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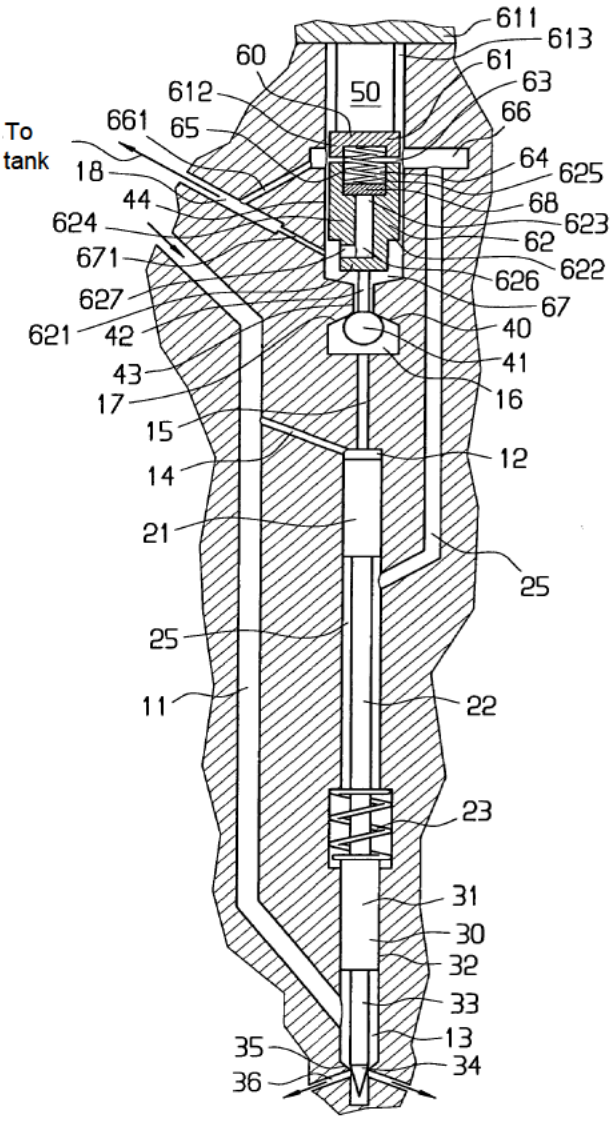
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(56) Publications considered for the assessment of patentability:
DE 195 19 192 C1
DE 37 42 241 C2
DE 197 08 304 A1

(54) Designation: **Device for transmitting a deflection of an actuator to a final control element and fuel injector with such a device**

(57) Main claim: Device for transmitting a deflection of an actuator (50) to a final control element (40) having a play-compensating transmission module (60) which creates an operative connection between the actuator (50) and the final control element (40) and comprising a pressure chamber (64) connected via a throttle connection (63) to a space (66) filled with a hydraulic medium,
in which the transmission module (60) consists of two sub-elements which can be displaced axially relative to one another, the first sub-element (61, 610) of which is operatively connected to the actuator (50) and the second sub-element (62, 620) of which is operatively connected to the final control element (40), in which the pressure chamber (64) is formed in the space enclosed by the first sub-element and the second sub-element, which is connected via the throttle connection (63) formed in the transmission module (60) to the space (66) filled with the hydraulic medium, and
in which one between the pressure chamber (64) and one filled with the hydraulic medium...



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Description

Prior art

[0001] The invention relates to a device for transmitting the movement of an actuator to a final control element according to the preamble of patent claim 1. Such a device, also referred to below as a transmission module, is known from DE 195 19 192 C1.

[0002] Storage injection systems using very high injection pressures are increasingly being used in motor vehicle technology. In such injection systems, known, for example, under the designation "common rail system", fuel is applied under high pressure to the fuel injectors arranged in the cylinders of an internal combustion engine. The injection process in the cylinder is triggered by the opening and closing of injection nozzles in the fuel injectors, wherein the injection nozzles are actuated via actuators that operate according to the electromagnetic principle or, in order to achieve high switching speeds, also according to the piezoelectric principle.

[0003] The actuator in the fuel injector generally actuates a servo valve that hydraulically controls a pressure on the injection nozzle in the fuel injector. In order to transmit the deflection of the actuator to a drive plunger of the servo valve, DE 197 08 304 A1 discloses a transmission module which is essentially cylindrical and has a pressure chamber which is delimited by a flexible membrane. The drive plunger of the servo valve rests against this flexible membrane. The pressure chamber of the transmission module is connected via a connecting bore with a throttling effect to a further compensation chamber provided inside the transmission module, the pressure chamber and the compensation chamber being filled with a hydraulic fluid.

[0004] At rest, the pressure of the hydraulic fluid prevailing in the compensation chamber is transmitted to the pressure chamber via the connecting bore, so that the flexible membrane always rests against the drive plunger of the servo valve, even if there are shifts in the arrangement of the individual components in the fuel injector due to thermal effects or aging processes. When the actuator is actuated, the deflection of this actuator is transmitted by the transmission module essentially unchanged to the drive plunger of the servo valve. The connecting bore between the pressure chamber and the compensation chamber is designed in such a way that essentially no hydraulic fluid can flow out of the pressure chamber due to the actuation times being in the millisecond range.

[0005] Since the hydraulic fluid in the transmission module used in DE 197 08 304 A1 is enclosed in the transmission module, there is a risk that a pressure drop will occur in the transmission module as a result of fluid leakage due to leaks, which pressure drop will impair the functionality of the transmission module and thus of the fuel injector. Furthermore, in the known transmission module, the deflection of the actuator is transmitted to the drive plunger of the servo valve virtually undamped and without a time delay. This in turn results in the servo valve opening the injection nozzle in the fuel injector without braking, which significantly impairs the quality of the combustion process.

[0006] A generic device is known from DE 195 19 192 C1. This has a nozzle needle arranged in a valve body, a fuel inlet and a control device. In this case, a transmission module is provided with a pressure chamber, wherein the pressure chamber is a space formed by two sub-elements of the transmission module. Furthermore, the device of DE 195 19 192 C1 has a throttle connection via which the pressure chamber is connected to a space filled with a hydraulic medium. No fill device is provided between the pressure chamber and the filling space filled with the hydraulic medium, so that the filling device is closed when the pressure chamber is not completely filled.

Object description

[0007] The object of the present invention is to provide a transmission module that is characterized by high reliability, a simple structure and a long service life.

[0008] This object is achieved by the features of patent claim 1.

[0009] The transmission module according to the invention is preferably used in a fuel injector for internal combustion engines and is characterized by two sub-elements which can be displaced axially relative to one another, with a first sub-element being operatively connected to an actuator and a second sub-element being operatively connected to a final control element, wherein a pressure chamber is formed in a space enclosed by the first sub-element and the second sub-element and is connected via a throttle connection formed in the transmission module to a compensation space filled with a hydraulic medium, and wherein a filling device provided between the pressure chamber and this compensation space is designed such that the filling device is open when the pressure space is not completely filled.

[0010] The transmission module according to the invention has a simple structure, wherein component changes due to manufacturing tolerances, temperature fluctuations and wear effects are reliably compensated and bridged. Furthermore, the hydraulic medium in the pressure chamber of the transmission module is not under increased pressure, which can lead to a liquid leakage and thus to an impairment of the functionality of the transmission module. The additional filling device in the transmission module between the pressure chamber and the compensation space prevents the functionality of the transmission module from being impaired by a pressure space which is not completely filled with hydraulic medium, as may result, for example, after prolonged downtimes of an internal combustion engine due to the formation of air bubbles in the pressure chamber of the transmission module, since a pressure space containing air bubbles results in the actuator deflection being transmitted to the final

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control element only incompletely and with a delay.

[0011] According to a preferred embodiment, the filling device is a check valve arranged in the connection between the pressure chamber and the compensation space and is loaded by a compression spring, which check valve is acted upon by the internal pressure of the pressure chamber on the side loaded by the compression spring and is acted upon by the pressure prevailing in the compensation space on the opposite side, wherein the compression spring is designed such that the check valve opens when a pressure increase takes place in the compensation space when the final control element is actuated by the second sub-element and, at the same time, there is a pressure reduction in the pressure chamber due to an incomplete filling state. This design allows particularly simple and reliable venting of the pressure chamber in the transmission module.

[0012] Further preferred embodiments are set forth in the dependent claims.

Exemplary embodiment

[0013] The invention is explained in more detail below with reference to the drawings.

[0014] **FIG.** 1 schematically shows a fuel injector with a first embodiment of the transmission module according to the invention;

[0015] **FIG.** 2 schematically shows an actuator of a fuel injector with a second embodiment of the transmission module according to the invention;

[0016] **FIG.** 3 schematically shows an actuator of a fuel injector with a third embodiment of a transmission module according to the invention; and [0017] **FIG.** 4 shows a top view of the valve plate used in the first and third embodiments of the transmission module according to the invention.

[0018] In the fuel injector shown schematically in **FIG.** 1 having a first embodiment of the transmission module according to the invention, fuel having a system pressure prevailing in a high-pressure accumulator is supplied via a high-pressure bore **11** to both a control chamber **12** and a nozzle chamber **13**. An inlet throttle **14** is arranged between the high-pressure bore **11** and the control chamber **12**. In the control chamber **12**, the pressure prevailing there acts on the rear end of a movably arranged control piston **21**, which presses with its front end via a coupling rod **22** onto the rear end of a needle shaft **31** of a nozzle body **30**. This rear end of the needle shaft **31** is additionally subjected to pressure by a nozzle spring **23**.

[0019] The nozzle body **30** is axially movable, but is inserted with its needle shaft **31** in a needle guide **32** so as to seal against the system pressure in the nozzle chamber **13**. In the region of the nozzle chamber **13**, the needle shaft **31** of the nozzle body **30** merges via a shoulder or a step into a nozzle needle **33**, the diameter of which is smaller than the diameter of the needle guide **32** in the region of the nozzle chamber **13**, so that fuel can reach the lower end of the nozzle needle **33**. At its lower end, the nozzle needle **33** has a cone **34** which, when at rest, is pressed onto a likewise conical sealing surface **35** at the front end of the needle guide **32**. A number of fuel injection holes **36** are formed in the needle guide **32** in the area of the conical sealing surface **35** or adjacent thereto. The injection holes **36** open into the combustion space of an internal combustion engine and are arranged at different angles to match the combustion space. When the full system pressure is applied both in the control chamber **12** and in the nozzle chamber **13**, the nozzle body **30** is pressed downwards due to the larger effective area in the control chamber **12** and the holding pressure of the nozzle spring **23**, so that the nozzle needle **33** closes the fuel injection holes **36** with its cone **34**.

[0020] As **FIG.** 1 shows, the control chamber **12** of the fuel injector is connected via an outlet throttle **15** to a valve space **16** of a final control element **40** designed as a servo valve. The servo valve **40** is composed of a valve element **41** designed as a ball and a valve tappet **42**, which rests on the valve element and is arranged in a guide **43**. The valve space **16** of the servo valve **40** is connected via the guide **43** to a fuel return **18** which leads to a fuel tank (not shown). The valve tappet **42** of the servo valve **40** is furthermore connected to an actuator **50** via a transmission module **60**.

[0021] At rest, when the actuator **50** is not actuated, the valve element **41** is pressed onto a valve seat **17** by the fuel pressure prevailing in the valve space **16**, so that the servo valve **40** is closed and the full system pressure is present in the control chamber **12**, as a result of which the nozzle needle **33** at the front end of the nozzle body **30** closes the injection holes **36**. When the actuator **50** is actuated, the actuator lifts the valve element **41** off the valve seat **17** with the aid of the transmission module **60** and the valve tappet **42**, so that fuel can flow out of the control chamber **12** via the outlet throttle **15** and the valve space **16** past the valve element **41** to the fuel return **18**. This fuel flow leads to a defined pressure drop at the inlet throttle **14** and the outlet throttle **15**, so that the pressure in the control chamber **12** is reduced. This reduces the force acting on the control piston **21**, so that the fuel pressure acting on the nozzle body **30** in the nozzle chamber **13** lifts the nozzle needle **33** with its cone **34** off the sealing surface **35** and the injection holes **36** open to the outside and fuel can be injected.

[0022] To exclude any play between the actuator **50** and the valve tappet **42** of the servo valve **40**, the transmission module **60** is configured as a hydraulic compensation element. For this purpose, the essentially cylindrical transmission module **60** consists of a first short piston element **61**, hereinafter also referred to as the drive element, and a second long piston element **62**, hereinafter also referred to as the receiving element, which lie opposite one another and are separated from one another by a squeeze gap **63**. The short drive element **61** has an essentially U-shaped cross section with a base plate **611** and an annular side wall **612**, which define an internal blind

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bore **613**. The base plate **611** of the drive element **61** is fixedly connected to the actuator **50** or formed integrally therewith.

[0023] The receiving element **62** is likewise essentially U-shaped in its cross section, with a circumferential side wall **622** defining a two-stage blind bore **623**.

[0024] This two-stage blind bore **623** is divided by a circumferential annular shoulder **624** into an upper blind bore portion **625**, the diameter of which corresponds essentially to the diameter of the blind bore **613** in the drive element **61**, and a lower blind bore portion **626**, the diameter of which is reduced with respect to the diameter of the upper blind bore portion **625**. In the region adjoining a base plate **621**, the circumferential side wall **622** of the receiving element **62** has a portion with a reduced outer diameter, in which a through bore **627** is made laterally, which connects the lower blind bore portion **626** of the two-stage blind bore **623** to the outside. The base plate **621** of the receiving element **62** is fixedly connected to the valve tappet **42** or formed integrally therewith.

[0025] The drive element **61** and the receiving element **62** of the transmission module **60** are arranged relative to each other in such a way that the end face of the side wall **612** of the drive element **61** and the end face of the side wall **622** of the receiving element **62** are opposite each other, so that the blind bore **613** of the drive element **61** and the upper blind bore portion **625** of the two-stage blind bore **623** form a cylindrical pressure chamber **64**. Arranged in this pressure chamber **64** is a spring element **65**, preferably a spiral spring, which is supported on the base plate **611** of the drive element **61** and, when at rest, presses a valve plate **68** against the annular shoulder **624** in the two-stage blind bore **623** of the receiving element **62**. The valve plate **68** is designed in such a way that it closes the lower blind bore portion **626** when it is placed on the annular shoulder **624** in the receiving element **62**.

[0026] As the top view in **FIG.** 4 shows, the valve plate **68** is disk-shaped, with the disk diameter essentially corresponding to the diameter of the upper blind bore portion **625** of the two-stage blind bore **623** in the receiving element **62**, but being flattened on two opposite sides. This design of the valve plate **68** ensures, on the one hand, that the valve plate is guided by the upper blind bore portion **625** of the two-stage blind bore **623**, but that the flattened side surfaces leave a sufficient flow gap between the valve plate **68** and the inner wall of the upper blind bore portion **625**.

[0027] In addition to closing the lower blind bore portion **626** of the two-stage blind bore **623** with the valve plate **68**, the spring element **65** in the pressure chamber **64** also ensures that the valve tappet **42** always rests on the valve element **41** of the servo valve **40** without play when it is at rest, irrespective of length tolerances, thermal length changes, or wear.

[0028] The transmission module **60** is guided in a cylindrical bore **44** which adjoins the guide **43** for the valve tappet **42**. In the region of the squeeze gap **63** between the drive element **61** and the receiving element **62** of the transmission module **60**, the bore **44** is widened to form an annular compensation space **66** which is connected via a leakage channel **24** to a leakage space **25** around the coupling rod **22** between the control piston **21** and the nozzle body **30**. The fuel escaping from the nozzle chamber **13** or from the control chamber **21** is collected in this leakage space **25**. The compensation space **66** is connected to the fuel return **18** so that the fuel accumulating in the leakage space **25** can be diverted into the fuel tank via the leakage channel **24** and the fuel return **18**. In order to ensure that the compensation space **66** is constantly filled with fuel, a leakage throttle **661** is arranged in the connection between the compensation space **66** and the fuel return **18**, which ensures that a fuel backflow occurs in the compensation space **66** when the fuel is diverted. As an alternative to the leakage throttle **661**, a check valve can also be arranged in the connection between the compensation space **66** and the fuel return **18**.

[0029] In the lower region of the cylindrical bore **44** around the lower portion of the receiving element **62** with the through bore **627**, a fuel filling space **67** is furthermore formed. The fuel filling space **67** is arranged in such a way that the fuel diverted by the servo valve **40** when the valve element **41** is open flows out of the control chamber **12** via the valve guide **43** into the fuel filling space **67** and is discharged from there to the fuel return **18**, with a return throttle **671** being provided in the connection between the fuel filling space **67** and the fuel return **18**.

[0030] During operation, both the compensation space **66** and the filling space **67** are constantly filled with fuel, as shown. Since the compensation space **66** is connected to the pressure chamber **64** via the squeeze gap **63** and the filling space **67** is connected to the lower portion **626** of the two-stage blind bore **623** in the receiving element **62** via the through bore **627**, the pressure chamber **64** or the lower blind bore portion **626** is also constantly filled with fuel. The fuel in the compensation space **66**, the pressure chamber **64**, the filling space **67** and the lower blind bore portion **626** in the receiving element **62** is essentially under normal pressure.

[0031] The actuator shown in **FIG.** 1 for a fuel injector with a transmission module **60** operates as follows: At rest, i.e. when the nozzle needle **33** is closed and the actuator **50** is not actuated, the pressure chamber **64** is connected to the compensation space **66** via the squeeze gap **63**, which is formed between the drive element **61** and the receiving element **62**, so that fuel can be exchanged between the pressure chamber **64** and the compensation space **66**. Therefore, at rest, the same pressure prevails in the pressure chamber **64** as in the compensation space **66**, with a pressureless state preferably being set, as shown. Furthermore, the lower blind bore portion 626 in the receiving element **62** of the transmission module **60** is filled with fuel from the filling space **67** via the through bore **627**. When at rest, the spring element **65** presses the valve plate **68** against the annular shoulder **624** in the two-stage blind bore **623** of the receiving element **62**, so that the connection between the lower blind

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bore portion **626** and the pressure chamber **64** is interrupted.

[0032] When the actuator **50** is actuated, it is displaced in the direction of the drive element **61** of the transmission module **60**. In this case, the drive element **61** of the transmission module **60**, which is fixedly connected to the actuator **50**, is likewise deflected, as a result of which the pressure on the fuel in the pressure chamber **64** of the transmission module **60** increases. Since the fuel cannot reduce this rapid pressure increase in the pressure chamber **64** by flowing out through the narrow squeeze gap **63** between the drive element **61** and the receiving element **62** of the transmission module **60**, the fuel transmits the pressure via the receiving element **62** of the transmission module to the valve tappet **42**, so that the drive element **61**, the receiving element **62** and the valve tappet **42** are moved downwards together and the valve element **41** of the servo valve **40** is pushed away from the valve seat **17**. This opening of the valve element **41** of the servo valve **40** in turn causes fuel to flow out of the control chamber **12** via the outlet throttle **15** and the valve space **16** past the valve element **41** into the filling space **67** and from there into the fuel return **18**. The resulting pressure drop in the control chamber **12** in turn reduces the force acting on the control piston **21**, so that the fuel pressure acting on the nozzle needle **33** in the nozzle chamber **13** lifts the nozzle needle 33 and opens the injection holes **36** of the fuel injector, triggering an injection process.

[0033] As shown, the squeeze gap **63** between the drive element **61** and the receiving element **62** of the transmission module **60** can be dimensioned such that no fuel can escape from the pressure chamber **64** into the compensation space **66** via this gap during the short time when the actuator **50** is actuated. On the other hand, however, there is also the possibility of designing the squeeze gap **63** in such a way that the pressure increase caused by the deflection of the drive element **61** of the transmission module **60** first always forces some fuel out of the pressure chamber **63** into the compensation space **66**. This then has the effect that the force transmitted by the actuator **50** to the drive element **61** is transmitted in a damped manner to the receiving element **62** of the transmission module and thus to the valve element **41** of the servo valve. Furthermore, it can also be achieved in this way that the valve element **41** is opened by the deflection of the transmission module **60** with a time delay in relation to the actuation of the actuator. This time-delayed and damped transmission of the actuator deflection to the valve element **41** of the servo valve **40** reduces the dynamics when the valve element **41** opens, which ensures precise actuation of the nozzle needle **33** at the high sound velocities desired in the fuel injector.

[0034] The valve plate **68** in the pressure chamber **64** of the transmission module **60** is pressed against the annular shoulder **624** in the two-stage blind bore **623** of the receiving element **62** during the entire working cycle by the holding force of the spring element **65** and by the pressure exerted by the fuel in the pressure chamber **64** on the valve plate **68**, so that the connection between the lower blind bore portion **626** and the pressure chamber **64** is interrupted. However, if the pressure chamber **63** is not completely filled with fuel, for example due to the formation of air bubbles, as could result after the internal combustion engine has been idle for a long time, then the resulting rapid pressure increase in the filling space **67** and thus also in the lower blind bore portion **626**, resulting from the fuel flow occurring from the control chamber **12** when the valve element **41** of the servo valve **40** is opened, causes the valve plate **68** to lift off the annular shoulder **624** against the holding force of the spring element **65**. With the valve plate **68** open, fuel can then flow out of the lower blind bore portion **626** past the flattened side surfaces of the valve plate **68** into the pressure chamber **64**, so that the latter is filled with fuel and the air bubbles are pressed out of the pressure chamber **64**. As soon as the pressure chamber **64** is completely filled with fuel again, the internal pressure of the pressure chamber **64** and thus the pressure on the valve plate **68** increases again, so that this internal pressure together with the holding force of the spring element **65** presses the valve plate **68** back onto the annular shoulder **624**, as a result of which the connection between the lower blind bore portion **626** and the pressure chamber **64** is interrupted again. [0035] This venting of the pressure chamber **64** of the transmission module **60** ensures that the pressure chamber 64 is essentially always completely filled with fuel and thus the functionality of the transmission module **60** is constantly guaranteed. A pressure chamber **64** which is not completely filled would mean that the effect of the hydraulic play compensation cannot develop in the transmission module and thus the servo valve **40** is opened only incompletely and with an undesired delay when the actuator 50 is actuated by the transmission module.

[0036] In order to ensure that the pressure surge in the fuel filling space **67** when the servo valve **40** is opened and thus the pressure surge in the lower blind bore portion **626** of the receiving element **62** is sufficient to open the valve plate **68** when the pressure space **64** is not completely filled, the magnitude of this pressure surge can be adjusted by a corresponding dimensioning of the return throttle **671** between the filling space **67** and the fuel return **18**. However, when designing the return throttle **671**, care must also be taken to ensure that sufficient fuel can flow back from the control chamber **12** into the fuel tank when the servo valve **40** is open, so that the ability of the servo valve **40** to open the nozzle needle **33** is not impaired. The strength of the pressure surge acting on the valve plate **68** when the servo valve **40** is opened can also be adjusted by a suitable design of the diameter of the lower blind bore portion **626** of the receiving element in the transmission module **60**.

[0037] In addition, the force required to open the valve plate **68** can be influenced by a suitable choice of the spring element **65**.

[0038] **FIG.** 2 shows a further embodiment of the transmission module according to the invention, in which a valve ball **680** is used instead of a valve plate.

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By using a valve ball **680** instead of a valve plate, the inertia when opening the valve can be positively influenced.

[0039] In the further embodiment of the transmission module shown in **FIG.** 3, in comparison to the embodiment shown in **FIG.** 1, the drive element **610** and the receiving element **620** are designed as inner and outer parts of a telescopic arrangement. For this purpose, the drive element **610** has a slightly larger outer diameter than the receiving element **620**, wherein the receiving element extends into a recess in the end face of the drive element, but a squeeze gap **630** remains between the end face of the drive element **610** and the end face of the receiving element **620**. This design allows a particularly compact structure of the transmission module.

Patent claims

1. Device for transmitting a deflection of an actuator (**50**) to a final control element (**40**) having a play-compensating transmission module (**60**), which establishes an operative connection between the actuator (**50**) and the final control element (**40**) and which comprises a pressure chamber (**64**) that is connected via a throttle connection (**63**) to a space (**66**) filled with a hydraulic medium,
in which the transmission module (**60**) consists of two sub-elements that can be displaced axially relative to one another, the first sub-element (**61**, **610**) of which is operatively connected to the actuator (**50**) and the second sub-element (**62**, **620**) of which is operatively connected to the final control element (**40**),
in which the pressure chamber (**64**) is formed in the space enclosed by the first sub-element and the second sub-element, said pressure chamber being connected to the space (**66**) filled with the hydraulic medium via the throttle connection (**63**) formed in the transmission module (**60**), and
in which a filling device provided between the pressure chamber (**64**) and a filling space (**67**) filled with the hydraulic medium is designed in such a way that the filling device is open when the pressure chamber (**64**) is not completely filled,
characterized in that
the filling device comprises a spring element (**65**) and a valve (**68**, **680**).

2. Device according to claim 1, characterized in that the filling device comprises the valve (**68**, **680**) arranged in a two-stage blind bore (**623**) between the pressure chamber (**64**) and the filling space (**67**) filled with the hydraulic medium, which valve opens the two-stage blind bore (**623**) when the pressure chamber (**64**) is not completely filled in order to supply the hydraulic medium to the pressure chamber (**64**).

3. Device according to claim 2, characterized in that the filling space (**67**) filled with the hydraulic medium is connected to the final control element (**40**) in such a way that when the final control element (**40**) is actuated by the second sub-element (**62**, **620**), there is a pressure increase in the filling space (**67**) filled with the hydraulic medium, which pressure increase then opens the valve (**68**, **680**) in the two-stage blind bore (**623**) when the pressure chamber (**64**) in the transmission module (**60**) is not completely filled with the hydraulic medium.

4. Device according to claim 3, characterized in that the valve is a check valve (**68**, **680**) which is loaded with the spring element (**65**) and arranged on a valve seat in the two-stage blind bore (**623**),
which, on the side on which the spring element (**65**) engages, is acted upon by an internal pressure of the pressure chamber (**64**), and
which is acted upon on the opposite side by a pressure in the filling space (**67**) filled with the hydraulic medium,
wherein when the pressure chamber (**64**) is completely filled, the internal pressure pushes the check valve (**68**, **680**) onto the valve seat (**624**) and closes the two-stage blind bore (**623**).

5. Device according to claim 4, characterized in that, when the deflection of the actuator (**50**) is transmitted to the final control element (**40**) with the play-compensating transmission module (**60**), there is a pressure increase in the filling space (**67**) filled with the hydraulic medium, which lifts the check valve (**68**, **680**) from the valve seat in the two-stage blind bore (**623**) against the holding force of the spring element (**65**) when the pressure chamber (**64**) in the transmission module (**60**) is not completely filled with the hydraulic medium, so that further hydraulic medium can flow out of the filling space (**67**) filled with the hydraulic medium via the two-stage blind bore (**623**) into the pressure chamber (**64**).

6. Device according to claim 5, characterized in that
the first sub-element (**61**, **610**) of the transmission module (**60**) is a first piston element with an essentially U-shaped cross section, in which a baseplate (**611**) and an annular side wall (**612**) define a blind bore (**613**),
the second sub-element (**62**, **620**) of the transmission module (**60**) is a second piston element with an essentially U-shaped cross section, in which a base plate (**621**) and an annular side wall (**622**) define the two-stage blind bore (**623**) with a circumferential annular shoulder (**624**),
wherein the diameter of an upper blind bore portion (**625**) essentially corresponds to the diameter of the blind bore (**613**) in the first piston element (**61**),
wherein a through bore (627) is formed in a lower blind bore portion (**626**) having a reduced diameter compared to the diameter of the upper blind bore portion (**625**), said through bore (**627**) connecting the lower blind bore portion (**626**) to the filling space (**67**) filled with the hydraulic medium, and

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the first piston element (**61**, **610**) and the second piston element (**62**, **620**) are arranged relative to one another in such a way that a squeeze gap (**63**) is formed as the throttle connection between the side walls,
wherein the blind bore (**613**) of the first piston element and the upper blind bore portion (**625**) of the two-stage blind bore (**623**) in the region of the second piston element (**62**) form the pressure chamber (**64**) in which the spring element (**65**) is supported on the first piston element (**61**) in order to press the check valve (**68**) in the rest state against the annular shoulder (**624**) in the two-stage blind bore (**623**) in the region of the second piston element (**62**).

7. Device according to claim 6, characterized in that the first piston element (**610**) and the second piston element (**620**) are designed as inner and outer parts of a telescopic arrangement.

8. Device according to claim 6 or 7, characterized in that the check valve is designed as a disk-shaped valve plate (**68**),
wherein the disk diameter essentially corresponds to the diameter of the upper blind bore portion (**625**) of the two-stage blind bore (**623**) in the second piston element (**62**), and
wherein two opposite sides are flattened so that a sufficient flow gap remains between the valve plate (**68**) and the inner wall of the upper blind bore portion (**625**).

9. Device according to claim 6 or 7, characterized in that the check valve is designed as a ball valve (**680**).

10. Device according to any one of claims 6 to 9 for use in a fuel injector, characterized in that the hydraulic medium is the fuel of the fuel injector, in that the actuator is a servo valve (**40**) for actuating a nozzle needle in the fuel injector, and in that the transmission module (**60**) is guided in a cylindrical bore (**44**) between the actuator (**50**) and the servo valve (**40**), the bore being widened in the region of the squeeze gap (**63**) between the first piston element (**61**) and the second piston element (**62**) to form a compensation space (**66**) which is connected to a leakage space (**25**) in the fuel injector and to a fuel return (**18**), with a leakage throttle (**661**) or a check valve being arranged in the connection between the compensation space (**66**) and the fuel return (**18**) in order to ensure that the compensation space is constantly filled with fuel.

11. Device according to claim 10, characterized in that the filling space is a fuel filling space (**67**) which is arranged in the lower region of the bore (**44**) around the through bore (**627**) in the second piston portion (**62**) in such a way that the fuel discharged when the servo valve (**40**) is open flows into the fuel filling space (**67**) and is discharged from there to the fuel return (**18**), with a return throttle (**671**) being provided in the connection between the fuel filling space (**67**) and the fuel return (**18**).

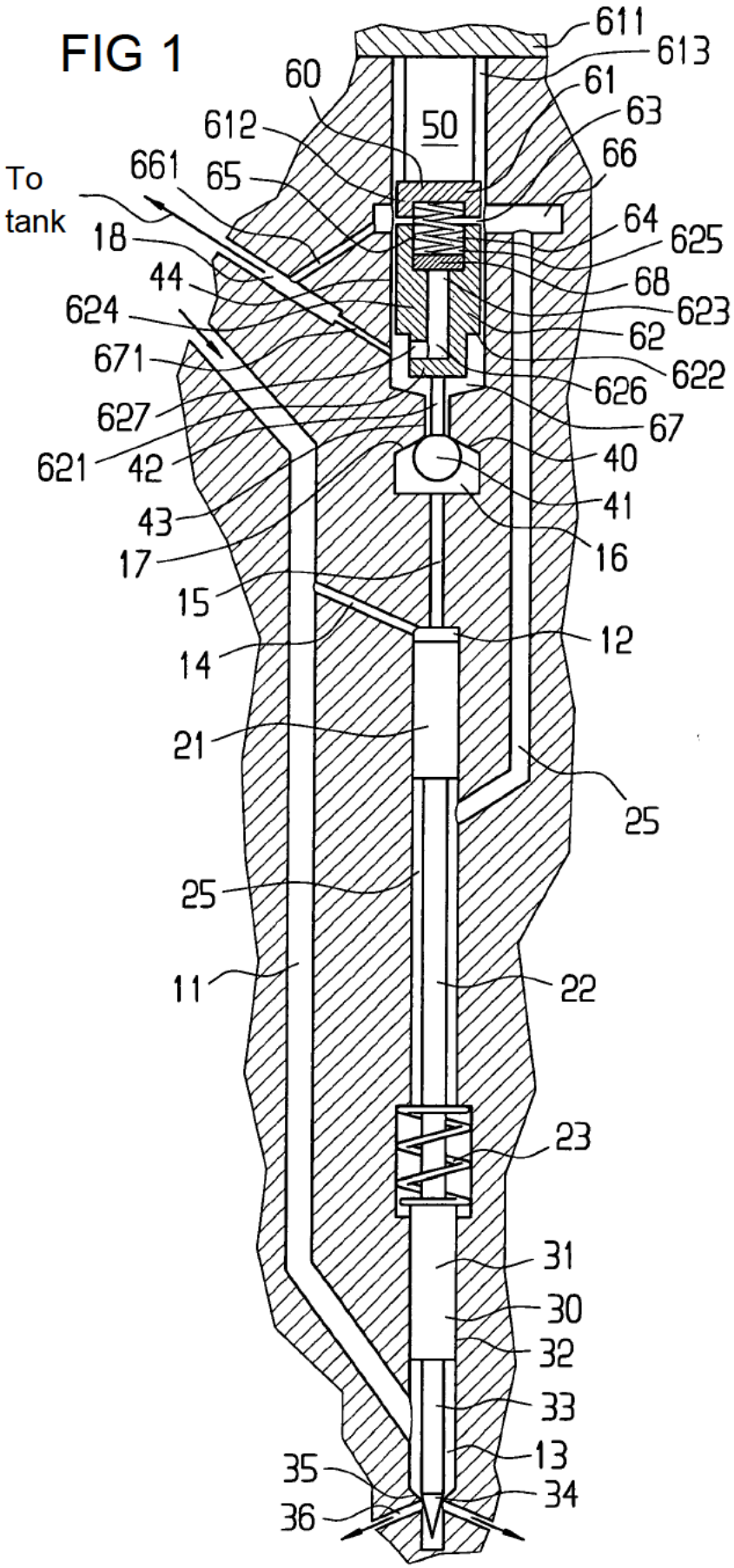
12. Device according to claim 11, characterized in that the spring element (**65**) acting on the check valve (**68**, **680**) and/or the return throttle (**671**) between the fuel filling space (**67**) and the fuel return (**18**) are set in such a way that the pressure surge in the fuel filling space (**67**), when the servo valve (**40**) is opened, opens the check valve in the transmission module (**60**) when the pressure space (**64**) is not completely filled with fuel.

Followed by 2 sheets of drawings

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Attached drawings

FIG 1



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FIG 2

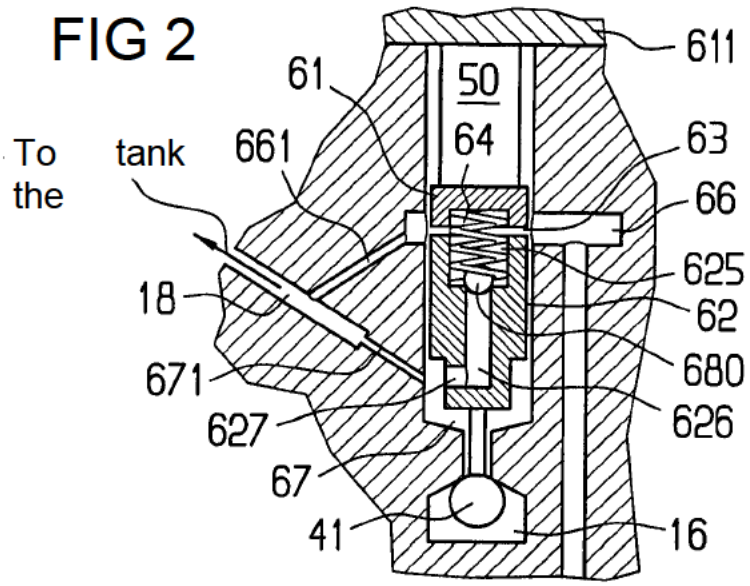


FIG 3

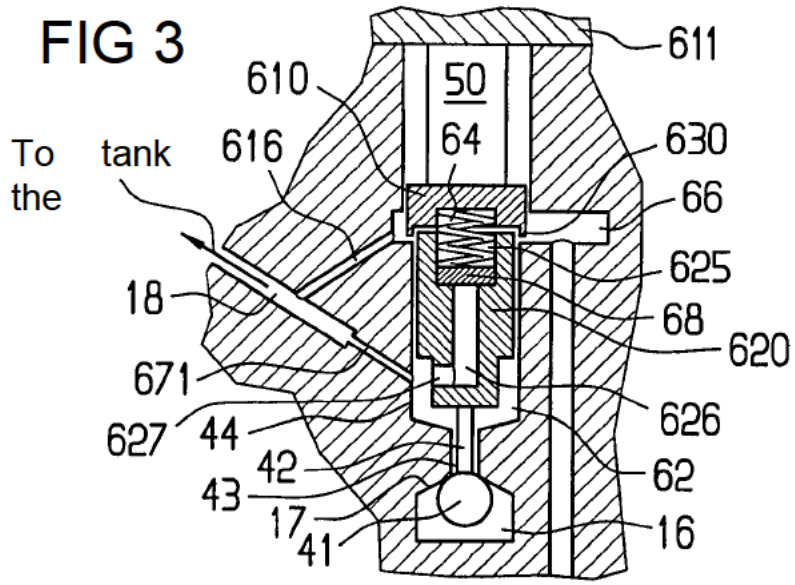
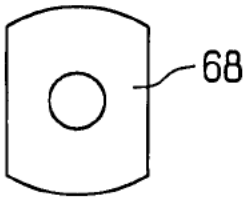


FIG 4



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TRANSLATION CERTIFICATION

Date: March 6, 2023

To whom it may concern:

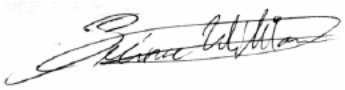
This is to certify that the attached translation from German into English is an accurate representation of the documents received by this office.

The documents are designated as:

- DE19946732B4 (Schmutzler)
- DE19962177A1 (Gottlieb2)
- DE19856617A1 (Klugl2)
- DE19942816A1 (Klenk)

Prince Williams, Project Manager, attests to the following:

"To the best of my knowledge, the aforementioned documents are a true, full and accurate translation of the specified documents. I affirm that the provided translation was produced under the ISO 9001:2015 certified quality management process and the agents responsible for the specified translations are qualified to translate and review documents for the above language pair."



Signature of Prince Williams

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