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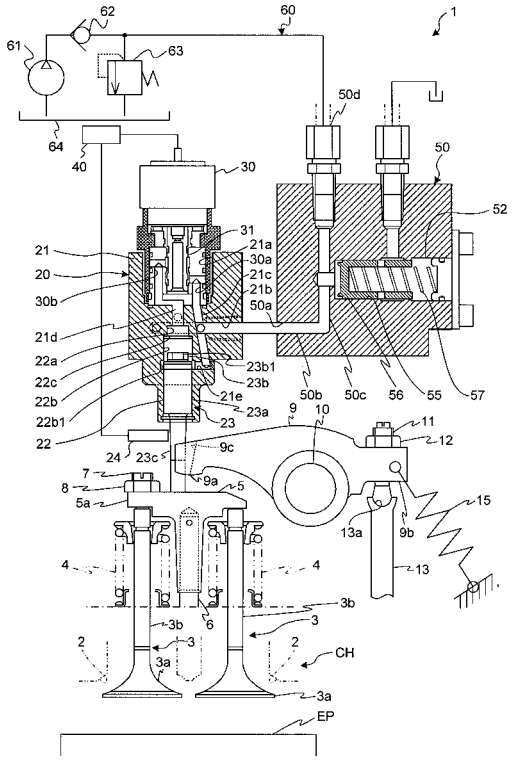
(54) ENGINE VALVE DEVICE

(57) With the goal of providing an engine valve device, which can follow a high revolution of an engine and can be efficiently operated, although the engine valve device varies an open and close motion of a valve, an engine valve device includes an intake valve 3 which opens and closes an intake port by a pressing force of a rotating cam and a pressing force of a valve spring, a piston 23 which is movable in a same direction as the intake valve 3, a cylinder portion 22 which houses the piston 23 such that the piston 23 is movable inside, a hydraulic actuator 20 including the piston 23 and the cylinder portion 22, a supply discharge pipe line 21d which communicates with a pressure chamber formed by the piston 23 and the cylinder portion 22, an accumulator 50 which accumulates hydraulic oil flowed out from the pressure chamber via the supply discharge pipe line 21d, and an electromagnetic on-off valve 30 which controls a flow of the hydraulic oil between the pressure chamber and the accumulator 50. The electromagnetic on-off valve 30 is arranged on the supply discharge pipe line between the hydraulic actuator 20 and the accumulator 50.

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an engine valve device and technology allowing variable motion of the engine valve device.

BACKGROUND ART

[0002] FIG. 7 is a sectional side view showing a structure of a known engine valve device. FIG. 8 is a circuit diagram showing a configuration of a fluid circuit of the engine valve device shown in FIG. 7. As shown in FIG. 7, an engine valve device 100 is configured to maintain an open state of an intake valve 103 by a fluid actuator 101 via a rocker arm 102. As shown in FIG. 8, this engine valve device 100 includes the fluid actuator 101 that follows the rocker arm 102, a direction control valve 105 that stops a flow of fluid from fluid actuator 101 at a predetermined timing, and a fluid source that supplies fluid to the direction control valve 105. The direction control valve 105 stops the flow of fluid from the fluid actuator 101 at the predetermined timing, and the fluid actuator 101 acts on the rocker arm 102. Therefore, the engine valve device 100 can maintain the open state of the intake valve 103. The fluid source used as such usage is, for example shown in FIG. 8, a part of a lubrication unit 107, which is attached to the engine to supply lubricating oil to the engine, and is capable of supplying pressurized oil of a pressure from about 210 KPa to 620 KPa. On the other hand, a pump may be provided separately from the lubrication unit 107 attached to the engine to supply pressurized oil of a pressure from 10 MPa to 35 MPa to the direction control valve 105 (for example, see Patent Document 1).

[0003] Patent Document 1: Japanese Patent Application Laid-Open No.2003-328715

DISCLOSURE OF INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] However, if the part of lubrication unit 107 attached to the engine as the fluid source supplies pressurized oil of the pressure from 210 KPa to 620 KPa to the direction control valve 105, a piston 106 cannot follow an open-close motion of the intake valve 103 when the engine is at a high revolution, for example, over 1000 rpm. Therefore, the piston 106 can not reach to a predetermined position and can not put the intake valve into the open state at a desired amount of opening. On the other hand, if the pump is provided separately from the lubrication unit 107 attached to the engine to supply pressurized oil of a pressure from 10 MPa to 35 MPa, it is subject to a considerable increase in cost as well as the engine becomes larger. Also, because the lubrication unit 107 attached to the engine supplies and discharges pressurized oil every time the fluid actuator 101 acts on, an energy loss becomes tremendously large.

[0005] The present invention is made in view of the above problems and an object of the present invention is to provide an engine valve device which is capable of following a high revolution of an engine and of highly efficient operating although the engine valve device is configured to vary a motion, utilizing a part of a lubricating oil unit attached to the engine as an oil source.

MEANS FOR SOLVING PROBLEM

[0006] To solve the problem and achieve the above object, an engine valve device according to the present invention includes a cam which rotates by engaging with a crankshaft, a rocker arm which follows a movement of the cam, and an intake valve which opens and closes an intake port by interacting the rocker arm and a spring. The engine valve device comprises: a piston which is movable in a same direction as the intake valve; a cylinder which houses the piston such that the piston is movable inside the cylinder; a hydraulic actuator including the piston and the cylinder; a hydraulic pipe line which communicates with a pressure chamber formed by the piston and the cylinder; an accumulation unit which accumulates hydraulic oil flowed out from the pressure chamber via the hydraulic pipe line; and an electromagnetic on-off valve which controls a flow of the hydraulic oil between the pressure chamber and the accumulation unit. The hydraulic actuator, the hydraulic pipe line, the accumulation unit, and the electromagnetic on-off valve make up a hydraulic circuit. The electromagnetic on-off valve is arranged on the hydraulic pipe line between the hydraulic actuator and the accumulation unit.

[0007] Also, according to the present invention, an engine valve device includes a cam which rotates by engaging with a crankshaft, a rocker arm which follows a movement of the cam, an intake valve which opens or closes an intake port by interacting the rocker arm and a spring, and a hydraulic circuit. The hydraulic circuit includes: a hydraulic actuator which is activated by an open and close motion of the intake valve, the hydraulic actuator stopping a closing motion of the intake valve in an open state when hydraulic oil is sealed in a pressure chamber; an accumulation unit which accumulates the hydraulic oil flowed out from the pressure chamber of the hydraulic actuator when the intake valve moves to close, and which provides the hydraulic oil to the pressure chamber of the hydraulic actuator when the intake valve moves to open; and an electromagnetic on-off valve which controls a flow of the hydraulic oil from the hydraulic actuator to the accumulation unit. The electromagnetic on-off valve is arranged between the hydraulic actuator and the accumulation unit.

[0008] Also, according to the present invention, the invention described above further comprises a hydraulic oil supply unit which provides the hydraulic oil to the hydraulic circuit.

[0009] Also, according to the present invention, in the invention described above, the hydraulic oil supply unit is a lubrication unit which provides lubricating oil to an engine and is attached to the engine.

[0010] Also, according to the present invention, the invention described above further comprises an auxiliary pipe line which allows the flow of the hydraulic oil from the pressure chamber of the hydraulic actuator to the accumulation unit. The auxiliary pipe line includes a port which opens when the piston of the hydraulic actuator comes to a predetermined interval, the piston of the hydraulic actuator follows the intake valve moving to a closing direction.

[0011] Also, according to the present invention, the invention described above further comprises a check valve which supplies the hydraulic oil from the hydraulic oil supply unit to the hydraulic circuit only if an oil pressure of the hydraulic circuit is lower than that of the hydraulic oil supply unit, and the check valve is arranged between the hydraulic oil supply unit and the hydraulic circuit.

[0012] Also, according to the present invention, in the invention described above, the pressure chamber of the hydraulic actuator is configured to cushion a shock when the intake valve closes.

[0013] Also, according to the present invention, the invention described above further comprises: a push rod which transmits motion from the cam to the rocker arm, the push rod being disposed between the cam and the rocker arm; and a biasing unit which biases the rocker arm to tightly contact with the push rod.

EFFECT OF THE INVENTION

[0014] The engine valve device according to the present invention includes the hydraulic circuit including the accumulation unit which accumulates hydraulic oil flowed out from the pressure chamber of the hydraulic actuator when the intake valve moves to close, and provides hydraulic oil to the pressure chamber of the hydraulic actuator when the intake valve moves to open, and the electromagnetic on-off valve which controls a flow of the hydraulic oil from the hydraulic actuator to the accumulation unit. The electromagnetic on-off valve is arranged between the hydraulic actuator and the accumulation unit. Accordingly, to precisely make the intake valve an open state, the engine valve device can follow a high revolution of the engine and be efficiently operated.

[0015] Also, in the engine valve device according to the present invention, the lubrication unit, which is attached to the engine and provides lubricating oil to the engine, provides hydraulic oil to the hydraulic circuit. Accordingly, there is no need to provide an oil pump separately from the lubrication unit attached to the engine, there is no need to grow in size, and an increase in cost is suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

FIG. 1 is a schematic view of an engine valve device according to an embodiment of the present invention;
FIG. 2A is a view showing a behavior of the engine valve device shown in FIG. 1 and showing a close state of an intake valve;
FIG. 2B is a view showing a behavior of the engine valve device shown in FIG. 1 and showing a full open state of the intake valve;
FIG. 2C is a view showing a behavior of the engine valve device shown in FIG. 1 and showing a close starting state of the intake valve;
FIG. 2D is a view showing a behavior of the engine valve device shown in FIG. 1 and showing a state in which the intake valve is closed to a predetermined gate opening;
FIG. 2E is a view showing a behavior of the engine valve device shown in FIG. 1 and showing a full close state of the intake valve;
FIG. 3 is a view showing a hydraulic circuit of the engine valve device shown in FIG. 1;
FIG. 4 is a view showing a relation between a cam rotating angle and an amount of valve lift for an intake stroke of the engine valve device shown in FIG. 1;
FIG. 5 is a flowchart showing control of the engine valve device shown in FIG. 1;
FIG. 6 is a timing chart showing a control timing of the engine valve device shown in FIG. 1;
FIG. 7 is a sectional side view showing a structure of a known engine valve device;
FIG. 8 is a view showing a configuration of a fluid circuit of the engine valve device shown in FIG. 7;

DESCRIPTION OF THE NUMERALS

[0017]

1	Engine valve device
2	Intake port
3	Intake valve
3a	Valve portion
3b	Stem
4	Valve spring
5	Crosshead
9	Rocker arm
9a	Pressing portion
9b	Action portion
9c	Groove
13	Push rod
14	Tappet arm
15	Return spring
18	Cam
20	Hydraulic actuator
21	Block

21a	Concave portion
21b	First pipe line
21c	Second pipe line
21d	Supply discharge pipe line
21e	Flow pipe line
22	Cylinder portion
22a	Small diameter chamber
22b	Large diameter chamber
22b1	Oil groove
23	Piston
23a	Piston portion
23b	Buffering portion
23b1	Longitudinal groove
23c	Rod portion
24	Gap sensor
30	Electromagnetic on-off valve
40	Engine control unit (ECU)
50	Accumulator
52	Pressure accumulating portion
55	Cylinder
56	Plunger
57	Compression spring
60	Hydraulic circuit
61	Lubrication unit attached to engine
62	Check valve
63	Relief valve
64	Oil pan
CH	Cylinder head

BEST MODE FOR CARRYING OUT THE INVENTION

[0018] Referring to attached figures, an embodiment of an engine valve device according to the present invention is described below. Meanwhile, the present invention is not limited by the embodiment.

[0019] FIG. 1 is a schematic view of an engine valve device according to an embodiment of the present invention; FIG. 2 is a view showing a behavior of the engine valve device shown in FIG. 1; FIG. 3 is a view showing a hydraulic circuit of the engine valve device shown in FIG. 1; and FIG. 4 is a view showing a relationship between a cam rotating angle and an amount of valve lift for an intake stroke of the engine valve device shown in FIG. 1; FIG. 5 is a flowchart showing control of the engine valve device shown in FIG. 1; FIG. 6 is a timing chart showing control timing of the engine valve device shown in FIG. 1

[0020] An engine valve device 1 according to an embodiment of the present invention is applied to an engine valve device of a four-cycle diesel engine.

[0021] The diesel engine includes a cylinder block and a cylinder head CH. The cylinder block is provided with a cylindrically shaped cylinder which allows an engine piston EP slides in up-and-down direction.

[0022] The cylinder head is provides with a pair of intake ports 2 which are in communication with an outside of the cylinder and a pair of exhaust ports which is not shown in the figure. At each intake port 2, an intake valve 3 is provided such that the intake valve 3 closes or opens the intake port 2 by moving up and down with respect to FIG. 1. At each exhaust port, an exhaust valve, not shown in the figure, is provided such that the exhaust valve closes or opens the exhaust port by moving up and down.

[0023] The intake valve 3 and the exhaust valve are poppet valves which are formed in an umbrella shape, and include valve portions (umbrella shaped portion) 3a that close the intake port 2 and the exhaust port and stems (rod shaped portion) 3b that slides through the cylinder head CH.

[0024] The stem 3b of the intake valve 3 which is in communication with the intake port 2 is provided with a valve spring 4, and the valve portion 3a of the intake valve 3 is biased to close the intake port 2. In a similar way, the stem of the exhaust valve which is in communication with the exhaust port is provided with a valve spring, not shown in the figure, and the valve portion of the exhaust valve is biased to close the exhaust port.

[0025] Above the cylinder head CH, a crosshead 5 which has a side view of a T shape and pushes the ends of stems of the pair of the intake valves 3 at the same time is provides. The crosshead 5 is guided by a shaft 6 provided to be placed parallel to a moving direction of the intake valve 3 and the exhaust valve, and is allowed to move up and down with respect to FIG. 1. Therefore, the crosshead 5 pushes the ends of the stems of the intake valves 3 to open the intake valves 3 against biasing forces of the valve springs 4 when the crosshead 5 moves down.

[0026] One side of arm 5a of the crosshead 5 (left side arm in FIG. 1) is provided with an adjustable screw 7 such that the crosshead 5 closely contacts with the intake valve 3. The adjustable screw 7 can be screwed with respect to the crosshead 5 to adjust a clearance of one of the pear of the intake valves 3 (left side intake valve in FIG. 1). For example, it is adjustable such that one of the intake valves 3 opens the intake port 2 at the same time the other of the intake valves 3 opens the intake port 2. A locknut 8 is threadably mounted on the adjustable screw 7 to prevent from loosening by closely sticking the locknut 8 to the crosshead 5 after adjusting.

[0027] A rocker arm 9 is provided above the crosshead 5 as shown in FIG. 1. The rocker arm 9 is rotatable around a rocker shaft 10 as an axis. The rocker arm 9 includes a pressing portion 9a which pushes the crosshead 5 on an end portion (left side portion in FIG. 1) and an action portion 9b on the other end portion. The pressing portion 9a of the rocker arm 9 is allowed to push around a central portion of the crosshead 5. Thus, when the rocker arm 9 rotates counterclockwise with respect to FIG. 1, the pressing portion 9a of the rocker arm 9 pushes the crosshead 5, and the intake valve 3 opens the intake port 2. In contrast, when the rocker arm 9 rotates clockwise with respect to FIG. 1, the intake valve 3 closes the intake port 2 by the biasing force of the valve spring 4 and moves up the crosshead 5. On a central portion of the pressing portion 9a, a groove 9c which has a planar view of a U

shape is formed.

[0028] An adjust screw 11 is threadably mounted on the action portion 9b of the rocker arm 9 to adjust a clearance between the pressing portion 9a and the crosshead 5. The adjust screw 11 includes a hemisphere portion on an end portion and a male screw on the other end portion. A locknut 12 is threadably mounted on the adjust screw 11 which is threadably mounted on the other end portion of the rocker arm 9. The adjust screw 11 is allowed to prevent from loosening by closely sticking the locknut 12 to the rocker arm 9.

[0029] The end portion of hemisphere of the adjust screw 11 is housed in an end portion of a push rod 13. The end portion of the push rod 13 is provided with a concave portion 13a of hemisphere and has a capacity of housing the end portion of hemisphere of the adjust screw 11.

[0030] The push rod 13 rotates the rocker arm 9 counterclockwise with respect to FIG. 1. As shown in FIG.2, the other end portion 13b of the push rod 13 is housed in a push rod housing 14a provided above an arm portion of a tappet arm 14.

[0031] As shown in FIG. 1, a return spring 15 is tacked between the action portion 9b of the rocker arm 9 and the cylinder head CH. The return spring 15 pushes the rocker arm 9 clockwise with respect to FIG. 1, and is capable of maintaining to house the end portion of the adjust screw 11 in the concave portion 13a of the push rod 13. Meanwhile, the return spring 15 is to push the rocker arm 9 clockwise with respect to FIG. 1, and the return spring 15 is replaced by a torsion coil spring which is wound around the rocker shaft 10. In this case, an end of the coil spring is fixed to the rocker arm 9, and the other end is fixed to the cylinder head CH.

[0032] As shown in FIG. 2, a tappet arm 14 is rotatably attached to a tappet shaft as an axis. Thus, when the tappet arm 14 rotates clockwise with respect to FIG. 2, the tappet arm 14 pushes up the push rod 13 and causes the rocker arm 9 to rotate counterclockwise with respect to FIG. 2.

[0033] Below an arm portion of the tappet arm 14, a roller follower 17 is rotatably attached. Below the roller follower 17, a cam 18 is rotatably provided to allow a rolling contact with the roller follower 17. The cam 18 rotates by engaging with a crankshaft, not shown in the figure, of the engine. The cam 18 moves (lifts) the intake valve 3 via the tappet arm 14, the push rod 13, the rocker arm 9, and the crosshead 5, thereby, allowing the intake port 2 to open. Thus, an opening timing of the intake port 2 and a valve lift amount of the intake valve 3 are controlled by a surface configuration (cam profile) of the cam 18. The valve lift amount describes an action toward an open direction at a closing time of 0 as a lift, and takes a positive value at the moment.

[0034] The crankshaft is connected to the other end portion of a con-rod of which an end portion is connected to the engine piston EP sliding in the cylinder. Thus, the intake valve 3 can be opened and closed in the intake stroke, and the intake valve 3 can be closed in a compression stroke, a combustion stroke, and an exhaust stroke.

[0035] As shown in FIG. 1, an hydraulic actuator 20 is provided above the crosshead 5. The hydraulic actuator 20 is arranged such that a tip of a rod portion 23c of a piston 23 contacts with the crosshead 5 and is capable of engaging with a movement of the crosshead 5. The hydraulic actuator 20 pushes the crosshead 5 at a predetermined timing and maintains an open state of the intake valve 3 regardless of movements of the cam 18, the tappet arm 14, the push rod 13, and the rocker arm 9.

[0036] The hydraulic actuator 20 applied to the embodiment is a single acting type. In the hydraulic actuator 20, a cylinder portion 22 is integrally formed with a block 21, and an electromagnetic on-off valve 30 can be housed to be attached.

[0037] A supply discharge pipe line 21d which communicates with an output port 30b of the electromagnetic on-off valve 30 is formed on the block 21. Also, a first pipe line 21b which communicates with an output port 50a of an accumulator 50, which will be explained later in detail, is formed. The first pipe line 21b communicates with an intake port 30a of the electromagnetic on-off valve 30 and a flow pipe line 21e, which will be explained later in detail, by a second pipe line 21c.

[0038] The cylinder portion 22 includes a small diameter chamber 22a and a large diameter chamber 22b, which constitute a pressure chamber and have cylindrical shapes. One end of the large diameter chamber 22b is opened to accept an insertion of the piston 23, and closed by the piston 23. The other end of the large diameter chamber 22b is formed such that the small diameter chamber 22a coincides and communicates with an axis of the large diameter chamber 22b. The small diameter chamber 22a communicates with the supply discharge pipe line 21d. A step 22c is formed on a border of the large diameter chamber 22b and the small diameter chamber 22a.

[0039] An oil groove 22b1 is formed on a predetermined section of the large diameter chamber 22b. The flow pipe line 21e which communicates with a second pipe line 21c is formed on the oil groove 22b1.

[0040] The cylinder portion 22 houses the piston 23 which slides in an axial direction of the large diameter chamber 22b and the small diameter chamber 22a (up and down direction with respect to FIG. 1). The piston 23 includes a piston portion 23a, a buffering portion 23b, and a rod portion 23c. The piston portion 23a is a portion which slides in the large diameter chamber 22b of the cylinder portion 22. The buffering portion 23b is a portion which is housed in the small diameter chamber 22a of the cylinder portion 22, and is provided to one end of axial direction (above the piston portion in FIG. 1) of the piston portion 23a. The buffering portion 23b is capable of, by interaction between the buffering portion 23b and the small diameter chamber 22a of the cylinder portion 22, cushioning a shock caused when the intake valve 3

closes. Within the meaning, the pressure chamber is configured to cushion the shock caused when the intake valve 3 is closed.

[0041] To be more specific, the buffering portion 23b includes a buffering shape which cushions the shock caused when the intake valve 3 is closed (when the intake valve 3 seats). The buffering shape is, for example, a plurality of longitudinal grooves 23b1 (four longitudinal grooves in this embodiment) which are formed from a circumferential root to a tip of the buffering portion 23b. When the buffering portion 23b is housed into the small diameter chamber 22a, the shock caused when the buffering portion 23b is housed into the small diameter chamber 22a is cushioned by flowing out hydraulic oil accumulated in an upper end corner portion of the large diameter chamber 22b via the longitudinal grooves 23b1. Accordingly, the shock caused when the intake valve 3 engaging the piston 23 of the hydraulic actuator 20 is closed is cushioned, and a valve portion 3a is protected from a crash by the shock caused when the valve portion 3a seats.

[0042] Meanwhile, the buffering shape is not limited to the longitudinal groove 23b1, and may be formed in a tapered shape which gradually tapers from the circumferential root to the tip of the buffering portion 23b. Also, the buffering shape may be formed in a tapered shape in which the small diameter chamber 22a gradually gets thick from a bottom portion to the large diameter chamber 22b. The rod portion 23c is a portion which extends outside of the cylinder portion 22, and is provided to an end opposite to the buffering portion 23b in axial direction of the piston portion 23a (below the piston portion 23a with respect to FIG. 1). The rod portion 23c is formed in a taper shape which gradually tapers from the root to the tip. The rod portion 23c is capable of pushing the crosshead 5 without interference of the rocker arm 9 by inserting the groove 9c formed on the pressing portion 9a of the rocker arm 9. Thus, the rod portion 23c is capable of pushing the crosshead 5 separately from the rocker arm 9.

[0043] A gap sensor (clearance measurement means) 24 is provided on a side of the rod portion 23c of the piston 23. The gap sensor 24 measures a clearance between the rod portion 23c and the gap sensor 24, and is connected to an engine control unit (ECU) 40. The gap sensor 24 is capable of measuring the clearance, for example, by measuring a current surge. The engine control unit 40 is capable of monitoring an action of the hydraulic actuator 20 by monitoring the clearance of the rod portion 23c measured by the gap sensor 24. To be more specific, since the clearance becomes small when the rod portion 23c protrudes from the cylinder portion 22, and the clearance becomes large when the rod portion 23c recedes in the cylinder portion 22, the monitoring of the hydraulic actuator 20 can be achieved by monitoring the clearance.

[0044] The electromagnetic on-off valve 30 is housed in the concave portion 21a of the block 21. The electromagnetic on-off valve 30 is a two port type electromagnetic on-off valve which includes an intake port 30a and an output port 30b. The intake port 30a communicates with the second pipe line 21c of the block 21, and the output port 30b communicates with the supply discharge pipe line 21d of the block 21. The electromagnetic on-off valve 30 includes inside a spool 31 as well as a spring and a solenoid, not shown in the figure. In the electromagnetic on-off valve 30, the spring pushes the spool 31 to connect the intake port 30a and the output port 30b when a normal condition, and the spool 31 cuts off the communication between the intake port 30a and the output port 30b against a biasing force of the spring when the solenoid is excited. Thus, the electromagnetic on-off valve 30 is capable of switching between a hydraulic oil supply discharge condition and a hydraulic oil cut off condition.

[0045] Thus, when the hydraulic oil is provided to the supply discharge pipe line 21d formed on the block 21 via the first pipe line 21b and the second pipe line 21c, both of which are formed on the block 21, and the electromagnetic on-off valve 30, the hydraulic oil is provided into the large diameter chamber 22b via the small diameter chamber 22a. Then, the hydraulic oil acts on the piston portion 23a of the piston 23, the piston 23 is pushed out of the cylinder portion 22 (downward with respect to FIG. 1), and the rod portion 23c protrudes downward with respect to FIG. 1. Then, when the solenoid of the electromagnetic on-off valve 30 is excited, the communication between the intake port 30a and the output port 30b is cut off. In this condition, if the rod portion 23c is pushed up to a side of the cylinder portion 22 (upward with respect to FIG. 1), the piston 23 is plunged into the cylinder portion 22 until the piston portion 23a of the piston 23 closes the longitudinal groove 23b1 communicated with the flow pipe line 21e of the block 21, thereby, sealing hydraulic oil in the small diameter chamber 22a and the large diameter chamber 22b. At this time, the piston 23 is stopped by hydraulic oil sealed by the small diameter chamber 22a and the large diameter chamber 22b.

[0046] Afterward, when the solenoid of the electromagnetic on-off valve 30 is not excited, the intake port 30a and the output port 30b returns to a condition in which the intake port 30a and the output port 30b are in communication. In this condition, if the rod portion 23c of the piston 23 is pushed up to the side of the cylinder portion 22 (upward with respect to FIG. 1), the piston 23 moves upward and hydraulic oil flows out from the supply discharge pipe line 21d of the block 21. The flowed hydraulic oil flows out outside of the hydraulic actuator 20 via the output port 30b and intake port 30a of the electromagnetic on-off valve 30, the second pipe line 21c, and the first pipe line 21b. Then, the buffering portion 23b of the piston 23 is housed in the small diameter chamber 22a of the cylinder portion 22, and a sequence of functions of the hydraulic actuator 20 ends.

[0047] The electromagnetic on-off valve 30 is connected to the engine control unit 40. The engine control unit 40 controls an exciting timing and an exciting time period

of the electromagnetic on-off valve 30, and is capable of controlling the electromagnetic on-off valve 30 in units of milliseconds (1/1000 seconds) as desired.

[0048] An output port 50a of the accumulator 50 is connected to the first pipe line 21b of the block 21. The accumulator 50 is an accumulating means for accumulating oil pressure, and the accumulator 50 according to the embodiment is a mechanical accumulator.

[0049] As shown in FIG. 1, the accumulator 50 includes the output port 50a explained above, an output pipe line 50b which extends from the output port 50a, an input pipe line 50c which crosses to the output pipe line 50b, and a input port 50d which communicates with the input pipe line 50c. The input pipe line 50c communicates with a pressure accumulating portion 52.

[0050] The pressure accumulating portion 52 includes a cylinder 55 formed on a body of the accumulator 50. The cylinder 55 communicates with the input pipe line 50c, and is configured such that hydraulic oil provided from the input port 50d and hydraulic oil provided from the output port 50a can flow in. The cylinder 55 includes inside a plunger 56 which slides in an axial direction of the cylinder 55 and a compression spring 57 which pushes the plunger 56 toward a bottom wall of the cylinder 55 (toward left in the figure).

[0051] Thus, although hydraulic oil is provided from the input port 50d of the accumulator 50 and hydraulic oil pushes plunger 56 toward the side (right side with respect to FIG. 1), the plunger 56 can not resist a basing force of the compression spring 57, and hydraulic oil flows out from the output port 50a. In contrast, when hydraulic oil, which is flowed out from the hydraulic actuator 20 and posses a higher oil pressure than an oil pressure of hydraulic oil provided from the input port 50d, is provided from the output port 50a of the accumulator 50, the hydraulic oil pushes the plunger 56 toward the side (right side with respect to FIG. 1), and the plunger 56 moves toward the side (toward left in the figure) against the biasing force of the compression spring 57. At this time, hydraulic oil is accumulated (pressure accumulation) in the pressure accumulating portion 52.

[0052] The hydraulic actuator 20, the electromagnetic on-off valve 30, and the accumulator 50 make up a hydraulic circuit 60, as shown in FIG. 3. A lubrication unit 61 which is attached to the engine and provides lubricating oil to the engine is capable of providing low pressure hydraulic oil to the hydraulic circuit 60. A check valve 62 is arranged between the lubrication unit 61 attached to the engine and the hydraulic circuit 60. The check valve 62 allows providing hydraulic oil to the hydraulic circuit 60 from the lubrication unit 61 attached to the engine only if an oil pressure of the hydraulic circuit 60 is lower than that of the lubrication unit 61 attached to the engine, and does not allow hydraulic oil to flow from the hydraulic circuit 60 side to the lubrication unit 61 attached to the engine.

[0053] Also, a relief valve 63 is provided between the check valve 62 and the hydraulic circuit 60 explained above. The relief valve 63 is capable of discharging hydraulic oil of the hydraulic circuit 60 to an oil pan 64 of the engine when the oil pressure of the hydraulic circuit 60 becomes higher than a predetermined pressure.

[0054] As explained above, the engine control unit 40 connected to the gap sensor 24 and the electromagnetic on-off valve 30 is configured to detect which cylinder has the engine piston EP come to a top dead center, based on a cylinder determination signal (G signal) entered from TDC (Top Dead Center) sensor (cylinder determination signal output means), as shown in FIG. 6. Also, the engine control unit 40 calculates a revolution based on a revolution detection signal (Ne signal) entered from a crank angle sensor (revolution detection signal output means), not shown in the figure. The engine control unit 40 is configured to start to count number of pulses of the revolution detection signal (square wave) when the engine piston EP of a cylinder to delay a closing timing (for example, cylinder 5 in FIG. 6) comes to the upper dead center. Then, when the counted number of pulses of the revolution detection signal reaches to a preset VVA activation setup pulse, the engine control unit 40 turns on a VVA activation signal and excites the electromagnetic on-off valve 30 for a preset VVA holding time Tw.

[0055] According to the engine valve device 1 equipped with the hydraulic circuit 60 mentioned above, the lubrication unit 61 attached to the engine provides hydraulic oil to the hydraulic circuit 60 by starting the engine. To be more specific, hydraulic oil is provided to in order of the accumulator 50, the electromagnetic on-off valve 30, and the hydraulic actuator 20 via the check valve 62. Thus, hydraulic oil is filled in the electromagnetic on-off valve 30 and the hydraulic actuator 20.

[0056] Then, when the engine is started, power is transmitted to in order of the cam 18, the tappet arm 14, the push rod 13, the rocker arm 9, and the crosshead 5 by engaging with the crankshaft of the engine. The intake valve 3 opens and closes the intake port 2 during the intake stroke of the engine, and the intake valve 3 closes the intake port 2 during the compression stroke, the combustion stroke, and the exhaust stroke of the engine.

[0057] During the compression stroke, the combustion stroke, and the exhaust stroke of the engine, as shown in FIG. 2A, the intake valve 3 closes the intake port 2 by the biasing force of the valve spring 4. At this time, a relation between a rotational angle of the cam 14 and the valve lift amount has a relation shown by a close area in FIG. 4. More specifically, it has a relation in which the valve lift amount is 0 regardless of the rotational angle of the cam 18.

[0058] When the intake stroke of the engine is started, power is transmitted to in order of the tappet arm 14, the push rod 13, the rocker arm 9, and the crosshead 5 from the cam 18, and the intake valve 3 lifts to gradually open the intake port 2. At this time, a relation between the cam rotational angle and the valve lift amount has a relation shown by an open function area in FIG. 4. More specifically, it has a relation in which the valve lift amount grad-

ually increases as the rotational angle of the cam 18 increases.

[0059] At this time, the rod portion 23c of the piston 23 gradually protrudes (downward with respect to FIG. 1), contacting with the crosshead 5, by gradually providing hydraulic oil accumulated in the accumulator 50 to the small diameter chamber 22a and the large diameter chamber 22b of the cylinder portion 22. To be more specific, hydraulic oil is provided to in order of the electromagnetic on-off valve 30 and the hydraulic actuator 20. Here, if hydraulic oil is not accumulated in the accumulator 50, hydraulic oil is gradually provided to the hydraulic circuit 60 from the lubrication unit 61 attached to the engine via the check valve 62.

[0060] Then, when the valve lift amount becomes a maximum, as shown in FIG. 2B, the intake port 2 becomes a full open state.

[0061] Afterward, as shown in FIG. 2C, by the biasing forces of the valve spring 4 and the return spring 15, the crosshead 5, the rocker arm 9, the push rod 13, and the tappet arm 14 follow the cam 18, and the intake valve 3 gradually closes the intake port 2. At this time, a relation between the cam rotational angle and the valve lift amount has a relation shown by a close function area in FIG. 4. More specifically, it has a relation in which the valve lift amount gradually decreases as the rotational angle of the cam 18 increases.

[0062] At this time, the piston 23 is gradually housed in the cylinder portion 22, and hydraulic oil of the small diameter chamber 22a and the large diameter chamber 22b of the cylinder portion 22 is accumulated in the accumulator 50. Thus, the hydraulic actuator 20 has a function of a piston pump. To be more specific, hydraulic oil is accumulated in the accumulator 50 via the electromagnetic on-off valve 30 and the hydraulic actuator 20.

[0063] Then, as shown in fig. 4, when the valve lift amount becomes a minimum which is 0, the intake valve 3 becomes a full close state as shown in FIG. 2E.

[0064] In contrast, in the close function area shown in FIG. 4, when the electromagnetic on-off valve 30 is excited, the spool 31 cuts off the communication between the intake port 30a and the output port 30b against the biasing force of the spring. More specifically, the electromagnetic on-off valve 30 makes a transition from the hydraulic oil supply discharge state to the hydraulic oil cut off state. Then, the piston 23 is pushed into the cylinder portion 22 until the piston portion 23a of the piston 23 closes the oil groove 22b1 communicated with the flow pipe line 21e of the block 21, and, afterward, hydraulic oil is sealed in the small diameter chamber 22a and the large diameter chamber 22b of the cylinder portion 22. Thus, the piston 23 is stopped by hydraulic oil sealed in the small diameter chamber 22a and the large diameter chamber 22b.

[0065] Then, the rod portion 23c of the piston 23 pushes the crosshead 5, and the intake valve 3 keeps to open at a predetermined gate opening, as shown in FIG. 2D. More specifically, the closing timing of the intake port 2 by the intake valve 3 during the intake stroke is delayed. Because of a mechanism in which the oil groove 22b1 is provided inside the cylinder portion 22 and the piston portion 23a closes the oil groove 22b1, the open state is maintained at the same gate opening. At this time, a relation between the cam rotational angle and the valve lift amount has a relation shown by a close delay area in FIG. 4. More specifically, it has a relation in which the valve lift amount is constant although the rotational angle of the cam 18 increases.

[0066] As described above, although the rod portion 23c of the piston 23 pushes the crosshead 5 and the intake valve 3 keeps to open at the predetermined gate opening, the rocker arm 9 tightly contacts with the push rod 13 by the biasing force of the return spring 15, and controlled by the surface configuration (cam profile) of the cam 18. Thus, the clearance is generated between the crosshead 5 and the rocker arm 9 without dropping the push rod 13 from the rocker arm 9.

[0067] When the electromagnetic on-off valve 30 is demagnetized after a predetermined time period, the intake port 30a becomes in communication with the output port 30b again. Thus, the intake valve 3 gradually closes the intake port 2 by the biasing force of the valve spring 4.

[0068] At this time, the crosshead 5 pushes the piston 23, the piston 23 is housed inside the cylinder portion 22 again, and hydraulic oil of the small diameter chamber 22a and the large diameter chamber 22b of the cylinder portion 22 is accumulated in the accumulator 50.

[0069] Then, as shown in FIG. 4, when the valve lift amount becomes the minimum which is 0, the intake valve 3 becomes a full close state as shown in FIG. 2E.

[0070] As described above, to delay the closing timing of the intake port 2 by the intake valve 3 during the intake stroke, the engine control unit 40starts to count the number of pulses of the revolution detection signal (Step S2), when the engine piston EP of the cylinder to delay a closing timing (for example, cylinder 5 in FIG. 6) comes to the upper dead center (Step S1: Yes), as shown in FIG. 5 and FIG. 6. Then, when the counted number of pulses of the revolution detection signal reaches to the preset VVA activation setup pulse (Step S3: Yes), the engine control unit 40 turns on the VVA activation signal (Step S4). As described above, when the VVA activation signal is turned on, the electromagnetic on-off valve 30 is excited for the preset VVA holding time Tw (Step S5). Afterward, these routines are repeated to control the closing timing of the intake port 2 to be delayed by the intake valve 3.

[0071] According to the engine valve device 1 of the embodiment described above, when the electromagnetic on-off valve 30 is closed, the intake valve 3 engages with the rocker arm 9 until the piston 23 of the hydraulic actuator 20 closes the oil groove 22b1 (flow pipe line 21e). After closing the oil groove 22b1 which is communicated with the flow pipe line 21e, the open state of the intake valve 3 is maintained until the electromagnetic on-off valve 30 is opened. Thus, the open state of the intake

port 2 is maintained at the preset amount of opening regardless of the closing timing of the electromagnetic on-off valve 30.

INDUSTRIAL APPLICABILITY

[0072] As explained above, an engine valve device of the present invention is applicable to an engine valve device which varies an action of an engine valve, especially, is adapted to an engine valve of a diesel engine.

Claims

1. An engine valve device including a cam which rotates by engaging with a crankshaft, a rocker arm which follows a movement of the cam, and an intake valve which opens and closes an intake port by interacting the rocker arm and a spring, the engine valve device comprising:

a piston which is movable in a same direction as that of the intake valve;
a cylinder which houses the piston such that the piston is movable inside the cylinder;
a hydraulic actuator including the piston and the cylinder;
a hydraulic pipe line which communicates with a pressure chamber formed by the piston and the cylinder;
an accumulation unit which accumulates hydraulic oil flowed out from the pressure chamber via the hydraulic pipe line; and
an electromagnetic on-off valve which controls a flow of the hydraulic oil between the pressure chamber and the accumulation unit, wherein
the hydraulic actuator, the hydraulic pipe line, the accumulation unit, and the electromagnetic on-off valve make up a hydraulic circuit, and
the electromagnetic on-off valve is arranged on the hydraulic pipe line between the hydraulic actuator and the accumulation unit.

2. An engine valve device including a cam which rotates by engaging with a crankshaft, a rocker arm which follows a movement of the cam, and an intake valve which opens or closes an intake port by interacting the rocker arm and a spring, the engine valve device comprising a hydraulic circuit, wherein
the hydraulic circuit includes:

a hydraulic actuator which is activated by an open and close motion of the intake valve, the hydraulic actuator stopping a close motion of the intake valve in an open state when hydraulic oil is sealed in a pressure chamber;
an accumulation unit which accumulates the hydraulic oil flowed out from the pressure chamber of the hydraulic actuator when the intake valve moves to close, and which provides the hydraulic oil to the pressure chamber of the hydraulic actuator when the intake valve moves to open; and
an electromagnetic on-off valve which controls a flow of the hydraulic oil from the hydraulic actuator to the accumulation unit, wherein
the electromagnetic on-off valve is arranged between the hydraulic actuator and the accumulation unit.

3. The engine valve device according to claim 1 or 2, further comprising a hydraulic oil supply unit which provides the hydraulic oil to the hydraulic circuit.

4. The engine valve device according to claim 3, wherein the hydraulic oil supply unit is a lubrication unit which provides lubricating oil to an engine and is attached to the engine.

5. The engine valve device according to any of claims 1 to 4, further comprising an auxiliary pipe line which allows the flow of the hydraulic oil from the pressure chamber of the hydraulic actuator to the accumulation unit, wherein
the auxiliary pipe line includes a port which opens when the piston of the hydraulic actuator comes to a predetermined section, the piston of the hydraulic actuator follows the intake valve moving to a closing direction.

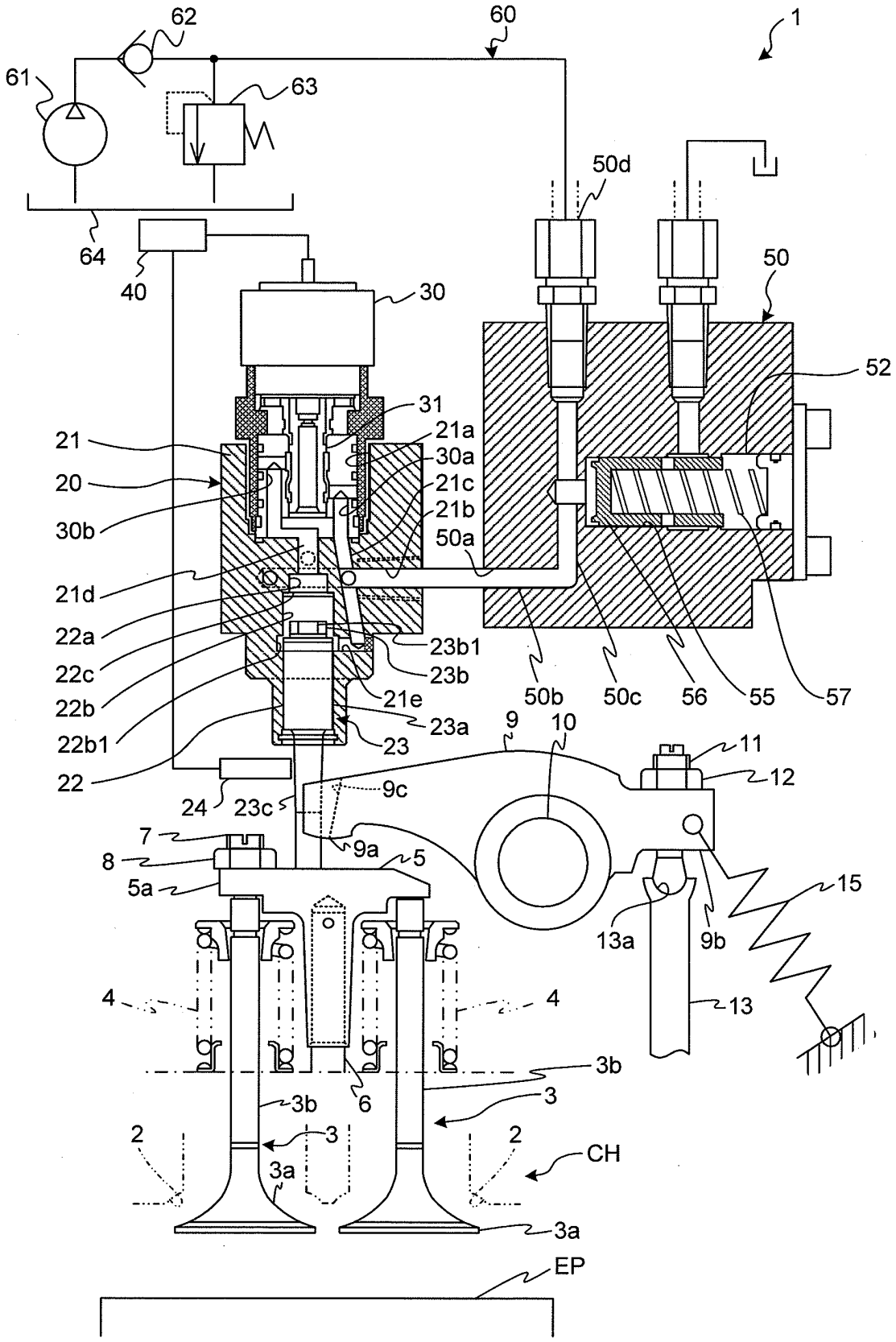
6. The engine valve device according to any of claims 3 to 5, further comprising a check valve which supplies the hydraulic oil from the hydraulic oil supply unit to the hydraulic circuit only if an oil pressure of the hydraulic circuit is lower than that of the hydraulic oil supply unit, and the check valve is arranged between the hydraulic oil supply unit and the hydraulic circuit.

7. The engine valve device according to any of claims 1 to 6, wherein the pressure chamber of the hydraulic actuator is configured to cushion a shock when the intake valve closes.

8. The engine valve device according to any of claims 2 to 7, further comprising:

a push rod which transmits motion from the cam to the rocker arm, the push rod being disposed between the cam and the rocker arm; and
a biasing unit which biases the rocker arm to tightly contact with the push rod.

FIG.1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52
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20
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30b
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50a
21d
22a
22c
22b
22b1
22
23b1
23b
21e
23a
23
50b
50c
56
55
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12
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23c
9c
7
9a
5
8
5a
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13a
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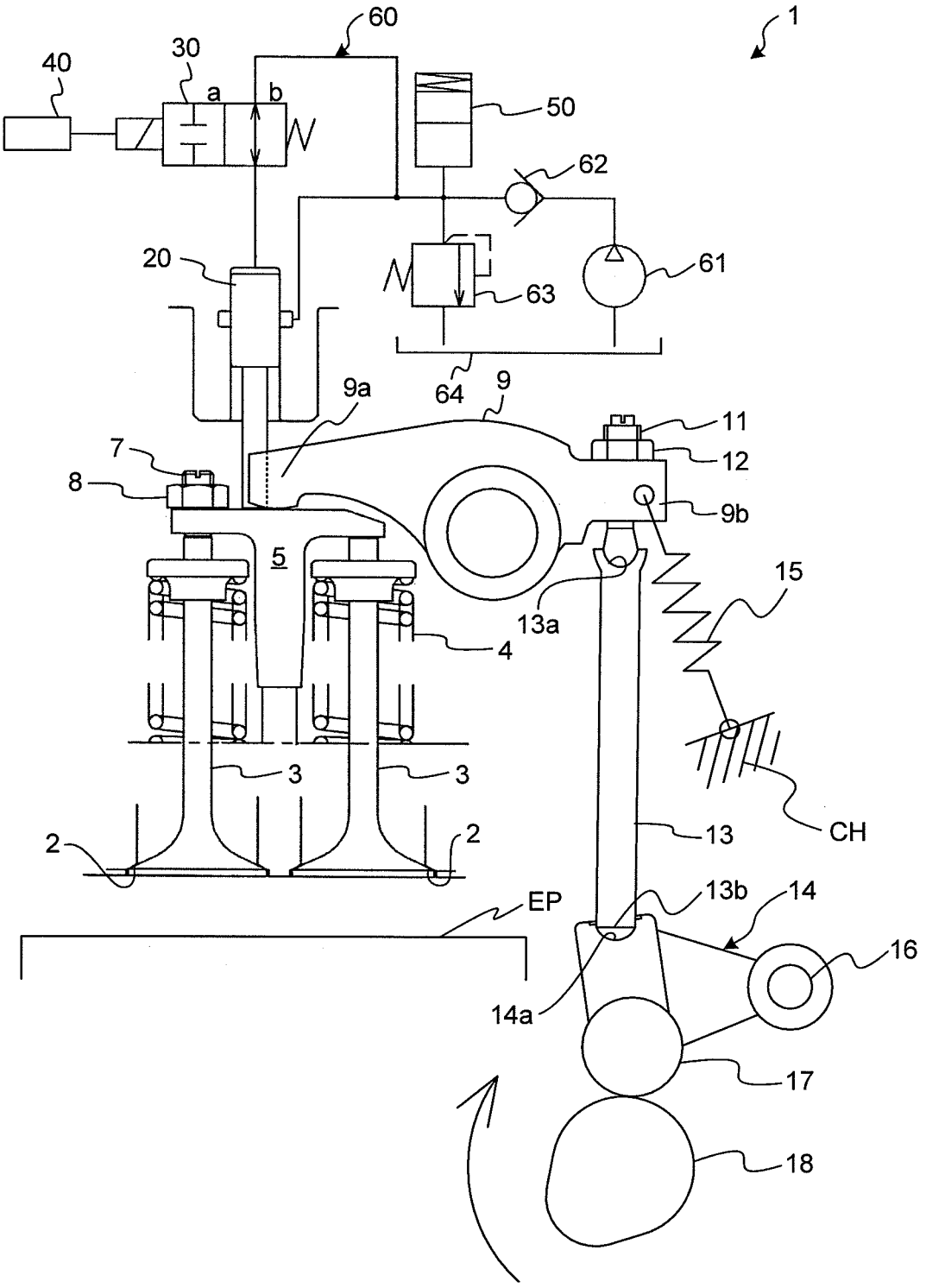
2
3
2
CH
3a
3a
EP

FIG.2A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64
9
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9b
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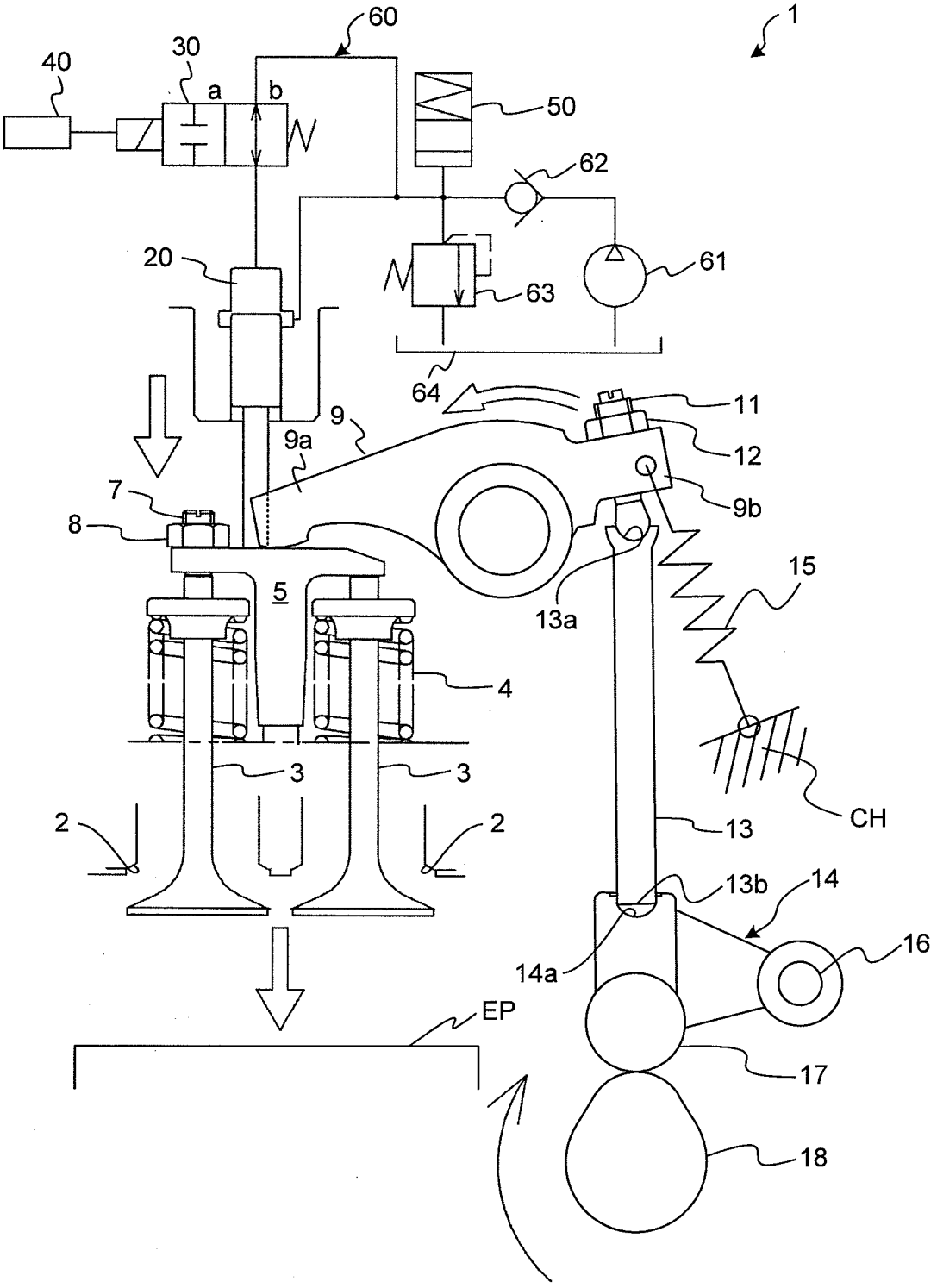
13b
14
16
14a
17
18

FIG.2B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14a
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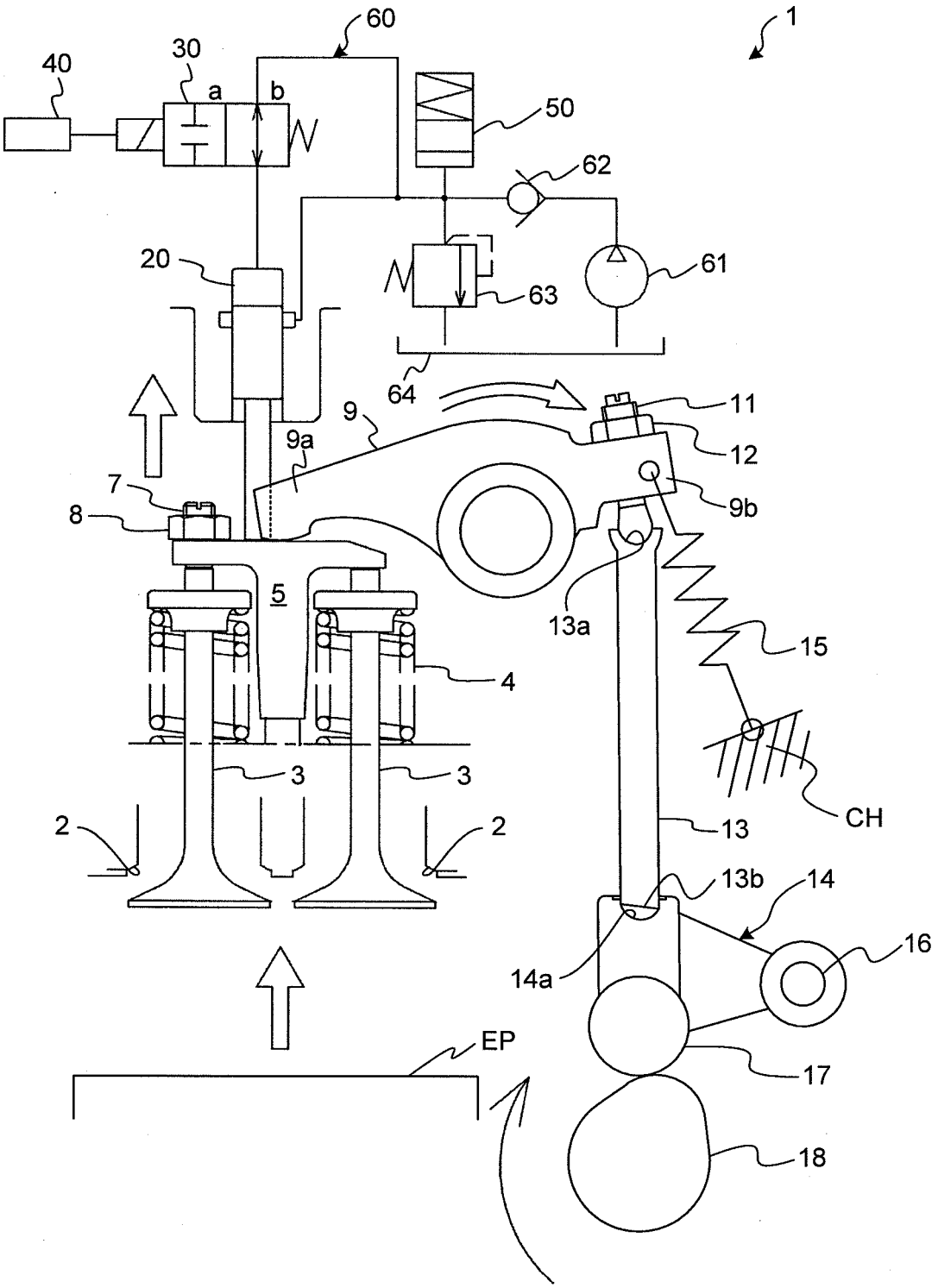
FIG.2C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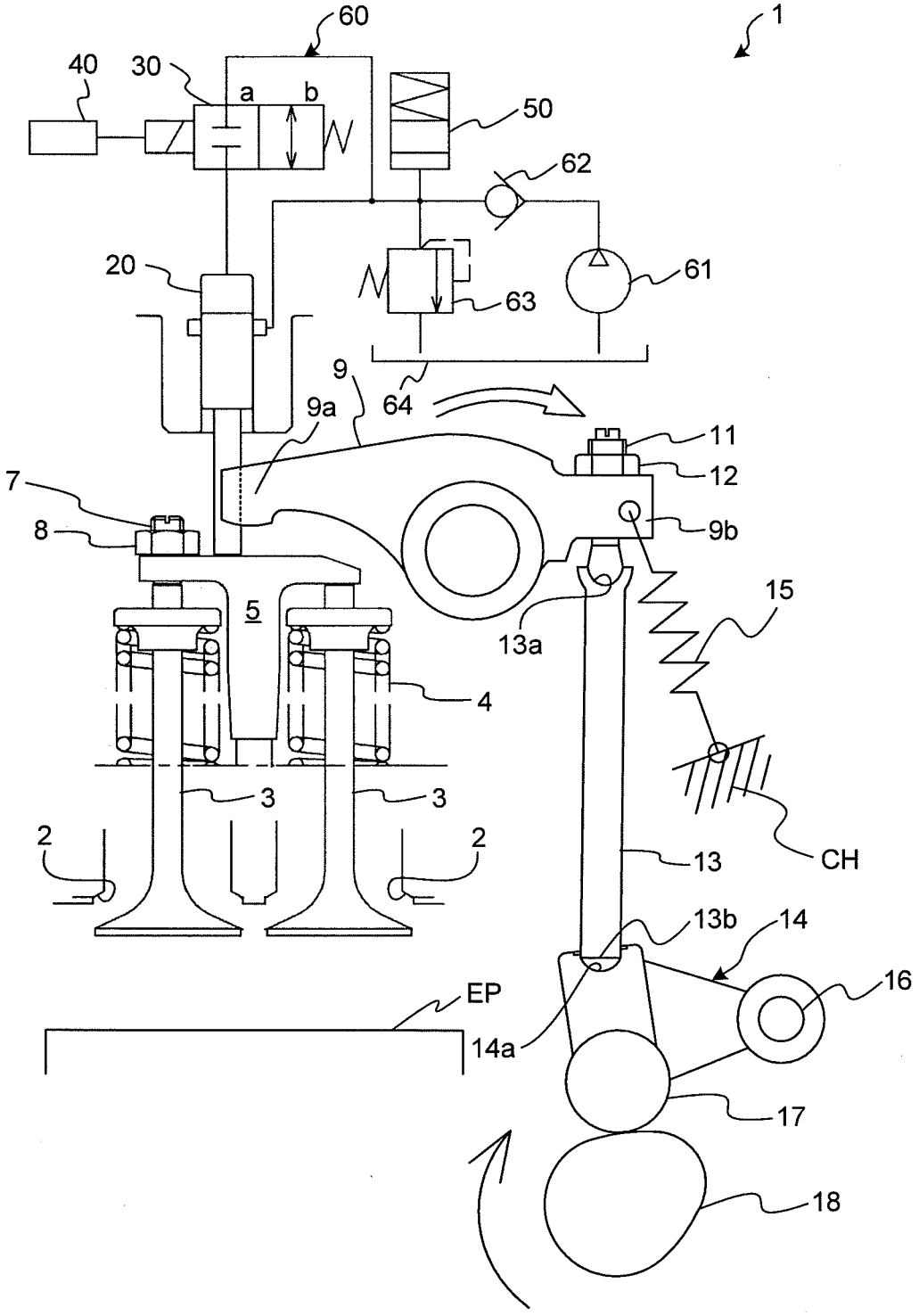
18

FIG.2D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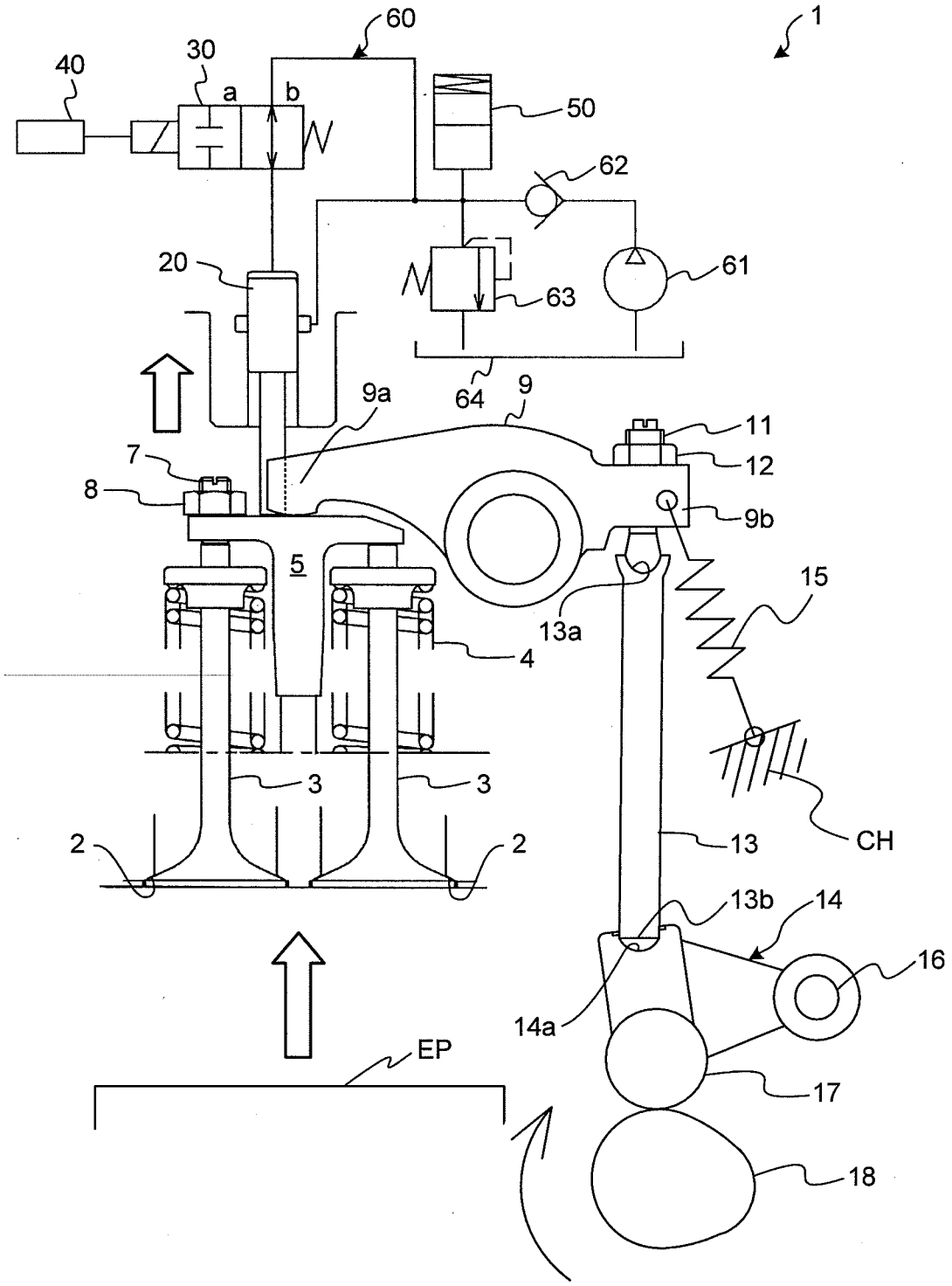
8
9b
15
5
13a
4
3
3
2
2
13
CH
13b
14
16
EP
14a
17
18

FIG.2E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14a
EP
17
18

FIG.3

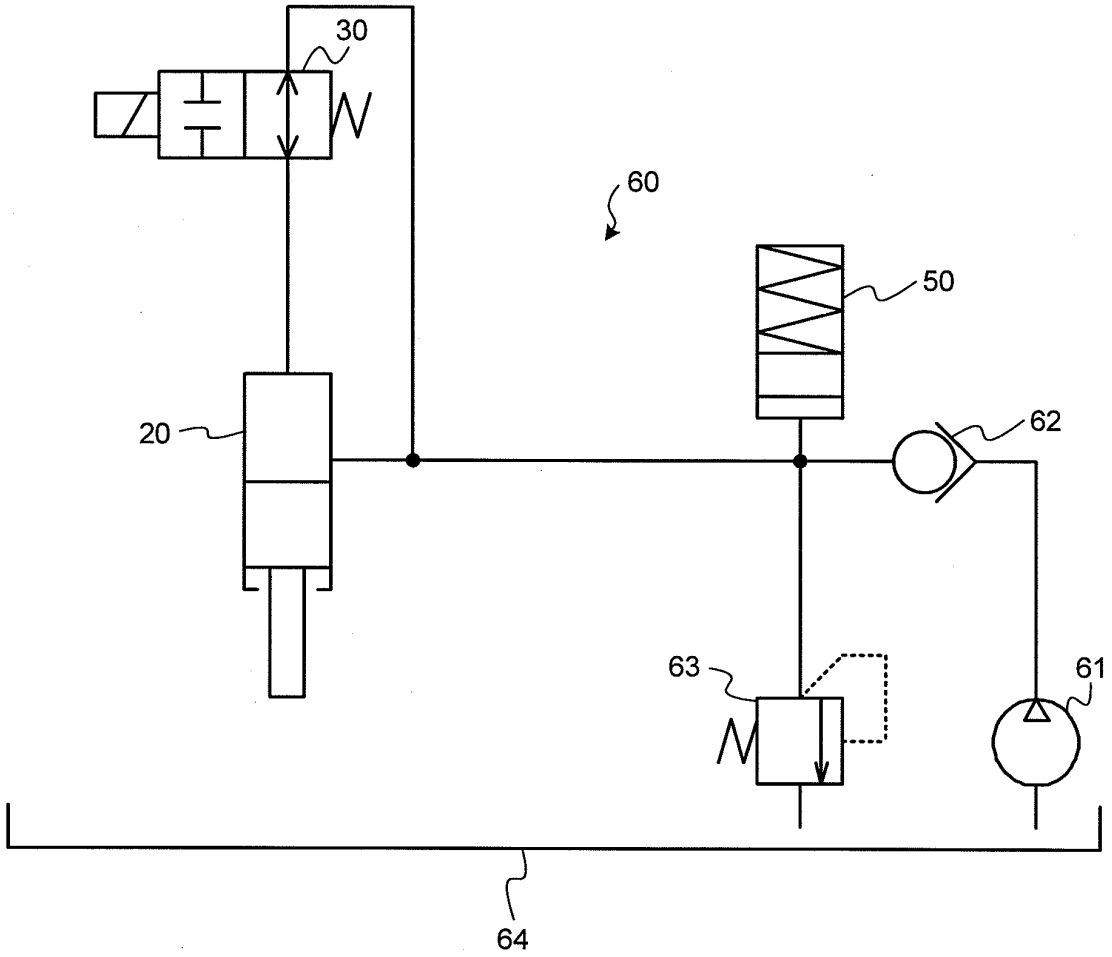


FIG.4

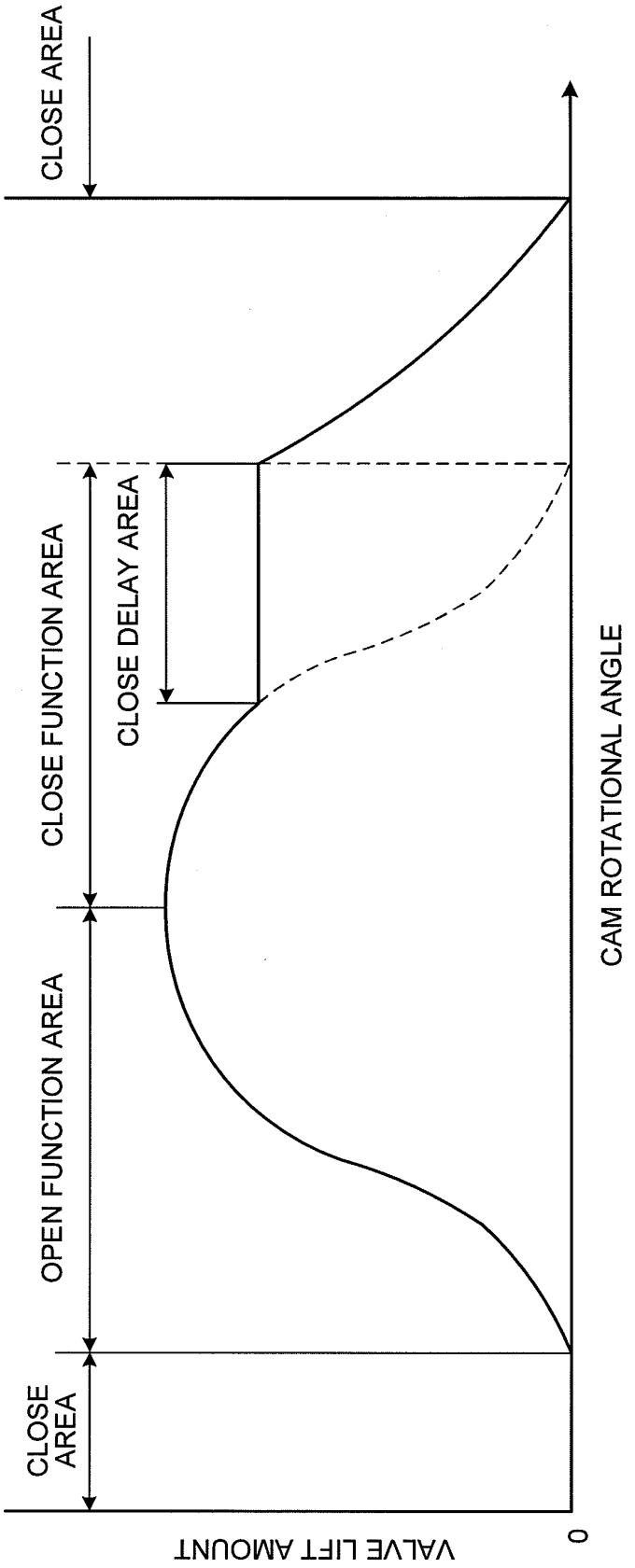

CLOSE AREA
CLOSE FUNCTION AREA
CLOSE DELAY AREA
OPEN FUNCTION AREA
CLOSE AREA
VALVE LIFT AMOUNT
0
CAM ROTATIONAL ANGLE

FIG.5

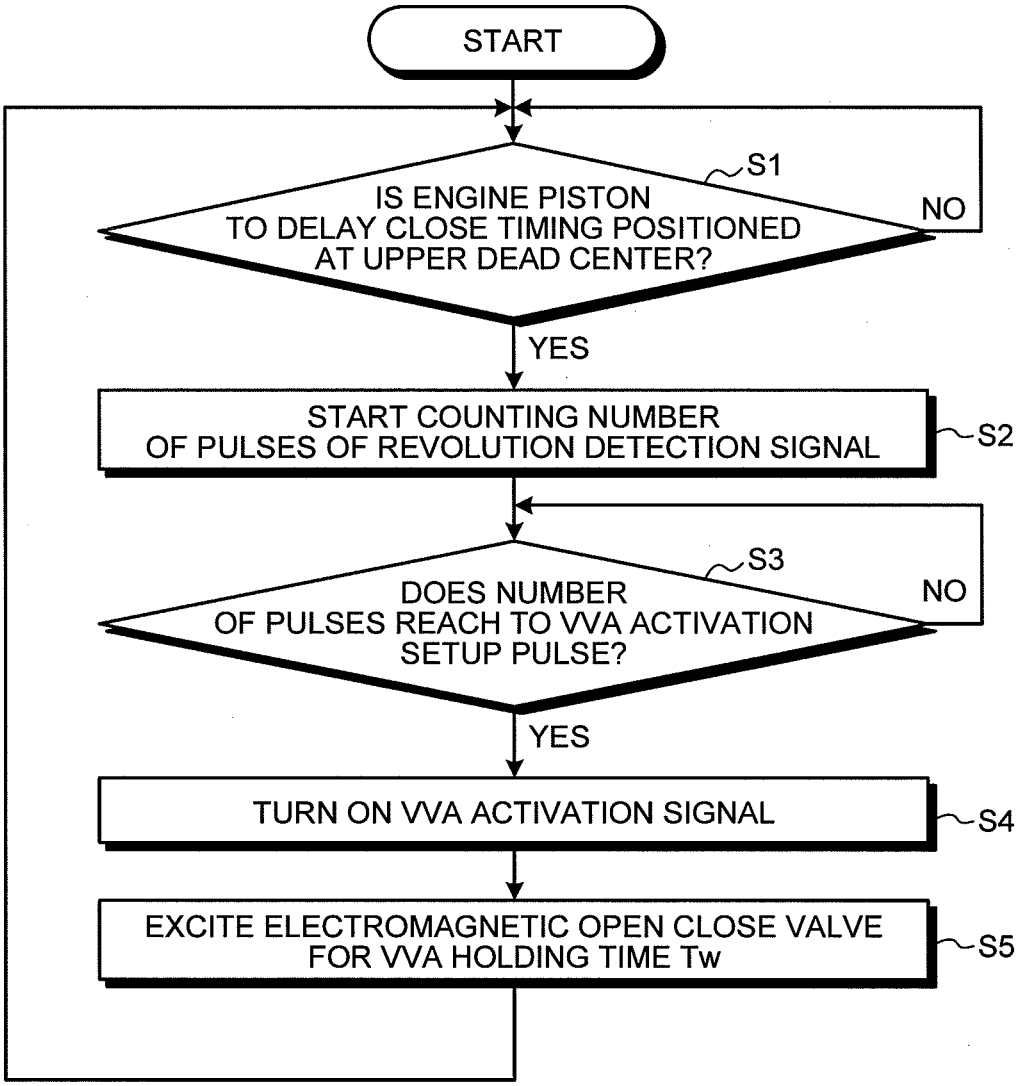

START
S1
IS ENGINE PISTON TO DELAY CLOSE TIMING POSITIONED AT UPPER DEAD CENTER?
NO
YES
START COUNTING NUMBER OF PULSES OF REVOLUTION DETECTION SIGNAL
S2
S3
DOES NUMBER OF PULSES REACH TO VVA ACTIVATION SETUP PULSE?
NO
YES
TURN ON VVA ACTIVATION SIGNAL
S4
EXCITE ELECTROMAGNETIC OPEN CLOSE VALVE FOR VVA HOLDING TIME Tw
S5

FIG.6

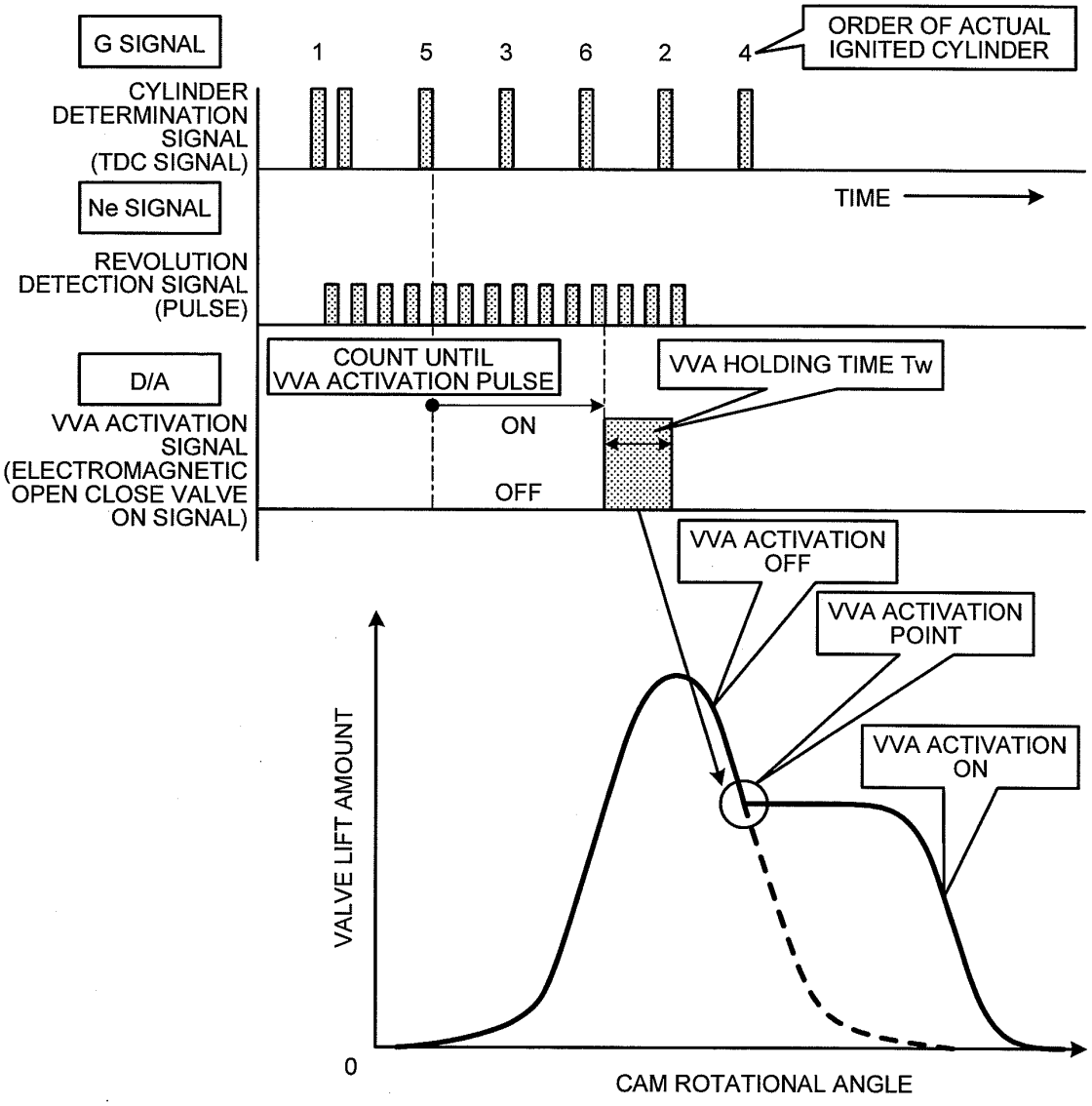

G SIGNAL
1
5
3
6
2
4
ORDER OF ACTUAL IGNITED CYLINDER
CYLINDER DETERMINATION SIGNAL (TDC SIGNAL)
TIME
Ne SIGNAL
REVOLUTION DETECTION SIGNAL (PULSE)
D/A
COUNT UNTIL VVA ACTIVATION PULSE
VVA HOLDING TIME Tw
VVA ACTIVATION SIGNAL (ELECTROMAGNETIC OPEN CLOSE VALVE ON SIGNAL)
ON
OFF
VVA ACTIVATION OFF
VVA ACTIVATION POINT
VVA ACTIVATION ON
VALVE LIFT AMOUNT
0
CAM ROTATIONAL ANGLE

FIG.7

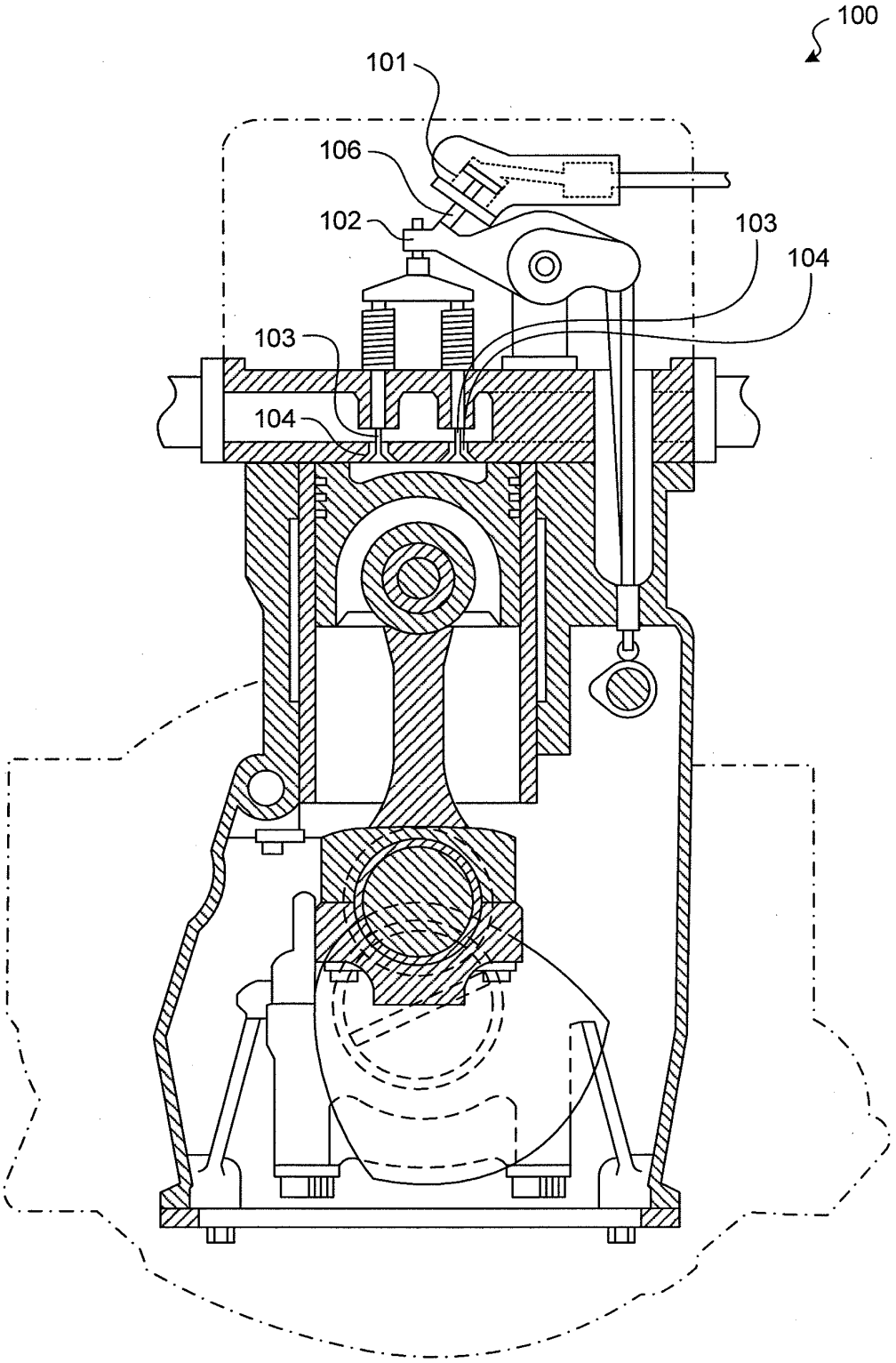
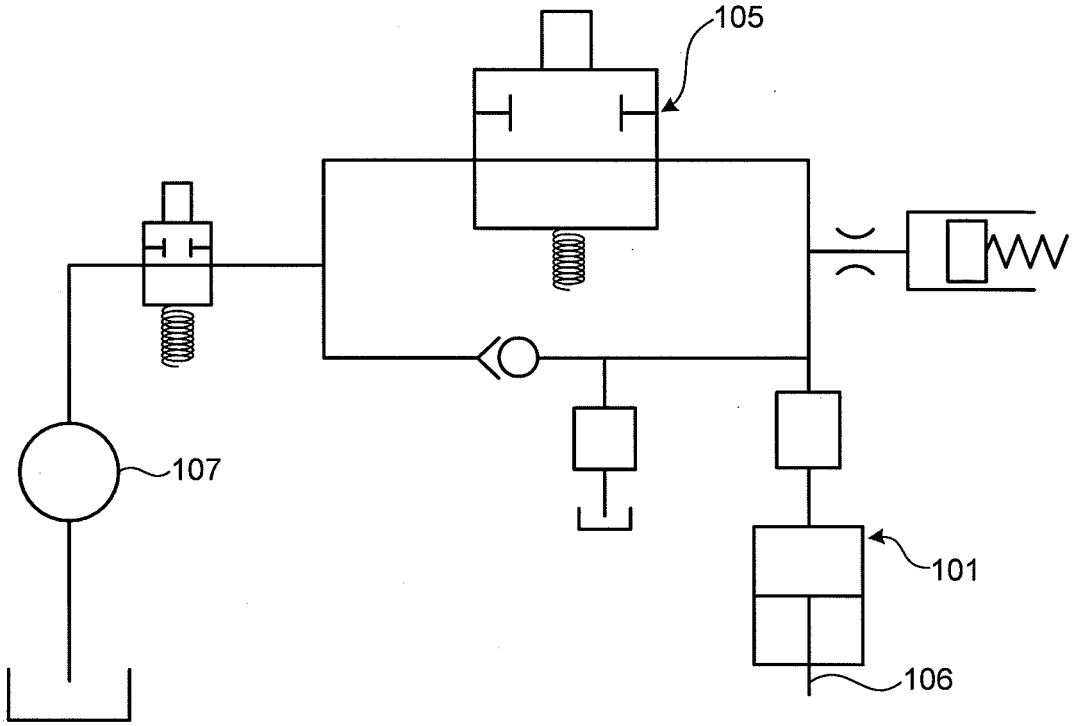


FIG.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/062630

A. CLASSIFICATION OF SUBJECT MATTER
F01L9/02(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)
F01L9/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

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	JP 2005-517110 A (Caterpillar Inc.), 09 June, 2005 (09.06.05), Figs. 2 to 5 & US 2003/0145812 A1 & US 2004/0206331 A1 & US 2005/0247286 A1 & EP 001472437 A1 & WO 2003/067036 A1	1-8
Y	JP 2003-328715 A (Caterpillar Inc.), 19 November, 2003 (19.11.03), Figs. 2, 5, 6 & US 2003/0213442 A1 & US 2003/0213443 A1 & US 2003/0213444 A1 & US 2003/0221644 A1 & US 2005/0235953 A1 & US 2006/0090717 A1 & US 2006/0086329 A1 & EP 001362990 A1 & EP 001416128 A1 & DE 010351940 A1	1-8

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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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
31 August, 2007 (31.08.07)	11 September, 2007 (11.09.07)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/062630

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 9-60506 A (Kubota Corp.), 04 March, 1997 (04.03.97), Figs. 1 to 3 (Family: none)	8
Y	JP 4-330309 A (Mitsubishi Motors Corp.), 18 November, 1992 (18.11.92), Fig. 1 (Family: none)	8
Y	JP 5-248219 A (Mitsubishi Motors Corp.), 24 September, 1993 (24.09.93), Fig. 1 & US 005320082 A & EP 000559199 A1	8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003328715 A **[0003]**