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(54) Perfected electromagnetic fuel injector.

(57) An injector (1) comprising a ferromagnetic armature (2); a ferromagnetic core (3) with an electric coil (4); a ferromagnetic anchor (6) attracted by the core (3), against the action of elastic means (51), when the coil (4) is supplied with electric current; and a fuel injection nozzle (5). The main characteristic of the present invention is that it comprises a plunger (7) operating, along an axis substantially parallel to that along which the anchor (6) is attracted by the core (3), between two positions wherein the nozzle (5) is respectively closed and opened.

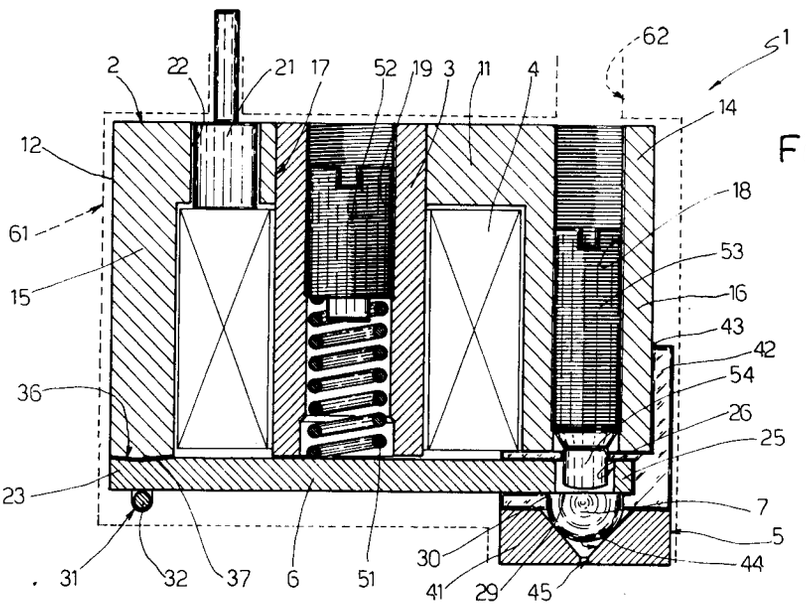

Fig.1

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The present invention relates to an electromagnetic fuel injector, particularly for vehicle internal combustion engines.

Current electromagnetic injectors are all cylindrically symmetrical in design, and comprise a housing having a projecting longitudinal injection nozzle, and fitted inside with a coaxial plunger for the nozzle, an anchor integral with the plunger, and a core with an electric winding. When current is fed through the winding, the core attracts the anchor, so as to move the plunger and so open the nozzle long enough for injecting the fuel. Electromagnetic injectors of the aforementioned type present numerous drawbacks, all due the their cylindrically symmetrical design.

In particular, all the component parts of the injector require high-precision machining (hence, high production cost) for ensuring perfect centering of the components and also of the plunger in relation to the injection nozzle. Moreover, the mass (anchor and plunger) activated on the injector is substantial, thus resulting in relatively sluggish response to the attraction exerted by the core, and in inaccurate fuel supply, which, as is known, depends on how long the injection nozzle is kept open. In addition, fuel supply also depends on the travel of the plunger, so that an increase in supply achieved by increasing the travel of the plunger also results in an increase in the size of the winding on the core and in the size of the injector as a whole.

It is an object of the present invention to provide a perfected electromagnetic fuel injector designed to overcome the aforementioned drawbacks, i.e. featuring components requiring less accurate machining; a reduction in the activated mass, thus providing for improved response time and more accurate fuel supply; and an increase in the travel of the plunger for a given size of the winding.

Further aims and advantages of the present invention will be disclosed in the following description.

According to the present invention, there is provided an electromagnetic fuel injector comprising a ferromagnetic armature; a ferromagnetic core with an electric coil; a ferromagnetic anchor attracted, against the action of elastic means, by said core when said coil is supplied with electric current; and a fuel injection nozzle; characterised by the fact that it comprises a plunger designed to operate, along an axis substantially parallel to that along which said anchor is attracted by said core, between two positions wherein said nozzle is respectively closed and opened.

A preferred non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Fig.1 shows a section of an injector in accordance with the teachings of the present invention;

Fig.2 shows a plan view of the body of the Fig.1 injector;

Fig.3 shows a plan view of a component on the Fig.1 injector;

Fig.4 shows the system and a clip by which the Fig.2 body and Fig.3 component are hinged.

Number 1 in Fig.1 indicates an electromagnetic fuel injector for any known type of internal combustion engine (not shown). Injector 1 comprises an armature 2; a cylindrical core 3; a toroidal electric coil 4 fitted coaxially about core 3; a fuel injection nozzle 5; and an anchor 6 having a first end hinged to armature 2 and a second opposite end supporting a plunger 7 for nozzle 5. Armature 2, core 3 and anchor 6 are made of ferromagnetic material.

As shown in Fig.s 1 and 2, armature 2 comprises a horizontal top plate 11 substantially in the form of an isosceles triangle. As shown particularly in Fig.2, the edge of plate 11 presents a portion 12 representing the bottom side, and two identical oblique portions 13 extending from opposite ends of portion 12 and representing the oblique sides of the isosceles triangle. Plate 11 is formed in one piece with a coplanar, rectangular appendix 14, the longitudinal axis of which coincides with a straight line perpendicular to portion 12 and defining the height of the triangle. Two opposite sides of appendix 14 blend with portions 13, which thus do not converge in a vertex. Appendix 14 is shorter in length than plate 11.

Armature 2 also comprises a vertical plate 15 extending downwards from portion 12 of plate 11, and equal in width to the length of portion 12; and a body 16 having a vertical longitudinal axis, and extending from the lower face of, and having the same section as, appendix 14. In the embodiment shown, plate 15 and body 16 are formed in one piece with plate 11, body 16 being slightly shorter in length than plate 15.

As shown in Fig.1, in the center portion of plate 11 there is formed a vertical through hole 17 inside which core 3 is fitted with its top end flush with the upper face of plate 11, and its bottom end halfway between the bottom end of plate 15 and the bottom end of body 16. Core 3 presents a threaded axial through hole 19. Along appendix 14 and body 16 there is formed a threaded vertical through hole 18. In the space defined between plate 15 and body 16, core 3 is surrounded by coil 4 from which originate connectors 21 extending upwards through respective holes 22 formed through plate 11 between portion 12 and hole 17. Connectors 21 are connected to an electrical source (not shown) and provide for supplying coil 4.

As shown in Fig.s 1 and 3, anchor 6 is fitted

parallel to plate 11, beneath the bottom ends of plate 15 and body 16, and is defined by a horizontal plate of substantially the same shape as plate 11. In particular, the edge of anchor 6 presents a portion 23 of the same length as and lying in the same vertical plane as portion 12; and two oblique portions 24. Anchor 6 is formed in one piece with a coplanar, rectangular appendix 25, two opposite sides of which blend with portions 24, which thus do not converge in a vertex. Though appendix 25 is longer than appendix 14, the combined length of anchor 6 and appendix 25 is less than that of plate 11 and appendix 14. The free end of appendix 25 is in the form of an arc.

As shown in Fig.s 1 and 3, appendix 25 presents a vertical through hole 26 substantially coaxial with hole 18. On the lower face of appendix 25, hole 26 is closed by a flat face 29 of semispherical plunger 7, which is secured, e.g. by means of weld 30, to the edge of hole 26 on the lower face of appendix 25. The center of the geometrical figure of plunger 7 lies substantially on the longitudinal axis of hole 26.

As shown in Fig.s 1 and 4, portion 23 of anchor 6 is hinged to the bottom end of plate 15. In the embodiment shown, the hinge consists of a clip 31 in turn consisting of an elastically flexible, substantially U-shaped metal segment. Clip 31 presents a center portion 32 contacting the lower face of anchor 6; and two lateral portions 33 extending upwards and each comprising a bent end portion 34 designed to engage a seat 35 formed on the lateral face of plate 15. Two minor provisions are made for improving the efficiency of the hinge. The first involves portion 32, which presents a central undulation, which, by virtue of the selected size of clip 31, provides for contacting the lower face of anchor 6 with a given pressure.

The second consists in forming, on the upper face of portion 23 of anchor 6, a shallow recess 36 parallel to portion 23; and in forming, on the bottom end of plate 15, a short tip 37 designed to engage recess 36. Both recess 36 and tip 37 are V-shaped so as to define between the two a straight line of contact constituting the hinge axis of anchor 6. In Fig.4, recess 36 and tip 37 are accentuated for the sake of clarity.

As shown in Fig.1, nozzle 5 in the embodiment shown consists of a cylindrical body having a recess making it substantially U-shaped. Nozzle 5 presents a base wall 41 parallel to and beneath appendix 25; and two lateral walls 42 extending upwards and surrounding appendix 25 and the bottom portion of body 16 to which they are secured integral by weld 43: On the upper face of wall 41, there is formed a conical prechamber 44, from the bottom of which extends a calibrated injection orifice 45 which comes out through the lower face of wall 41. A number of injection orifices 45 may, of course, be formed. Plunger 7 is pressed on to the surface of prechamber 44 for hydraulically sealing the same.

As shown in Fig.1, hole 19 of core 3 presents a spring 51 contacting the center portion of the upper face of anchor 6. Spring 51 is adjusted by means of a screw 52 screwed inside hole 19 and which presses spring 51 against anchor 6. Injector 1 also presents a system for adjusting the travel of plunger 7, and which consists of a screw 53 screwed inside hole 18, and having an axial end portion 54 extending inside hole 26 and contacted by flat face 29 of plunger 7. The end of portion 54 is rounded.

As shown in Fig.1, injector 1 is fitted inside a housing 61 in which is defined a fuel inlet 62, the fuel outlet being defined by nozzle 5. As housing 61 is hydraulically sealed, injector 1 is immersed entirely inside the fuel. In particular, provision is made inside housing 61 for sealing connectors 21 and nozzle 5. Needless to say, nozzle 5 may be an integral part of, formed in one piece or mechanically integral with, housing 61. Injector 1 may be housed inside the fuel manifold, in which case also, nozzle 5 may be formed in the manifold body.

Injector 1 may be likened to a normally-closed on-off fuel valve. Spring 51 in fact presses on anchor 6 so as to rotate it (Fig.1) clockwise about the hinge point. Plunger 7 is thus pressed against the surface of prechamber 44 so as to seal it hydraulically by virtue of the geometry of both. As on any injector, when current is fed through coil 4, a magnetic flux is produced, which attracts anchor 6 to core 3 against the action of spring 51. The resulting anticlockwise rotation of anchor 6 detaches plunger 7 from the contact surface defined in prechamber 44, thus allowing fuel supply through nozzle 5. The travel of plunger 7 is determined by screw 53, the end portion 54 of which contacts flat face 29 of plunger 7. Due to the design of injector 1, the travel of plunger 7 is naturally greater than the air gap between core 3 and anchor 6.

The advantages of the present invention will be clear from the foregoing description.

In particular, the above design of injector 1 defines a first axis (the longitudinal axis of core 3) along which anchor 6 is drawn towards core 3, and a second axis, parallel to the first, along which the fuel is injected. Such a design provides for advantages in terms of both manufacture and operation.

From the manufacturing standpoint, injector 1 clearly presents fewer components as compared with current types, which components do not require high-precision machining, other than grinding of the taper of prechamber 44. By virtue of the geometrical design of plunger 7 and prechamber 44, effective hydraulic sealing is assured even if

they are not perfectly centered. Semispherical plunger 7 thus acts as an effective, and what is more, low-cost sealing element. Moreover, when assembling nozzle 5, the sphere of plunger 7 may be used as a reference in relation to armature 2. Being of little or no importance as regards passage of the magnetic flux, screw 53, plunger 7 and nozzle 5 may be made of hard, i.e. mechanically strong, materials, thus further improving hydraulic sealing performance, which, as is known, is more effective between parts of the same material. This also reduces wear on the contact surfaces of screw 53 and plunger 7, unlike similar components on known injectors, which, being affected by the magnetic flux, must be made of ferromagnetic, i.e. mechanically weaker, material and are thus subject to severe wear. At the hinge point, a very small contact surface is defined between anchor 6 and armature 2, which obviously further improves the operating precision of anchor 6. Finally, the fuel inlet may be defined at any point on housing 61, thus simplifying the fuel supply circuit upstream from injector 1. In view of the above considerations, injector 1 is clearly cheap and easy to produce.

From the operating standpoint, injector 1 undoubtedly presents a number of original characteristics. The most obvious is that it provides for rendering operation of anchor 6 independent of the travel of plunger 7, which, by virtue of the design of injector 1, and of anchor 6 in particular, is thus increased and provides for improved dynamic performance of the plunger. The above separation also enables independent adjustment of the operation of anchor 6 and the travel of plunger 7, thus enabling independent adjustment of what is known as static capacity (slope) and dynamic capacity (offset). Adjustment of the above moving elements is thus not only more accurate but also cheaper, for the reasons already discussed in connection with precision machining of the components. Another point to note is the reduced activated mass of injector 1, which provides for relatively rapid response to the attraction exerted by the core and, consequently, more accurate fuel supply which, as is known, depends on the opening time of the injection nozzle. Moreover, as fuel supply also depends on the travel of the plunger, injector 1, as compared with known injectors, provides for assembling a smaller, compact coil for a given travel of the plunger, or vice versa, for increased travel of the plunger and, consequently, increased fuel supply for a given coil size.

To those skilled in the art it will be clear that changes may be made to the injector as described and illustrated herein without, however, departing from the scope of the present invention.

For example, the hinge system of anchor 6 may be other than as described herein, and consist, for example, of a thin music wire spot welded electrically to anchor 6 and plate 15; nozzle 5 may present a number of injection orifices 45; and injector 1 may be installed in a housing or fuel manifold with which nozzle 5 may be formed in one piece or made mechanically integral.

Claims

1. An electromagnetic fuel injector comprising a ferromagnetic armature (2); a ferromagnetic core (3) with an electric coil (4); a ferromagnetic anchor (6) attracted, against the action of elastic means (51), by said core (3) when said coil (4) is supplied with electric current; and a fuel injection nozzle (5); characterised by the fact that it comprises a plunger (7) designed to operate, along an axis substantially parallel to that along which said anchor (6) is attracted by said core (3), between two positions wherein said nozzle (5) is respectively closed and opened.

2. An injector as claimed in Claim 1, characterised by the fact that said plunger (7) is mechanically integral with said anchor (6).

3. An injector as claimed in Claim 2, characterised by the fact that said anchor (6) presents a first end hinged to said armature (2), and a second end supporting said plunger (7); attraction by said core (3) being exerted on a center portion of said anchor (6).

4. An injector as claimed in Claim 3, characterised by the fact that said armature (2) comprises a horizontal top plate (11); a vertical plate (15) extending from a first end of said horizontal plate (11); and a vertical body (16) extending from a second end of said horizontal plate (11); said anchor (6) being hinged to said vertical plate (15); said plunger (7) being substantially coaxial with said body (16); and said core (3) being supported on a center portion of said horizontal plate (11).

5. An injector as claimed in Claim 4, characterised by the fact that said body (16) houses means (53) for adjusting the travel of said plunger (7).

6. An injector as claimed in Claim 4 and/or 5, characterised by the fact that said core (3) houses means (52) for calibrating said elastic means (51).

7. An injector as claimed in at least one of the foregoing Claims from 4 to 6, characterised by

the fact that said horizontal plate (11) is shaped substantially in the form of an isosceles triangle; the edge of said horizontal plate (11) presenting a first portion (12) representing the base side, and two identical oblique second portions (13) extending from opposite ends of said first portion (12) and representing the oblique sides of said isosceles triangle.

8. An injector as claimed in Claim 7, characterised by the fact that said horizontal plate (11) is formed in one piece with a first coplanar, short, rectangular appendix (14); the longitudinal axis of said first appendix (14) coinciding with a straight line perpendicular to said first portion (12) and defining the height of said triangle; two opposite sides of said first appendix (14) blending with said second portions (13).

9. An injector as claimed in Claim 8, characterised by the fact that said vertical plate (15) extends downwards from said first portion (12) of said horizontal plate (11); and that said body (16) extends downwards from the lower face of said first appendix (14).

10. An injector as claimed in Claim 9, characterised by the fact that said center portion of said horizontal plate (11) presents a first vertical through hole (17) housing said core (3); said core (3) having its top end flush with the upper face of said horizontal plate (11) and its bottom end halfway between the bottom end of said vertical plate (15) and the bottom end of said body (16); said core (3) also presenting a second threaded axial through hole (19).

11. An injector as claimed in Claim 10, characterised by the fact that said second hole (19) houses said elastic means (51) pressing on the upper face of said anchor (6), and a screw (52) for calibrating said elastic means (51).

12. An injector as claimed in Claim 10 and/or 11, characterised by the fact that, in the space defined between said vertical plate (15) and said body (16), said coil (4) is fitted about said core (3); a number of connectors (21) extending upwards from said coil (4) through respective third through holes (22) formed in said horizontal plate (11) between said first portion (12) and said first hole (17), and being connected to an electrical source.

13. An injector as claimed in at least one of the foregoing Claims from 9 to 12, characterised by the fact that said anchor (6) is installed parallel to said horizontal plate (11) and beneath the bottom ends of said vertical plate (15) and said body (16); said anchor (6) being defined by a horizontal plate of substantially the same shape as said horizontal plate (11); the edge of said anchor (6) presenting a third portion (23) of the same length and lying in the same vertical plane as said first portion (12), and two fourth oblique portions (24).

14. An injector as claimed in Claim 13, characterised by the fact that said anchor (6) is formed in one piece with a second coplanar rectangular appendix (25), two opposite sides of which blend with said fourth portions (24); said second appendix (25) being longer than said first appendix (14); and the combined length of said anchor (6) and said second appendix (25) being less than that of said horizontal plate (11) and said first appendix (14).

15. An injector as claimed in Claim 14, characterised by the fact that said second appendix (25) presents a fourth vertical through hole (26) closed, on the lower face of said second appendix (25), by a face (29) of said plunger (7).

16. An injector as claimed in Claim 15, characterised by the fact that, in said first appendix (14) and said body (16), there is formed a fifth threaded vertical through hole (18) substantially coaxial with said fourth hole (26); a screw (53) being screwed inside said fifth hole (18) and presenting an axial end portion (54) extending inside said fourth hole (26) and which is contacted by said face (29) of said plunger (7).

17. An injector as claimed in any one of the foregoing Claims, characterised by the fact that said plunger (7) is semispherical.

18. An injector as claimed in Claim 17, characterised by the fact that said nozzle (5) presents a conical prechamber (44) and at least one injection orifice (45); said plunger (7) acting inside said prechamber (44).

19. An injector as claimed in Claim 13, characterised by the fact that said third portion (23) of said anchor (6) is hinged to the bottom end of said vertical plate (15); said hinge consisting of a clip (31) in turn consisting of a flexible, substantially U-shaped metal segment having a preferably undulated center portion (32) contacting the lower face of said anchor (6), and

two lateral portions (33) extending upwards and each comprising a bent end portion (34) engaging a seat (35) formed in the lateral face of said vertical plate (15).

20. An injector as claimed in Claim 19, characterised by the fact that the upper face of said anchor (6) presents a shallow recess (36) parallel to said third portion (23), and the bottom end of said vertical plate (15) presents a short tip (37) engaging said recess (36); both said recess (36) and said tip (37) being V-shaped, so as to define a straight line of contact constituting the hinge axis of said anchor (6).

21. An injector as claimed in Claim 18 and dependent on Claim 14, characterised by the fact that said nozzle (5) presents a base wall (41) parallel to and beneath said second appendix (25), and two lateral walls (42) extending upwards about said second appendix (25) and the bottom portion of said body (16) with which they are mechanically integral; said prechamber (44) being formed on the upper face of said base wall (41), and from the bottom of which extends at least one of said injection orifices (45).

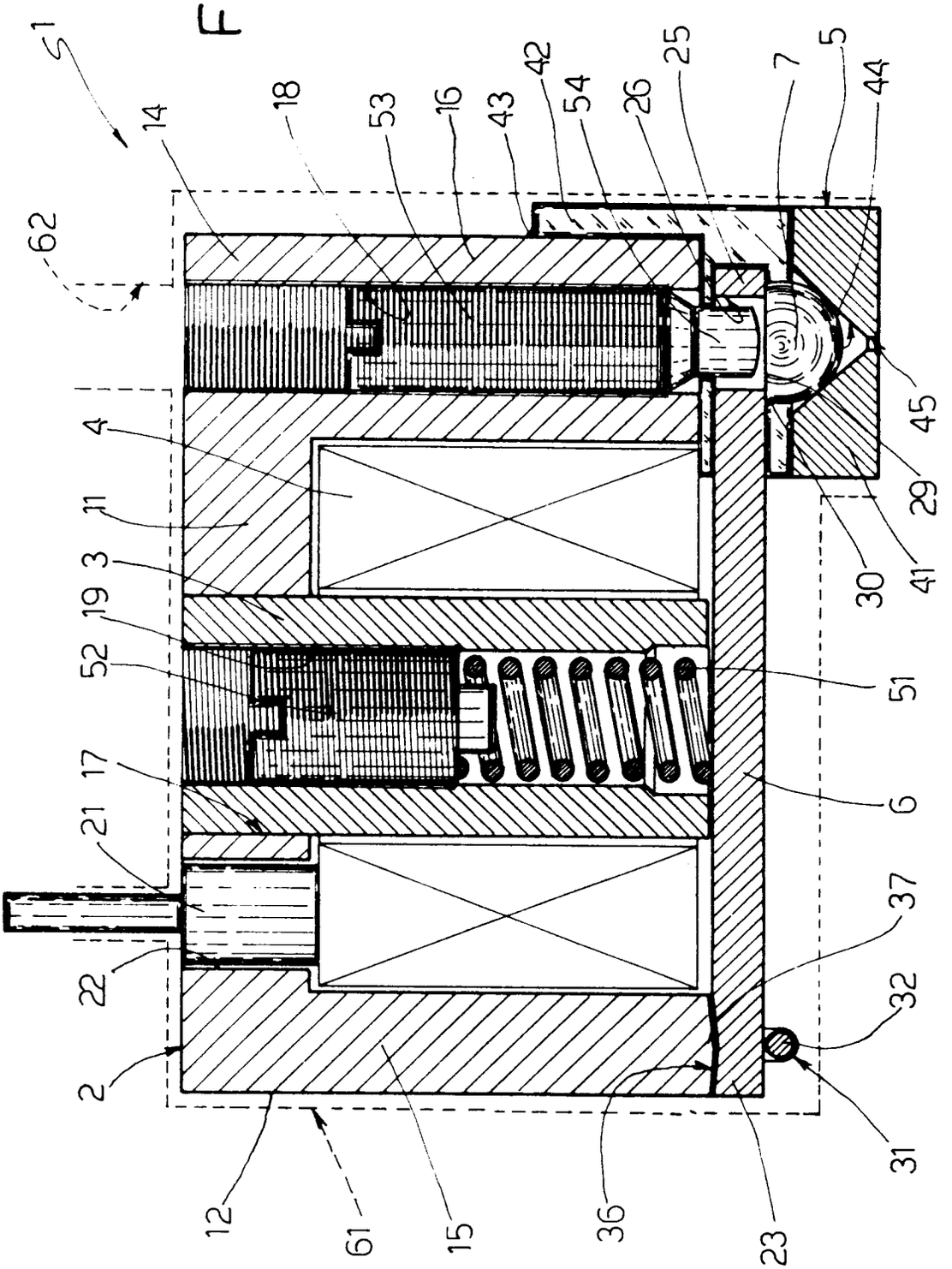
22. An injector as claimed in any one of the foregoing Claims, characterised by the fact that it is housed inside a housing (61) in which a fuel inlet (62) is defined; the fuel outlet being defined by said nozzle (5); and said housing (61) being hydraulically sealed so that the injector is totally immersed in the fuel.

23. An injector as claimed in Claim 22, characterised by the fact that said nozzle (5) is formed on a portion of said housing (61).

24. An injector as claimed in any one of the foregoing Claims from 1 to 21, characterised by the fact that it is installed in a fuel manifold.

25. An injector as claimed in Claim 24, characterised by the fact that said nozzle (5) is formed on a portion of said manifold.

Fig.1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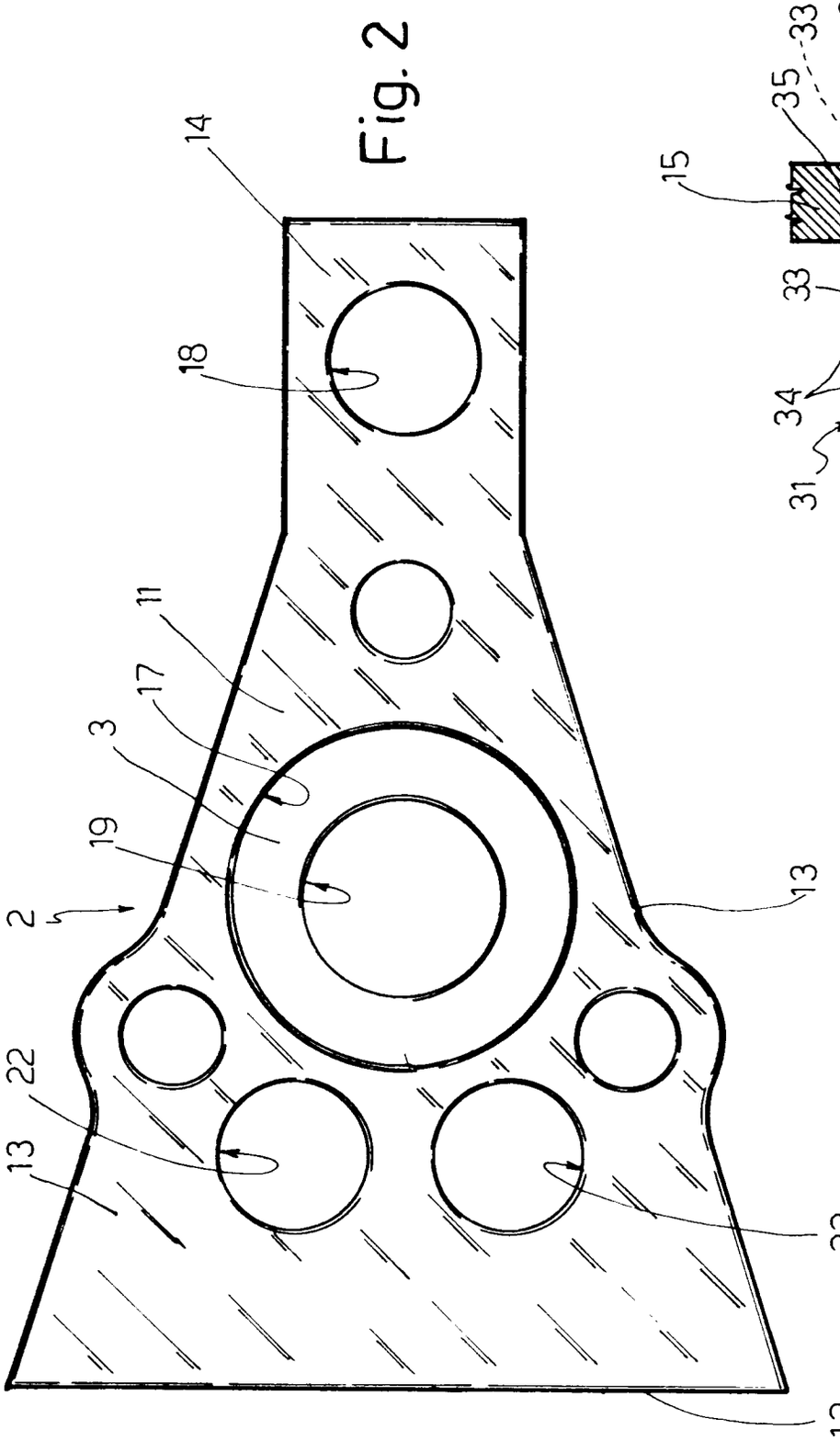

Fig. 2

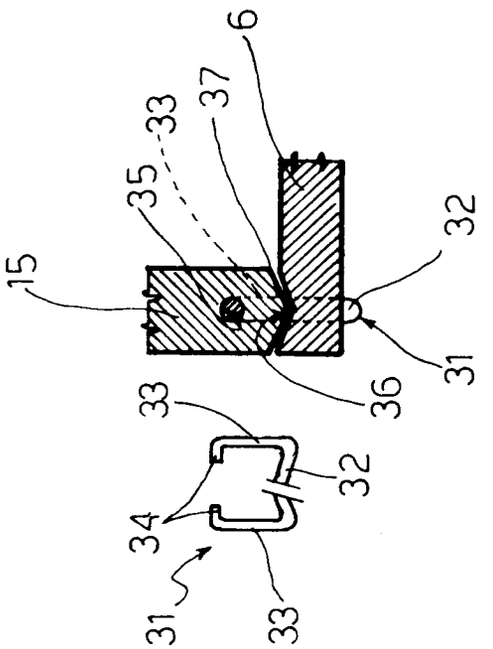

Fig.4

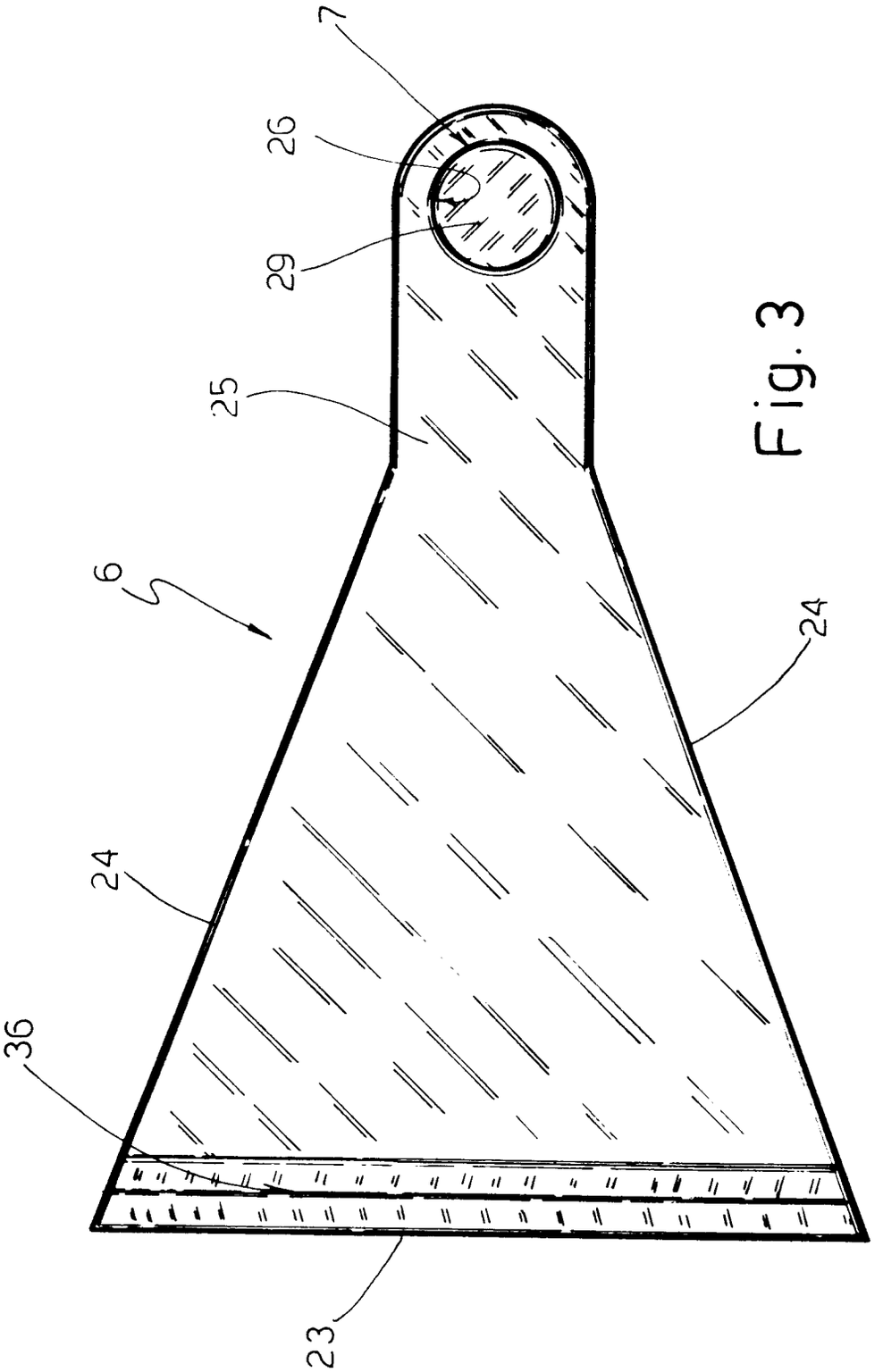

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number

EP 91 12 0337

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.5)
X A	FR-A-2 384 122 (THE BENDIX CORPORATION) * page 17, line 37 - page 20, line 40 * * figures 11-14 * ---	1 2-6,22, 23	F02M51/06
X A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 342 (M-536)(2398) 19 November 1986 & JP-A-61 142 358 (HITACHI LTD) 30 June 1986 * abstract * -----	1 2-5,22, 23	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	02 MARCH 1992	KLINGER T.G.

CATEGORY OF CITED DOCUMENTS

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