder liner 3b. In addition, a piston ring (not shown) is provided on the outer circumferential surface of the piston 4, and a gap between the piston 4 and the cylinder liner 3b is sealed by the piston ring. The piston 4 slides inside the cylinder liner 3b together with the piston rod 6 due to a fluctuation in pressure in the combustion chamber R1.

[0020] The exhaust valve unit 5 includes an exhaust valve 5a, an exhaust valve casing 5b, and an exhaust valve driving unit 5c. The exhaust valve 5a is provided on the inner side of the cylinder head 3c and closes the exhaust port H in the cylinder portion 3 by the exhaust valve driving unit 5c. The exhaust valve casing 5b is a cylindrical housing that accommodates an end portion of the exhaust valve 5a. The exhaust valve driving unit 5c is an actuator that moves the exhaust valve 5a in a direction parallel to a stroke direction of the piston 4.

[0021] The piston rod 6 is an elongate member having one end connected to the piston 4 and the other end coupled to the crosshead pin 7a. An end portion of the piston rod 6 is inserted into the crosshead pin 7a, and the connecting rod 9 is rotatably coupled to the crosshead pin 7a. A portion of the end portion of the piston rod 6 on the crosshead pin 7a side has a large diameter portion formed to have a large diameter. Further, a sealing member is provided on the outer circumference of a portion of the piston rod 6 disposed inside a hydraulic chamber R3 to be described later.

[0022] The crosshead 7 includes the crosshead pin 7a (connection member), a guide shoe 7b, and a lid member 7c. The crosshead pin 7a is a columnar shape member that movably couples the piston rod 6 and the connecting rod 9 to each other. The hydraulic chamber R3 (fluid chamber) to and from which hydraulic oil (working fluid) is supplied and discharged is formed in an insertion space of the crosshead pin 7a where the end portion of the piston rod 6 is inserted. An outlet hole O penetrating the crosshead pin 7a in the axial direction of the crosshead pin 7a is formed on a side lower than the center of the crosshead pin 7a. The outlet hole O is an opening through which cooling oil having passed through a cooling flow passage (not shown) of the piston rod 6 is discharged. In addition, the crosshead pin 7a is provided with a supply flow passage R4 that connects the hydraulic chamber R3 and a plunger pump 8c to be described later to each other, and a relief flow passage R5 that connects the hydraulic chamber R3 and a relief valve 8f to be described later to each other. Further, in the crosshead 7, an auxiliary flow passage R6 that makes the crosshead pin 7a and the lid member 7c communicate with each other and opens on the circumferential surface of the lid member 7c and the circumferential surface of the crosshead pin 7a is formed.

[0023] The guide shoe 7b rotatably supports the crosshead pin 7a. The guide shoe 7b moves, on a guide rail (not shown), in the stroke direction of the piston 4 in association with the crosshead pin 7a. The guide shoe 7b moves along the guide rail, so that the crosshead pin 7a is regulated with respect to movement other than a rotational motion and movement in a linear direction parallel to the stroke direction of the piston 4. The lid member 7c is an annular member which is fixed to an upper portion of the crosshead pin 7a and into which the end portion of the piston rod 6 is inserted. The crosshead 7 transmits a linear motion of the piston 4 to the connecting rod 9.

[0024] As shown in Fig. 2, the hydraulic portion 8 includes a supply pump 8a, an oscillating pipe 8b, the plunger pump 8c, a first check valve 8d and a second check valve 8e included in the plunger pump 8c, and the relief valve 8f. In addition, the piston rod 6, the crosshead 7, the hydraulic portion 8, the movement regulation unit 15, and the controller 300 function as a variable compression device in the present disclosure. Further, the supply pump 8a, the oscillating pipe 8b, the plunger pump 8c, the first check valve 8d, and the second check valve 8e are equivalent to a boosted fluid supply unit in the present disclosure.

[0025] The supply pump 8a boosts hydraulic oil supplied from a hydraulic oil tank (not shown) and supplies the boosted hydraulic oil to the plunger pump 8c on the basis of an instruction received from the controller 300. The supply pump 8a is driven using power of a battery of the ship and can be operated before a liquid fuel is supplied to the combustion chamber R1. The oscillating pipe 8b connects the supply pump 8a and the plunger pump 8c of each cylinder to each other. The oscillating pipe 8b is slidable between the plunger pump 8c moving in association with the crosshead pin 7a and the fixed supply pump 8a.

[0026] The plunger pump 8c is fixed to the crosshead pin 7a. The plunger pump 8c includes a rod-shaped plunger 8c1, a tubular cylinder 8c2 that slidably accommodates the plunger 8c1, and a plunger driving unit 8c3. In the plunger pump 8c, the plunger 8c1 slides inside the cylinder 8c2 by a driving unit (not shown) connected to the plunger 8c1, thereby boosting hydraulic oil and supplying the boosted hydraulic oil to the hydraulic chamber R3. In addition, the first check valve 8d is provided in an opening, on an ejection side of hydraulic oil, which is provided in an end portion of the cylinder 8c2, and the second check valve 8e is provided in an opening, on an injection side of hydraulic oil, which is provided on the side circumferential surface of the cylinder 8c2. The plunger driving unit 8c3 is connected to the plunger 8c1 and reciprocates the plunger 8c1 on the basis of an instruction received from the controller 300.

[0027] The first check valve 8d is configured to be closed by a valve body being biased toward the inner side of the cylinder 8c2 and prevents hydraulic oil supplied to the hydraulic chamber R3 from flowing backward to the cylinder 8c2. In addition, the first check valve 8d is opened by the valve body being pressed by hydraulic oil when the pressure of the hydraulic oil in the cylinder 8c2 becomes equal to or higher than a biasing force (valve-opening pressure) of a biasing member of the first check valve 8d. The second check valve 8e is biased toward the outer side of the cylinder 8c2 and prevents the hydraulic oil supplied to the cylinder 8c2 from flowing backward to the supply pump 8a. In addition, the second check valve 8e is opened by the valve body being pressed by hydraulic oil when the pressure of the hydraulic oil supplied from the supply pump 8a becomes equal to or higher than a biasing force (valve-opening pressure) of a biasing member of the second check valve 8e. Meanwhile, the valve-opening pressure of the first check valve 8d is higher than the valve-opening pressure of the second check valve 8e, and the first check valve 8d is not opened by the pressure of hydraulic oil supplied from the supply pump 8a in a normal operation state where the system is operated at a preset compression ratio.

[0028] The relief valve 8f is provided in the crosshead pin 7a. The relief valve 8f includes a main body portion 8f1 and a relief valve driving unit 8f2. The main body portion 8f1 is a valve which is connected to the hydraulic chamber R3 and the hydraulic oil tank (not shown). The relief valve driving unit 8f2 is connected to a valve body of the main body portion 8f1 and opens and closes the main body portion 8f1 on the basis of an instruction received from the controller 300. The relief valve 8f is opened by the relief valve driving unit 8f2, so that hydraulic oil stored in the hydraulic chamber R3 is returned to the hydraulic oil tank.

[0029] As shown in Fig. 1, the connecting rod 9 is an elongate member which is coupled to the crosshead pin 7a and coupled to the crank shaft 11. The connecting rod 9 converts a linear motion of the piston 4 which is transmitted to the crosshead pin 7a into a rotational motion.

The crank angle sensor 10 is a sensor for measuring a crank angle of the crank shaft 11, and transmits a crank pulse signal for calculating a crank angle to the controller 300.

[0030] The crank shaft 11, which is an elongate member which is connected to the connecting rod 9 provided in the cylinder, is rotated by rotational motions transmitted to the respective connecting rods 9 to transmit power to, for example, a screw or the like. The scavenging reservoir 12 is provided between the cylinder jacket 3d and the supercharger 200, and air pressurized by the supercharger 200 flows into the scavenging reservoir 12. In addition, the air cooler 14 is provided inside the scavenging reservoir 12. The exhaust reservoir 13 is a tubular member which is connected to the exhaust port H of each cylinder and connected to the supercharger 200. A gas discharged from the exhaust port H is temporarily stored in the exhaust reservoir 13 and is thus supplied to the supercharger 200 in a state where pulsation is suppressed. The air cooler 14 cools air inside the scavenging reservoir 12.

[0031] As shown in Fig. 3, the movement regulation unit 15 is provided in the crosshead pin 7a. The movement regulation unit 15 includes a driving unit 15a, a worm wheel portion 15b, and a worm 15c (supporting portion). The driving unit 15a is connected to the worm wheel portion 15b through a ratchet gear. The driving unit 15a rotates the worm wheel portion 15b centering on a rotation axis intersecting the stroke direction of the piston 4 on the basis of an instruction received from the controller 300. Meanwhile, the ratchet gear is provided with a switching mechanism for switching a rotation direction of the worm wheel portion 15b, and the rotation direction of the worm wheel portion 15b can be switched between a clockwise direction and a counterclockwise direction around the rotation axis. In addition, the switching mechanism is constituted by two locking members capable of being locked while abutting the teeth of the ratchet gear, and a cam for switching between abutting and non-abutting of each of the two locking members. The worm wheel portion 15b is rotated centering on the rotation axis by the driving unit 15a. Teeth engaging with the worm 15c are provided at an end portion of the worm wheel portion 15b on the hydraulic chamber R3 side. The worm 15c is a cylindrical member in which the piston rod 6 is disposed at the center thereof. Screw-shaped teeth are provided on the outer circumferential surface of the worm 15c. The worm 15c is accommodated on the bottom surface of the hydraulic chamber R3. The worm 15c is moved in a direction of a top dead center (a direction in which a compression ratio is increased) while engaging with the teeth of the worm wheel portion 15b. In a state where the worm 15 is moved in the direction of the top dead center, the worm 15c abuts the lower surface of the large diameter portion of the piston rod 6 and supports the piston rod 6 from below.

[0032] The supercharger 200 pressurizes air suctioned from an intake port (not shown) and supplies the pressurized air to the combustion chamber R1 by a turbine which is rotated by a gas discharged from the exhaust port H.

[0033] The controller 300 is a computer that controls the amount of fuel to be supplied, and the like on the basis of an operation of an operator of the ship, or the like. In addition, the controller 300 changes a compression ratio in the combustion chamber R1 by controlling the hydraulic portion 8. Specifically, the controller 300 controls the plunger pump 8c, the supply pump 8a, and the relief valve 8f to adjust the amount of hydraulic oil in the hydraulic chamber R3, thereby changing the position of the piston rod 6 to change a compression ratio. In addition, the controller 300 raises the worm 15c in the direction of the top dead center by controlling the driving unit 15a of the movement regulation unit 15.

[0034] The engine system 100 causes the piston 4 to slide within the cylinder liner 3b to rotate the crank shaft 11 by igniting and exploding fuel injected into the combustion chamber R1 from the fuel injection valve (not shown). In detail, the fuel supplied to the combustion chamber R1 is mixed with air flowing from the scavenging port S and is then compressed due to the movement of the piston 4 in the direction of the top dead center, which results in a rise in temperature and spontaneous ignition. Further, in the case of a liquid fuel, the liquid fuel is vaporized due to a rise in temperature in the combustion chamber R1 and is spontaneously ignited.

[0035] In addition, the fuel in the combustion chamber R1 is rapidly expanded by spontaneous ignition, and a pressure directed in a direction of a bottom dead center is applied to the piston 4. Thereby, the piston 4 moves in the direction of the bottom dead center, the piston rod 6 is moved in association with the piston 4, and the crank shaft 11 is rotated via the connecting rod 9. Further, the piston 4 is moved to the bottom dead center, so that pressurized air flows into the combustion chamber R1 from the scavenging port S. The exhaust port H is opened due to the exhaust valve unit 5 being driven, and an exhaust gas in the combustion chamber R1 is pushed out to the exhaust reservoir 13 by pressurized air.

[0036] In a case where a compression ratio is increased, the controller 300 drives the supply pump 8a to supply hydraulic oil to the plunger pump 8c. In addition, the controller 300 drives the plunger pump 8c to pressurize hydraulic oil to a pressure capable of lifting the piston rod 6, and supplies the pressurized hydraulic oil to the hydraulic chamber R3. The end portion of the piston rod 6 is lifted by the pressure of the hydraulic oil in the hydraulic chamber R3, and accordingly, the position of the top dead center of the piston 4 is moved upward (to the exhaust port H side). In addition, at the same time when the piston rod 6 is moved in a direction of a high compression ratio using the hydraulic oil, the controller 300 controls the driving unit 15a so that the worm 15c is raised until the worm 15c abuts the piston rod 6. Thereby, when the piston rod 6 is moved to a position of a high compression ratio, the worm 15c supports a portion of the load of the piston rod 6.

[0037] In a case where a compression ratio is decreased, the controller 300 drives the relief valve 8f to make the hydraulic chamber R3 and the hydraulic oil tank (not shown) communicate with each other. The load of the piston rod 6 is applied to the hydraulic oil in the hydraulic chamber R3, and the hydraulic oil in the hydraulic chamber R3 is pushed out to the hydraulic oil tank through the relief valve 8f. Thereby, the hydraulic oil of the hydraulic chamber R3 is reduced, and the piston rod 6 is moved downward (to the crank shaft 11 side), thereby moving the position of the top dead center of the piston 4 downward. In addition, at the same time when the piston rod 6 is moved in a direction of a low compression ratio using the hydraulic oil, the controller 300 controls the driving unit 15a so that the worm 15c is lowered until the worm 15c is separated from the piston rod 6 and is completely accommodated in the bottom portion of the hydraulic chamber R3.

[0038] According to the variable compression device in the present embodiment, the movement regulation unit 15 supports the piston rod 6 from below during an operation at a high compression ratio, and thus it is possible to regulate the movement of the piston rod 6 in a direction of a low compression ratio (downward), prevent an unintended decrease in a compression ratio, and maintain a compression ratio. Therefore, according to the variable compression device in the present embodiment, it is possible to prevent deterioration of the performance of the engine 1 and prevent deterioration of the performance of the sealing member provided in the piston rod 6.

[0039] While a preferred embodiment of the present disclosure has been described with reference to the accompanying drawings, the present disclosure is not limited to the embodiment. Shapes, combinations, and the like of the components described in the above-described embodiment are examples and can be modified in various ways on the basis of a request for changing the design without departing from the scope of the present disclosure.

[0040] As shown in Fig. 4, the movement regulation unit 15 may include the driving unit 15a, the worm wheel portion 15b, and a worm 15d (supporting portion). The worm 15d is a cylindrical member which is provided below the end portion of the piston rod 6 disposed below the hydraulic chamber R3. Similarly to the worm 15c of the embodiment, the worm 15d engages with the teeth of the worm wheel portion 15b to be capable of abutting and being separated from the piston rod 6. Also in the case of such a configuration, similarly to the embodiment, it is possible for the worm 15d to support the piston rod 6 from below to regulate the movement of the piston rod 6 in a direction of a low compression ratio (downward) and prevent a decrease in a compression ratio.

[0041] In addition, as shown in Fig. 5, the movement regulation unit 15 may include the driving unit 15a, a ratchet gear 15e, and a supporting rod 15f (a supporting portion, a regulation pin). Further, in this case, a groove 6a (concave portion) extending in a circumferential direction of the piston rod 6 is formed in the circumferential surface of the large diameter portion of the piston rod 6. The ratchet gear 15e is provided between the driving unit 15a and the supporting rod 15f and transmits the power of the driving unit 15a to the supporting rod 15f. A screw groove is formed in the circumferential surface of the supporting rod 15f. The supporting rod 15f is disposed such that, during a high compression operation, a tip end of the supporting rod 15f engages with the groove 6a of the piston rod 6. The supporting rod 15f is capable of being moved in a direction intersecting the stroke direction of the piston 4 by the driving unit 15a and is capable of abutting and being separated from the piston rod 6. In the case of such a configuration, the piston rod 6 is supported from the side by the supporting rod 15f, so that it is possible to regulate the movement of the piston rod 6 in a direction of a low compression ratio (downward) and a direction of a high compression ratio (upward) and prevent an unintended decrease or increase in a compression ratio.

[0042] In addition, as shown in Fig. 6, the movement regulation unit 15 may include the driving unit 15a, a ratchet gear 15g, a worm 15h, a worm wheel 15i, and a hanging rod 15j (supporting portion). Further, in this case, a screw hole is formed in an upper surface of the large diameter portion of the piston rod 6. The worm 15h is rotated by the ratchet gear 15g and transmits a rotational motion to the worm wheel 15i. The worm wheel 15i is provided between the lid member 7c and the piston rod 6. The hanging rod 15j is inserted into and fixed to the inner side of the worm wheel 15i. A screw groove is formed in the circumferential surface of the hanging rod 15j. The hanging rod 15j is disposed so that, during an operation at a high compression ratio, the screw groove of the hanging rod 15j is screwed into the screw hole of the piston rod 6. The hanging rod 15j is capable of being moved in the stroke direction of the piston 4 by the driving unit 15a so that the hanging rod 15j is capable of abutting and being separated from the piston rod 6. In the case of such a configuration, the piston rod 6 is supported from above by the hanging rod 15j, and thus it is possible to regulate the movement of the piston rod 6 in a direction of a low compression ratio (downward) and a direction of a high compression ratio (upward) and prevent a decrease in a compression ratio.

Industrial Applicability

[0043] According to the present disclosure, it is possible to prevent an unintended change in a compression ratio and maintain a compression ratio.

Description of Reference Signs

[0044]

1 Engine

2	Frame
3	Cylinder portion
3a	Cylinder cover
3b	Cylinder liner
3c	Cylinder head
3d	Cylinder jacket
4	Piston
5	Exhaust valve unit
5a	Exhaust valve
5b	Exhaust valve casing
5c	Exhaust valve driving unit
6	Piston rod
6a	Groove
7	Crosshead
7a	Crosshead pin (connection member)
7b	Guide shoe
7c	Lid member
8	Hydraulic portion
8a	Supply pump
8b	Oscillating pipe
8c	Plunger pump
8c1	Plunger
8c2	Cylinder
8c3	Plunger driving unit
8d	First check valve
8e	Second check valve
8f	Relief valve
8f1	Main body portion
8f2	Relief valve driving unit
8g	Boosting pump
9	Connecting rod
10	Crank angle sensor
11	Crank shaft
12	Scavenging reservoir
13	Exhaust reservoir
14	Air cooler
15	Movement regulation unit (regulation member)
15a	Driving unit
15b	Worm wheel portion
15c	Worm (supporting portion)
15d	Worm (supporting portion)
15e	Ratchet gear
15f	Supporting rod (supporting portion)
15g	Ratchet gear
15h	Worm
15i	Worm wheel
15j	Hanging rod (supporting portion)
100	Engine system
200	Supercharger
300	CONTROLLER
H	Exhaust port
O	Outlet hole
R1	Combustion chamber
R2	Scavenging chamber
R3	Hydraulic chamber (fluid chamber)
R4	Supply flow passage
R5	Relief flow passage
R6	Auxiliary flow passage
S	Scavenging port

Claims

1. A variable compression device that is configured to change a compression ratio in a combustion chamber of an engine, the variable compression device comprising:

   a piston rod;
   a connection member which is connected to the piston rod;
   a fluid chamber which is provided between the connection member and the piston rod and is configured to move the piston rod, in a direction in which a compression ratio is increased, with respect to the connection member by supplying a boosted working fluid thereto; and
   a regulation member which is capable of abutting and being separated from the piston rod, and when the piston rod is moved in a direction in which a compression ratio is increased, abuts the piston rod to regulate movement of the piston rod such that a compression ratio is maintained.

2. The variable compression device according to claim 1, wherein

   the regulation member includes a regulation pin which is capable of being moved, toward the piston rod, in an intersection direction intersecting an extension direction of the piston rod, and
   the piston rod includes a concave portion into which the regulation pin is capable of being inserted.

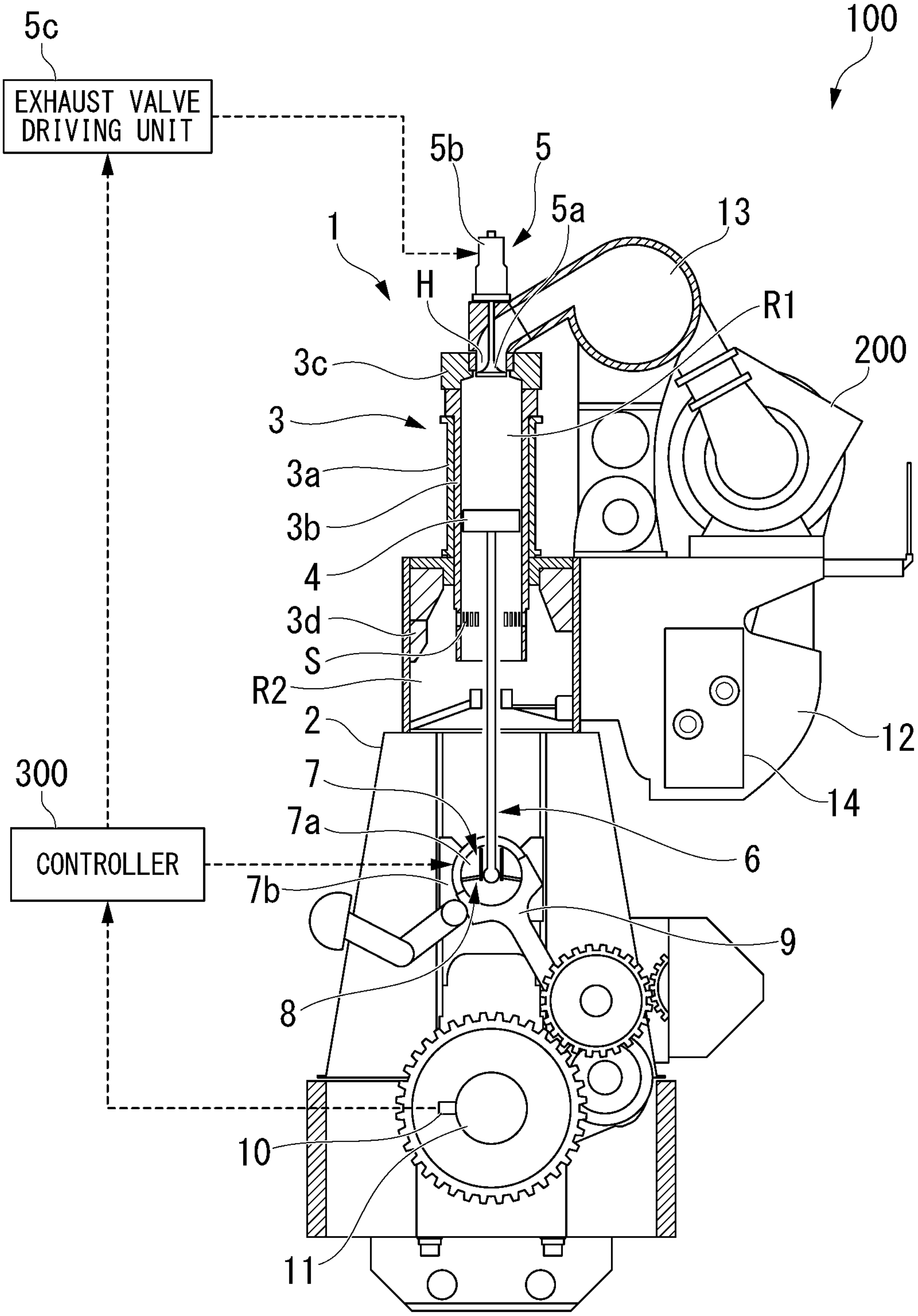
3. The variable compression device according to claim 1, wherein the regulation member includes a supporting portion which is capable of being moved in an extension direction of the piston rod and is configured to support the piston rod from below.

4. The variable compression device according to claim 1, wherein

   the piston rod includes an opening into which the regulation member is capable of being inserted, and
   the regulation member includes a supporting portion which is inserted into the opening of the piston rod and is configured to hang and support the piston rod from above.

5. An engine system comprising the variable compression device according to any one of claims 1 to 4.

FIG. 1


5c
EXHAUST VALVE DRIVING UNIT
100
5b
5
5a
13
1
H
R1
200
3c
3
3a
3b
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3d
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CONTROLLER
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7a
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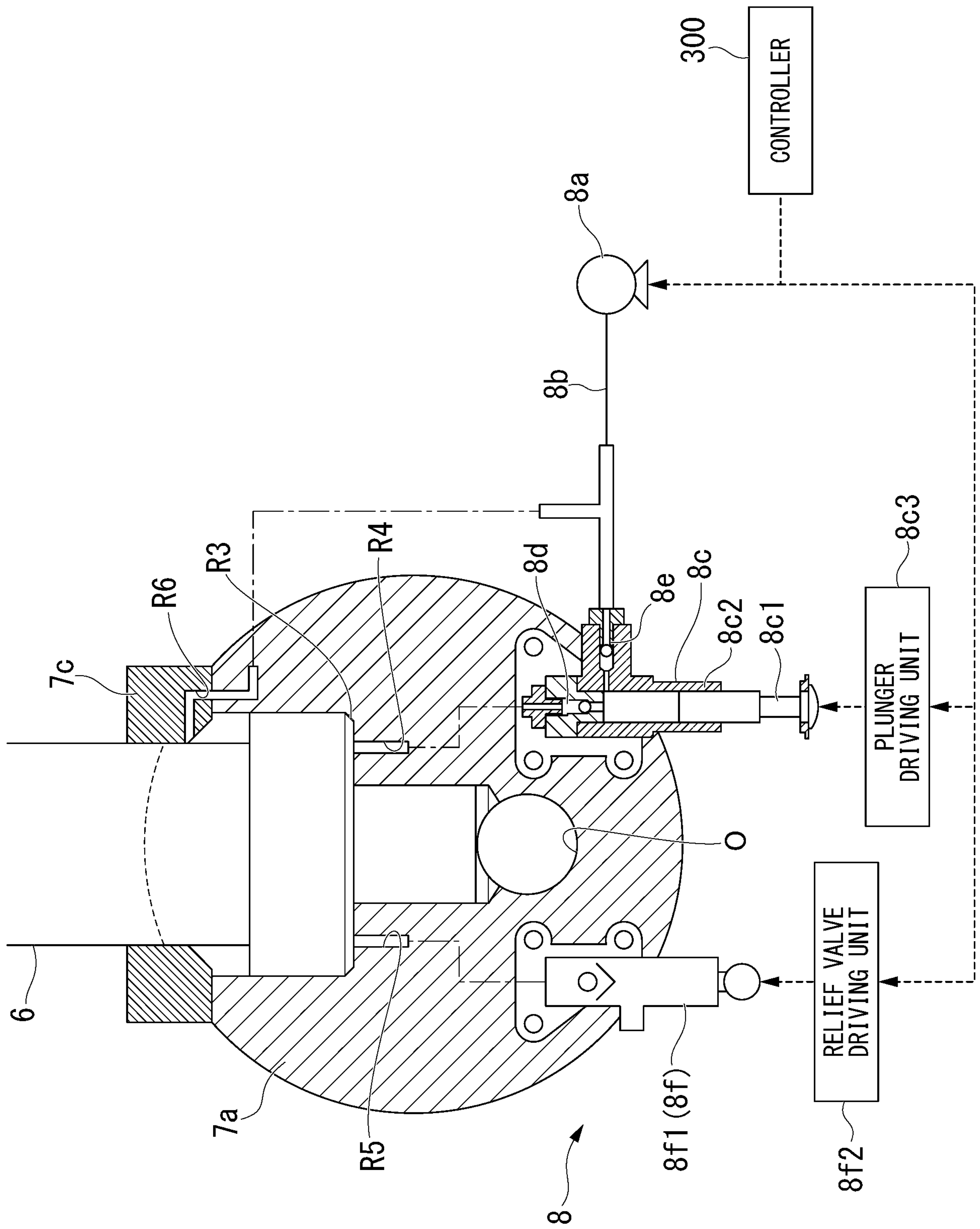
10
11



300
CONTROLLER
8a
8b
R3
R4
R6
7c
8d
8e
8c
8c2
8c1
8c3
PLUNGER DRIVING UNIT
O
RELIEF VALVE DRIVING UNIT
6
7a
R5
8f1 (8f)
8f2
8

FIG. 2

FIG. 3

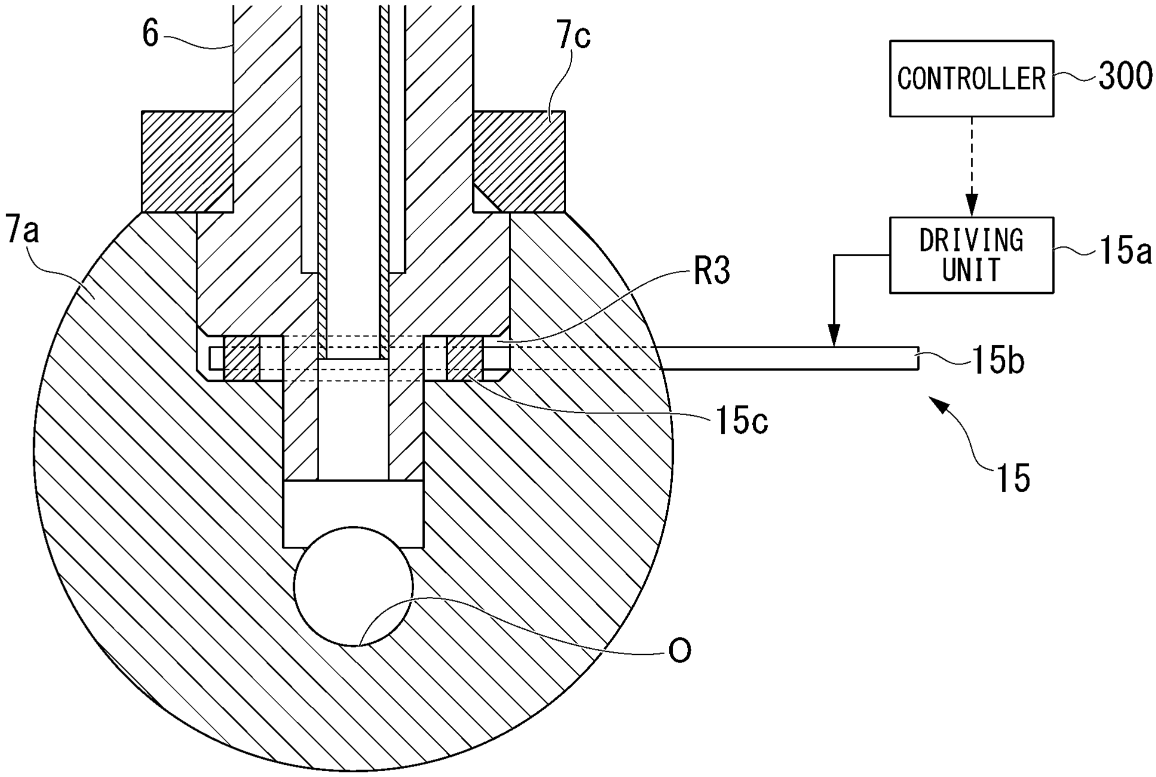

6
7c
CONTROLLER
300
7a
DRIVING UNIT
15a
R3
15b
15c
15
O

FIG. 4

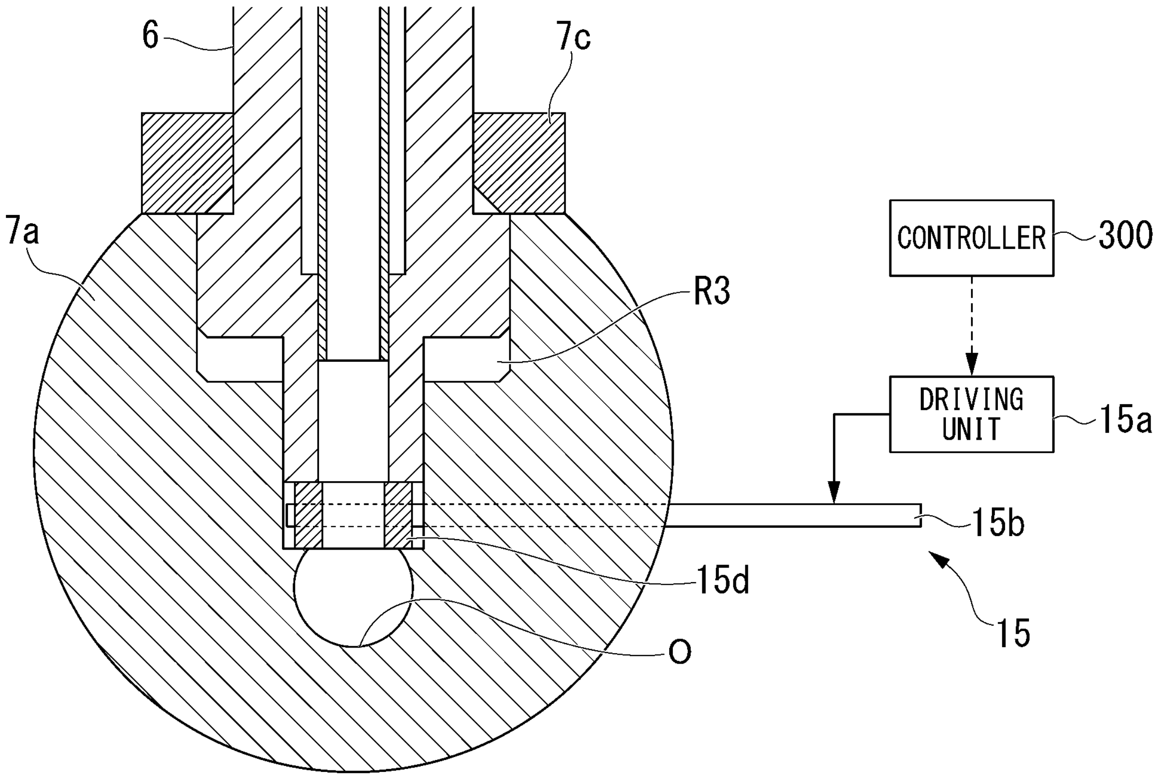

6
7c
CONTROLLER
300
7a
R3
DRIVING UNIT
15a
15b
15d
15
O

FIG. 5

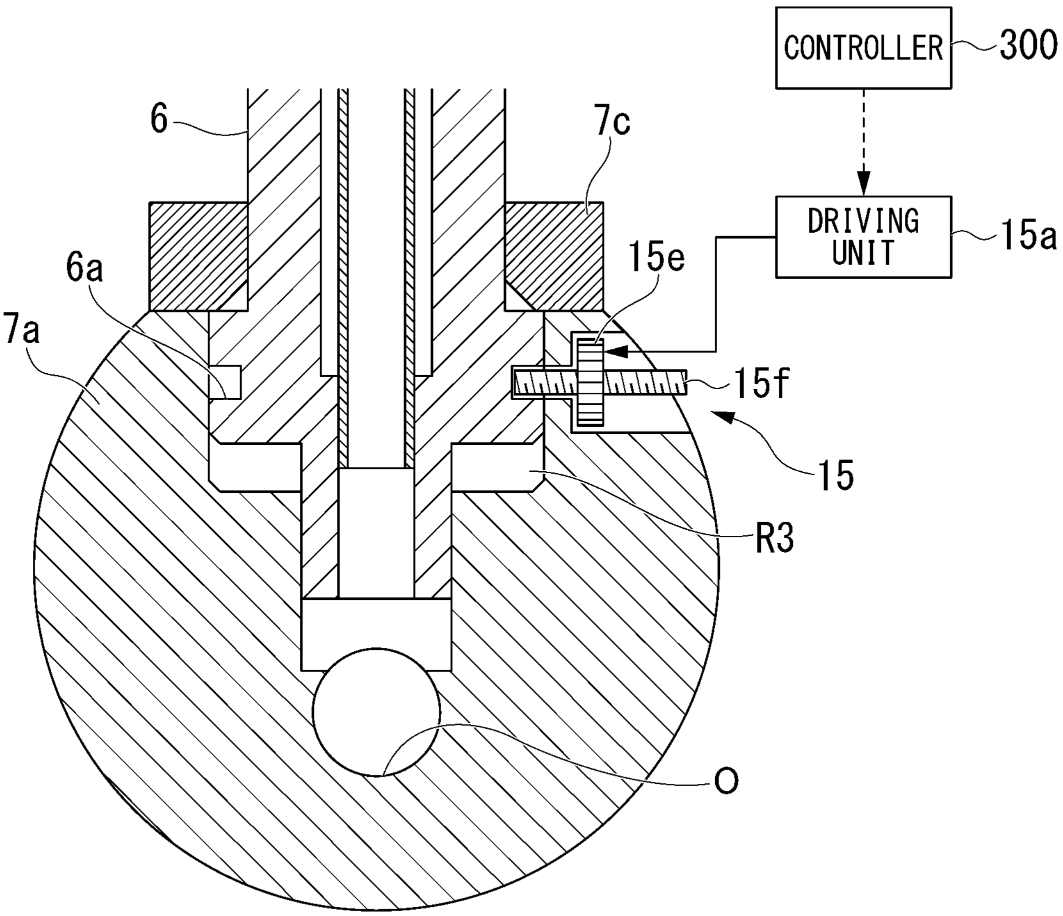
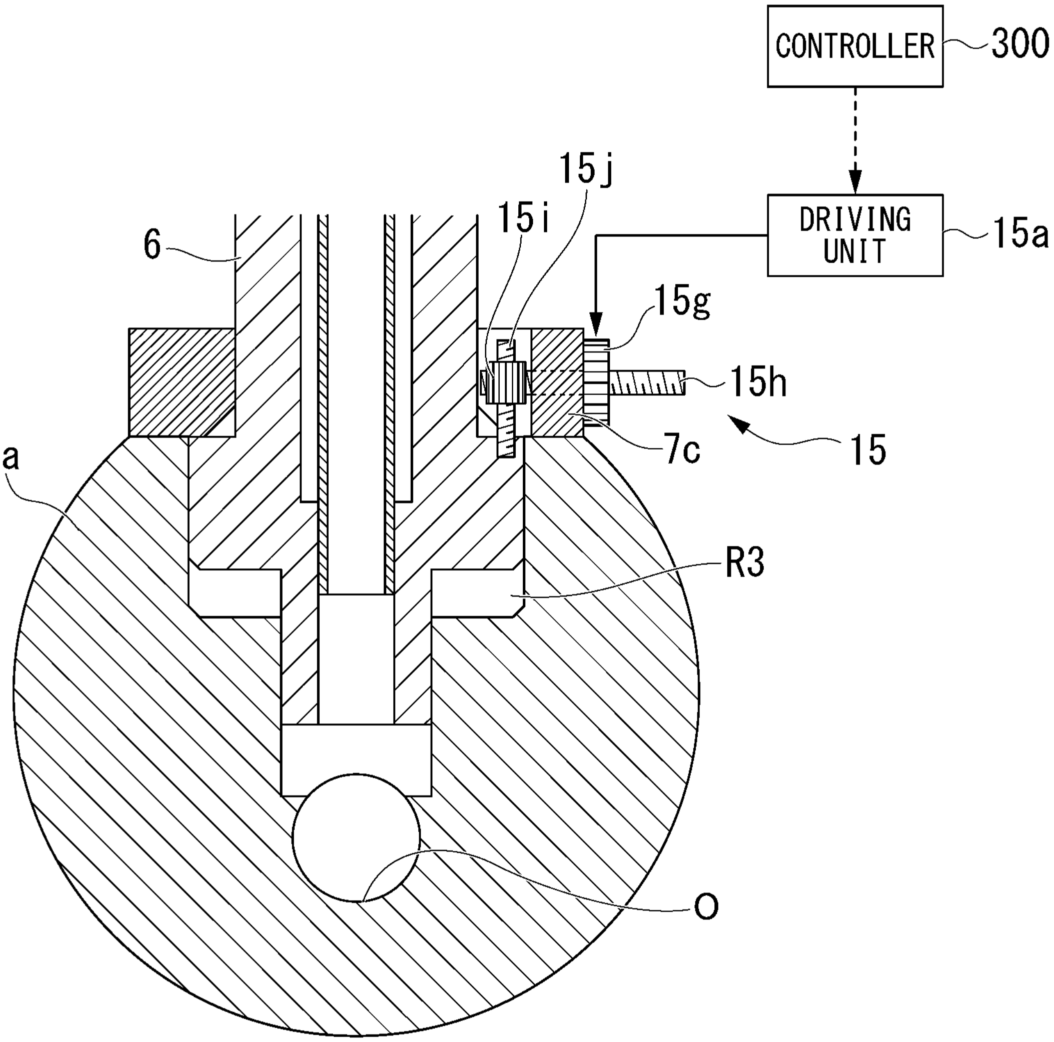


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/030763

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F02B75/04(2006.01)i, F02B75/32(2006.01)i, F02D15/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. F02B75/04, F02B75/32, F02D15/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2014-20375 A (WAERTSILAE SCHWEIZ AG) 03 February 2014, claim 6, paragraphs [0027]-[0044], fig. 1-3 & EP 2687707 A2, claim 6, paragraphs [0024]-[0041], fig. 1-3 & KR 10-2014-0010908 A & CN 103541819 A	1-2, 5 3-4
Y A	JP 11-294210 A (TOYOTA MOTOR CORP.) 26 October 1999, paragraphs [0008][0014], fig. 2 (Family: none)	1-2, 5 3-4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 November 2018 (06.11.2018)	20 November 2018 (20.11.2018)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/030763

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 11-257110 A (TOYOTA MOTOR CORP.) 21 September 1999, paragraphs [0008]-[0023], fig. 5-6 (Family: none)	1-2, 5 3-4
A	JP 8-28314 A (HONDA MOTOR CO., LTD.) 30 January 1996, paragraphs [0031]-[0034], fig. 8 & US 5562068 A, column 6, line 55 to column 7, line 25, fig. 8	1-5
A	WO 2016/182000 A1 (IHI CORP.) 17 November 2016, entire text, all drawings & JP 2016-211680 A & EP 3296597 A1, entire text, all drawings & KR 10-2017-0083148 A & CN 107429841 A	1-5
A	WO 2015/108178 A1 (IHI CORP.) 23 July 2015, entire text, all drawings & US 2016/0319738 A1, entire text, all drawings & EP 3098416 A1 & KR 10-2016-0090394 A & CN 105899781 A	1-5
A	WO 2015/108182 A1 (IHI CORP.) 23 July 2015, entire text, all drawings & US 2016/0319739 A1, entire text, all drawings & EP 3098417 A1 & KR 10-2016-0090393 A & CN 106414951 A	1-5
A	US 6394047 B1 (FORD GLOBAL TECHNOLOGIES, INC.) 23 May 2002, entire text, all drawings & GB 2378743 A & DE 10235852 A1	1-5
A	US 2013/0247879 A1 (VON MAYENBURG, Michael) 26 September 2013, entire text, all drawings (Family: none)	1-5
A	JP 2015-124639 A (MITSUBISHI MOTORS CORPORATION) 06 July 2015, entire text, all drawings (Family: none)	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- JP 2014020375 A **[0004]**