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(54) **A fuel injection pump**

(57) The present disclosure provides a fuel injection pump comprising a pump housing (101) having a fuel inlet port (102), a high pressure fuel discharge port (103), and a cylindrical bore (104). A pump piston (106) is guided in the cylindrical bore of the pump housing. An inlet control valve (110) is mounted on the cylindrical bore of the pump housing; the inlet control valve is configured to control inlet flow of the fuel into the cylindrical bore. A piston drive arrangement is coupled to the pump piston (106) for regulating the movement of the pump piston. More particularly, the high pressure fuel discharge port of the pump housing is configured into more than one outlet connectors (111) for supplying fuel to injectors of an internal combustion engine; and a pressure sensor (109) provided in the high pressure fuel discharge port of the pump housing to detect pressure of fuel at the fuel discharge port.

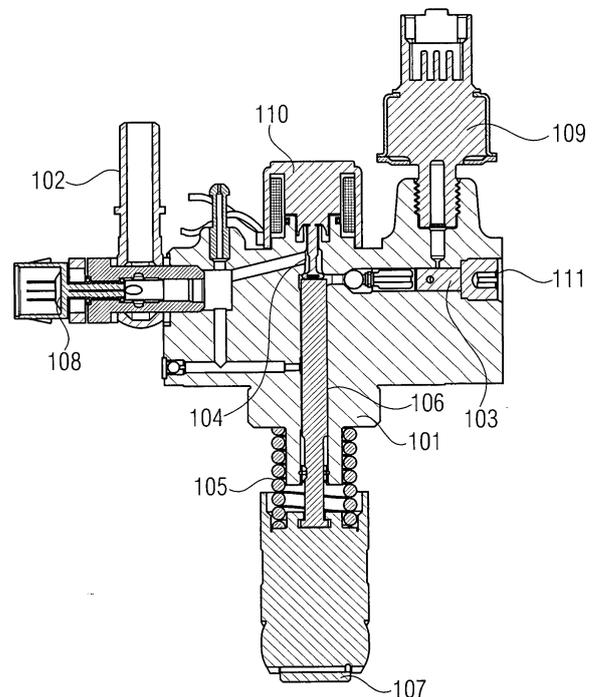


FIG. 2

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Description

[0001] The present invention relates to a fuel injection pump, more particularly embodiments relate to a high pressure fuel injection pump for an internal combustion engine.

[0002] An injection pump is the device that pumps fuel into the cylinders of an internal combustion engine. The conventional fuel injection pump includes a pumping plunger, which is slidably mounted within a cylinder or plunger bore to cause pressurisation of fuel within a pumping chamber. A drive arrangement, typically including a tappet and roller arrangement driven by a cam, is operable to cause reciprocal movement of the plunger within its bore. Further, a non-return inlet valve is provided to the pumping chamber and is operable in response to suction pressure created in pump working chamber. A delivery valve is operable in response to fuel pressure in the pumping chamber to control the supply of fuel from the pumping chamber. The delivery valve is connected to a common rail for injecting the fuel to the cylinders of the engine through injectors.

[0003] The plunger in the fuel injection pump moves as the tappet rides over the cam surface of the drive arrangement. As the plunger performs a pumping stroke to reduce the volume of the pump chamber, the inlet valve is caused to close and fuel pressure within the pumping chamber is increased. When fuel pressure within the pumping chamber exceeds the spring force of delivery valve, the delivery valve is caused to open to permit high pressure fuel to flow from the pumping chamber to the common rail. During return stroke of the plunger, the delivery valve is caused to close as fuel pressure within the pumping chamber is reduced to less than the spring force of the delivery valve to prevent reverse flow from the common rail. Subsequently, the inlet valve is caused to open to permit fuel at feed pressure to be drawn in through the inlet valve, filling the pumping chamber ready for commencement of the next pumping stroke.

[0004] The conventional fuel injection pump delivers pressurized fuel to the rail which has the High Pressure sensor for monitoring the pressure of fuel supplied to the cylinders. The provision of common rail in the fuel injection system would involve additional cost of manufacturing and assembly of the rail and connectors. Also, would increase the space consumption in the vehicle. With the conventional fuel injection pump there is no option to eliminate rail in the system.

[0005] Further, the temperature of the fuel at inlet has to be measured for increasing the volumetric efficiency of the fuel injection pump. Conventionally, sensors are provided outside of the pump. Thus, external sensors are attached in the fuel injection system inlet in order to measure the temperature of the fuel, thus the cost of the fuel injection system increases, since there is need to attach an external setup in order to measure inlet temperature.

[0006] In addition, the conventional fuel injection pumps are provided with a mechanical non-return valve at the inlet valve portion of the pump for opening and closing the inlet valve during suction and return stroke respectively. And a volumetric control valve is provided in the fuel injection pump for controlling the flow rate of fuel into the pump working chamber. The provision of the above two would increase the number of components in the fuel injection pump which in turn results in increase in the cost of the fuel injection system.

[0007] The conventional fuel injection pumps are directly mounted onto an engine by a provision of a hole on the engine, and the pump is driven by the cam lobe mounted on engine cam shaft. The mounting of fuel injection pump directly above the engine of the automobile, and providing the drive through engine cam shaft is a complex mechanism.

[0008] In light of foregoing description, it is the object of the present invention to develop a fuel injection system comprising a compact fuel injection pump to overcome the problems stated above.

[0009] The shortcomings of the prior art are overcome by the subject-matter of the independent claims. Advantageous and additional modifications are provided in the sub-claims, and through the provision of a pump and method of controlling the fuel flow from the pump as claimed in the present disclosure.

[0010] Additional features and advantages are realized through the techniques of the present disclosure. Other embodiments and aspects of the disclosure are described in detail herein and are considered a part of the claimed disclosure.

[0011] One embodiment of the present disclosure provides a fuel injection pump comprising: a pump housing having a fuel inlet port, a fuel discharge port, and a cylindrical bore in fluid communication with the fuel inlet port and the fuel discharge port. A pump piston guided in the cylindrical bore of the pump housing. An inlet control valve is mounted on the cylindrical bore of the pump housing, the inlet control valve is configured to control inlet flow of the fuel into the cylindrical bore. A piston drive arrangement coupled to the pump piston for regulating the movement of the pump piston. More particularly in the fuel injection pump of the present disclosure, the high pressure fuel discharge port is configured into more than one outlet connectors for supplying fuel to injectors of an internal combustion engine, and a pressure sensor provided in the high pressure fuel discharge port of the pump housing detects pressure of fuel at the fuel discharge port, wherein the pressure sensor is electrically connectable to an electronic control unit.

[0012] In an embodiment of the present disclosure, the fuel inlet port is provided with a temperature sensor for measuring the temperature of fuel at the fuel inlet port.

[0013] In an embodiment of the present disclosure, the inlet control valve is selected from at least one of digital control valve, volumetric control valve and mechanical valve.

[0014] In an embodiment of the present disclosure, one of the outlet connectors of the high pressure fuel discharge port is kept open, and opened outlet connector is connectable to injectors of an internal combustion engine through a

common rail.

[0015] In an embodiment of the present disclosure, cam box housing is connected to the pump housing, and the cam box housing encompasses the piston drive arrangement, and a cam shaft.

5 [0016] In an embodiment of the present disclosure, the piston drive arrangement is mounted above the cam shaft, and said piston drive arrangement is configured to follow a cam lobe mounted on the cam shaft for regulating movement of the pump piston through at least one of chain drive or belt drive.

[0017] In an embodiment of the present disclosure, the camshaft is connectable to atleast one of a balancer shaft and an engine cam drive shaft of the internal combustion engine through a drive mechanism for operating the fuel injection pump.

10 [0018] Another embodiment of the present disclosure relates to a method of controlling the fuel supply from a fuel injection pump. The method comprises steps of detecting pressure of the fuel at the high pressure fuel discharge port by the pressure sensor provided in the high pressure fuel discharge port of the pump housing, the high pressure fuel discharge port is configured into more than one outlet connectors, and controlling inlet flow of fuel into cylindrical bore by the inlet control valve mounted above the cylindrical bore of the pump housing based on the pressure detected by the pressure sensor to control the fuel supply from the fuel injection pump.

15 [0019] The novel features and characteristic of the disclosure are set forth in the appended claims. The disclosure itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying figures. One or more embodiments are now described, by way of example only, with reference to the
20 accompanying figures wherein like reference numerals represent like elements and in which:

FIG. 1 illustrates perspective view of fuel injection pump of the present disclosure.

FIG. 2 illustrates sectional view of fuel injection pump of the present disclosure.

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FIG. 3 illustrates perspective view of fuel injection pump of the present disclosure with cam box housing.

FIG. 4 illustrates sectional view of fuel injection pump of the present disclosure with cam box housing.

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FIG.5 illustrates fuel injection pump of the present disclosure directly connected to injectors of the internal combustion engine.

FIG. 6 illustrates fuel injection pump of the present disclosure connected to injectors of the internal combustion engine through a common rail.

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[0020] The figures depict embodiments of the disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the disclosure described herein.

40 [0021] The foregoing has broadly outlined the features and technical advantages of the present disclosure in order that the detailed description of the disclosure that follows may be better understood. Additional features and advantages of the disclosure will be described hereinafter which form the subject of the claims of the disclosure. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the disclosure as set forth in the appended claims. The novel features which are believed to be characteristic of the disclosure, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present disclosure.

50 [0022] To overcome the drawbacks mentioned in the background, it is necessary to develop a compact fuel injection system comprising a fuel injection pump having high pressure fuel discharge port, temperature sensor at inlet valve, high pressure sensor at high pressure fuel discharge port, and digital inlet valve.

55 [0023] The fuel injection pump according to embodiments of the present disclosure is used in the internal combustion engine for supplying the high pressure fuel into the fuel injectors. The fuel injection pump can be connected to the injectors through common rail using high pressure pipes, or outlet connectors of the fuel injection pump can be connected directly to the injectors using high pressure pipes. The high pressure fuel discharge port in the instant fuel injection pump is configured into more than one outlet connectors for connecting the fuel injection pump to the injectors with rail or rail-less system.

[0024] In an embodiment of the present disclosure, optimum volume has been provided in high pressure discharge port of the fuel injection pump, which acts as a storage space for pressurised fuel to work on a rail-less principle.

[0025] The fuel injection pump of the present disclosure is provided with a temperature sensor at inlet port for precise measurement of inlet fuel temperature. The integration of temperature sensor in the inlet of the fuel injection pump would help in easy measurement of temperature at the pump inlet. The output from the sensor can be used to monitor the temperature of the inlet fuel which directly corresponds to volumetric efficiency of the pump. Based on the output the fuel temperature can be controlled and is possible to get a stable temperature before the inlet valve. In an embodiment of the present disclosure, the fuel injection pump of the present disclosure is provided with a digital inlet valve to improve the volumetric efficiency of the pump. The digital inlet valve acts as suction valve and volumetric control valve.

[0026] The fuel injection pump of the present disclosure is configured to mount on engine driven by belt, gear drive or chain drive. The pump is mounted on the housing of cam box; the cam box housing encompasses the restoring spring, the roller tappet, a cam lobe and a cam shaft of the fuel injection pump. The cam shaft is connected to either one of balancer shaft and the engine cam drive shaft of the internal combustion engine to drive the cam lobe.

[0027] The terms 'upper' and 'lower' are used with reference to the orientation of the fuel injection pump 100 as shown in the drawings and, as such, are not intended to limit the fuel injection pump 100 to a particular orientation.

[0028] FIGS. 1 and 2 are exemplary embodiments of the present disclosure illustrating perspective view and sectional view of fuel injection pump 100 respectively. The fuel injection pump 100 comprises following main structural sections: a pump housing 101 having a fuel inlet port 102, a high pressure fuel discharge port 103, a cylindrical bore 104 in fluid communication with the fuel inlet port 102 and the high pressure fuel discharge port 103, and a piston drive arrangement connected to a lower end of a pump piston 106 disposed in the cylindrical bore 104 of the pump housing 101.

[0029] The pump housing 101 has a generally tubular configuration, having a longitudinal cylindrical bore 104, which defines an opening at upper and lower ends of the pump housing 101. The fuel inlet port 102 of the fuel injection pump 100 is connectable to a fuel reservoir [shown in FIG. 5] using tubing system/flexible hoses 119 [shown in FIG. 5] for supplying the fuel to the fuel injection pump 100. The high pressure fuel discharge port 103 is configured into more than one outlet connectors 111 which are connectable to a fluid conduit for the purposes of conveying pressurised fuel to an associated fuel injector (neither the fluid conduit nor the fuel injector are shown in FIGS. 1 and 2). The function of the outlet connectors 111 is to provide an output at a predetermined pressure to the fuel injection pump 100, however the structural details of the outlet connectors 111 are not described in further detail here.

[0030] The fuel injection pump 100 includes a pump piston 106, a portion of the pump piston is disposed in the cylindrical bore 104 of the pump housing 101, such that a pump working chamber is defined within the cylindrical bore 104 of the pump housing 101. The pump working chamber is defined as space created between the inlet control valve 110 and upper end of the pump piston 106 in the cylindrical bore 104 of the pump housing during suction stroke, i.e. fuel from the fuel reservoir is drawn to cylindrical bore 104.

[0031] The pump piston 106 defines a sliding clearance with the cylindrical bore 104 such that it is able to reciprocate back and forth. Further, a pump piston drive arrangement is provided in the fuel injection pump 100 for driving the pump piston 106 in a reciprocating manner. The pump piston 106 drive arrangement includes a roller tappet 107 which is coupled to the lower end of the pump piston 106. The roller tappet 107 is configured to follow the cam lobe 113 [shown in FIG. 4] is driven by the cam shaft 112 [shown in FIG.3]. The cam lobe 113 rides as the cam rotates, to cause the pump piston 106 to reciprocate within the cylindrical bore 104.

[0032] In use, the pump piston 106 is driven on a suction stroke during which fuel from the fuel reservoir is drawn to the pump working chamber through the fuel inlet port 102. During pumping stroke, fuel within the pump working chamber is pressurised. When the pressure of fuel within the pump working chamber reaches a predetermined pressure a valve gets activated to permit pressurised fuel to flow into the discharge port 103. In order to assist the pump piston 106 to perform a return stroke following a pumping stroke, the pump piston drive arrangement includes a piston biasing means in the form of a restoring spring 105 inserted concentric to a portion of pump piston 106 is disposed between the pump housing 101 and the roller tappet 107.

[0033] The high pressure fuel discharge port 103 of the fuel injection pump 100 is configured into three outlet connectors 111 which are connectable to injectors 117 [shown in FIG. 5] for supplying the fuel to the internal combustion engine 115 [shown in FIG.5]. In an embodiment of the present disclosure, the number of outlet connectors 111 at the high pressure fuel discharge port 103 can be varied based on the requirement i.e. based on number of cylinders in the internal combustion engine 115 [shown in FIG. 5]. The high pressure fuel discharge port 103 is provided with optimum volume which acts as a storage space for pressurised fuel. The optimum volume is achieved by increasing the volume i.e. length and diameter of the high pressure fuel discharge port 103.

[0034] Further, the fuel injection pump 100 of the present disclosure is provided with a pressure sensor 109 at the high pressure fuel discharge port 103 of the fuel injection pump 100 for measuring pressure in the fuel outlet line connected to an injector 117 [shown in FIG. 5] of the internal combustion engine 115. The pressure sensor 109 is connectable to Electronic Control Unit (ECU) 120 [shown in FIG.5] of an automobile [not shown]. The Electronic Control Unit 120 receives the signal from the pressure sensor and accordingly vary the input fuel flow into the pump working chamber using an

inlet control valve 110. The inlet control valve 110 is mounted above the cylindrical bore 104 of the pump housing 101, and said control valve is configured to control the inlet flow of fuel into the pump working chamber. The control valve 110 is selected from a group comprising but not limited to digital control valve, volumetric control valve, and a mechanical control valve. As an exemplary embodiment, in the present disclosure, the control valve 110 is digital control valve which acts as both suction valve and volumetric control valve. The digital control valve 110 is interfaced with the Electronic Control Unit 120 (ECU), and the ECU operates the digital control valve 110 based on the pressure of the fuel detected by the pressure sensor.

[0035] The digital inlet valve 110 is a switch valve mounted on cylindrical bore 104 of the fuel injection pump 100. The digital inlet valve 110 comprises following components: inlet valve seat, the solenoid actuator and the inlet valve pin connected to the solenoid actuator. The solenoid actuator of the digital inlet valve 110 is operated to open and close the fuel inlet port of the fuel injection pump 110. The solenoid actuator is operated by a mechanism selected from a group comprising but not limited to magnetic force, a spring force, a hydraulic force or any other forces known in the art.

[0036] In an embodiment of the present disclosure, solenoid actuator of the digital inlet valve 110 is operated by a magnetic force by applying variable current to a magnetic armature placed in the solenoid actuator, and the solenoid actuator is held closed by the pressure of a spring or similar mechanisms known in the art.

[0037] The digital control valve 110 is normally in open state during suction stroke, whereby the fuel inlet port 102 is in fluid communication with the fuel reservoir [shown in FIG. 5], and is operable to a closed state during pumping stroke whereby fluid communication between the fuel inlet port 102 and the fuel source is obstructed based on the pressure detected by the pressure sensor 109. When the piston reaches a defined lift position the digital inlet valve 110 switches to "closed position" and the remaining volume in the piston chamber is moved to the high pressure fuel discharge port 102 of the fuel injection pump 100 by the upwards movement of the pump piston 106. The digital control valve 110 is operated to the closed state by an electrical signal applied to the digital control valve 110.

[0038] In an embodiment of the present disclosure, the fuel injection pump 100 is provided with a temperature sensor 108 to measure the temperature of the fuel at the fuel inlet port 102 of the fuel injection pump 100. The provision of temperature sensor 108 at the fuel inlet port 102 of the fuel injection pump 100 helps in easy measurement of temperature at fuel inlet port 102, and output from the temperature sensor 108 is used to monitor the temperature of the inlet fuel which directly corresponds to volumetric efficiency of the fuel injection pump 100. Based on the output of the temperature sensor 108 the fuel temperature can be controlled, and it is possible to get a stable temperature of the fuel before supplying to the fuel inlet port 102.

[0039] In an embodiment of the present disclosure, the fuel injection pump 100 can be directly mounted onto an engine by a provision of a hole on the engine, and the pump is driven by the cam lobe mounted on engine cam shaft.

[0040] FIGS. 3 and 4 are exemplary embodiments of the present disclosure illustrating perspective view and sectional view of fuel injection pump 300 respectively with cam box housing 114. The cam box housing 114 is connected to the pump housing 101, which includes a cam lobe 113 mounted on a cam shaft 112. The cam lobe 113 is structured such that lobes on the cam lobe 113 operate the pump piston 106 through the roller tappet 107. The roller tappet 107 of the fuel injection pump 300 is mounted on the cam lobe 113 such that the roller tappet 107 is configured to follow the cam lobe 113 for regulating the sliding movement of the pump piston 106 in the cylindrical bore 104 of the pump housing 101. The cam lobe 113 is rotated by the cam shaft 112, which is connectable to either one of a balancer shaft and a cam drive shaft of the internal combustion engine 115 [shown in FIG. 5]. The cam box housing 114 connected to the pump housing 101 using suitable means, in an embodiment of the present disclosure; the cam box housing 114 is fastened to lower end of the pump housing 101. The cam box housing 114 encompasses the restoring spring 105, the roller tappet 107, the cam lobe 113 and the cam shaft 112 of the fuel injection pump 300.

[0041] In an embodiment of the present disclosure, the cam box housing 114 of the fuel injection pump 300 is configured to mount on an internal combustion engine 115 [shown in FIG. 5]. The cam box housing 114 comprises a casing 116 to mount the cam box housing 114 onto the internal combustion engine 115. The cam box housing 114 can be connected to the internal combustion engine 115 using any method known in the art, such as fastening, welding. In an embodiment of the present disclosure, the casing 116 of the cam box housing 114 is provided with plurality of provisions to fasten the cam box housing onto the internal combustion engine 115.

[0042] The cam shaft 112 is connectable to atleast one of the balancer shaft (not shown) and the cam drive shaft (not shown) of the internal combustion engine 115 through chain drive or belt drive or any other drive mechanism known in the art for driving the cam lobe 113.

[0043] FIG. 5 is an exemplary embodiment of the present disclosure which illustrates a block diagram of a fuel injection system 500 with the fuel injection pump 100/300 of the present disclosure which is directly connected to injectors 117 of the internal combustion engine 115. The fuel injection system 500 system comprises a fuel reservoir of the automobile (not shown) which is fluidly connected to the fuel inlet port 102 of the fuel injection pump 100/300. During working of the automobile (not shown), fuel from the fuel reservoir is drawn to the pump working chamber through the fuel inlet port 102, and fuel within the pump working chamber is pressurised. When the pressure of fuel within the pump working chamber reaches a predetermined pressure a valve gets activated to permit pressurised fuel to flow into the discharge

port 103. The discharge port 103 of the fuel injection pump 100/300 is configured into three outlet connectors 111. The outlet connectors 111 are connected to the injectors 117 using high pressure pipes 119 for supplying the pressurised fuel to cylinders of the internal combustion engine 115. The provision of multiple outlets 111 in the fuel injection pump 100/300 helps to eliminate the common rail (not shown) for storing and supplying the pressurised fuel to cylinders of the internal combustion engine 115.

[0044] Since, the common rail is removed from the fuel injection system 500 the storage volume of pressurised fuel is lost. The loss of storage volume is partially added in the pump housing by increasing the volume i.e. length and diameter of the high pressure fuel discharge port 103. However, complete lost volume cannot be accommodated alone in the pump housing. The remaining lost volume is compensated in the high pressure pipes 119 which connects between outlet connector 111 and injectors 117. Depending on the required volume, the length and internal diameter of the high pressure pipes 119 are adjusted. If increasing in the length is not possible due to space constraint then diameter of the high pressure pipes 119 to accommodate more volume.

[0045] FIG. 6 is an exemplary embodiment of the present disclosure which illustrates a block diagram of a fuel injection system 600 with the fuel injection pump 100/300 of the present disclosure which is connected to injectors 117 of the internal combustion engine 115 through a common rail 118. The fuel injection system 600 comprises a fuel reservoir of the automobile (not shown) which is fluidly connected to the fuel inlet port 102 of the fuel injection pump 100/300. During working of the automobile (not shown), fuel from the fuel reservoir is drawn to the pump working chamber through the fuel inlet port 102, and fuel within the pump working chamber is pressurised. When the pressure of fuel within the pump working chamber reaches a predetermined pressure a valve gets activated to permit pressurised fuel to flow into the discharge port 103. The discharge port 103 of the fuel injection pump 103 is configured into three outlet connectors 111. In an embodiment of the present disclosure, one outlet valve 111 of the discharge port 103 is kept open and other two outlet connectors 111 are closed. The opened outlet connectors 111 are connected to the injectors 117 through the common rail 118 using the high pressure pipes 119 for supplying the pressurised fuel to cylinders of the internal combustion engine 115.

[0046] Further as shown in FIGS. 5 and 6 the pressure sensor 109 provided in the high pressure fuel discharge port 103 and the digital control valve 110 mounted on the cylindrical bore 104 of the fuel injection pump 100/300 are interfaced with the Electronic Control Unit 120 (ECU) of the automobile (not shown) . The pressure sensor 109 detects the pressure of fuel in the high pressure fuel discharge port 103 of the fuel injection pump 100/300 and communicates pressure value to the ECU. The ECU controls the digital control valve 110 to vary the flow of fuel into the pump working chamber through the fuel inlet port 102 based on the pressure of fuel detected by the pressure sensor 109.

[0047] The present disclosure provides a fuel injection pump which has multiple outlet connectors in the high pressure fuel discharge port, which helps to connect the fuel injection pump directly to the injectors without the need of common rail. This reduces cost, number of components and space consumption of the fuel injection system. Further, it obviates the use of common rail in the fuel injection system.

[0048] The present disclosure provides a fuel injection pump which has multiple outlet connectors which can be used in both rail and rail-less fuel injection systems.

[0049] The present disclosure provides a fuel injection pump which has a temperature sensor for sensing the temperature of fuel at fuel inlet port and to monitor the temperature of fuel before supplying it to the inlet port, which in turn improves a volumetric efficiency of the fuel injection pump. This avoids the requirement of external temperature sensors to measure the temperature of the fuel at the inlet port.

[0050] The present disclosure provides a fuel injection pump which has a digital inlet valve for controlling the inlet flow of fuel into the fuel injection pump and to admit the fuel into the fuel injection pump, which obviates the use of two valves i.e. mechanical valve and volumetric control valve to achieve aforementioned aspects. This reduces cost, number of components and space consumption of the fuel injection system.

[0051] The present disclosure provides a fuel injection pump which has a cam box housing connected to the pump housing to operate the pump. Therefore, the pump is made into single module with the driving arrangement. This results in ease of manufacturing the fuel injection system.

[0052] The present disclosure provides a fuel injection pump which has an integrated temperature sensor and pressure sensor, which reduces assembling time and cost of the fuel injection system.

Equivalentents

[0053] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for the sake of clarity.

[0054] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term

"includes" should be interpreted as "includes but is not limited to, "etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean *at least* the recited number (e.g., the bare recitation of "two recitations," without other modifiers, typically means *at least* two recitations, or *two or more* recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0055] While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

[0056] It is to be noted at this point that all of the above described components, whether alone or in any combination, are claimed as being essential to the invention, in particular the details depicted in the drawings and reference numerals in the drawings are as given below.

Referral Numeral:

[0057]

Reference Number	Description
100	Fuel Injection Pump
101	Pump housing
102	Fuel inlet port
103	High pressure fuel discharge port
104	Cylindrical bore
105	Restoring spring
106	Pump piston
107	Roller tappet
108	Temperature sensor
109	Pressure sensor
110	Inlet control valve
111	Outlet connectors
112	Cam shaft
113	Cam lobe
114	Cam box housing

(continued)

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Reference Number	Description
115	Internal combustion engine
116	Casing on the cam box housing
117	Injectors
118	Common rail
119	High pressure pipes
120	Electronic Control Unit
300	Fuel Injection Pump with cam box housing
500	Rail-less Fuel injection system
600	Fuel injection system with common rail

Claims

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1. A fuel injection pump (100) comprises:

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a pump housing (101) having a fuel inlet port (102), a high pressure fuel discharge port (103), and a cylindrical bore (104) in fluid communication with the fuel inlet port (102) and the high pressure fuel discharge port (103);
 a pump piston (106) guided in the cylindrical bore (104) of the pump housing (101);
 an inlet control valve (110) mounted on the cylindrical bore (104) of the pump housing (101), wherein the inlet control valve (110) is configured to control inlet flow of the fuel into the cylindrical bore (104);
 a piston drive arrangement coupled to the pump piston (106) for regulating the movement of the pump piston (106);

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characterized in that,

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the high pressure fuel discharge port (103) of the pump housing (101) is configured into more than one outlet connectors (111) for supplying fuel to injectors (117) of an internal combustion engine (115); and
 a pressure sensor (109) provided in the high pressure fuel discharge port (103) of the pump housing (101) detects pressure of fuel at the high pressure fuel discharge port (103), wherein the pressure sensor (109) is electrically connectable to an electronic control unit (120).

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2. The pump (100) as claimed in claim 1, wherein the fuel inlet port (102) is provided with a temperature sensor (108) for measuring the temperature of fuel at the fuel inlet port (102).

3. The pump (100) as claimed in claim 1 or 2, wherein the inlet control valve (110) is selected from at least one of digital control valve, volumetric control valve and mechanical valve.

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4. The pump as claimed in one of the claims 1 to 3, wherein one of the outlet connectors (111) of the high pressure fuel discharge port (103) is kept open.

5. The pump as claimed in claim 4, wherein the opened outlet connector (111) is connectable to injectors (117) of an internal combustion engine (115) through a common rail (118).

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6. The pump as claimed in one of the claims 1 to 5, wherein the piston drive arrangement comprises a roller tappet (107) coupled to lower end of the pump piston (106), and a restoring spring (105) positioned between the pump housing (101) and the roller tappet (107).

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7. The pump as claimed in one of the claims 1 to 6 comprises a cam box housing (114) connected to the pump housing (101), wherein the cam box housing (114) encompasses the piston drive arrangement, and a cam shaft (112).

8. The pump as claimed in claims 6 and 7, wherein the roller tappet (107) of piston drive arrangement is mounted

above the cam shaft (112), and said roller tappet (107) is configured to follow a cam lobe (113) mounted on the cam shaft (112) for regulating movement of the pump piston (106).

5 9. The pump as claimed in claim 7, wherein the camshaft (112) is connectable to at least one of a balancer shaft and an engine cam drive shaft of the internal combustion engine (115) through a drive mechanism to operate the fuel injection pump (100).

10 10. A method of controlling a fuel supply from a fuel injection pump (100), said method comprising steps of:
detecting pressure of the fuel at a high pressure fuel discharge port (103) by a pressure sensor (109) provided in the high pressure fuel discharge port (103) of a pump housing (101), wherein, the high pressure fuel discharge port (103) is configured into more than one outlet connectors (111); and
controlling inlet flow of fuel into a cylindrical bore (104) of the pump housing (101) by an inlet control valve (110) mounted above the cylindrical bore (104) based on the pressure detected by the pressure sensor (109) to control the fuel supply from the fuel injection pump (100).
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11. The method as claimed in claim 10 comprises a step of measuring temperature of fuel at a fuel inlet port (102) by a temperature sensor (108) provided in the fuel inlet port (102) of the pump housing (101).

20 12. A vehicle comprising a fuel injection pump (100) as claimed in one of the claims 1 to 9.

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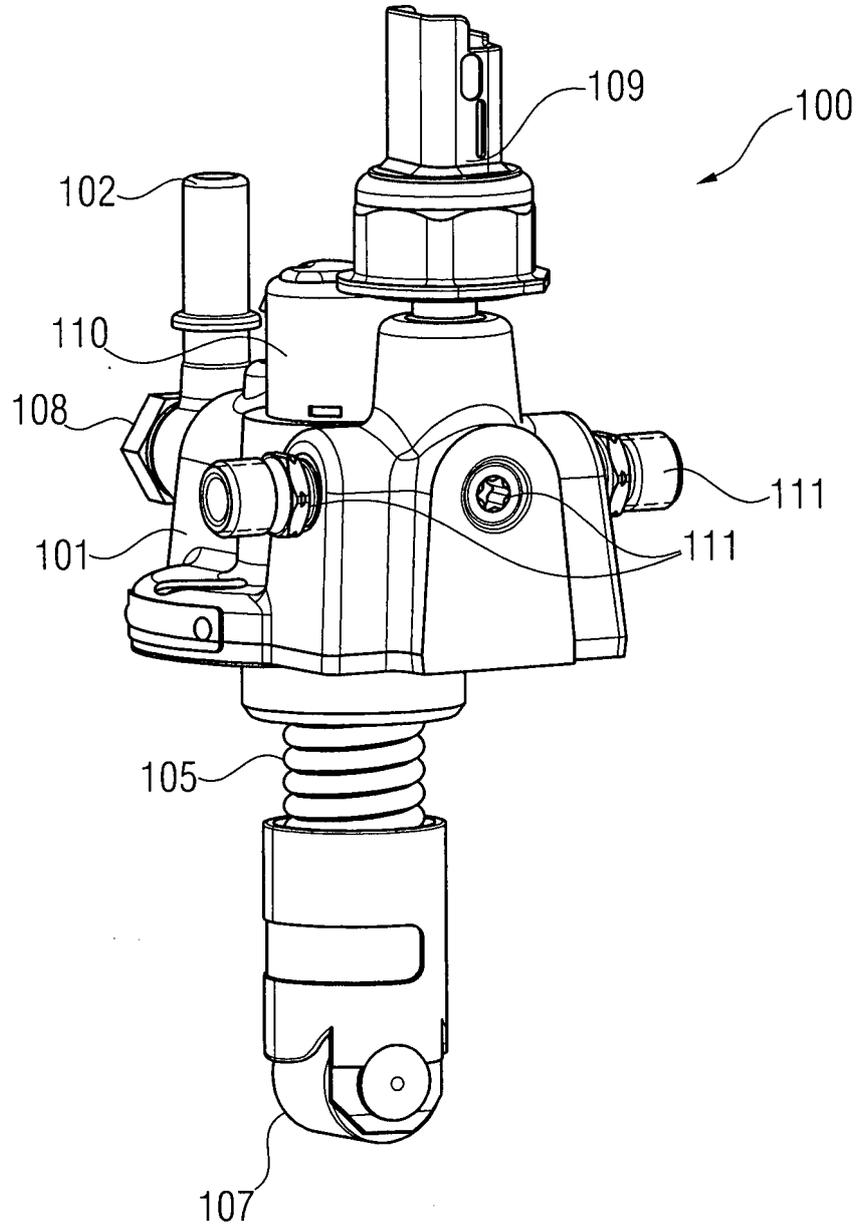


FIG. 1

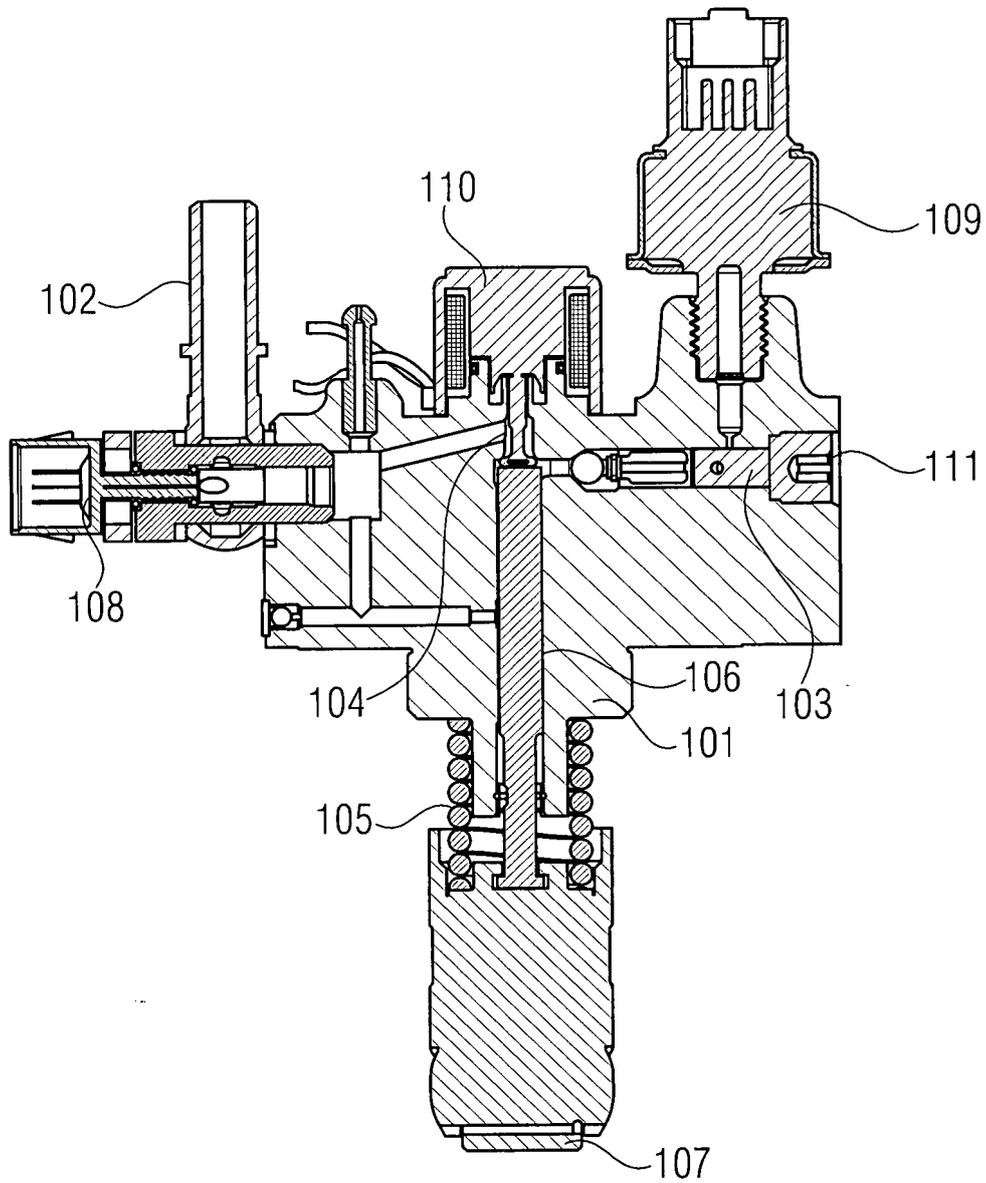


FIG. 2

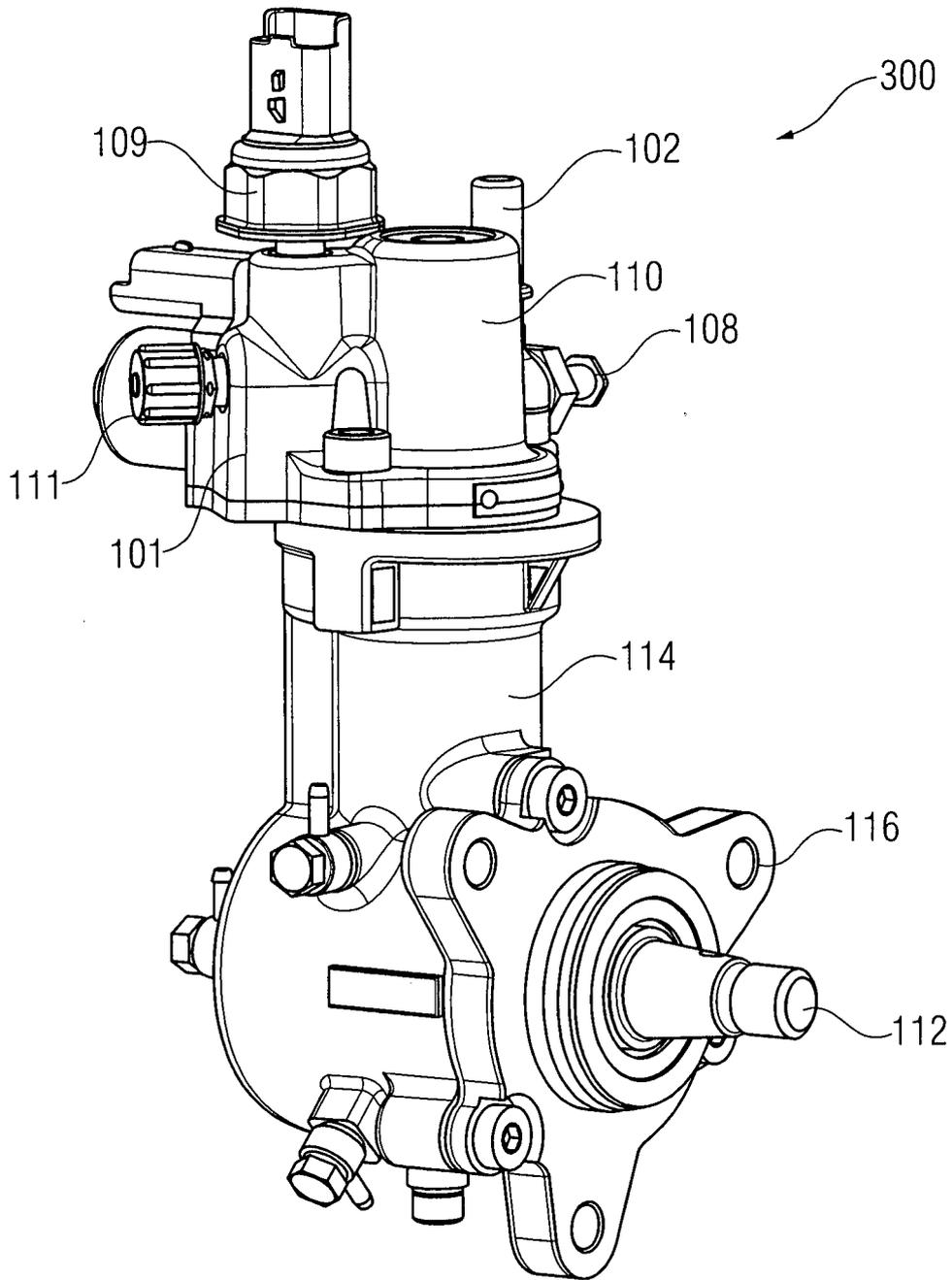


FIG 3

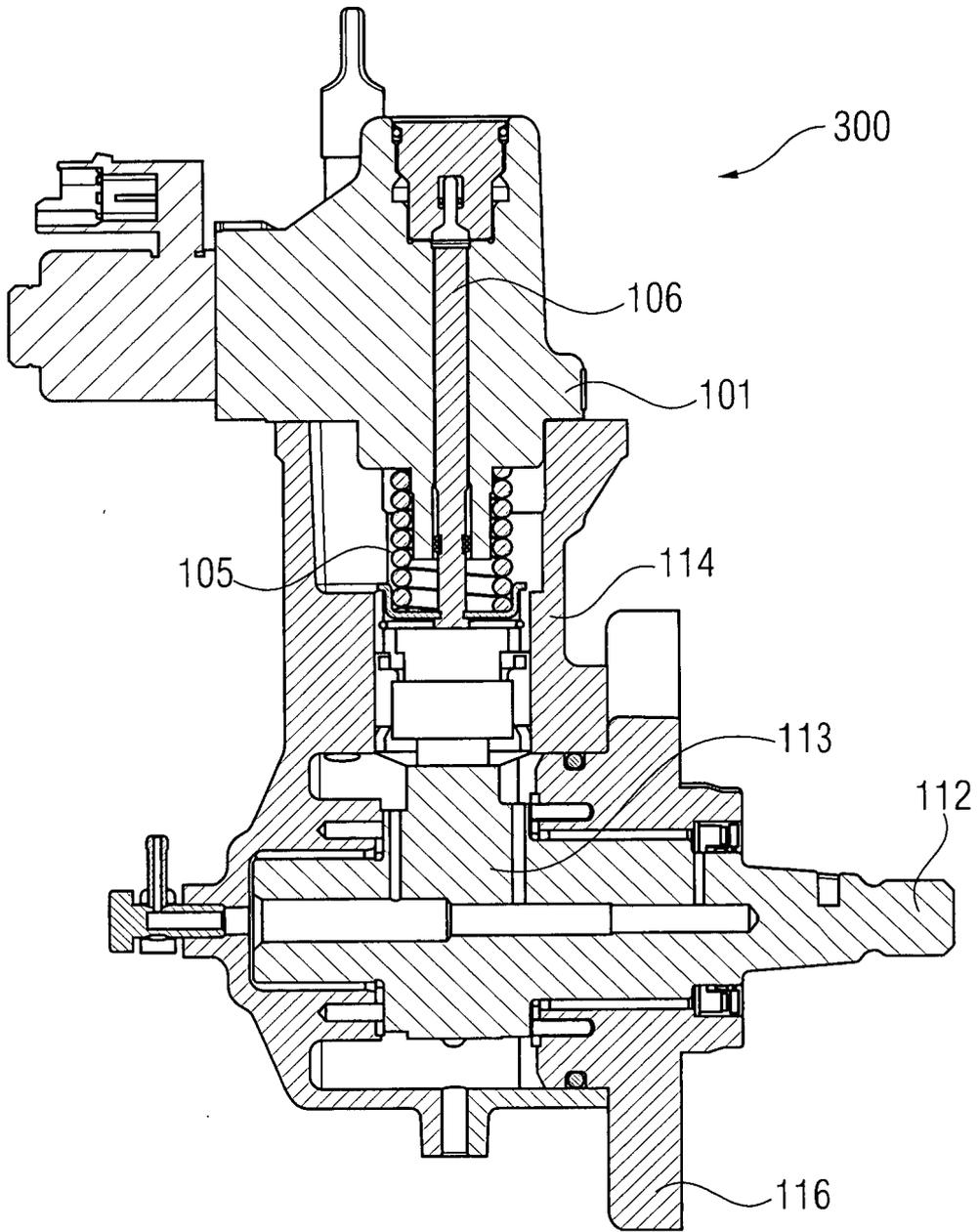


FIG 4

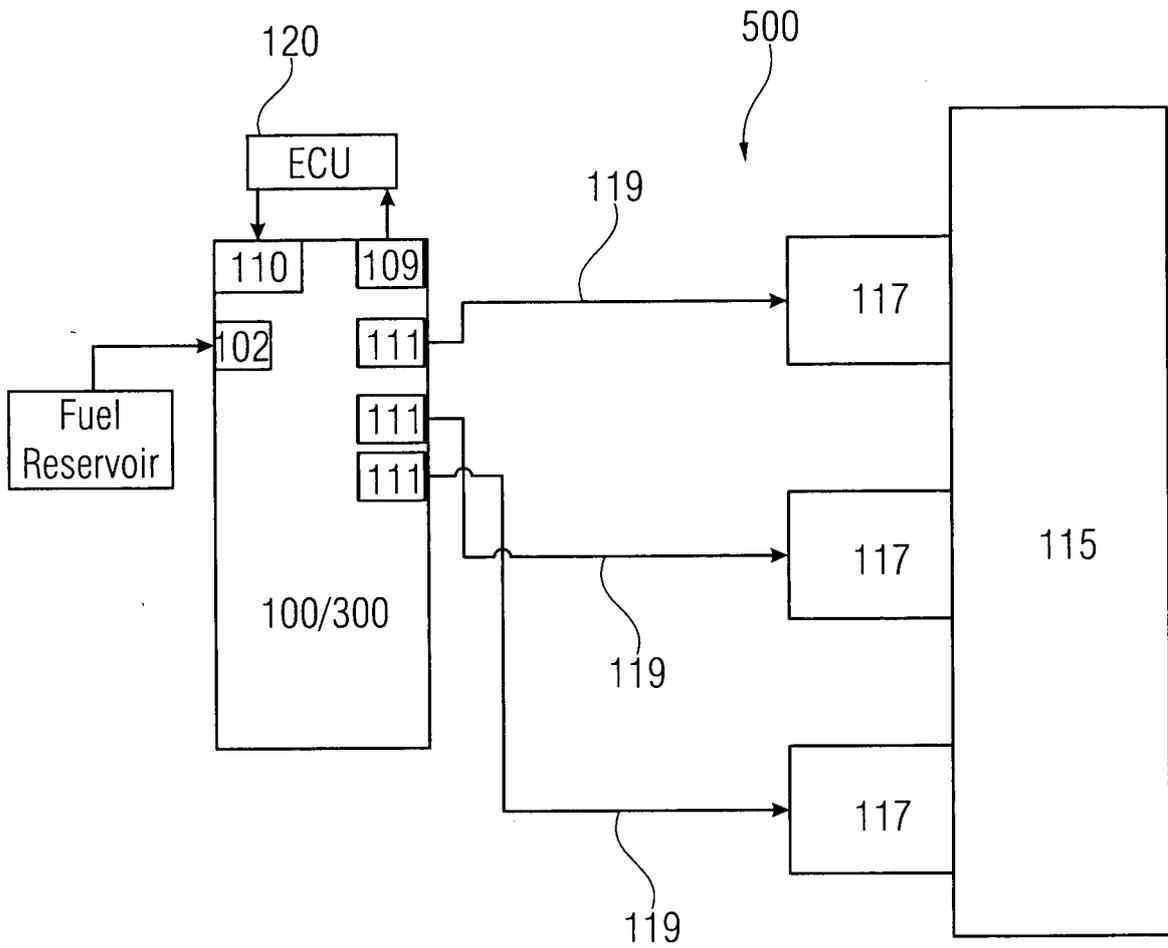


FIG 5

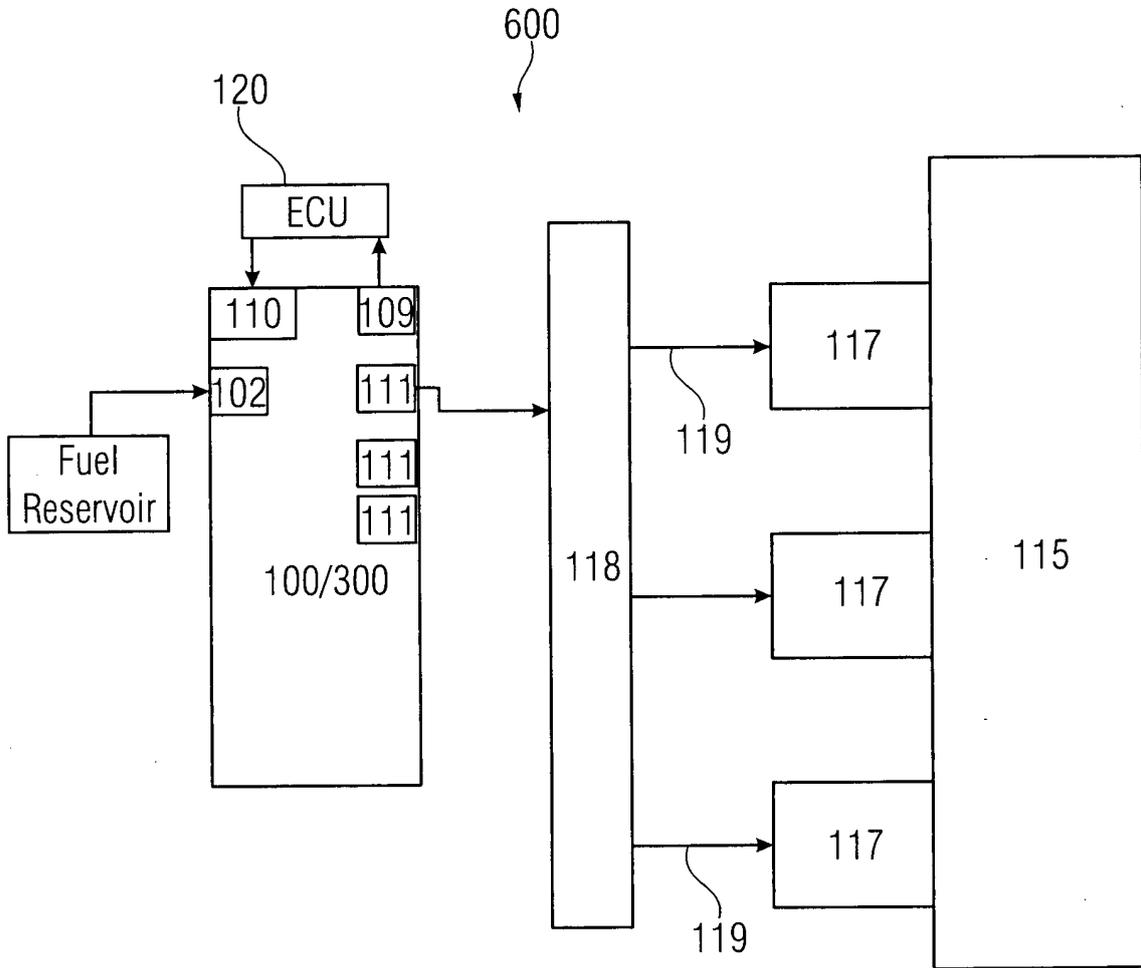


FIG 6



EUROPEAN SEARCH REPORT

Application Number
EP 13 18 8048

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Place of search Munich		Date of completion of the search 11 February 2014	Examiner Landriscina, V
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