(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 445 474 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.08.2004 Bulletin 2004/33

(51) Int Cl.[7]: **F02M 55/02**, F02M 61/14

(21) Application number: **03001800.6**

(22) Date of filing: **28.01.2003**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT SE SI SK TR
Designated Extension States:
AL LT LV MK RO

(71) Applicant: **Siemens VDO Automotive S.p.A.**
56040 Fauglia (Pisa) (IT)

(72) Inventor: **Ricci, Roberto**
57121 Livorno (IT)

(74) Representative: **Berg, Peter, Dipl.-Ing.**
European Patent Attorney,
Siemens AG,
Postfach 22 16 34
80506 München (DE)

(54) Fuel injector, fuel rail and injection system with the fuel rail and the fuel injector

(57) The invention describes a fuel injector (1), a fuel rail (22) and a fuel injection system with a fuel rail and a fuel injector that are connected by a fuel tube (4). The fuel tube is flexible and elastic without changing its diameter. Using the flexible and elastic fuel tube different distances between the fuel rail and a cylinder head or a misalignment between a fuel connecting tube of the fuel rail that is connected with the fuel injector and an injection opening in a cylinder head will be compensated.

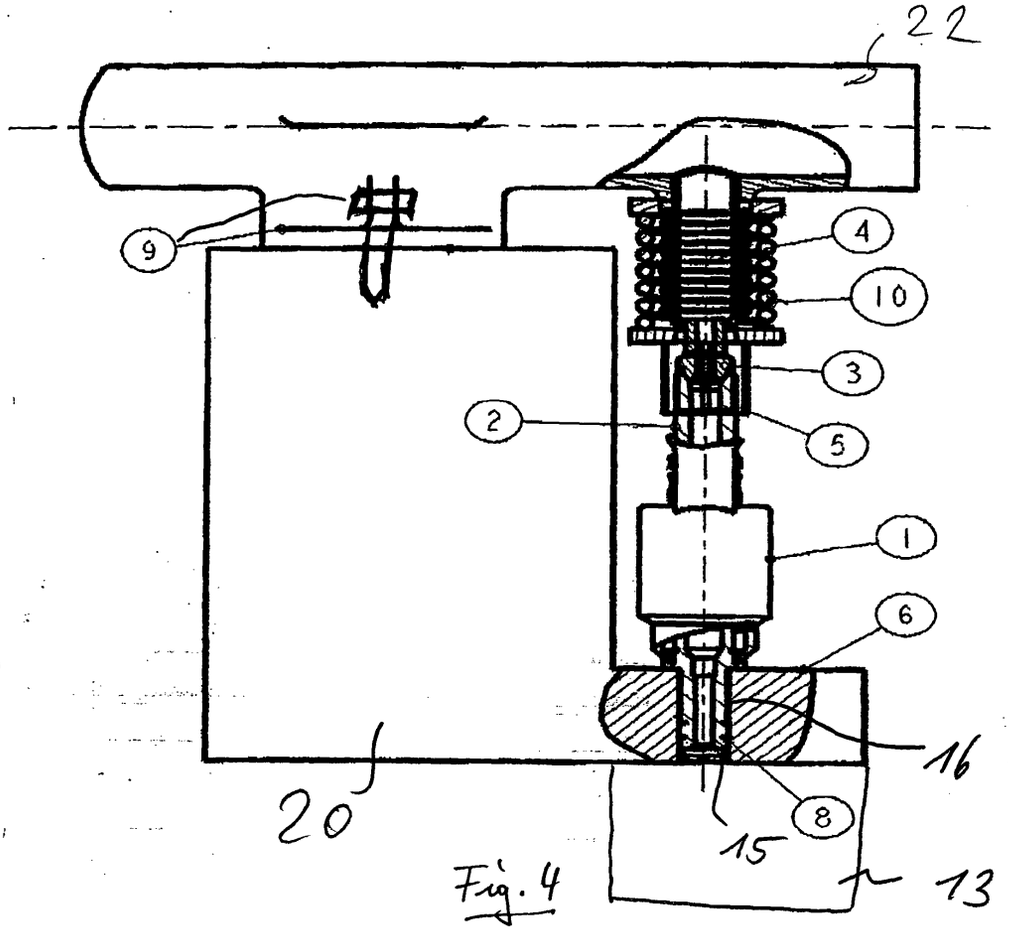

Fig. 4

EP 1 445 474 A1

Description

[0001] The invention relates to a fuel injector with a fuel tube, whereby the end of the fuel tube can be used for connecting the fuel injector to a fuel rail. Furthermore, the invention relates to a fuel rail that is used for supplying a fuel injector with fuel. The fuel rail comprises a fuel tube that can be used for connecting the fuel rail with the fuel injector. Moreover, the invention relates to a fuel injection system with a fuel rail that is connected to the fuel injector via a fuel tube.

[0002] Fuel injection systems with a fuel rail and a fuel injector are used for example for direct injection that provides fuel with a high pressure in a fuel rail. The fuel rail supplies the fuel to the fuel injector. If the fuel is under high pressure then the fuel rail has to be connected to the fuel injector by a tube. The tube has the function to deliver the pressurized fuel to the injector and to maintain the pressure of the fuel. Therefore it is not possible to use elastic fuel lines as these are known to be used in injection systems that use fuel with low or no pressure. Normally, a fuel rail supplies some fuel injectors with fuel and the position of the fuel injectors is determined by the position of the fuel rail, because the connection between the fuel rail and the fuel injectors is rigid. Each fuel injector however must fit in a corresponding fuel injector opening of a cylinder head. Misalignment and production tolerances result in fitting problems.

[0003] In the prior art, DE 19 748 593 A1 provides the use of fuel injectors that are connected to a fuel rail that is divided into two parts. The two parts are connected by a flexible part. Each fuel injector is pressed into an injector opening of the cylinder head by a spring element, whereby tips of the injectors are arranged within a longitudinal cylindrical bore. The longitudinal axis of a bore is in alignment with the direction of a fuel injector. Because of the cylindrical shape of the bore the longitudinal position of the fuel injector does not have to fit precisely. Deviations in the longitudinal positions of the fuel injectors are compensated by the flexible tube of the fuel rail.

[0004] WO 2001/71179 A2 describes a fuel injector assembly for mounting a fuel injector to a fuel rail and permitting alignment of the fuel injector. The assembly includes a cup having an upper portion and a lower portion, the upper portion being connected to a fuel rail and the lower portion including an interior, an exterior and a lower surface. The fuel injector comprises an inlet, an outlet and a fuel passage way extending from the inlet to the outlet, the inlet being positioned within the interior of the cup. A collar can be positioned in proximity to the lower surface of the cup, the collar cincturing the inlet of the fuel injector. A fastener is secured to the exterior of the cup in such a way that the ring establishes an interference fit between the collar and the inlet of the fuel injector.

[0005] The inlet extends to a given distance in the cup, allowing different positions of the fuel injector in a given longitudinal axis, whereby the fuel injector is tightly connected with the fuel rail. Depending on the distance between the cylinder head and the fuel rail, the inlet of the fuel injector is more or less inserted into the cup.

[0006] It is an object of the invention to provide an improved fuel injector, an improved fuel rail and an improved fuel injection system.

[0007] The object of the invention is achieved by the fuel injector according to claim 1, by the fuel rail according to claim 3 and by the fuel injection system according to claim 6.

[0008] Further preferred embodiments of the invention are disclosed in the figures and in the dependent claims.

[0009] The proposed fuel injector has the advantage that different distances between a cylinder head and the fuel rail can be compensated by the fuel injector or the fuel rail. That advantage is achieved by a flexible fuel tube that is part of the fuel injector or part of the fuel rail. The flexible fuel tube can be elongated, compressed or bended if necessary. The flexible tube however does not change its diameter, so that the pressure of the fuel does not decrease.

[0010] A preferred embodiment of the flexible fuel tube is a metallic expansion bellow. Using the metallic expansion bellow has the advantage that high pressure of the fuel can reliably be maintained and the metallic expansion bellow is a well-known tool that is cheaply produced. Using the inventive fuel injector or the inventive fuel rail has the advantage that the fuel rail could be fixed to the cylinder head in a predetermined position. The fixing of the fuel rail to the cylinder head shows the advantage that the fixing is easy and cheap.

[0011] The accompanying drawings, that are incorporated herein and constitute part of this specification, illustrate preferred embodiments of the invention, and, together with the general description given above and the detailed description given below, serve to explain the invention.

[0012] Fig. 1 is a schematic view of a fuel injection system.

[0013] Fig. 2 is a detailed view of a first embodiment of the invention.

[0014] Fig. 3 is a detailed view of a second embodiment of the invention.

[0015] Fig. 4 is a view of a third embodiment of the invention.

[0016] Fig. 1 shows a fuel injection system that can be used for injecting petrol or gasoline. The fuel injection system comprises a fuel rail 22 that is connected with a pressure pump 11. The pressure pump is hydraulically connected with a fuel tank 12. The pressure pump 11 sucks fuel from the fuel tank 10 and pumps the fuel to the fuel rail 22. The pressure in the fuel rail 22 may be up to 150 bar for petrol and up to 1800 bar for gasoline. The fuel rail is hydraulically connected with fuel injectors 1. The fuel injectors 1 are fixed in injector openings 16 of a cylinder head 6 of a motor block 20.

[0017] The motor block 20 comprises combustion chambers 13 that are provided with fuel by the fuel injectors 1. The fuel injectors 1 and the pressure pump 11 are electrically connected with a controlling unit 14. The controlling unit 14 controls the pressure and the volume of fuel that is pumped by the pressure pump 11. The controlling unit 14 also controls the injection of the fuel injectors 1. The fuel injectors 1 inject fuel in the combustion chambers 13 at predetermined points of time.

[0018] The fuel rail 22 is fixed to the motor block 20. Therefore the position of the fuel rail is determined depending to the position of the injector openings 16 of the cylinder head 6, into which the fuel injectors 1 are inserted.

[0019] Fig. 2 shows a part of the motor block 20, a part of the fuel rail 22 and the fuel injector 1. The fuel rail 22 is fixed to the motor block 20 by means of a screw 24. The fuel injector 1 comprises an injector tip 15 that injects fuel into the combustion chamber 13. The injector tip 15 is inserted in the injection hole 16 that is arranged in the cylinder head 6. The injection opening 16 is connected to the combustion chamber 13. The injector tip 15 comprises a sealing ring 17 that seals the combustion chamber 13. At an upper end, the fuel injector 1 comprises an inlet tube 2 that is connected to a rail connecting tube 21 of the fuel rail 22. The rail connecting tube 21 is produced in one piece with the fuel rail and is not flexible. At the end of the rail connecting tube 21 a thread is provided to which a nut 5 is screwed providing a hydraulic connection between a tube end 3 of a flexible tube 4 and the rail connecting tube 21. The tube end 3 is pressed against a sealing face of the rail connecting tube 21 with a sealing face, providing a tight connection between the fuel injector 1 and the fuel rail 22.

[0020] The flexible tube 4 is for example produced as a metallic expansion bellow. The metallic expansion bellow is flexible within a predetermined range. The expansion bellow can be extended or bended but its diameter does not change. If the bellow is mounted between the fuel rail and a fuel injector, that are fixed to the motor block, then the length of the metallic bellow is steady and the volume of the bellow does not change with the change of pressure in the fuel. Therefore the pressure of the fuel that is delivered from the fuel rail 22 to the fuel injector 1 does not decrease passing the bellow.

[0021] Instead of the metallic bellow, use can also be made of other tubes that can be bended and/or extended, whereby the diameter of the tube does not change with the pressure in the tube.

[0022] There are some injection openings 16 and each injection opening 16 may have a different distance to the fuel injector and the injection openings 16 may not always be in line with the assigned rail connecting tubes 21. Deviations of an optimum position of the injection openings 16 are compensated by the flexible fuel tube 4 that allow different positions of the fuel injectors referred to the fuel rail 22.

[0023] Fig. 3 shows another embodiment of the invention with a flexible fuel tube 4 that is directly connected to the rail connecting tube 21. The flexible fuel tube 4 is i.e. welded to the rail connecting tube 21. In this embodiment the flexible tube 4 is connected to an inlet tube 2 of the fuel injector 1 by means of a nut 5. The fuel rail 22 is hydraulically connected with the fuel injector 1 via a tight connection. Also in this embodiment, deviations of an optimum position of the injection openings 16 at a distance to the fuel rail 22 and/or in lateral position to the assigned rail connecting tubes 21 can be compensated by the flexible tube 4.

[0024] Fig. 4 shows a third embodiment of the invention that is basically constructed as the embodiment of Fig. 3, but comprises a spring element 10 that is arranged between the fuel rail 22 and the inlet tube 2 of the fuel injector 1. The spring element 10 surrounds the flexible tube 4 and presses the fuel injector 1 with its inlet tube 2 in the direction of the injection opening 16. This embodiment has the advantage that deviations of the optimum position of the injection opening can be compensated by the flexible tube 4 and the fuel injector 1 is additionally pressed against the cylinder head 6 providing a sealing of the injection opening 16. The flexible tube 4 is arranged within the axis of the spring element 10. This embodiment shows the advantage that the fuel injector 1 is safeguarded against the pressure in the combustion chamber 13 by the spring element. Furthermore the flexible tube 4 is protected against the pressure that is guided from the combustion chamber 13 by the fuel injector 1 to the flexible tube 4 by the spring element 10.

[0025] The flexible tube 4 has the advantage that it can be bended or elongated but does not change its diameter. This means that the flexible tube could be used for compensating different distances between the fuel rail and the cylinder head 6 or misalignments between the axis of the rail line 21 and the axis of the injection opening 16. In the mounted position the flexible tube 4 does not change its size, which means that the pressure of the fuel rail cannot change the volume of the flexible tube 4 so that the pressure does not decrease using the flexible tube 4.

Claims

1. Fuel injector with a fuel tube with a tube end that can be used for connecting the fuel injector to a fuel rail,
   characterised in
   that the fuel tube (4) is flexible and elastic without changing its diameter under pressure.

2. Fuel injector according to claim 1 or 2, **characterised in that** the fuel tube (4) is made of a metallic expansion bellow.

3. Fuel rail for supplying a fuel injector with fuel by

means of a fuel tube that can be used for connecting the fuel rail with the fuel injector,
characterised in
that the fuel tube (4) is flexible and elastic without changing its diameter under pressure.

4. Fuel rail according to claim 4 or 5, **characterised in that** the fuel tube is made of a metallic expansion bellow.

5. Fuel rail according to claim 3, **characterised in that** a spring element (10) is arranged that the spring element is supported against the fuel rail (22) and the fuel injector (1) and that the spring element (10) pushes the fuel injector (1) from the fuel rail (22).

6. Fuel rail according claim 5, **characterised in that** the fuel tube (4) is surrounded by a spring element (10), that the spring element (10) is supported above and below the elastic part of the fuel tube (4) with the fuel rail (22) and the fuel injector (1).

7. Injection system with a fuel rail that is connected to a fuel injector by a fuel tube, **characterised in that** the fuel tube (4) is flexible and elastic without changing its diameter under pressure.

8. Injection system according to claim 7, **characterised in that** the fuel rail (22) is fixed in a predetermined position to a cylinder head (6), that the fuel injector (1) is arranged in an injection opening (16) of the cylinder head (6) and that a spring element (10) is arranged between the fuel rail (22) and the fuel injector (1) pushing the fuel injector (1) against the cylinder head (6).

9. Injection system according to one of the claims 7 or 8 **characterised in that** the fuel tube (4) is made of a metallic expansion bellow.

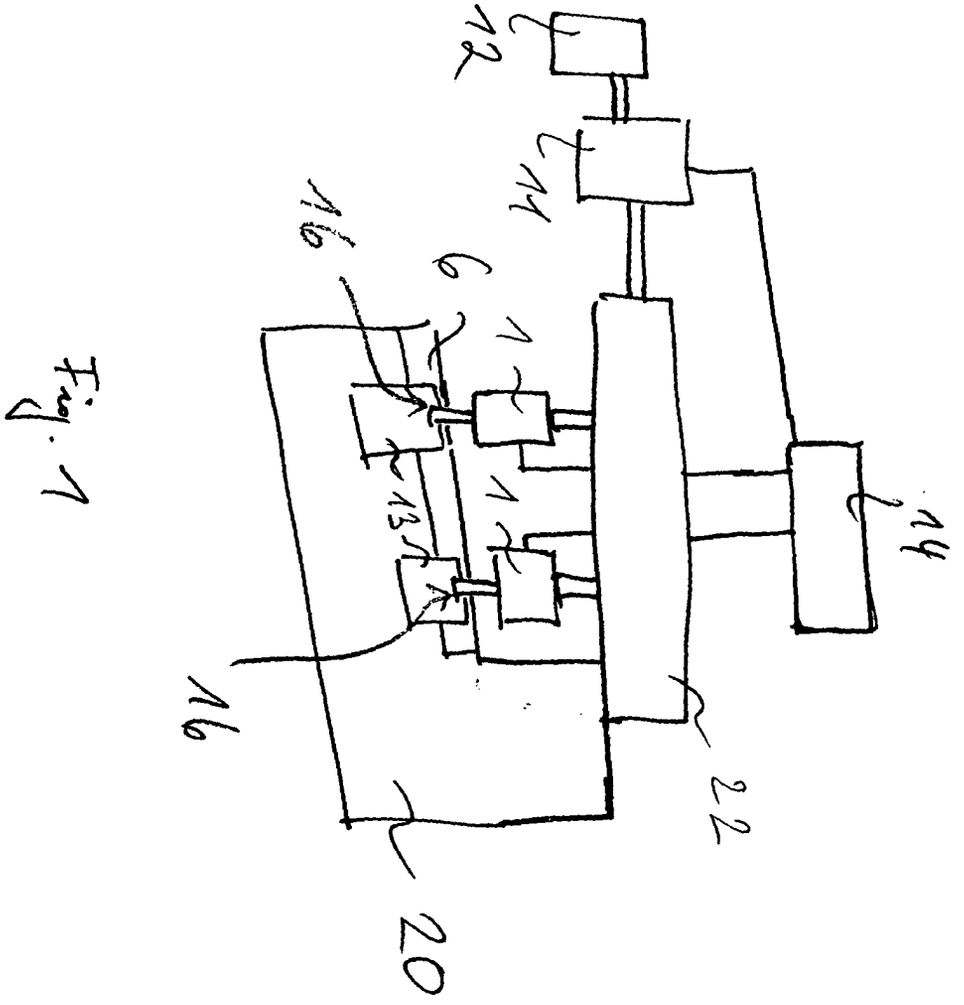

Fig. 1

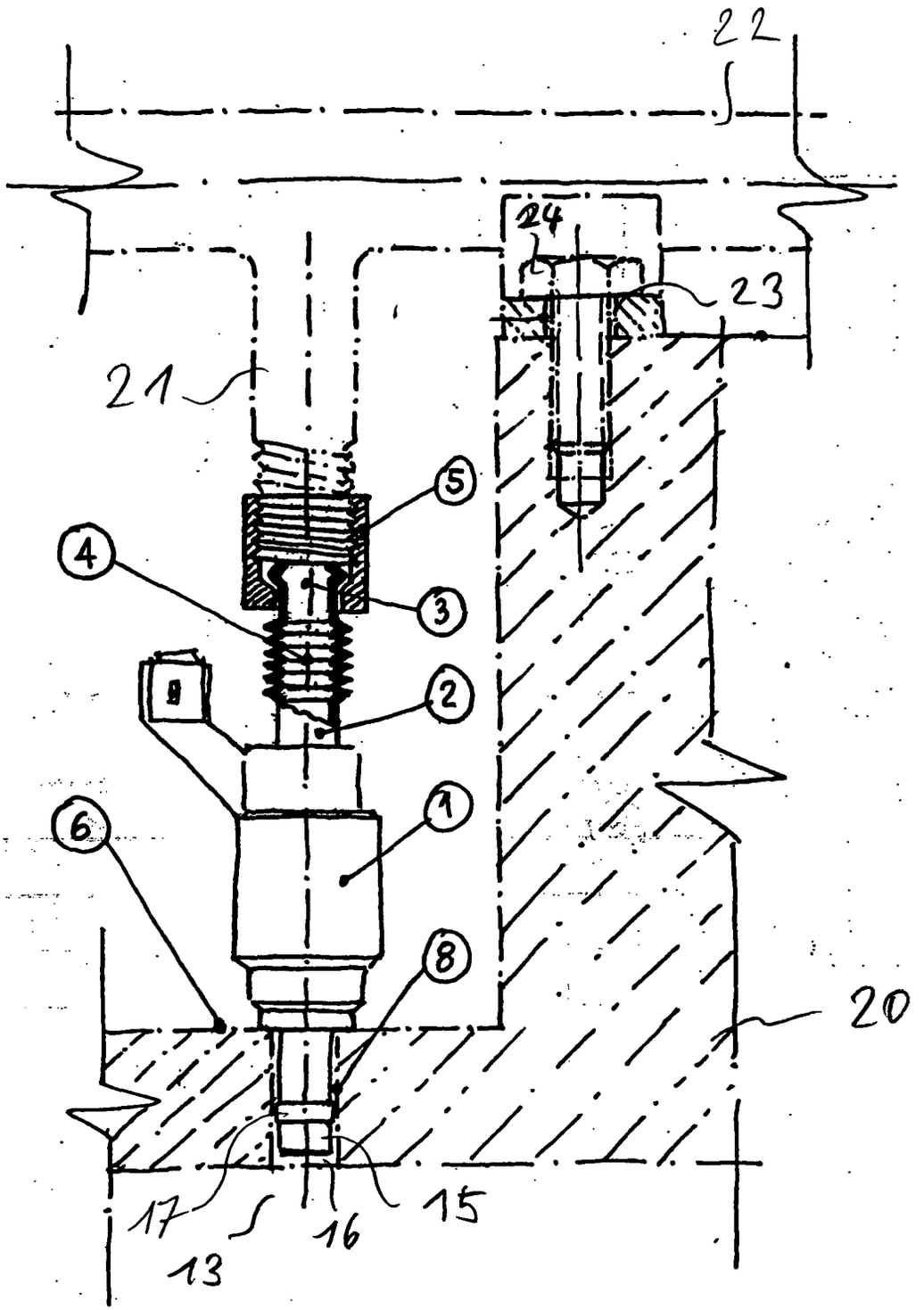

Fig. 2

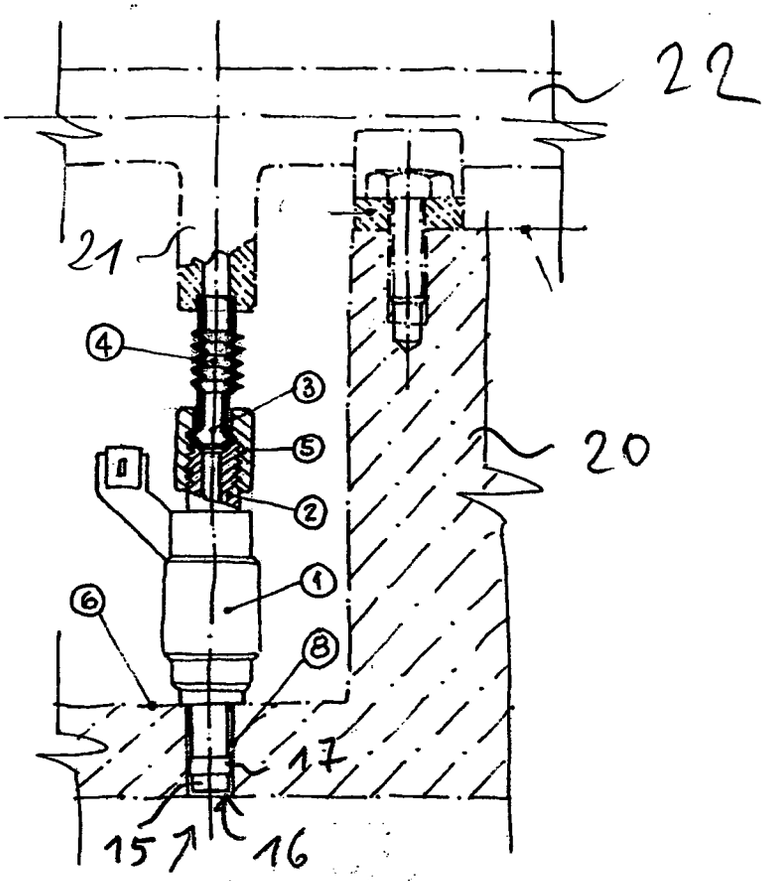

Fig. 3

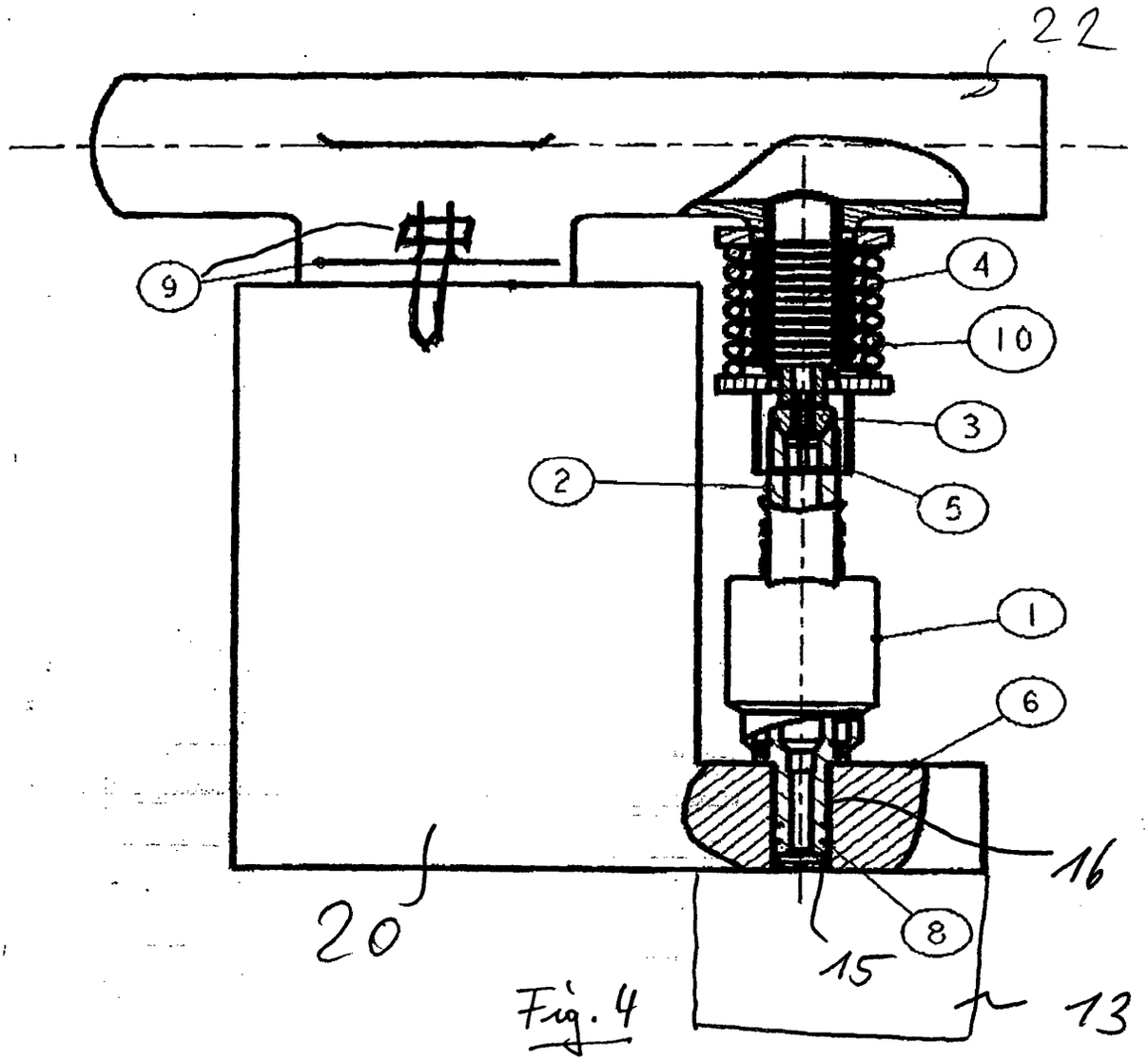

Fig. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 00 1800

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	US 4 295 452 A (KNAPP HEINRICH ET AL) 20 October 1981 (1981-10-20) * column 3, line 5 - column 4, line 2; figures 2,3 *	1-4,7,9 5,6,8	F02M55/02 F02M61/14
Y	US 6 148 797 A (GMELIN KARL) 21 November 2000 (2000-11-21) * column 3, line 7 - line 19; figures *	5,6,8	
D,A	WO 01 71179 A (SIEMENS AUTOMOTIVE CORP LP) 27 September 2001 (2001-09-27) * abstract *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	19 May 2003	Torle, E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 00 1800

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-05-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4295452 A	20-10-1981	DE 2829057 A1	10-01-1980
		GB 2024937 A ,B	16-01-1980
		JP 55010095 A	24-01-1980
US 6148797 A	21-11-2000	DE 19756102 A1	24-06-1999
		WO 9931381 A1	24-06-1999
		EP 0988448 A1	29-03-2000
		JP 2001511867 T	14-08-2001
WO 0171179 A	27-09-2001	AU 4929401 A	03-10-2001
		EP 1278956 A2	29-01-2003
		WO 0171179 A2	27-09-2001
		US 2001037796 A1	08-11-2001

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82