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(72) Inventors:  
• **JEON, Wan Jae**  
**42702 Daegu (KR)**  
• **LEE, Jun Hyeok**  
**42702 Daegu (KR)**  
• **PARK, Yong Deok**  
**42702 Daegu (KR)**  
• **KIM, Dae Yong**  
**42702 Daegu (KR)**  
• **KIM, Dong Sub**  
**42702 Daegu (KR)**

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(74) Representative: **Müller Verweyen**  
**Patentanwälte**  
**Friedensallee 290**  
**22763 Hamburg (DE)**

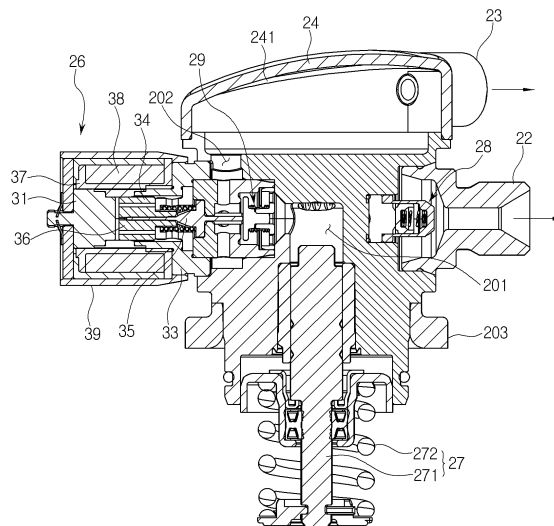
(71) Applicant: **Motonic Corporation**  
**Seoul 03142 (KR)**

(54) **HIGH PRESSURE FUEL PUMP AND LPDI SYSTEM WITH THE SAME**

(57) Disclosed are a high pressure fuel pump and a liquid petroleum direct injection system including the same. The high pressure fuel pump includes a body having an intake port and an exhaust port, and provided therein with a pressing device configured to press a portion of fuel at a high pressure, a spill valve coupled to one side of the body to control a supply flow rate and exhaust pressure of the fuel, and a cover coupled to an

upper portion of the body and having a recovery port for recovering a portion of the fuel to a bombe. The cover has a dome shape that is convex upward. The cover collects gaseous fuel generated by heat of an engine when the engine is turned off after driving, that is, collects vapor to recover the vapor to the bombe, thereby improving the restartability.

FIG. 3



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## Description

### BACKGROUND ART

#### 1. Field of the Invention

**[0001]** The present invention relates to a liquid petroleum direct injection (LPDI) system, and more particularly, to a high pressure fuel pump for driving an engine by discharging liquid fuel stored in a bombe at high pressure and injecting the liquid fuel into a cylinder, and an LPDI system including the same.

#### 2. Description of the Related Art

**[0002]** In general, unlike a mechanical LPG fuel system that relies on pressure of a fuel tank, a liquid petroleum direct injection (LPDI) system installs a high pressure fuel pump on a fuel supply line and drives an engine by injecting liquid fuel, which is discharged at high pressure by the high pressure fuel pump, into a cylinder using an injector.

**[0003]** The LPDI system has the effects of improving power performance of a vehicle, improving fuel efficiency by reducing fuel consumption, and reducing an amount of carbon emission.

**[0004]** For example, the applicant of the present invention has disclosed and filed patent applications for an LPDI system and configuration of a high pressure fuel pump applied thereto as shown in Patent Documents 1 to 3 below.

**[0005]** Since the LPDI system uses LPG fuel, vaporization and compression of the LPG fuel may occur in the process of using the LPG fuel due to the property of the LPG fuel. This phenomenon is called 'vapor rock'.

**[0006]** The vapor rock phenomenon is known to occur because liquid and gaseous fuels coexist on a fuel line due to residual heat of an engine compartment when the engine is turned off after driving.

**[0007]** FIG. 10 is a sectional view of a high pressure fuel pump applied to an LPDI system according to a related art.

**[0008]** As shown in FIG. 10, low pressure fuel, which is supplied to a fuel recovery line 122 via a low pressure portion 120 provided at an upper portion of a body 110, may cool a piston 130 by passing through a pair of cooling passages 112 connected to upper and lower portions of a high pressure fuel pump 100 through the volume change of the piston 130 generated when the high pressure fuel pump 100 is driven and the piston 130 moves up and down. In this case, the low pressure fuel introduced through a low pressure fuel inlet 114 is directly introduced into the low pressure portion 120 and then supplied through the fuel recovery line 122.

**[0009]** For this reason, there is a problem that an adverse effect may be caused on the cooling rate of the piston 120 because the flow rate of fuel may vary depending on the drive RPM of the high pressure fuel pump

100.

**[0010]** Meanwhile, the vapor rock phenomenon occurring in the LPDI system of the related art may become a cause of deterioration of startability at the next start after the vehicle has been driven and turned off.

**[0011]** The vapor rock phenomenon may occur at various positions of a fuel supply system, and the vapor rock phenomenon occurring at the high pressure portion may cause a problem.

**[0012]** In particular, the vapor rock phenomenon occurring in a closed space such as a high pressure fuel pump and a delivery pipe is not easy to solve due to the characteristics of high pressure devices, and thus it is difficult to improve startability.

**[0013]** For example, when the vapor rock phenomenon occurs in the high pressure fuel pump applied to the LPDI system of the related art, liquid and gaseous fuels coexist at an upper end of the high pressure fuel pump.

**[0014]** That is, according to the high pressure fuel pump of the related art, a cover is formed in a planar shape by reducing a volume for fuel circulation and pulsation reduction such that the volume is optimized at the time of fuel return, so the vapor inside the cover is not completely eliminated at the time of restarting and fuel circulation, but partially remains inside the cover.

**[0015]** In addition, the high pressure fuel pump according to the related art has a problem in that main components may be worn during driving due to low lubrication caused by the characteristics of the LPG fuel.

[Related Documents]

[Patent Document]

**[0016]**

(Patent Document 1) Korean Patent Registration No. 10-1975824 (issued on April 30, 2019)

(Patent Document 2) Korean Patent Registration No. 10-1987458 (issued on June 3, 2019)

(Patent Document 3) Korean Unexamined Patent Publication No. 10-2014-0106764 (published on September 4, 2014)

#### 45 SUMMARY OF THE INVENTION

**[0017]** In order to solve the problems occurring in the related art, an object of the present invention is to provide a high pressure fuel pump and a liquid petroleum direct injection (LPDI) system including the same, capable of improving startability at the time of restarting by collecting vapor generated due to heat of an engine after driving a vehicle.

**[0018]** Another object of the present invention is to provide a high pressure fuel pump and an LPDI system including the same, capable of preventing components from being worn caused by the characteristics of LPG fuel.

**[0019]** Still another object of the present invention is to provide a high pressure fuel pump and an LPDI system including the same, capable of cooling a piston at a constant rate by circulating low pressure fuel supplied from a fuel tank to a cooling passage provided inside the high pressure fuel pump at constant pressure and flow rate.

**[0020]** In order to achieve the objects as described above, the present invention provides a high pressure fuel pump including: a body formed at a lateral side thereof with an intake port and an exhaust port, and provided therein with a pressing device configured to press a portion of fuel, which is supplied through the intake port, at a high pressure; a spill valve coupled to one side of the body to control a supply flow rate and exhaust pressure of the fuel; and a cover coupled to an upper portion of the body and having a recovery port for recovering a portion of the fuel supplied into the body to a bombe, wherein the cover collects gaseous fuel vaporized by heat of an engine when the engine is turned off after driving, and has a dome shape which is convex upward to recover the gaseous fuel to the bombe when the engine is restarted.

**[0021]** Further, in order to achieve the objects as described above, a liquid petroleum direct injection system including the high pressure fuel pump according to the present invention includes: a fuel pump configured to pump the fuel stored in the bombe to supply the fuel toward the engine; the high pressure fuel pump configured to receive the fuel supplied from the fuel pump through the intake port formed in the body, press a portion of the fuel at high pressure in a high pressure portion formed inside the body, and transfer the fuel that remains after the fuel is pressurized to a fuel recovery line through the recovery port communicating with the low pressure portion such that the remaining fuel is recovered to the bombe; a delivery pipe connected to the exhaust port of the high pressure fuel pump through which the pressurized fuel is exhausted and filled with the pressurized fuel; an injector configured to directly inject the fuel filled in the delivery pipe into a combustion chamber of an engine; an electronic control unit configured to generate control signals for controlling a motor in the fuel pump, the injector, and a valve of the high pressure fuel pump based on a target rpm of the engine; and a motor controller configured to control a driving of the motor in accordance with the control signal, wherein the cover of the high pressure fuel pump collects gaseous fuel vaporized by heat of the engine when the engine is turned off after driving, and has a dome shape which is convex upward to recover the gaseous fuel to the bombe when the engine is restarted.

**[0022]** As described above, according to the high pressure fuel pump and the LPDI system including the same of the present invention, a cover is formed in a convex dome shape so that gaseous fuel can be collected in an inside of the cover, and the collected gaseous fuel can be returned to a bombe at the time of restarting an engine.

**[0023]** Thus, according to the present invention, re-

startability can be improved by collecting gaseous fuel, that is, vaporized fuel generated due to heat of an engine when the engine is turned off after driving, and delivering the vaporized fuel into a bombe upon restarting.

**[0024]** In addition, according to the present invention, when a damper portion is provided at an upper portion of a body, a portion of an upper surface of a cover is formed as an inclined surface to collect gaseous fuel, which is vaporized by heat of an engine inside the cover, and the collected gaseous fuel is recovered to a bombe when the engine is restarted so that vapor inside the high pressure fuel pump can be easily eliminated.

**[0025]** Further, according to the present invention, it is possible to prevent main components from being worn upon driving of a high pressure fuel pump due to low lubrication caused by the characteristics of LPG fuel.

**[0026]** In addition, according to the present invention, a piston can be cooled always at a constant rate by circulating low pressure fuel, which is supplied from a fuel tank, at constant pressure and flow rate through a cooling passage provided inside a high pressure fuel pump, so the piston can be smoothly operated, thereby ensuring high reliability.

**[0027]** Further, according to the present invention, compatibility can be improved by applying a high pressure fuel pump to an LPDI system.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0028]**

FIG. 1 is a block diagram showing a configuration of an LPDI system including a high pressure fuel pump according to an exemplary embodiment of the present invention.

FIG. 2 is a perspective view showing a high pressure fuel pump according to a first embodiment of the present invention.

FIG. 3 is a sectional view taken along line A-A' of FIG. 2.

FIG. 4 is a sectional view taken along line B-B' of FIG. 2.

FIG. 5 is a partially enlarged sectional view of a high pressure fuel pump according to a second embodiment of the present invention.

FIG. 6 is a sectional view of a high pressure fuel pump shown in FIG. 5.

FIG. 7 is a view showing an operation state of a high pressure fuel pump shown in FIG. 5.

FIG. 8 is a sectional view showing a cover and a damper portion of a high pressure fuel pump according to a third embodiment of the present invention.

FIG. 9 is an exploded perspective view of a cover and a damper portion shown in FIG. 8.

FIG. 10 is a sectional view of a high pressure fuel pump applied to an LPDI system according to a related art.

## DETAILED DESCRIPTION OF THE INVENTION

**[0029]** Hereinafter, a high pressure fuel pump and a liquid petroleum direct injection (LPDI) system including the same according to an exemplary embodiment of the present invention will be described in detail with reference to the accompanying drawings.

**[0030]** In the following description, the terms indicating directions such as 'left', 'right', 'front', 'backward', 'upward' and 'downward' are defined as indicating respective directions based on the state shown in the drawings.

**[0031]** First, the configuration of the LPDI system including the high pressure fuel pump according to the exemplary embodiment of the present invention will be described with reference to FIG. 1.

**[0032]** FIG. 1 is a block diagram showing the configuration of an LPDI system including the high pressure fuel pump according to an exemplary embodiment of the present invention.

**[0033]** In the present embodiment, fuel supplied through a fuel supply line S by the pumping operation of a fuel pump 12 at the start of an engine is initially delivered to a high pressure fuel pump 14 at a constant pressure, for example, a pressure of  $\Delta 5$  bar, and the fuel pressure supplied at the initial stage of the start is called a 'low pressure'.

**[0034]** In addition, a transfer path for transferring low pressure LPG fuel from an intake port of the high pressure fuel pump 14 to a fuel recovery line R through a recovery port is referred to as a 'low pressure portion 202 (see FIG. 3)'.

**[0035]** As shown in FIG. 1, the LPDI system 10 according to the exemplary embodiment of the present invention may include a bombe 11 in which the fuel is stored, the fuel pump 12 installed in the bombe 11 to pump the fuel, the fuel supply line S for supplying the fuel pumped from the fuel pump 12 to an engine E, the high pressure fuel pump 14 for pressurizing the fuel pumped by the fuel pump 12 to a high pressure, a fuel recovery line R for recovering a portion of the fuel supplied to the high pressure fuel pump 14 from the low pressure portion 202 of the high pressure fuel pump 14 to the bombe 11, a delivery pipe 15 in which the fuel pressurized by the high pressure fuel pump 14 is filled at a high pressure, an injector I for directly injecting the fuel, which is filled in the delivery pipe 15 at a high pressure, to a combustion chamber of the engine E, an electronic control unit (17, hereinafter referred to as ECU) for generating control signals to control the driving of a motor inside the fuel pump 12 and the injector I based on the target RPM of the engine E, and a motor controller 18 for controlling the driving of the motor according to the control signal of the ECU 17.

**[0036]** A shut-off valve, which is opened or closed according to the driving signal of the motor controller 18 based on the control signal of the ECU 17 to shut off the fuel supplied from the bombe 11, may be installed at a front end of the high pressure fuel pump 14 of the fuel

supply line S and a fuel pressure regulator 16, which reduces the pressure of the fuel recovered from the low pressure portion 202 of the high pressure fuel pump 14 to the bombe 11, may be installed at a rear end of the high pressure fuel pump 14 of the fuel recovery line R.

**[0037]** The fuel pump 12 pumps the LPG fuel stored in the bombe 11 to supply the fuel to the fuel supply line S. In this case, the fuel supplied through the fuel supply line S is initially delivered to the high pressure fuel pump 14 in a low pressure state, for example, a pressure of about  $\Delta 5$  bar.

**[0038]** The high pressure fuel pump 14 may pressurize a portion of the fuel, which is pumped by the fuel pump 12 and supplied through the fuel supply line S at a low pressure, such that a portion of the fuel has a high pressure, for example, about 40 bar to 150 bar. Then, the high pressure fuel pump 14 may supply a portion of the fuel to the delivery pipe 15 and recover the remaining fuel from the low pressure portion 202 to the bombe 11 through the fuel recovery line R.

**[0039]** Meanwhile, first and second pressure sensors (not shown) may be installed at a front end of the high pressure fuel pump 14 of the fuel supply line S and a rear end of the high pressure fuel pump 14 of the fuel recovery line R, respectively, to detect the pressure of the fuel that is moved, and a third pressure sensor (not shown) may be installed on the delivery pipe 15.

**[0040]** Thus, the ECU 17 may generate the control signals to allow the motor controller 18 to control the driving of the shut-off valve SV, the fuel pump 12, a multi-valve 13 and the fuel pressure regulator 16 according to the fuel pressure detected from the first and second pressure sensors and the third pressure sensor installed on the delivery pipe 15.

**[0041]** In addition, the LPDI system 10 including the high pressure fuel pump according to the exemplary embodiment of the present invention may further include a cut-off valve (not shown).

**[0042]** The cut-off valve may open or close the fuel recovery line R according to the control signal of the ECU 17. For example, the cut-off valve may be configured as a solenoid valve. Such a cut-off valve may be operated to close the fuel recovery line R for a predetermined time if an ignition key is operated at the start of the engine. Therefore, the fuel recovered to the bombe 11 may be temporarily cut-off by closing the cut-off valve during the start of the engine, so that the pressure of the fuel supplied to the high pressure fuel pump 14 through the fuel supply line S by the pumping operation of the fuel pump 12 can be increased, thereby compressing the vaporized fuel inside the fuel supply line S.

**[0043]** Accordingly, the high pressure fuel pump 14 may stably receive the fuel, and supply the fuel to the injector I through the delivery pipe 15 by pressurizing all of the supplied fuel to a predetermined high pressure.

[Embodiment 1]

**[0044]** Next, the configuration of the high pressure fuel pump according to a first embodiment of the present invention will be described in detail with reference to FIGS. 2 to 4.

**[0045]** FIG. 2 is a perspective view showing a high pressure fuel pump according to a first embodiment of the present invention, FIG. 3 is a sectional view taken along line A-A' of FIG. 2, and FIG. 4 is a sectional view taken along line B-B' of FIG. 2.

**[0046]** As shown in FIGS. 2 to 4, the high pressure fuel pump 14 according to the first embodiment of the present invention may include a body 20 formed at a lateral side thereof with an intake port 21 and an exhaust port 22, and provided therein with a pressing device 27 configured to press a portion of fuel, which is supplied through the intake port 21, at a high pressure, a spill valve 26 coupled to one side of the body 20 to control a supply flow rate and exhaust pressure of the fuel, and a cover 24 coupled to an upper portion of the body 20 and having a recovery port 23 for recovering a portion of the fuel supplied into the body to a bombe 11.

**[0047]** In addition, the high pressure fuel pump 14 may further include a roller tappet (not shown) installed between the body 20 and a cam of an engine camshaft (not shown) to convert a rotational motion of the cam into a linear reciprocating motion and transmit the linear reciprocating motion to the pressing device 27.

**[0048]** A space in which the pressing device 27 is installed is formed may be formed at a lower portion of the body 20, and the intake port 21 and the exhaust port 22 may be formed at the lateral side of the body 20.

**[0049]** The fuel introduced into the body 20 through the intake port 21 may be transferred to the low pressure portion 202 provided at an upper portion and an inner portion of the body 20 and the recovery port 23 formed in the cover 24.

**[0050]** That is, the low pressure portion 202 may serve as a movement passage for the fuel, which is connected to a high pressure portion 201 through the intake port 21, the spill valve 26 and an upper space of the body 20, the inlet 21, the spill valve 26, and the upper space of the body 20, and the high pressure portion 201 may serve as a movement passage for the fuel, which connects an upper portion of the pressing device 27 to the exhaust port 22.

**[0051]** A bracket 203 may be coupled to an outer peripheral surface of the body 20 to fix the body 20 to a vehicle body.

**[0052]** The pressing device 27 may generate suction force and pressing force for the fuel in the body 20.

**[0053]** To this end, as shown in FIG. 3, the pressing device 27 may include a piston 271 connected to the camshaft of the engine via the roller tappet to move up and down and a return spring 272 coupled to the piston 271 to provide a restoring force.

**[0054]** As shown in FIG. 3, the pressing device 27 may

constitute the high pressure portion 201 together with the body 20. The high pressure portion 201 may be a space in which a portion of the fuel is pressurized and may function as a movement passage through which the pressurized fuel moves. That is, the high pressure portion 201 may be formed on a passage through which a portion of the pressurized fuel introduced into the intake port 21 is supplied to the exhaust port 22, and may be formed at an upper portion of the piston 271 of the pressing device 27.

**[0055]** Meanwhile, when a portion of the fuel is vaporized in an inner space of the high pressure portion 201, a micro pipe (not shown) for discharging the vaporized fuel to the low pressure portion 202 may be formed between the high pressure portion 201 defined by the pressing device 27 and the body 20 and the low pressure portion 202 formed inside the body 20.

**[0056]** The cover 24 may be coupled to the upper portion of the body 20 to shield an upper surface of the body 20, and have a function of collecting the gaseous fuel, which is obtained as liquid-phase fuel is vaporized into gas-phase fuel by the heat of the engine when the engine is turned off after driving.

**[0057]** To this end, the cover 24 may have a dome shape which is convex upward such that a space for collecting the gaseous fuel is provided in the cover 24.

**[0058]** In detail, the upper surface of the cover 24 may be configured as an inclined surface inclined downward to the left in a direction opposite to the recovery port 23 when viewed from FIG. 3.

**[0059]** Therefore, the fuel vaporized by the heat of the engine, that is, the gaseous fuel may move to an upper portion of the liquid-phase fuel due to the difference in specific gravity. That is, the gaseous fuel may be collected in the upper portion of the inner space of the cover 24 along the inclined surface in the inner space of the cover 24, and may be recovered to the bombe 11 through the recovery port 23 when the engine is restarted.

**[0060]** As described above, according to the present invention, the cover has the dome shape which is convex upward so that the gaseous fuel inside the cover may be collected, and the collected gaseous fuel may be recovered to the bombe when the engine is restarted.

**[0061]** Therefore, according to the present invention, the vapor existing in the high pressure fuel pump may be collected and recovered to the bombe when the engine is turned off, thereby improving restartability.

**[0062]** Referring again to FIGS. 2 to 4, an exhaust-side check valve 28 coupled to the exhaust port 22 and an intake-side check valve 29 connected to the spill valve 26 to supply the fuel introduced into the body 20 to the exhaust-side check valve 28 while preventing the fuel from flowing back may be provided inside the body 20.

**[0063]** In addition, the intake port 21, the exhaust port 22, and the recovery port 23 may be provided with an exhaust opening, an intake opening, and a recovery opening, respectively.

**[0064]** The spill valve 26 may include a core 31 through

which the magnetic flux flows, a sleeve 32 coupled to one side of the core 31, a casing 33 coupled to one side of the sleeve 32, a plunger 34 configured to reciprocate a needle 35 by power applied from an inside of the casing 33, and a spring 36 for providing restoring force to the needle 35.

**[0065]** A bobbin 37 may be installed at an outer portion of the core 31, a coil 38 may be wound around the bobbin 37, and a housing 39 may be coupled to an outer portion of the bobbin 37.

**[0066]** In the present embodiment, a coating layer coated with a coating material may be formed on an outer surface of the plunger 34, which performs the reciprocating motion, to prevent the plunger from being worn due to the characteristics of the LPG fuel having the low lubrication property.

**[0067]** Therefore, the present invention can prevent main components, especially the plunger from being worn due to the characteristics of the LPG fuel when the high pressure fuel pump is driven.

**[0068]** Meanwhile, although the configuration in which the recovery port 23 is formed at the lateral side of the cover 24 is described in the present embodiment, the present invention is not necessarily limited thereto.

[Embodiment 2]

**[0069]** FIG. 5 is a partially enlarged sectional view of the high pressure fuel pump according to a second embodiment of the present invention.

**[0070]** As shown in FIG. 5, the high pressure fuel pump 14 according to the second embodiment of the present invention may have a configuration similar to the configuration of the high pressure fuel pump 20 according to the first embodiment described with reference to FIGS. 2 to 4, except that the recovery port 23 is formed on the upper surface of the cover 24.

**[0071]** Therefore, the cover 24 may have a dome shape in which a central portion of the upper surface of the cover 24 formed with the recovery port 23 is convex upward, and the upper surface of the cover 24 may be formed as an inclined surface 241 inclined downward in the outward direction from the center thereof.

**[0072]** As described above, according to the present invention, the cover has a dome shape, which is convex upward, to collect gaseous fuel inside the cover and recover the collected gaseous fuel to the bombe when the engine is restarted so that the vapor may be completely removed, thereby improving restartability.

**[0073]** Meanwhile, FIG. 6 is a sectional view of the high pressure fuel pump shown in FIG. 5, and FIG. 7 is a view showing an operational state of the high pressure fuel pump shown in FIG. 6.

**[0074]** As described above reference to FIG. 10, in the conventional high pressure fuel pump 100, the low pressure fuel supplied to the fuel recovery line 122 via the low pressure portion 120 provided at the upper portion of the body 110 may cool the piston 130 by passing

through a pair of cooling passages 112 connected to upper and lower portions of the high pressure fuel pump 100 through the volume change of the piston 130 generated when the high pressure fuel pump 100 is driven and the piston 130 moves up and down.

**[0075]** However, the conventional high pressure fuel pump 100 changes the flow rate of fuel in association with the change in driving RPM of the high pressure fuel pump 100 in order to cool the piston 130, thereby affecting the cooling rate of the piston 130, which may cause a problem.

**[0076]** In order to solve the above problem, according to the present invention, the low pressure fuel supplied from the fuel tank is circulated through the cooling passage provided inside the high pressure fuel pump at a constant pressure and a constant flow rate to cool the piston of the high pressure fuel pump at a constant rate always.

**[0077]** In detail, as shown in FIGS. 6 and 7, the high pressure fuel pump 14 according to the present invention may include a blocking wall 40 for blocking an upper end of a cooling passage 205 adjacent to the intake port 21 from the low pressure portion 202.

**[0078]** The blocking wall 40 may be integrally formed with the body 200 when the high pressure fuel pump 14 is manufactured, or may seal the upper end of the cooling passage 205 by normal welding, pressing or the like to maintain the airtightness of the cooling passage 205 and the low pressure portion 202 such that the blocking wall 40 can be applied to another high pressure fuel pump 14 that has been already manufactured.

**[0079]** Alternatively, the cooling passage 205 may be sealed by welding or the like after inserting a conventional sealing cap or a conventional sealing rod into the cooling passage 205.

**[0080]** However, in order to improve workability, it is desirable to form the blocking wall 40 integrally with the body 20 when the high pressure fuel pump is manufactured.

**[0081]** As the blocking wall 40 formed as described above may block the upper end of the cooling passage 205, the connection structure between the cooling passage 112 and the low pressure portion 120 in the high pressure fuel pump 100 according to the related art is modified and this is one of the technical configurations for circulating the low pressure fuel.

**[0082]** In addition, a connection passage 206 may be provided between the intake port 21 and the cooling passage 205 which is blocked from the low pressure portion 202 by the blocking wall 40.

**[0083]** In other words, according to the configuration of the related art as shown in FIG. 10, the low pressure fuel introduced through the intake port 114 is directly supplied to the low pressure portion 120 to cool the piston 130 by passing through the cooling passages 112 connected to the upper and lower portions of the high pressure fuel pump 100 through the volume change of the piston 130 generated when the high pressure fuel pump

100 is driven and the piston 130 moves up and down, so that the cooling efficiency is degraded.

**[0084]** In contrast, according to the present invention, the low pressure fuel introduced through the blocking wall formed in the cooling passage and the connection passage formed between the cooling passage and the intake port may not be directly supplied to the low pressure portion, but circulated through the cooling passage, so that the high cooling efficiency may be achieved with respect to the heat generated when the piston moves up and down.

**[0085]** That is, according to the present invention, the low pressure fuel flowing into the intake port may be introduced into the low pressure portion and the cooling passage having a closed upper end through the connection passage, and then circulated to the low pressure portion through another cooling passage surrounding the piston, so that the heat exchange may occur by the low pressure fuel having the low temperature, thereby cooling the body provided therein with the piston. As a result, heat generated from the piston may be cooled so that the piston may be cooled.

**[0086]** In particular, according to the present invention, the cooling efficiency of the piston may be further increased by continuously circulating the low temperature fuel to the low pressure portion through the connection passage and the cooling passage.

**[0087]** In this manner, the present invention may increase the cooling efficiency of the piston by circulating the low pressure fuel inside the body of the high pressure fuel pump with a simple technical configuration, other than a complicated technical configuration, so that the cooling efficiency for the piston may not be affected even when the flow rate of fuel is changed according to the driving RPM of the high pressure fuel pump, thereby ensuring the high reliability due to the smooth operation of the piston.

**[0088]** Meanwhile, the spill valve 26 may be coupled to the connection passage 206 such that a portion of the low pressure fuel flows into the cooling passage 205 at a constant pressure and a constant flow rate.

**[0089]** In other words, the low pressure fuel flowing into the cooling passage through the connection passage may be constantly introduced when the high pressure fuel pump is driven or operated and even when the low pressure fuel supplied from the fuel tank has an abnormal pressure, so that a constant cooling efficiency may be achieved and the higher reliability may be ensured.

**[0090]** Meanwhile, although the first and second embodiments have been described with the configuration in which a damper portion for reducing pulsation of the fuel is omitted, the present invention may be modified such that the damper portion can be applied to the high pressure fuel pump 14.

[Embodiment 3]

**[0091]** FIG. 8 is a sectional view of a cover and a damp-

er portion of a high pressure fuel pump according to the third embodiment of the present invention, and FIG. 9 is an exploded perspective view of the cover and the damper portion shown in FIG. 8.

**[0092]** As shown in FIGS. 8 and 9, the high pressure fuel pump 14 according to the third embodiment of the present invention may include a damper portion 25 coupled to an upper portion of a body 20 to reduce pulsation of the fuel.

**[0093]** The cover 24 may be formed in a cylindrical shape with a lower surface opened so that a space for installing the damper portion 25 may be provided in the cover 24, and an edge portion of the cover 24 may be coupled to a plurality of coupling ribs 204 provided at an upper surface of the body 20.

**[0094]** The damper portion 25 may include a damper 251 having a plurality of valleys formed on an outer surface of the damper portion 25 and an upper guide 252 coupled to an upper portion of the damper 251 to fix the damper 251 to an upper surface of the body.

**[0095]** A plurality of delivery holes 253 may be formed in the upper guide 252 to deliver the fuel of the low pressure portion 202 to the damper 251.

**[0096]** Flanges may be provided on outer peripheral surfaces of the damper 251 and the upper guide 252, respectively, and each flange may be press-fitted between the plurality of coupling ribs provided on the upper surface of the edge of the body 20.

**[0097]** Meanwhile, the cover 24 may have a dome shape in which a portion thereof is convex upward so as to collect gaseous fuel vaporized by heat of the engine.

**[0098]** That is, a portion of the upper surface of the cover 24 may be configured as an inclined surface 241 inclined downward in a direction opposite to the recovery port, and the gaseous fuel may be collected in an upper portion of an inner space of the cover 24 along the inclined surface 241.

**[0099]** As described above, when the damper portion is provided on the upper portion of the body, a portion of the upper surface of the cover may be configured as an inclined surface to collect the gaseous fuel, which is vaporized by the heat of the engine, in the cover, and the collected gaseous fuel may be recovered to the bombe when the engine is restarted, so that the vapor inside the high pressure fuel pump may be easily eliminated.

**[0100]** As mentioned above, although the invention made by the inventor(s) of the present invention has been specifically described, the present invention is not limited to the above embodiments and variously changes may be made without departing from the spirit of the present invention.

**[0101]** That is, although the configuration of the blocking wall has been described in the second embodiment in which the recovery port is formed on the upper surface of the cover, the present invention is not necessarily limited thereto.

**[0102]** For example, the present invention may be modified to adopt the blocking wall even when the recov-

ery port is formed on the lateral side of the cover or the damper is provided inside the cover in order to improve the cooling efficiency of the piston.

**[0103]** The present invention can be applied to the high pressure fuel pump, in which the cover has a dome shape to collect the gaseous fuel vaporized by the heat of the engine and the collected gaseous fuel is recovered to the bombe when the engine is restarted so that the vapor inside the high pressure fuel pump can be easily eliminated, and the LPDI system including the high pressure fuel pump.

## Claims

### 1. A high pressure fuel pump comprising:

a body formed at a lateral side thereof with an intake port and an exhaust port, and provided therein with a pressing device configured to press a portion of fuel, which is supplied through the intake port, at a high pressure;

a spill valve coupled to one side of the body to control a supply flow rate and exhaust pressure of the fuel; and

a cover coupled to an upper portion of the body and having a recovery port for recovering a portion of the fuel supplied into the body to a bombe, wherein the cover collects gaseous fuel vaporized by heat of an engine when the engine is turned off after driving, and has a dome shape which is convex upward to recover the gaseous fuel to the bombe when the engine is restarted.

2. The high pressure fuel pump of claim 1, wherein an upper surface of the cover is configured as an inclined surface inclined to one side, and the gaseous fuel in an inner space of the cover is moved along the inclined surface and collected in an upper portion of the inner space of the cover.

3. The high pressure fuel pump of claim 2, wherein the upper surface of the cover is configured as an inclined surface inclined downward in a direction opposite to the recovery port when the recovery port is formed at a lateral side of the cover.

4. The high pressure fuel pump of claim 2, wherein the upper surface of the cover is configured as an inclined surface inclined downward in an outward direction from the recovery port when the recovery port is formed at the upper surface of the cover.

5. The high pressure fuel pump of one of claims 1 to 4, further comprising a damper portion provided at an upper portion of the body to reduce pulsation of the fuel,  
Wherein the cover has a cylindrical shape with a low-

er surface opened to provide a space in which the damper portion is installed, and an inclined surface inclined downward in a direction opposite to the recovery port formed at the lateral side of the cover is formed on a portion of the upper surface of the cover.

6. The high pressure fuel pump of one of claims 1 to 5, wherein a pair of cooling passages are formed in the body, in which the fuel introduced through the intake port is moved to a low pressure portion formed inside the cover through the cooling passages before the fuel is pressurized at high pressure to cool a piston, a blocking wall is formed at an upper end of one of the pair of cooling passages adjacent to the intake port to block the fuel introduced through the intake port such that the fuel is not transferred to the low pressure portion, and a connection passage is formed between the intake port and the cooling passage in which the blocking wall is formed.

7. The high pressure fuel pump of claim 6, wherein the blocking wall is formed integrally with the body, or configured to seal an upper end of the cooling passage such that the cooling passage and the low pressure portion have airtightness.

8. The high pressure fuel pump of one of claims 1 to 7, wherein the spill valve includes:

a core through which a magnetic flux flows;  
a sleeve coupled to one side of the core;  
a casing coupled to one side of the sleeve;  
a plunger configured to reciprocate a needle by power applied from an inside of the casing;  
a spring configured to apply restoring force to the needle; and  
a bobbin installed outside the core, in which a coil is wound on an outer peripheral surface of the bobbin,  
wherein an outer surface of the plunger is coated with a coating material to prevent the plunger from being worn during a reciprocating motion.

9. A liquid petroleum direct injection system including the high pressure fuel pump according to one of claims 1 to 8, the liquid petroleum direct injection system comprising:

a fuel pump configured to pump the fuel stored in the bombe to supply the fuel toward the engine;  
the high pressure fuel pump configured to receive the fuel supplied from the fuel pump through the intake port formed in the body, press a portion of the fuel at high pressure in a high pressure portion formed inside the body, and

transfer the fuel that remains after the fuel is  
 pressurized to a fuel recovery line through the  
 recovery port communicating with the low pres-  
 sure portion such that the remaining fuel is re-  
 covered to the bombe; 5

a delivery pipe connected to the exhaust port of  
 the high pressure fuel pump through which the  
 pressurized fuel is exhausted and filled with the  
 pressurized fuel;

an injector configured to directly inject the fuel 10  
 filled in the delivery pipe into a combustion  
 chamber of an engine;

an electronic control unit configured to generate  
 control signals for controlling a motor in the fuel  
 pump, the injector, and a valve of the high pres- 15  
 sure fuel pump based on a target rpm of the  
 engine; and

a motor controller configured to control a driving  
 of the motor in accordance with the control sig- 20  
 nal,

wherein the cover of the high pressure fuel pump  
 collects gaseous fuel vaporized by heat of the  
 engine when the engine is turned off after driv-  
 ing, and has a dome shape which is convex up- 25  
 ward to recover the gaseous fuel to the bombe  
 when the engine is restarted.

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FIG. 2

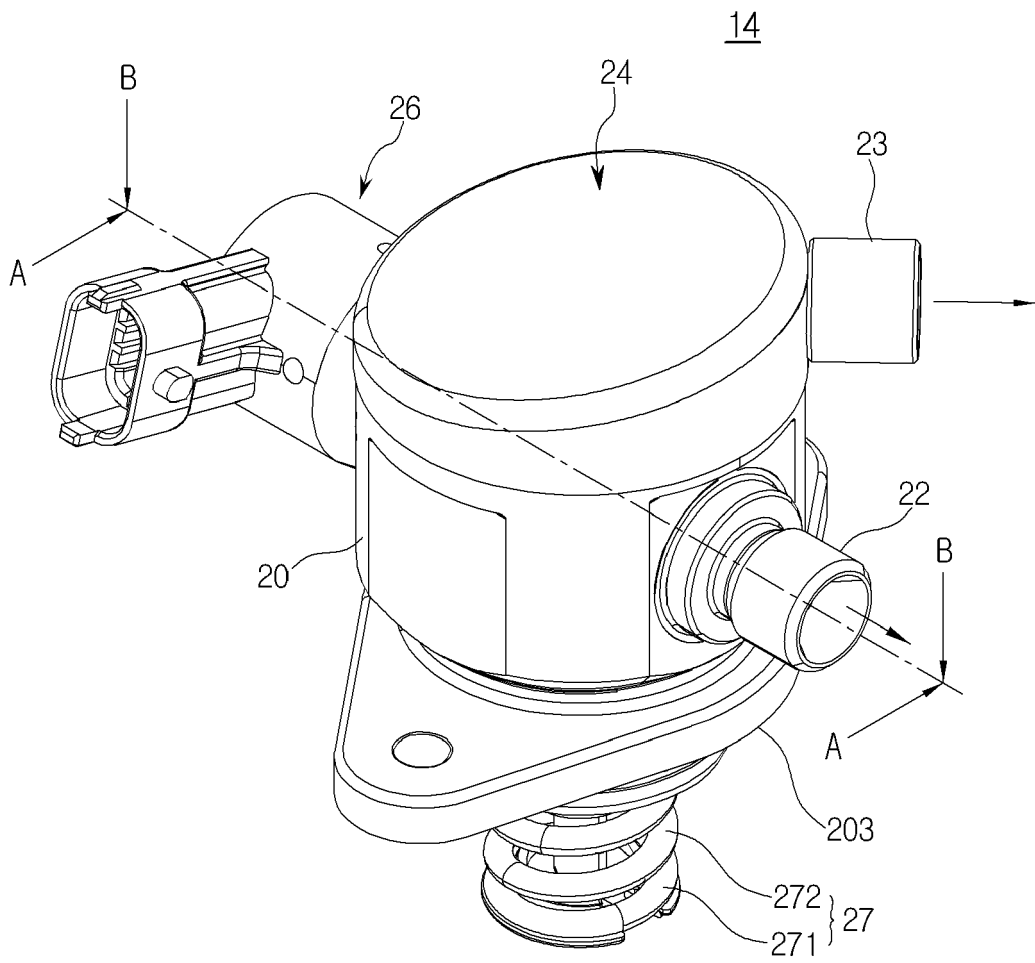


FIG. 3

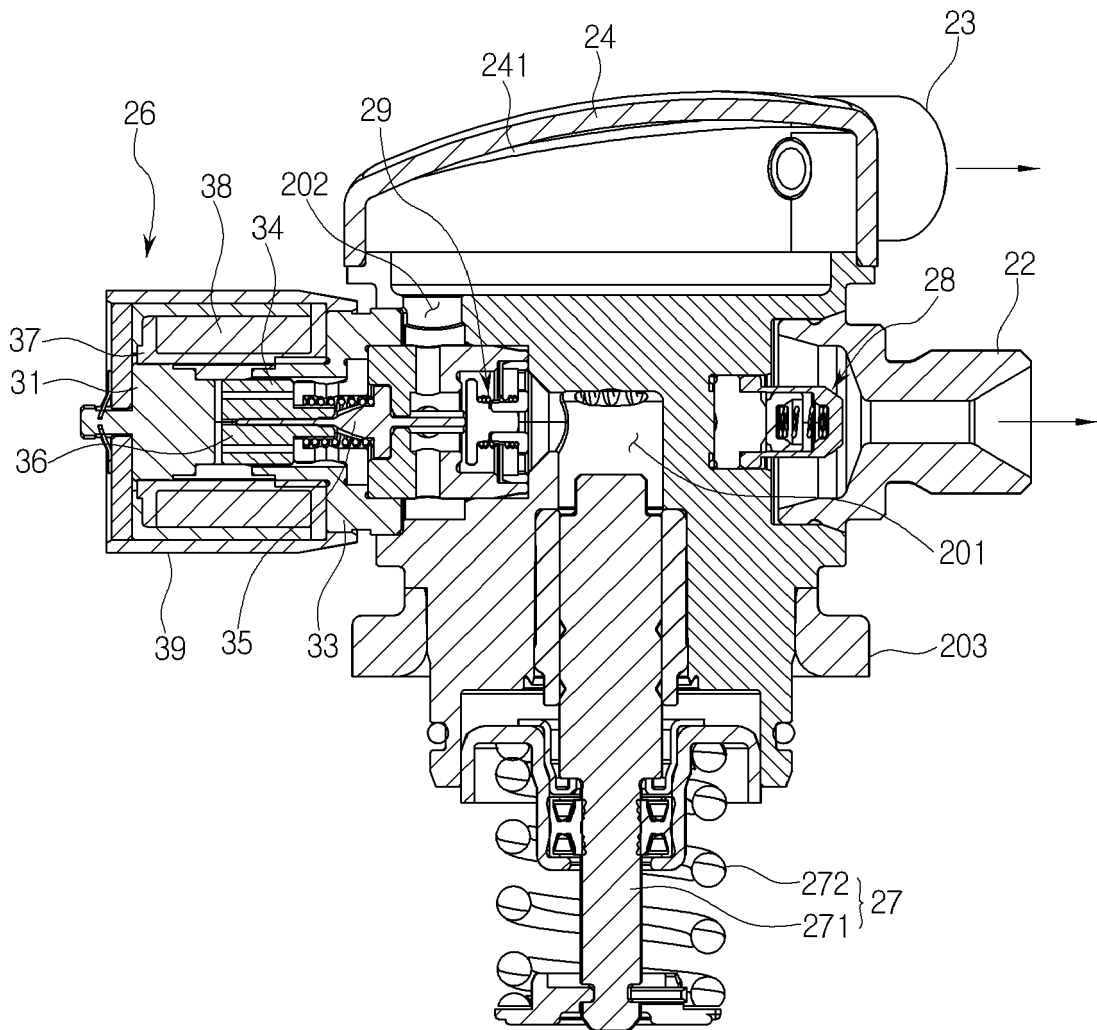


FIG. 4

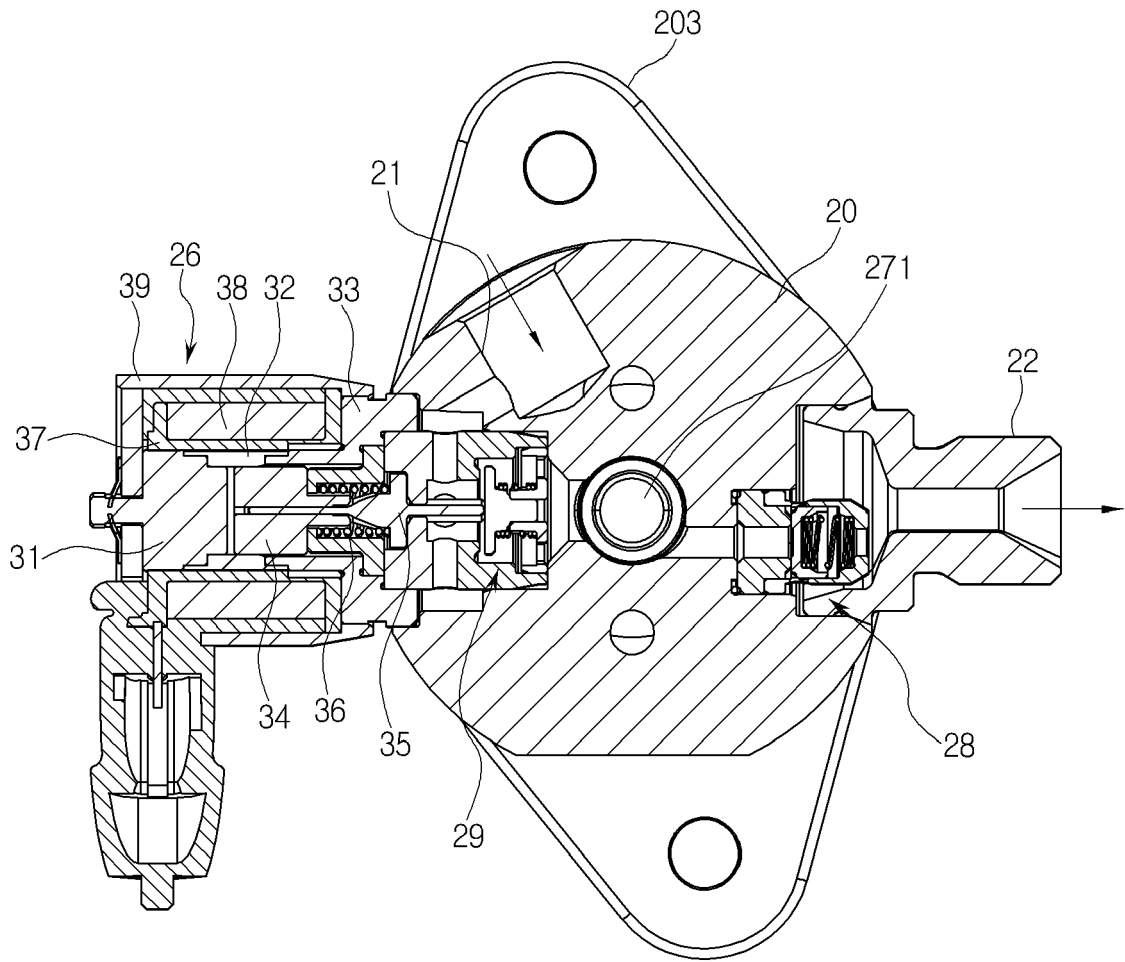


FIG. 5

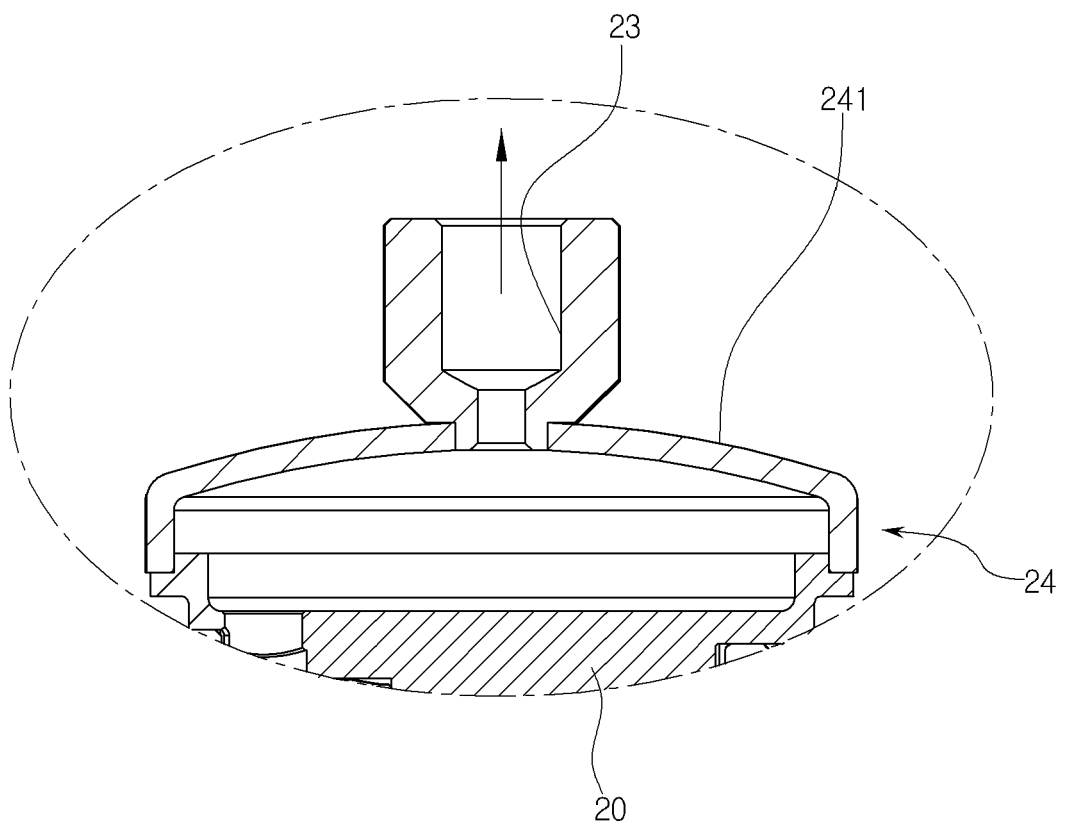


FIG. 6

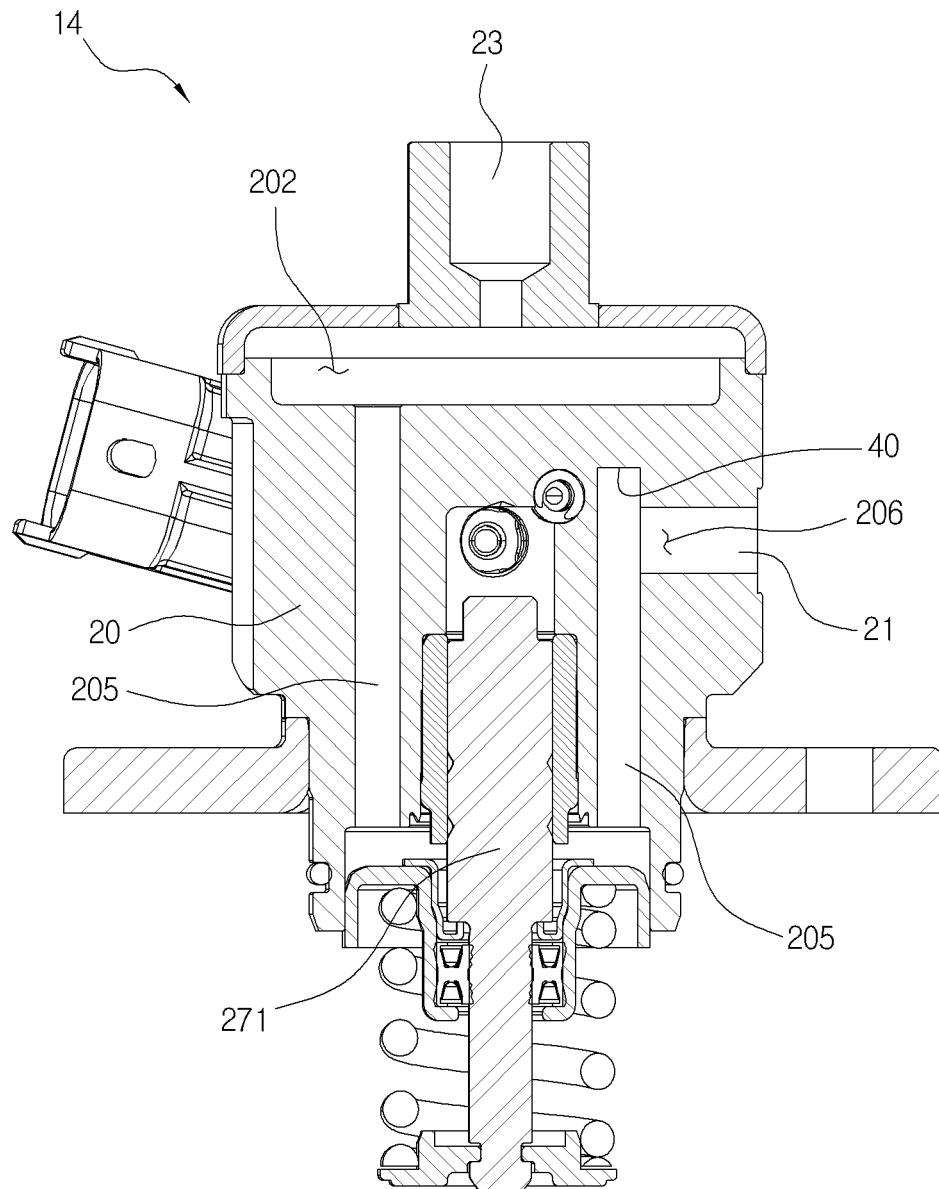


FIG. 7

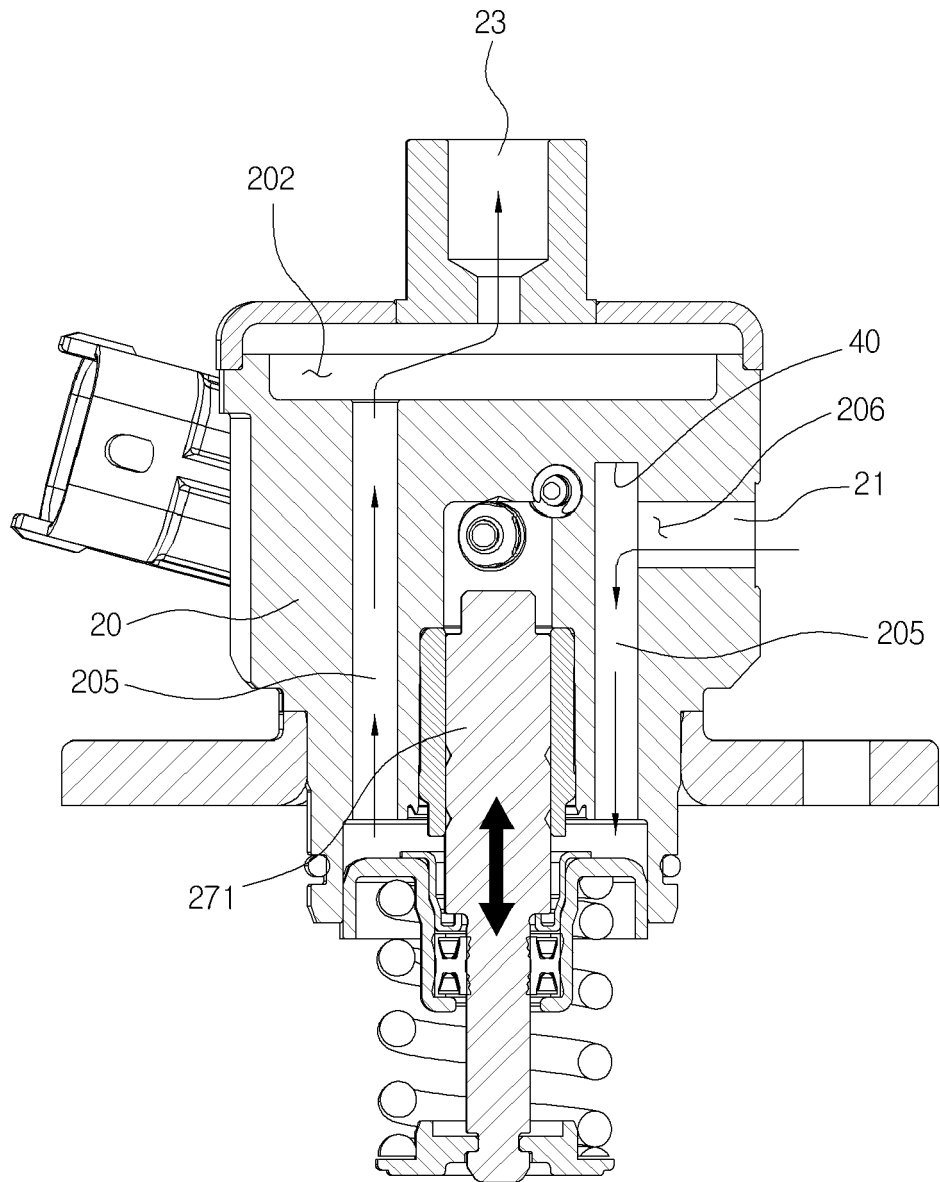


FIG. 8

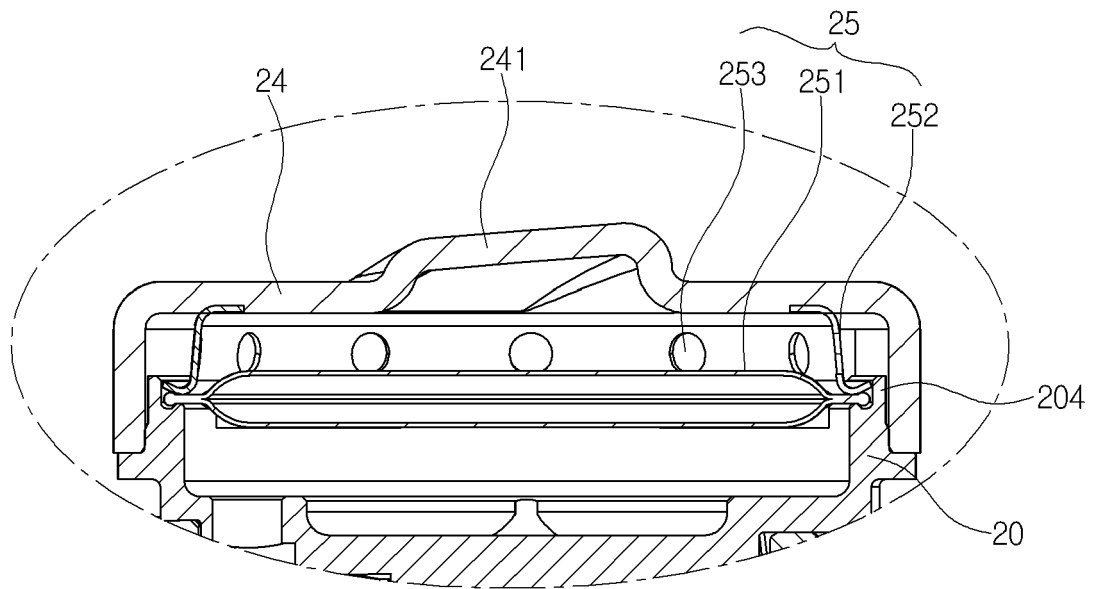


FIG. 9

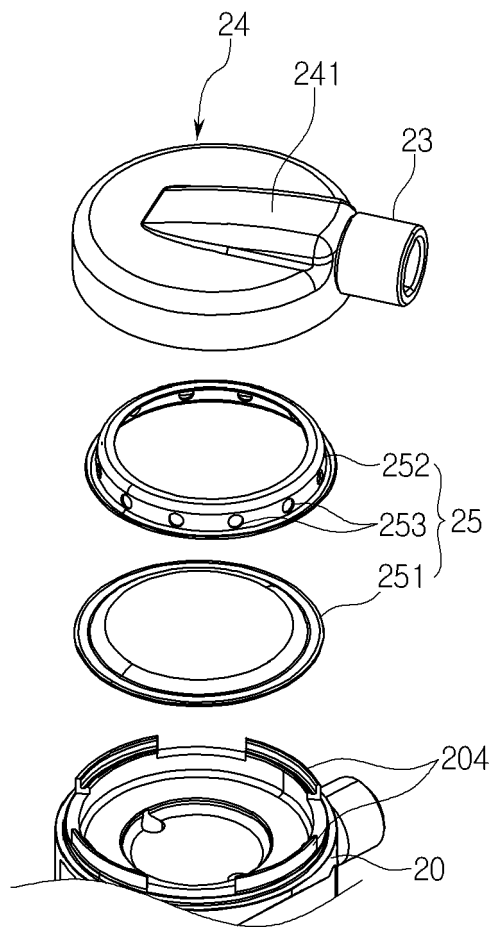
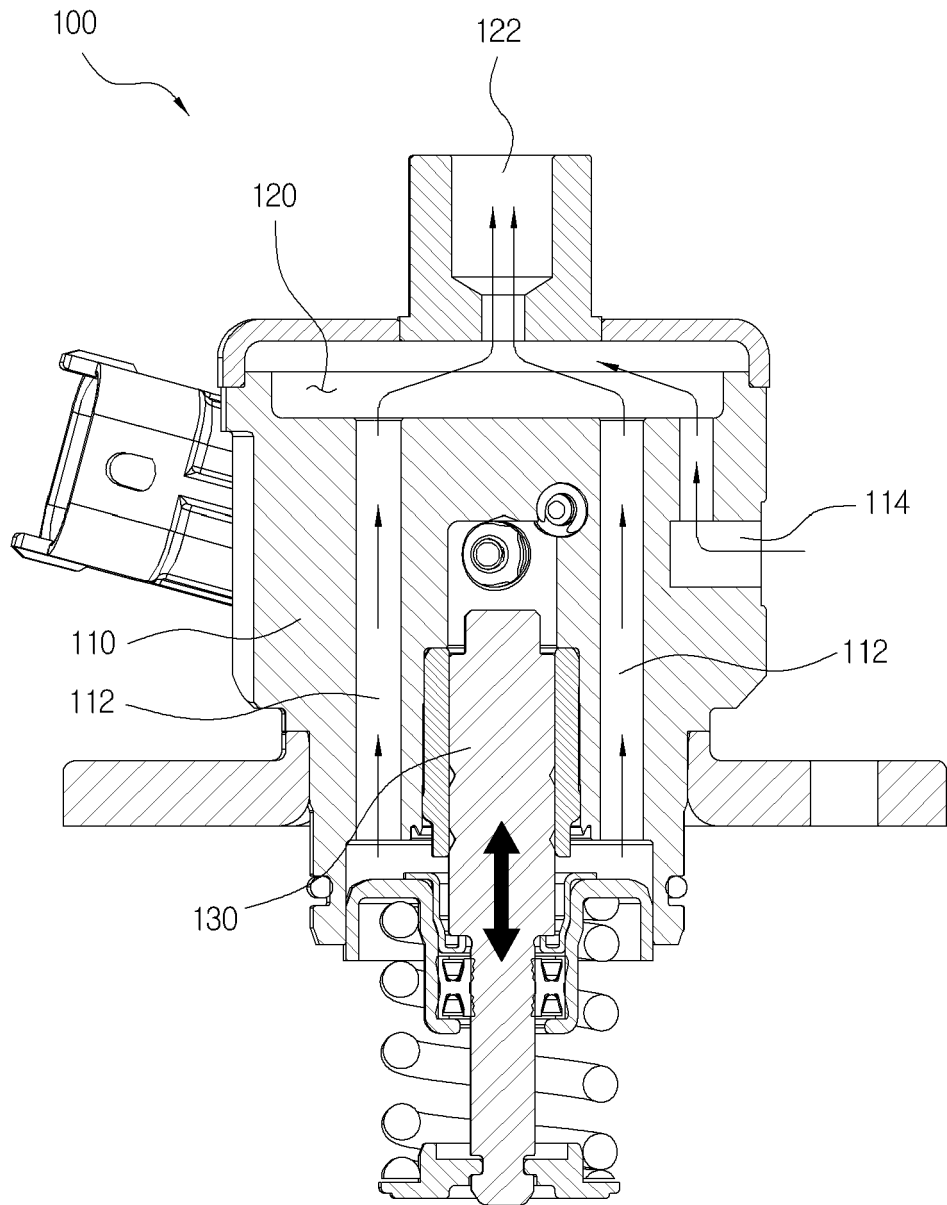


FIG. 10





EUROPEAN SEARCH REPORT

Application Number  
EP 19 20 7062

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			F02M
Place of search		Date of completion of the search	Examiner
Munich		12 February 2020	Karstens, Thede
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**REFERENCES CITED IN THE DESCRIPTION**

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