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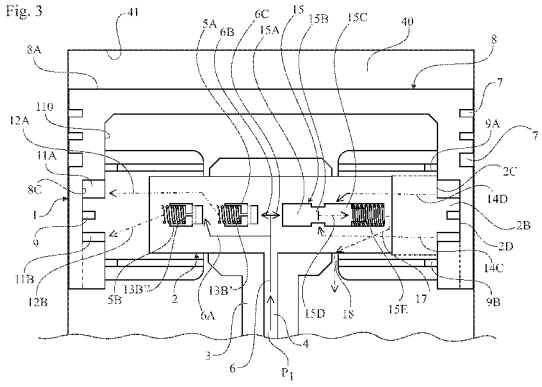
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(54) **Title:** COMBUSTION ENGINE

Fig. 3



(57) **Abstract:** The present invention relates to a combustion engine comprising at least one combustion chamber (40), which is delimited at one end by a head (41) and delimited at a second end by a piston (1), the piston being arranged on a connecting rod (3) by means of a piston pin (2), a moveable piston body (8) with a delimiting surface (8A) that is movable in relation to the piston pin (2) and facilitates a variable volume in said combustion chamber (40), a first pressure chamber (11A) and a second pressure chamber (11B), which via a supply line (6) and a check valve equipped feed duct (12A, 12B) is supplied with pressurised hydraulic oil from a pressure source (202), which pressure chambers (11A, 11B) are disposed by means of hydraulic oil to be able to cause the movement of said movable piston body (8)/delimiting surface (8A) with the aim of being able to adjust the size of the combustion chamber (40), wherein that the replenishment of hydraulic oil to each one of said pressure chambers (11A, 11B) is achieved by means of separate feed ducts (12A, 12B) respectively, wherein each feed duct (12A, 12B) is arranged with a check valve (13B?, 13B??) and that a control valve (15) is arranged to control the position of said body (8) by means of controlling the communication between any of said pressure chambers (11A, 11B) and a drainage (18).

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COMBUSTION ENGINE

SPHERE OF THE INVENTION

The present invention relates to a combustion engine comprising at least one combustion chamber, which is delimited at one end by a head and delimited at a second end by a piston, the piston being arranged by means of a piston pin on a connecting rod, a body with a delimiting surface that is movable in relation to the piston pin and facilitates a variable volume in said combustion chamber, a pressure chamber that can be supplied via a feed duct with hydraulic oil from a pressure source, which pressure chamber is intended by means of the hydraulic oil to be able to influence movement of said movable delimiting surface with the aim of being able to adjust the size of the combustion chamber. The engines in which the invention is intended to be used are engines of different types, such as diesel engines and petrol engines and in particular engines of this kind in which supercharging occurs.

PRIOR ART AND PROBLEMS

Combustion engines for cars are well known. They occur in various versions but four-stroke engines of various types are the most dominant. What is common to all engines is that they comprise one or more cylinders in which a piston can move up and down and drive a crankshaft to which they are connected depending on the pressure in the combustion chamber, which pressure changes between a vacuum and a very high momentary pressure. The pistons are normally provided with a transverse so-called piston pin, around which the connecting rod is supported rotatably, which connecting rod is supported at its other end around the crankshaft and drives this. In the cylinder chamber is lubricating oil, which is pumped round at a pressure of 4-5 bar and lubricates all surfaces that slide against one another.

A combustion engine develops its driving energy in that a fuel-air mixture is aspirated or introduced through pressure into a fuel chamber above the piston, a spark igniting the fuel-air mixture that is quickly combusted and produces a high pressure that presses the piston down, the downward movement of which is converted into a rotary movement in the crankshaft. The power tapping of the engine is dependent to a very high degree on the composition of the fuel-air mixture and the pressure in this prior to ignition. When the fuel-

air mixture is compressed by the upward movement of the piston, the temperature in this increases and there is a risk that the mixture shall be ignited before the spark appears and thereby produce an undesirable combustion process. This premature ignition is called knocking and can easily be heard outside the engine. This problem is particularly great in turbocharged engines in which the fuel-air mixture is forced in instead of being aspirated. To avoid knocking etc. when feeding the fuel-air mixture, it is necessary to start out from an extremely low compression ratio. When driving a turbocharged car with low loading, for example, on normal main roads, there will be a vacuum in the inlet manifold. The vacuum and the fact that there is a low compression ratio in the engine from the outset means that the optimum combustion and economy that the fuel can actually provide are not obtained.

The ideal would be to have a compression pressure close to the knocking limit at all speeds and engine loads. Optimum combustion can thus be obtained in all conditions; a high compression ratio with low power tapping and a low ratio that permits turbocharging with high power tapping. This can be achieved with a variable compression chamber. It is previously known from DE 3714762 to use hydraulic adjustment to change/optimize the compression ratio during operation in such a manner. DE 3714762, however, utilizes rigid hydraulic adjustment, i.e. adjustment that does not offer the possibility of automatic momentary adjustment of the compression ratio during operation. It is previously known from US 4,286,552 to use a device that facilitates momentary adjustment, which is achieved by means of a spring that acts on the position of a movable delimiting surface of the piston depending on the counter pressure inside the combustion chamber. A solution according to US 4,286,552 results in the great disadvantage, however, that in certain operating conditions unfavourable vibration can take place, which can lead to total destruction in the worst case. Thus such a solution is very difficult if not impossible to realize in practice.

Many other neighbouring prior art solutions may be found, that demonstrates the enormous amount of research that has been performed within this field to try to solve the problem. In the following, some patents will briefly be presented that confirms this situation.

US 6,595,177 describes an invention in which is provided a porting apparatus for delivering and exhausting gasses in an internal combustion engine. Each of the cylinders is further provided with a pair of apertures in diametrically opposing and axially offset positions

through the wall of the cylinder, such that within each of the cylinders and corresponding through ports, a gas flow is enabled for communication from one of the pair of apertures to the other of the pair of apertures through the through port upon each full rotation of the cylinders which are driven in coordination with the engine. US 6,202,605 describes an invention in which is provided an internal combustion engine equipped with an arrangement to adjust the compression ratio. GB 2019487 discloses an invention in which is described a four cylinder two stroke engine in which the ignition occurs simultaneously in two of the four cylinders, and the contour of the cam can be designed in such a manner that the pistons can be moved in a most favourable manner in context of the expansion of the combustion product. FR-A-2732722 describes an invention which illustrates a two part driving shaft for controlling the compression ratio by axially adjusting the relative distance between the drive shaft parts and accordingly the relative distance between each pair of opposed pistons.

US 4,572,116 discloses an internal combustion engine having at least one chamber containing a moving working member through which the compression of a gaseous working medium is achieved. The said internal combustion engine is provided with at least one inlet valve and at least one outlet valve and a device for regulating compression, wherein intake and exhaust of working fluid and combustible fuel into the engine cylinder is controlled by means of a poppet valve, whereas the induction air is diverted by rotary valve means between intake and exhaust, and the referred valve means are being operated in timed manner with respect to each other, thereby utilizing blower induction of air as the working fluid.

None of the above different solutions has provided any significant practical improvements.

Accordingly there exists a need for providing an internal combustion engine that provides an efficient mechanism to adjust and optimize the compression process.

From US 4,784,093 there is known a solution presenting a design that corresponds to the precharacterizing portion of claim 1. Accordingly US 4,784,093 presents a design having a movable piston body that facilitates variable volume in the combustion chamber. However, the design is disadvantageous in that aspect that it does not allow different adjustments

adapting to different needs regarding varying operating parameters. As a consequence undesired adjustments may occur in some situations.

From WO 02081886 there is known a solution which partially solves the above mentioned problem, by means of a pressure chamber that communicates with an inlet duct that always facilitates replenishment of hydraulic oil and an outlet that communicates with at least one restricting device that continuously facilitates a flow of hydraulic oil out of the pressure chamber. However, due to the fact that hydraulic oil is unable to handle a too great an underpressure, cavitation may occur in the single oil filled pressure chamber under certain conditions, which may lead to undesired control problems and also cause undesired stress within the construction.

In view of the foregoing disadvantages inherent in the above-mentioned prior art, the general purpose of the present invention is:
to provide an improved combination of convenience and utility,
to overcome at least some disadvantages/drawbacks of the prior art, and
to provide an internal combustion engine equipped with a compression regulating mechanism, which is quicker and/or more efficient.

SOLUTION

According to the present invention, the aforementioned problems have been solved or at least minimized by a combustion engine as defined in claim 1.

The present invention provides an internal combustion engine in which a variable volume of the compression chambers is used to adjust and optimize the compression process and, wherein said object preferably is achieved by equipping the internal combustion engine with a compression regulating mechanism, to facilitate optimization of the combustion in an extremely flexible manner, i.e. at every load, rpm, etc.
It is another objective of the present invention to provide an internal combustion engine that is capable of handling adjustability in addition to and in conjunction to extremely high accelerations and decelerations, i.e. that can provide dampening and controllability at the same time.

It is yet another objective of the invention to provide an adjustable degree of compression which is not dependent upon parameters like rotational speed and fuel ratio.

For a better understanding of the invention, its operating advantages and the specific objects attained by its user, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated embodiments of the invention.

DESCRIPTION OF DRAWINGS

The invention will be described below in greater detail with reference to the enclosed drawings, in which

Figure 1 is a block diagram schematically depicting some essential components of an internal combustion engine, according to the invention,

Figure 2 is a schematic presentation of one possible embodiment of a pressure regulating arrangement according to the invention,

Figure 3 is a schematic but detailed cross-sectional view of an embodiment of a piston depicted in Fig. 1.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 is a block diagram schematically depicting the components of an internal combustion engine 100 having at least one combustion chamber 40 with a piston 1/piston rod 3, having one or more adjustable body/piston portions 8 (here merely one is shown), which achieves the objective of providing an adjustable compression, by means of displacement provided by pressurised oil supplied in a supply line 6, from supply an internal supply source 101 via a pressure producing and regulating mechanism 200. The pressure producing and regulating mechanism 200 enables a variable pressure P1 within the supply line 6 of the engine 100. A control unit 300 is provided to control the pressure of said regulating mechanism 200 in dependence on input from one or more control and/or sensor signals, e.g. ion current sensors, pressure sensors, temperature sensors, etc (not shown), used to sense different, chosen parameters of the engine, environment and/or vehicle. (as is known per se).

In Fig. 2 there is a schematic view of a pressure producing an pressure regulating mechanism 200 that may be used in connection with the invention. For the skilled person it is evident that many different solutions do exist to achieve the desired function, i.e. to obtain a controllable, variable pressure out put. In Fig. 2 is schematically shown an embodiment in more detail, wherein an internal pressure producing oil pump 202 is used to produce the pressure, normally within the range of 3-6 bar. The oil to the pump 202 is supplied by means of an oil reserve 101 contained in the lower portion of the engine 100. The pump 202 supplies oil into supply line 6 that is connected to all of the piston rods 3 of the engine 100 (see Fig. 3). In order to control the pressure within the supply line 6 there is arranged a branch off line 205 which is normally sealed by means of a spring 204 acting on a ball 203. The spring force from the spring 204 acting on the ball determines the maximum pressure level within the supply line 6. By means of having the spring 204 positioned on a moveable piston portion 210 the force acting on the ball 203 may be varied. The piston portion 210 is positioned by means of controlling the pressure in a communicating pressure chamber 211, that may be replenished drained in many different ways. Here it is presented that the pressure chamber 211 is in communication via a supply line 206, 208 with the pump 202. By means of a three way valve 207, oil is either supplied to the pressure chamber 211 or to a drainage 209. By means of a drainage line 212 oil may be drained from the pressure chambers 211. Accordingly the amount of oil within the pressure chamber 211, and thereby also the spring force of spring 204 is possible to regulate by controlling the supply and drainage respectively to/from the pressure chamber 211. In this manner it is possible by assistance of the control unit 300 to automatically control the pressure in the supply line 6, i.e. to vary the pressure in line 6 to a desired pressure level.

Fig. 3 shows the piston 1 in more detail, comprising a piston pin 2, around which pin a connecting rod 3 is fitted. These elements are known in themselves and are not described in greater detail. The connecting rod 3 has a continuous duct 4, through which oil from the supply line 6 is supplied into the piston pin 2. A first branch line 6A, leads to a first cavity 5B, within the pin 2, including a first check valve 13B''. A second branch line 6B leads to a second cavity 5A, within the pin 2, including a second check valve 13B'. A third branch line 6C leads to a pressure chamber 15A of a control valve 15. From the first cavity 5B there is a oil channel 12B leading to a lower pressure chamber 11B. From the second cavity 5A there is a second oil channel 12A leading to an upper pressure chamber 11A. The pressure chambers 11A, 11B are annularly arranged, to provide for movement of the

adjustable piston portion 8 in relation to the piston pin 2. On the outside of the piston 1, by its upper end, grooves 7 are provided to receive the piston rings.

The distribution of oil among the components of the said pressure chamber, 11A and 11B respectively controls the position of the body/adjustable piston 8 in relation to the said piston pin 2.

Arranged in between said pressure chambers 11A, 11B, there is an annular flange 8B, with a seal 9, which flange 8B is fixedly attached in relation to the piston pin 2. The periphery 2D of the flange 2B, with its sealing 9 is in contact with an intermediate wall portion 8C of the adjustable piston portion 8, which wall portion 8C forms the outer delimiting surfaces of said pressure chambers 11A, 11B. Opposing said intermediate wall 8C, and delimiting said pressure chambers 11A, 11B at the inside, are arranged cylindrical surfaces 2C fixedly attached in relation to said piston pin 2. Said latter surfaces 2C are in line with an innermost cylindrical surface 11D of the moveable piston 8, and interacting by means of appropriate seals 9A, 9B, whereby said pressure chambers 11A, 11B will be sealed in vertical directions, i.e. both upwards and downwards. Drainage from the upper pressure chamber 11A is feasible via a first drainage line 14D leading to the control valve 15. A second drainage line 14C facilitates drainage from the lower pressure chamber 11B to said control valve 15. From said control valve 15 there is arranged an outlet channel 17 leading to a drainage 18 whereby oil is returned to the oil bath of the engine 100.

According to the new solution supply of oil to and drainage from said two pressure chambers 11A, 11B, is achieved by the control valve 15, which by means of the control pressure via line 6C determines which one (if any) of the two chambers 11A, 11 B that shall be connected to drainage 18. The distribution of oil among the two pressure chambers 11A, 11B controls the position of the adjustable piston 8 (i.e. its top surface 8A) in relation to the piston pin 2. The oil that is used to position the adjustable piston 8 is supplied from the pressure producing/regulating system 200 via the channel 4 within the piston rod 3.

Hence the oil pressure P1 supplied in supply line 6 via control valve 15 is used to actively position the adjustable valve body 8. For instance, when running the engine at a lower level of load a relatively low pressure P1' is used to allow drainage from the lower pressure chamber 11B, via its drainage line 14 C into the control valve body 15B and via its

drainage passage 15D, to finally escape via drainage 17, 18. At the same time oil will be replenished into the upper pressure chamber 11A via feed duct 12A. When it is desired to actively lower the position of the movable body 8 (which e.g. facilitates supercharging, for instance in connection with overtaking) a higher pressure P1'' is provided in the feed line 6. This higher pressure P1'' will cause the valve body 15B to compress the resilience spring 15E and thereby move out from connection with the first drainage line 14C and eventually move into connection with the first drainage line 14D, to thereby allow drainage from the upper pressure chamber 11 A. Simultaneously hydraulic oil will be supplied to the lower pressure chamber via feed duct 12B.

The concept is intended to provide completely adjustable degree of compression irrespective of the rotational speed of the engine and/or air/fuel ratio etc. The position of the adjustable piston 8 is controlled by the pressure of the oil that is supplied to line 6 via the channel in the piston rod 4, which in turn is controlled by the pressure regulator. In turn, the pressure regulator 200 of the engine 100 is controlled by a control unit 300, in contact with desired/chosen set of sensors (not shown) that may sense a number of different parameters to optimize the setting of the oil pressure and thereby also the position of the adjustable piston 8, to optimize its position within the combustion chamber 40. Generally a compression ratio is chosen that is just below the limit where knocking will otherwise occur. As is well known within the field a lower compression ratio is needed to avoid knocking in connection with turbo charging, etc., i.e. when higher power output is desired.

Accordingly at maximum power output the adjustable piston 8 should be positioned as far down as possible in relation to the piston pin 2. This position is achieved by controlling the control valve 15 to drain oil via passage 14D from the upper pressure chamber 11A, and to allow oil to be supplied via supply channel 12B to the lower pressure chamber 11B. In the opposite extreme, at very low power delivery, the control valve 15B will instead allow passage 14C to drain, via 18, from the lower pressure chamber 11B to arrange for the adjustable piston 8 to be positioned in its maximum extended position, thereby achieving a maximum compression ratio.

Although, a particular exemplary embodiment of the invention has been disclosed in detail for illustrative purposes, it will be recognized to those skilled in the art that numerous variations or modifications of the disclosed invention, including the rearrangement in the

configurations the of the present invention as well as method of use being amenable to modifications on account of an organization's/customer's need, are possible.

As stated above, the position of the adjusting piston 8 is adjusted automatically depending on the work effort of the engine.
In a simulated example of an engine according to the invention, pistons are used with a diameter of 80 mm for an Otto engine, i.e. a piston surface of approx. 50 cm^2. The compression ratio is then between 1 : 8 and 1 : 17. Depending on various contributory variables, the optimum force in the starting position/top dead centre is then at least 400 N and in the maximum compressed position in certain cases up to 4000 N to obtain the desired power. Great advantages can be obtained with an engine equipped according to the invention. By increasing the compression ratio from 1 : 10.5 to 1 : 18, the power in a simulated 1.6 litre engine increased under partial load from 8.2 to 11.0 kW.

If starting out from a small engine with turbocharging, very good performance can be obtained with variable compression, i.e. a high torque and a fuel saving of 30 – 40%. By only increasing the compression ratio under partial load, a fuel saving of 10 – 15% is achieved.

The exemplary embodiment described herein in detail for illustrative purposes are subject to numerous variations. It is understood that various omissions, substitutions or equivalents are contemplated as circumstances may suggest or render expedient, but is intended to cover the application or implementation without departing from the spirit or scope of the invention. For instance it is perceived that different kind of valves may be used to achieve the same function as described above. Adjustment is best controlled by means of a computer on the basis of the desired control data, e.g. load, speed, emission values, air temperature, engine temperature, etc., due to which the state of equilibrium can be adapted momentarily. Many modifications are possible of some of most of the sub systems described above, e.g. instead of having an internal oil pressure producing system it is of course possible to have the oil source 101 positioned outside the engine and/or also pressure regulating and producing mechanism 200.

CLAIMS

1. Combustion engine comprising at least one combustion chamber (40), which is delimited at one end by a head (41) and delimited at a second end by a piston (1), the piston being arranged on a connecting rod (3) by means of a piston pin (2), a moveable piston body (8) with a delimiting surface (8A) that is movable in relation to the piston pin (2) and facilitates a variable volume in said combustion chamber (40), a first pressure chamber (11A) and a second pressure chamber (11B), which via a supply line (6) and a check valve equipped feed duct (12A, 12B) is supplied with pressurised hydraulic oil from a pressure source (202), which pressure chambers (11A, 11B) are disposed by means of hydraulic oil to be able to cause the movement of said movable piston body (8)/delimiting surface (8A) with the aim of being able to adjust the size of the combustion chamber (40), characterized in that the replenishment of hydraulic oil to each one of said pressure chambers (11A, 11B) is achieved by means of separate feed ducts (12A, 12B) respectively, wherein each feed duct (12A, 12B) is arranged with a check valve (13B', 13B'') and that a control valve (15) is arranged to control the position of said body (8) by means of controlling the communication between any of said pressure chambers (11A, 11B) and a drainage (18).

2. Combustion engine according to claim 1, characterized in that there is arranged a compression regulating mechanism (200) arranged to apply a variable pressure (P1) of oil supplied by said pressure source (202).

3. Combustion engine according to claim 2, characterized in that said engine (100) forms the power drive of said pressure source (202).

4. Combustion engine according to any preceding claim, characterized in that said control valve (15) is arranged to control said communication by means of control via said pressure (P1) in said engine (100).

5. Combustion engine according to claim 4, characterized by providing said control valve (15) in or adjacent the piston pin (2) and a branch conduit (6C) communicating said variable pressure (P1).

6. Combustion engine according to claim 4 or 5, characterized in that said control valve (15) comprises a valve body (15B) and a resilient device (15E).

7. Combustion engine according to claim 6, characterized in that said valve body (15B) is arranged to be controllably positioned by means of said pressure (P1) acting in a direction opposite to said resilient device.

8. Combustion engine according to claim 1, characterized in that each one of said feed ducts (12A, 12B) is replenished via a common supply channel (6) extending along said connecting rod (3).

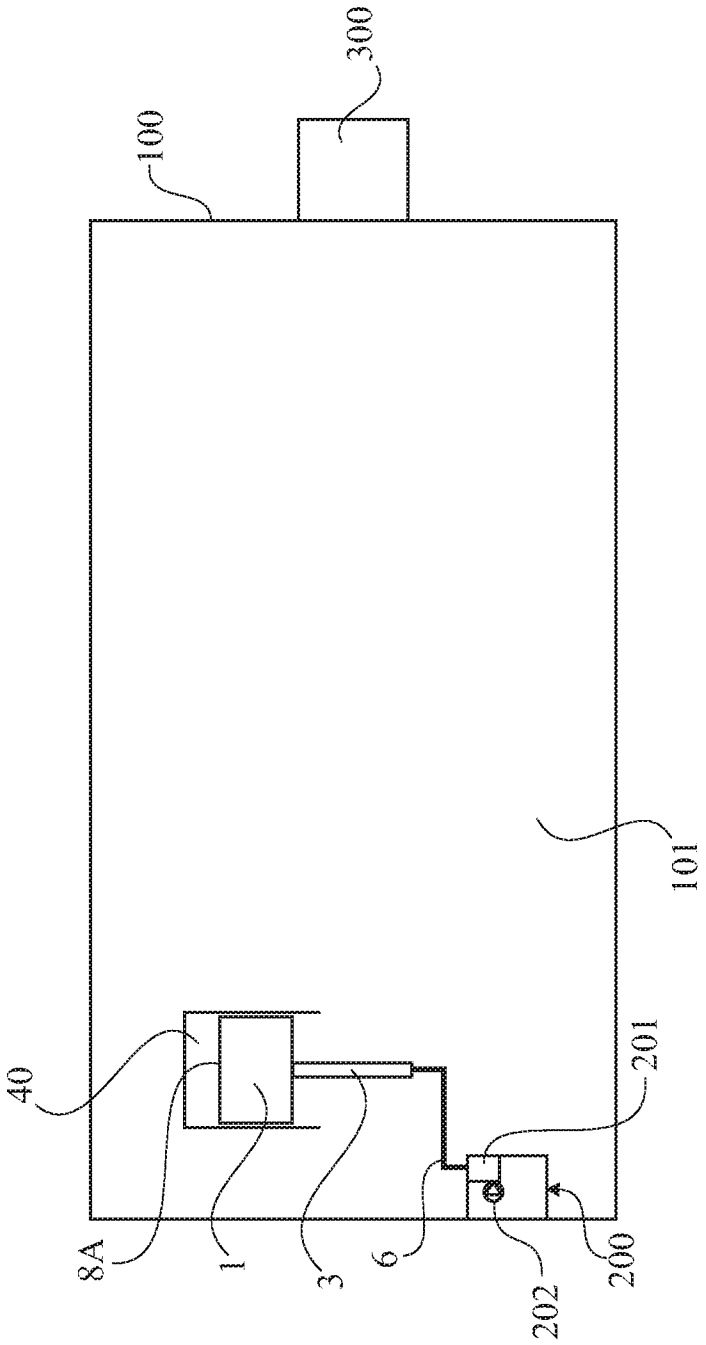


Fig. 1

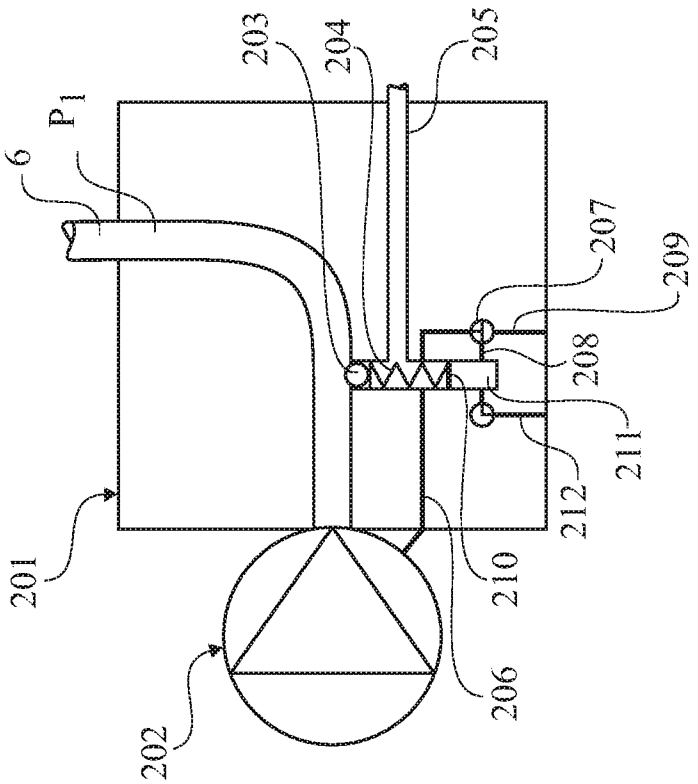


Fig. 2

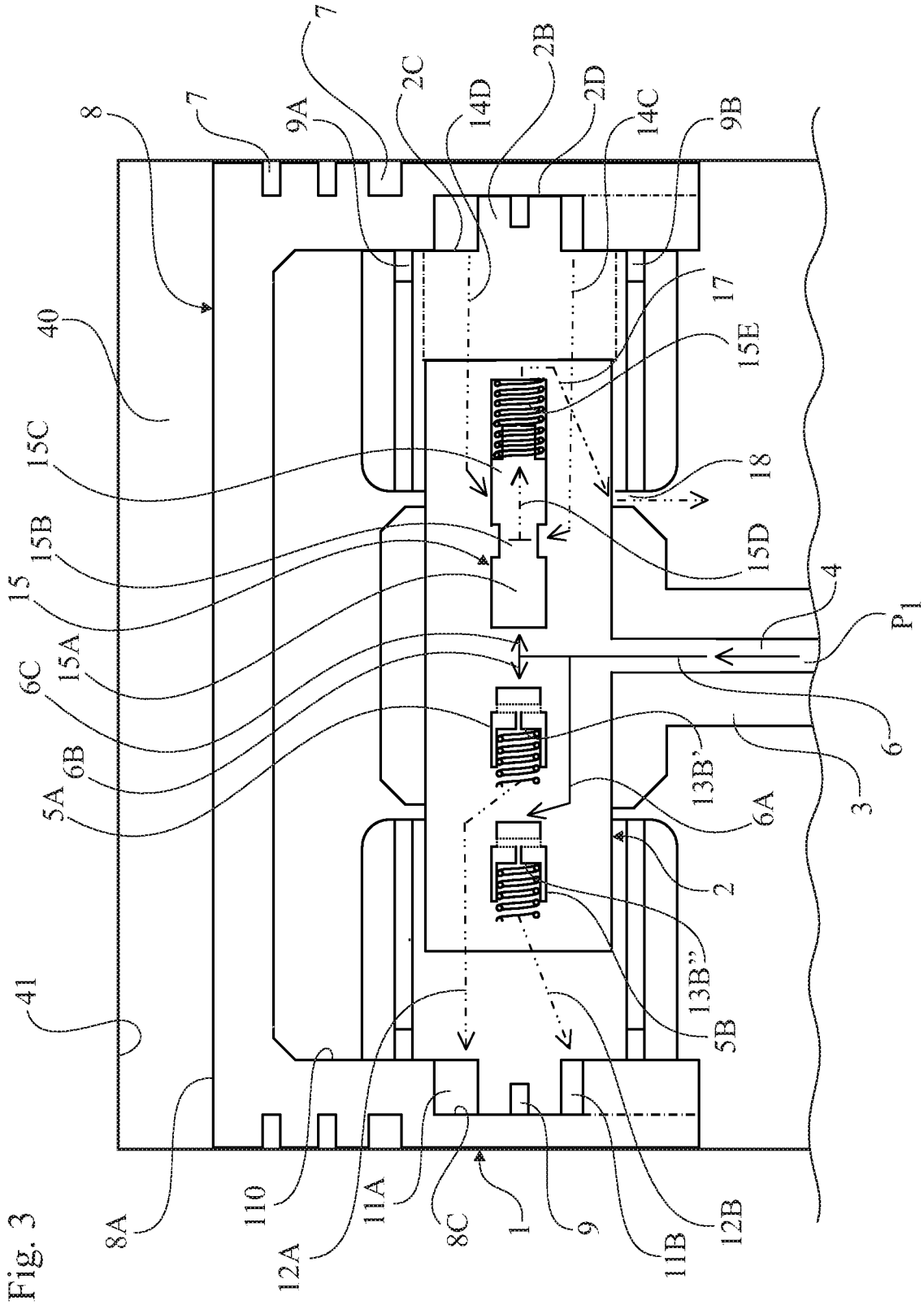

8
7
9A
7
2C
14D
2B
2D
14C
9B
40
17
15E
15C
18
15D
15B
15
4
P_1
6C
15A
6
6B
13B'
5A
6A
3
2
41
13B''
5B
110
11A
8C
1
9
11B
12B
8A
12A

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2008/050170

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: F02D, F02B

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4784093 A (PFEFFER ET AL), 15 November 1988 (15.11.1988), figures 1,2, abstract ---	
A	US 7146940 B2 (KNUTSEN), 12 December 2006 (12.12.2006), figures 1-2, abstract ---	
A	DE 3714762 A1 (BAYERISCHE MOTOREN WERKE AG), 24 November 1988 (24.11.1988), figures 1-9, abstract ---	
A	US 4934347 A (SUGA ET AL), 19 June 1990 (19.06.1990), figures 1-15, abstract --- --------	

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

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
13 May 2008	20-05-2008
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Dan Ionesco / JA A Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (April 2007)

CORRECTED

International patent classification (IPC)

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F02B 75/04 (2006.01)

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Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

CORRECTED

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				JP	1657782	C	21/04/1992
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