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(54) **DUAL SWITCH ELECTROMAGNETIC VALVE-BASED LEVEL 3 OR LEVEL 4 VARIABLE DISPLACEMENT OIL PUMP**

(57) A three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves uses a structure of two variable feedback cavities. One variable feedback cavity is directly connected to a pump outlet, and the other variable feedback cavity is controlled by a pressure control valve. The control valve includes two independent control cavities that are both in communication with a main oil gallery and are each controlled by a switch solenoid valve. The two switch solenoid valves are in four different combined states: off and off, on and off, off and on, and on and on, so that the pressure control valve has four different pressure control modes, and an engine oil pump correspondingly forms four different pressure control modes, which can meet pressure requirements of various different working conditions of an engine, to realize a pressure control target that is very close to actual requirements of the engine; power saving of the pump is very close to that of a continuously variable displacement engine oil pump controlled by an electro-hydraulic proportional valve, and the control modes in the present invention are logically simple and reliable, fast in response, and stable in pressure control, and have a small pressure fluctuation.

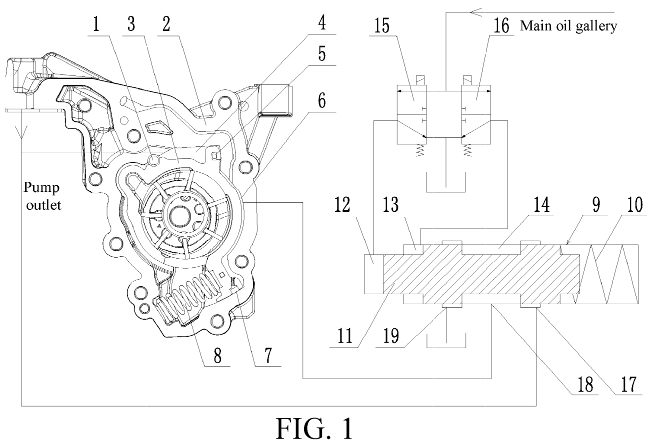

FIG. 1

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Description

BACKGROUND

Technical Field

[0001] The present invention relates to the technical field of internal combustion engine lubrication systems, and in particular, to a lubrication oil pump with multi-stage variable displacement.

Related Art

[0002] With the development of an automobile energy saving and emission reduction technology, variable displacement oil pumps are widely applied in internal combustion engine lubrication systems. A variable displacement oil pump experiences a primary variable feedback by a pump outlet, a primary variable feedback by a main oil gallery, a secondary variable that a switch solenoid valve controls two cavities to feedback, and multi-stage variable displacement controlled by an electro-hydraulic proportional valve. A variable region of the primary variable has a relatively small overlap region with an actual typical operating condition of an engine, and thus saving is limited. A two-stage variable displacement engine oil pump controlled by the switch solenoid valve respectively performs low-pressure and high-pressure control according to different working conditions of the engine, so that an energy-saving effect is obviously improved. However, because the working conditions of the engine are relatively complex, compared with the actual requirements of the engine, the two-stage variable displacement engine oil pump still has relatively large functional richness, and energy-saving potential still needs to be excavated.

[0003] A continuously variable displacement engine oil pump based on electro-hydraulic proportion technology has gradually become the first choice for the development of new-generation engines. An electro-hydraulic proportional valve is controlled according to different duty ratios, so that the engine oil pump obtains different performance outputs to meet pressure requirements of the engine under different working conditions. A response characteristic of the electro-hydraulic proportional valve is: there is a contradiction between pressure control precision and stability and reliability of pressures, and matching of electro-hydraulic proportional valve and mechanical parts of the oil pump and matching of an engine control unit (ECU) and an oil pump assembly both increase design and manufacture difficulty of the engine oil pump and the complexity of calibration.

SUMMARY

Technical Objectives

[0004] An objective of the present invention is to overcome the foregoing defect in the prior art to provide a novel three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves.

Technical Solution

[0005] Technical solutions of the present invention are: a three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves, including: a pump body, a variable slider, a variable spring, and a variable feedback cavity, where the variable feedback cavity is divided by an intermediate seal component into a first variable feedback cavity and a second variable feedback cavity, the first variable feedback cavity and the second variable feedback cavity are separately connected to a pump outlet through an oil line, the first variable feedback cavity is directly interlinked with the pump outlet, and an oil line between the second variable feedback cavity and the pump outlet is provided thereon with a pressure control valve for controlling on and off of the oil line; the pressure control valve includes a valve body having an inner cavity and a valve core mounted in the inner cavity of the valve body, two control cavities not in communication with each other are formed between one end of the valve core and an inner cavity wall of the valve body, the other end of the valve core is provided with a spring, a transfer chamber is formed between a middle portion of the valve core and the inner cavity wall of the valve body, the two control cavities are separately in communication with a main oil gallery through an oil line, and one switch solenoid valve is mounted on each of the oil lines between the two control cavities and the main oil gallery, and a position of the valve core in the inner cavity of the valve body is determined by an elastic force of the spring and hydraulic pressures in the two control cavities.

[0006] A solenoid valve A (15) and a solenoid valve B (16) are separately electrically connected to an engine control system; the solenoid valve A (15) and the solenoid valve B (16) separately obtain a voltage or current or PWM signal from the engine control system, to separately control the solenoid valve A (15) and the solenoid valve B (16) to be turned on and turned off. The voltage or current or PWM signal separately obtained by the solenoid valve A (15) and the solenoid valve B (16) from the engine control system is a target control pressure of the variable displacement engine oil pump that is determined by the engine control system ECU according to an engine rotation speed, an engine oil temperature, an engine oil pressure, and a load sensor signal, and combined control modes of the solenoid valve A (15) and the solenoid valve B (16) are selected according to the target pressure of the variable displacement engine oil pump, to output the combined control modes in a form of the voltage or current or PWM signal to control on and off of the solenoid valve A (15) and the solenoid valve B (16). Four different states are provided: when A and B solenoid valve signals are 0, A is off, and B is off. When the A solenoid valve signal is a set value, and the B solenoid valve signal is

0, A is on, and B is off. When the A solenoid valve signal is 0, and the B solenoid valve signal is a set value, A is off, and B is on. When the A and B solenoid valve signals are set values, A is on, and B is on, so that the pressure control valve forms four different pressure control modes. The set values of the solenoid valve signals are determined according to control requirements of the solenoid valves, the solenoid valve may be turned on when the signal is 0 and turned off when the signal reaches the set value, and different control modes do not affect the claims of the patent of the present invention.

[0007] In an embodiment, a port P in communication with the pump outlet, a port A in communication with the second variable feedback cavity, and a port T in communication with an oil pan are provided on the valve body of the pressure control valve; when the hydraulic pressures in the two control cavities are greater than the elastic force of the spring, the hydraulic pressures push the valve core to move toward an end of the spring; in this case, the port A is not in communication with the port T, and the port A is in communication with the port P via the transfer chamber, to allow pressure oil at the pump outlet to enter the second variable feedback cavity; pressure oil in the two variable feedback cavities together push the variable slider to rotate toward a direction of reducing displacement until a set pressure is obtained, and the valve core returns to an equilibrium state position; and when the hydraulic pressures in the two control cavities are less than the elastic force of the spring, the spring pushes the valve core to move toward an end of the control cavities; in this case, the port A is not in communication with the port P, and the port A is in communication with the port T via the transfer chamber, so that pressure oil in the second variable feedback cavity is discharged outward, the variable slider is pushed by the elastic force of the variable spring to rotate toward a direction of increasing displacement until a set pressure is obtained, and the valve core returns to the equilibrium state position.

[0008] In an embodiment, the two control cavities in the pressure control valve are respectively a first control cavity and a second control cavity, the first control cavity is controlled by the solenoid valve A, and the second control cavity is controlled by the solenoid valve B; four different states: A off and B off, A on and B off, A off and B on, and A on and B on are provided through combination by separately turning on and turning off the solenoid valve A and the solenoid valve B, so that the pressure control valve has four different pressure control modes.

[0009] In an embodiment, the first control cavity is a chamber formed between an end face of one end of the valve core and the inner cavity wall of the valve body, and the second control cavity is an annular chamber formed between a peripheral surface of one end of the valve core and the inner cavity wall of the valve body.

[0010] In an embodiment, the valve body and the pump body are integrally formed.

Beneficial effects

[0011] Beneficial effects of the present invention are: the variable displacement engine oil pump uses a structure of two feedback cavities. One feedback cavity is directly connected to a pump outlet, and the other feedback cavity is controlled by a pressure control valve. The control valve includes two control cavities that are each controlled by a switch solenoid valve. The two switch solenoid valves are in four different combined states: off and off, on and off, off and on, and on and on, so that the pressure control valve has four different pressure control modes, and an engine oil pump correspondingly forms four different pressure control modes, which can meet pressure requirements of various different working conditions of an engine, to realize a pressure control target that is very close to actual requirements of the engine; power saving of the pump is very close to that of a continuously variable displacement engine oil pump controlled by an electro-hydraulic proportional valve, and the control modes in the present invention are logically simple and reliable, fast in response, and stable in pressure control, and have a small pressure fluctuation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a schematic diagram of a control structure of a variable displacement engine oil pump according to an embodiment of the present invention.

[0013] Reference numerals are: 1--rotating positioning pin, 2--pump body, 3--variable slider, 4--first variable feedback cavity, 5--intermediate seal component, 6--second variable feedback cavity, 7--seal component, 8--variable spring, 9--pressure control valve, 10--spring, 11--valve core, 12--first control cavity, 13--second control cavity, 14--transfer chamber, 15--solenoid valve A, 16--solenoid valve B, 17--port P, 18--port A, 19--port T.

DETAILED DESCRIPTION

[0014] For ease of understanding of a person skilled in the art, the present invention is further described below with reference to the embodiments and the accompanying drawings, and content mentioned in the implementations is not a limitation to the present invention.

[0015] In description of the present invention, it should be understand that orientation or position relationship indicated by terms "center", "longitudinal", "transverse", "length", "width", "thickness", "up", "down", "front", "rear", "left", "right", "vertical", "horizontal", "top", "bottom", "inside", "outside", "clockwise", "counterclockwise" or the like are orientation or position relationships shown based on the accompanying drawings, are only for the purpose of describing the present invention and simplifying the description, do not indicate or imply that indicated apparatuses or elements necessarily have particular orientations or are necessarily constructed and operated at particular orientations, and therefore should not be construed as a limitation to the present invention.

[0016] In addition, terms "first" and "second" are only for the purpose of description and cannot be construed as indicating or implying relative importance or implicitly indicating a quantity of the indicated technical features. In description of the present invention, "multiple" means two or more unless explicitly specifically defined otherwise. In descriptions of the present invention, it should be noted that unless otherwise stipulated and defined, terms "mount", "link", and "connect" should be understood in the broad sense. For example, "mount", "link", and "connect" may be a mechanical connection or an electric connection, communication between interiors of two elements, a direct connection, or an indirect connection through an intermediary. Specific meanings of the terms may be understood according to specific situations.

[0017] As shown in FIG. 1, a preferred embodiment of the present invention is: a three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves, including: a rotating positioning pin 1, a pump body 2, a variable slider 3, a seal component 7, and a variable spring 8. A sealed capacity composed by the pump body 2, the variable slider 3, the seal component 7, and a pump cover together forms a variable feedback cavity, and the variable feedback cavity is divided by an intermediate seal component 5 into a first variable feedback cavity 4 and a second variable feedback cavity 6, the first variable feedback cavity 4 and the second variable feedback cavity 6 are separately connected to a pump outlet through an oil line, the first variable feedback cavity 4 is directly interlinked with the pump outlet, and an oil line between the second variable feedback cavity 6 and the pump outlet is provided thereon with a pressure control valve 9 for controlling on and off of the oil line. The pressure control valve 9 includes a valve body having an inner cavity and a valve core 11 mounted in the inner cavity of the valve body, two control cavities 12, 13 not in communication with each other are formed between one end of the valve core 11 and an inner cavity wall of the valve body, the other end of the valve core 11 is provided with a spring 10, a transfer chamber 14 is formed between a middle portion of the valve core 11 and the inner cavity wall of the valve body, the two control cavities 12, 13 are separately in communication with a main oil gallery through an oil line, and one switch solenoid valve 15, 16 is mounted on each of the oil lines between the two control cavities 12, 13 and the main oil gallery, and a position of the valve core 11 in the inner cavity of the valve body is determined by an elastic force of the spring 10 and hydraulic pressures in the two control cavities; the valve body and the pump body 2 are integrally formed.

[0018] As shown in FIG. 1, a port P 17 in communication with the pump outlet, a port A 18 in communication with the second variable feedback cavity 6, and a port T 19 in communication with an oil pan are provided on the valve body of the pressure control valve. When a hydraulic pressure at the left end of the valve core 11 is greater than a set pressure of the spring 10, the port P 17 and the port A 18 of the pressure control valve 9 are in communication via the transfer chamber 14, oil is supplemented to the second variable feedback cavity 6, pressure oil in the feedback cavities pushes the variable slider 3 to rotate around the rotating positioning pin 1 toward a direction of reducing displacement until a set pressure is obtained, and the valve core 11 returns to an equilibrium state position. When the hydraulic pressure at the left end of the valve core 11 is less than the set pressure of the spring 10, the port A 18 and the port T 19 of the pressure control valve 9 are in communication via the transfer chamber 14, so that pressure oil in the second variable feedback cavity 6 is discharged outward, and variable slider 3 rotates around the rotating positioning pin 1 toward a direction of increasing displacement under the action of the elastic force of the variable spring 8 until a set pressure is obtained, and the valve core 11 returns to the equilibrium state position.

[0019] As shown in FIG. 1, the two control cavities in the pressure control valve 9 are respectively a first control cavity 12 and a second control cavity 13, the first control cavity 12 is a chamber formed between an end face of one end of the valve core and the inner cavity wall of the valve body, and the second control cavity 13 is an annular chamber formed between a peripheral surface of one end of the valve core and the inner cavity wall of the valve body; the first control cavity 12 is controlled by a solenoid valve A 15, and the second control cavity 13 is controlled by a solenoid valve B 16; four different states: A off and B off, A on and B off, A off and B on, and A on and B on are provided through combination by separately turning on and turning off the solenoid valve A 15 and the solenoid valve B 16, so that the pressure control valve 9 has four different pressure control modes.

[0020] The solenoid valve A (15) and the solenoid valve B (16) are separately electrically connected to an engine control system; the solenoid valve A (15) and the solenoid valve B (16) separately obtain a voltage or current or PWM signal from the engine control system, to separately control the solenoid valve A (15) and the solenoid valve B (16) to be turned on and turned off. The voltage or current or PWM signal separately obtained by the solenoid valve A (15) and the solenoid valve B (16) from the engine control system is a target control pressure of the variable displacement engine oil pump that is determined by the engine control system ECU according to an engine rotation speed, an engine oil temperature, an engine oil pressure, and a load sensor signal, and combined control modes of the solenoid valve A (15) and the solenoid valve B (16) are selected according to a target pressure of the variable displacement engine oil pump, to output the combined control modes in a form of the voltage or current or PWM signal to control on and off of the solenoid valve A (15) and the solenoid valve B (16). Four different states are provided: when A and B solenoid valve signals are 0, A is off, and B is off. When the A solenoid valve signal is a set value, and the B solenoid valve signal is 0, A is on, and B is off. When the A solenoid valve signal is 0, and the B solenoid valve signal is a set value, A is off, and B is on. When the A and B solenoid valve signals are set values, A is on, and B is on, so that the pressure control valve forms four different pressure control modes. The set values of the solenoid valve signals are determined according to control requirements of the solenoid valves, the solenoid valve may be turned on when the signal is 0 and turned off when the signal reaches the set value, and different control modes do not affect the claims of the patent of the present invention.

[0021] Working processes of the four states of the two switch solenoid valves are described in detail below.

[0022] When the two switch solenoid valves are in a state of A off and B off, the first control cavity 12 and the second control cavity 13 are both in a pressure-free state; the engine oil pump performs variable feedback under the action of a pressure in the first variable feedback cavity 4 and is in a high pressure control mode. Lubrication security of the engine is mainly considered in the high pressure control mode, a ratio of contribution to oil saving is not high, and therefore, the pump outlet may be used for feedback control.

[0023] When the two switch solenoid valves are in a state of A on and B off, the second control cavity 13 is in a pressure-free state, pressures of the first control cavity 12 and the main oil gallery are in communication, and the engine oil pump performs variable feedback under the joint action of the first variable feedback cavity 4 and the second variable feedback cavity 6. When a hydraulic pressure of the first control cavity 12 is greater than a set pressure of the spring 10, the port P 17 and the port A 18 of the pressure control valve 9 are in communication, oil is supplemented to the second variable feedback cavity 6, pressure oil in the feedback cavities pushes the variable slider 3 to rotate around the rotating positioning pin 1 toward a direction of reducing displacement until a set pressure is obtained, and the valve core 11 returns to an equilibrium state position. When the hydraulic pressure of the first control cavity 12 is less than the set pressure of the spring 10, the port A 18 and the port T 19 of the pressure control valve 9 are in communication, oil is discharged from the second variable feedback cavity 6, the elastic force of the variable spring 8 pushes the variable slider 3 to rotate around the rotating positioning pin 1 toward a direction of increasing displacement until a set pressure is obtained, and the valve core 11 returns to the equilibrium state position. In this case, the oil pump is in sub high pressure control state.

[0024] When the two switch solenoid valves are in a state of A off and B on, the first control cavity 12 is in a pressure-free state, pressures of the second control cavity 13 and the main oil gallery are in communication, and the engine oil pump performs variable feedback under the joint action of the first variable feedback cavity 4 and the second variable feedback cavity 6. When a hydraulic pressure of the second control cavity 13 is greater than a set pressure of the spring 10, the port P 17 and the port A 18 of the pressure control valve 9 are in communication, oil is supplemented to the second variable feedback cavity 6, pressure oil in the feedback cavities pushes the variable slider 3 to rotate around the rotating positioning pin 1 toward a direction of reducing displacement until a set pressure is obtained, and the valve core 11 returns to an equilibrium state position. When the hydraulic pressure of the second control cavity 13 is less than the set pressure of the spring 10, the port A 18 and the port T 19 of the pressure control valve 9 are in communication, oil is discharged from the second variable feedback cavity 6, the elastic force of the variable spring 8 pushes the variable slider 3 to rotate around the rotating positioning pin 1 toward a direction of increasing displacement until a set pressure is obtained, and the valve core 11 returns to the equilibrium state position. In this case, the oil pump is in a sub low pressure control state.

[0025] When the two switch solenoid valves are in a state of A on and B on, pressures of the first control cavity 12 and the second control cavity 13 and the main oil gallery are in communication, and the engine oil pump performs variable feedback under the joint action of the first variable feedback cavity 4 and the second variable feedback cavity 6. When a common hydraulic pressure of the first control cavity 12 and the second control cavity 13 is greater than a set pressure of the spring 10, the port P and the port A of the pressure control valve 9 are in communication, oil is supplemented to the second variable feedback cavity 6, the pressure oil in the feedback cavities pushes the variable slider 3 to rotate around the rotating positioning pin 1 toward a direction of reducing displacement until a set pressure is obtained, and the valve core 11 returns to an equilibrium state position. When the common hydraulic pressure of the first control cavity 12 and the second control cavity 13 is less than the set pressure of the spring 10, the port A and the port T of the pressure control valve 9 are in communication, oil is discharged from the second variable feedback cavity 6, the elastic force of the variable spring 8 pushes the variable slider 3 to rotate around the rotating positioning pin 1 toward a direction of increasing displacement until a set pressure is obtained, and the valve core 11 returns to the equilibrium state position. In this case, the oil pump is in a low pressure control state.

[0026] In the four states, the state of A on and B off may be designed into a sub low pressure control mode, and correspondingly, the state of A off and B on may be designed into a sub high pressure control mode.

[0027] The foregoing embodiments are preferred implementations of the present invention. In addition, the present invention may also be implemented in other manners, and any obvious replacement made without departing from the idea of the technical solutions falls within the protection scope of the present invention.

[0028] To make a person skilled in the art more conveniently understand improvements of the present invention with respect to the prior art, some accompanying drawings and descriptions of the present invention have been simplified, and for the purpose of clearness, some other elements are omitted in the present application documents. A person skilled in the art would be aware that these omitted elements may also constitute content of the present invention.

Claims

1. A three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves, comprising: a pump body (2), a variable slider (3), a variable spring (8), and a variable feedback cavity, wherein the variable feedback cavity is divided by an intermediate seal component (5) into a first variable feedback cavity (4) and a second variable feedback cavity (6), the first variable feedback cavity (4) and the second variable feedback cavity (6) are separately connected to a pump outlet through an oil line, the first variable feedback cavity (4) is directly interlinked with the pump outlet, and an oil line between the second variable feedback cavity (6) and the pump outlet is provided thereon with a pressure control valve (9) for controlling on and off of the oil line.

2. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves according to claim 1, wherein the pressure control valve (9) comprises a valve body having an inner cavity and a valve core (11) mounted in the inner cavity of the valve body, two control cavities (12, 13) not in communication with each other are formed between one end of the valve core (11) and an inner cavity wall of the valve body, the other end of the valve core (11) is provided with a spring (10), a transfer chamber (14) is formed between a middle portion of the valve core (11) and the inner cavity wall of the valve body, the two control cavities are separately in communication with a main oil gallery through an oil line, one switch solenoid valve is mounted on each of the oil lines between the two control cavities and the main oil gallery, and a position of the valve core (11) in the inner cavity of the valve body is determined by an elastic force of the spring (10) and hydraulic pressures in the two control cavities.

3. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves according to claim 2, wherein a port P (17) in communication with the pump outlet, a port A (18) in communication with the second variable feedback cavity, and a port T (19) in communication with an oil pan are provided on the valve body of the pressure control valve (9).

4. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves according to claim 3, wherein in the pressure control valve (9), when the hydraulic pressures in the two control cavities are greater than the elastic force of the spring (10), the hydraulic pressures push the valve core (11) to move toward an end of the spring; in this case, the port A (18) is not in communication with the port T (19), and the port A (18) is in communication with the port P (17) via the transfer chamber (14), to allow pressure oil at the pump outlet to enter the second variable feedback cavity (6); pressure oil in the two variable feedback cavities together push the variable slider (3) to rotate toward a direction of reducing displacement until a set pressure is obtained, and the valve core (11) returns to an equilibrium state position; and when the hydraulic pressures in the two control cavities are less than the elastic force of the spring (10), the spring (10) pushes the valve core (11) to move toward an end of the control cavities; in this case, the port A (18) is not in communication with the port P (17), and the port A (18) is in communication with the port T (19) via the transfer chamber (14), so that pressure oil in the second variable feedback cavity (6) is discharged outward, the variable slider (3) is pushed by the elastic force of the variable spring (8) to rotate toward a direction of increasing displacement until a set pressure is obtained, and the valve core (11) returns to the equilibrium state position.

5. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves according to any one of claims 1, 2, and 4, wherein the two control cavities in the pressure control valve are respectively a first control cavity (12) and a second control cavity (13), the first control cavity (12) is controlled by a solenoid valve A (15), and the second control cavity (13) is controlled by a solenoid valve B (16); four different states: A off and B off, A on and B off, A off and B on, and A on and B on are provided through combination by separately turning on and turning off the solenoid valve A (15) and the solenoid valve B (16), so that the pressure control valve forms four different pressure control modes.

6. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves according to claim 5, wherein the first control cavity (12) is a chamber formed between an end face of one end of the valve core (11) and the inner cavity wall of the valve body, and the second control cavity (13) is an annular chamber formed between a peripheral surface of one end of the valve core (11) and the inner cavity wall of the valve body.

7. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves

according to claim 5, wherein the solenoid valve A (15) and the solenoid valve B (16) are separately electrically connected to an engine control system.

8. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves according to claim 7, wherein the solenoid valve A (15) and the solenoid valve B (16) separately obtain a voltage or current or PWM signal from the engine control system, to separately control the solenoid valve A (15) and the solenoid valve B (16) to be turned on and turned off, to implement the four different states: A off and B off, A on and B off, A off and B on, and A on and B on, so that the pressure control valve forms the four different pressure control modes.

9. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves according to claim 8, wherein when the solenoid valves are in three different states: A on and B off, A off and B on, and A on and B on, and the second variable feedback cavity (6) is in an overflow control state, a very stable pressure output can be obtained.

10. The three-stage or four-stage variable displacement engine oil pump based on two switch solenoid valves according to any one of claims 1, 2, and 3, wherein the valve body and the pump body (2) are integrally formed.

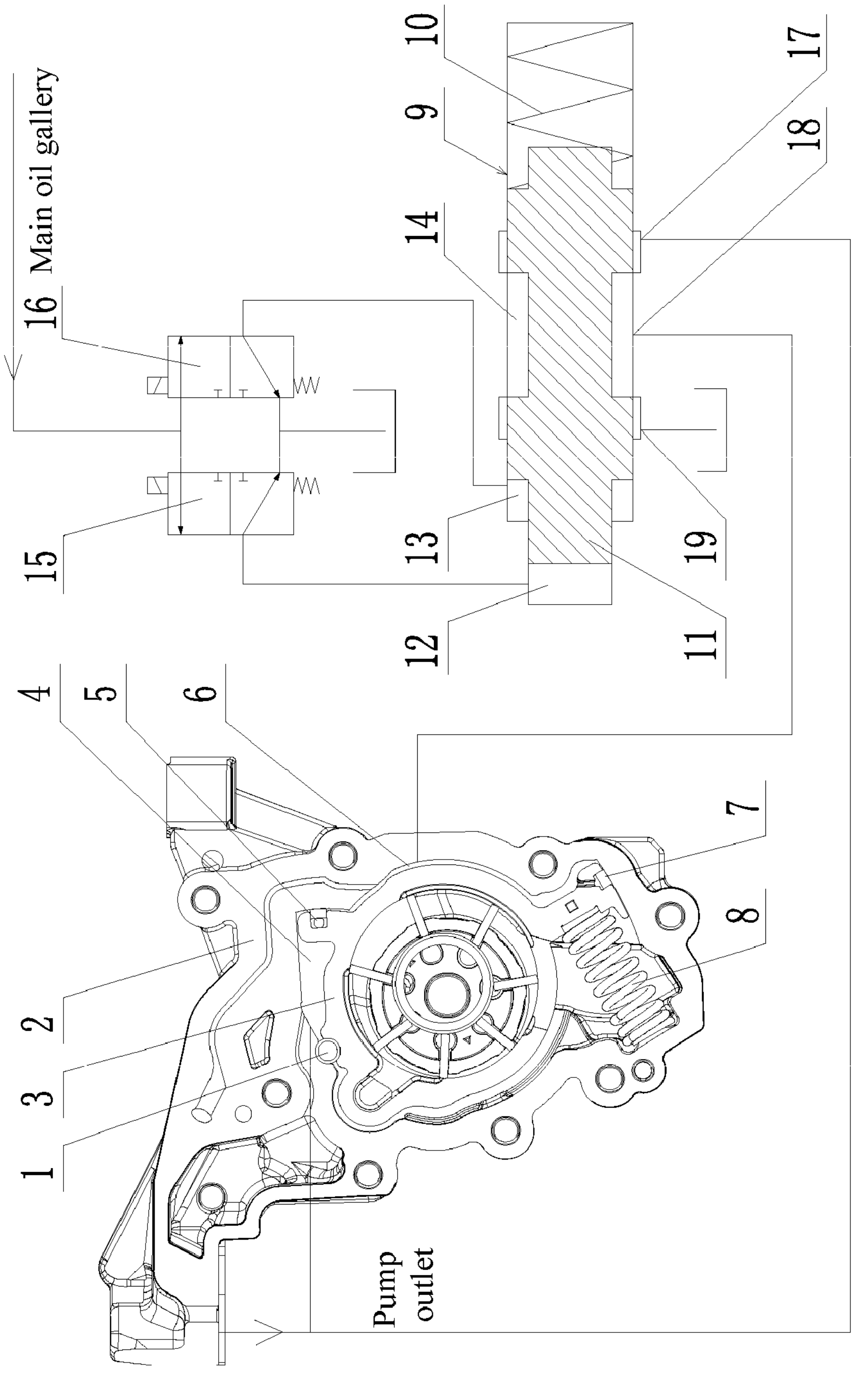
Main oil gallery
Pump
outlet
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FIG. 1

INTERNATIONAL SEARCH REPORT

International application No. **PCT/CN2018/097838**

A. CLASSIFICATION OF SUBJECT MATTER

F04C 2/344(2006.01)i; F04C 14/24(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04C

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)

CNABS, VEN, CNKI: 油泵, 变排量, 第二, 腔, 室, 弹簧, 阀, oil, pump, variable, displacement, two, second, multiple, chamber, cavity, spring, valve

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 107605720 A (HUNAN OIL PUMP CO., LTD.) 19 January 2018 (2018-01-19) see description, paragraphs 15-23, and figure 1	1-10
PX	CN 207485654 U (HUNAN OIL PUMP CO., LTD.) 12 June 2018 (2018-06-12) see description, paragraphs 22-30, and figure 1	1-10
X	CN 105074217 A (MAGNA POWERTRAIN USA INC.) 18 November 2015 (2015-11-18) see description, paragraphs 27-48, and figures 1-3	1, 10
X	CN 103671093 A (NINGBO SHENGLONG AUTOMOTIVE POWERTRAIN SYSTEM CO., LTD.) 26 March 2014 (2014-03-26) see description, paragraphs 22-31, and figures 1-4	1, 10
A	US 2016348673 A1 (MAZDA MOTOR) 01 December 2016 (2016-12-01) see entire document	1-10
A	JP 2000104674 A (KAYABA INDUSTRY CO., LTD.) 11 April 2000 (2000-04-11) see entire document	1-10

☐ Further documents are listed in the continuation of Box C. ☑ 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 application or patent but published on or after the international filing date

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Date of the actual completion of the international search	Date of mailing of the international search report
12 October 2018	**07 November 2018**

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