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(54) METHOD TO CONTROL A FUEL INJECTION SYSTEM

VERFAHREN ZUR STEUERUNG EINES KRAFTSTOFFEINSPRITZSYSTEMS

PROCÉDÉ DE COMMANDE D'UN SYSTÈME D'INJECTION DE CARBURANT

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Description

TECHNICAL FIELD

[0001] This invention relates to a method to control a fuel injection system; preferably, the direct injection system is used in a spark-ignition internal combustion engine and, thus, is powered by petrol or similar fuels.

PRIOR ART

[0002] A direct injection system comprises multiple injectors, a "common rail" supplying the pressurised fuel to the injectors, a high-pressure fuel pump, which supplies the fuel to the common rail via a high-pressure supply duct and is provided with a flow rate adjustment device, and a control unit driving the flow rate adjustment device to keep the pressure of the fuel within the common rail equal to a desired value that generally varies over time depending on the engine's operating conditions.

[0003] The high-pressure fuel pump described in the patent application EP2236809A1 comprises: a main body, a pumping chamber made in the main body and inside of which a piston slides with reciprocating motion, an intake duct adjusted by an intake valve to supply the fuel at low pressure inside the pumping chamber, and a delivery duct adjusted by a delivery valve to supply the fuel at high pressure outside the pumping chamber and towards the common rail.

[0004] A modern vehicle normally implements the "Start & Stop" system that, to reduce the consumption of fuel during city use, stops and starts the internal combustion engine automatically when the vehicle is stopped, typically due to a red light (generally the internal combustion engine remains stopped for a few tens of seconds or even for some minutes). To enable a fast and regular restart of the internal combustion engine, it is preferable that, during the shutdown of the internal combustion engine (which also entails the stoppage of the high-pressure fuel pump that is driven by the engine shaft of the internal combustion engine), the pressure of the fuel in the common rail remains basically unchanged. As a result, it is necessary to minimise all the fuel leakages entailing a loss of fuel from the common rail and, thus, a decrease in the pressure of the fuel in the common rail.

[0005] The main cause of fuel leakage from the common rail is linked to the imperfect seal of the delivery valve of the high-pressure fuel pump and the imperfect seal of the pressure relief valve of the high-pressure fuel pump. To reduce the leakage of fuel through the delivery valve and the pressure relief valve, it has been suggested to improve the construction features of the valves, modifying their shape, increasing their processing precision, and using higher performing materials; in any case, these solutions entail a notable increase in the cost of the high-pressure fuel pump.

[0006] The patent applications EP2187038A1 and DE102008042371A1 describe a high-pressure fuel

pump for an internal combustion engine; when the internal combustion engine is stopped (shut off), the fuel pump is controlled so as to reduce the pressure of the fuel in a high-pressure supply system.

DESCRIPTION OF THE INVENTION

[0007] The purpose of this invention is to provide a control method of a fuel injection system reducing the leakage of fuel through the delivery valve of the high-pressure fuel pump and through the pressure relief valve of the high-pressure fuel pump when the internal combustion engine is stopped and, at the same time, is easy and fast to implement.

[0008] According to this invention, a method to control a fuel injection system is provided, according to what is set forth in the attached claims.

[0009] The claims describe preferred embodiments of this invention forming an integral part of this description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] This invention will now be described with reference to the attached drawings that illustrate a non-limiting embodiment thereof, in which:

- Figure 1 is a schematic view with the removal of details for clarity of a direct fuel injection system of the common rail type for an internal combustion engine;
- Figure 2 is a longitudinal cross-section view of a high-pressure fuel pump of the injection system in Figure 1;
- Figure 3 is a plan view of a deformable sheet of an intake valve of the high-pressure fuel pump of Figure 2; and
- Figure 4 is a longitudinal cross-section view of a variant of high-pressure fuel pump in Figure 2.

PREFERRED EMBODIMENTS OF THE INVENTION

[0011] In Figure 1, reference number 1 denotes, as a whole, a direct fuel injection system of the common rail type for an internal combustion engine.

[0012] The direct injection system 1 comprises multiple injectors 2, a common rail 3 that supplies the pressurised fuel to the injectors 2, a high-pressure pump 4, which supplies the fuel to the common rail 3 via a supply duct 5, and is provided with a flow rate adjustment device 6, a control unit 7 that maintains the pressure of the fuel inside the common rail 3 equal to a desired value that generally varies over time depending on the operating conditions of the internal combustion engine, and a low-pressure fuel pump 8 that supplies the fuel from a tank 9 to the high-pressure pump 4 via a supply duct 10.

[0013] The control unit 7 is coupled to the flow rate adjustment device 6 to control the flow rate of the high-pressure pump 4 so as to supply, moment by moment, to the common rail 3 the quantity of fuel needed to have the desired pressure value inside the common rail 3; in particular, the control unit 7 adjusts the flow rate of the high-pressure pump 4 via a feedback control using, as a feedback variable, the value of the fuel pressure (detected in real time by the pressure sensor 11) inside the common rail 3.

[0014] According to what was illustrated in Figure 2, the high-pressure pump 4 comprises a main body 12 that has a longitudinal axis 13 and defines, inside, a pumping chamber 14 with a cylindrical shape. Inside the pumping chamber 14, a piston 15 is mounted so as to slide that, moving by reciprocating motion along the longitudinal axis 13, determines a cyclical variation of the volume of the pumping chamber 14. A smaller portion of the piston 15 is, on the one hand, coupled to a spring 16 that tends to push the piston 15 towards a maximum volume position of the pumping chamber 14 and, on the other hand, is coupled to a cam (not illustrated) that is rotated by an engine shaft of the internal combustion engine to cyclically move the piston 15 upwards, compressing the spring 16.

[0015] An intake duct 17, which is adjusted by an intake valve 18 arranged at the pumping chamber 14, starts from one side wall of the pumping chamber 14. The intake valve 18 is normally controlled under pressure and in the absence of external interventions, the intake valve 18 is closed when the pressure of the fuel in the pumping chamber 14 is greater than the pressure of the fuel in the intake duct 17 and is open when the pressure of the fuel in the pumping chamber 14 is less than the pressure of the fuel in the intake duct 17. The flow rate adjustment device 6 is mechanically coupled to the intake valve 18 to allow the control unit 7 to keep, when necessary, the intake valve 18 open during a pumping step of the piston 15 and, thus, to enable fuel to flow out of the pumping chamber 14 through the intake duct 17.

[0016] A delivery duct 19 that is adjusted by a one-way delivery valve 20 (also called an "OCV - Outlet Closing Valve"), which is arranged at the pumping chamber 14 and only allows fuel to flow out of the pumping chamber 14, starts from a side wall of the pumping chamber 14 and from the opposite side to the intake duct 17. The delivery valve 20 is controlled under pressure and is open when the pressure of the fuel in the pumping chamber 14 is greater than the pressure of the fuel in the intake channel 19 and is closed when the pressure of the fuel in the pumping chamber 14 is less than the pressure of the fuel in the delivery channel 19.

[0017] The intake duct 17 is adjusted by the intake valve 18 (arranged at the pumping chamber 14) and extends partially inside the main body 12. A damping device 21 (compensator), which is fixed to the main body 12 of the high-pressure pump 4 and has the function of reducing, in the low-pressure branch, the quantity of

pulsations of the fuel flow rate and, thus, the quantity of oscillations of the fuel pressure, is arranged along the intake duct 17 (upstream of the intake valve 18).

[0018] The flow rate adjustment device 6 comprises a control rod 22, which is coupled to the intake valve 18 and is movable between a passive position, in which it allows the intake valve 18 to close, and an active position, in which it does not allow the intake valve 18 to close. The flow rate adjustment device 6 also comprises an electromagnetic actuator 23, which is coupled to the control rod 22 to move the control rod 22 between the active position and the passive position.

[0019] According to what is illustrated in Figure 2, the electromagnetic actuator 23 comprises a spring 24, which holds the control rod 22 in the active position, and an electromagnet 25, which is designed to move the control rod 22 to the passive position magnetically attracting a ferromagnetic anchor 26 integral with the control rod 22 and, thus, overcoming the elastic force generated by the spring 24. When the electromagnet 25 is excited, the control rod 22 is recalled to the passive position and the communication between the intake duct 7 and the pumping chamber 4 may be interrupted by the closure of the intake valve 18. The control rod 22 and the anchor 26 together form mobile equipment of the flow rate adjustment device 6 that is moved axially between the active position and the passive position under the control of the electromagnetic actuator 23.

[0020] According to what is illustrated in Figure 2, the intake valve 18 comprises a disc 27 that has a series of feeding holes that the fuel may flow through and a flexible sheet 28 with a circular shape (better illustrated in Figure 3) that rests on a base of the disc 27 closing the passage through the feeding holes. The intake valve 18 is normally controlled under pressure and in the absence of external interventions (i.e., of interventions of the flow rate adjustment device 6), the intake valve 18 is closed when the pressure of the fuel in the pumping chamber 14 is greater than the pressure of the fuel in the intake duct 17 and is open when the pressure of the fuel in the pumping chamber 14 is less than the pressure of the fuel in the intake duct 17. In particular, when the fuel flows towards the pumping chamber 14, the sheet 28 is deformed moving away from the disc 27 under the thrust of the fuel allowing the passage of the fuel through the feeding holes; instead, when the fuel flows from the pumping chamber 14, the sheet 28 is crushed against the disc 27 sealing the feeding holes and, thus, preventing the passage of the fuel through the feeding holes. In its active position, the control rod 22 centrally pushes on the sheet 28 preventing the sheet 28 from adhering to the disc 27 and, thus, preventing the sheet 28 from sealing the feeding holes; instead, in the passive position, the control rod 22 is relatively far from the sheet 28 allowing the sheet 28 to adhere to the disc 27 and, thus, allowing the sheet 28 to seal the feeding holes.

[0021] According to what is illustrated in Figures 2 and 4, in the main body 12 and below the pumping chamber

14, a containing seat 29 is formed with a cylindrical shape having a greater diameter than the diameter of the pumping chamber 14 and houses a guide bushing 30 of the piston 15; the guide bushing 30 has, essentially, the function of guiding the axial, alternative sliding of the piston 15. The guide bushing 30 is made of a material with a suitable hardness and with a superficial finish so as to facilitate the axial sliding of the piston 15.

[0022] The guide bushing 30 has a tubular shape and has, inside, a central through hole 31 that houses the piston 15 so as to slide; the central hole 31 of the guide bushing 30 (in which the piston 15 is arranged) and the piston 15 are processed with great precision so as to minimise the mechanical play (i.e. the distance) existing between the central hole 31 of the guide bushing 30 and the piston 15 (so as to limit, as much as possible, the leaking of fuel along the piston 15) without, in any case, completely eliminating this mechanical play (which is, obviously, indispensable for allowing the sliding of the piston 15 inside the guide bushing 30).

[0023] According to the embodiment illustrated in Figure 4, between the piston 15 and the central hole 31 of the guide bushing 30 a sealing gasket 32 is interposed that has the function of further limiting the leaking of fuel along the piston 15. The sealing gasket 32 has a certain elasticity for being able to deform elastically (in particular for being radially compressed against the internal surface of the central hole 31 of the guide bushing 30). The sealing gasket 32 is preferably made with a material with a low friction coefficient; for example, the sealing gasket 32 could be made from a material based on PTFE (polytetrafluoroethylene, also commercially known with the name Teflon®) potentially loaded with glass or graphite.

[0024] According to a preferred embodiment illustrated in the attached figures, the piston 15 has an annular throat that houses the sealing gasket 32; in other words, the annular throat constitutes a site where the sealing gasket 32 is accommodated so that the sealing gasket 32 cannot make axial movements in relation to the piston 15.

[0025] According to a preferred embodiment, there is also a one-way pressure relief valve (also called a "PRV - Pressure Relieve Valve") that only allows fuel to flow inside the pumping chamber 14 through the delivery duct 19 and may be integrated together with the delivery valve 20. The function of the pressure relief valve is to allow a release of fuel in the event that the pressure of the fuel in the common rail 3 (i.e. downstream of the delivery valve 20) exceeds a maximum value established in the design phase (for example, in the event of errors in the check performed by the control unit 7 or in the event of a failure of an injector 2 connected to the common rail 3); in other words, the pressure relief valve is calibrated to automatically open when the jump in pressure at its ends is greater than a threshold value established in the design phase and, thus, to prevent the pressure of the fuel in the common rail 3 from exceeding the maximum value established in the design phase.

[0026] From the above, it is clear that the flow rate

adjustment device 6 only acts on the intake valve 18 and does not have any effect on the delivery valve 20; in other words, the intake valve 18 is completely separate and independent of the delivery valve 20.

[0027] In use, the control unit 7 detects when the internal combustion engine is stopped (switched off) and controls, immediately after (i.e. without any appreciable delay) the internal combustion engine has been stopped, the flow rate adjustment device 6 to allow the intake valve 18 to close (i.e., it activates the electromagnetic actuator 23 to move the control rod 22 from the normally active position assumed due to the thrust of the spring 24 to the passive position that allows the intake valve 18 to close).

[0028] The control unit 7 preferably continues to control the flow rate adjustment device 6 to enable the intake valve 18 to close for a predetermined amount of time (generally lasting between 1 and 5 seconds). In other words, the control unit 7 keeps the electromagnetic actuator 23 active to keep the control rod 22 in the passive position that allows the intake valve 18 to close for the predetermined amount of time.

[0029] As soon as the internal combustion engine is stopped (and, as a result, the piston 15 stops all its alternating, sliding movements), the fuel pressure in the pumping chamber 14 becomes equal to the pressure of the fuel in the intake duct 17 and, thus, the pressure differential across the delivery valve 20 and the pressure relief valve becomes very high, causing the fuel to leak through the delivery valve 20 and the pressure relief valve (i.e. the high-pressure fuel that is found in the delivery duct 19 leaks through the delivery valve 20 and the pressure relief valve entering into the pumping chamber 14). At the same time as the shutdown of the internal combustion engine (i.e. immediately after the internal combustion engine has been stopped), the control unit 7 controls the flow rate adjustment device 6 to allow the intake valve 18 to close: when the pressure in the pumping chamber 14 increases (due to the high-pressure fuel that leaks through the delivery valve 20 and the pressure relief valve), the intake valve 18 spontaneously closes since the pressure of the fuel in the pumping chamber 14 has become greater than the pressure of the fuel in the intake duct 17. Once the intake valve 18 has closed (since the flow rate adjustment device 6 has allowed it to close), the pressure of the fuel in the pumping chamber 14 increases gradually (but increasingly slowly) due to the continuous (but increasingly reduced) leakage of fuel through the delivery valve 20 and the pressure relief valve. After a relatively short time (even less than a second or, in any case, very few seconds), the pressure of the fuel in the pumping chamber 14 reaches a value so as to keep the intake valve 18 closed irrespective of the action of the flow rate adjustment device 6; in other words, the flow rate adjustment device 6 is able to prevent the intake valve 18 from closing when the pressure of the fuel in the pumping chamber 14 is only slightly (marginally) higher than the pressure of the fuel in the intake duct

17 but is not able to reopen the intake valve 18 when the pressure of the fuel in the pumping chamber 14 is basically higher than the pressure of the fuel in the intake duct 17.

[0030] In other words, the control unit 7, in the moment when the internal combustion engine has been stopped and without an appreciable delay, controls the flow rate adjustment device 6 to allow the intake valve 18 to close keeping, at the same time, the delivery valve 20 completely closed (i.e. without causing the delivery valve 20 to open, even partially), so as to minimise, from the moment when the internal combustion engine has been stopped and without an appreciable delay, both the fuel flowing out of the pumping chamber 14 through the intake valve 18 and the fuel flowing into the pumping chamber 14 through the delivery valve 20. In this way, the reduction of the pressure of the fuel in the delivery duct 19 and downstream of the pumping chamber 14 is minimised.

[0031] The embodiments described herein may be combined between them without departing from the scope of protection of this invention.

[0032] The control method described above has numerous advantages.

[0033] In the first place, the control method described above is able to significantly reduce the leaking of fuel both through the delivery valve 20 and through the pressure relief valve when the internal combustion engine is stopped (shut off). This result is obtained thanks to the fact that allowing the intake valve 18 to close when the internal combustion engine is stopped (shut off), the fuel that initially flows through the delivery valve 20 and through the pressure relief valve remains in the pumping chamber 14, increasing the pressure of the fuel inside the pumping chamber 14 and, thus, significantly reducing the pressure differential between the delivery valve 20 and the pressure relief valve. Of course, reducing (almost eliminating) the pressure differential between the delivery valve 20 and the pressure relief valve reduces (almost eliminates), as a consequence, the leaking of fuel through the delivery valve 20 and the pressure relief valve.

[0034] The control method described above is still more effective when the sealing gasket 32 is included that makes it possible to minimise the leaking of fuel from the pumping chamber 14 and through the play between the guide bushing 30 and the piston 15.

[0035] The control method described above has an implementation cost that is basically zero since it only entails the addition of a small portion of code in the software of the control unit 7.

[0036] The control method described above can also be applied to an injection system 1 already marketed via a simple update to the software of the control method 7.

REFERENCE NUMBER LIST FOR FIGURES

[0037]

1	injection system
2	injectors
3	common rail
4	high-pressure fuel pump
5	5 supply duct
6	adjustment device
7	control unit
8	low-pressure fuel pump
9	tank
10	10 supply duct
11	pressure sensor
12	main body
13	longitudinal axis
14	pumping chamber
15	15 piston
16	spring
17	intake duct
18	intake valve
19	delivery duct
20	20 delivery valve
21	damping device
22	control rod
23	electromagnetic actuator
24	spring
25	25 electromagnet
26	anchor
27	disc
28	sheet
29	containing seat
30	30 guide bushing
31	central hole
32	sealing gasket

Claims

1. A method to control a fuel injection system (1) for an internal combustion engine and provided with a fuel pump (4); the fuel pump (4) comprises: a pumping chamber (14); a piston (15) mounted so as to slide within the pumping chamber (14); an intake duct (17), which ends in the pumping chamber (14) and is provided with an intake valve (18); a delivery duct (19), which starts from the pumping chamber (14) and is provided with a delivery valve (20); and a flow rate adjustment device (6), which is coupled to the intake valve (18) and can be controlled so as to prevent the intake valve (18) from closing or allow it to close when a fuel pressure inside the pumping chamber (14) exceeds a fuel pressure in the intake duct (17);

the control method comprises the step of detecting when the internal combustion engine is stopped;

the control method is **characterized in that it** comprises the further step of controlling, in the moment when the internal combustion engine has been stopped and without an appreciable

- delay, the flow rate adjustment device (6) to allow the intake valve (18) to close keeping, at the same time, the delivery valve (20) completely closed so as to minimise, from the moment when the internal combustion engine has been stopped and without an appreciable delay, both the fuel flowing out of the pumping chamber (14) through the intake valve (18) and the fuel flowing into the pumping chamber (14) through the delivery valve (20).
2. The control method according to claim 1 and comprising the further step of continuing to control the flow rate adjustment device (6) to allow the intake valve (18) to close for a predetermined amount of time.
 3. The control method according to claim 2, wherein the predetermined amount of time ranges from 1 to 5 seconds.
 4. The control method according to claim 1, 2 or 3, wherein the flow rate adjustment device (6) is controlled to allow the intake valve (18) to close immediately after the internal combustion engine has been stopped.
 5. The control method according to one of the claims from 1 to 4, wherein the flow rate adjustment device (6) only acts on the intake valve (18) and does not have any effect on the delivery valve (20).
 6. The control method according to one of the claims from 1 to 5, wherein the intake valve (18) is completely separate and independent from the delivery valve (20).
 7. The control method according to one of the claims from 1 to 6, wherein, in the moment when the internal combustion engine has been stopped and without an appreciable delay, the flow rate adjustment device (6) is controlled to allow the intake valve (18) to close while keeping, at the same time, the delivery valve (20) completely closed so as to minimise the reduction in pressure of the fuel in the delivery duct (19) and downstream of the pumping chamber (14).
 8. The control method according to one of the claims from 1 to 7, wherein:

the pressure of the fuel in the pumping chamber (14), after the internal combustion engine has been stopped, increases due to the high-pressure fuel that seeps through the delivery valve (20) and the intake valve (18) closes spontaneously since the pressure of the fuel in the pumping chamber (14) became greater than the pressure of the fuel in the intake duct (17);
 9. The control method according to one of the claims from 1 to 8, wherein the flow rate adjustment device (6) comprises a control rod (22), which is coupled to the intake valve (18) and is movable between a passive position, in which it allows the intake valve (18) to close, and an active position, in which it does not allow the intake valve (18) to close.
 10. The control method according to claim 9, wherein the flow rate adjustment device (6) comprises an electromagnetic actuator (23), which is coupled to the control rod (22) to move the control rod (22) between the active position and the passive position.
 11. The control method according to claim 10, wherein the electromagnetic actuator (23) comprises a spring (24), which holds the control rod (22) in the active position, and an electromagnet (25), which is designed to move the control rod (22) to the passive position overcoming the elastic force generated by the spring (24).
 12. The control method according to claim 9, 10 or 11, wherein the intake valve (18) comprises a disc (27) having a series of feeding through holes, through which the fuel can flow, and a flexible sheet (28) with a circular shape, which rests against a base of the disc (27), thus closing the passage through the feeding holes, and is coupled to the control rod (22) of the flow rate adjustment device (6).
 13. The control method according to one of the claims from 1 to 12, wherein the fuel pump (4) comprises:

a containing seat (29), which is defined in the main body (12) below the pumping chamber (14);

a guide bushing (30), which is housed in the containing seat (29) and is provided with a central hole (31), where the piston (15) is arranged in a sliding manner; and

a sealing gasket (32) interposed between the piston (15) and the central hole (31) of the guide bushing (30).

14. The control method according to one of the claims from 1 to 13, wherein the fuel pump (4) comprises a one-way pressure relief valve, which only allows fuel to flow into the pumping chamber (14) through the delivery duct (19).

Patentansprüche

1. Verfahren zum Steuern eines Kraftstoffeinspritzsystems (1) für einen Verbrennungsmotor, das mit einer Kraftstoffpumpe (4) versehen ist; wobei die Kraftstoffpumpe (4) umfasst:

eine Pumpkammer (14); einen Kolben (15), der so montiert ist, dass er in der Pumpkammer (14) gleitet; einen Einlasskanal (17), der in der Pumpkammer (14) endet und mit einem Einlassventil (18) versehen ist; einen Abgabekanal (19), der von der Pumpkammer (14) ausgeht und mit einem Abgابهventil (20) versehen ist; und eine Durchflusseinstellvorrichtung (6), die mit dem Einlassventil (18) gekoppelt ist und so gesteuert werden kann, dass sie ein Schließen des Einlassventils (18) verhindert oder ein Schließen desselben ermöglicht, wenn ein Kraftstoffdruck im Inneren der Pumpkammer (14) einen Kraftstoffdruck im Einlasskanal (17) übersteigt;

wobei das Verfahren zum Steuern den Schritt umfasst, zu erfassen, wenn der Verbrennungsmotor abgestellt wird; wobei das Verfahren zum Steuern **dadurch gekennzeichnet ist, dass** es ferner den Schritt umfasst, die Durchflusseinstellvorrichtung (6) in dem Moment, in dem der Verbrennungsmotor abgestellt worden ist, ohne nennenswerte Verzögerung so zu steuern, dass ermöglicht wird, dass das Einlassventil (18) schließt, wobei gleichzeitig das Abgابهventil (20) vollständig geschlossen gehalten wird, um ab dem Moment, in dem der Verbrennungsmotor abgestellt worden ist, und ohne eine nennenswerte Verzögerung sowohl den aus der Pumpkammer (14) durch das Einlassventil (18) ausströmenden Kraftstoff als auch den durch das Abgابهventil (20) in die Pumpkammer (14) einströmenden Kraftstoff zu minimieren.

2. Verfahren zum Steuern nach Anspruch 1, das ferner den Schritt umfasst, fortgesetzt die Durchflusseinstellvorrichtung (6) zu steuern, um zu ermöglichen, dass das Einlassventil (18) für eine vorbestimmte Zeitspanne schließt.

3. Verfahren zum Steuern nach Anspruch 2, wobei die vorbestimmte Zeitspanne im Bereich von 1 bis 5 Sekunden liegt.

4. Verfahren zum Steuern nach Anspruch 1, 2 oder 3, wobei die Durchflusseinstellvorrichtung (6) so gesteuert wird, dass ermöglicht wird, dass das Einlassventil (18) sich unmittelbar nach Abstellen des Verbrennungsmotors schließt.

5. Verfahren zum Steuern nach einem der Ansprüche 1 bis 4, wobei die Durchflusseinstellvorrichtung (6) nur auf das Einlassventil (18) wirkt und keine Wirkung auf das Abgابهventil (20) hat.

6. Verfahren zum Steuern nach einem der Ansprüche 1 bis 5, wobei das Einlassventil (18) vollständig getrennt und unabhängig von dem Abgابهventil (20) ist.

7. Verfahren zum Steuern nach einem der Ansprüche 1 bis 6, wobei in dem Moment, in dem der Verbrennungsmotor abgestellt worden ist, ohne nennenswerte Verzögerung die Durchflusseinstellvorrichtung (6) so gesteuert wird, dass ermöglicht wird, dass das Einlassventil (18) schließt, während gleichzeitig das Abgابهventil (20) vollständig geschlossen gehalten wird, um die Reduktion des Kraftstoffdrucks in dem Abgabekanal (19) und stromabwärts der Pumpkammer (14) zu minimieren.

8. Verfahren zum Steuern nach einem der Ansprüche 1 bis 7, wobei:

der Druck des Kraftstoffs in der Pumpkammer (14) nach dem Abstellen des Verbrennungsmotors aufgrund des unter hohem Druck stehenden Kraftstoffs, der durch das Abgابهventil (20) dringt, ansteigt und das Einlassventil (18) sich spontan schließt, da der Druck des Kraftstoffs in der Pumpkammer (14) größer geworden ist als der Druck des Kraftstoffs im Einlasskanal (17); sobald das Einlassventil (18) geschlossen ist, da die Durchflusseinstellvorrichtung (6) dessen Schließen ermöglicht hat, der Druck des Kraftstoffs in der Pumpkammer (14) allmählich und immer langsamer ansteigt, und zwar aufgrund des kontinuierlichen, aber zunehmend reduzierten Eindringens von Kraftstoff durch das Abgابهventil (20); an einem bestimmten Punkt der Druck des Kraftstoffs in der Pumpkammer (14) einen Wert erreicht, der es ihm ermöglicht, das Einlassventil (18) unabhängig von der Wirkung der Durchflusseinstellvorrichtung (6) geschlossen zu halten.

9. Verfahren zum Steuern nach einem der Ansprüche 1

bis 8, **dadurch gekennzeichnet, dass** die Durchflusseinstellvorrichtung (6) eine Steuerstange (22) umfasst, die mit dem Einlassventil (18) gekoppelt ist und zwischen einer passiven Stellung, in der sie das Schließen des Einlassventils (18) zulässt, und einer aktiven Stellung, in der sie das Schließen des Einlassventils (18) nicht zulässt, bewegbar ist.

10. Verfahren zum Steuern nach Anspruch 9, wobei die Durchflusseinstellvorrichtung (6) einen elektromagnetischen Aktor (23) umfasst, der mit der Steuerstange (22) gekoppelt ist, um die Steuerstange (22) zwischen der aktiven Stellung und der passiven Stellung zu bewegen.

11. Verfahren zum Steuern nach Anspruch 10, wobei der elektromagnetische Aktor (23) eine Feder (24), die die Steuerstange (22) in der aktiven Stellung hält, und einen Elektromagneten (25) umfasst, der dazu ausgelegt ist, die Steuerstange (22) unter Überwindung der von der Feder (24) erzeugten elastischen Kraft in die passive Stellung zu bewegen.

12. Verfahren zum Steuern nach Anspruch 9, 10 oder 11, wobei das Einlassventil (18) eine Scheibe (27) mit einer Reihe von Durchgangslöchern, durch die der Kraftstoff fließen kann, und eine flexible Platte (28) mit einer Kreisform aufweist, die an einer Basis der Scheibe (27) anliegt, wodurch der Durchgang durch die Durchgangslöcher geschlossen wird, und die mit der Steuerstange (22) der Durchflusseinstellvorrichtung (6) gekoppelt ist.

13. Verfahren zum Steuern nach einem der Ansprüche 1 bis 12, wobei die Kraftstoffpumpe (4) umfasst:

einen Aufnahmesitz (29), der in dem Hauptkörper (12) unterhalb der Pumpkammer (14) ausgebildet ist;
eine Führungsbuchse (30), die in dem Aufnahmesitz (29) untergebracht ist und mit einem zentralen Loch (31) versehen ist, in dem der Kolben (15) gleitend angeordnet ist; und
eine Dichtung (32), die zwischen dem Kolben (15) und dem zentralen Loch (31) der Führungsbuchse (30) angeordnet ist.

14. Verfahren zum Steuern nach einem der Ansprüche 1 bis 13, **dadurch gekennzeichnet, dass** die Kraftstoffpumpe (4) ein Einweg-Druckentlastungsventil umfasst, das dem Kraftstoff nur ermöglicht, durch den Abgabekanal (19) in die Pumpkammer (14) zu fließen.

Revendications

1. Procédé de commande d'un système d'injection de

carburant (1) pour un moteur à combustion interne et doté d'une pompe à carburant (4) ; la pompe à carburant (4) comprend : une chambre de pompage (14) ; un piston (15) monté afin de coulisser à l'intérieur de la chambre de pompage (14) ; un conduit d'admission (17), qui se termine dans la chambre de pompage (14) et est prévu avec une valve d'admission (18) ; un conduit de refoulement (19), qui commence à partir de la chambre de pompage (14) et est prévu avec un clapet de refoulement (20) ; et un dispositif de réglage de débit (6) qui est couplé à la valve d'admission (18) et peut être commandé afin d'empêcher la fermeture de la valve d'admission (18) ou lui permettre de se fermer lorsqu'une pression de carburant à l'intérieur de la chambre de pompage (14) dépasse une pression de carburant dans le conduit d'admission (17) ;

le procédé de commande comprend l'étape de détection lorsque le moteur à combustion interne est arrêté ;

le procédé de commande est **caractérisé en ce qu'il** comprend l'étape supplémentaire de commande, au moment où le moteur à combustion interne a été arrêté et sans délai notable, du dispositif de réglage de débit (6) pour permettre à la valve d'admission (18) de se fermer, maintenant en même temps le clapet de refoulement (20) complètement fermé afin de minimiser, à partir du moment où le moteur à combustion interne a été arrêté et sans délai notable, à la fois le carburant sortant de la chambre de pompage (14) à travers la valve d'admission (18) et le carburant entrant dans la chambre de pompage (14) à travers le clapet de refoulement (20).

2. Procédé de commande selon la revendication 1 et comprenant l'étape supplémentaire permettant de continuer la commande du dispositif de réglage de débit (6) pour permettre à la valve d'admission (18) de se fermer pendant un intervalle de temps prédéterminé.

3. Procédé de commande selon la revendication 2, dans lequel l'intervalle de temps prédéterminé est dans la plage de 1 à 5 secondes.

4. Procédé de commande selon la revendication 1, 2 ou 3, dans lequel le dispositif de réglage de débit (6) est contrôlé pour permettre à la valve d'admission (18) de se fermer immédiatement après que le moteur à combustion interne a été arrêté.

5. Procédé de commande selon l'une des revendications 1 à 4, dans lequel le dispositif de réglage de débit (6) agit uniquement sur la valve d'admission (18) et n'a pas d'effet sur le clapet de refoulement

- (20).
6. Procédé de commande selon l'une des revendications 1 à 5, dans lequel la valve d'admission (18) est complètement séparée et indépendante du clapet de refoulement (20). 5
 7. Procédé de commande selon l'une des revendications 1 à 6, dans lequel, au moment où le moteur à combustion interne a été arrêté et sans délai notable, le dispositif de réglage de débit (6) est commandé pour permettre à la valve d'admission (18) de se fermer, tout en maintenant en même temps le clapet de refoulement (20) complètement fermé afin de minimiser la réduction de pression du carburant dans le conduit de refoulement (19) et en aval de la chambre de pompage (14). 10
 8. Procédé de commande selon l'une des revendications 1 à 7, dans lequel : 15

la pression du carburant dans la chambre de pompage (14), après que le moteur à combustion interne a été arrêté, augmente en raison du carburant à haute pression qui s'infiltre à travers le clapet de refoulement (20) et la valve d'admission (18) se ferme spontanément étant donné que la pression du carburant dans la chambre de pompage (14) est devenue plus importante que la pression du carburant dans le conduit d'admission (17) ; 20

une fois que la valve d'admission (18) a été fermée, étant donné que le dispositif de réglage de débit (6) lui a permis de se fermer, la pression du carburant dans la chambre de pompe (14) augmente progressivement et de plus en plus lentement en raison de l'infiltration continue mais de plus en plus réduite de carburant à travers le clapet de refoulement (20) ; 25

à un certain point, la pression du carburant dans la chambre de pompage (14) atteint une valeur qui lui permet de maintenir la valve d'admission (18) fermée indépendamment de l'action du dispositif de réglage de débit (6). 30
 9. Procédé de commande selon l'une des revendications 1 à 8, dans lequel le dispositif de réglage de débit (6) comprend une tige de commande (22) qui est couplée à la valve d'admission (18) et est mobile entre une position passive, dans laquelle elle permet à la valve d'admission (18) de se fermer, et une position active, dans laquelle elle ne permet pas à la valve d'admission (18) de se fermer. 35
 10. Procédé de commande selon la revendication 9, dans lequel le dispositif de réglage de débit (6) comprend un actionneur électromagnétique (23), qui est couplé à la tige de commande (22) pour 40

déplacer la tige de commande (22) entre la position active et la position passive.

11. Procédé de commande selon la revendication 10, dans lequel l'actionneur électromagnétique (23) comprend un ressort (24), qui maintient la tige de commande (22) dans la position active, et un électro-aimant (25) qui est conçu pour déplacer la tige de commande (22) dans la position passive, venant à bout de la force élastique générée par le ressort (24). 45
12. Procédé de commande selon la revendication 9, 10 ou 11, dans lequel la valve d'admission (18) comprend un disque (27) ayant une série de trous débouchants d'alimentation, à travers lesquels le carburant peut s'écouler et une feuille flexible (28) avec une forme circulaire, qui s'appuie contre une base du disque (27), fermant ainsi le passage à travers les trous d'alimentation et est couplée à la tige de commande (22) du dispositif de réglage de débit (6). 50
13. Procédé de commande selon l'une des revendications 1 à 12, dans lequel la pompe à carburant (4) comprend : 55

un siège de confinement (29) qui est défini dans le corps principal (12) au-dessous de la chambre de pompage (14) ;

une douille de guidage (30) qui est logée dans le siège de confinement (29) et est prévue avec un trou central (31), où le piston (15) est agencé d'une manière coulissante ; et

un joint d'étanchéité (32) intercalé entre le piston (15) et le trou central (31) de la douille de guidage (30).
14. Procédé de commande selon l'une des revendications 1 à 13, dans lequel la pompe à carburant (4) comprend une soupape de décharge de pression unidirectionnelle, qui permet uniquement au carburant de s'écouler dans la chambre de pompage (14) à travers le conduit de refoulement (19). 60

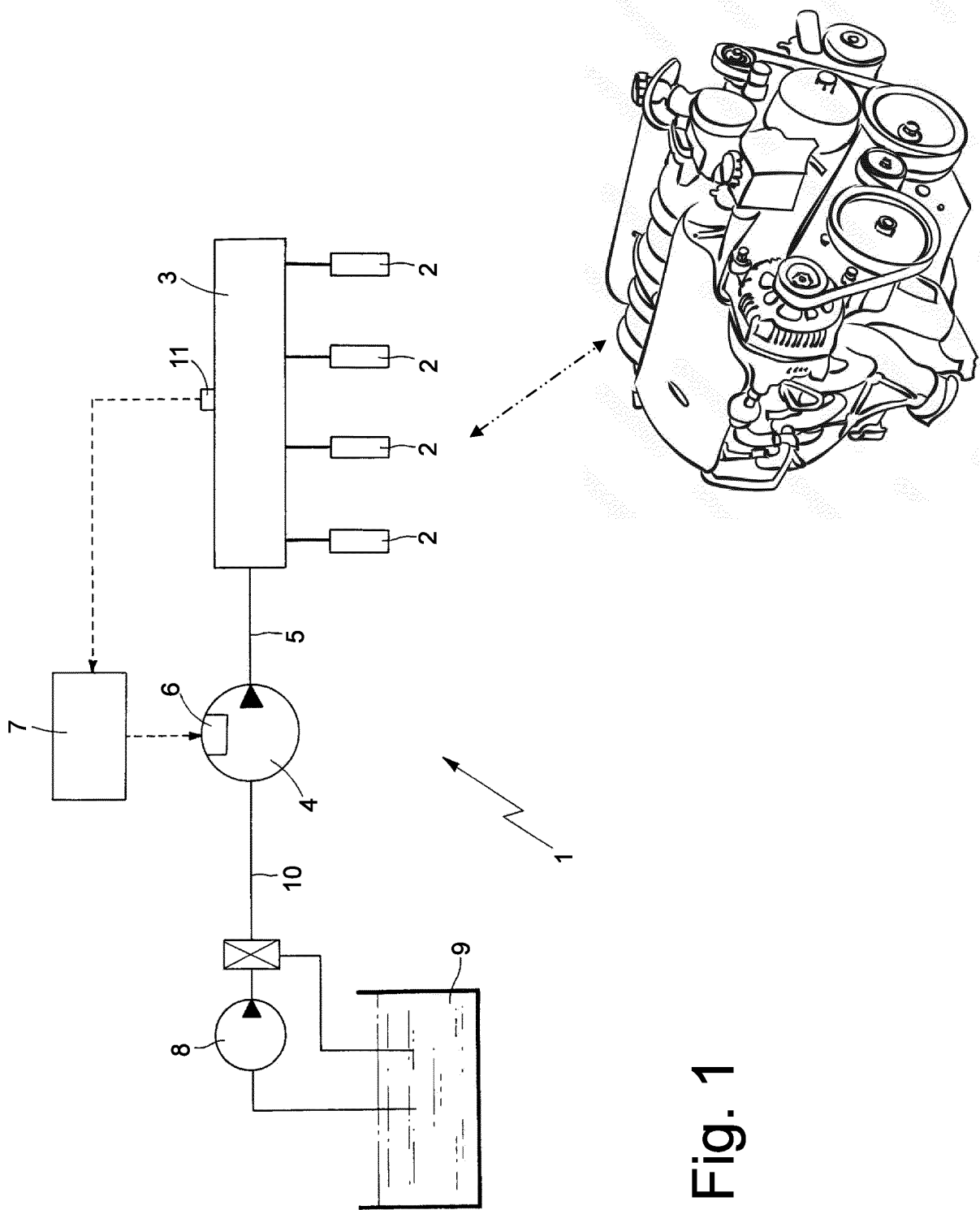


Fig. 1

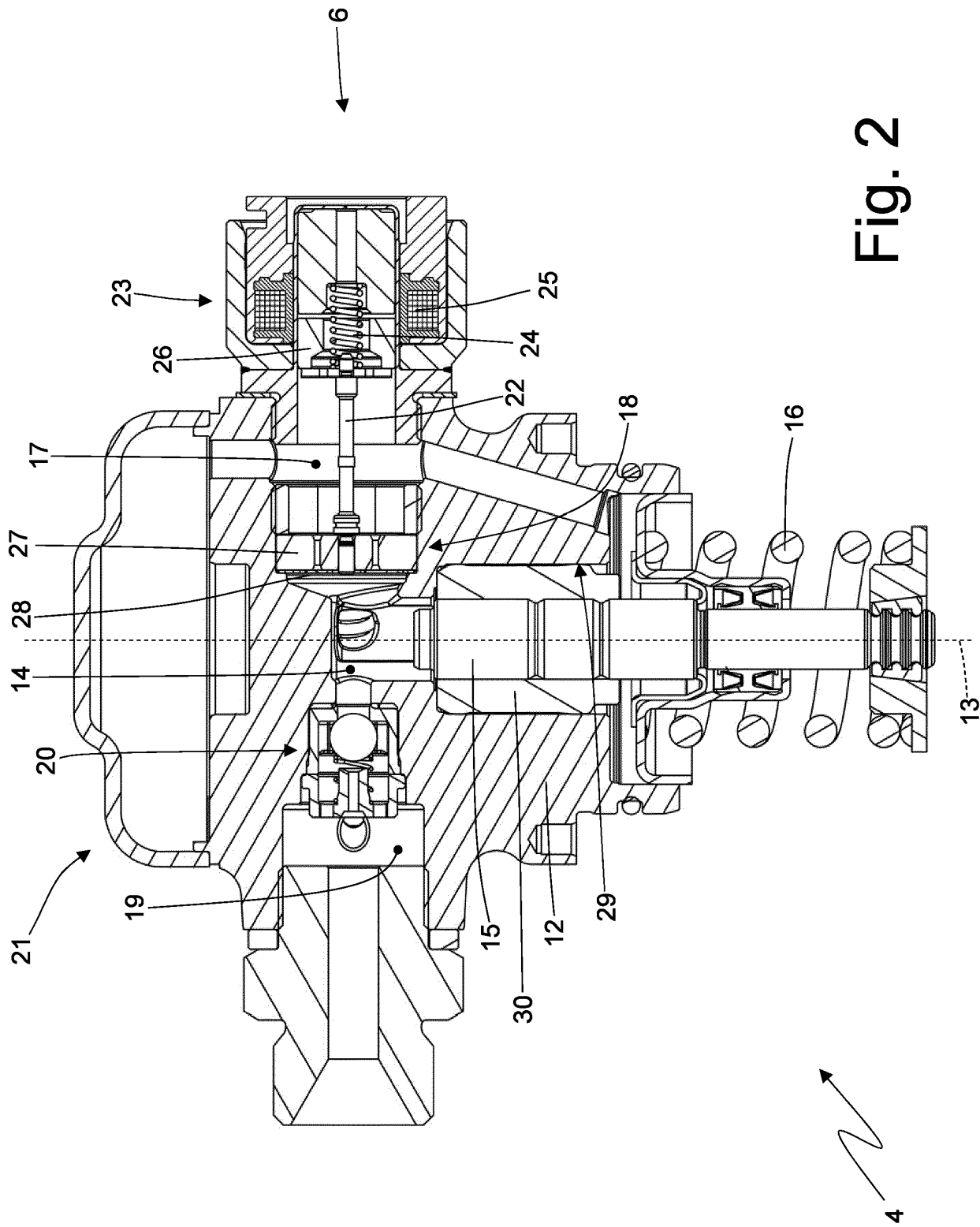


Fig. 2

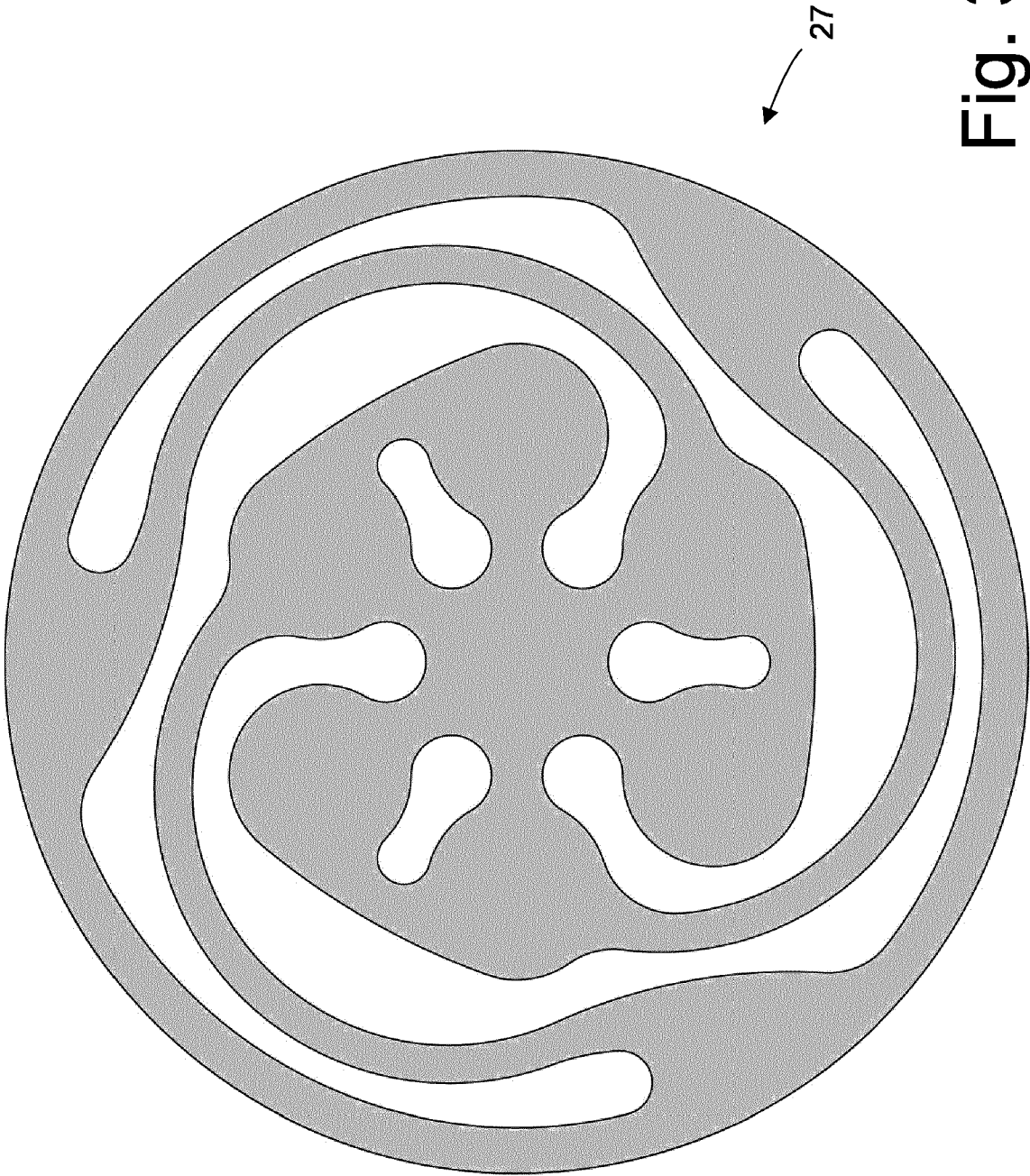


Fig. 3

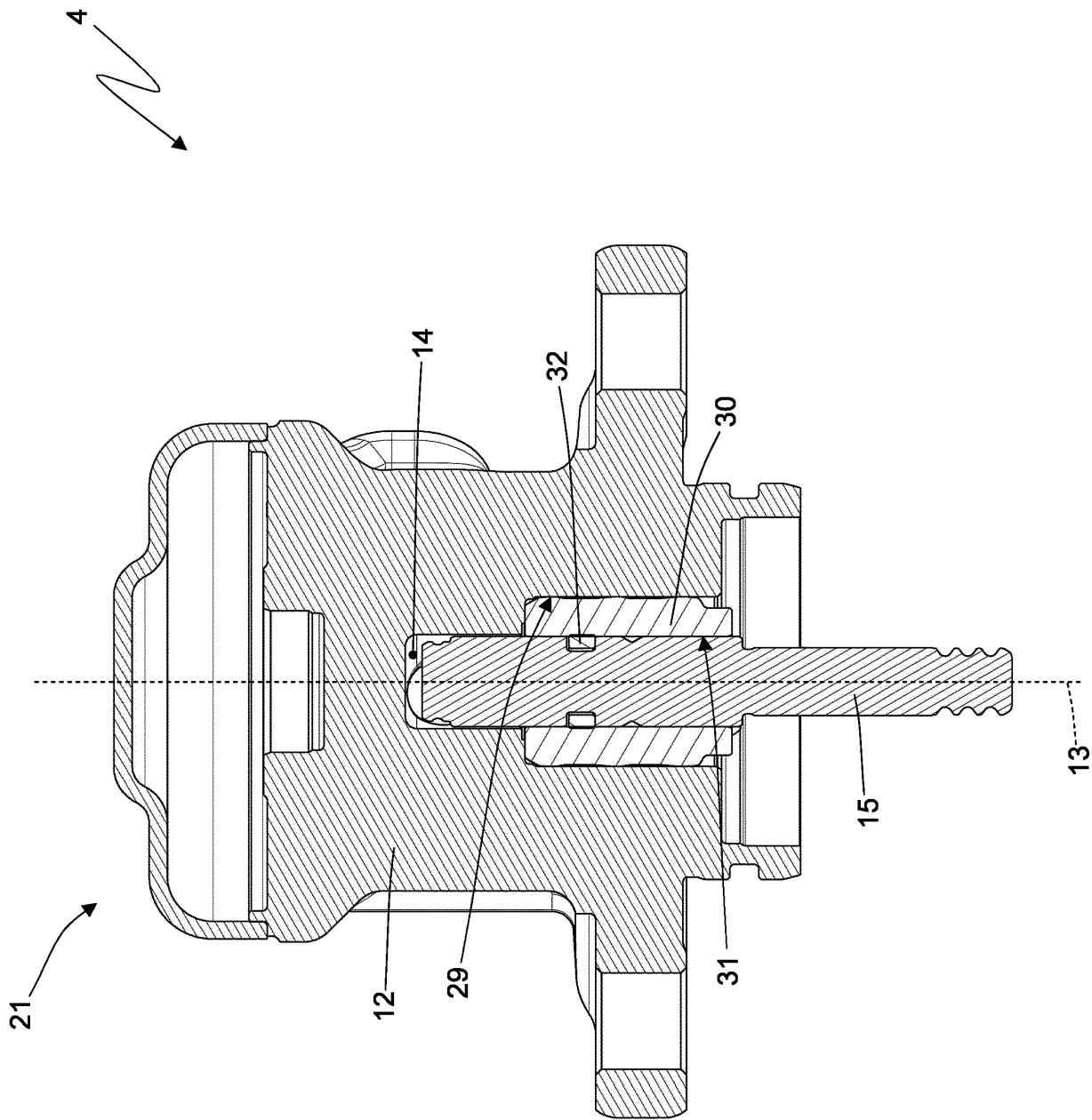


Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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