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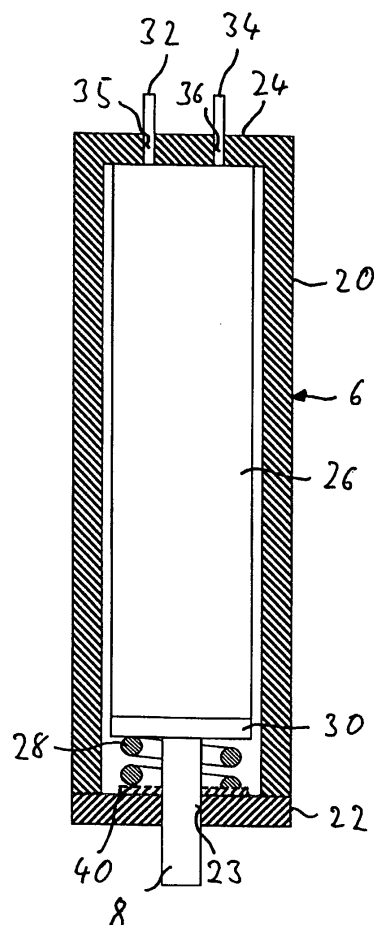
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(54) **Piezo-actuator-unit for an injector**

(57) A piezo-actuator-unit (6) for an injector comprises a piezo-element (26) and a tube-shaped housing (20) which takes in the piezo-element (26). A top portion (24) of the tube-shaped housing (20) is coupled to a first axial end of the piezo-element (26). A bottom portion (22) of the tube-shaped housing (20) has a needle recess (23) and is coupled to a second axial end of the piezo-element (26). A needle body (8) protrudes from the needle recess (23) and is axially coupled to the piezo-element (26). An actuator spring (28) is axially coupled to the piezo-element (26) and the bottom portion (22) of the tube-shaped housing (20) for forcing the piezo-element (26) away from the bottom portion (22) of the tube-shaped housing (20).

**FIG 2**



## Description

**[0001]** The invention relates to a piezo-actuator-unit for an injector. The piezo-actuator-unit comprises a piezo-element and a housing.

**[0002]** US 6,969,009 B2 discloses an injector with a piezo-actuator-unit. A jacket surface of the piezo-actuator-unit is surrounded by an injector housing. The injector housing maintains an intermediate space to the piezo-actuator-unit. The injector housing is cooled by direct contact with an inert fluid which does not conduct electricity. A fluid space in the injector housing is filled with fluid except for an air reservoir. A volume of the air reservoir is at least large enough to allow the thermal expansion of the heat coupling fluid which occurs at the highest operating temperature of the piezo-actuator-unit. A piezo-element of the piezo-actuator-unit is incorporated into a tubular spring which is the housing of the piezo-actuator-unit.

**[0003]** The producing of such a tubular spring is time intensive, complicated, and very expensive.

**[0004]** The object of the invention is to create a piezo-actuator-unit which may be produced and/or assembled in a very simple way.

**[0005]** The object of the invention is achieved by the independent claim 1. Advantageous embodiments of the invention are given in the sub-claims.

**[0006]** The invention is distinguished by a piezo-actuator-unit for an injector. The piezo-actuator-unit comprises a piezo-element and a tube-shaped housing. The tube-shaped housing takes in the piezo-element. A top portion of the tube-shaped housing is coupled to a first axial end of the piezo-element. A bottom portion of the tube shaped housing has a needle recess and is coupled to a second axial end of the piezo-element. A needle body protrudes from the needle recess and is axially coupled to the piezo-element. An actor spring is axially coupled to the piezo-element and the bottom portion of the tube-shaped housing for forcing the piezo-element away from the bottom portion of the tube-shaped housing.

**[0007]** Preferably, the tube-shaped housing is a simple tube. This contributes to a very easy and cheap production of the piezo-actuator-unit. The actor spring contributes to a proper coupling of the piezo-element to the tube-shaped housing independent from the axial expansion of the piezo-element. This contributes to a proper function of the piezo-actuator-unit. Preferably, in a closing position of the needle body, the needle body prevents a fluid flow through an injection nozzle of an injector at an axial end of the needle body facing away from the piezo-element. Alternatively, the needle body is coupled to a needle which prevents the fluid flow through the injection nozzle in the closing position of the needle.

**[0008]** In an advantageous embodiment of the piezo-actuator-unit, the piezo-actuator-unit comprises a spring washer. The spring washer couples the actor spring with the piezo-element. This contributes to a proper coupling of the actor spring to the piezo-element and to a low abra-

sion of the piezo-element.

**[0009]** In a further advantageous embodiment of the piezo-actuator-unit, the piezo-element has at least a first wire. The top portion of the tube-shaped housing has a first wire recess for guiding the first wire of the piezo-element to the outside of the tube-shaped housing. This enables in a very simple way an electrical contact to the piezo-element.

**[0010]** In a further advantageous embodiment of the piezo-actuator-unit, the top portion and/or the bottom portion comprises plastic. This may contribute to a very cheap production of the piezo-actuator-unit.

**[0011]** In a further advantageous embodiment of the piezo-actuator-unit, the piezo-actuator-unit comprises a metallic washer which is axially arranged between the actor spring and the bottom portion and/or between the piezo-element and the top portion of the tube-shaped housing. This contributes to a low abrasion of the bottom portion and, respectively, of the top portion. This is especially advantageous, if the bottom portion and, respectively, the top portion comprise plastic.

**[0012]** The invention is explained in the following with the help of schematic drawings.

**[0013]** These are as follows:

figure 1 an injector,

figure 2 a piezo-actuator-unit.

**[0014]** Elements with the same design and function that appear in the different illustrations are identified by the same reference characters.

**[0015]** An injector (Figure 1) comprises an injector body 2 with an injector body recess 4 and an injector head 7. A piezo-actuator-unit 6 is arranged in the injector body recess 4. The piezo-actuator-unit 6 is coupled to a needle body 8 which is arranged in the injector body recess 4 movable in axial direction. The injector may be used to inject fluid into a combustion chamber of an internal combustion engine.

**[0016]** A spring 12 is arranged in the injector body recess 4 in such a way that the spring 12 forces the needle body 8 away from an injection nozzle 10 via a needle plate 14. A fluid may flow through a fluid path 16 into the injector body recess 4 towards the injection nozzle 10. Bellows 18 prevent the fluid from leaking into that area of the injector body recess 4 in which the piezo-actuator-unit 6 and the spring 12 are arranged.

**[0017]** The needle body 8 prevents in a closing position of the needle body 8 a fluid flow through an injection nozzle 10 of the injector body 2. Outside of the closing position of the needle body 8 the needle body 8 enables the fluid flow through the injection nozzle 10. The needle body 8 may be made of one or more pieces. For example, the needle body 8 may comprise a pressure transferring element which is coupled to the piezo-element 26 and a needle element which forms the injection nozzle 10.

**[0018]** Whether the needle body 8 is in its closing po-

sition or not depends on a force balance of the forces which are acting on the needle body 8. A first force acts on the needle body 8 in the closing direction of the needle body 8 because of the spring 12. A second force may act on the needle body 8 against the closing direction of the needle body 8 because of the piezo-actuator-unit 6, for example, if a piezo-element 26 (figure 2) of the piezo-actuator-unit 6 gets energized and increases its axial length. A third force acts on the needle body 8 because of the pressure of the fluid in the injector body recess 4. If the sum of the forces in the opening direction of the needle body 8 is bigger than the sum of the forces in the closing direction of the needle body 8, the needle body 8 is not in its closing position. If the needle body 8 is not in its closing position, there is a gap between the needle body 8 and the injector body 2 at an axial end of the injector body 2 facing away from the injector head 7. The gap forms the injection nozzle 10.

**[0019]** In this embodiment the injector is of an outward opening type. In an alternative embodiment of the invention the injector may be an injector of an inward opening type. Then, the injection nozzle 10 preferably is at least one injection hole in the injector body 2.

**[0020]** The piezo-actuator-unit 6 comprises a tube-shaped housing 20 and a piezo-element 26. The piezo-element 26 is arranged in the tube-shaped housing 20. Preferably, the tube-shaped housing 20 is made of a simple tube. Simple means in this context that the tube is not elastic like a spring. Using the simple tube for the tube-shaped housing 20 contributes to a very simple and cheap production of the piezo-actuator-unit 6.

**[0021]** The tube-shaped housing 20 has a top portion 24 which closes the tube-shaped housing 20 in a first axial direction. The top portion 24 of the tube-shaped housing 20 may be made of one or of two pieces with the tube-shaped housing 20. If the piezo-element 26 comprises a first wire 32 for connecting the piezo-element 26 to a first terminal 39 of the injector, the top portion 24 of the tube-shaped housing 20 comprises a first wire recess 35 through which the first wire 32 of the piezo-element 26 may protrude. If the piezo-element 26 comprises a second wire 34 for connecting the piezo-element 26 to a second terminal 37 of the injector, the top portion 24 of the tube-shaped housing 20 comprises a second wire recess 36. Alternatively, if the wires of the piezo-element 26 are arranged at different positions of the piezo-element 26, the wire recesses may be arranged at different positions of the tube-shaped housing 20.

**[0022]** Preferably, the first and the second terminal 39, 37 are connected to an electric circuit for controlling the axial expansion of the piezo-element 26. The axial expansion of the piezo-element 26 may be controlled by energizing the piezo-element. The piezo-element may be energized by applying a voltage on the first and, respectively, the second wire 32, 34 of the piezo-element 26. If the piezo-element 26 gets energized, it increases its axial length in some microseconds. If the piezo-element 26 gets de-energized, it decreases its axial length

in some microseconds. The piezo-element 26 mainly comprises stacked piezoelectric crystals.

**[0023]** The tube-shaped housing 20 is closed towards a second direction through a bottom portion 22 of the tube-shaped housing 20. The bottom portion 22 of the tube-shaped housing 20 may be made of one or two pieces with the tube-shaped housing 20. The bottom portion 22 has a needle recess 23. The needle body 8 protrudes through the needle recess 23 into the tube-shaped housing 20. Preferably, the needle body 8 is not rigidly coupled to the piezo-element 26. In contrast, a spring washer 30 may be rigidly coupled to the piezo-element 26 and the needle body 8 just has a loose coupling to the piezo-element and, in case, to the spring washer 30. The actor spring 28 forces the spring washer 30 and the piezo-element 26 away from the bottom portion 22. So, the piezo-element 26 has a proper coupling to the tube-shaped housing 20, in particular to the bottom portion 22 and the top portion 24 of the tube-shaped housing 20 independent from the axial expansion of the piezo-element 26.

**[0024]** The bottom portion 22 and/or the top portion 24 of the tube-shaped housing 20 may comprise plastic. This may contribute to a very cheap assembling of the piezo-actuator-unit 6. In this context it is very advantageous, if there is a metallic washer arranged between the actor spring 28 and the bottom portion 22 which comprises the plastic. Additionally, there may be arranged a further metallic washer between the piezo-element 26 and the top portion 24 of the tube-shaped housing 20.

**[0025]** The invention is not restricted on the explained embodiment. For example, the actor spring 28 may be directly coupled to the piezo-element 26.

## Claims

### 1. Piezo-actuator-unit (6) for an injector comprising

- a piezo-element (26),
- a tube-shaped housing (20) which takes in the piezo-element (26),
- a top portion (24) of the tube-shaped housing (20) which is coupled to a first axial end of the piezo-element (26),
- a bottom portion (22) of the tube-shaped housing (20) which has a needle recess (23) and which is coupled to a second axial end of the piezo-element (26),
- a needle body (8) protruding from the needle recess (23) and being axially coupled to the piezo-element (26),
- an actor spring (28) which is axially coupled to the piezo-element (26) and the bottom portion (22) of the tube-shaped housing (20) for forcing the piezo-element (26) away from the bottom portion (22) of the tube-shaped housing (20).

2. Piezo-actuator-unit (6) in accordance with claim 1 comprising a spring washer (30) which couples the actor spring (28) with the piezo-element (26).
3. Piezo-actuator-unit (6) in accordance with one of the preceding claims with the piezo-element (26) having at least a first wire (32) and with the top portion (24) of tube-shaped housing (20) having a first wire recess (35) for guiding the first wire (32) of the piezo-element (26) to the outside of the tube-shaped housing (20). 5 10
4. Piezo-actuator-unit (6) in accordance with one of the preceding claims with the top portion (24) and/or the bottom portion (22) comprising plastic. 15
5. Piezo-actuator-unit (6) in accordance with one of the preceding claims comprising a metallic washer which is axially arranged between the actor spring (28) and the bottom portion (22) and/or between the piezo-element (26) and the top portion (24). 20

element (26) to the outside of the tube-shaped housing (20).

4. Piezo-actuator-unit (6) in accordance with one of the preceding claims comprising a metallic washer which is axially arranged between the actor spring (28) and the bottom portion (22) and/or between the piezo-element (26) and the top portion (24).

#### Amended claims in accordance with Rule 137(2) EPC.

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1. Piezo-actuator-unit (6) for an injector comprising
  - a piezo-element (26),
  - a tube-shaped housing (20) which takes in the piezo-element (26), 30
  - a top portion (24) of the tube-shaped housing (20) which is coupled to a first axial end of the piezo-element (26),
  - a bottom portion (22) of the tube-shaped housing (20) which has a needle recess (23) and which is coupled to a second axial end of the piezo-element (26), 35
  - a needle body (8) protruding from the needle recess (23) and being axially coupled to the piezo-element (26), 40
  - an actor spring (28) which is axially coupled to the piezo-element (26) and the bottom portion (22) of the tube-shaped housing (20) for forcing the piezo-element (26) away from the bottom portion (22) of the tube-shaped housing (20), 45
  - characterized in that** the top portion (24) and/or the bottom portion (22) comprise plastic.
2. Piezo-actuator-unit (6) in accordance with claim 1 comprising a spring washer (30) which couples the actor spring (28) with the piezo-element (26). 50
3. Piezo-actuator-unit (6) in accordance with one of the preceding claims with the piezo-element (26) having at least a first wire (32) and with the top portion (24) of tube-shaped housing (20) having a first wire recess (35) for guiding the first wire (32) of the piezo- 55

FIG 1

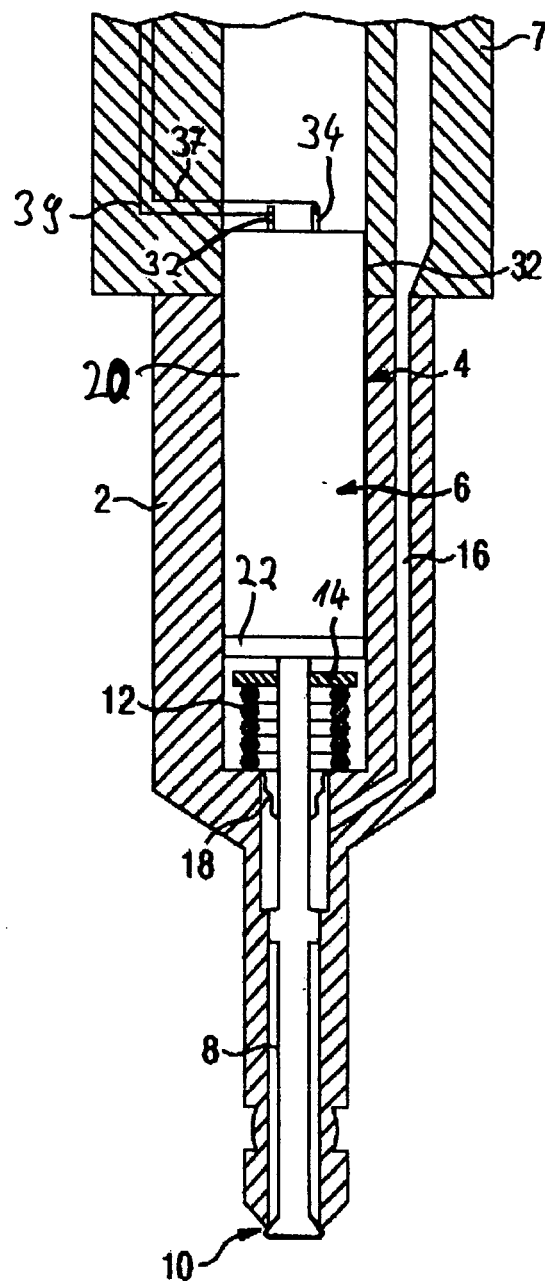
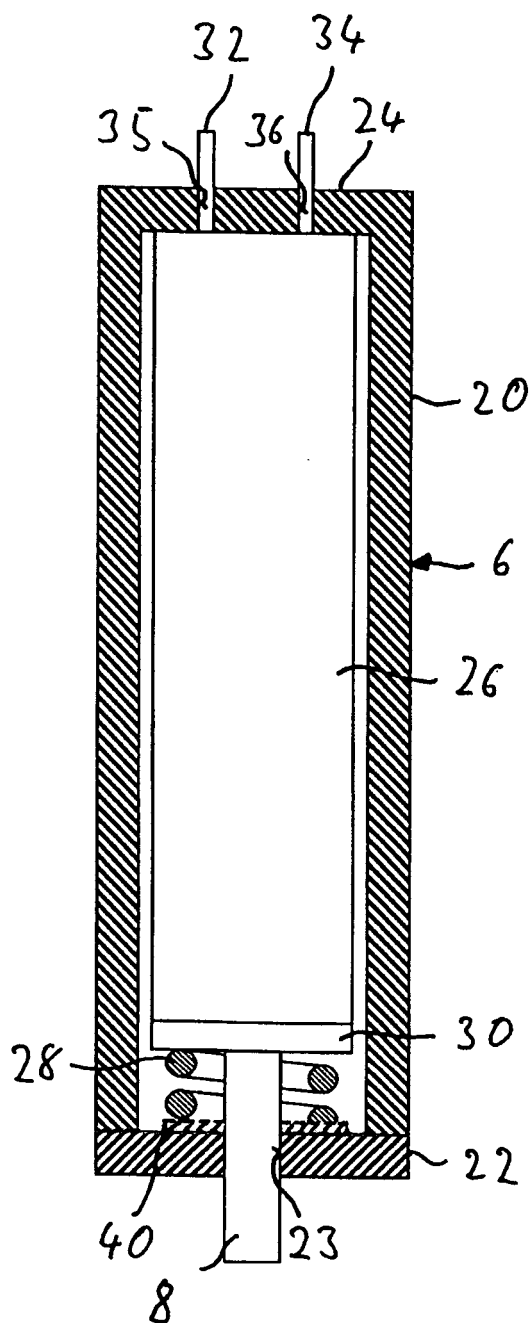


FIG 2





European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 06 01 5489

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                                            |                                         |
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| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                 | 3                                                          |                                         |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | US 6 467 460 B1 (STIER HUBERT [DE]) 22 October 2002 (2002-10-22)<br>* figure 1 *                                                | 3                                                          |                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                 |                                                            | TECHNICAL FIELDS SEARCHED (IPC)         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                 |                                                            | F02M                                    |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                 |                                                            |                                         |
| Place of search<br><b>Munich</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                 | Date of completion of the search<br><b>31 October 2006</b> | Examiner<br><b>LANDRISCINA, V</b>       |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone<br/>Y : particularly relevant if combined with another document of the same category<br/>A : technological background<br/>O : non-written disclosure<br/>P : intermediate document</p> <p>T : theory or principle underlying the invention<br/>E : earlier patent document, but published on, or after the filing date<br/>D : document cited in the application<br/>L : document cited for other reasons<br/>&amp; : member of the same patent family, corresponding document</p> |                                                                                                                                 |                                                            |                                         |

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
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