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(54) NOZZLE ASSEMBLY AND FUEL INJECTOR

(57) ABSTRACT OF THE DISCLOSURE

A nozzle assembly (26) of a fuel injector (10) comprises a nozzle body (28) defining an inner bore extending along a main axis (X), said bore forming at a first extremity a tapered fixed valve seat (42) adapted to receive in sealing contact a complementary tapered needle seating face (52) of a needle valve slidably arranged in the bore, and adapted to translate along the main axis (X) between a closed position where the needle seating face (52) is in sealing contact with the fixed valve seat (42) and, a fully open position where the needle seating face is lifted away from the fixed valve seat.

The nozzle assembly (26) is further provided with a spring assembly radially compressed between the needle and the bore so that in use, when beginning a lift of the needle (36) from the closed position toward the open position, the tapered needle seating face (52) slides and remains in contact against the fixed valve seat (52) instead of coaxially separating immediately.

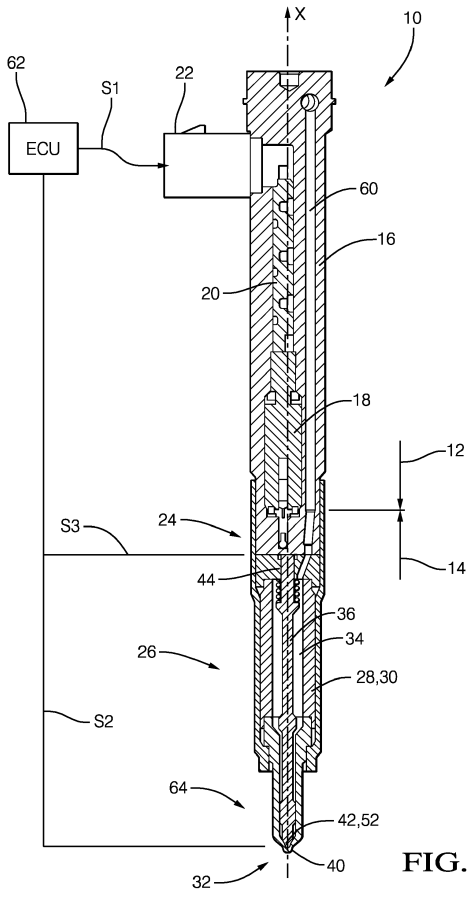

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a nozzle assembly of a fuel injector particularly adapted to close loop control of the injector.

BACKGROUND OF THE INVENTION

[0002] A known fuel injector comprises a nozzle assembly having a cylindrical body defining an inner bore, an extremity of which defining a tapered valve seat face. The nozzle assembly is also provided with a needle valve slidably arranged in the bore, the needle having a tapered extremity defining a complementary tapered valve seating face. In use, the needle valve axially commutes between a closed position where fuel injection is prevented the two complementary tapered faces being in sealing contact and, an open position enabling fuel injection the two complementary tapered faces being distant from each other. The needle valve and the bore are designed to be coaxial so that when initiating an opening displacement the tapered faces immediately split from each other.

[0003] In reality, due to manufacturing tolerances, fuel pressure and other operating conditions, the needle is not perfectly coaxial to the bore and, when initiating an opening displacement the tapered valve seat face of the needle slides against the tapered valve seating face of the bore. During this sliding phase, the tapered faces remain in contact while the needle is no longer in closed position and fuel injection has started through injection holes.

[0004] In close loop control fuel injection equipment, the injector is provided with a first electrical circuit for commanding displacement of the needle, and also with a second electrical circuit for monitoring the needle position. The second circuit is closed when the tapered faces are in contact and, said second circuit is open when the tapered faces are split away. A control unit is arranged to deliver a command signal to the actuator via the first circuit, and to receive a needle position signal from the second circuit, the command signal being computed in a command unit (ECU) as a function of the needle position signal.

[0005] Unfortunately, during the sliding phase the second circuit remains closed delivering a position signal corresponding to a closed position of the needle, while in reality the needle has started to lift and fuel injection has been initiated. Furthermore, said sliding phase corresponds to a non-coaxiality of the needle and the bore that is dependent upon each injector and its operating conditions. Certain injectors may have no sliding phase, while others have a much longer sliding phase.

[0006] Technologies have been developed in an attempt to monitor this sliding phase and in particular, coating the tapered faces with resistive piezo material enables the position signal to continuously vary as a function of the contact pressure between the tapered faces. This technology is difficult to implement to ensure that coating will last the expected life span of an injector, to ensure that the delivered signal will not shift during said life span and to ensure proper computing of the command signal. More simple and reliable method is required.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing a nozzle assembly of a fuel injector. The nozzle assembly comprises a nozzle body having a peripheral wall defining an inner bore extending along a main axis. The bore forms at a first extremity a tapered fixed valve seat adapted to receive in sealing contact a complementary tapered needle seating face of a needle valve. The needle valve is slidably arranged in the bore, and it is adapted to translate along the main axis between a closed position where the needle seating face is in sealing contact with the fixed valve seat and, a fully open position where the needle seating face is lifted away from the fixed valve seat.

[0008] Advantageously, the nozzle assembly is further provided with a spring assembly radially compressed between the needle and the bore so that, in use, when beginning a lift of the needle from the closed position toward the open position, the tapered needle seating face slides and remains in contact against the fixed valve seat instead of coaxially separating immediately.

[0009] Particularly, the spring assembly comprises a fixing portion fixed to the needle and a resilient protruding portion protruding from the needle to a distant extremity that is in contact against the bore.

[0010] In an embodiment, the spring assembly is a coil spring fixedly wound around the needle, the last turn of the spring enlarging and separating from the needle toward an extremity contacting the bore.

[0011] In another embodiment the spring assembly is a collar member having a circular base arranged around the needle and an outwardly resiliently bent tong extending from said base toward a distant end in contact with the bore.

[0012] In yet another embodiment, the needle is provided with a radial blind hole in which is arranged the spring assembly.

[0013] More particularly, in said embodiment the spring assembly comprises a spherical pushing member and a spring compressed in the blind hole, the spherical member being outwardly pushed from the hole and biased in contact against the bore.

[0014] In any case, the spring is electrically isolated.

[0015] The invention further extands to a fuel injector having an actuator portion and a nozzle assembly as described above. Said fuel injector is further provided with an electrical circuit that is closed when the needle seating face is in contact with the fixed valve seat, and that is open when the needle seating face is distant from

the fixed valve seat so that an electrical signal S can be obtained said signal S varying as a function of the needle position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The present invention is now described by way of example with reference to the accompanying drawings in which:

Figure 1 is an axial section of a fuel injector as per the invention.
Figure 2 is an axial section magnifying the nozzle end of the injector of figure 1 provided with a spring member as per a first embodiment of the invention.
Figure 3 is a top section of figure 2.
Figure 4 is a top section of a second embodiment of the invention.
Figure 5 is an axial section magnifying the nozzle end of the injector of figure 1 provided with a spring member as per a third embodiment of the invention.
Figure 6 is an isometric view the spring member of figure 5.
Figure 7 and 8 represent a fourth embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] An axial section of a fuel injector 10 is represented on figure 1. The elongated shape of the injector 10 extends along a main axis X, the injector 10 comprising an actuator portion 12 fixedly arranged over a hydraulic portion 14.

[0018] The general top-down orientation of figure 1 is only utilized for easiness and clarity of the description therefore, words and expressions such as "over, under, up, down" may be used without any intent to limit the scope of the invention.

[0019] The actuator portion 12 has a body 16 provided in its lower end with a bore in which is arranged an electromagnetic actuator 18. The actuator 18 is electrically connected via electrical cables 20 to a connector 22 arranged on the top of the injector 10.

[0020] The hydraulic portion 14 comprises a valve member 24 and a nozzle assembly 26, the valve member 24 being fixedly maintained compressed between the bottom of the actuator portion 12 and the nozzle assembly 26.

[0021] The nozzle assembly 26 has a body 28 defined by a peripheral wall 30 downwardly extending toward a bottom tip end 32, said wall 30 defining an inner volume 34 in which is slidably guided along the main axis X an elongated needle valve 36.

[0022] The bottom end of the nozzle body 28, better visible on figure 2, is narrower than the top portion and, the very bottom of the inner volume 34 forms a sac 38 from which injection holes 40 extend through the wall 30 toward an outlet opening in the outer face of the wall. Above said sac 38, the inner face 41 of the wall defines a tapered fixed valve seat 42.

[0023] The needle valve 36 is a shaft comprising several coaxial X cylindrical portions extending from a top guiding portion 44 toward a bottom tip end 46 and, in order to be guided along the main axis X, it is provided with a complementary bottom guiding portion 48 adjusted to slide against an inner guiding portion 50 of the inner face 41 of the nozzle body 28. As visible on the transverse section of figure 3, the cross-section of said bottom guiding portion 48 has an quasi-isosceles triangular shape which three vertices are truncated, rounded and adjusted to the circular profile of said inner guiding portion 50, the three flats extending between the vertices enabling, in use, non-restricting fuel passage toward the injection holes 40. Furthermore, the bottom tip end 46 of the needle defines a tapered seating face 52 complementary adjusted to the tapered fixed valve seat 42 of the body.

[0024] A spring 54 is arranged to permanently generate on the needle valve 36 a radial force F and, figure 2 represents a first embodiment of said spring 54 that is a coil spring fixedly wound around the needle 36 the final turn 56 of the spring enlarging and moving away from the needle so that it comes in pressure contact with the inner face 41 of the nozzle body.

[0025] Being in contact with both the needle and the nozzle body, the spring 54 is electrically isolated. This electrical insolation can be achieved for instance by utilising a spring material having intrinsically isolating properties or, by covering a metallic spring with isolation coating. The coating can entirely cover the spring or can be limited to the end portion of the final turn 56 which contacts the nozzle body also, the coating can be made on the spring 54 alone or after being assembled on the needle, said coating also isolating part of the needle. A further alternative is to arrange on said contact end portion an isolating covering member or capsule.

[0026] The main portion of the spring is wound slightly smaller in section than the needle and, when it is arranged around the needle said main portion is elastically enlarged and engaged in place over the needle prior to be relieved so that it fixedly tighten on the needle. The last turn 56 has resilient properties and it acts as a compression spring against the inner face 41, generating the force F pushing the needle 36 away from the coaxial position.

[0027] As well-known, so just briefly mentioned, the fuel injector 10 further accommodates a high pressure fuel circuit 60 extending through the injector from an inlet arranged by the head of the actuator portion to the injection holes 40. In the nozzle assembly 26 said hydraulic circuit 60 occupies the inner volume 34.

[0028] From an electrical and control stand point, in addition to a command circuit comprising the connector 22 and the cables 20 for transmitting an injection signal S1 from an electronic command unit, hereafter ECU, 62 to the actuator 18, the fuel injector, and more particularly the nozzle assembly 26 is provided with a needle position

electrical circuit 64 adapted to be connected to the ECU 62 for close loop control of the injector. Said circuit 64 comprises the needle valve 36 and the nozzle body 28 that are electrically isolated from each other except for the two tapered faces of the valve seat 42, 52, which are electrically conductive.

[0029] In use, the fuel injector 10 is arranged in an injection equipment (FIE) generally controlled by the ECU 62. Pressurized fuel is received in the high pressure circuit 60 from a high pressure reservoir, such as a well-known common rail. The ECU 62 generates and sends the injection signal S1 to the actuator 18, forcing the needle 36 to slide in the nozzle body 28 and to lift from a closed position PC, where the complementary tapered seating faces 42, 52, are in sealing contact with each other preventing any fuel flow toward the injection holes 40 to, an open position PO where said tapered faces are distant from each other, no longer in contact with each other, enabling fuel flow toward the holes 40 and an injection event. When the needle 36 is in closed position PC, the needle position electrical circuit 64 is closed and, a correspondent closed needle position signal S2 is received by the ECU 62. When the needle 36 is in open position PO, the needle position electrical circuit 64 is open and, a correspondent open needle position signal S3 is received by the ECU 62. The reason for which the spring 54 must be electrically isolated is here clearly apparent since, in case an electrical contact would occur via the spring 54, this would create a permanent short between the needle and the nozzle body permanently closing the needle position electrical circuit 64.

[0030] When the command signal S1 is received by the actuator 18, the needle 36 stars to lift-up and it is radially pushed by the spring 54 away from the coaxial alignment. When initially lifting, the tapered seating face 52 of the needle, instead of immediately splitting away from the fixed valve seat 42 of the body as if the needle were in a perfect coaxial position, it slides against a generatrix of the tapered face maintaining electrical contact between the tapered faces 42, 52, before splitting away. A flow passage to the injection holes 40 is therefore open during said initial opening sliding phase OSP, the electrical needle position circuit 64 being still closed, the ECU 62 receiving the closed needle position signal S2 while the needle is no longer in closed position PC.

[0031] Similarly, when the command signal S1 is interrupted, the needle 36 is biased back toward the closed position PC and, since the needle is radially pushed by the spring 54 when approaching the closing position PC, the tapered faces 42, 52, get in contact with each other and close the needle position electrical circuit 64 before the needle reaches the closed position PC. A flow passage to the injection holes 40 remains therefore open during said final closing sliding phase CSP, the electrical position circuit 64 being already closed, the ECU 62 receiving the closed needle position signal S2 while the needle is not yet in closed position CP.

[0032] Although opening a fuel passage while maintaining closed the position circuit 64 may seem to be contradictory events, the described embodiment provides a major advantage in that the opening sliding phase OSP and the closing sliding phase CSP are reproducible, easily determined, they do not change over time and, they are consistent from an injector to another. Therefore the sliding duration T1 of said opening sliding phase OSP and the sliding duration T2 of said closing sliding phase CSP are known and determined and are taken into account in the close loop command method for controlling the fuel injector 10.

[0033] Furthermore, as it is well-known, in use the relative position of the needle 36 to the nozzle body 28 varies, since the needle 36 may rotate about the main axis X in the nozzle body, the tapered faces 42, 52, not being always in contact along the same generatrix, the sliding phases in opening and in closing varying. In a prior art embodiment where the needle is not radially biased, said variation generates uncontrolled changes in the closed needle position signal S2. Thanks to the embodiment presented where the needle 36 is radially biased, the rotations of the needle 36 inside the nozzle body and consequent changes in sliding contact generatrix have no influence on the closed needle position signal S2. Indeed, the needle is consistently radially biased and, whichever the contact sliding generatrix of the sliding phases is, the misalignment of the needle does not vary and the durations T1, T2, of the sliding phases remain identical.

[0034] A second embodiment of the invention is presented on figure 4 where a resilient member 66 fixedly attached to the needle 36 protrudes from said needle and extends toward contacting the inner face 41 of the nozzle body. The member 66 comprises a fixing portion 68 and a resilient protruding portion 70. For instance, the fixing portion 68 can be cylindrical and inserted in a complementary hole of the needle and therein secured by welding, press-fitting or even by screwing. Also, the resilient protruding portion 70 can be accommodated with various shapes such as being bent by the contacting extremity so that it provides improved resilient properties.

[0035] A third embodiment of the invention is proposed on figures 5 and 6 where a an resilient collar member 72 is arranged around the needle 36.

[0036] The resilient collar member 72 comprises an annular base 74 from which upwardly protrude three T-shaped arms 76 and a resilient tong 78. Said tong 78 is bent so that it firstly extends upwardly from the base 74, then it is curved for half-turn prior to downwardly extend toward a final portion, said final portion of the tong being radially distant from the annular base 74.

[0037] The arrangement of the collar member 72 over the needle 36 is shown on figure 5 where the collar is inserted by the tip end 46 of the needle so the annular base 74 adjusts just below the quasi-triangular bottom guiding portion 48 of the needle. Each of the T-shaped arm 76 upwardly extend along a flat between the vertices so the upper horizontal bar of the T-shaped arm 80 can

be arranged over the guiding portion 48 around the needle. The resilient tong 78 radially extends from the base 74, the final portion of the tong being in resilient contact against the inner face 41 if the nozzle body. There again, the collar 72 is electrically isolated, either entirely or partially limited to the tong 78. Being bent as shown and described, the tong 78 has resilient properties generating the radial force F that biases the needle 36 on the side away from the coaxial X position.

[0038] A fourth embodiment of the invention is now described in reference to figures 7 and 8. As shown, the bottom guiding portion 48 of the needle is provided with a radial blind hole 82 opening in one of the flats that is between the vertices. In said blind hole 82 is arranged a spring 84, for instance a coil spring, and a pin 86 having a cylindrical body 88 and a semi-spherical head 90, the cylindrical body 88 connecting to the head 90 in the centre of the flat under face of the head 90.

[0039] The spring 84 is arranged around the cylindrical body 88 and, in use, said spring 84 get compressed between the bottom end of the blind hole 82 and said flat under face of the head 90, the spherical face 90 of the head being outwardly pushed in contact against the inner face 41 of the nozzle body, so generating the radial force F proportional to the compression of the spring 84 that biases the needle on the side, away from the coaxially aligned position. To ensure the required electrical isolation, the pin 86 can be a made in ceramic or any nonconductive material or, the spherical head 90 can be coated as previously mentioned.

[0040] In an alternative, the pin could be replaced by a spherical ball outwardly pushed by the spring 84, the ball being made in ceramic, or being coated,. This ball alternative enables the rolling of the sphere against the inner face 41 while in the pin alternative the spherical face slides against the inner face 41.

LIST OF REFERENCES

[0041]

X	main axis
S1	command signal
S2	closed needle position signal
S3	open needle position signal
PO	open position
PC	closed position
SP	sliding phase
T1	opening sliding duration
T2	closing sliding duration
P	adjustment parameter
OSP	open sliding phase
CSP	closing sliding phase

10	injector
12	actuator portion
14	hydraulic portion
16	body of the actuator portion
18	actuator
20	cables
22	connector
24	valve member
26	nozzle assembly
28	nozzle body
30	peripheral wall of the nozzle
32	tip end
34	inner volume
36	needle valve
38	sac
40	injection hole
41	inner face of the nozzle body
42	fixed valve seat
44	top guiding portion
46	tip end of the needle
48	bottom guiding portion of the needle
50	inner guiding portion of the nozzle body
52	tapered seating face of the needle
54	coil spring
56	final turn of the spring
60	high pressure hydraulic circuit
62	electrical command unit (ECU)
64	needle position electrical circuit
66	resilient member
68	fixing portion
70	resilient protruding portion
72	resilient collar member
74	annular base
76	T-shaped arm
78	resilient tong
80	horizontal bar of the T-shaped arm
82	blind hole
84	spring
86	pin
88	cylindrical body of the pin
90	spherical head of the pin

Claims

1. Nozzle assembly (26) of a fuel injector (10), said nozzle assembly comprising a nozzle body (28) having a peripheral wall (30) defining an inner bore extending along a main axis (X), said bore forming at a first extremity a tapered fixed valve seat (42) adapted to receive in sealing contact a complementary tapered needle seating face (52) of a needle valve slidably arranged in the bore, and adapted to translate along the main axis (X) between a closed position (PC) where the needle seating face (52) is in sealing contact with the fixed valve seat (42) and, a fully open position (PO) where the needle seating face is lifted away from the fixed valve seat,
characterized in that
the nozzle assembly (26) is further provided with a spring assembly (54, 66, 72, 84, 86) radially compressed between the needle and the bore so that in

use, when beginning a lift of the needle (36) from the closed position (PC) toward the open position (PO), the tapered needle seating face (52) slides and remains in contact against the fixed valve seat (52) instead of coaxially separating immediately.

2. Nozzle assembly (26) as claimed in claim 1 wherein the spring assembly (66) comprises a fixing portion (68) fixed to the needle (36) and a resilient protruding portion (70) protruding from the needle to a distant extremity that is in contact against the bore.

3. Nozzle assembly (26) as claimed in claim 1 wherein the spring assembly (54) is a coil spring fixedly wound around the needle (36), the last turn (56) of the spring enlarging and separating from the needle toward an extremity contacting the bore.

4. Nozzle assembly (26) as claimed in claim 1 wherein the spring assembly (72) is a collar member (72) having a circular base (74) arranged around the needle and an outwardly resiliently bent tong (78) extending from said base toward a distant end in contact with the bore.

5. Nozzle assembly (26) as claimed in claim 1 wherein the needle is provided with a radial blind hole (82) in which is arranged the spring assembly (84, 86).

6. Nozzle assembly (26) as claimed in claim 5 wherein the spring assembly (84, 86) comprises a spherical pushing member (90) and a spring (84) compressed in the blind hole (82), the spherical member (90) being outwardly pushed from the hole and biased in contact against the bore.

7. Nozzle assembly (26) as claimed in anyone of the preceding claims wherein the spring is electrically isolated.

8. Fuel injector (10) having an actuator portion (14) and a nozzle assembly (26) as claimed in claim 5, said fuel injector being further provided with an electrical circuit (64) that is closed when the needle seating face (52) is in contact with the fixed valve seat (42), and that is open when the needle seating face (52) is distant from the fixed valve seat (42) so that an electrical signal (S2) can be obtained said signal (S2) varying as a function of the needle position.

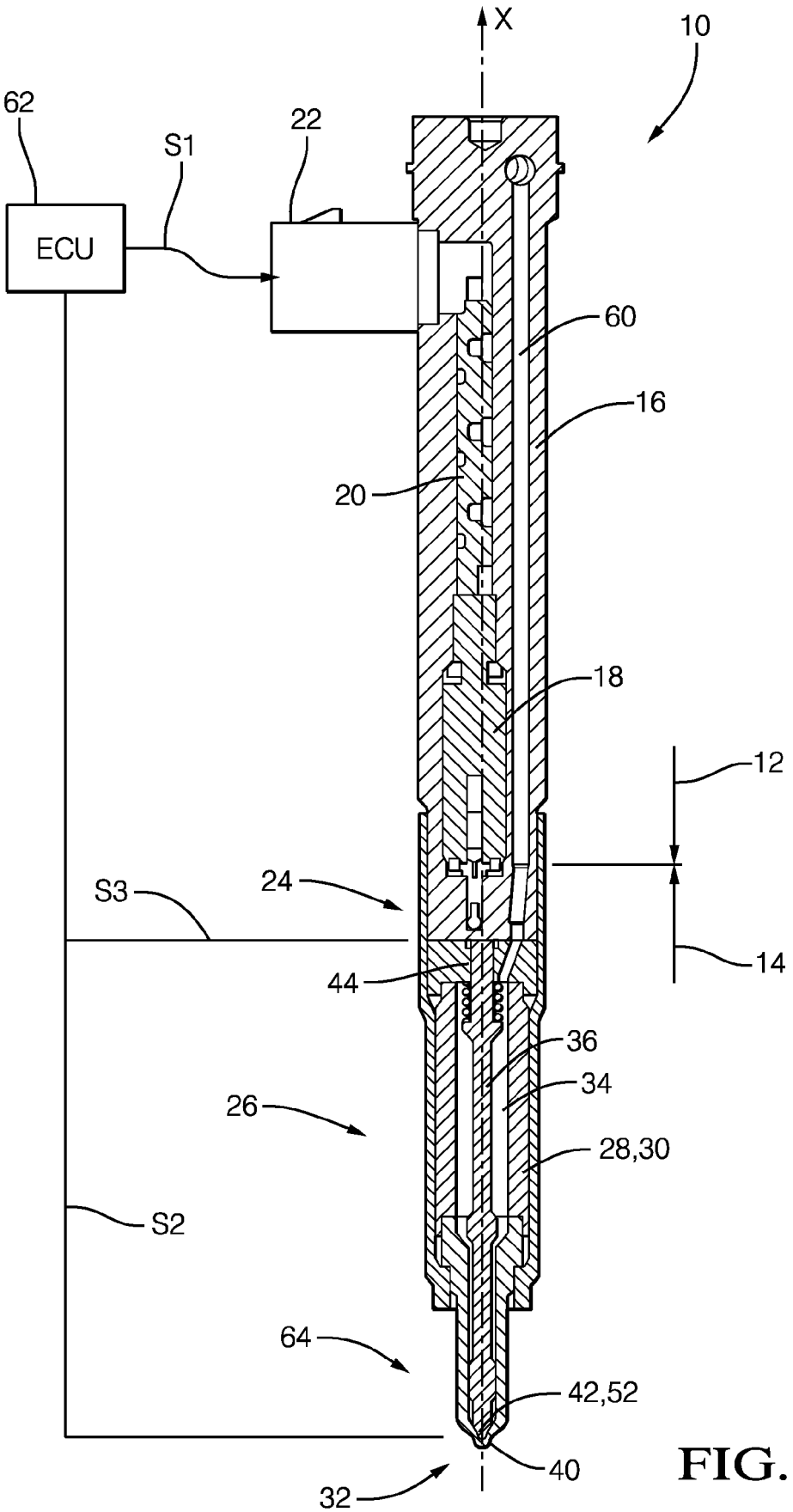
X
10
62
S1
22
ECU
60
16
20
18
12
24
S3
14
44
36
34
26
28,30
S2
64
42,52
40
32

FIG. 1

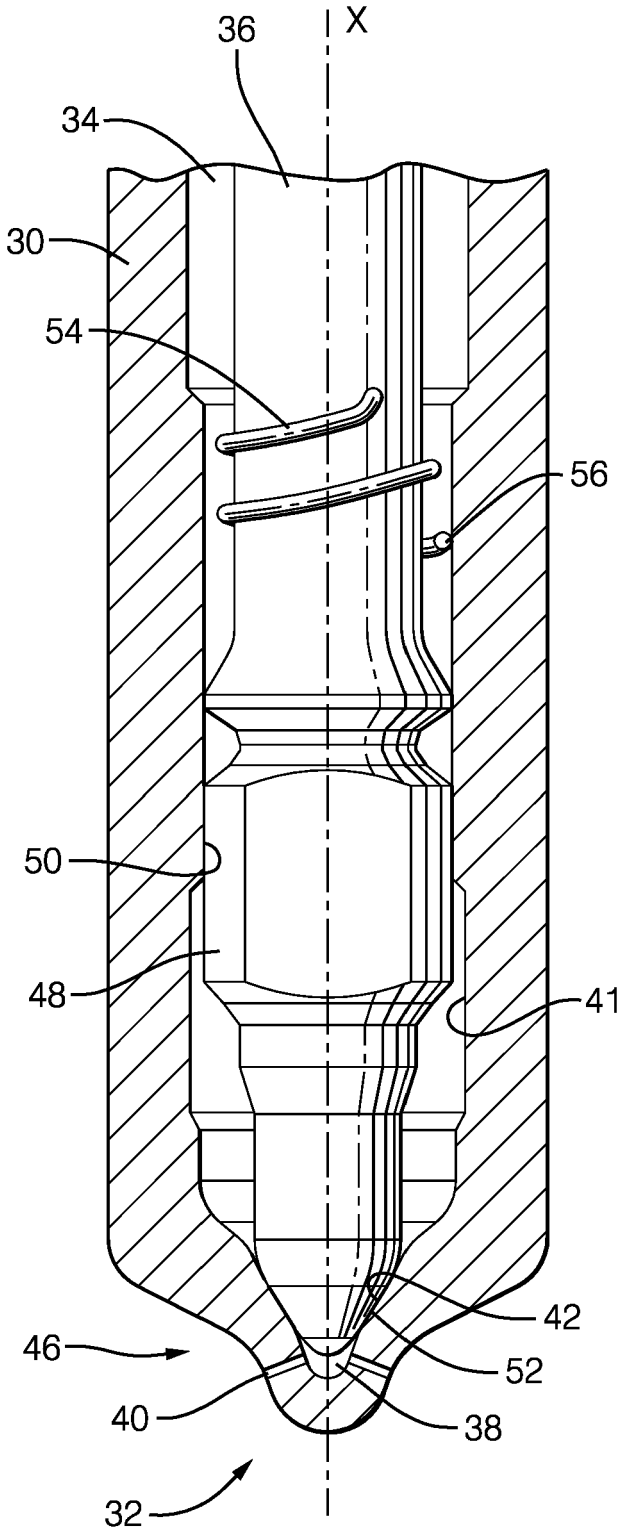

FIG. 2

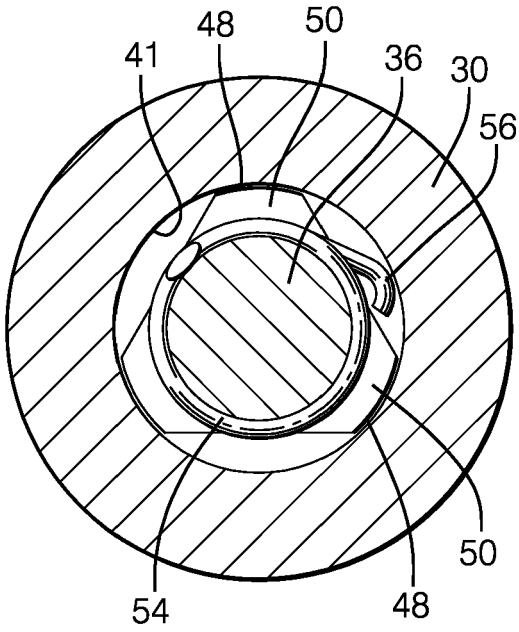

FIG. 3

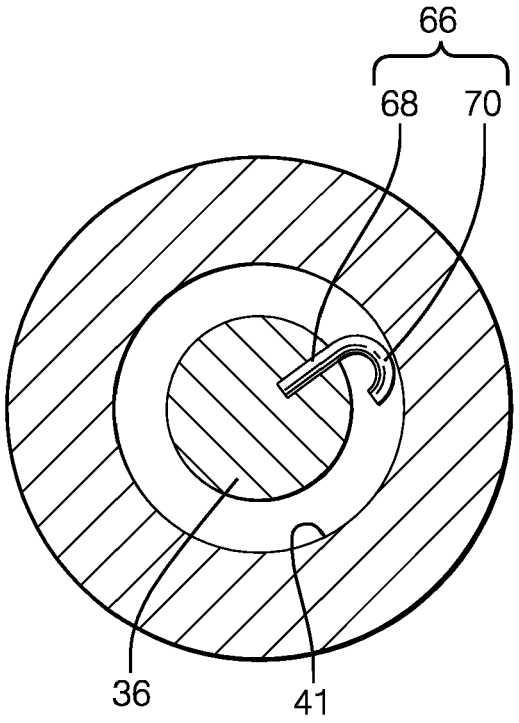

FIG. 4

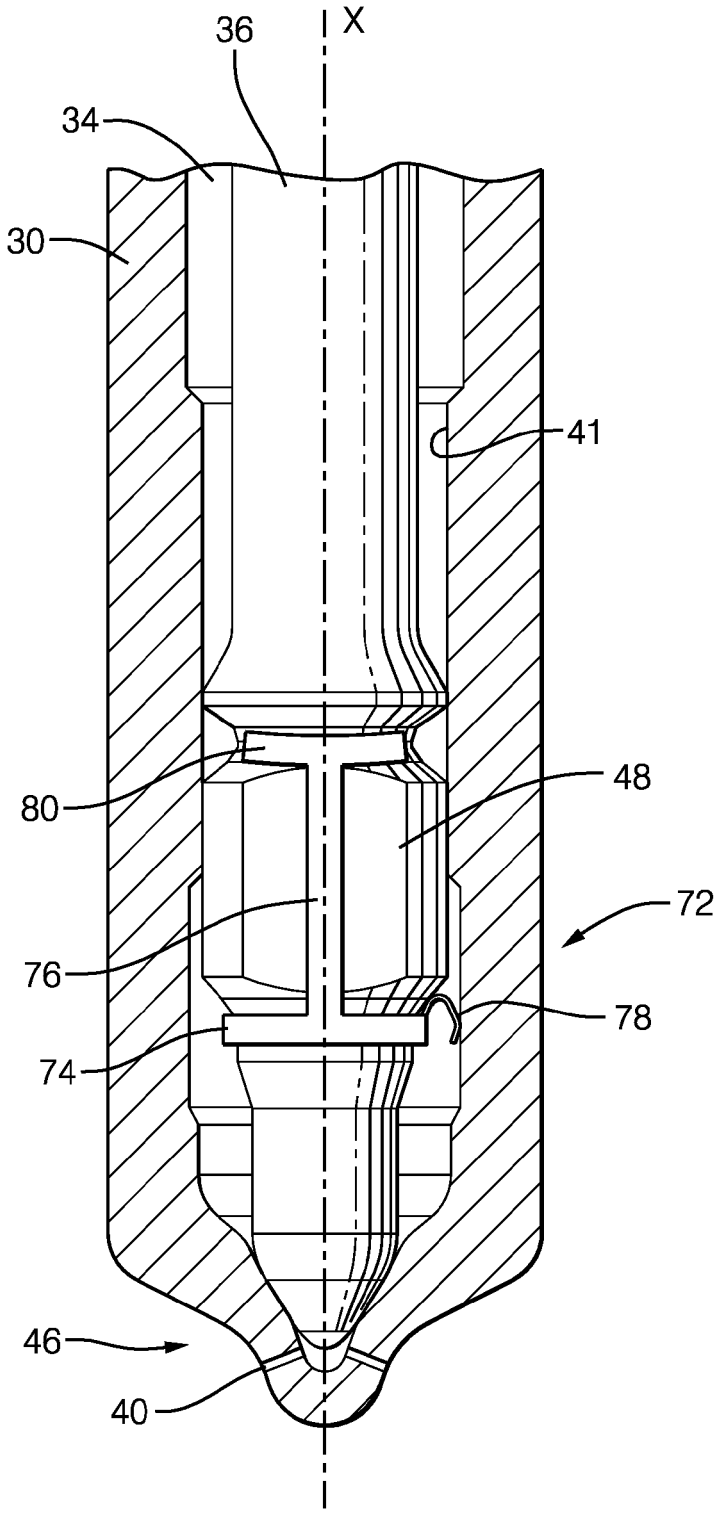

FIG. 5

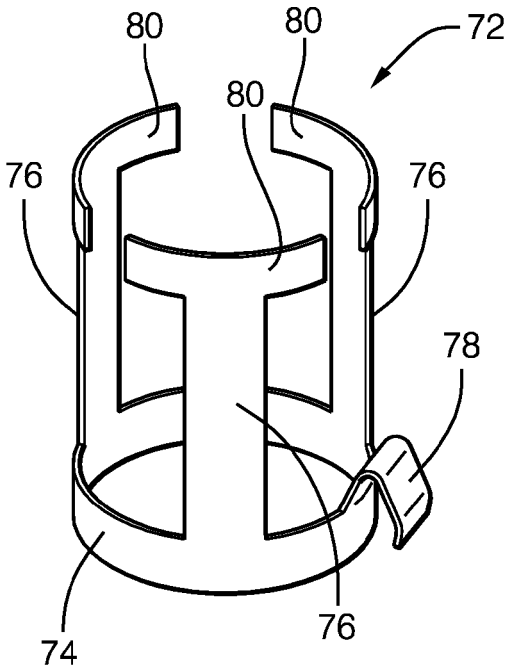

FIG. 6

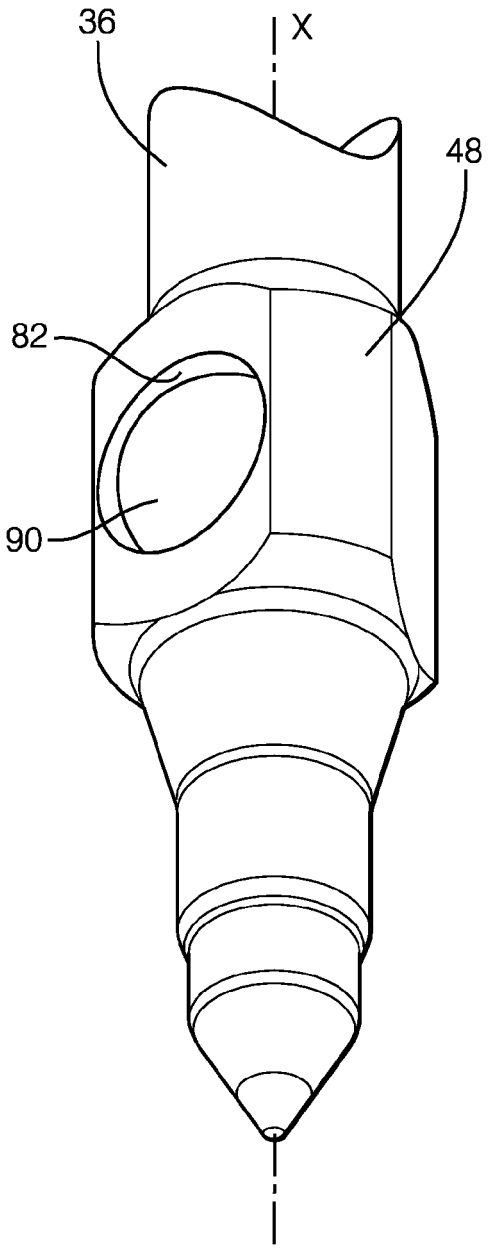

FIG. 7

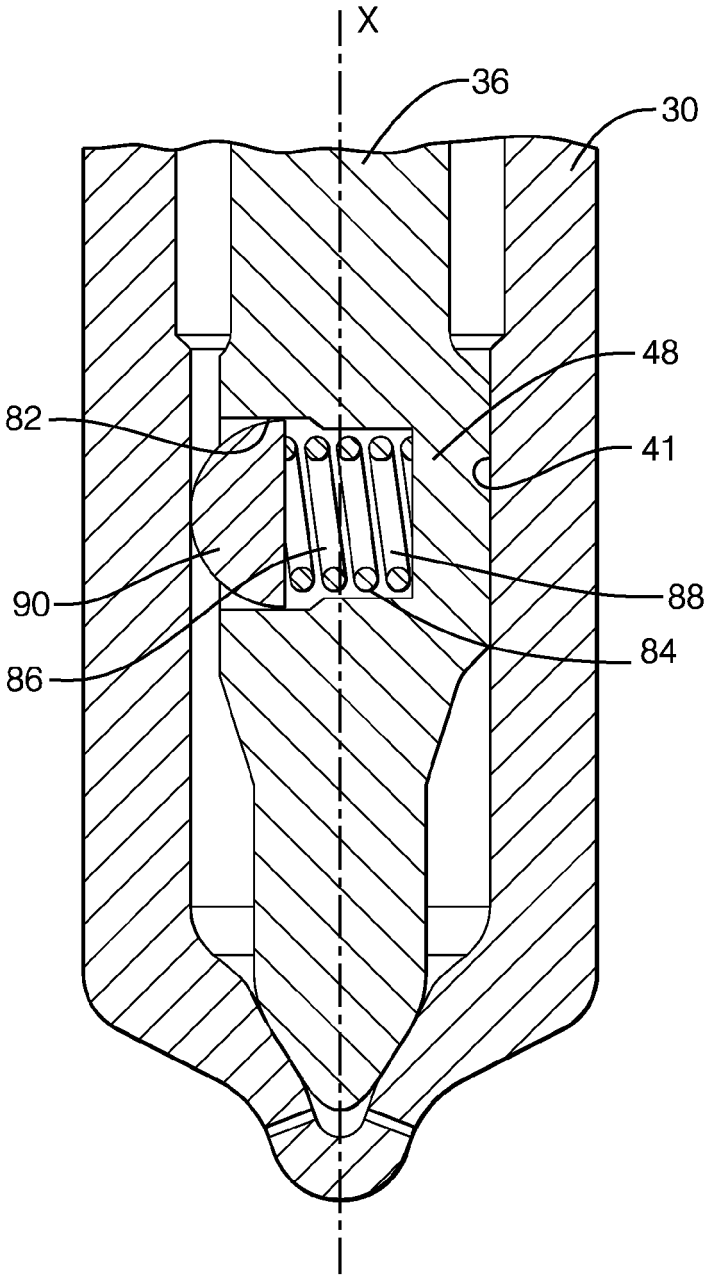

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 17 15 5490

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	26 May 2017	Tortosa Masiá, A

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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