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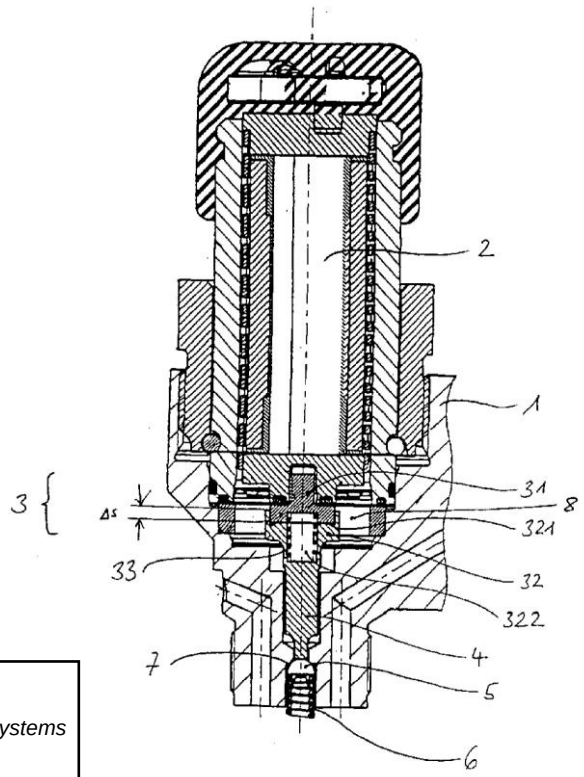
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The following information is taken from the documents submitted by the applicant

The request for examination pursuant to § 44 of the German Patent Act has been submitted

(54) Element for transmitting a movement and injection valve with such an element

(57) Between the piezo actuator (2) and the valve element (5) of a servo valve for an injection valve, a play-compensating transmission element (3) is provided which comprises a drive piston (31) and a receiving element (32) that engage telescopically into one another and enclose a chamber (322) with a hydraulic medium. The gap between the drive piston (31) and the receiving element (32) is dimensioned in such a way that a brief pressure increase in the chamber (322) is not compensated, but longer-lasting pressure differences are reduced.



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Description

The invention relates to an element for transmitting a movement according to the preamble of patent claim 1 and in particular to an injection valve with such an element. Such an element is known from DE 197 08 304 A1.

High-pressure accumulator injection systems are increasingly used to supply fuel to internal combustion engines. Such injection systems are known as common rail systems (for diesel engines) and HPDI injection systems (for gasoline engines). In these injection systems, the fuel is delivered by a high-pressure pump into a pressure accumulator which is common to all cylinders of the engine and from which the injection valves on the individual cylinders are supplied. The opening and closing of the injection valves can be controlled electromagnetically or electrically, for example by means of piezo actuators, which consist of a number of piezo elements stacked one on top of the other.

In this case, the piezo actuator usually acts on a servo valve which hydraulically controls the pressure that is exerted on the nozzle needle of the injection valve. The nozzle needle of the injection valve is therefore not controlled directly by the piezo actuator, but indirectly via the servo valve.

The element for transmitting a movement known from the publication mentioned at the outset consists of a transmission module which, when used in an injection valve, is arranged between the piezo actuator and a drive plunger for the servo valve. The transmission module is essentially cylindrical and has a pressure chamber which is delimited by a flexible membrane. The drive plunger for the servo valve rests against the flexible membrane. A connecting bore with a throttling effect leads from the pressure chamber to a compensation chamber which is provided inside the transmission module and is closed off by a prestressed spring plate. The pressure chamber and the compensation chamber are filled with a hydraulic medium. A rigid cover plate on which the piezo actuator rests is arranged above the compensation chamber.

At rest, the pressure of the transmission medium is transmitted from the compensation chamber through the connecting bore into the pressure chamber, so that the flexible membrane is always in contact with the drive plunger, even if the overall length of the arrangement changes due to thermal effects or aging influences. On the other hand, when the piezo actuator is actuated the hydraulic transmission medium cannot flow out of the pressure chamber fast enough, so that when the piezo actuator is actuated electrically, for which the actuation times are in the millisecond range, the movement of the piezo actuator via the transmission module is transmitted via the transmission module virtually unchanged to the drive plunger for the servo valve.

However, the known arrangement has the disadvantage of a complicated structure, since the connecting bore and the compensation chamber, including the spring plate pressurizing the transmission medium, are formed within the transmission module. The hydraulic transmission medium is enclosed under pressure in the transmission module. Even a slight leak in the system leads to a loss of transmission medium. The resulting pressure drop in the transmission module immediately results in failure of the transmission module and thus of the injection valve.

The object of the present invention is therefore to configure the element for transmitting a movement mentioned at the outset in such a way that it is reliable with a simple structure.

This object is achieved according to the invention with the measures specified in patent claim 1. Preferred embodiments of the invention are set forth in the claims following this claim 1. The element according to the invention is preferably used in conjunction with an injection valve for internal combustion engines.

According to the invention, a play-compensating transmission element is provided between an actuator and a final control element, which transmission element comprises a drive piston and a receiving element that engage telescopically into one another and enclose a chamber with a hydraulic medium. The gap between the drive piston and the receiving element is dimensioned in such a way that a brief pressure increase in the chamber is not compensated, but longer-lasting pressure differences are reduced.

The transmission element according to the invention has the advantage of forming an open system that is less sensitive to disturbances and with which varying distances can be compensated and bridged. There are no intricately shaped components; assembly is simple and component tolerances can be reduced.

A further advantage of the transmission element according to the invention is that the hydraulic medium is not under increased pressure when it is at rest. It is thus possible to connect the space around the transmission element in the case of an injection valve, for example, to the essentially pressureless fuel return system.

An exemplary embodiment of the invention is explained in more detail below with reference to the illustration in the drawing, which shows a section through the upper part of an injection valve.

The figure of the drawing schematically shows a part of an injection valve in section. A piezo actuator **2** is built into the housing **1** of the injection valve. The piezo actuator **2**, when it is actuated electrically via supply lines (not shown), acts on a valve tappet **4** via a transmission element **3**. The valve tappet **4** rests against a valve element **5** of a servo valve. As long as the piezo actuator **2** is not actuated, the valve element **5** is pressed into its valve seat **7** by a valve spring **6**.

When the piezo actuator **2** is actuated, the valve tappet **4** lifts the valve element **5** off the valve seat **7**, so that fuel can flow past the valve element **5** in the known manner and the injection valve thereby opens.

In order to exclude any play between the piezo actuator **2** and the valve element **5**, the transmission element **3** is designed as a hydraulic compensation element. For this purpose, the transmission element **3** consists of a drive piston **31**, which is fixedly attached to the piezo actuator **2** or is fixedly connected thereto, and a receiving element **32**, which is fixedly connected to the valve tappet **4** or is formed integrally therewith.

On the side facing the drive piston **31**, the outer diameter of the receiving element **32** is greater than that of the drive piston **31**. The drive piston **31**, which is essentially cylindrical in the connecting region, projects by a distance s into a cylindrical axial recess **321** in the receiving element **32**. A slight distance or a small gap is provided between the cylindrical outer wall of the drive piston **31** and the cylindrical inner wall of the recess **321**.

The drive piston **31** and the receiving element **32** thus form the inner part and the outer part of a telescopic arrangement, for the length adjustment of which the inner part and the outer part, that is to say the drive piston **31** and the receiving element **32**, are axially displaceable relative to one another, whereby the distance s by which the drive piston **31** and the receiving element **32** overlap in the axial direction thus changes.

Recesses that form a chamber **322** are provided on the end face of the drive piston **31** facing the receiving element **32**

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and/or on the end face of the receiving element **32** facing the drive piston **31**. The chamber **322** is preferably formed radially symmetrically around the longitudinal axis of the transmission element **3**. Arranged in the chamber **322** is a spring **33**, preferably a spiral spring, which pushes the drive piston **31** and the receiving element **32** apart in the axial direction.

The spring **33** thus ensures that the valve tappet **4** always rests without play on both the drive piston **31** connected to the piezo actuator **2** and on the valve element **5** of the servo valve, even when at rest, regardless of length tolerances, thermal length changes and the like. In this case, the end face of the drive piston **31** outside the chamber **322** does not bear directly against the opposite end face of the recess **321** in the receiving element **32**.

During operation, the chamber **322** in the transmission element **3** is filled with a hydraulic medium. The space **8** around the transmission element **3** in the housing **1** of the injection valve also contains hydraulic medium. The hydraulic medium is preferably the fuel for the respective engine.

It is not necessary for the hydraulic medium in the space **8** to be under increased pressure. If the hydraulic medium is the fuel, the space **8** can therefore be connected, for example, to the essentially pressureless fuel return from the injection valve to the vehicle tank. However, the space **8** can also be closed off from the outside by membranes, sealing disks and the like.

Also in the chamber **322** in the transmission element **3**, the hydraulic medium is in the rest state, that is to say when the injection valve is closed, the piezo actuator **2** is not actuated and the thermal and other effects are balanced, essentially not under increased pressure. Pressure is only exerted on the hydraulic medium by the drive piston **2** when the piezo actuator **2** is actuated and its length is thereby increased. Since the hydraulic medium cannot reduce the associated rapid pressure increase by quickly flowing away through the narrow gap between the cylindrical outer wall of the drive piston **31** and the cylindrical inner wall of the receiving element **32**, it transmits this pressure to the valve tappet **4** via the receiving element **32**, so that the drive piston **31**, the receiving element **32** and the valve tappet **4** move downwards together and push the valve element **5** of the servo valve away from the valve seat **7** against the action of the valve spring **6**.

The distance or gap between the cylindrical outer wall of the drive piston **31** and the cylindrical inner wall of the recess **321** in the receiving element **32** is, as mentioned, so small that the hydraulic medium cannot escape from the chamber **322** through this gap during the short time the piezo actuator **2** is being actuated. On the other hand, however, this distance or gap is dimensioned such that liquid can flow through this gap into the chamber **322** during the remaining, much longer time of a working cycle in which the valve is closed, in order to compensate for any valve play in cooperation with the spring **33**. In the same way, compensation takes place through the slow outflow of the hydraulic medium if the piezo actuator **2**, for example due to thermal effects, exerts permanent pressure on the transmission element **3** already in the non-actuated state, which seeks to lift the valve element **5** from the valve seat **7** against the action of the valve spring **6**. If necessary, the compensation can take place again in each direction with each working cycle.

The distance between the end face of the drive piston **31** and the end face of the receiving element **32** around the chamber **322** is in any case large enough not to hinder the outflow and inflow of the hydraulic medium during the compensation processes mentioned. If necessary, suitable inflow and outflow channels can be created in this area by means of spacers, grooves or the like.

The present invention is characterized by the transmission element **3**, which has a telescopic construction. In the simplest case, a telescopic arrangement consists of an outer part in which an inner part is arranged coaxially, which inner part can be displaced relative to the outer part in the direction of the common longitudinal axis of the two parts, thereby changing the overall length of the telescopic arrangement.

In the present invention, the space enclosing the outer part and the inner part of the telescopic arrangement forms the chamber that houses the hydraulic medium, which can be pressurized to transmit power and movement. The distance between the outer wall of the inner part and the inner wall of the outer part of the telescopic arrangement is dimensioned such as to establish the connection with a throttling effect between the chamber **322** acting as a pressure chamber and the compensation space **8**. If there is a longer pressure difference between the pressure chamber and the compensation space, the hydraulic medium between the outer part and the inner part of the telescopic arrangement can thus flow into or out of the pressure chamber. However, a rapid pressure increase in the pressure chamber as a result of actuation of the actuator **2** cannot be compensated, so that a force and thus a movement can be transmitted via the increased pressure.

A preferred embodiment of the element according to the invention, which is used in an injection valve for an internal combustion engine, consists of only three simply designed parts; the drive piston **31**, which is fixedly attached to the piezo actuator **2** of the injection valve, the receiving element **32**, which is fixedly arranged on a valve tappet **4** for the servo valve or is formed integrally therewith, and the spring **33** between the drive piston and the receiving element. The drive piston **31** and the receiving element **32** form the inner part and outer part of a telescopic arrangement. The hydraulic function of this transmission element **3** is determined by the shape and dimensions of the drive piston and the receiving element, in particular by the distance of the outer wall of the drive piston from the opposite inner wall of the receiving element and the degree of overlap of the driving piston and the receiving element.

The cylindrical drive piston preferably plunges a distance s into the cylindrical axial recess **322** in the receiving element **32**. The opposite end faces of the drive piston **31** and receiving element **32** have axial recesses which form the chamber **321** for the hydraulic transmission medium. The distance or gap between the drive piston **31** and the recess **321** is dimensioned in such a way that, during the brief, periodic actuation of the servo valve via the piezo actuator, virtually no hydraulic medium escapes from the chamber **322**, but on the other hand, during the much longer remaining time of the working cycle in which the valve is closed, the chamber can be filled with hydraulic medium to compensate for play when the overall length of the arrangement changes, or the medium can flow out of the chamber. The compensation can take place at each working cycle.

Patent claims

1. Element for transmitting a movement from an actuator **(2)** to a final control element **(5)**, comprising a play-compensating transmission element **(3)** between the actuator **(2)** and the final control element **(5)** having a chamber **(322)** containing a hydraulic medium which can be pressurized to thereby transmit the movement, there being a connection from the chamber **(322)** to another space **(8)** which is configured such that a brief pressure increase in the chamber **(322)** essentially does not result in the hydraulic medium flowing out of the

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chamber **(322)**, but a longer-lasting pressure difference brings about a compensation of the hydraulic medium between the space **(8)** and the chamber **(322)**, **characterized** in that the transmission element **(3)** comprises an outer part **(31; 32)** and an inner part **(32; 31)**, which engage telescopically into one another in a longitudinally displaceable manner, whereby the chamber **(322)** is formed in the space enclosed by the outer part **(31; 32)** and the inner part **(32; 31)**, and wherein the gap between the outer wall of the inner part **(32; 31)** and the inner wall of the outer part **(31; 32)** is dimensioned such as to provide the above-mentioned connection between the chamber **(322)** and the space **(8)**.

2. Element according to claim 1, characterized in that a spring **(33)** is arranged between the outer part **(31; 32)** and the inner part **(32; 31)** and presses the outer part **(31; 32)** and the inner part **(32; 31)** apart in the longitudinal direction.

3. Element according to claim **2**, characterized in that the spring **(33)** is arranged in the chamber **(322)**. **4**. Element according to claim 1, characterized in that the outer part is formed by a receiving element **(32)** and the inner part by a drive piston **(31)**, with the drive piston **(32)** projecting axially displaceably into a recess **(321)** in the receiving element **(32)**.

5. Element according to claim 4, characterized in that the chamber **(322)** is formed by a recess in the drive piston **(31)** and/or the receiving element **(32)**.

6. Element according to claim 5, characterized in that the spring **(33)** is arranged in the chamber **(322)** between the drive piston **(31)** and the receiving element **(32)** in such a way that the drive piston **(31)** and the receiving element **(32)** are pressed apart in the longitudinal direction.

7. Element according to claim 4, characterized in that the drive piston **(31)** is fixedly connected to the actuator **(2)**.

8. Element according to claim 4, characterized in that the receiving element **(32)** is fixedly connected to or integrally formed with a tappet **(4)** which acts on the final control element **(5)**.

9. Injection valve for injecting fuel into an internal combustion engine, characterized in that the injection valve comprises an element according to one of claims **1** to **8**, the element being arranged between a piezo actuator **(2)** and the valve element **(5)** of a servo valve.

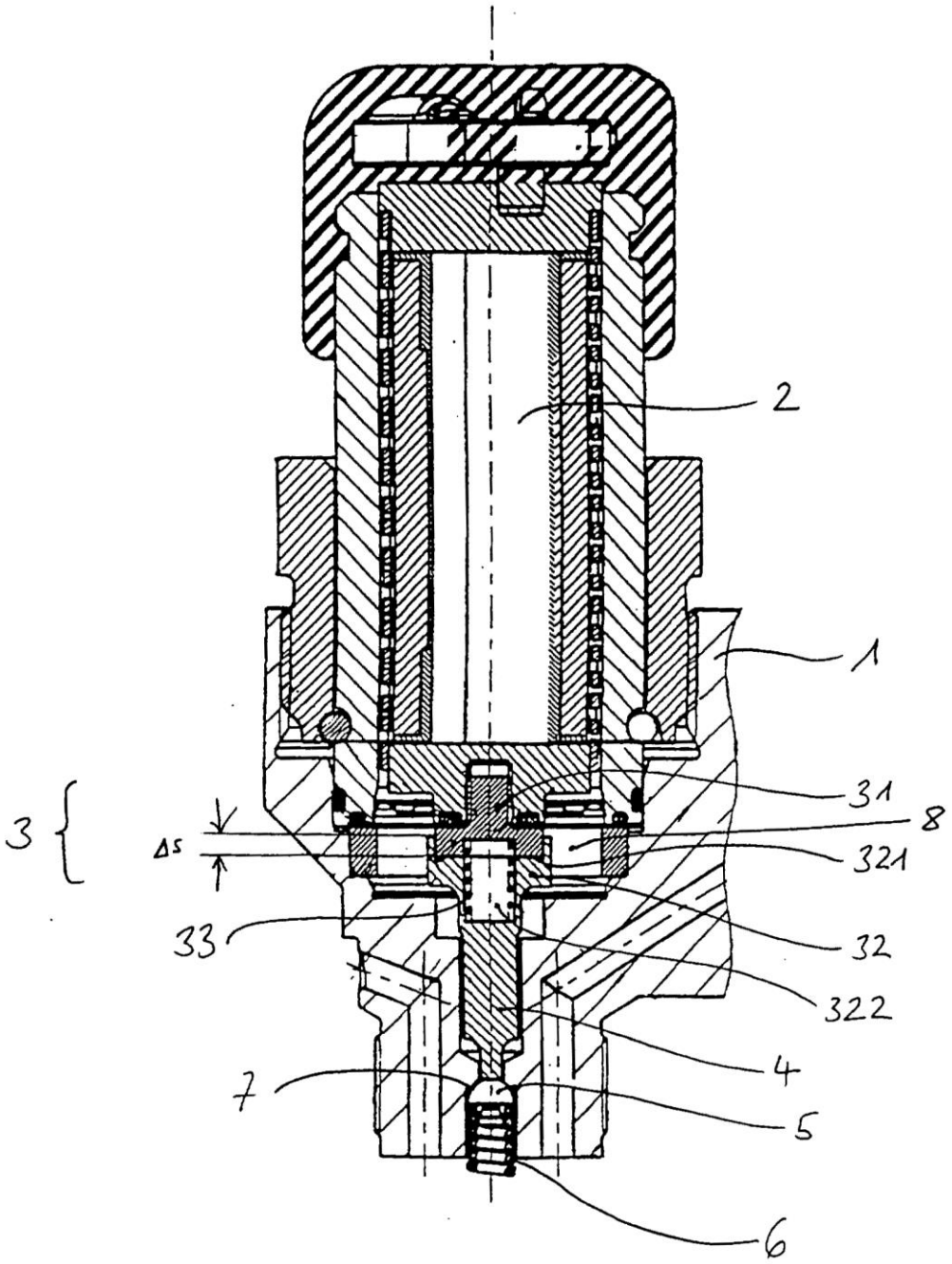
10. Injection valve according to claim 9, characterized in that the hydraulic medium is the fuel used for the engine.

11. Injection valve according to claim 10, characterized in that the space **(8)** is connected to an essentially pressureless fuel line.

Related 1 page(s) of drawings

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TRANSLATION CERTIFICATION

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To whom it may concern:

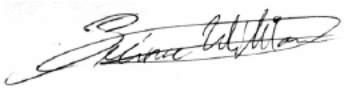
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"To the best of my knowledge, the aforementioned documents are a true, full and accurate translation of the specified documents. I affirm that the provided translation was produced under the ISO 9001:2015 certified quality management process and the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



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