(12) UK Patent Application (19) GB (11) 2567201 (13) A

(43) Date of A Publication 10.04.2019

(21) Application No: 1716321.3

(22) Date of Filing: 05.10.2017

(71) Applicant(s):
Delphi Technologies IP Limited
Erin Court, Bishop's Court Hill, St Michael, Barbados

(72) Inventor(s):
Michael Peter Cooke

(74) Agent and/or Address for Service:
Delphi France SAS
c/o Delphi Technologies, Campus Saint Christophe, Batiment Galilee 2, 10 avenue de l'Entreprise, 95863 Cergy Pontoise CEDEX, France (including Overseas Departments and Territories)

(51) INT CL:
F02M 51/06 (2006.01) ***F02M 63/00*** (2006.01)

(56) Documents Cited:
WO 2017/063972 A1

(58) Field of Search:
INT CL **F02M**
Other: **WPI, EPODOC, Patent Fulltext**

(54) Title of the Invention: **Fuel Injector**
Abstract Title: **Fuel Injector**

(57) A fuel injector (10, Fig. 1) is provided with an electromagnetic actuator assembly (12, Fig. 2) having a solenoid 56 wound around a pole piece 60 fixed to the actuator body, the pole piece 60 being axially press-fitted in an upper chamber (20, Fig. 2) and a fluid communication 61 between the upper chamber (20, Fig. 2) and a nozzle chamber (44, Fig. 2) is defined, at least partially, by a hole provided in the pole piece, the magnetic armature 58 being, in use, immersed in high pressure fuel, the solenoid 56 being outside said high pressure zone.

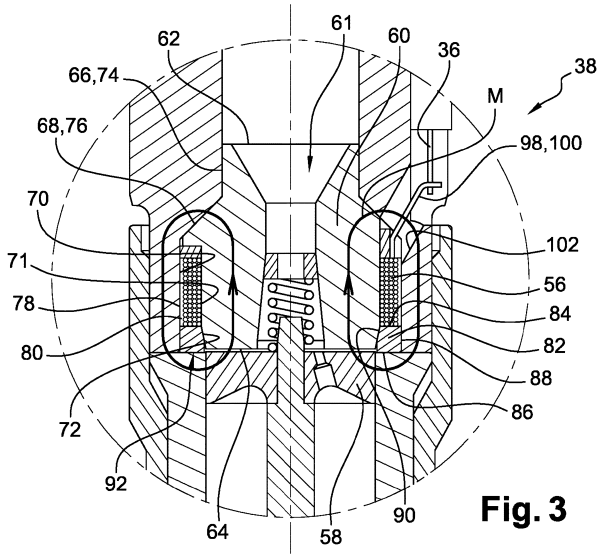

Fig. 3

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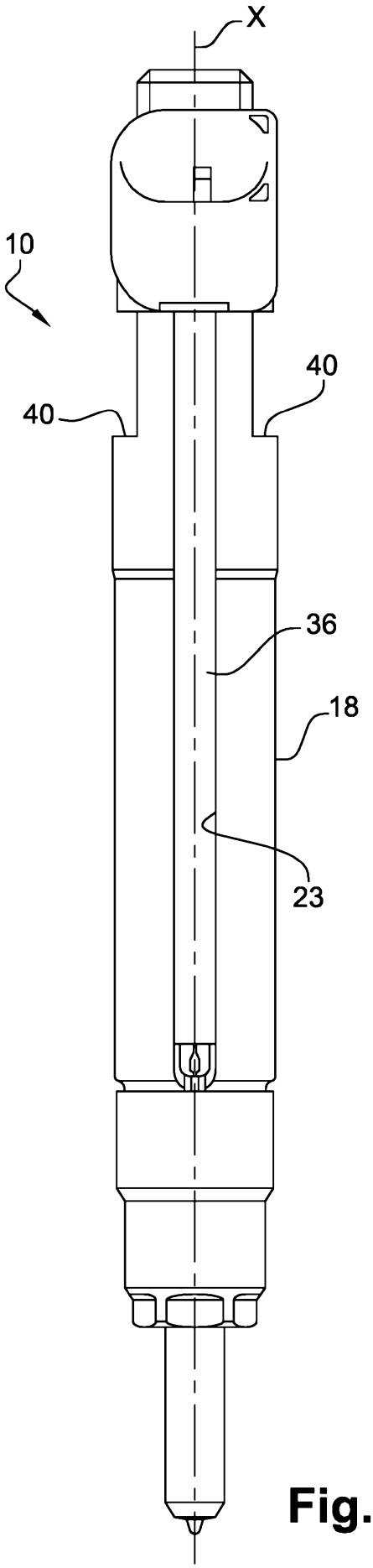
X
10
40
40
36
18
23

Fig. 1

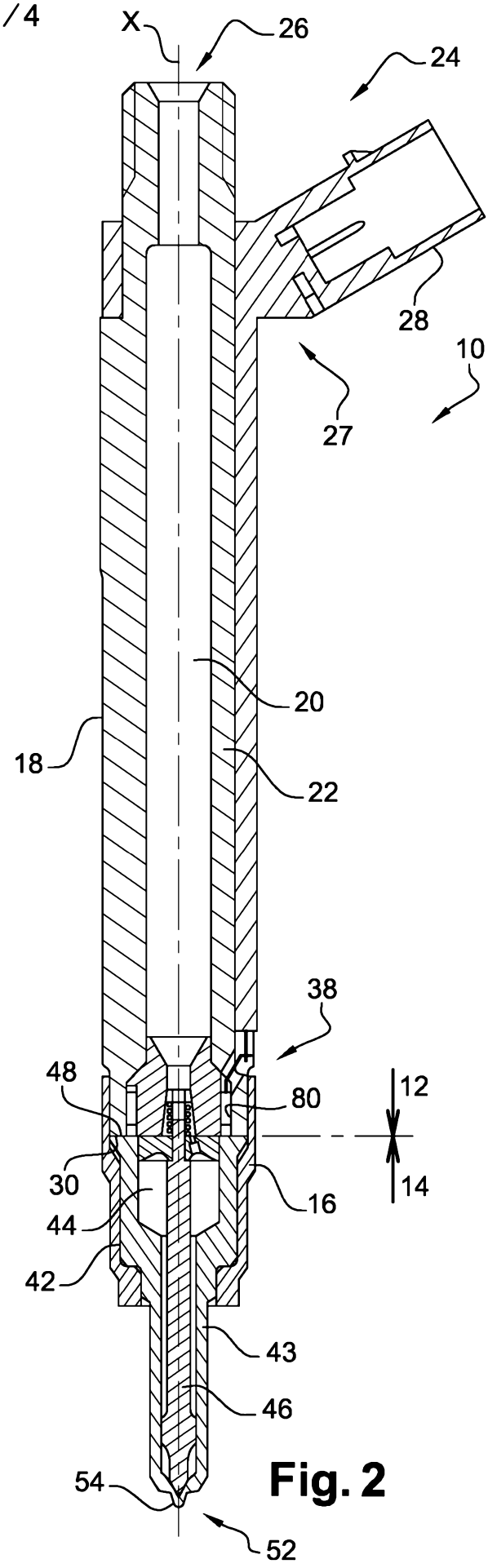
X
26
24
28
10
27
20
18
22
38
48
80
12
14
30
16
44
42
43
46
54
52

Fig. 2

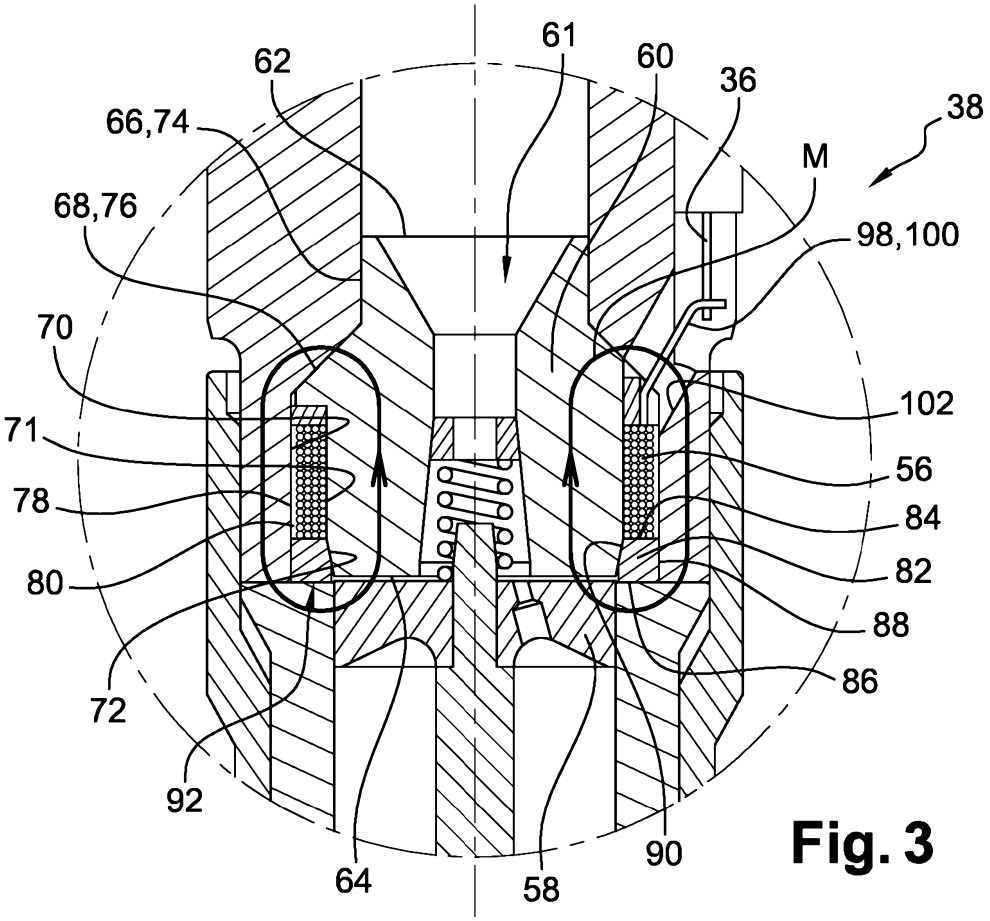
61
62
60
36
38
66,74
M
68,76
98,100
70
102
71
56
78
84
80
82
88
86
72
92
64
58
90

Fig. 3

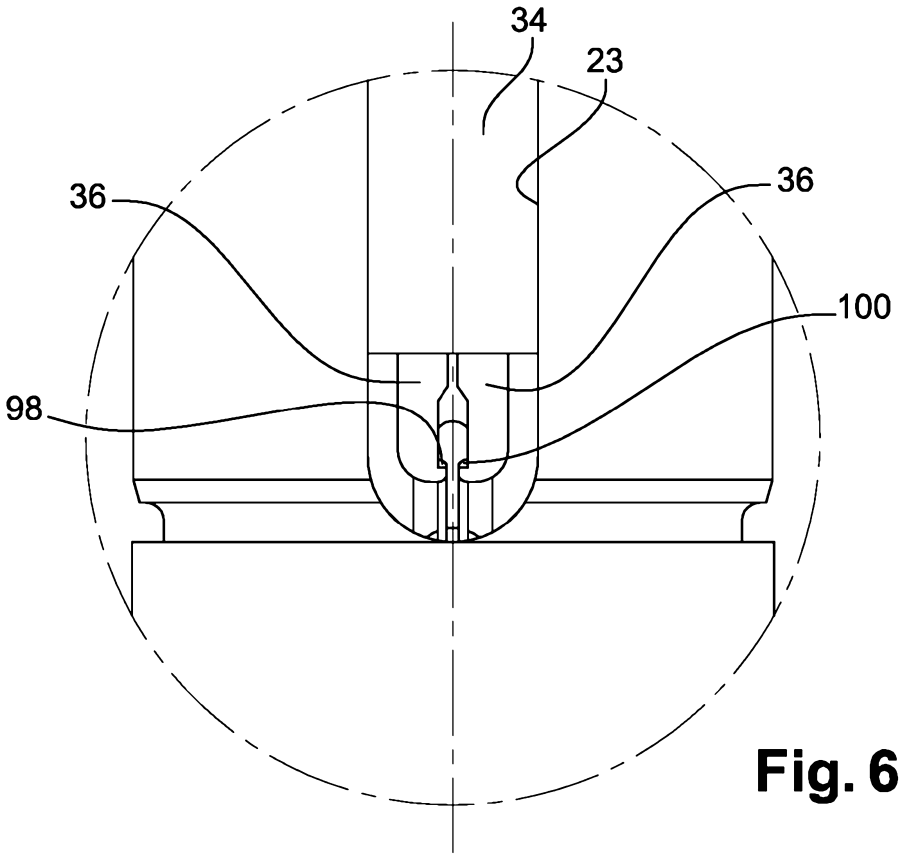
34
23
36
36
100
98

Fig. 6

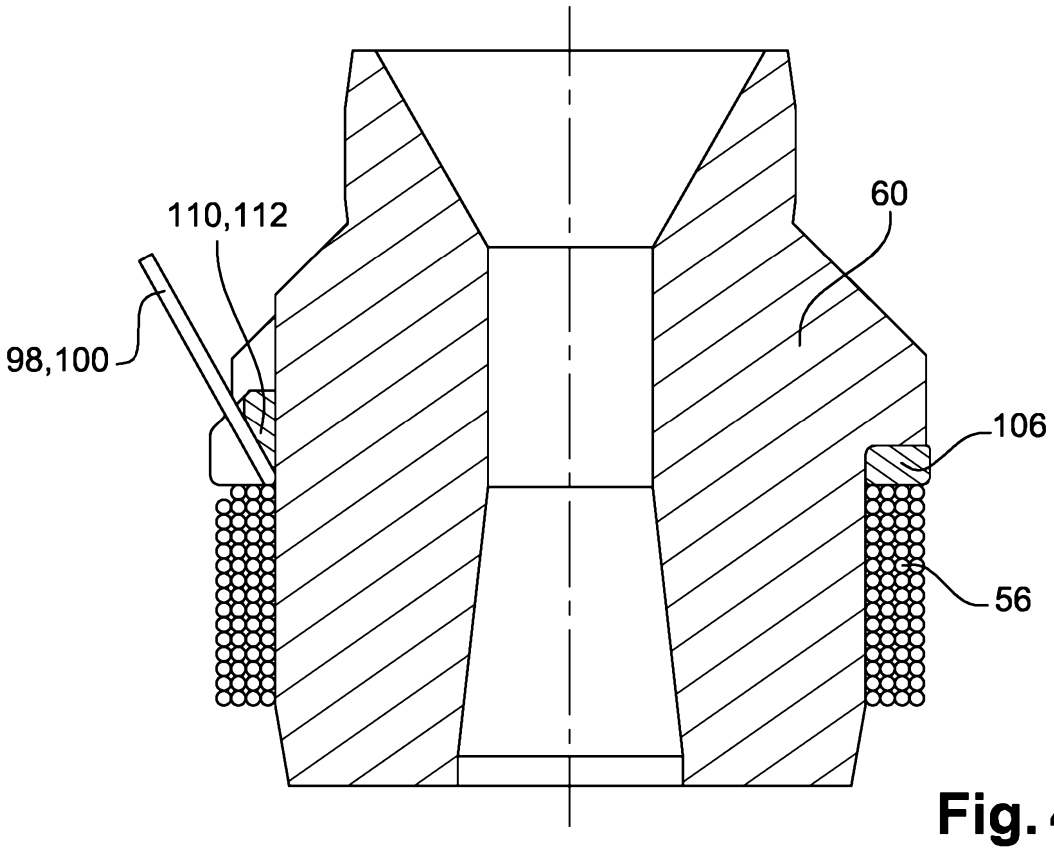

Fig. 4

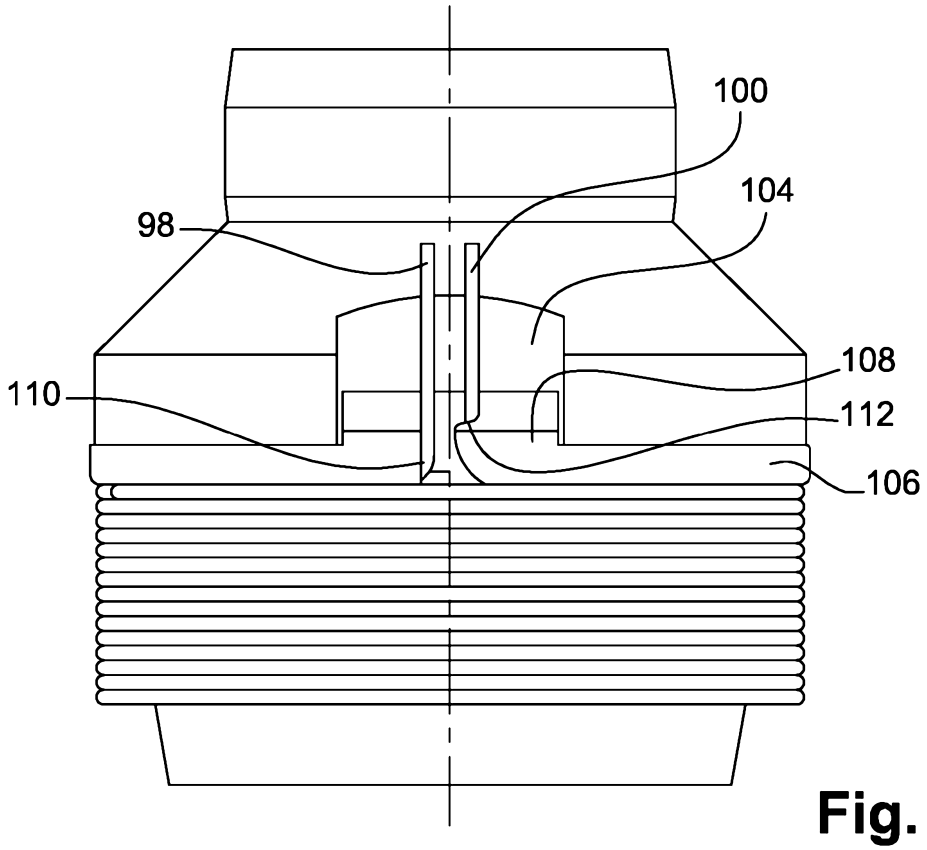

Fig. 5

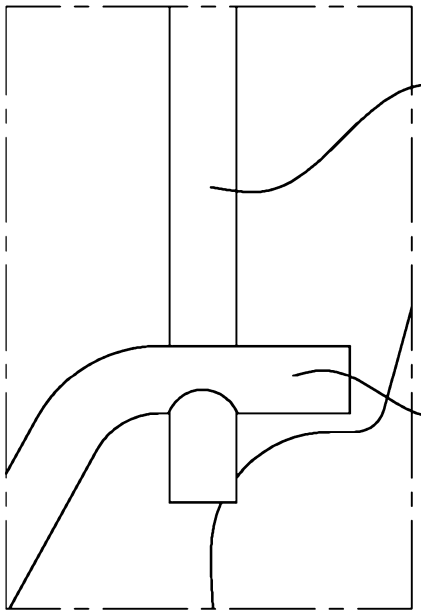

Fig. 7

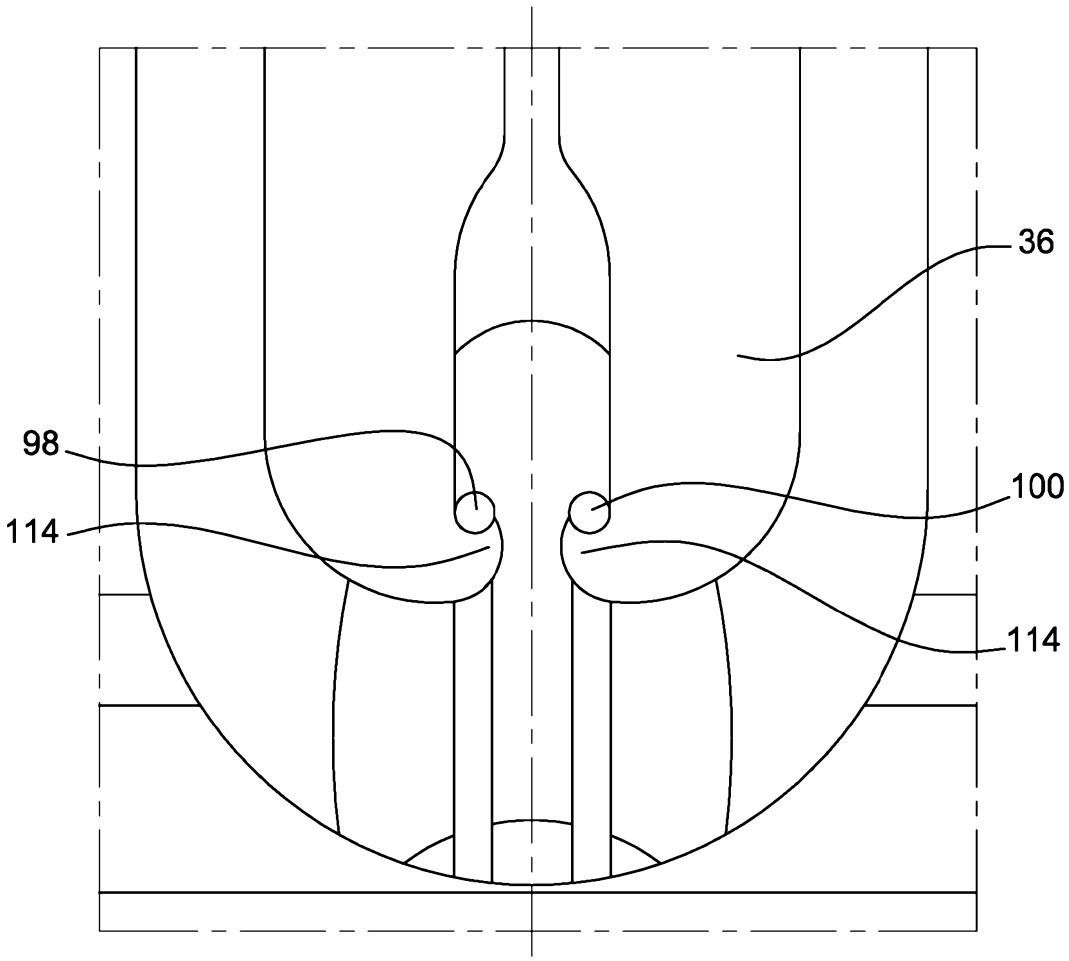

Fig. 8

FUEL INJECTOR

TECHNICAL FIELD

The present invention relates to a direct acting solenoid diesel fuel injector and more particularly to the electric connection of its actuator.

BACKGROUND OF THE INVENTION

For applications such as a direct acting solenoid common rail injector it is desirable to have a solenoid with its pole face in a high pressure environment to transmit forces to components such as a nozzle needle which are within the high fuel pressure fluid that can be 3000 bar and above. It is desirable for the solenoid coil however to be in a low pressure environment as sealing electrical connections at high pressure is difficult and expensive. Also high pressure fluids such as fuels can be aggressive to polymers and can react with the copper used for coil wire. Prior art such as DE102012224247, DE102013218881, DE102013221484, DE102013221536, and DE102013224863 use an axially compressed high pressure sealing component which must have sufficient radial thickness to withstand the pressure difference from inside to outside. The solenoid armature needs to fit through the bore of this sealing component and the coil must be wound around the outside of it. This means that the inner diameter of the coil is significantly larger than the solenoid pole face. Not only does this waste space in the limited diameter available in a typical fuel injector, limiting the force that can be achieved from the solenoid, but the coil wire is longer than necessary which means its resistance and therefore coil heating are higher than desirable (hence the need for special measures such a flat wire and high temperature insulation in DE102013226572). Application GB 1711913.2 and GB 1716285.0 show but don't describe a solenoid construction since their inventions are directed towards how the force required to operate the nozzle is reduced.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing a fuel injector adapted to be part of a direct fuel injection equipment of an internal combustion engine. Said injector is adapted to

be part of a direct diesel fuel injection equipment of an internal combustion engine, said injector extending along a longitudinal axis and it comprises an actuation assembly firmly tightened to a nozzle assembly by a capnut abutting, at an end, on a shoulder of the body of the nozzle assembly and, being screwed, at the other end, onto the body of the actuator assembly. said actuator and nozzle bodies define an inner space divided in an upper chamber in the actuator body and a lower chamber in the nozzle body wherein, in use, high pressure fuel enters said upper chamber via an inlet arranged in the wall of the actuator body and exits via spray holes arranged in the wall of the nozzle body.

Also, said injector is provided with an electromagnetic actuator assembly wherein, a solenoid wound around a pole piece fixed to the actuator body cooperates with a magnetic armature fixed to a nozzle needle guided in the nozzle body, said solenoid generating when electrically energised a magnetic field attracting said armature with sufficient force to move said needle from a closed position to an open position.

Also, the pole piece is axially inserted in the upper chamber and is press-fitted with interference against a cylindrical inner face of the wall of the actuator body and advantageously a fluid communication between the upper chamber and the nozzle chamber is defined, at least partially, by an axial through hole provided in the pole piece, the magnetic armature being, in use, immersed in high pressure fuel, the solenoid being outside said high pressure zone.

Also, the two ends of the coil wire exit the upper chamber via a through hole drilled in the wall of the actuator body, each of said two wire ends being in electrical connection with electric terminals extending from an electric connector arranged on the actuator body at an end distant from the nozzle.

Also, said electrical connection is arranged in the close vicinity to said through hole said electric terminals extending from the connector to said through hole wherefrom the coil wire exit.

Also, said terminals are hook-shaped and said coil wire ends are complementary bent and arranged in said hooks.

Also, the fuel injector further comprises an annular wire guide member arranged against the solenoid around the pole piece for preventing the coil wire from unwinding, said wire guide being provided with a first groove wherein one

of the two wire ends is and, with a second groove wherein the other wire end is, said grooves being shaped to orient said wire ends in said through hole .

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now described by way of example with reference to the accompanying drawings in which:

Figures 1 and 2 are axial views of a fuel injector as per the invention.

Figure 3 is an embodiment of the actuator assembly of the injector of figures 1 and 2.

Figures 4 to 8 detail the electric connection of the actuator assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In reference to the figures 1 and 2 is generally described a diesel fuel injector 10 of a direct injection equipment of an internal combustion engine. Said injector 10 has an elongated shape extending along a longitudinal axis X and it is designed to be inserted and clamped in a well provided in the engine block. The injector 10 comprises an actuation assembly 12, show on the upper part of the figures, and a nozzle assembly 14, said assemblies being fixed together by an injector capnut 16.

The actuation assembly 12 comprises a tubular actuator body 18 defining an inner chamber 20, also identified as upper chamber 20, surrounded by a peripheral wall 22 extending about said longitudinal axis X from an upper end 24, where are provided a fuel inlet 26 and an electric connector 28, to a lower end defining a transverse lower face 30 wherein opens said upper chamber 20, said lower face 30 being limited to the annular area surrounding said opening. The peripheral wall 22 is further provided with a longitudinal groove 23 arranged on its outer face and extending between the upper and the lower ends. Over the upper end 24 of the body is engaged a plastic moulded electric connection assembly 27 defining an opening for said body engagement, and comprising an electrical connector 28 from where extends a lengthy arm wherein are overmoulded electrical terminals 36 overmoulded, said wires being arranged in said longitudinal groove 23.

The actuator body 18 is further provided with flats 40 arranged in the upper part in the vicinity to the inlet 26 and of the connector 28 so that when arranged on the engine the fuel inlet 26, the connector 28 and said flats 40 protrude outside the well enabling clamping of the injector to the engine block.

On the lower part of the injector, the nozzle assembly 14 has a body 42 with a large upper portion joining via an intermediate shoulder, a narrow lower portion, said body 42 defining a peripheral wall 43 surrounding a lower chamber 44 in which is axially X guided a needle valve member 46. The body 42 longitudinally extends from an annular upper face 48 surrounding the opening of the lower chamber to a tip end 52 provided with spray holes 54.

As shown, the lower face 30 of the actuator body is pressed in surface contact against the upper face 48 of the nozzle body, the capnut 16 abutting at an end against said intermediate shoulder of the nozzle body and being firmly tightened at the other end, onto the actuator body 18.

The actuator assembly 38 is an electromagnetic assembly comprising an annular solenoid 56 fixed to the actuator body and cooperating with a disc-like magnetic armature 58 fixed to the valve member 46. The solenoid 56 is wound around a core member 60, or magnetic pole piece 60 that is arranged in the lower end of the upper chamber 20, said pole piece 60 being substantially cylindrical and axially extending from an upper face 62, facing said upper chamber 20 to an opposed transverse under face 64 facing the lower chamber 44 in the nozzle body. Between said opposed faces 62, 64 the pole piece 60 has a peripheral face complementary inserted in the lower end of the actuator body, the under face 64 being in approximately flush surface continuity with the lower face 30 of the actuator body.

As shown on figure 3 the pole piece 60 is provided with an axial through hole 61 opening in said opposed upper and under faces 62, 64, said hole 61 defining a fluid communication between the upper and lower chambers. The pole piece 60 outer face comprises coaxial faces defining a thin cylinder on the upper part close to the upper face 62, an intermediate conical thrust face enlarging said thin cylinder to join a larger cylinder on the lower part close to the lower face 64 and, a final small conical face narrowing the large cylinder when joining the under face 64. As shown on the figures, the larger cylindrical face has a smaller

diameter than the larger end of the conical face, defining an annular space in which is wound the solenoid.

The inner face of the peripheral wall 22 of the actuator body has in the lower end of the upper chamber 20 a profile complementary to the pole piece 60 with a thin cylinder and, a female conical face enlarging to a larger cylinder.

The pole piece 60 is press fitted in the actuator body with interference between the male and the female thin cylinders the intermediate conical faces lying against one another. The large cylindrical faces are concentric and, the annular space in which is arranged the solenoid 56 defines therebetween an annular void 80 that, in use remains at low pressure.

To ensure sealing of said void 80 for avoiding fuel to wet the solenoid 56, the actuator assembly further comprises an annular non-magnetic seal 82 arranged right below the solenoid 56.

The void 80 is sealed by said seal 82, and the low pressure zone wherein the solenoid is, is perfectly separated from the high pressure zone comprising the upper chamber 20 the lower chamber 44 and the through hole 61.

In use, when the solenoid 56 is not energised, the needle valve member, downwardly pushed by a spring compressed between the magnetic armature 58 and an annular seat press fitted in the axial through hole 61 of the pole piece, seats in a closed position of the spray holes 54 preventing injection event and, in said position a small air gap G is defined between the armature 58 and the pole piece 60.

When the solenoid is energised, a magnetic field M is generated and loops around the solenoid circulating within a magnetic circuit comprising the pole piece 60, the actuator body 18, the nozzle body 42 and the armature 58, said field M upwardly attracting the armature 58 closing said air gap G and moving the needle valve member 46 in an open position for enabling fuel injection through the spray holes 54.

The solenoid 58 is arranged in the sealed low pressure void 80 and, the two ends of the coil wire 98, 100 exit said void 80 via a hole 102 drilled through the peripheral wall 22 of the actuator body, said hole 102 opening in the longitudinal groove 23 defined on the outer face of the actuator body 18.

In reference to figures 6 and 7, to prevent unwinding of the coil wire and also to ensure a correct orientation the two coil wire ends 98, 100, a notch 104 is arranged in the pole piece upwardly extending from the annular space 71 and, an annular wire guide 106 is arranged in the annular space 71 between the solenoid and the pole piece, the wire guide 106 being provided with male protrusion 108 complementary registered in the notch 104 therefore preventing the wire guide to rotate around the pole piece. The wire guide 104 is further provided with a first guiding groove 110 guiding the first coil wire end 98 and with a second guiding groove 112 guiding the second wire end 100, said two guiding grooves 110, 112 being arranged in said male protrusion 108 serving to orient the coil wire ends 98, 100 toward the hole 102.

Outside the hole 102, the two ends 98, 100 of the coil wire connect to the two electrical terminals 36 of the connector and as shown on figures 8, 9 and 10, to prepare and ease the welding connection, the ends of the coil wires are bent so the very end of said wires radially extend and, at the end of each of the connector wires is formed a hook 114 adapted to complementary receive said bent ends of the coil wires.

LIST OF REFERENCES

X	longitudinal axis
M	magnetic field
G	air gap
10	fuel injector
12	actuation assembly
14	nozzle assembly
16	capnut
18	actuator body
20	inner chamber - upper chamber
22	peripheral wall of the actuator body
23	longitudinal groove
24	upper end
26	inlet
27	electric connection assembly
28	electric connector
30	lower face
36	electrical terminals

38	actuator assembly
40	flats
42	nozzle body
43	peripheral wall of the nozzle body
44	lower chamber
46	needle valve member
48	upper face
52	tip end of the injector
54	spray holes
56	solenoid
58	magnetic armature
60	magnetic pole piece
61	through hole
62	upper face
64	under face
80	void
82	seal
98	coil wire end
100	coil wire end
102	hole
104	notch
106	wire guide
108	male protrusion
110	guiding groove
112	guiding groove
114	hook

CLAIMS:

1. Fuel injector (10) adapted to be part of a direct diesel fuel injection equipment of an internal combustion engine, said injector extending along a longitudinal axis (X) and comprising an actuation (12) assembly firmly tightened to a nozzle assembly (14) by a capnut (16) abutting, at an end, on a shoulder of the body (42) of the nozzle assembly and, being screwed, at the other end, onto the body (18) of the actuator assembly, said actuator and nozzle bodies (18, 42) defining an inner space divided in an upper chamber (20) in the actuator body and a lower chamber (44) in the nozzle body wherein, in use, high pressure fuel enters said upper chamber (20) via an inlet (26) arranged in the wall of the actuator body and exits via spray holes (54) arranged in the wall of the nozzle body,

said injector being provided with an electromagnetic actuator assembly (38) wherein, a solenoid (56) wound around a pole piece (60) fixed to the actuator body cooperates with a magnetic armature (58) fixed to a nozzle needle (46) guided in the nozzle body, said solenoid (56) generating, when electrically energised, a magnetic field (M) attracting said armature (58) with sufficient force to move said needle (46) from a closed position to an open position, and wherein

the pole piece (60) is axially inserted in the upper chamber (20) and is press-fitted with interference against a cylindrical inner face (74) of the wall of the actuator body and wherein,

a fluid communication between the upper chamber and the nozzle chamber is defined, at least partially, by an axial through hole (61) provided in the pole piece, the magnetic armature (58) being, in use, immersed in high pressure fuel, the solenoid being outside said high pressure zone.

2. Fuel injector (10) as claimed in the preceding claim wherein the two ends of the coil wire (98, 100) exit the upper chamber via a through hole (102) drilled in the wall (22) of the actuator body, each of said two wire ends being in electrical connection with electric terminals (36) extending from an electric connector (28) arranged on the actuator body at an end distant from the nozzle.

3. Fuel injector (10) as claimed in claim 2 wherein said electrical connection is arranged in the close vicinity to said through hole (102), said electric terminals (36) extending from the connector (28) to said through hole (102) wherefrom the coil wire exit.

4. Fuel injector (10) as claimed in claim 3 wherein said terminals (36) are hook-shaped and said coil wire ends are complementary bent and arranged in said hooks (114).

5. Fuel injector (10) as claimed in any of the claims 2 to 4 further comprising an annular wire guide member (106) arranged against the solenoid around the pole piece for preventing the coil wire from unwinding, said wire guide (106) being provided with a first groove (110) wherein one of the two wire ends is and, with a second groove (112) wherein the other wire end is, said grooves being shaped to orient said wire ends in said through hole (102).

Application No:	GB1716321.3	**Examiner:**	Bryce D'Souza
Claims searched:	1-5	**Date of search:**	13 March 2018

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	WO 2017/063972 A1 (CONTINENTAL) See especially pole piece 13

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F02M

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, Patent Fulltext

International Classification:

Subclass	Subgroup	Valid From
F02M	0051/06	01/01/2006
F02M	0063/00	01/01/2006