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(54) Title: A HYDRAULIC VALVE ARRANGEMENT FOR CONTROLLABLY OPERATING A GAS EXCHANGE VALVE OF AN INTERNAL COMBUSTION PISTON ENGINE

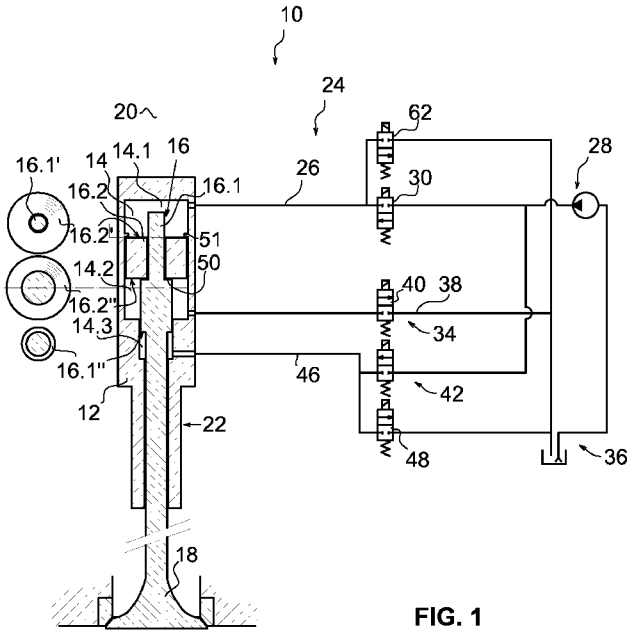

FIG. 1

(57) Abstract: Invention relates to a hydraulic valve arrangement (10) for controllably operating a gas exchange valve of an internal combustion piston engine, the arrangement comprising a body part (12) in which body part a first fluid chamber (14.1) is arranged bordered by radial surfaces (16.1', 16.2') of first and second piston parts and having a volume that increases in response to the piston parts (16.1, 16.2) moving relative to the body part in a first direction, and a second fluid chamber (14.2) is arranged bordered by radial surface (16.2") of the second piston part having a volume that decreases in response to the second piston part moving relative to the body part in a first direction. The first and the second piston parts are arranged slidably in respect to each other and that the movement of the second piston (16.2) part relative to the body part (12) is arranged controllable by a fluid control system (24) arranged in connection with the hydraulic valve arrangement (10).

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A hydraulic valve arrangement for controllably operating a gas exchange valve of an internal combustion piston engine

Technical field

[001] The present invention relates to a hydraulic valve arrangement for controllably operating a gas exchange valve of an internal combustion piston engine, the arrangement comprising a body part having a working space into which an operating piston is arranged, which operating piston comprises at least a first and a second concentric piston parts, and in which body part a first fluid chamber is arranged bordered by radial surfaces of both the first and the second piston parts and having a volume that increases in response to the piston parts moving relative to the body part in a first direction, and a second fluid chamber is arranged bordered by radial surface of the second piston part having a volume that decreases in response to the second piston part moving relative to the body part in a first direction.

Background art

[002] An internal combustion engine typically includes a plurality of gas exchange valves. These valves control the intake and exhaust gas flow through the combustion chamber(s) of the engine. A typical engine will include at least one intake valve and at least one exhaust valve for each cylinder or combustion chamber of the engine. The opening of each valve is timed to occur at a predetermined cam or crank shaft angle in the operating cycle of the engine. It's well known that it is beneficial to control the time that gas exchange valves of engine are open while the engine is running. The maximum capacity of the engine may be effected by prolonging the time valves are open when running speed is high and when the maximum

capacity is needed, for example. Also, the available engine torque can be increased at partial load and lower revolutions, for example, by choosing suitable opening times for the valves. By adjusting the optimal open time of valves during each stroke of the engine according to its operating mode, the consumption of fuel and harmful emissions can be reduced.

[003] The actuation of such adjustable valves may be accomplished by means of a hydraulic valve operating system. As an example of such system EP 140347381 B1 discloses an actuation assembly having a body, a valve moving piston arranged slidable relative to the body, and first, second, and third hydraulic chambers defined between the piston and the body, wherein the first and second chambers have volumes that decrease and the third chamber has a volume that increases in response to the piston moving relative to the body in a first direction.

[004] US 2004055547 A1 shows a hydraulic actuator in which an operating piston is designed in such a way that the areal surface of at least one of the two effective areas changes along the sliding path of the operating piston. Specifically it shows an arrangement in which the piston has a plurality of parts and has two partial pistons which have different axial lengths and they are concentrically inserted inside each other so as to be movable relative to each another. Thus, by means of the combined effective areas of the concentric pistons gas exchange valve may be rapidly opened with great displacement force, which then rapidly drops and remains constant over the rest of the valve lift by means of the inner piston only.

[005] Hydraulic actuators provide extensive possibilities for controlling and adjusting the valve opening and closing during the operation of the engine. However, a challenge of hydraulic gas exchange valve actuation is energy efficiency due to considerably high flow rates of hydraulic fluid.

[006] It is an object of the invention to provide a hydraulic valve arrangement for controllably operating a gas exchange valve of an internal com-

bustion piston engine which provides flexible controllability and minimizes energy consumption.

Disclosure of the Invention

[007] The objects of the invention are substantially met by a hydraulic valve arrangement for controllably operating a gas exchange valve of an internal combustion piston engine, the arrangement comprising a body part having a working space into which an operating piston is arranged, which operating piston comprises at least a first and a second concentric piston parts arranged slidably in respect to each other, and in which body part a first fluid chamber is arranged bordered by radial surfaces of both the first and the second piston parts and having a volume that increases in response to the piston parts moving relative to the body part in a first direction, and a second fluid chamber is arranged bordered by radial surface of the second piston part having a volume that decreases in response to the second piston part moving relative to the body part in a first direction. It is characteristic to the invention that the movement of the second piston part in the first direction relative to the body part is arranged independently from the first piston part controllable by a fluid control system arranged in connection with the hydraulic valve arrangement.

[008] This way it is possible to adjust the arrangement the work done by the hydraulic fluid with optimum flow rate in respect to the required force for moving the piston in the first direction.

[009] .

[0010] According to an embodiment of the invention the fluid control system comprises a pressure line connected to a source of pressurized fluid and to the first fluid chamber and being provided with a pressure valve, and each of the fluid chambers having a volume that decreases in response to at

least one of the piston parts moving relative to the body part in a first direction, is in controllable fluid communication with the pressure line.

[0011] According to an embodiment of the invention the fluid control system comprises a fluid line connecting the second fluid chamber controllably to a low pressure part of the fluid control system.

[0012] According to an embodiment of the invention a third fluid chamber is arranged being bordered by radial surfaces of at least the first piston part having a volume that decreases in response to the first piston part moving relative to the body part in a first direction. The first and the third fluid chambers are selectively connectable to a pressurized hydraulic fluid source.

[0013] According to an embodiment of the invention the radial surface of the first piston part bordering the first fluid chamber is smaller than the radial surface of the first piston part bordering the third fluid chamber and the radial surface of the first piston part bordering the third fluid chamber is smaller than the radial surface of the second piston part bordering the second fluid chamber.

[0014] According to an embodiment of the invention first piston part is arranged freely movable in respect to the second piston part in the first direction and it is provided with a mechanical stop which delimits the movement of the second piston part in respect to the first piston part.

Brief Description of Drawings

[0015] In the following, the invention will be described with reference to the accompanying exemplary, schematic drawings, in which

Figure 1 illustrates a hydraulic valve arrangement for controllably operating a gas exchange valve of an internal combustion piston engine according to an embodiment of the invention,

Figure 2 illustrates a hydraulic valve arrangement for controllably operating a gas exchange valve of an internal combustion piston engine according to another embodiment of the invention, and

Figure 3 illustrates a hydraulic valve arrangement for controllably operating a gas exchange valve of an internal combustion piston engine according to still another embodiment of the invention.

Detailed Description of Drawings

[0016] In figure 1 there is schematically shown a hydraulic valve arrangement 10 for an internal combustion piston engine according to an embodiment of the invention.

[0017] By means of the hydraulic valve arrangement the operation of a valve i.a. its timings in respect to the cycle of the piston and opening and/or closing ramps may be controlled in very flexibly manner. The arrangement comprises a body part 12 into which a working space 14 is arranged. The arrangement comprises further an operating piston 16 which is arranged into the working space. The operating piston is in force transmission connection with a gas exchange valve 18 of the engine. The operating piston 16 is arranged movably in the working space 14 so that it may move in first direction which causes opening movement of the gas exchange valve 18 and respectively in second direction opposite to the first direction which causes closing movement of the gas exchange valve 18. The working space 14 is arranged rotationally symmetrical manner in respect to its central axis 20. The working space extends as a guiding section 22 at its one end which has inner diameter selected in respective to the outer diameter

of the operating piston 16 at corresponding area so that desired guiding effect for the piston 16 is achieved.

[0018] The operating piston 16 comprises at least a first 16.1 and a second 16.2 concentric piston parts. The first and the second piston parts 16.1, 16.2 are arranged slidably in respect to each other so that the movement of the second piston part 16.2 in the first direction relative to the first part is delimited by a mechanical stop 50 arranged to the first piston part 16.1. There is also a second mechanical stop 51 arranged to the body part 12 which cooperates with the second piston part 16.2 The second stop limits the movement of the second piston part 16.2 in the second direction to a predetermined position in respect to the body part 12. The second stop defines the initial position of the second piston part 16.2. The piston parts are arranged controllable by a fluid control system 24 arranged in connection with the hydraulic valve arrangement.

[0019] In figure 2 there is shown a valve arrangement 10 which identical to that shown in figure 1 described above but which is controllable by a fluid control system 24 which allow more sophisticated control of the valve arrangement.

[0020] During the operation of the hydraulic valve arrangement according to an embodiment of the invention shown in figure 1 and figure 2 the second piston part 16.2 is assisting the movement of the first piston part 16.1 in the first direction when the valve 18 is to be opened. During the returning movement of the operating piston the first piston part 16.1 pushes the second piston part back to its initial position against the second mechanical stop 51.

[0021] In the body part 12 there is a first fluid chamber 14.1 arranged in the working space partially bordered by radial surfaces 16.1', 16.2' of both the first and the second piston parts 16.1 16.2 at their first ends and having a volume that increases in response to either or both of the piston parts 16.1,

16.2 moving relative to the body part 14 in the first direction, that is downwards in the figures 1 and 2. The working space includes also a second fluid chamber 14.2 which is arranged in the working space partially bordered at least by radial surface 16.2'' of the second piston part at its second end having a volume that decreases in response to the second piston part moving relative to the body part in the first direction being downwards direction in the figures1 and 2.

[0022] As shown in figure 1 and 2 radial surfaces 16.1', 16.2', 16.2'' define effective areas so that 16.1' defines the area of the first end of the first piston part 16.1, 16.2' defines the area of the first end of the second piston part 16.2 and 16.2'' defines the area of the second end of the second piston part when being against the mechanical stop 50 arranged to the first piston part in a form of shoulder.

[0023] The fluid control system 24 comprises a pressure line 26 connected to a source of pressurized fluid 28 and also to the first fluid chamber 14.1 and is provided with a pressure valve 30. Thus it is possible to controllably admit pressurized fluid in to the chamber 14.1 and subject force to the piston parts 16.1 and 16.2. Now, the movement of the second piston part 16.2 relative to the body part 12 is arranged controllable by a fluid control system 24 so that the second fluid chamber 14.2 having a volume that decreases in response to the second piston part 16.2 moving relative to the body part in a first direction is in controllable fluid communication 34 to a low pressure part 36 of the fluid control system. This way the movement of the second piston part 16.2 is arranged independently controllable in the by the fluid control system 24. More particularly, the fluid control system 24 comprises a fluid line 38 having a valve 40 connecting the second fluid chamber 14.2 controllably to the low pressure part 36. By means of the valve 40 in the fluid line it is possible to control the flow of fluid from the second fluid chamber 14.2. The fluid flow out from the second chamber defines the state of moving of the second piston part 16.2. Thus, when the flow of fluid is prevented

out of the second fluid chamber 14.2 the second piston part 16.2 may not move even if the valve 30 is open. In that case only the piston part 16.1 moves and the piston part 16.2 substantially remains its current position representing to position when the valve 30 is closed. The valve 30 may be controlled to be closed at any suitable moment during the movement of the piston 16 so that the movement of the second piston part 16.2 is moved along the first piston part 16.1 only to a desired extent.

[0024] As depicted in figure 2, according to an embodiment of the invention the second fluid chamber 14.2 is additionally in controllable fluid communication 32 with the first fluid chamber 14.1. In the embodiment of figure 2 this has been realized by controllable fluid communication 32 with pressure line 26 downstream the pressure valve 30 having a valve 31. This way the pressurized fluid may be caused to effect on both ends of the second piston part 16.2. Since the radial surface 16.2' at the first end of the second piston part is bigger than the radial surface 16.2'' at the second end of the second piston part at the initial position shown in figure 2 the force subjected by the second piston part 16.2 to the first piston part 16.1 is defined by the difference of the surface areas 16,2' and 16,2''. Thus, the effect of the second piston part 16.2 is controlled by opening the fluid flow communication from the second fluid chamber 14.2 to either to pressure line or the low pressure part 36 of the system or closing the fluid flow communication from the second fluid chamber 14.2. In case the control valve 31 is open and the control valve 40 is closed and hydraulic fluid is fed to the first fluid chamber 14.1 hydraulic fluid is returned from the second fluid chamber 14.2 to the pressure line 26, and thus the needed flow rate from the pressurized hydraulic fluid source is smaller. Thus, the stopping of the movement of the second piston part in the first direction relative to the body part is arranged independently from the first piston part. This also means stopping of the transmitting force from the second piston part to the first piston part. This feature is shown in all figures 1 - 3.

[0025] The working space 14 and the first piston part 16.1 delimit a third fluid chamber 14.3 which is arranged partially bordered by radial surface 16.1'' of at least the first piston part 16.1 the chamber having a volume that decreases in response to the first piston part moving relative to the body part in a first direction. The third fluid chamber is selectively connectable by means of a fluid line 46 having a valve 42 to a pressurized hydraulic fluid source 28 which facilitates the movement of the piston in the second direction i.e. the direction causing the movement of the gas exchange valve 18 in its closing direction. The pressure line i.e. the first chamber 14.1 is also selectively connectable by means of a fluid line having a valve 62 to the low pressure part 36 of the system.

[0026] As shown in figure 2 the third fluid chamber 14.3 is also in controllable fluid communication 44 with the first fluid chamber 14.1. In the embodiment of figure 2 this has been realized by controllable fluid communication 44 with the pressure line 26 downstream the pressure valve 30 having a valve 43. This way the pressurized hydraulic fluid may be caused to effect on first end of the first piston part 16.1 and its radial surface 16.1''. Since the radial surface 16.1' at the first end of the first piston part is bigger than the radial surface 16.1'' bordering the third chamber the force subjected to the first piston part 16.1 is defined by the difference of the surface areas when the communication from the third chamber to the pressure line 26 is open. Thus, the effect of the first piston part 16.1 is controlled by opening the fluid flow communication from the third fluid chamber 14.3 to either to pressure line or the low pressure part 36 of the system. The third chamber 14.3 connected to the low pressure part 36 by a line 46 provided with a control valve 48. Additionally the second chamber 14.2 is controllably connected to the low pressure part 36 by a fluid line 38 provided with a control valve 40.

[0027] Preferably each of the fluid chambers which has a volume that decreases in response to at least one of the piston parts moving relative to the

body part in a first direction is in controllable fluid communication with the pressure line downstream the pressure valve, that is at the side of the first fluid chamber.

[0028] Since the arrangement of figure 1 and figure 2 includes two piston parts, and it is possible to select the way their effective areas are utilized in applying different forces to the piston 16 by several combinations of suitably opened and closed control valves. In practise the benefit in this arrangement is to have selectable effective area i.e. combined radial surfaces in the working space 14. This way, depending e.g. on the engine load, the engine automation may select what effective area is used. When the effective area is chosen so that the force produced by the hydraulic pressure equals the restricting forces, the required hydraulic flow is minimized, thus saving energy. If the effective area is bigger than what is required by the forces, the needed hydraulic flow is also bigger and the system consumes extra energy, which is minimized by the present invention.

[0029] As an example of the working of the valve arrangement the hydraulic cylinder has at least three fluid chambers 14.1, 14.2, 14.3. The chamber 14.1 on top in the figure 1 and figure 2 is for pressing the piston 16 down which movement opens the gas exchange valve 18. The third chamber 14.3 in the figure is used also for pressing the piston up which closes the gas exchange valve. The second i.e. middle chamber 14.2 is a control volume.

[0030] If the second chamber 14.2 control valve 40 is closed, the hydraulic fluid (e.g. oil) in the second chamber 14.2 may not flow out while the inner piston tends to move down. Thus the second piston part 16.2 cannot move, and so the only member doing the work is the first piston part 16.1. Provided that the force obtained in this manner is adequate less flow rate of the fluid is required. In this case, the produced force is the surface area 16.1' hydraulic pressure in the chamber 14.1. The third chamber 14.3 volume is

connected to the low pressure part 36 (tank). If a greater force is required (engine load is for example maximum), the second volume 14.2 control valve 40 is opened connecting the second volume 14.2 to the low pressure part 36 and both piston parts move down, the outer piston part 16.2 pressing the inner piston part 16.1. Now the effective force is obtained by the combined piston areas 16.1' and 16.2'. The system may be provided with more pistons part and radial surfaces than two.

[0031] It is also an advantage of the invention that it is possible to change the applied force, i.e. change the effective area, even during a stroke of the piston, which makes the operation of the hydraulic valve arrangement even more energy effective.

[0032] The third chamber 14.3 is pressurized when the piston is returned to the initial position. Now the first chamber 14.1 is connected to the low pressure part 36 (tank). According to an embodiment of the invention also the valve 31 is opened. This makes is possible that fluid from both chambers 14.1 and 14.2 may flow to the low pressure part 36 either through the valve 62 or the valve 40 (or both), This way the piston 16 may be return back to its initial position even if either of the valve 62 or 40 is inoperative. Generally, the first chamber 14.1 and the second chamber 14.2 are selectably and/or controllably connected the low pressure part 36 because operational selections may be made by means of the control valve 31.

[0033] . The returning of the gas exchange valve requires much less force because there isn't an engine pressure restricting the movement. Because of that, the area causing the return movement may be smaller than the area causing the movement in the first direction.

[0034] The arrangement of the figure 1 and figure 2 allows adjusting the actuator effective area for each load case.

[0035] In the following table there are shown possible force combinations obtainable by the arrangement of figure 1 and figure 2 with a predetermined pressure.

Effective areas	valve 30	valve 40	valve 48	valve 31	valve 43
16.1'	on	off	on	off	off
16.1' + 16.2'	on	on	on	off	off
16.1' + 16.2'– 16.2''	on	off	on	on	off
16.1' + 16.2'– 16.1''	on	on	off	off	on
16.1' + 16.2' – 16.2'' – 16.1''	on	off	off	on	on

[0036] These alternative effective areas are for movement of the piston 16 in the first direction allowing seven different forces to be applied to the piston with same pressure level. Valve 30 is open in all combinations. Available forces depend on the actual dimensioning of the areas and also hydraulic pressure used.

[0037] In figure 2 there is also shown pressure accumulator system 55 selectively connectable by means of valve 56 and 57 to the pressure line 26 and the line 46 in connection with the low pressure part 36 of the system. By making use the accumulator system and the valve movement of the piston 16 may be decelerated, making also re-using of energy possible.

[0038] In figure 3 there is shown another embodiment of the invention where three piston parts, the first part 16.1, the second piston part 16.2, and a third piston part 16.3, are arranged in coaxial manner. In figure 3 there is used corresponding reference numbering to those in figure 1 and figure 2 for corresponding elements. Each of the fluid chambers 14.2, 14.3 and 14.4 which have a volume that decreases in response to at least one of the piston parts moving relative to the body part in a first direction is in controllable fluid communication 27,32,44 having a control valve 29,31,43 with the pressure line 26 downstream the pressure valve. In the embodiment of figure 3 the fluid control system 24 comprises a fluid line 23 having a valve

25 connecting also the fourth fluid chamber 14.4 controllably to the low pressure part 36.

[0039] An inner coaxial piston part and an outer coaxial piston part are so arranged that the movement of the outer coaxial piston part is limited to a predetermined longitudinal position in respect to the inner coaxial piston part. The movement of the outer coaxial piston part is limited preferably by the form of the opposing surfaces of the inner coaxial piston part and the outer coaxial piston part.

[0040] The arrangement may be provided with a spring element 60 urging the piston to move in the second direction for example in the third fluid chamber.

[0041] While the invention has been described herein by means of examples in connection with what are, at present, considered to be the most preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features, and several other applications included within the scope of the invention, as defined in the appended claims. The details mentioned in connection with any embodiment above may be used in connection with another embodiment when such combination is technically feasible.

Claims

1. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve of an internal combustion piston engine, the arrangement comprising a body part (12) having a working space (14) into which an operating piston (16) is arranged, which operating piston comprises at least a first and a second concentric piston parts (16.1, 16.2), arranged slidably in respect to each other, and in which body part a first fluid chamber (14.1) is arranged bordered by radial surfaces (16.1', 16.2') of both the first and the second piston parts and having a volume that increases in response to the piston parts (16.1, 16.2) moving relative to the body part in a first direction, and a second fluid chamber (14.2) is arranged bordered by radial surface (16.2'') of the second piston part having a volume that decreases in response to the second piston part moving relative to the body part in the first direction, **characterized** in that the movement of the second piston (16.2) part in the first direction relative to the body part (12) is arranged independently from the first piston part (16.1) controllable by a fluid control system (24) arranged in connection with the hydraulic valve arrangement (10).

2. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claim 1, **characterized** in that the fluid control system comprises a pressure line (26) connected to a source of pressurized fluid (28) and to the first fluid chamber (14.1) and being provided with a pressure valve (30), and that each of the fluid chambers (14.2, 14.3,14.4) having a volume that decreases in response to at least one of the piston parts (16.1,16.2,16.3) moving relative to the body part (12) in a first direction, is in controllable fluid communication with the pressure line (26).

3. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claim 1, **characterized** in that the fluid control system (24) comprises a fluid line (38) comprising a valve (40) connecting

the second fluid chamber (14.2) controllably to a low pressure part (36) of the fluid control system.

4. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claim 1, **characterized** in that the arrangement comprises a third fluid chamber (14.3) arranged bordered by radial surfaces of at least the first piston part (16.1'') having a volume that decreases in response to the first piston part moving relative to the body part in a first direction, and that the first and the third fluid chambers are selectively connectable (30, 42) to a pressurized hydraulic fluid source (28).

5. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claim 1, **characterized** in that the radial surface (16.1') of the first piston part (16.1) bordering the first fluid chamber (14.1) is smaller than the radial surface (16.1'') of the first piston part bordering the third fluid chamber (14.3) and that the radial surface (16.1'') of the first piston part bordering the third fluid chamber (14.3) is smaller than the radial surface (16.2'') of the second piston part (16.2) bordering the second fluid chamber (14.2).

6. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claim 1, **characterized** in that fist piston part (16.1) is arranged freely movable in respect to the second piston part (16.2) in the first direction and it is provided with a mechanical stop (50) which delimits the movement of the second piston part (16.2) in respect to the first piston part (16.1).

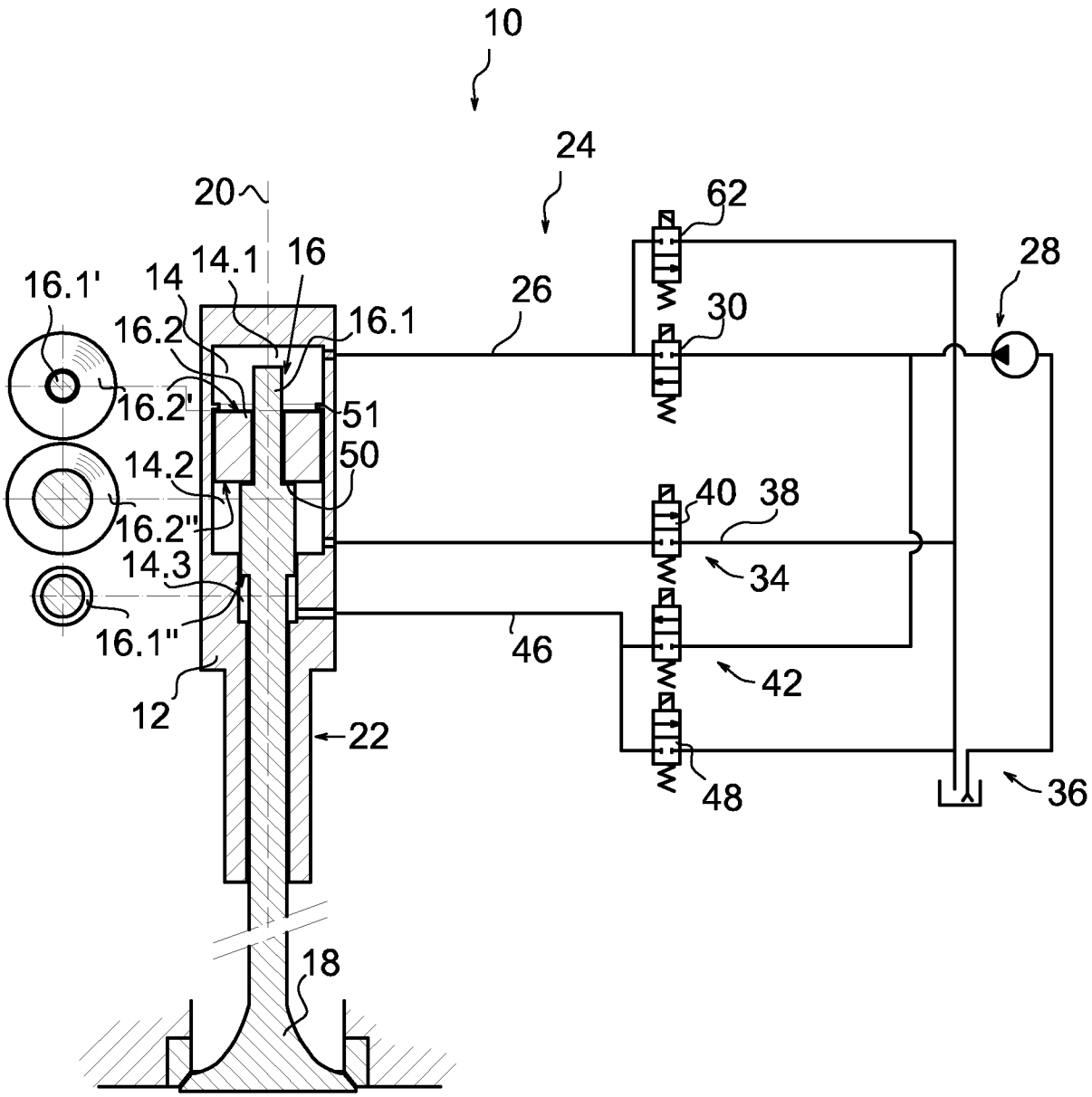
7. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claim 1 or 6, **characterized** in that the body part (12) is provided with a second stop (51) in cooperation with the second piston part (16.2) which limits the movement of the second piston part 16.2 in the second direction to a predetermined position.

8. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claim 1, **characterized** in that the arrangement comprises a controllable fluid communication (32) between the first fluid chamber (14.1) and the second fluid chamber (14.2).

9. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claim 1, **characterized** in that the arrangement comprises a controllable fluid communication (44) between the first fluid chamber (14.1) and the third fluid chamber (14.3).

10. A hydraulic valve arrangement (10) for controllably operating a gas exchange valve according to claims 3, 8 and 9, **characterized** in that the controllable fluid communication (32) between the fist fluid chamber (14.1) and the second fluid chamber (14.2) comprises a control valve (31), and the controllable fluid communication (44) between the fist fluid chamber (14.1) and the third fluid chamber (14.3) comprises a control valve (43), and that the arrangement provides effective areas with combinations of opened and/or closed control valves (30,40,48,31,43) defining applied force to the piston (16) with a predetermined fluid pressure as follows:

Effective areas	valve 30	valve 40	valve 48	valve 31	valve 43
16.1’	on	off	on	off	off
16.1’ + 16.2’	on	on	on	off	off
16.1’ + 16.2’– 16.2’’	on	off	on	on	off
16.1’ + 16.2’– 16.1’’	on	on	off	off	on
16.1’ + 16.2’ – 16.2’’ – 16.1’’	on	off	off	on	on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24
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14
14.1
16
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16.2
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51
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16.2"
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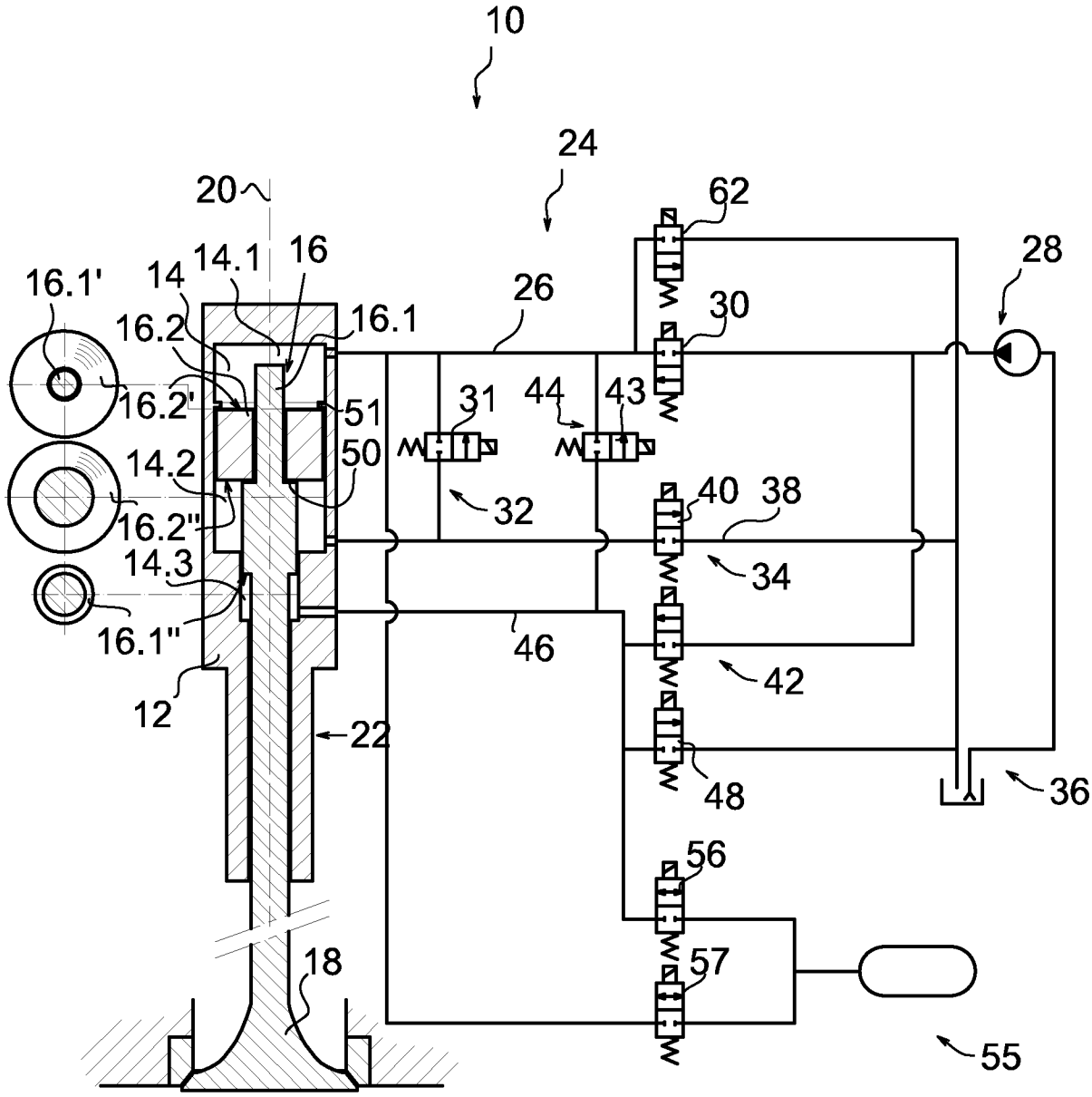
14.3
16.1"
46
42
12
22
48
36
18

FIG. 1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62
28
16.1'
14
14.1
16
26
30
16.2
16.1
16.2'
51
31
44
43
14.2
50
32
40
38
16.2"
34
14.3
46
16.1"
42
12
22
48
36
56
18
57
55

FIG. 2

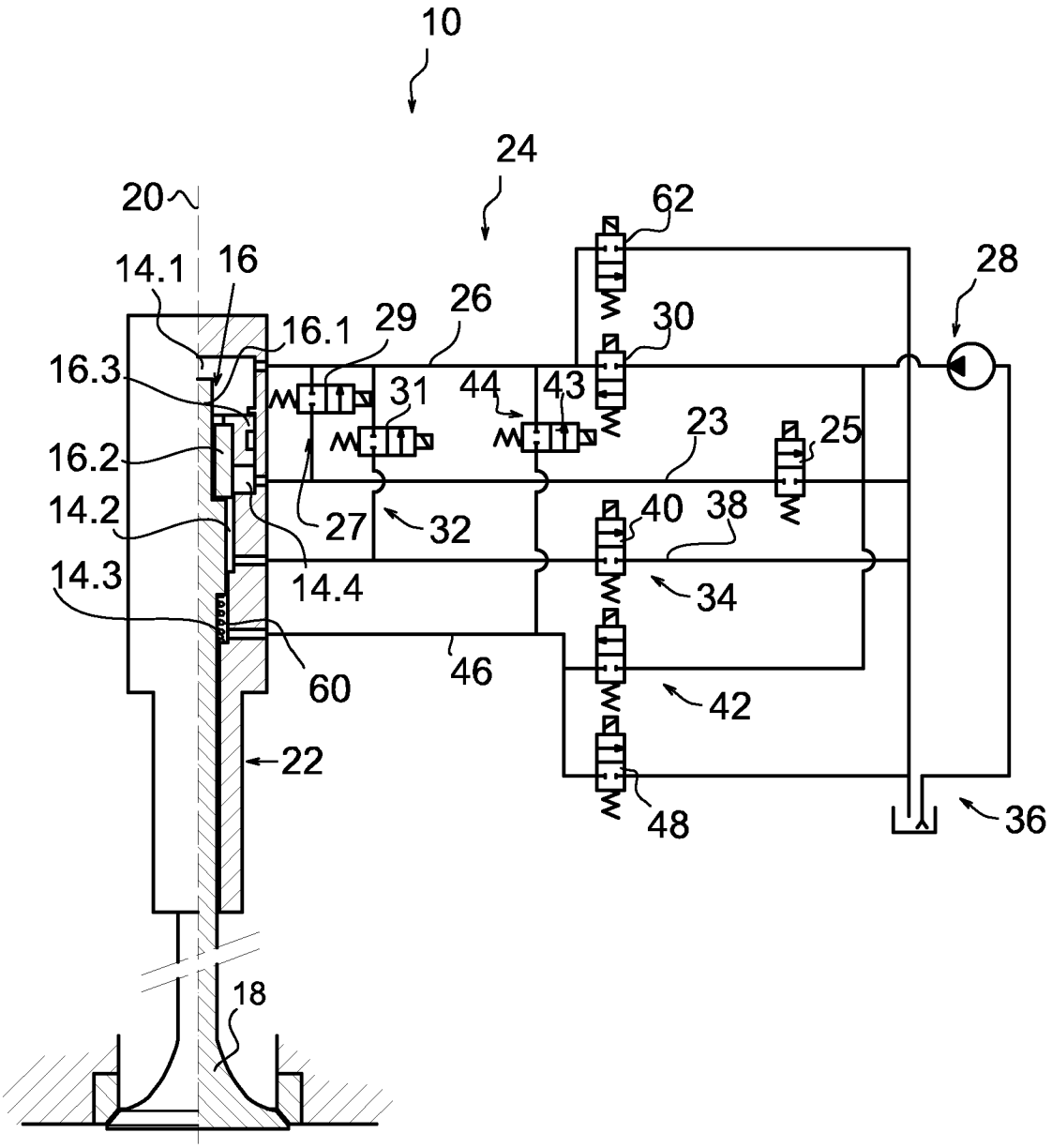
10
24
20
62
28
14.1
16
16.1
29
26
30
16.3
31
44
43
23
25
16.2
14.2
27
32
40
38
14.3
14.4
34
60
46
42
22
48
36
18

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2013/050146

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01L9/02
ADD.

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)
F01L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2008 040840 A1 (BOSCH GMBH ROBERT [DE]) 4 February 2010 (2010-02-04) abstract; figures	1,2
X	WO 03/027450 A1 (BOSCH GMBH ROBERT [DE]; DIEHL UDO [DE]; MISCHKER KARSTEN [DE]; ROSENAU) 3 April 2003 (2003-04-03) abstract; figure 2	1,2
A	WO 03/027449 A1 (BOSCH GMBH ROBERT [DE]; DIEHL UDO [DE]; ROSENAU BERND [DE]; HAMMER UWE) 3 April 2003 (2003-04-03) the whole document	1-10
A	US 6 223 846 B1 (SCHECHTER MICHAEL M [US]) 1 May 2001 (2001-05-01) the whole document	1-10

☐ 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
30 July 2013	06/08/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Paulson, Bo

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/FI2013/050146

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