



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 088 986 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.04.2001 Bulletin 2001/14

(51) Int. Cl.⁷: **F02M 51/06**, F02M 61/16

(21) Application number: **00120863.6**

(22) Date of filing: **25.09.2000**

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

(30) Priority: **28.09.1999 IT BO990521**

(71) Applicant:
MAGNETI MARELLI S.p.A.
20145 Milano (IT)

(72) Inventors:
• **Boaro, Maurizio**
40055 Castenaso (IT)

• **Cernoia, Fabio**
40069 Zola Predosa (IT)
• **Cristiani, Marcello**
40026 Imola (IT)
• **Neretti, Massimo**
40068 San Lazzaro di Savena (IT)

(74) Representative:
Jorio, Paolo et al
STUDIO TORTA S.r.l.,
Via Viotti, 9
10121 Torino (IT)

(54) **Fuel injector**

(57) Fuel injector (1) comprising a tubular body (2), provided with a through pipe (3) which ends in a spray nozzle (4) which can spray the fuel present inside the through pipe (3), a shutter unit (5), which is mobile axially inside the through pipe (3), from and towards a position of closure, wherein the shutter unit (5) itself abuts the spray nozzle (4), and seals it in a fluid-tight manner, and a coil of electrically conductive material fitted onto the tubular body (2), in order to generate by command a magnetic field which can displace the said shutter unit (5); a central portion (9) of the tubular body (2) and the shutter unit (5) in fact being made of ferro-magnetic material, such as to define the fixed part and the mobile part of a magnetic core (5, 9), onto which the said coil (7) is fitted; a layer of highly resistant material being present on the outer surface of the shutter unit (5), i.e. the mobile part of the magnetic core (5, 9), but not on the central portion (9) of the tubular body (2), i.e. the fixed part of the magnetic core (5, 9) itself.

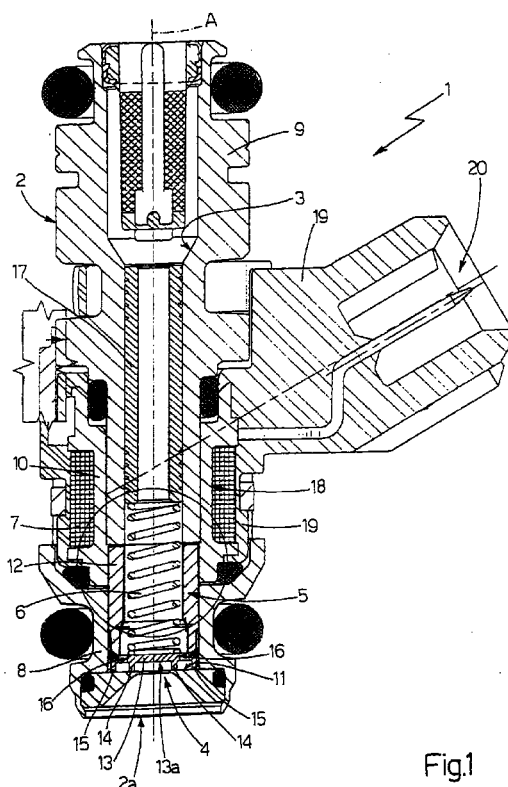


Fig.1

EP 1 088 986 A1

Description

[0001] The present invention relates to a fuel injector.

[0002] In particular, the present invention relates to a fuel injector for internal-combustion engines, to which the following description specifically refers, without detracting from generality.

[0003] As is known, the fuel injectors for internal-combustion engines which are commercially available at present comprise: a main tubular body, which is provided with a central through pipe, which ends at an axial end of the tubular body, in a spray nozzle, which can project outside the injector a jet of finely sprayed fuel; a shutter unit, which is fitted such as to be axially mobile inside the central pipe, from and towards the position of closure, in which it closes the spray nozzle, such as to prevent discharge of the fuel; and a contrast spring which can maintain the shutter unit in the said position of closure.

[0004] Outside the main tubular body, the fuel injectors additionally comprise a coil made of electrically conductive material, which, when electric current is passed through it, can generate a magnetic field which can overcome the resilient force of the spring, such as to move the shutter unit away temporarily from the position of closure, so as to permit controlled discharge of the fuel.

[0005] In fact, the central portion of the main tubular body and the shutter unit are made from ferro-magnetic material, and are disposed aligned one in front of the other, such that the magnetic field produced by the coil of electrically conductive material tends to bring the shutter unit into contact with the central portion of the main tubular body, thus overcoming the resilient force of the spring.

[0006] Substantially therefore, the central portion of the main tubular body and the shutter unit define the fixed part and the mobile part of the magnetic core of the coil of the fuel injector.

[0007] In view of the strong mechanical stresses to which the central portion of the main tubular body and the shutter unit are subjected, it is common practice in all companies which manufacture fuel injectors to subject these items to surface treatment which deposits a layer of highly-resistant material on their entire outer surface.

[0008] Unfortunately, the highly-resistant material (for example chromium) which is deposited on the surface of the two components has non-magnetic or diamagnetic properties, and when it is diffused on the interior, it contaminates the ferro-magnetic material of which the two components are made, thus reducing their ferro-magnetic properties. In turn, this reduction gives rise to deterioration of the performance of the magnetic surface of the injector.

[0009] In addition, the above-described surface treatment has high costs, which affect significantly the

overall production costs of the above-described fuel injectors.

[0010] The object of the present invention is to provide a fuel injector for internal-combustion engines, which is free from the above-described disadvantages.

[0011] According to the present invention, a fuel injector is provided, which comprises a main tubular body, which has at least one through pipe which ends in a spray nozzle, which can spray to the exterior the fuel which is present inside the through pipe, and a shutter unit, which is mobile inside the through pipe, from and towards a position of closure, in which it abuts the spray nozzle, and seals it in a fluid-tight manner; the shutter unit being made of ferro-magnetic material, and the injector additionally comprising a coil which can generate selectively a magnetic field, which can displace the shutter unit from the said position of closure; a portion of the said main tubular body in turn being made of ferro-magnetic material, such as to define together with the said shutter unit respectively the fixed part and the mobile part of a magnetic core made of ferro-magnetic material; the said fuel injector being characterised in that the portion of the main tubular body which defines the fixed part of the magnetic core is not provided with any surface treatment.

[0012] The present invention will now be described with reference to the attached drawings, which illustrate a non-limiting embodiment of it, in which:

- figure 1 is a view in cross-section of a fuel injector produced according to the dictates of the present invention; whereas
- figure 2 illustrates on an enlarged scale a detail of the fuel injector illustrated in figure 1.

[0013] With reference to figure 1, the number 1 indicates as a whole a fuel injector which is particularly suitable for being fitted onto internal-combustion engines of a known type.

[0014] The injector 1 comprises a main tubular body 2, which is provided with a through pipe 3 with a variable diameter, into which pressurised fuel is supplied. This through pipe 3 extends co-axially relative to the longitudinal axis A of the tubular body 2, and ends at an axial end 2a of the tubular body 2, in a spray nozzle 4, which can project outside the injector 1 itself a finely sprayed jet of fuel.

[0015] The injector 1 additionally comprises a shutter unit 5, which is made at least partially of ferro-magnetic material, and is fitted such as to be axially mobile inside an end portion of the through pipe 3, from and towards a position of closure, in which the shutter unit 5 itself shuts the spray nozzle 4, such as to prevent discharge of the fuel; a contrast spring 6, which can maintain the shutter unit 5 in the said position of closure; and a coil 7 of electrically conductive material, which can displace the shutter unit 5 by command from the position of closure, thus overcoming the resilient force of the

contrast spring 6. In this case, the coil 7 is fitted onto the tubular body 2 upstream from the shutter unit 5, and, when electric current is passed through it, it can generate a magnetic field which can overcome the resilient force of the contrast spring 6, and displace the shutter unit 5 axially, thus moving it away from the position of closure.

[0016] In order to increase the intensity of the electro-magnetic forces which act on the shutter unit 5, the central portion of the tubular body 2 onto which the coil 7 is fitted, and which is aligned with the shutter unit 5, is made of ferro-magnetic material, such as to intensify the magnetic field which acts on the shutter unit 5.

[0017] It should be emphasised that in practice, the central portion of the tubular body 2, and the shutter unit 5 define respectively the fixed part and the mobile part of a magnetic core made of ferro-magnetic material, which is disposed co-axially relative to the coil 7, in order to intensify the magnetic field produced by the latter.

[0018] With reference to figure 2, in order to resist the mechanical stresses to which it is subjected in operation, the shutter unit 5 is subjected to surface treatment, which consists of depositing on part or all of its outer surface a layer of highly-resistant material which preferably, but not necessarily, has non-magnetic or diamagnetic characteristics.

[0019] In the example illustrated, in particular, the shutter unit 5 is subjected to galvanic treatment, which, by means of electro-plating, is designed to produce a layer of chromium on the entire outer surface of the shutter unit 5 (see figure 2). It will be appreciated that this layer of chromium can optionally be produced only on the part of the outer surface of the shutter unit 5 which is subjected directly to the mechanical stresses.

[0020] Contrary to the situation at present, the central portion of the tubular body 2, i.e. the fixed part of the magnetic core of the coil 7, is on the other hand not provided with any surface treatment.

[0021] With reference to figures 1 and 2, in the example illustrated, the tubular body 2 consists of three tubular segments, which are connected to one another in a telescopic manner, such as to permit easy, quick assembly of the injector 1. The first tubular segment, which is indicated hereinafter by the number 8, defines the end portion of the tubular body 2, inside which the shutter unit 5 is mobile axially; the second tubular segment, which is indicated hereinafter by the number 9, defines the initial portion of the tubular body 2, through which the pressurised fuel enters the through pipe 3; whereas the third tubular segment, which is indicated hereinafter by the number 10, connects the tubular segments 8 and 9 to one another, and defines the housing for the coil 7.

[0022] In view of the particular structure of the tubular body 2, in the example illustrated, the fixed part of the magnetic core of the coil 7, i.e. the central portion of the tubular body 2, onto which the coil 2 is fitted, and

which is simultaneously aligned with the shutter unit 5, consists of an end portion of the tubular segment 9, which is thus made of ferro-magnetic material, and is obviously not provided with any surface treatment.

[0023] On the other hand, in the example illustrated, the shutter unit 5 consists of a cup-type body with a cylindrical shape, which is fitted such as to slide axially inside the pipe 3, with its own end facing the spray nozzle, such that, when it is in the position of closure, it can be positioned with its base abutting a sealing surface 11 provided on the spray nozzle 4 itself, in order to provide the hydraulic sealing. This sealing surface 11, is preferably, but not necessarily flat.

[0024] In particular, with reference to figure 1, the spray nozzle 4 consists of a disc with a calibrated central hole, which is fitted onto the axial end 2a of the tubular body 2, i.e. onto the tubular segment 8, such as to be perpendicular to the longitudinal axis A of the tubular body 2 itself. The surface of the disc which faces the through pipe 3 defines the sealing surface 11, whereas the surface of the disc which faces in the direction opposite the through pipe 3, has, in the example illustrated, a frusto-conical flare, which serves the purpose of guaranteeing improved spraying and diffusion of the jet of fuel.

[0025] On the other hand, the shutter unit 5 consists of a cylindrical tubular element 12 made of ferro-magnetic material, and a sealing disc 13 made of highly-resistant material, which is welded to an axial end of the cylindrical tubular element 12, such as to define the base of the cup-type body. On its own outer flat surface 13a, i.e. on its surface which does not face the cylindrical tubular element 12, this sealing disc 13 has two concentric annular projections 14 and 15, which are co-axial relative to the axis A, each of which can abut the spray nozzle 4, i.e. the sealing surface 11, such as to surround the calibrated central hole, so as to form the hydraulic seal.

[0026] Finally, the sealing disc 13 has a plurality of through holes 16, which can permit passage of the fuel from the interior of the cup-type body, i.e. inside the shutter unit 5, towards the outer flat surface 13a of the disc, at the area delimited by the two annular projections 14 and 15.

[0027] With reference to figure 1, the contrast spring 6 is disposed inside the pipe 3, co-axially relative to the axis A, with a first end abutting the base of the shutter unit 5, i.e. the sealing disc 13, and a second end abutting a shoulder provided inside the pipe 3.

[0028] In the example illustrated, this shoulder is defined by the axial end of a spring-thrust body 17 inserted inside the pipe 3, immediately upstream from the section of the through pipe 3 in which the shutter unit 5 is mobile, i.e. inside the tubular segment 9. This spring-thrust body 17 constitutes an integral part of the tubular body 2, has a cylindrical tubular shape, and is preferably, but not necessarily, made of ferro-magnetic material. The position of the spring-thrust body 17

inside the pipe 3 can be adjusted during fitting of the injector 1, such as to regulate the compression of the contrast spring 6.

[0029] Finally, the coil 7, which is made of electrically conductive material, is fitted on the tubular segment 10 of the tubular body 2, inside an outer annular seat 18 provided on the tubular segment 10 itself, and has an outer protective housing 19 fitted onto the coil 7, such as to close the latter onto the tubular body 2.

[0030] In the example illustrated, on the outer housing 19, there is provided an electrical connector 20, by means of which it is possible to convey the electric current to the coil 7.

[0031] The functioning of the fuel injector 1 can easily be understood from the foregoing description and illustration, and further explanations are therefore not required.

[0032] It should however be emphasised that repeated experimental tests have shown that elimination of the layer of highly-resistant material from the fixed part of the magnetic core has not given rise to any reduction in the average service life of the fuel injector, although the production costs have been substantially reduced.

[0033] A further advantage of the injector 1 is that there is reduction of the thickness of the gap which exists between the fixed part and the mobile part of the magnetic core, thus improving the efficiency of the magnetic circuit, and reducing the dispersion of the functional characteristics.

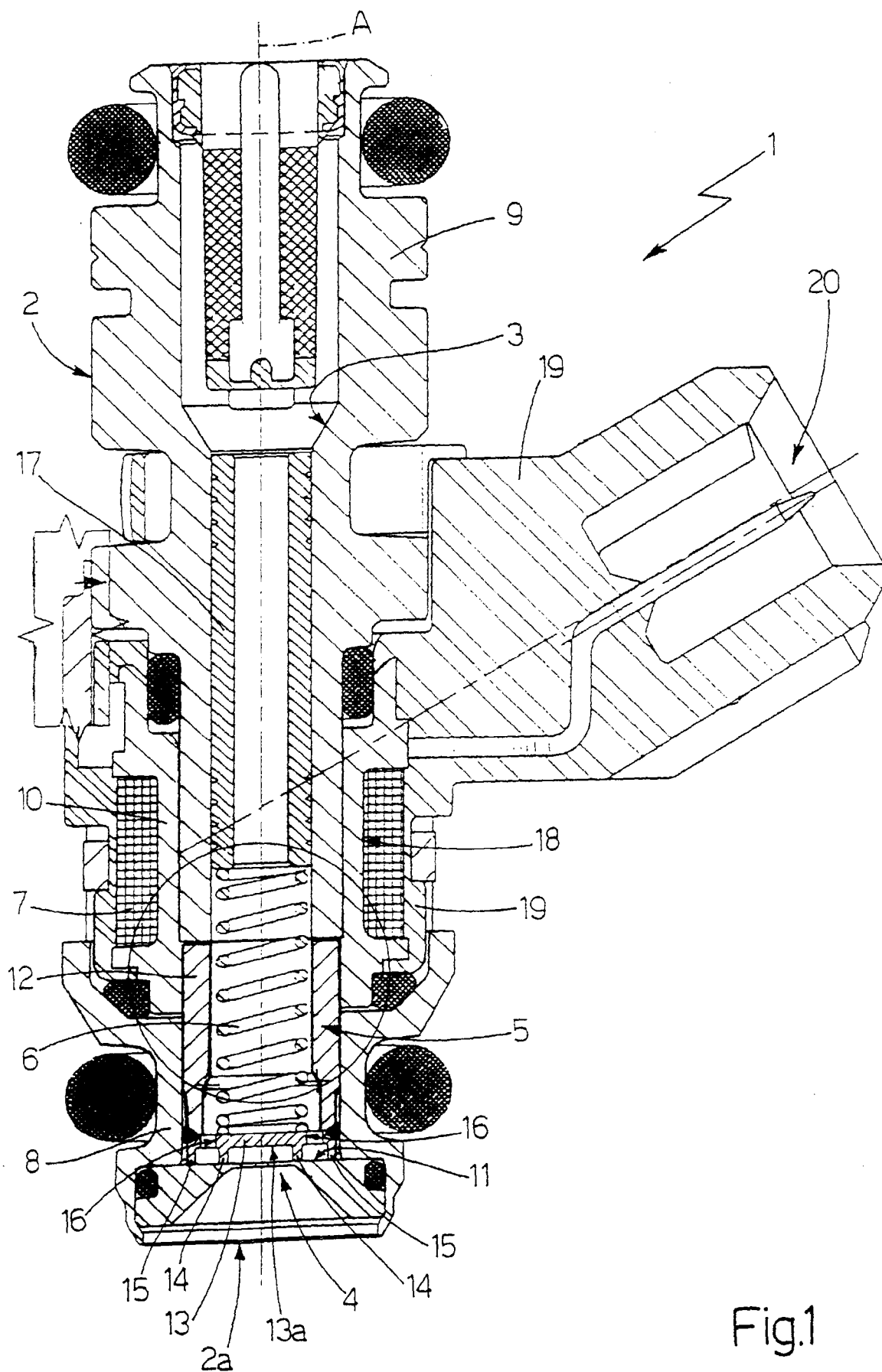
[0034] Finally, it is apparent that modifications and variants can be made to the injector 1 described and illustrated here, without departing from the context of the present invention.

Claims

1. Fuel injector (1), comprising a main tubular body (2), provided with at least one through pipe (3) which ends in a spray nozzle (4) which can spray to the exterior the fuel which is present inside the through pipe (3), and a shutter unit (5), which is mobile inside the through pipe (3), from and towards a position of closure in which it abuts the spray nozzle (4), and seals it in a fluid-tight manner; the shutter unit (5) being made of ferro-magnetic material, and the injector (1) additionally comprising a coil (7), which can generate selectively a magnetic field which can displace the shutter unit (5) from the said position of closure; a portion (9) of the said main tubular body (2) in turn being made of ferro-magnetic material, such as to define together with the said shutter unit (5) respectively the fixed part and the mobile part of a magnetic core (5, 9) made of ferro-magnetic material; the said fuel injector (1) being characterised in that the portion (9) of the main tubular body (2) which defines the fixed part of the magnetic core (5, 9) is not provided with

any surface treatment.

2. Fuel injector according to claim 1, characterised in that the said shutter unit (5) which defines the mobile part of the magnetic core (5, 9), has a layer of highly-resistant material, substantially on all of its own outer surface.
3. Fuel injector according to claim 2, characterised in that the said layer of highly-resistant material has non-magnetic characteristics.
4. Fuel injector according to claim 2, characterised in that the said layer of highly-resistant material has diamagnetic characteristics.



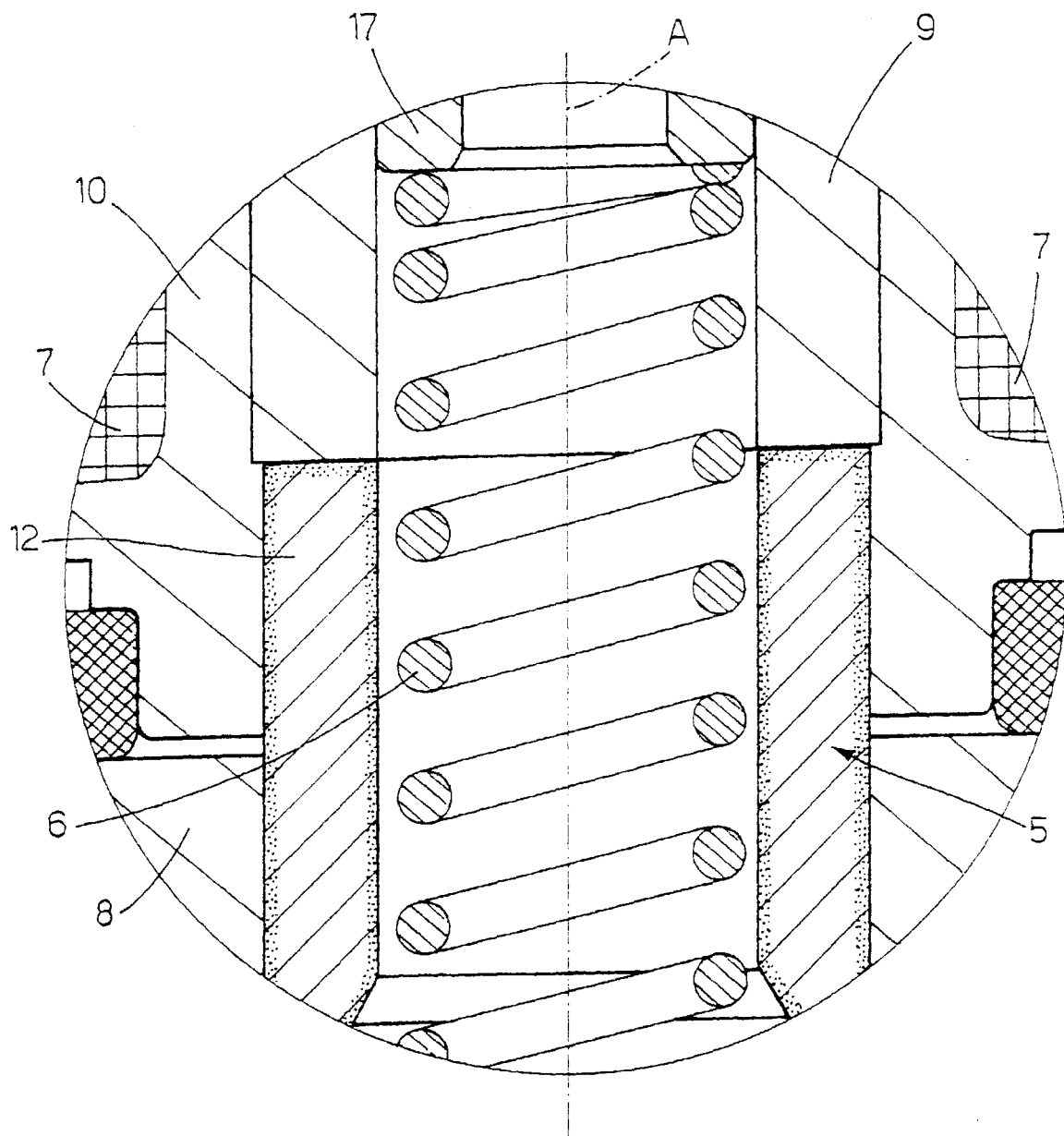


Fig.2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 12 0863

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.CI.7)
X	US 4 527 744 A (HAFNER UDO ET AL) 9 July 1985 (1985-07-09) * column 3, line 52 - column 4, line 8; figure *	1-4	F02M51/06 F02M61/16
X	US 4 313 571 A (MOLINARI FRANCO ET AL) 2 February 1982 (1982-02-02) * column 3, line 30 - line 39; figures * * column 5, line 57 - line 62 *	1-4	
X	DE 44 21 935 A (BOSCH GMBH ROBERT) 14 June 1995 (1995-06-14) * claim 7 *	1	
X	EP 0 301 620 A (WEBER SRL) 1 February 1989 (1989-02-01) * column 3, line 49 - column 4, line 33; figures *	1	
X	EP 0 172 591 A (SPICA SPA) 26 February 1986 (1986-02-26) * abstract; figures *	1-3	TECHNICAL FIELDS SEARCHED (Int.CI.7)
X	US 4 360 161 A (CLAXTON WILLIAM B ET AL) 23 November 1982 (1982-11-23) * column 11, line 66 - column 12, line 14; figure 10 *	1-4	F02M
X	EP 0 536 773 A (WEBER SRL) 14 April 1993 (1993-04-14) * column 4, line 14 - line 30; figures *	1-4	
X	DE 38 10 826 A (PIERBURG GMBH) 12 October 1989 (1989-10-12) * abstract *	1	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 21 December 2000	Examiner 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 00 12 0863

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.

21-12-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4527744 A	09-07-1985	DE 3230844 A	23-02-1984
		FR 2532006 A	24-02-1984
		GB 2125939 A,B	14-03-1984
		JP 1752323 C	08-04-1993
		JP 4032270 B	28-05-1992
		JP 59050286 A	23-03-1984
US 4313571 A	02-02-1982	DE 2942928 A	21-05-1981
		FR 2466630 A	10-04-1981
		GB 2061014 A,B	07-05-1981
DE 4421935 A	14-06-1995	BR 9406079 A	16-01-1996
		CN 1116871 A,B	14-02-1996
		CZ 9501977 A	15-05-1996
		WO 9516126 A	15-06-1995
		DE 59406220 D	16-07-1998
		EP 0683862 A	29-11-1995
		ES 2118531 T	16-09-1998
		JP 8506877 T	23-07-1996
		RU 2131549 C	10-06-1999
		US 5732888 A	31-03-1998
		BR 9406081 A	06-02-1996
		CN 1116870 A,B	14-02-1996
		CZ 9501980 A	15-05-1996
		DE 4421947 A	14-06-1995
		WO 9516125 A	15-06-1995
		DE 59405392 D	09-04-1998
		EP 0683861 A	29-11-1995
		ES 2113722 T	01-05-1998
EP 0301620 A	01-02-1989	IT 1222137 B	05-09-1990
EP 0172591 A	26-02-1986	IT 1175561 B	01-07-1987
		DE 3568610 D	13-04-1989
US 4360161 A	23-11-1982	AU 532777 B	13-10-1983
		AU 5502180 A	07-08-1980
		CA 1132417 A	28-09-1982
		DE 3000622 A	18-09-1980
		FR 2447470 A	22-08-1980
		GB 2039993 A,B	20-08-1980
		IT 1129548 B	04-06-1986
		JP 55104564 A	11-08-1980

EPO FORM P0459

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

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 12 0863

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.

21-12-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0536773 A	14-04-1993	IT 1250845 B	21-04-1995
		DE 69203197 D	03-08-1995
		DE 69203197 T	18-01-1996
		ES 2076645 T	01-11-1995
		US 5348232 A	20-09-1994
<hr/>			
DE 3810826 A	12-10-1989	NONE	
<hr/>			