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(71) Applicant: **Delphi Technologies, Inc.**
Troy, Michigan 480007 (US)

(72) Inventor: **Clerx, Franciscus**
2738 Luxembourg (LU)

(74) Representative: **Jones, Keith William et al**
Murgitroyd & Company
Scotland House
165-169 Scotland Street
Glasgow G5 8PL (GB)

(54) Fuel injector

(57) A fuel injector has a valve group formed by a pintle (16) and seat (14). The valve group is biased shut by a spring (18). In order to prevent the closing force and speed varying with the hydraulic effects of fuel pressure in the injector, fuel is passed via a bypass (26) to a location between the seat (14) and a seal (24) which is dimensioned to provide a cancelling hydraulic force. Other embodiments use auxiliary springs to give a cancelling force.

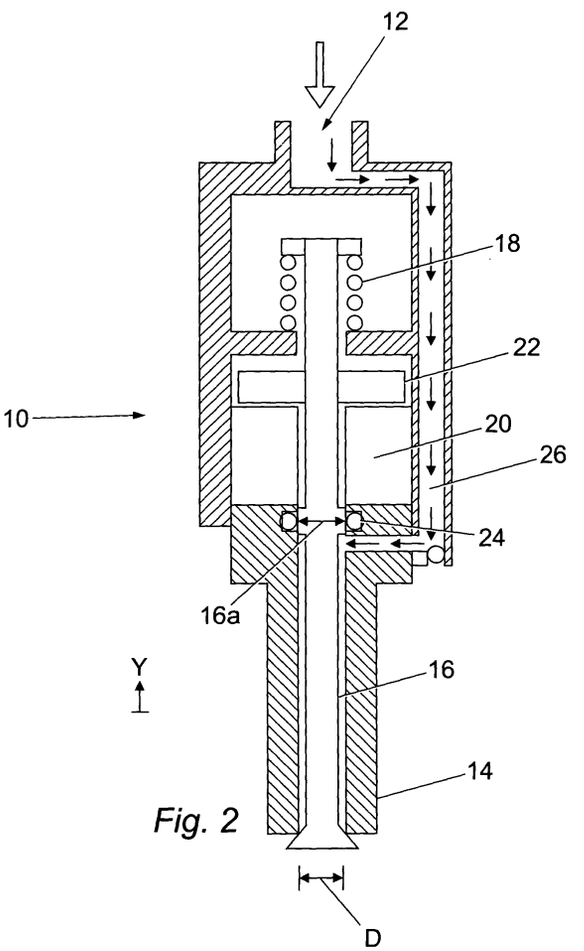

Fig. 2

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Description

[0001] This invention relates to fuel injectors for internal combustion engines.

[0002] Current engine developments, directed at reducing emissions and improving fuel efficiency, are leading to requirements for greater accuracy and greater speed in the operation of fuel injection equipment.

[0003] Figure 1 is a schematic depiction of a pintle-type, solenoid actuated fuel injector. A body 10 is formed with a fuel inlet 12 at one end and a seat 14 at the other. A pintle 16 cooperates with the seat 14 to form an outlet valve and nozzle. The pintle 16 is normally biased closed in the direction Y by a spring 18, and is opened for fuel injection by a solenoid actuator 20 acting on an armature 22 to move the pintle in the -Y direction.

[0004] Hydraulic forces produced by the fuel pressure within the body 10 produce a net force on the pintle in the -Y direction on a surface enclosed by diameter D. The hydraulic forces assist in opening of the pintle but resist closing. Therefore for opening the actuator must overcome the spring force plus some friction force minus the net hydraulic force. This means that, for the same spring force, as fuel pressure is reduced the actuator has to overcome more force and opening becomes more difficult or even impossible. Also, reducing the fuel pressure reduces the speed of opening and increases the speed of closing.

[0005] A similar situation applies to fuel injectors with other types of actuator and outlet valve.

[0006] When cranking the engine, hydraulic pressure is not yet available and thus injector opening becomes more difficult. This opening while cranking is of course crucial. It is therefore generally a requirement that the injector is able to open at very low system pressures, which in turn requires that the solenoid or other actuator can supply sufficient force. At the same time, to fulfil minimum and maximum fuelling requirements, the actuator switching times must be very short. Mostly, in trying to meet these requirements a trade-off between maximum force and speed has to be found, and both requirements remain difficult or impossible to meet simultaneously.

[0007] The present invention seeks to meet this problem by the fuel injector structure defined in claim 1.

[0008] Other features and advantages of the present invention will be apparent from the claims and from the following description of exemplary embodiments.

[0009] In the drawings:

Figure 1 shows a prior art injector, as discussed above;

Figure 2 is a schematic cross-sectional side view of a fuel injector forming a first embodiment of the invention;

Figure 3 is a schematic cross-sectional side view of a fuel injector forming a second embodiment of the invention;

Figure 4 is a schematic cross-sectional side view of a fuel injector forming a third embodiment of the invention; and

Figure 5 is a schematic cross-section of a further embodiment.

[0010] In Figures 2-5, parts which are similar to those shown in Figure 1 are denoted by the same reference numerals and will not be further described unless necessary.

[0011] Referring to Figure 2, an O-ring forms a seal between the body 10 and an enlarged area 16a of the pintle 16, this seal being on the diameter D. The body 10 is formed with a bypass passage 26 which conducts fuel from the fuel inlet 12 to the area beneath the O-ring 24. In this way, the hydraulic forces on the pintle 16 are balanced independently of fuel pressure, and the actuator 20 is opposed by the spring force alone (plus any frictional forces) under all circumstances. Also, the actuator 20 and armature 22 are now dry which increases freedom of material choice.

[0012] Figure 3 is similar, but a metal bellow seal 28 is used instead of the O-ring 24.

[0013] In Figure 4, a bypass passage is not used. An auxiliary spring/seal 30 bears on the top of the pintle 16. The spring/seal 30 is forms a closed partition with respect to the interior of the injector body 10 while being open to ambient pressure via an aperture 32, and may for example by pressed from spring steel.

[0014] The function of the spring/seal 30 is to apply a load to the pintle on the -Y direction, which load varies with hydraulic pressure within the injector body 10. When there is no hydraulic pressure, the spring/seal 31 applies a -Y force governed by its shape and material. As hydraulic pressure rises, this tends to displace the spring/seal 30 in the +Y direction, lessening its force on the pintle 16.

[0015] A similar arrangement is shown in Figure 5, the spring/seal 30 being replaced by a piston 34 sealedly sliding in a bore 36 and biased by an auxiliary spring 38.

[0016] In principle, the same effect could be achieved by replacing the spring 18 with a spring whose biasing force varies with the surrounding pressure.

[0017] Modifications may be made to the foregoing embodiments within the scope of the invention as defined in the claims. For example, the invention may be applied to a fuel injector with an inwardly-opening valve member rather than an outwardly-opening pintle, and to a fuel injector actuated hydraulically or mechanically rather than by a solenoid.

[0018] As noted above, in some embodiments the actuator can be dry, allowing a wider choice of materials; this could improve performance and reduce cost. By eliminating or mitigating hydraulic effects, the invention allows the actuator to be optimised only for speed, which permits the package size to be reduced.

Claims

1. A fuel injector comprising a body (10) defining a fuel inlet (12) and a valve seat (14), a valve member (16) movable with respect to the valve seat (14), and an actuator (20) for selectively moving the valve member (16) between open and closed positions
   characterised by hydraulic force equalising means (24,26,28;30;34,36,38) arranged to counter the effects of hydraulic forces caused by fuel pressure within the injector.

2. A fuel injector according to claim 1, in which the hydraulic force equalising means comprises a bypass passage (26) extending between the fuel inlet (12) and a location on the valve member (16) which is located between the valve seat (14) and a seal (24; 28) formed between the valve member (16) and the valve body (10), said seal (24;28) having a diameter selected to give a desired hydraulic force in one direction.

3. A fuel injector according to claim 2, in which the seal comprises an O-ring (24).

4. A fuel injector according to claim 2, in which the seal comprises a bellows seal (28).

5. A fuel injector according to claim 1, including a main spring (18) urging the valve member (16) in the closing direction, and in which said hydraulic force equalising means comprises an auxiliary spring (30;38) arranged to urge the valve member (16) in the opening direction with a force which decreases as fuel pressure with the injector rises.

6. A fuel injector according to claim 5, in which the auxiliary spring comprises a spring/seal (30) forming a curvilinear partition wall separating the injector interior and fuel pressure therein from ambient, the spring/seal (30) bearing on the inboard end of the valve member (16).

7. A fuel injector according to claim 5, in which the auxiliary spring comprises a coil spring (38) bearing upon a piston (34), the piston (34) being exposed to ambient at one end and to fuel pressure within the injector at the other end, and bearing upon the inboard end of the valve member (16).

8. A fuel injector according to any preceding claim, in which the valve member is an outwardly-opening pintle (16).

9. A fuel injector according to any preceding claim, in which the actuator comprises a solenoid (20).

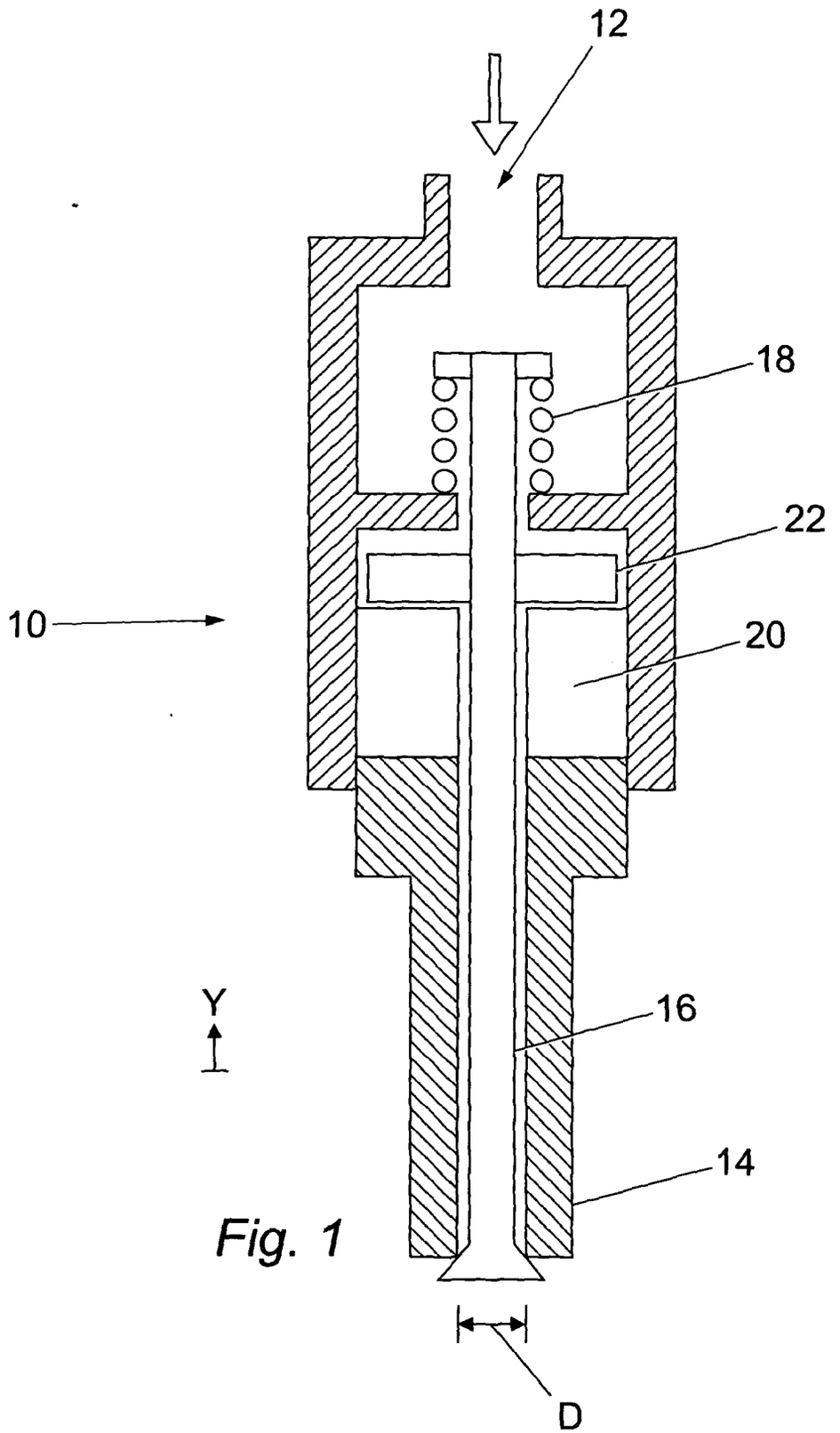

Fig. 1

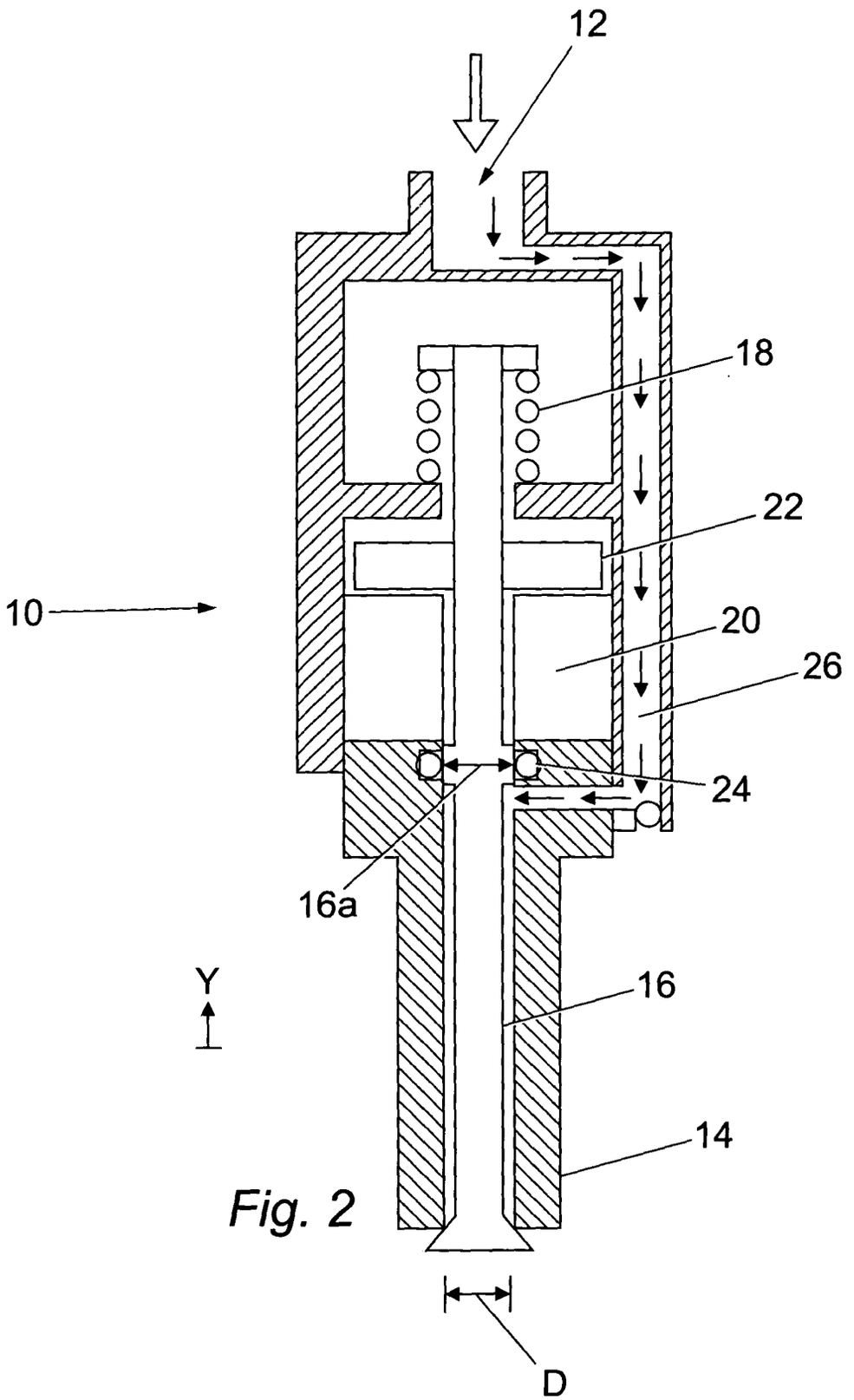

Fig. 2

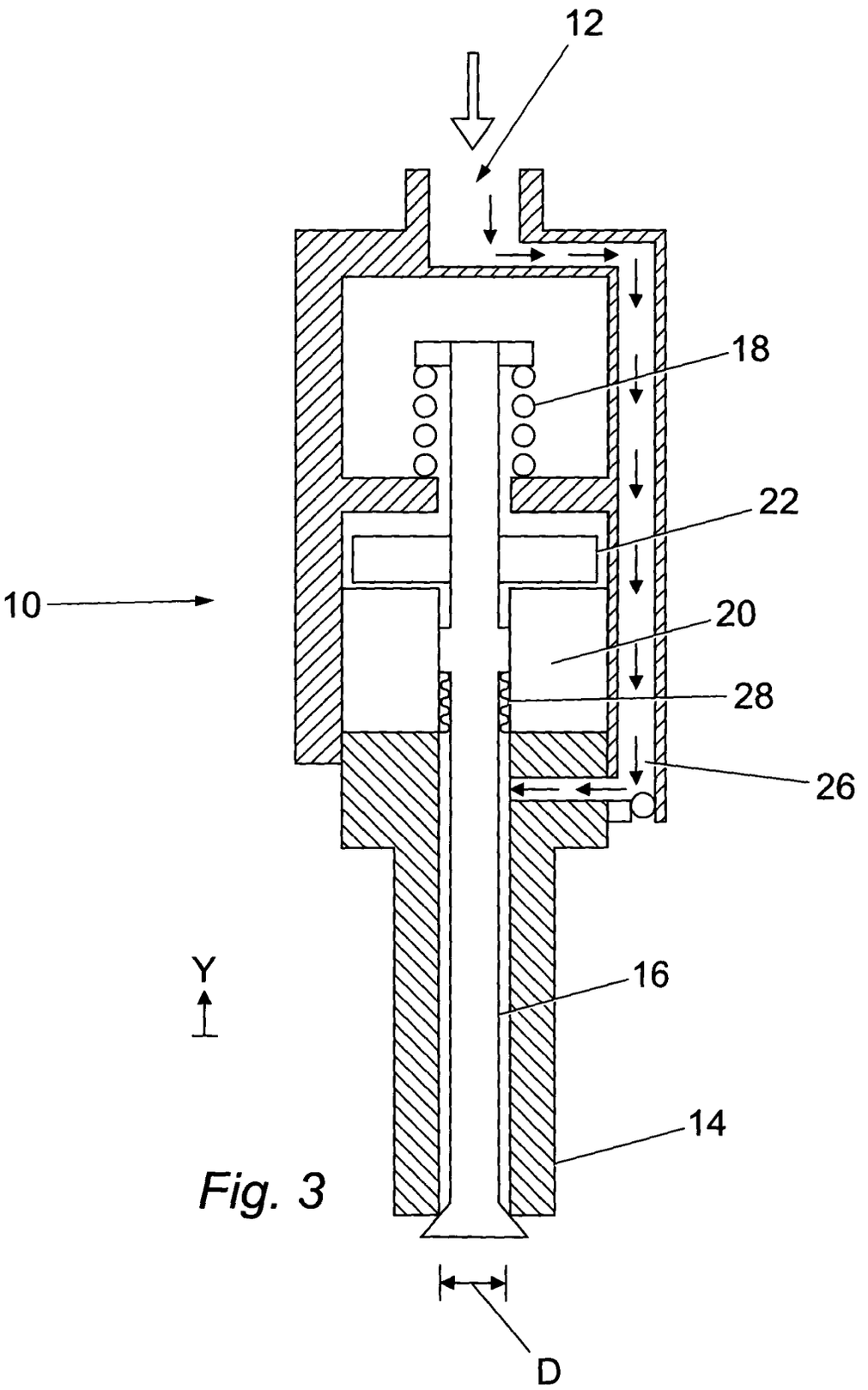

Fig. 3

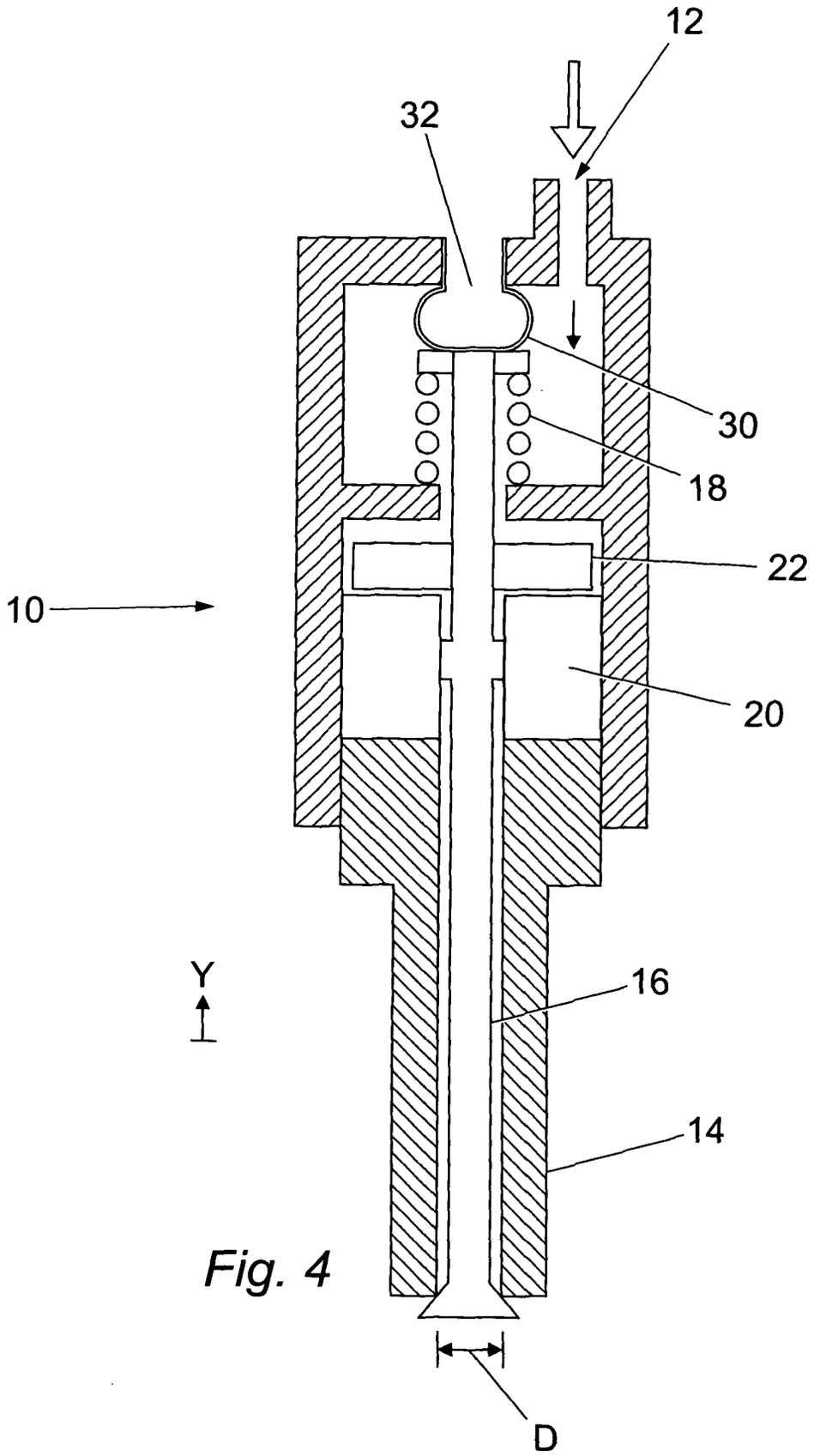

Fig. 4

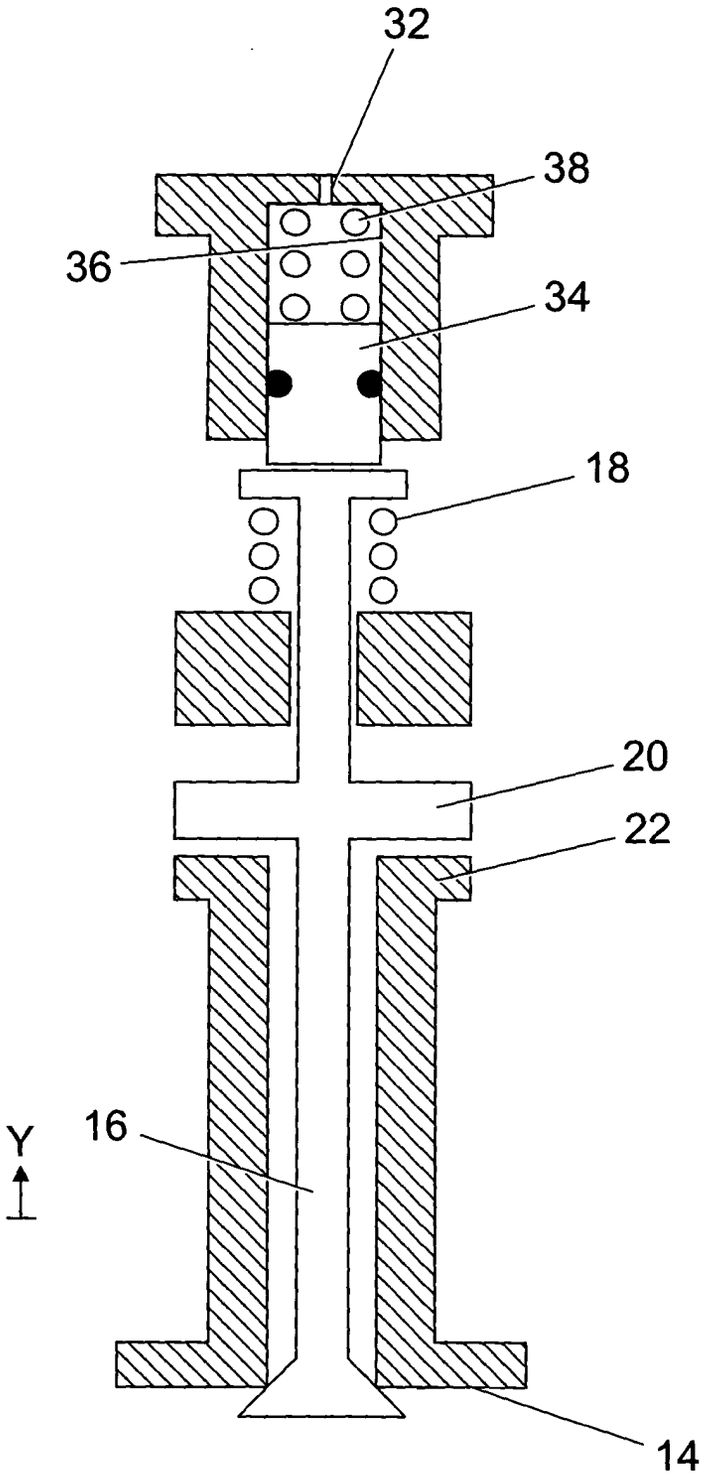

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 04 25 6547

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X Y	US 6 311 950 B1 (GOTTLIEB BERNHARD ET AL) 6 November 2001 (2001-11-06) * column 7, line 36 - line 59; figures 1-4 * -----	1,2,4,8 3,5,9	F02M61/08 F02M51/06
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X	EP 0 404 345 A (GEN MOTORS CORP) 27 December 1990 (1990-12-27) * figures 1,6,8 * -----	1,5,8,9	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
The Hague	30 September 2005	Morales, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 25 6547

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
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