(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 May 2010 (06.05.2010)

PCT

(10) International Publication Number
WO 2010/049583 A1

(51) International Patent Classification:
F01L 9/02 (2006.01) *F01L 1/14* (2006.01)
F01L 1/255 (2006.01)

(21) International Application Number:
PCT/FI2009/050804

(22) International Filing Date:
9 October 2009 (09.10.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20086021 29 October 2008 (29.10.2008) FI

(71) Applicant *(for all designated States except US)*: **WÄRTSILÄ FINLAND OY** [FI/FI]; Tarhaajantie 2, FI-65101 Vaasa (FI).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **SUNDSTEN, Magnus** [FI/FI]; Söderbyvägen 90, FI-65610 Korsholm (FI).

(74) Agent: **AWEK INDUSTRIAL PATENTS LTD OY**; PL 230, (Lautatarhankatu 6, 00580 Helsinki), FI-00101 Helsinki (FI).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM,

[Continued on next page]

(54) Title: CONTROL ARRANGEMENT FOR A VALVE OPERATING ASSEMBLY AND A METHOD FOR CONTROLLING THE CLOSING MOVEMENT OF A VALVE OPERATING ASSEMBLY

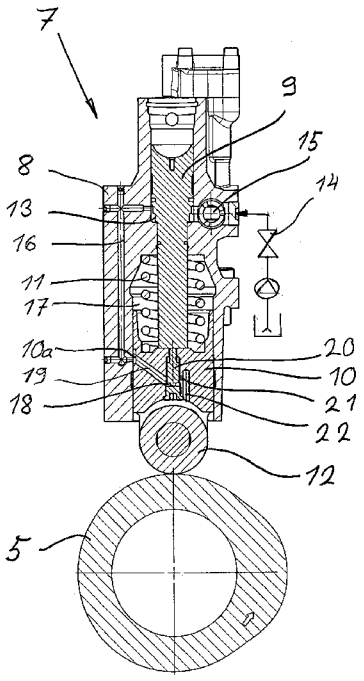

Fig. 2

(57) Abstract: A control arrangement for, and a method for controlling the closing movement of, a valve operating assembly in a piston engine adapted between a cam device (5) of a camshaft (4) of the engine (1) and an inlet valve mechanism (6) arranged to open and close the inlet valve (3) in association with a cylinder of the engine. The control arrangement (7) comprises a body part (8), in which a piston de¬ vice (9) is movably arranged to be in force transmission connection with the camshaft (4) and the valve mechanism (6), the body part (8) and the piston device (9) together defining a first chamber (13), into which hydraulic medium can be selectively fed for providing a delay in the closing of the inlet valve (3). The body part (8) is provided with a first duct (16) for releasing of pressure in the first chamber (13) under control of a gu ide member (10) movably arranged in the body part (8) between the cam device (5) and the piston device (9). The guide member (10) includes a third chamber (18), which is arranged to be in communication with the first duct (16) and a control piston (20) located in said third chamber (18) and movably arranged with regard to the guide member (10) for controlling pressure medium flow through said third chamber (18).

WO 2010/049583 A1

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

CONTROL ARRANGEMENT FOR A VALVE OPERATING ASSEMBLY AND A METHOD FOR CONTROLLING THE CLOSING MOVEMENT OF A VALVE OPERATING ASSEMBLY

Technical field

The invention relates to a control arrangement for a valve operating assembly in a piston engine according to preamble of claim 1 as well as to a method for controlling the closing movement of a valve operating assembly in a piston engine according to preamble of claim 6.

Background art

There are situations in the operation of a four stroke internal combustion engine in which the cylinders are not provided with enough air for self-ignition to happen during the compression stroke. Such situations may appear especially during engine start and during load variations. One solution is to provide for a delay in the closing of the inlet valve for prolonging the opening time of the inlet valve when needed. An example for an arrangement of this kind of a variable inlet valve closure (VIC) is disclosed in patent publication WO 2008/000899.

When a delay function is in use at the closing phase of the inlet valve the valve tappet member is for a while not directly in mechanical force transmission connection with the cam shaft. At a later phase this connection is however re-established, but this must occur slowly enough to ensure smooth operation and prevent breaking of the parts in question. Therefore an efficient and reliable control arrangement is needed for the operation of the valve operating assembly and specifically for providing efficient braking of the movement of the valve tappet and other valve moving members included in the valve operating assembly.

An object of the invention is to provide a control arrangement for a valve operating assembly and a method for controlling the closing movement of a valve operating assembly, which solve the above mentioned problems of the prior art. A specific object of the invention is further to provide an efficient, straightforward and reliable braking method and arrangement to be adapted for the closing phase of a valve operating assembly in connection with the delay function of the inlet valve.

Disclosure of the invention

The objects of the invention can be met substantially as is disclosed in claims 1 and 6 and in the other claims. According to the first aspect of invention the guide member includes a third chamber, which is arranged to be in communication with the first duct for releasing of pressure in the first chamber, and a control piston located in said third chamber and movably arranged with regard to the guide member for controlling pressure medium flow through said third chamber.

The guide member is provided with a second duct for communication between the first duct and the third chamber and a third duct for releasing of pressure in said third chamber. The control piston is then arranged to control the opening and closing of said third duct.

Efficient operation of the arrangement can be achieved if the diameter of the third duct is smaller that the diameter of the second duct.

The control piston is arranged to partly extend out from the guide member after releasing of pressure in the first chamber for engaging with the piston device and braking its movement toward the guide member.

The outward extending movement of the control piston is with advantage accomplished by means of the hydraulic medium entering from the first chamber into the third chamber.

By means of the invention the braking function takes place in the upper part as well as in the lower part of the piston device included in the control arrangement of the valve operating assembly making the operation efficient and smooth. The braking function is available always when also the delay function for delaying the closing of the inlet valve is in use, and it is practically independent on the operating speed on the engine. Since the operation of the control piston can be accomplished by making use of the hydraulic medium normally utilised for the inlet valve delay function, an uncomplicated construction and reliable operation can be achieved.

The invention is further defined by a method for controlling the closing movement of a valve operating assembly in accordance with claims 6 and 7.

Brief Description of Drawings

In the following the invention is described in more detail, by way of example only, with reference to the accompanying drawings, in which

- Figure 1 shows a piston engine and a skeleton diagram of its valve mechanism,

- Figures 2 - 6 show an embodiment of a control arrangement according to the invention in separate consecutive stages of operation with the delay function for the delayed closing of the inlet valve being on, and

- Figure 7 shows the embodiment of figures 2 - 6 in a certain stage of operation with the delay function for the delayed closing of the inlet valve being off.

Detailed Description of Drawings

Figure 1 shows a schematic view of a piston engine 1 as far as it is relevant to the understanding of the invention. The gas exchange of the cylinders (not

shown) in the piston engine 1 is carried out under the control of gas exchange valves, i.e. inlet valves and exhaust valves, located on a cylinder head 2. Only inlet valves 3 are shown and they are operated by means of valve mechanisms 6 which are typically guided by the cam profiles of cam devices 5 arranged on a camshaft 4 of the engine. The force transmission connection between each valve mechanism 6 and the corresponding cam device 5 is realised by a control arrangement 7.

The control arrangement 7 is shown in more detail in Figures 2 - 6. The control arrangement 7 comprises a body part 8, which is typically attached to the engine body. A piston device 9 is movably arranged within the body part 8. The upper end of the piston device 9 is arranged in force transmission connection with the valve mechanism 6 (not shown closer). This connection may be mechanical or hydraulic. The movements of the piston device 9 are controlled by a guide member 10 arranged at the lower end of the piston device within the body part 8. The guide member 10 is in engagement with and urged by a spring 11 towards a roller 12, which receives its guidance from the cam profile of the cam device 5. Thus, when the cam shaft 4 rotates, in figures 2 - 6 counter-clockwise, the roller 12 follows the cam profile of the cam device 5, and the changes in the cam profile are transmitted via the control arrangement 7 and the valve mechanism 6 to the inlet valve 3 so as to affect the opening and closing of the inlet valve 3.

The body part 8 and the piston device 9 together define a first chamber 13, into which hydraulic medium can be selectively fed for providing a delay in the closing of the inlet valve 3. The feed line is provided with a shut-off valve 14 and a non-return valve 15. By means of the shut-off valve 14 the feed line to the first chamber 13 may be connected or disconnected, depending on whether or not the aim is to use the delay function for the delayed closing of the inlet valve 3. Due to the non-return valve 15 the control arrangement cannot cause any pulsations in the source of hydraulic medium. This is of importance when lubricating oil is used as a hydraulic medium.

The body part 8 is additionally provided with a duct 16 for releasing of pressure in the first chamber 13 and with a second chamber 17, which encloses the guide member 10, the spring 11 as well as the lower end of the piston device 9.

The guide member 10 includes a groove 10a in its mantle surface and is additionally provided with a third chamber 18. A duct 19 connects the groove 10a to the third chamber 18. A control piston 20 is movably arranged in the third chamber 18 and said chamber is further connected with ducts 21 and 22 to an oil sump providing lubrication for the camshaft and the parts connected therewith.

The function of the arrangement is as follows. In figure 2 the control arrangement 7 is inoperative and the roller 12 is located on the base circle of the cam profile of the cam device 5. In this phase the inlet valve 3 is closed (not shown). In figure 3 the cam device 5 has rotated counter-clockwise so that the cam part of the cam device 5 has lifted the roller 12 upwards in the figure. Thus, also the guide member 12 and the piston device 9 have moved upwards and as a consequence the corresponding inlet valve 3 has opened. Simultaneously the first chamber 13 is filled with hydraulic medium fed through the feed line 14 and 15.

In figure 4 the roller 12 has returned on the base circle of the cam device 5. As a consequence the guide element 10 has moved downwards in the figure as well, pressed by the spring 11, so that the groove 10a in the mantle surface of the guiding member 10 has moved at the position of the duct 16 connecting the first and the third chambers 13 resp. 18. Hereby also the pressure in the first chamber 13 is released so that the piston device 9 starts to move downwards in the figure thereby allowing also the inlet valve to start closing. The movement of the piston device 9 is braked by the hydraulic medium still remaining in the chamber 13. Since the pressure in chamber 18 below the control piston 20 is at the same time increased and acts on the first end 20a of the control piston 20, the control piston 20 is forced upwards so that its second end 20b extends out from the guide member 10, as is disclosed in figure 4. As a consequence the connection between the chamber 18 and the duct 21 is opened. Since the diameter of the duct 21 is, however, smaller than that of the duct 19, the control

piston 20 remains in the outward position of figure 4. Further, due to the continued movement of the guide member 10 the engagement between the piston device 9 and the guide member 10 is hereby cut off and the guide member 10 reaches is lowermost position under the pressure of the spring 11 and defined by the base circle of the cam device 5.

In figure 5 the piston device 9 has moved further downwards and engages the second end 20b of the control piston 20 starting to press the control piston 20 downwards in the figure. As a consequence the first end 20a of the control piston 20 starts to close the duct 21. Due to the increasing of pressure in chamber 18 also the control piston 20 starts to brake the downward movement of the piston device 9. Finally, as apparent from figure 5, the duct 21 is entirely closed by the control piston 20 whereby full braking effect is achieved both by the hydraulic pressure affecting the control piston 20 and the hydraulic pressure in the upper chamber 13 effecting directly on the piston device 9. Due to this combined braking operation providing increased braking area efficient braking is achieved.

In figure 6 the piston device 9 has moved again into contact with the guide member 10 and the cycle can restart.

Since the delay function for the delayed closing of the inlet valve is an option to be availed of in certain special situations, figure 7 illustrates the operation of the arrangement according to the invention under normal load situations of the engine. The situation of figure 7 corresponds to the one disclosed in figure 4, but in this case the feed line 14 and 15 is closed. As a consequence no hydraulic medium is fed into the chamber 13. The guide member 10 and the piston device 9 remain in direct contact through the whole operation cycle and the control piston is inoperative, since the chambers and ducts are mainly filled with air.

It is clear that the invention is not limited to the example mentioned and described above but can be implemented in many other different embodiments within the scope of the inventive idea.

Claims

1. A control arrangement for a valve operating assembly in a piston engine adapted between a cam device (5) of a camshaft (4) of the engine (1) and an inlet valve mechanism (6) arranged to open and close the inlet valve (3) in association with a cylinder of the engine, which control arrangement (7) comprises a body part (8), in which a piston device (9) is movably arranged to be in force transmission connection with the camshaft (4) and the valve mechanism (6), the body part (8) and the piston device (9) together defining a first chamber (13), into which hydraulic medium can be selectively fed for providing a delay in the closing of the inlet valve (3), the body part (8) further being provided with a first duct (16) for releasing of pressure in the first chamber (13) under control of a guide member (10) movably arranged in the body part (8) between the cam device (5) and the piston device (9), **characterised** in that the guide member (10) includes a third chamber (18), which is arranged to be in communication with the first duct (16) and a control piston (20) located in said third chamber (18) and movably arranged with regard to the guide member (10) for controlling pressure medium flow through said third chamber (18).

2. Control arrangement according to claim 1, **characterised** in that the guide member (10) is provided with a second duct (19) for communication between the first duct (16) and the third chamber (18) and a third duct (21) for releasing of pressure in said third chamber (18), and that the control piston (20) is arranged to control the opening and closing of said third duct (21).

3. Control arrangement according to claim 2, **characterised** in that the diameter of the third duct (21) is smaller that the diameter of the second duct (19).

4. Control arrangement according to any one of the preceding claims, **characterised** in that the control piston (20) is arranged to partly extend out from the guide member (10) after releasing of pressure in the first chamber (13) for engaging with the piston device (9) and braking its movement toward the guide member (10).

5. Control arrangement according to claim 4, **characterised** in that the outward extending movement of the control piston (20) is accomplished by means of the hydraulic medium entering from the first chamber (13) into the third chamber (18).

6. A method for controlling the closing movement of a valve operating assembly in a piston engine by means of a control arrangement (7) adapted between a cam device (5) of a camshaft (4) of the engine (1) and an inlet valve mechanism (6) arranged to open and close the inlet valve (3) in association with a cylinder of the engine, which control arrangement (7) comprises a body part (8), in which a piston device (9) is movably arranged to be in force transmission connection with the camshaft (4) and the valve mechanism (6), the body part (8) and the piston device (9) together defining a first chamber (13), into which hydraulic medium is fed for providing a delay in the closing of the inlet valve (3), the body part (8) further being provided with a first duct (16) for releasing of pressure in the first chamber (13) under control of a guide member (10) movably arranged in the body part (8) between the cam device (5) and the piston device (9), **characterised** in that the guide member (10) is provided with a third chamber (18) arranged to be in communication with the first duct (16) for leading hydraulic medium from the first chamber (13) into and through the third chamber (18), and that a control piston (20) movable with regard to the guide member (10) is located in said third chamber (18) for controlling the pressure in said third chamber (18) in order to break the closing movement of the valve operating assembly.

7. A method according to claim 6, **characterised** in that the releasing of pressure in the first chamber (13) is arranged to increase the pressure in the third chamber (18) such that the control piston (20) is moved with regard to the guide member (10) to extend partly out from the guide member (10) for engaging with the piston device (9) and braking its movement toward the guide member (10).

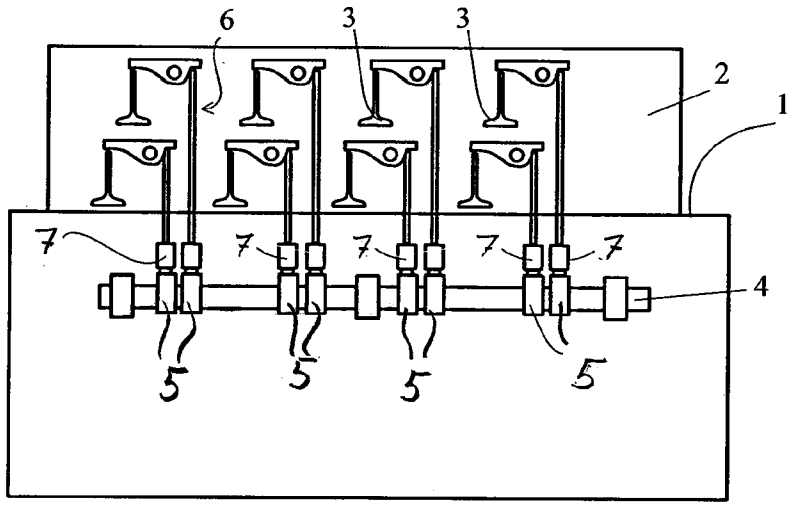

Fig. 1

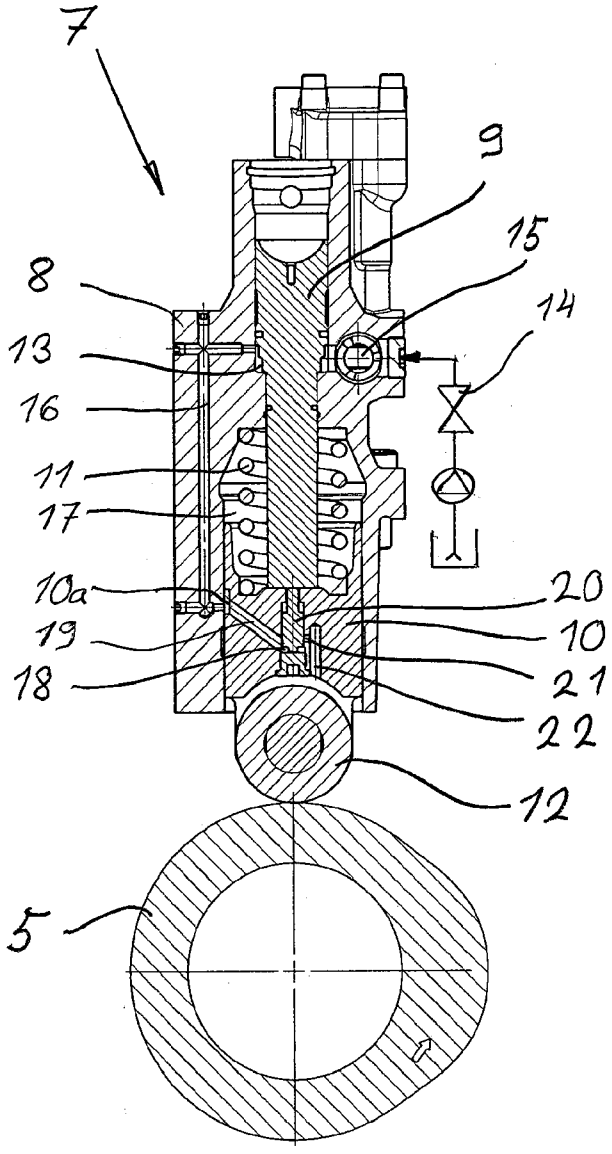

Fig. 2

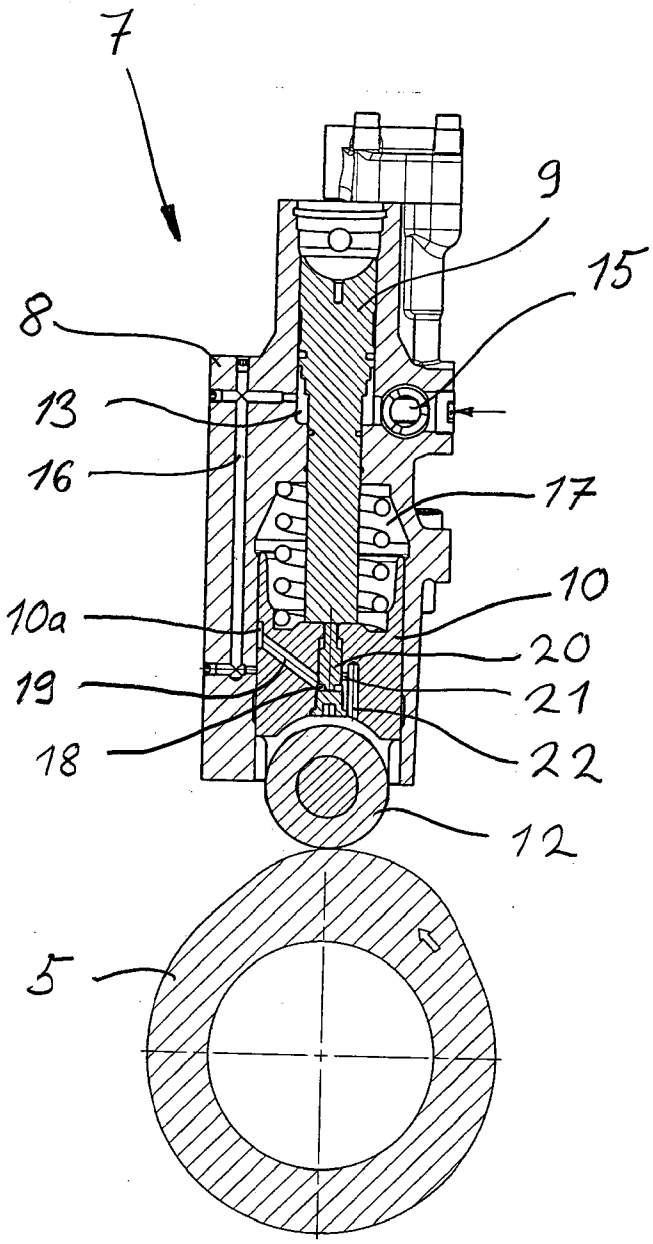

Fig. 3

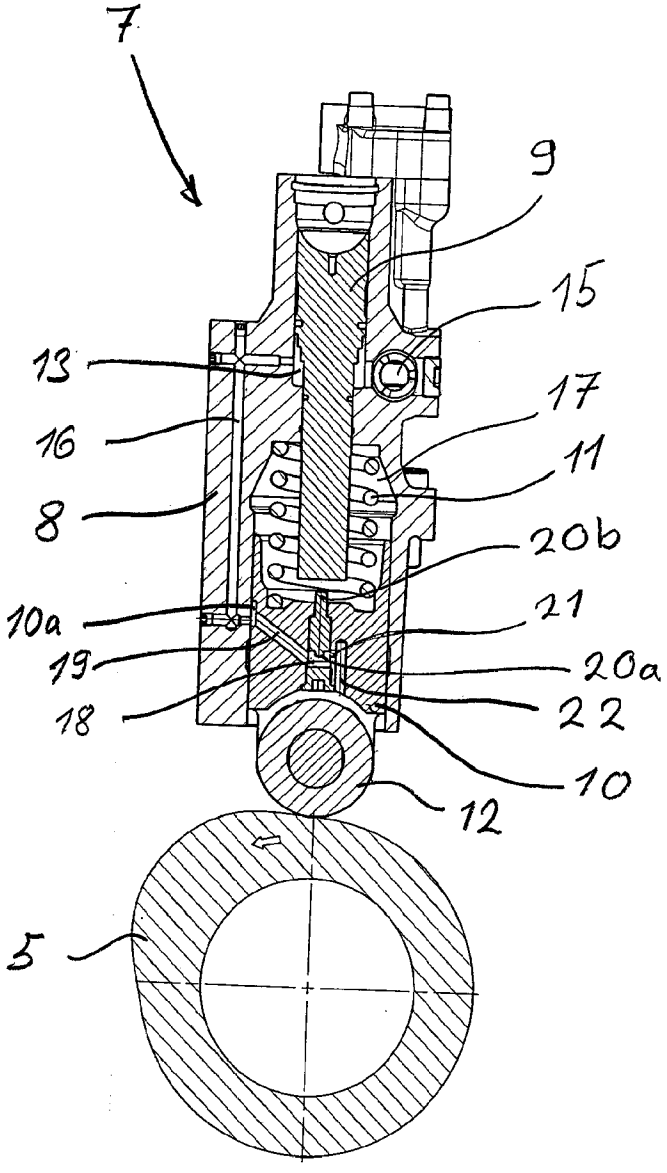

Fig. 4

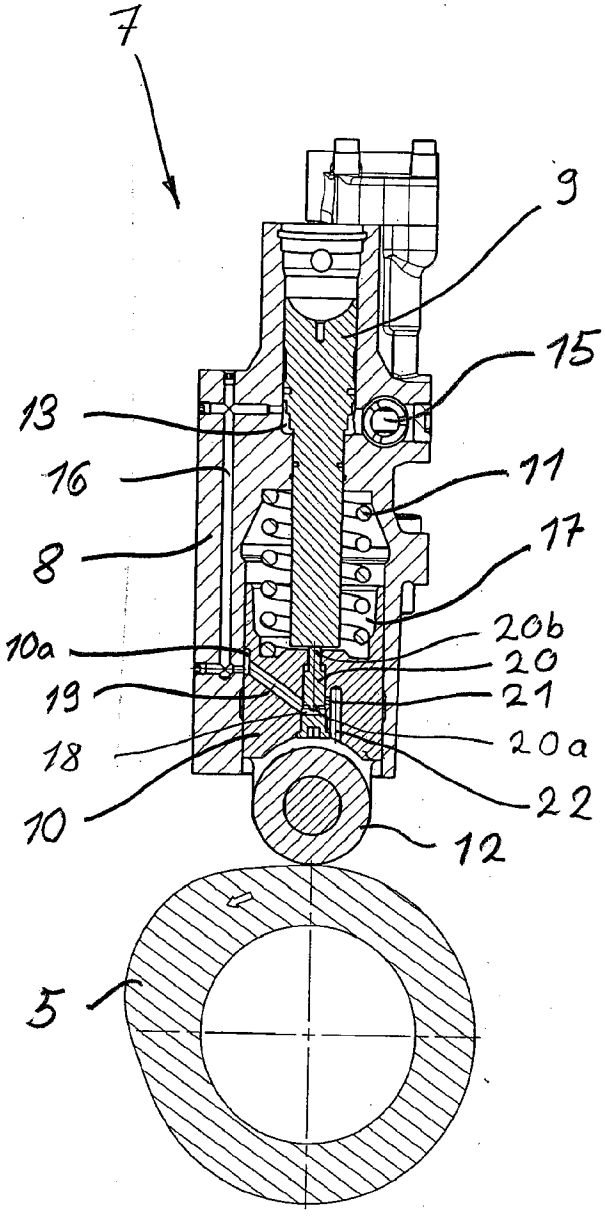

Fig. 5

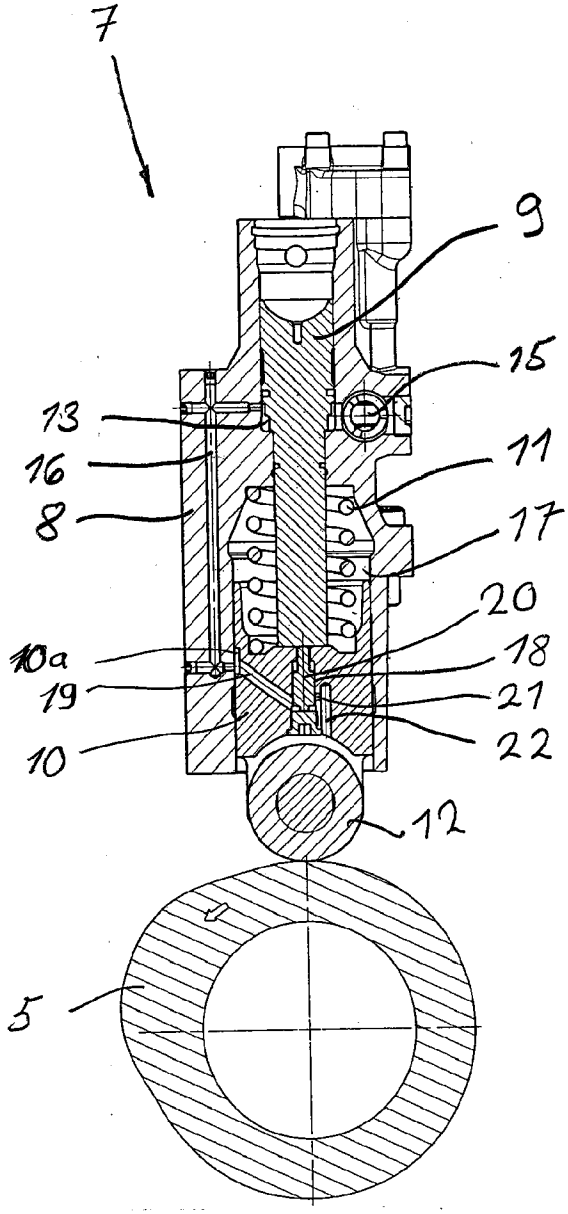

Fig. 6

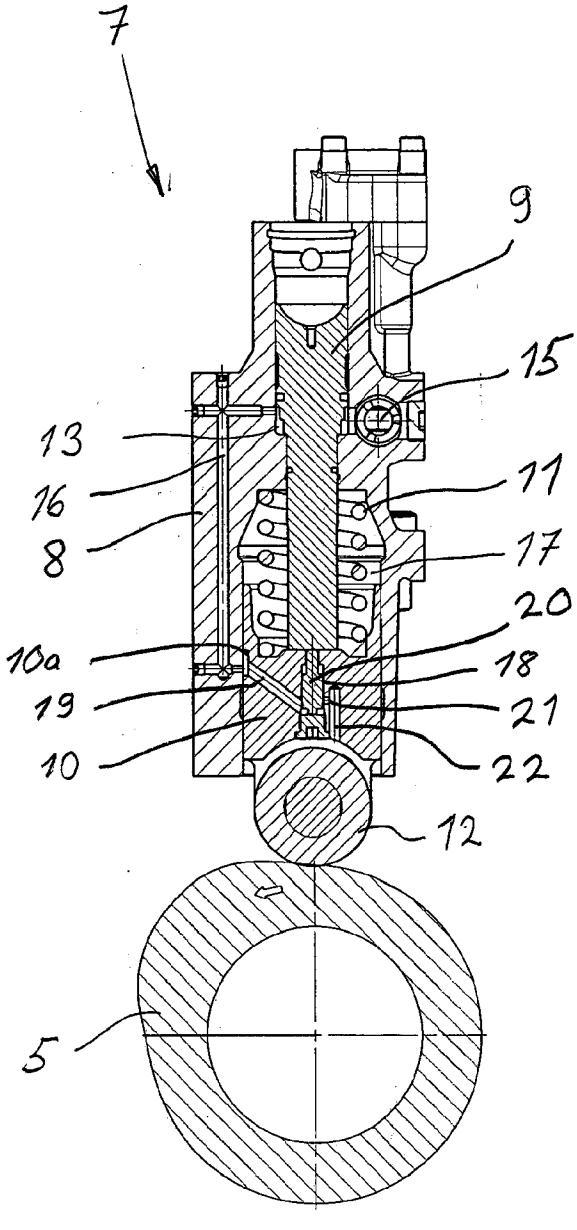

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2009/050804

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01L9/02 F01L1/255 F01L1/14

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2008/000899 A (WAERTSILAE FINLAND OY [FI]; NIINIKANGAS SAKU [FI]; SUNDSTEN MAGNUS [FI) 3 January 2008 (2008-01-03) cited in the application the whole document	1,6
Y	US 6 415 752 B1 (JANAK ROBB [US]) 9 July 2002 (2002-07-09) claim 1; figure 14	1,6
A	WO 2004/033863 A (RICARDO INC [US]) 22 April 2004 (2004-04-22) the whole document	1,6
A	DE 11 91 992 B (KLOECKNER HUMBOLDT DEUTZ AG) 29 April 1965 (1965-04-29) figure 1	1-7

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 December 2009	18/12/2009

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	Clot, Pierre

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2009/050804

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 002 022 A (PERR JULIUS P [US]) 26 March 1991 (1991-03-26) figures 1,2,4,5	1,6
A	FR 2 484 531 A (RENAULT [FR]) 18 December 1981 (1981-12-18) figures 1-3	1,6
A	WO 87/07677 A (SOUTH WESTERN IND RES [GB]) 17 December 1987 (1987-12-17) figures 1,8	1,6
A	DE 41 11 610 A1 (AUDI NSU AUTO UNION AG [DE]) 30 January 1992 (1992-01-30) figures 1,6	4,7

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/FI2009/050804

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2008000899 A	03-01-2008	CN 101479445 A	08-07-2009
		EP 2035662 A1	18-03-2009
		KR 20090028787 A	19-03-2009
US 6415752 B1	09-07-2002	US 2002157624 A1	31-10-2002
WO 2004033863 A	22-04-2004	AT 349604 T	15-01-2007
		AU 2003275443 A1	04-05-2004
		DE 60310743 T2	31-01-2008
		EP 1549833 A1	06-07-2005
DE 1191992 B	29-04-1965	NONE	
US 5002022 A	26-03-1991	NONE	
FR 2484531 A	18-12-1981	NONE	
WO 8707677 A	17-12-1987	EP 0309468 A1	05-04-1989
		GB 2194587 A	09-03-1988
DE 4111610 A1	30-01-1992	NONE	