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(54) **A fuel valve for large turbocharged two stroke diesel engines**

(57) A fuel valve (1) for injecting fuel into the combustion chamber of a large turbocharged two stroke diesel engine, with a resiliently biased and axially movable valve needle (20) cooperating with a valve seat (22), a plurality of nozzle holes (35) distributed axially and radially over the nozzle (30), an electronically controlled valve connected to a closing chamber in for urging the valve spindle (20) to its seat (22) for alternatively connecting the closing chamber to a tank port (18) or to a fuel inlet port (16).

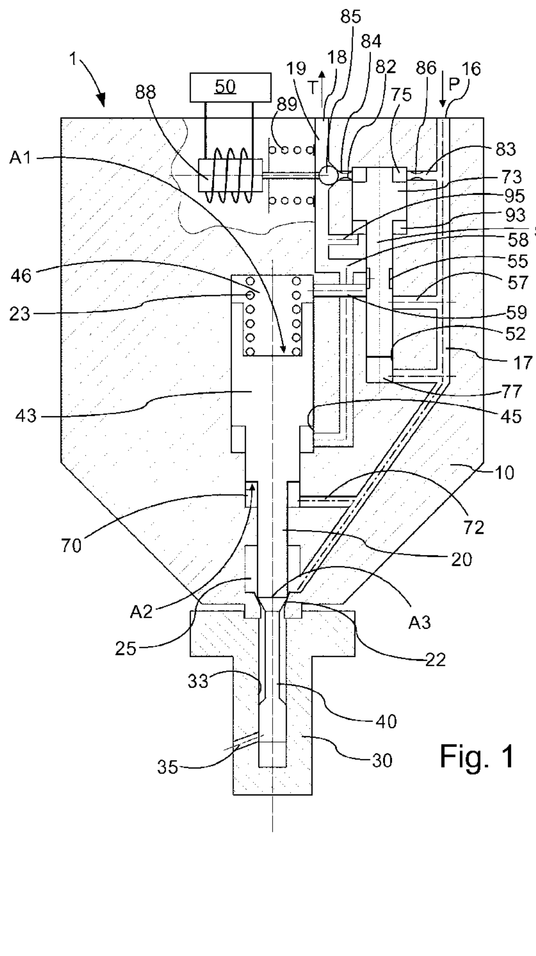

Fig. 1

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Description

[0001] The present invention relates to a fuel valve for large turbocharged two-stoke diesel engines, in particular to en electronically controlled fuel valve for the large turbocharged inflow two stroke diesel engines with cross heads.

BACKGROUND OF THE INVENTION

[0002] Large turbocharged two-stroke diesel engines with cross-heads are typically used as prime movers in large ocean going ships, such as container ships or in power plants.

[0003] These engines are typically provided with two or three fuel valves arranged in each cylinder cover. The fuel valve is provided with a spring biased axially movable valve needle that acts as a movable valve member. When the pressure of the fuel (typically heavy fuel oil) exceeds a preset pressure (typically 350 Bar) the axially movable valve needle is lifted from its seat and the fuel is allowed to flow into the combustion chamber via a nozzle at the front of the fuel valve.

[0004] A conventional nozzle has a longitudinal axis that is arranged roughly at an angle of 10 to 15 deg to the direction of the movement of the piston in the cylinder of the engine and the nozzle is provided with a central bore and a plurality of nozzle bores that direct the fuel away from the cylinder walls and into the combustion chamber. Typically, there is a swirl in the air in the combustion chamber at the moment of injection, provided by the charge air inflow. Most of the nozzle bores are directed to inject the fuel with the flow of the swirl although some of the bores may be directed to inject the fuel against the flow of the swirl.

[0005] A known fuel valve of this type is the MAN Diesel slide fuel valve that has a design with a minimized sac volume of residual fuel. This known fuel valve has two positions: open with all nozzle holes in use or closed. The position of the axially movable valve needle is controlled by a pressure chamber in the valve housing above the axially movable valve needle. The pressure chamber is permanently connected to a high pressure fluid source via a throttled connection, and to a drain via a closable throttled connection. This construction causes substantial drain loses during valve open time and causes relatively slow closing and opening speeds of the fuel valve. The high pressure fluid for controlling the needle valve is the fuel oil.

[0006] Ongoing demands for reduced emissions and improved specific fuel consumption require further development of the fuel injection system. Improved accuracy and faster opening and closing movement are key aspects.

[0007] In a conventional fuel valve for a large two stroke uniflow diesel engine with cross-heads the opening and closing of the valve needle of the fuel valve is controlled via a pressure chamber arranged in the fuel valve housing at an end of the valve needle that is opposite to the nozzle. The valve needle is slidably and sealingly received in a bore in the fuel valve housing with the pressure chamber forming the end of the bore. The pressure in the pressure chamber is controlled by a throttled connection to the high pressure fluid inlet port and another throttled connection to the tank port. The connection to the tank port can be opened and closed by an electrically controlled solenoid valve that typically is a solenoid controlled ball valve. The throttled connection to tank is less restricted than the throttled connection to the fuel port, and therefore pressure drops in the pressure chamber when the solenoid valve opens the connection to the tank port.

[0008] When the solenoid valve is closed the pressure in the pressure chamber increases until it reaches the pressure in the fuel inlet port. The speed with which the pressure in the pressure chamber increases is determined by the pressure difference between the pressure chamber and the fuel inlet port and the size of the restriction in the connection between the two.

[0009] When the solenoid valve is open, the pressure in the pressure chamber falls until a balance determined by the ratio between the size of the restriction in the connection to the tank port and the size of the restriction in the connection to the fuel port. The speed with which the pressure in the pressure chamber decreases is determined by this balance between the size of the two restrictions.

[0010] Thus, the speed with which the valve needle opens and closes is determined by the restrictions, and both the opening and closing movement of the valve needle is inherently slower than desired

[0011] The solenoid valve is open during a fuel injection event. The flow through the restricted connections when the solenoids valve is open represents a large leak flow and the energy loss associated with this leak flow is quite substantial since the pressure at the fuel inlet is very high, typically 300 bar or higher.

[0012] The present demand for lower emissions and improved specific fuel oil consumption require faster reacting fuel valves and reduced energy losses through leak oil

DISCLOSURE OF THE INVENTION

[0013] On this background, it is an object of the present invention to provide a fuel valve that is able to at least partially meet the demands indicated above and at least partially overcome the problems indicated above.

[0014] The present invention defines a fuel valve for injecting fuel into the combustion chamber of a large two stroke diesel engine, with a resiliently biased and axially movable valve needle cooperating with a valve seat, an electronically controlled pilot valve connected to a closing chamber for urging the needle valve to its seat for selectively, e.g. alternatingly, connecting the closing chamber to a tank port or to a fuel inlet port.

[0015] The object above is achieved by providing an electronically controlled fuel valve for injecting fuel into the combustion chamber of a large two stroke diesel engine with cross-heads, the fuel valve comprising a fuel valve housing, an elongated nozzle, a fuel inlet port for connection to a source of high pressure fuel, a conduit connecting the high pressure fuel inlet port to the nozzle, a resiliently biased and axially movable valve needle co-operating with a valve seat and configured to control the flow of fuel from the fuel inlet port to the nozzle, whereby lift of the axially movable valve needle allows flow from the fuel inlet port to the nozzle, a closing chamber in the valve housing acting on the valve needle with a first effective surface area and urging the valve needle towards the valve seat when the closing chamber is pressurized, an opening chamber in the valve housing said opening chamber being in fluid connection with said first duct to be pressurized by said source (P), pressure in said opening chamber (70), said opening chamber acting on the valve needle with a second effective surface area and urging the valve needle away from the valve seat, a control conduit directly connecting the closing chamber to a valve port of an electronically controlled pilot valve, the electronically controlled pilot valve being provided with a valve port connected to the tank port and with a valve port connected to the fuel inlet port, the electronically controlled valve being configured to selectively connect the control conduit to the tank port or to the fuel inlet port for electronically controlling lift of the valve spindle.

[0016] By using an electronically controlled pilot valve for controlling the pressure in the pressure chamber that urges the valve needle towards the seat, i.e. the closing chamber, by selectively connecting the control conduit to the tank port or to the fuel inlet port it becomes possible to reduce the leak oil flow significantly. The needle valve opening and closing can be electronically controlled and, the valve needle can be opened faster and closed faster which results in better control of the fuel injection. These measures are resulting in lower specific fuel of consumption and allow for emission reduction. Preferably, the electronically controlled valve is a spool valve.

[0017] In an embodiment in the spool valve is provided with a first pressure chamber acting on the spool and urging the spool to a position where the control conduit is connected to the fuel inlet port.

[0018] The spool valve may also be provided with a second pressure chamber acting on the spool and urging the spool to a position where the control conduit is connected to the tank port.

[0019] In another embodiment the pressure chamber is provided with a throttled connection to the fuel inlet port and with another throttled connection to the tank port, with the throttled connection to the tank port is less restricted than the throttled connection to the fuel inlet port and wherein the fuel valve (1) further comprises an electrically controlled solenoid valve for opening and closing the throttled connection to the tank port.

[0020] Preferably, the solenoid valve is a solenoid controlled ball valve. This construction allows for the use of an off-the shelf type solenoid valve to control the position of the spool.

[0021] In an embodiment the restricted connection to the tank port is located inside the valve housing.

[0022] In an embodiment the restricted connection to the tank port is located extends through the spool of the spool valve.

[0023] In an embodiment the nozzle is a nozzle with an axial bore and a closed front and the valve needle moves in unison with a cut-off shaft moving in unison with the valve needle and received axially displaceable in the central bore in the nozzle for opening and closing the nozzle holes.

[0024] Further objects, features, advantages and properties of the fuel valve according to the present disclosure will become apparent from the detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] In the following detailed portion of the present description, the invention will be explained in more detail with reference to the exemplary embodiments shown in the drawings, in which:

Fig. 1 is a longitudinal-section of an exemplary embodiment of a fuel valve, and

Fig. 2 is a longitudinal-section of another exemplary embodiment of a fuel valve.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0026] The fuel valve 1 according to an exemplary embodiment illustrated in Fig. 1 has an external housing 10 which at its rearmost end has a fuel inlet port 16 and a fuel outlet port or tank port 18. The inlet port 16 is to be connected to a source P of high pressure fuel such as fuel oil, heavy fuel oil from a fuel pump or from a common fuel rail. The outlet port 18 is to be connected to a return line to tank T.

[0027] The fuel valve 1 may in a known manner be mounted in the cylinder cover of a large two-stroke turbocharged uniflow diesel engine with cross-heads and be connected with a fuel pump, not shown.

[0028] The fuel inlet port 16 is in flow connection with a duct 17. Duct 17 extends to the seat of a valve needle 20 that is axially displaceable in an axial bore in the valve housing 10. The valve needle 20 is biased to its seat 22 by a closing spring 23. The foremost part of the valve housing 10 holds a nozzle 30 that projects from the valve housing 10 and into the combustion chamber of the engine cylinder (not shown) when the fuel valve 1 is mounted on the cylinder cover.

[0029] Fig. 1 shows the valve needle 20 resting on the valve seat 22. In this position, fluid flow of fuel from the fuel oil inlet port 16 to the nozzle 30 is blocked. A chamber 25 above the valve seat 22 is connected to duct 17 to receive pressurized fuel.

[0030] The valve needle 20 carries a foremost cut-off shaft 40 that is thinner than the rearmost section of the valve needle 20 and the cut-off shaft 40 projects into a central bore 33 in the nozzle 30. Thus, when the valve needle 20 is axially displaced in the bore in the housing 10 the cut-off shaft 40 is axially displaced in the central bore of the nozzle 30.

[0031] The nozzle 30 is further provided with a plurality of nozzle holes 35 through which the fuel is injected into the combustion chamber from the central bore 33. Thus, during a fuel injection event a jet of fuel comes from the nozzle holes 35.

[0032] The cut-off shaft 40 is in an exemplary embodiment made as one piece of material with the valve needle 20. The cut-off shaft 40 is hollow and the hollow interior of the cut-off shaft 40 connects to the space downstream of the valve seat 22. Thus, when the valve needle 20 is lifted from its seat the flow path extends all the way from the fuel oil inlet 16 to the hollow interior of the cut-off shaft 40.

[0033] A duct 19 is connected to the outlet port 18 and the duct 19 collects the return oil flow as will de explained in greater detail hereafter.

[0034] The foremost part of the cut-off shaft 40 is cylindrical and fits exactly into the central bore 33.

[0035] The upper (upper as in the drawings) part of the valve is a substantially cylindrical section 43 with an enlarged diameter and this section 43 that is slidably received in an axial bore 45 in the valve housing 10 so that the section 43 can act like a piston in the valve housing 10. A closing chamber 46 formed in the upper part (upper as in the drawing) of the valve housing 10 is disposed above the actuation section 43. The spring 23 for urging the valve needle 20 onto its seat 22 is received in the closing chamber 46, and acts on the top of the actuation section 43. The pressure in closing chamber 46 acts on the valve needle 20 to urge the latter in the closing direction with an effective surface area A1.

[0036] An opening chamber 70 for urging the valve needle 20 in the opening direction is located under section 43 and connected via bore 72 to duct 17. Opening chamber 70 is therefore always pressurized when the fuel inlet port 16 is connected to a source of pressurized fuel (such as a fuel pump). The pressure in opening chamber 70 acts on the valve needle 20 to urge the latter in the opening direction with an effective surface area A2.

[0037] A bore 52 is formed in the valve housing. In figure 1 the bore is oriented axially. However, other orientations for bore 52, such are radially or tangentially or orientations there in-between are also possible. A spool or slide 53 is slidably received in the axial bore 52 and the position of the spool 53 determines the flow to- and from three ports that open into the axial bore 52.

[0038] One of the ports connects via a conduit 57 to duct 17 that is connected the source of pressurized fuel via fuel inlet port 16. Another port is connected to duct 19 by a conduit 58 and the third port is connected to closing chamber 46 via a control conduit 59.

[0039] A reduced diameter section 55 of the spool 53 connects the control conduit 59 with conduit 57 in the lower (lower as in the drawing) position of the spool 53 and connects the control conduit 59 to conduit 58 in the upper (upper as in the drawing) position (shown in Figure 1) of the spool 53. In the upper position of the spool 53 closing chamber 46 is connected to the outlet port or tank port 18 (drain) and in the lower position of the spool 53 the closing chamber 46 is connected to the source of pressurized fuel (high pressure).

[0040] The upper (upper as in Figure 1) section of the spool 53 is formed as a piston section 73 with a diameter that is larger than the diameter of the rest of the spool 53 (in other embodiments the diameter of the upper section 73 of the spool 53 is equal or smaller than the diameter of the rest of the spool 53). A pressure chamber 75 above (above as in Figure 1) acts on the spool 53 in the downward (downward as in Figure 1) direction to urge the spool 53 to the position where closing chamber 46 is connected to the source of pressurized fuel (high pressure) P.

[0041] Another pressure chamber 77 below (below as in Figure 1) the spool 53 acts on the on the spool 53 in the upward (upward as in Figure 1) direction to urge the spool 53 to the position where closing chamber 46 is connected to the outlet port 18 (drain). Pressure chamber 77 is permanently connected to the source of pressurized fuel P via duct 17.

[0042] A restricted connection 82, e.g. in the form of a conduit with an orifice 84 that acts as a throttle connects pressure chamber 75 to duct 19 and thus to the tank port 18 (drain).

[0043] The restricted connection can be opened and closed by a ball valve 85 that is connected to a spring biased solenoid 88. The spring of the ball valve 85 urges the ball valve to its seat. Activation of the solenoid 88 causes the ball to be lifted from the seat against the action of the spring 89.

[0044] A restricted connection, e.g. in the form of a conduit with 83 an orifice 86 that acts as a throttle connects pressure chamber 75 to duct 17 and thus to the fuel inlet port 16.

[0045] The position of spool 53 is controlled by fuel oil pressure and the balance between the orifices 84 and 86.

[0046] When the solenoid 88 is activated the valve seat of the ball valve 85 is opened and pressure chamber 75 is connected to the outlet port 18 (drain) via the orifice 84. The fuel oil pressure in the pressure chamber 75 will drop because the flow area of orifice 86 is smaller than the flow area of orifice 84. The decrease pressure in pressure chamber 75 will cause the spool 53 to move upwards under influence of the pressure in pressure chamber 77 and closing chamber 46 will be connected to duct 19 and the outlet port 18 via control conduit 59. Hence, the pressure in closing chamber 46 will drop and the fuel oil pressure in opening chamber 70 acting on effective pressure area A2 will cause the valve needle 20 to move upwards (lift) and the fuel oil will pass via the valve seat 22 and thereby to the nozzle holes 35 for injection into a combustion chamber.

[0047] When the solenoid 88 is deactivated, the ball valve 85 will return to its seat by the action of the spring 89 and the pressure in pressure chamber 75 will rise by fuel oil passing through the orifice 86 and the spool 53 will start moving downwards since the effective pressure area of pressure chamber 75 acting on spool 53 is larger than the effective pressure area of pressure chamber 77 acting on spool 53. When the spool 53 has moved a certain distance, control conduit 59 will be connected to conduit 57 which is in turn connected to duct 17 and thereby to the source of pressurized fuel P. Hence the pressure in pressure chamber 46 will increase and cause the valve needle 20 to move downwards since effective pressure area A1 is larger than effective pressure are A2, until the valve needle 20 rests on its seat 22 and stops fuel oil from going through via the valve seat 22 to the nozzle holes 35.

[0048] A ring chamber 93 below the piston section 73 is connected to duct 19 via a conduit 95 and hence to the tank port. Thus, no force will act on the annulus area of the piston section 53.

[0049] When there is no fuel oil pressure on the system the spring 23 will keep the valve needle 20 engaged with the valve seat 22.

[0050] By providing a pilot valve to control the position of the to the valve needle, the amount of leak fuel, during the time the valve needle has lift is significantly reduced.

[0051] The spool 53 acts as a 3/2 way valve, hence the spool 53 can be replaced by ball valve or a seat valve. Thus, in an embodiment the spool 53 is replaced by a ball valve and in another embodiment the spool 53 is replaced by a seat valve.

[0052] The solenoid 88 can in an embodiment be connected to an electronic control unit 50, such as the electronic control unit of the engine. Hence the electronic control unit 50 determines if the solenoid 88 is active or not and thereby the electronic control unit 50 controls the start and end of a fuel injection event.

[0053] According to another embodiment the spool 53 is connected directly to an electronic actuator and then controlled according to the movement of the actuator.

[0054] Figure 2 shows an embodiment of the invention that is essentially identical to the embodiment of figure 1, except that the valve needle 20 is not provided with a cut off shaft. The construction of the nozzle 30 and the valve needle is more simple than in the embodiment of Figure 1. However, the sac volume in the nozzle 30 is larger than in the embodiment of Figure 1.

[0055] The embodiments described above can be combined in an desirable configuration.

[0056] The teaching of this disclosure has numerous advantages. Different embodiments or implementations may yield one or more of the following advantages. It should be noted that this is not an exhaustive list and there may be other advantages which are not described herein. One advantage of the teaching of this disclosure is that it provides for a fuel valve for a large two-stroke diesel engine that allows for precise control of a fuel injection event. It is another advantage of the present fuel valve that it reduces leak oil losses. It is yet another advantage of the of the present fuel valve that it provide for a faster response of the valve needle on control signals.

[0057] Although the teaching of this application has been described in detail for purpose of illustration, it is understood that such detail is solely for that purpose, and variations can be made therein by those skilled in the art without departing from the scope of the teaching of this application.

[0058] The term "comprising" as used in the claims does not exclude other elements or steps. The term "a" or "an" as used in the claims does not exclude a plurality. The single processor or other unit may fulfill the functions of several means recited in the claims.

Claims

1. An electronically controlled fuel valve (1) for injecting fuel into the combustion chamber of a large two stroke diesel engine with cross-heads, said fuel valve comprising:

   a fuel valve housing (10),
   a nozzle (30),
   a fuel inlet port (16) for connection to a source (P) of high pressure fuel,
   a first duct(17) connecting the high pressure fuel inlet port (16) to the nozzle (30),
   a resiliently biased and axially movable valve needle (20) cooperating with a valve seat (22) and configured to control the flow of fuel from the fuel inlet port (16) to the nozzle (30), whereby lift of the axially movable valve needle (20) allows flow from the fuel inlet port (16) to the nozzle (30),
   a closing chamber (46) in the valve housing (10) acting on the valve needle (20) with a first effective surface area (A1) and urging the valve needle towards the valve seat (22) when pressurized,
   an opening chamber (70) in the valve housing (10), said opening chamber being in fluid connection with said first duct to be pressurized by said source (P), pressure in said opening chamber (70) acts on the valve needle (20) with a second effective surface area (A2) and urges the valve needle (20) away from the valve seat (22),
   a control conduit (59) directly connecting the closing chamber to a valve port of an electronically controlled pilot valve,
   said electronically controlled pilot valve is provided with a valve port connected to said tank port (18) and with a valve port connected to said

fuel inlet port (16), said electronically controlled valve being configured to selectively connect said control conduit (59) to said tank port (18) or to said fuel inlet port (16) for electronically controlling lift of the valve spindle (20).

2. A fuel valve (1) according to claim 1, wherein said electronically controlled valve is a spool valve.

3. A fuel valve (1) according to claim 1, wherein said electronically controlled valve is a ball valve or a seat valve.

4. A fuel valve (1) according to claim 2, wherein said spool valve is provided with a first pressure chamber (75) acting on a spool (53) and urging the spool (53) to a position where said control conduit (59) is connected to said fuel inlet port (16).

5. A fuel valve (1) according to claim 4, wherein said spool valve is provided with a second pressure chamber (77) acting on the spool (53) and urging the spool (53) to a position where said control conduit (59) is connected to said tank port (18).

6. A fuel valve (1) according to claim 5, wherein said first pressure chamber (75) is provided with a first throttled connection (83) to the fuel inlet port (16) and with a second throttled connection (82) to the tank port (18), wherein said second throttled connection (82) to said tank port (18) is less restricted than the first throttled connection (83) to the fuel inlet port (16) and wherein said fuel valve (1) further comprises an electronically controlled solenoid valve for opening and closing said throttled connection to said tank port (18).

7. A fuel valve (1) according to claim 6, wherein said solenoid valve is a solenoid controlled ball valve (85).

8. A fuel valve (1) according to claim 6, wherein said restricted connection (82) to said tank port (18) is located inside the valve housing.

9. A fuel valve (1) according to any one of claims 2 to 8, wherein the spool (53) of said spool valve is connected to an electric actuator that controls the position of the spool (53).

10. A fuel valve (1) according to any one of claims 1 to 9, wherein said nozzle is a nozzle (30) with an axial bore and a closed front and said valve needle moves in unison with a cut-off shaft (40) moving in unison with the valve needle (20) and received axially displaceable in the central bore (33) in the nozzle (30) for opening and closing the nozzle holes (35).

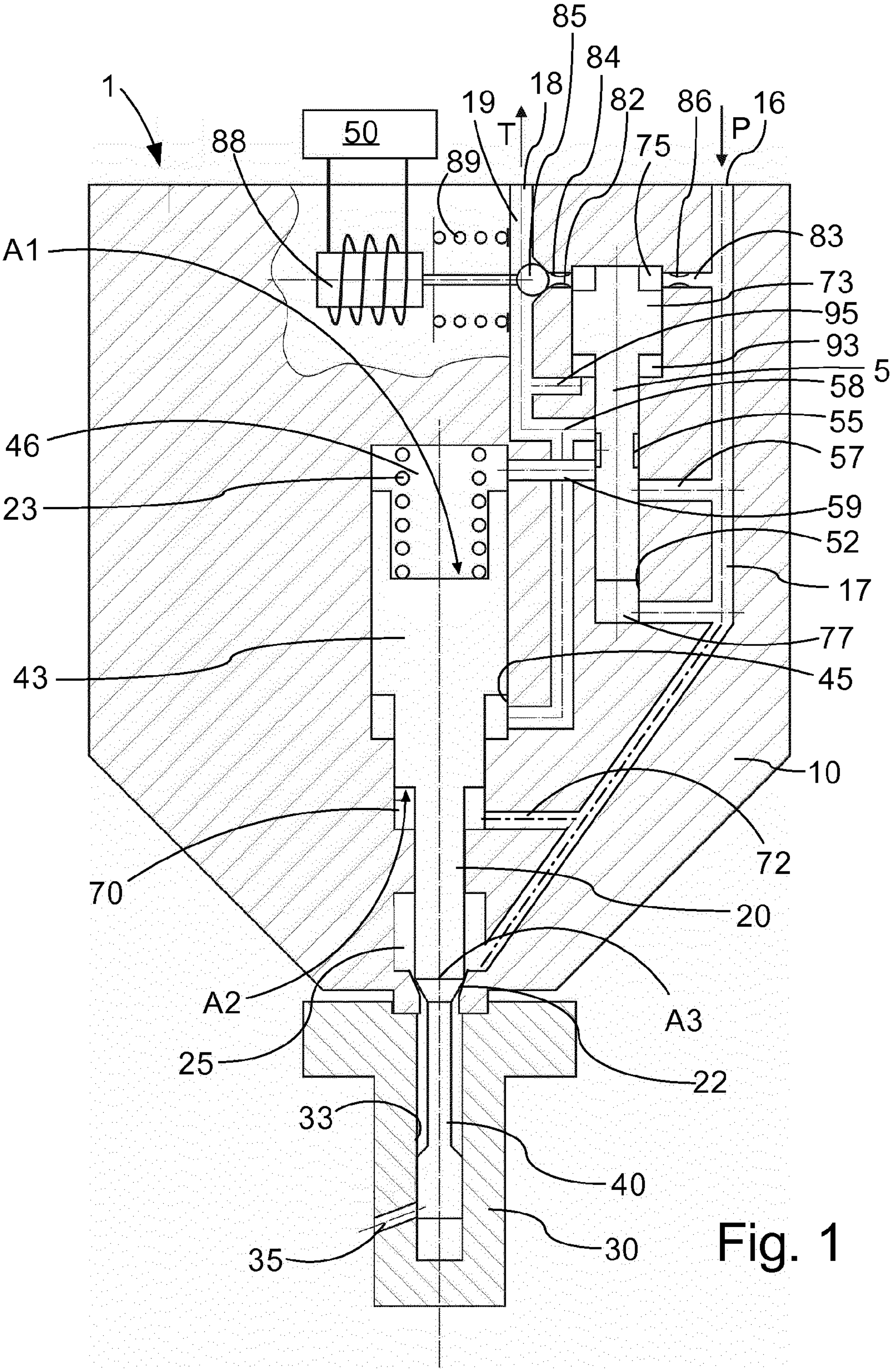
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Fig. 1

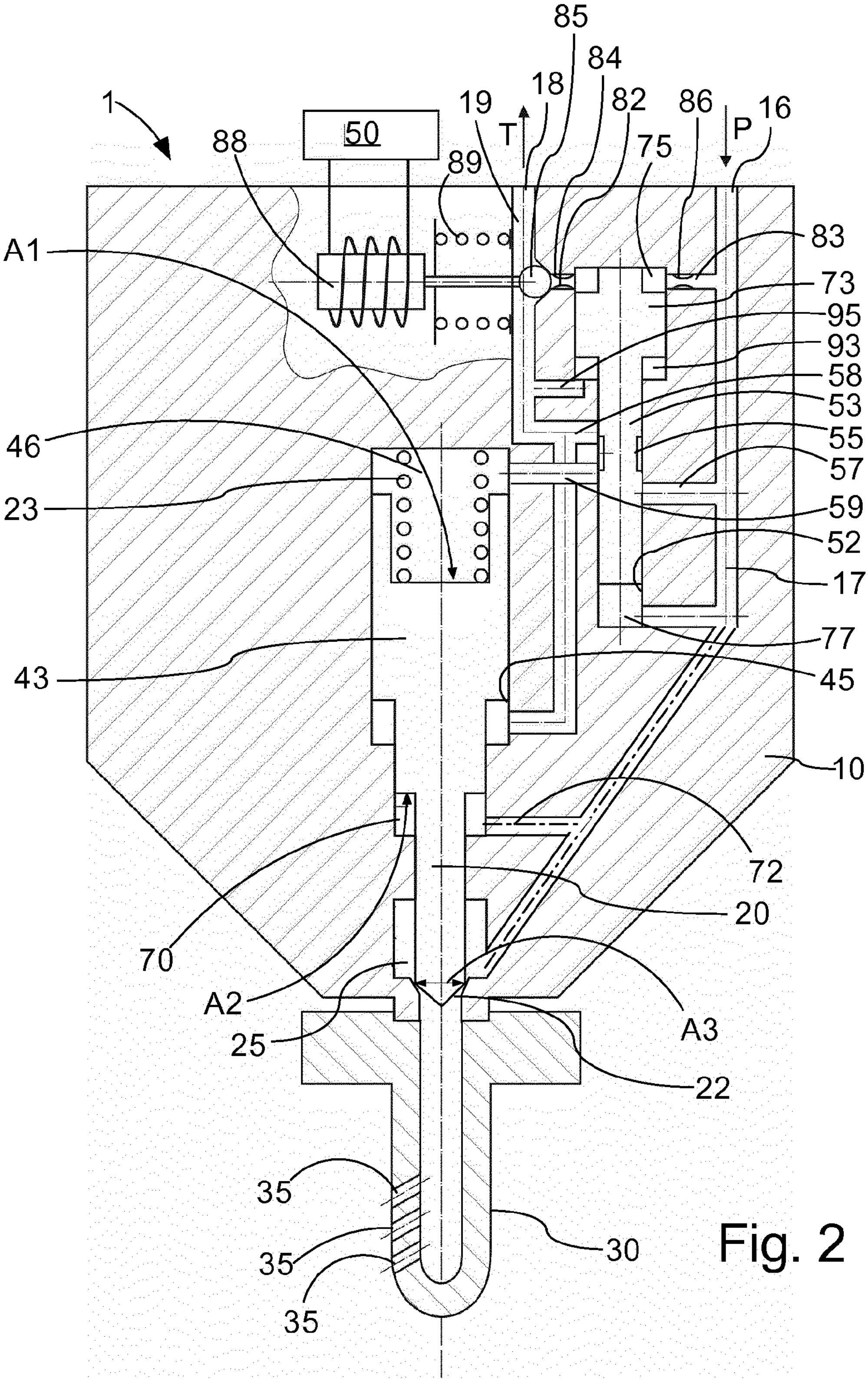
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Fig. 2