(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 455 937 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **91101372.0**

(51) Int. Cl.[5]: **F01L 9/02**

(22) Date of filing: **01.02.91**

(30) Priority: **11.05.90 JP 120073/90**

(43) Date of publication of application:
13.11.91 Bulletin 91/46

(84) Designated Contracting States:
CH DE DK LI

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(54) Valve driving apparatus of an internal combustion engine.

(57) The known valve driving apparatus of an internal combustion engine including a hydraulic pressure source (17) and an accumulator (16) for pressurizing operating hydraulic oil and accumulating the pressurized operating hydraulic oil, and adapted to drive an intake and exhaust valve (2) by controlling the operating hydraulic oil in the accumulator, is improved. The improved apparatus comprises two logic valves (11, 14) communicated with each other for opening and closing a high-pressure hydraulic oil path communicated with an upper side of an intake and exhaust valve driving piston (9), two electromagnetically driven control valves (13, 15) for controlling opening and closure of the two logic valves, the control hydraulic oil for opening and closing the logic valves and the operating hydraulic oil for driving the intake and exhaust valve to open being fed from the accumulator at a high pressure, and means for closing the intake and exhaust valve with a resilient force generated as a result of lift of the intake and exhaust valve driving piston upon opening of the intake and exhaust valve. Preferably, the means for closing the intake and exhaust valve with a resilient force, consists of an air cylinder (6), and an air piston (5) adapted to slide within the air cylinder as driven by the intake and exhaust valve driving piston (9) and to generate a pneumatic resilient force.

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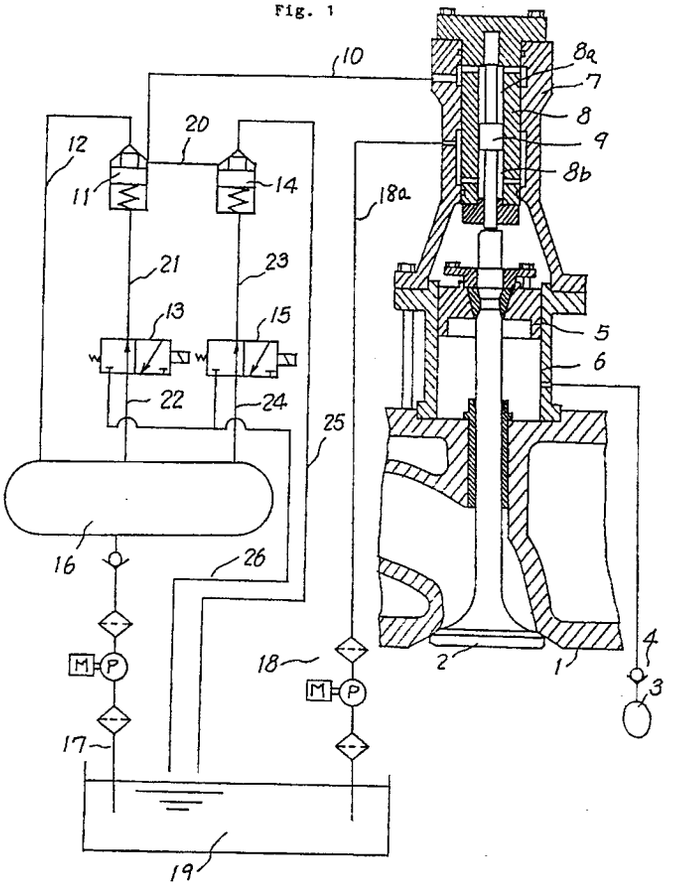
Fig. 1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BACKGROUND OF THE INVENTION:

Field of the Invention:

The present invention relates to a valve driving apparatus of an internal combustion engine of the type of opening and closing an intake and exhaust valve by means of an actuator.

Description of the Prior Art:

One example of an accumulator valve driving apparatus in the prior art is shown in Fig. 2. In the construction of the apparatus, reference numeral 01 designates a hydraulic pressure control valve main body having 5 ports. Numeral 02 designates a control valve, which is driven in synchronism of a crank shaft of an engine via a cam 03 and a roller 04. An intake and exhaust valve 07 is opened and closed on the inside of an actuator 06 mounted to a cylinder cover 05. The actuator 06 includes an upper hydraulic oil chamber 06a and a lower hydraulic oil chamber 06b, which are respectively connected to a control valve 01 via pipings 08 and 09. Reference numeral 010 designates a hydraulic pressure feeder composed of a filter and a pump, and numeral 010a designates a hydraulic oil tank. Reference numeral 011 designates an accumulator, which is maintained at a necessary constant hydraulic pressure and is communicated with the control valve 01 via a piping.

Next, description will be made on operations. Fig. 2 shows the state where the roller 04 is present on a basic circle of the cam 03 and the intake and exhaust valve is closed, and under this condition, hydraulic oil fed from the accumulator 011 flows from the control valve 01 through the piping 09, acts upon the lower hydraulic oil chamber 06b of the actuator 06, and pushes up the intake and exhaust valve 07. At this time, the hydraulic oil in the upper hydraulic oil chamber 06a is led back to the hydraulic oil tank 010a of the hydraulic pressure feeder or pressure source 010 through the piping 08 and the control valve 01.

As the cam 03 rotates, when the roller 04 has lifted, the hydraulic oil in the lower hydraulic pressure chamber 06b of the actuator 06 is discharged through the piping 09 and the control valve 01 to the tank 01a, and simultaneously the high-pressure hydraulic oil in the accumulator 011 is led through the control valve 01 and the piping 08 to the upper hydraulic pressure chamber 06a of the actuator 06 and depresses the intake and exhaust valve 07 to open the valve. As the cam 03 rotates further, when the lift of the cam has been reduced up to the basic circle, the hydraulic oil in the upper hydraulic pressure chamber 06a is discharged to the tank 010a, then the hydraulic oil in the accumulator 011 acts upon the lower hydraulic pressure chamber 06b, and the intake and exhaust valve 07 is raised up to close the same valve.

However, the above-described structure in the prior art involved the following problems.

The control valve 01 has 5 ports and is complicated in structure, also it is necessary to make the amount of hydraulic oil necessitated for opening and closing the intake and exhaust valve flow also through the control valve 01, and hence the hydraulic pressure source is large-sized.

In addition, two pipings 08 and 09 for effecting both opening and closing of the intake and exhaust valve with high-pressure hydraulic oil, are provided, a structure of an actuator is also complicated, consumption of the high-pressure hydraulic oil is much, and hence, a large amount of power is necessitated for that purpose.

Furthermore, the control valve 01 is driven by the cam 03, and so, opening and closing timing of the intake and exhaust valve cannot be varied arbitrarily.

SUMMARY OF THE INVENTION:

It is therefore one object of the present invention to provide an improved valve driving apparatus of an internal combustion engine, which is free from all the above-mentioned shortcomings of the valve driving apparatus in the prior art.

A more specific object of the present invention is to provide a valve driving apparatus of an internal combustion engine, in which a control valve is simple in structure, a large-sized hydraulic pressure source is not necessitated, pipings of high-pressure hydraulic oil for opening and closing a valve as well as a structure of an actuator are simplified, consumption of high-pressure hydraulic oil is reduced, and opening and closing timing of an intake and exhaust valve can be arbitrarily varied.

According to one feature of the present invention, there is provided a valve driving apparatus of an internal combustion engine including a hydraulic pressure source and an accumulator for pressurizing operating hydraulic oil and accumulating the pressurized operating hydraulic oil, and adapted to drive an intake and exhaust valve by controlling the operating hydraulic oil in the accumulator, which apparatus comprises two logic valves communicated with each other for opening and closing a high-pressure hydraulic oil path communicated with an upper side of an intake and exhaust valve driving piston, two electromagnetically driven control valves for controlling opening and closure of the two logic valves, the control hydraulic oil for opening and closing the logic valves and the operating hydraulic oil for driving the intake and ex-

haust valve to open being fed from the accumulator at a high pressure, and means for closing the intake and exhaust valve with a resilient force generated as a result of lift of the intake and exhaust valve driving piston upon opening of the intake and exhaust valve.

According to another feature of the present invention, there is provided the above-featured valve driving apparatus of an internal combustion engine, wherein the means for closing the intake and exhaust valve with a resilient force, consists of an air cylinder, and an air piston adapted to slide within the air cylinder as driven by the intake and exhaust valve driving piston and to generate a pneumatic resilient force.

More particularly, according to the novel features of the present invention, a structure such that the operating hydraulic oil at a high pressure is used only for opening an intake and exhaust valve and closure of the valve is effected with a resilient force of accumulated in a resilient means as a result of lift of the intake and exhaust valve, is employed.

Furthermore, two control valves and two logic valves are provided, and provision is made such that the control valves may be electrically driven to only control the action of a hydraulic pressure applied from an accumulator to large-diameter portions of the logic valves, and hydraulic oil necessitated for opening the intake and exhaust valve may be made to act upon a piston of a hydraulic cylinder within a valve driving actuator from the accumulator via one logic valve and one high-pressure piping.

In addition, the small-diameter sides of the two logic valves are communicated with each other, and upon closing the intake and exhaust valve, the other logic valve is opened so as to release the hydraulic pressure within the hydraulic cylinder and within the high-pressure piping.

In operation, the operating hydraulic oil at a high pressure accumulated in the accumulator acts upon the piston within the valve driving actuator when an opening side logic valve is opened by an opening side control valve which can be electrically driven at an arbitrary timing, and after the piston has depressed the intake and exhaust valve, the closure side control valve returns to its original state and the opening side logic valve is closed. While the intake and exhaust valve continues to be opened by the hydraulic pressure, a compression force of air caused by an air piston moving jointly with the intake and exhaust valve acts as a biassing force in the direction of opening the valve, and as a result of balance between the pneumatic compression force and a force generated by the hydraulic pressure, an appropriate lift can be maintained. When intake or exhaust necessary for the engine has been carried out, the closure side logic valve is opened by the closure side control valve, and since the hydraulic pressure is released, the intake and exhaust valve is closed by the pneumatic spring means.

The above-mentioned operation cycles are repeated.

According to the present invention, owing to the above-described structural and operational features, opening and closing characteristics of an intake and exhaust valve which are optimum for an engine can be obtained, and so, an internal combustion engine of low fuel consumption and excellent performance can be provided. Moreover, as consumption of high-pressure hydraulic oil for driving a valve is also little, a hydraulic pressure source can be designed small and it becomes less expensive. In addition, power consumption is also little, and hence a further low fuel consumption expense is resulted. Also, a small amount of hydraulic oil can suffice in the control valve portion, hence a compact control valve is provided, and a valve driving apparatus having a high reliability and a good durability can be realized.

The above-mentioned and other objects, features and advantages of the present invention will become more apparent by reference to the following description of one preferred embodiment of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

In the accompanying drawings:

Fig. 1 is a system diagram of a valve driving apparatus according to one preferred embodiment of the present invention; and

Fig. 2 is a system diagram of an accumulator type valve driving apparatus in the prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT:

Now, one preferred embodiment of the present invention will be described with reference to Fig. 1. In this figure, reference numeral 1 designates a cylinder cover, numeral 2 designates an intake and exhaust valve, numeral 3 designates an air reservoir, and numeral 4 designates a check valve. Reference numeral 5 designates an air piston, which slides within an air cylinder 6 jointly with the intake and exhaust valve 2. Reference numeral 7 designates a valve driving actuator main body, numeral 8 designates a hydraulic cylinder, numeral 9 designates an actuating piston, numeral 8a designates an upper hydraulic oil chamber, and numeral 8b designates a lower hydraulic oil chamber.

Reference numeral 10 designates a high-pres-

sure piping, numeral 11 designates an opening side logic valve, and numeral 12 designates an opening side logic valve oil path, which is connected to an accumulator 16. Reference numeral 13 designates an opening side spool control valve, which is driven by a controller not shown in synchronism with rotation of a crank of an engine. Reference numeral 14 designates a closure side logic valve, numeral 15 designates a closure side spool control valve, which is driven by a controller not shown similarly to the opening side spool control valve 13, and which is a 3-port control valve. Reference numeral 16 designates an accumulator, and numeral 17 designates a hydraulic pressure source, which feeds high-pressure hydraulic oil and consists of a pump and a filter. Reference numeral 18 designates a low-pressure hydraulic pressure source, which communicates with the valve driving actuator 7 through a piping 18a. Reference numeral 19 designates an oil tank, numeral 20 designates a communication oil path connecting the opening side logic valve 11 with the closure side logic valve 14, numeral 21 designates an oil path connecting a large-diameter side of the opening side logic valve 11 with the opening side spool control valve 13, numeral 22 designates an oil path connecting an opening side spool control valve 13 with the accumulator 16, numeral 23 designates an oil path connecting a large-diameter side of the closure side logic valve 14 with the closure side spool control valve 15, and numeral 24 designates an oil path connecting the closure side spool control valve 15 with the accumulator 16.

Reference numeral 25 designates an oil discharge piping extending from the closure side logic valve 14 to the oil tank 19, numeral 26 designates an oil discharge piping extending from the spool control valves 13 and 15.

These spool control valves are 3-port control valves having a P-port, a C-port and a T-port, and they are electromagnetically driven.

Next, description will be made on operations of the illustrated apparatus.

Fig. 1 shows the state where an air pressure in the air reservoir 3 acts upon the lower side of the air piston 5 and the intake and exhaust valve 2 is kept closed.

At this time, the opening side and closure side spool control valves 13 and 15 would make the hydraulic pressure fed from the accumulator 16 act upon the large-diameter sides of the opening and closure logic valves 11 and 14, and thereby the logic valves 11 and 14 are kept closed.

When the valve opening timing of the intake and exhaust valve 2 has come, the opening side spool control valve 13 is driven at an appropriate time determined by a computer in response to a trigger signal issue in synchronism with an engine not shown and on the basis of the operating condition of the engine. When the same control valve 13 operates, the oil path 22 is closed, the oil path 21 communicates with the oil discharge piping 26, and since the hydraulic pressure on the large-diameter side of the logic valve 11 is released, the logic valve 11 opens, and hence the hydraulic pressure in the accumulator 16 acts upon the upper hydraulic oil chamber 8a of the hydraulic cylinder 8 within the valve driving actuator 7 through the oil path 12 and the high-pressure piping 10. The hydraulic piston 9 is depressed by this hydraulic pressure, and thereby the intake and exhaust valve 2 is opened.

At this time, the air within the air cylinder 6 is compressed and exerts an upward force upon the air piston 5, and the intake and exhaust valve 2 lifts up to the point where the upward force balances with a downward force generated by the hydraulic pressure.

Thereafter, the opening side control valve 13 is returned to its original position, hence the hydraulic pressure in the accumulator 16 acts upon the large-diameter portion of the opening side logic valve 11, and the opening side logic valve 11 is closed.

When the intake or exhaust necessary for the engine has been done, the closure side spool control valve 15 is driven, the oil path 23 and the oil discharge piping 26 are communicated simultaneously with closure of the oil path 24, and since the hydraulic pressure on the large-diameter side of the logic valve 14 is released, the logic valve 14 is opened, hence the hydraulic pressure acting upon the upper hydraulic oil chamber 8a is released through the high-pressure piping 10 and the communication oil path 20 to the oil discharge piping 25, and the acting force of the hydraulic pressure disappears. Then, the intake and exhaust valve 2 is closed by the resilient force generated by compression of air and acting upon the air piston 5. At this time, hydraulic oil fed from the low-pressure hydraulic pressure source 18 is supplied to the lower hydraulic oil chamber 8a, and so, the actuating piston 9 returns to its raised position under a stable condition without producing a cavity.

It is to be noted that while a return device for the intake and exhaust valve by means of an air spring was employed in the above-described embodiment, a return device relying upon a conventional coil spring can be also utilized.

As will be obvious from the detailed description of one preferred embodiment above, according to the present invention, owing to the fact that in a valve driving apparatus of an internal combustion engine including a hydraulic pressure source and an accumulator for pressurizing operating hydraulic oil and accumulating the pressurized operating hy-

draulic oil and adapted to drive an intake and exhaust valve by controlling the operating hydraulic oil in the accumulator, there are provided two logic valves communicated with each other for opening and closing a high-pressure hydraulic oil path communicated with an upper side of an intake and exhaust valve driving piston, two electromagnetically driven control valves for controlling opening and closure of the two logic valves, the control hydraulic oil for opening and closing the logic valves and the operating hydraulic oil for driving the intake and exhaust valve to open being fed from the accumulator at a high pressure, and means for closing the intake and exhaust valve with a resilient force generated as a result of lift of the intake and exhaust valve driving piston upon opening of the intake and exhaust valve, the following advantages are offered:

(1) Since opening and closing characteristics of an intake and exhaust valve which are optimum for an engine can be obtained, an internal combustion engine of low fuel consumption and excellent performance can be provided.

(2) Since consumption of high-pressure hydraulic oil for driving a valve is also little, a hydraulic pressure source can be designed small, and it becomes less expensive. In addition, power consumption is also little, and hence, a further low fuel consumption expense is resulted.

(3) Since a small amount of hydraulic oil can suffice in the control valve portion, a compact control valve is provided, and a valve driving apparatus having a high reliability and a good durability can be realized.

While a principle of the present invention has been described above in connection to one preferred embodiment of the invention, it is intended that all matter contained in the above description and illustrated in the accompanying drawings shall be interpreted to be illustrative and not as a limitation to the scope of the invention.

Claims

1. A valve driving apparatus of an internal combustion engine including a hydraulic pressure source and an accumulator for pressurizing operating hydraulic oil and accumulating the pressurized operating hydraulic oil, and adapted to drive an intake and exhaust valve by controlling the operating hydraulic oil in the accumulator; characterized in that said apparatus comprises two logic valves communicated with each other for opening and closing a high-pressure hydraulic oil path communicated with an upper side of an intake and exhaust valve driving piston, two electromagnetically driven control valves for controlling opening and closure of said two logic valves, the control hydraulic oil for opening and closing said logic valves and the operating hydraulic oil for driving said intake and exhaust valve to open being fed from said accumulator at a high pressure, and means for closing said intake and exhaust valve with a resilient force generated as a result of lift of said intake and exhaust valve driving piston upon opening of the intake and exhaust valve.

2. A valve driving apparatus for an internal combustion engine as claimed in Claim 1, characterized in that said means for closing the intake and exhaust valve with a resilient force, consists of an air cylinder, and an air piston adapted to slide within said air cylinder as driven by said intake and exhaust valve driving piston and to generate a pneumatic resilient force.

Fig. 1

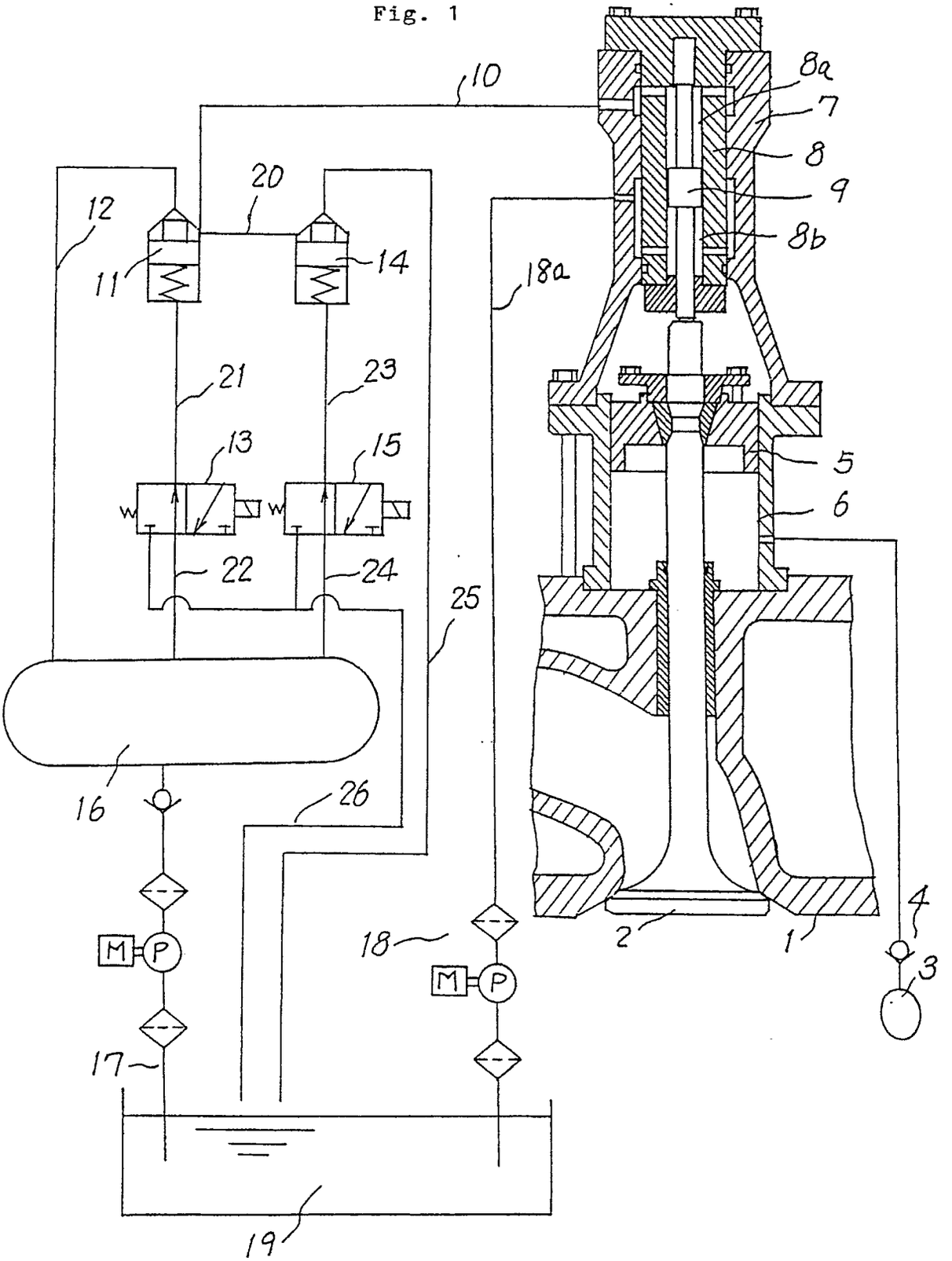
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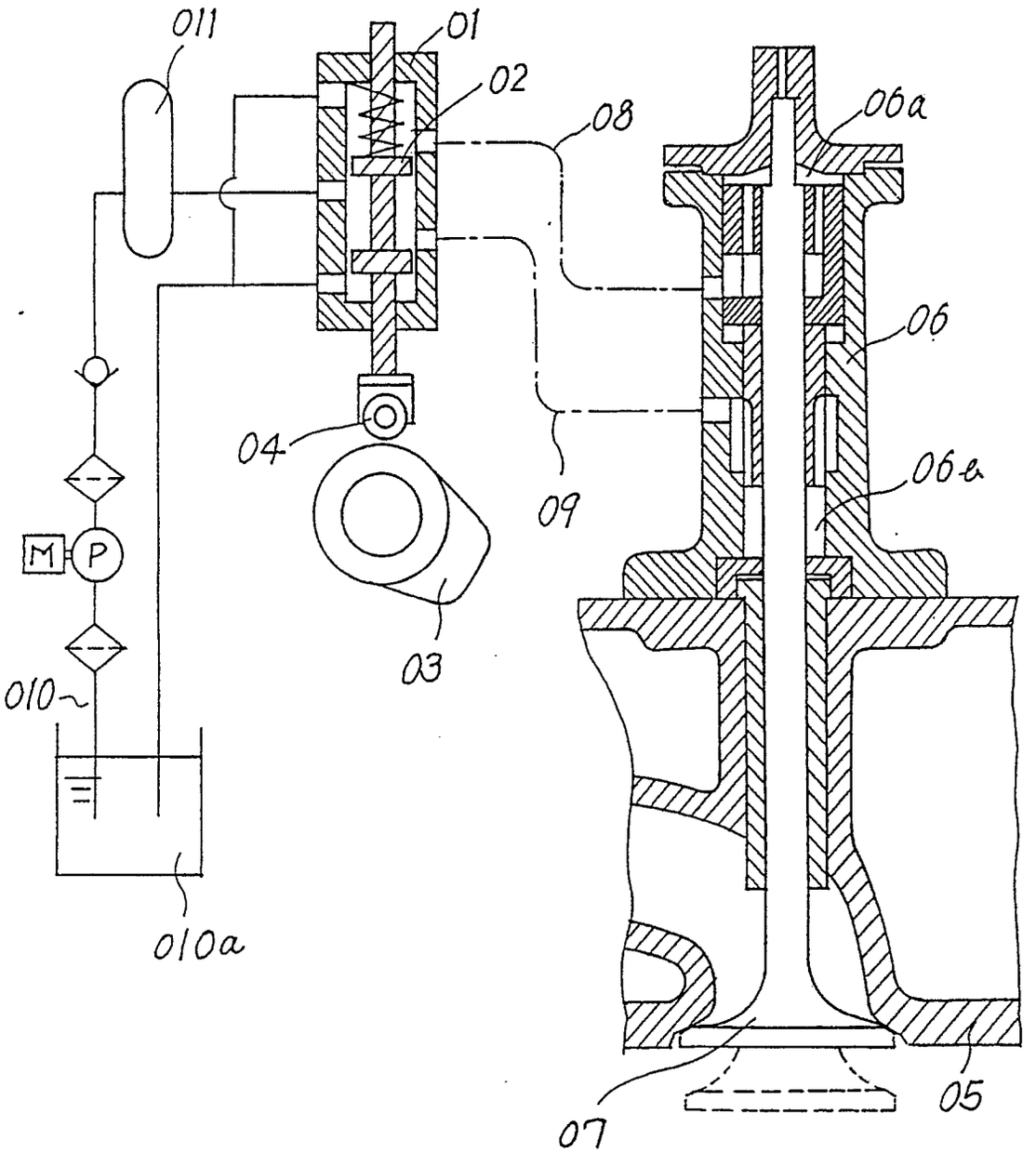
Fig. 2



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 10 1372

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A,D	PATENT ABSTRACTS OF JAPAN, vol. 14, no. 575 (M-1062)[4518], 20th December 1990; & JP-A-02 248 607 (TECH. RES. ASSOC. HIGHLY RELIAB. MARINE PROPUL. PLANT) 04-10-1990	1,2	F 01 L 9/02
A	PATENT ABSTRACTS OF JAPAN, vol. 9, no. 51 (M-361)[1774], 6th March 1985; & JP-A-59 188 016 (HITACHI) 25-10-1984	1	
A	FR-A-1 361 178 (MITSUBISHI) * Page 2, left-hand column, lines 47-50, right-hand column, lines 4-32; figure 1 *	1	
A,P	EP-A-0 391 507 (MITSUBISHI) * Abstract; figure 1 *	1,2	
A	GB-A-2 102 065 (SULZER) * Page 2, claim 1; sole figure *	2	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F 01 L

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	29 August 91	KLINGER T.G.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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