(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 808 533 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.12.2014 Bulletin 2014/49

(51) Int Cl.:
F02M 61/18 *(2006.01)*

(21) Application number: **13169668.4**

(22) Date of filing: **29.05.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **Delphi International Operations Luxembourg S.à r.l.**
4940 Bascharage (LU)

(72) Inventors:
- **Soteriou, Celia**
  Lyndhurst
  Hampshire SO43 7HD (GB)
- **Balin, Marion**
  41150 Onzain (FR)

(74) Representative: **Neill, Andrew Peter**
Delphi Diesel Systems
Patent Department
Courteney Road
Gillingham, Kent ME8 0RU (GB)

(54) **Fuel injector**

(57) A nozzle body (16) of the nozzle (14) of a fuel injector (12), the body (16) having a bore (20) and extending along a main axis (Z) toward a blind extremity which internally forms a seat (22) for receiving in circumferential contact a closing member, the tip portion of the bore (20) having a peripheral surface (28) of revolution about the main axis (Z) forming a sac chamber (24). The body (14) is further provided with a spray hole (26) axially (H) extending throughout the wall (18) of the body (16), between an entry (30) that is arranged in the peripheral surface (28) of the sac (24) and an exit (32) opening on the outer surface (38) of the wall (18). In the vicinity of its entry (30), the transversal section (SI) of the spray hole (26) is elongated along an elongation axis (E).

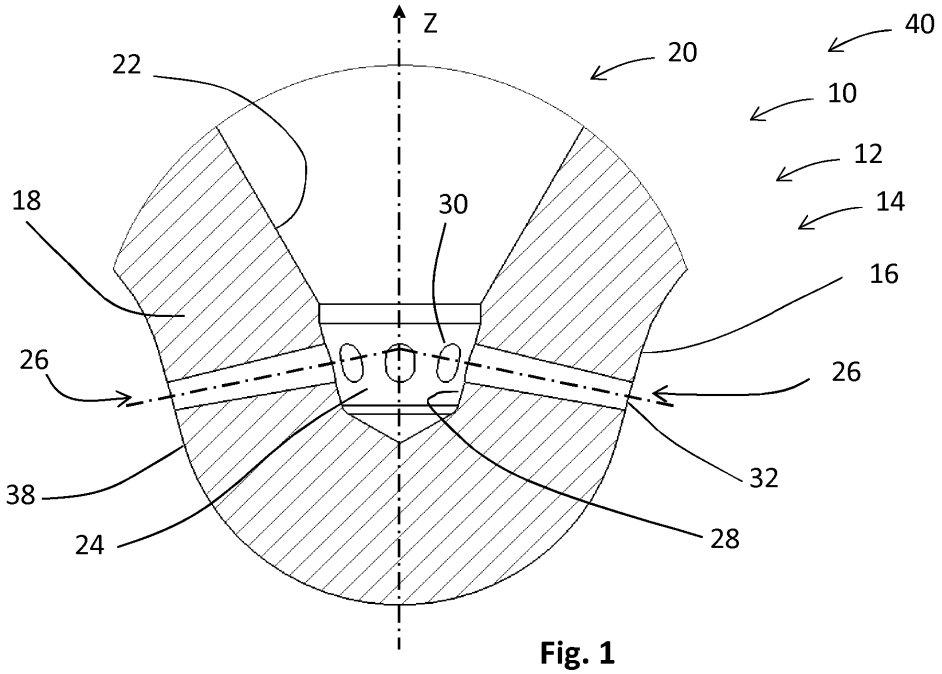

Fig. 1

EP 2 808 533 A1

Description

TECHNICAL FIELD

[0001] The present invention generally relates to a fuel injector and more particularly to the shape of the injection holes.

BACKGROUND OF THE INVENTION

[0002] Fuel injectors are known to have a housing in which flows the fuel under pressure. The housing has an internal axial bore in which is slidingly arranged a needle that controls a nozzle. The nozzle comprises a valve seat cooperating with the needle to open or close an annulus for the fuel to enter a sac chamber in which are located the entries of spray holes radially extending toward their exit which opens into a combustion chamber. Fuel injectors with a pointed tip have a small sac of which the peripheral wall is a surface of revolution. Such known sac walls are portions of cylinder, of sphere or of any kind of ovoid volume.

[0003] One way to improve fuel injectors is by the design of the spray holes. Over time the number of holes has increased, their cross sections have reduced and their profiles have also evolved, while at the same time the fuel pressure has increased. The entries of the holes are arranged around the sac and in some cases are so close to each other that the separation between adjacent holes has reached a physical limit, thereby jeopardizing the mechanical strength and impeding ways of improvements.

SUMMARY OF THE INVENTION

[0004] The present invention aims at solving the above mentioned problem by proposing a nozzle body of the nozzle of a fuel injector. The body has a bore extending along a main axis toward a blind extremity which internally forms a seat for receiving in circumferential contact, a closing member. The tip portion of the bore has a peripheral surface of revolution about the main axis forming a sac chamber. The body is further provided with at least one spray hole axially extending throughout the wall of the body, between an entry that is arranged in the peripheral surface of the sac and an exit opening on the outer surface of the wall.

[0005] In the vicinity of its entry, the transversal section of the spray hole is elongated along an elongation axis or is triangular having its height along the elongation axis and, in the vicinity of the exit, the transversal section of the spray hole is circular. The transversal section of the spray hole continuously and smoothly evolves from the entry to the exit.

[0006] The nozzle body is further provided with a plurality of spray holes, the axis of the spray holes intersects the peripheral surface of the sac along a line transversal to the main axis of the body. The line of intersection can be a circle.

[0007] Furthermore, in the vicinity of its entry the elongated section of the spray hole is oval or elliptical or oblong. In another embodiment the entries are triangular and alternated upside-down one every two holes so as to arrange said entries in a complementary manner around the peripheral surface of the sac.

[0008] The axis of the spray hole is in a main plane that is parallel to the main axis and that is at a distance from the main axis. The elongation axis of a transversal section taken in the close vicinity of the entry is inclined relative to said main plane by an inclination angle comprised between 0° and 360°. In a specific case, the elongation axis of the transversal section taken in the close vicinity of the entry is in the main plane, the inclination angle being 0°.

[0009] More precisely, the elongation axis of the transversal section taken in the close vicinity of the entry is inclined relative to the main plane, the inclination angle being comprised between 30° and 45°.

[0010] From the entry to the exit the inclination angle of the elongated axis of any transversal section is constant, the elongation axes of the transversal sections being coplanar.

[0011] In another alternative, from the entry to the exit the inclination angle of the elongated axis of the transversal sections evolves, the elongation axes of the transversal sections forming a helical surface.

[0012] In a specific embodiment the main axis and the spray hole axis intersect, the distance d being zero.

[0013] The spray hole has a ratio length over diameter equal to or greater than 2.5, the length is the distance from the entry to the exit and the diameter is that of the cross-section in the vicinity of the exit.

[0014] Furthermore, the spray hole is tapered: the area of its cross section diminishes from the entry to the exit.

[0015] The entry and the exit of the spray hole are rounded avoiding sharp edges.

[0016] The invention is also about a nozzle of a fuel injector having a nozzle body as described in the preceding paragraphs, a closing member, such as a needle axially arranged in the bore and able to cooperate with the seat.

[0017] The invention is also about a fuel injector comprising a nozzle a described above.

[0018] More precisely, the fuel injector is specially made for diesel fuel.

[0019] The fuel injector can also be part of the fuel injection system of an internal combustion engine, the system comprising a fuel injector as set above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The present invention is now described by way of example with reference to the accompanying drawings in which:

- Figure 1 is a magnified section of the tip of the nozzle

body of a fuel injector according to the invention.

- Figure 2 is a schematic section of a spray hole identifying geometrical planes utilized in the description.
- Figures 3 to 7 illustrate five different possibilities of spray holes in the nozzle of figure 1.
- Figures 8 to 13 are geometrical sketches of six different arrangements of spray holes in the nozzle of figure 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Vehicles have their engines equipped with fuel injection systems 10 where pressurized fuel is sent to a plurality of fuel injectors 12. In the injector 12, the fuel follows a path toward the nozzle 14 where it is sprayed into a combustion chamber. The nozzle 14 has a nozzle body 16, integral with or distinct from the fuel injector body, which extends along a main axis Z. The nozzle body 16 has a wall 18 internally provided with a bore 20 wherein is slidingly arranged a needle (not represented) cooperating with a seat 22 between an open position, that enables the fuel to flow, and a closed position that retains the fuel upstream the seat 22. Downstream of the seat 22, the nozzle body 16 closes in forming a sac chamber 24 from which depart a plurality of spray holes 26 leading the fuel to the combustion chamber.

[0022] Figure 1 generally depicts a nozzle body 16 having a pointed tip, thus the sac chamber 24 is relatively small and its peripheral surface 28 is a surface of revolution about the main axis Z. In figure 1 the sac 24 has a frusto conical shape; it could alternatively be a portion of a cylinder of revolution or an ovoid surface, or a semi-sphere or a combination of these surfaces. Each spray hole 26 extends throughout the wall 18 of the body along an axis H between an entry 30 and an exit 32. The entries 30 are circumferentially arranged around the peripheral surface 28 of the sac 24. As better seen on figures 3 to 6 the entries 30 are elongated having a long dimension and a perpendicular short dimension. In another alternative shown on figure 7, the entries 30 have the shape of isosceles triangles with rounded corners and are arranged in a complementary manner having their base and apex alternated upside-down. Many other shapes, elongated, triangular, isosceles or not can be chosen.

[0023] Since the peripheral surface 28 of the sac 24 can take various shapes, as mentioned above, the boundary line of the entry 30, that is the intersection between the spray hole 26 and the peripheral surface 28, slightly differs from the cross section S of the spray hole 26 observed on a plane PH transversal to the axis H of the spray hole 26. A similar explanation is valid for the boundary line of the exit 32 that depends upon the shape of the outer surface 38 of the wall 18. As a classical illustration of this, the line of intersection between a plane and a non-perpendicular cylinder of revolution is an ellipse and not a circle. Thus for the purpose of clarity, the spray holes 26 shall be described between an inner transversal plane PHI that is very close to the entry 30 and an outer transversal plane PHO that is very close to the exit 32 - figure 2.

[0024] On the inner transversal plane PHI, the inner cross section SI of the spray hole 26 is elongated along an elongation axis E. The inner cross section SI can be an ellipse as in figure 3, an oblong as in figure 4, or any kind of oval. The elongation can be more or less important.

[0025] By analogy, the triangular alternative, illustrated on figure 7, shall be considered as the elongated shapes, the height of the triangles corresponding to the elongation axis E.

[0026] On the outer transversal plane PHO, the outer cross section SO of the spray hole 26 is circular whatever the shape of entry 30.

[0027] As can be seen on the figures, the cross section S of the spray hole 26 regularly and continuously evolves from the inner cross section SI to the outer cross section SO. Furthermore, the spray hole 26 is tapered toward the exit 32, the area of the inner cross section SI being larger than the area of the outer cross section SO. Alternatively the inner and outer sections could have equal areas.

[0028] In a first embodiment, which geometry is sketched on figure 8, the axis H of the spray hole 26 intersects the main axis Z thus defining a main plane PM in which lie the elongation axes E of all the cross sections S of the spray hole 26. As can be observed on figures 3 and 4, the entries 30 are arranged on the peripheral surface 28 so their short dimensions lie on a circle line C that centers on the main axis Z. The elongated or triangular shape of the entries 30 enable to arrange around the sac 24 more holes than in the case of circular entries.

[0029] In an alternative to the first embodiment, which geometry is sketched on figure 9, the elongation axes E of all the cross sections S of the spray hole 26 are coplanar all axes being included in the same plane, but are making a constant angle A1 with the main plane PM. Consequently the entry 30 is inclined as shown on figure 5 or 6 and, all the entries 30 are set around the sac in a tilted arrangement. The constant angle A1 can be chosen at any value between 0° and 90°. When equal to 0°, this alternative is identical to the first embodiment and, when equal to 90°, the long dimension of the entries 30 aligns on the circle line C. An intermediate value of the fixed angle A1 is chosen on figures 5 and 6.

[0030] Whatever constant angle A1 is chosen, the spray hole 26 internal surface is generated by a straight line having an elongated, or triangular, extremity at the entry and a circular extremity at the exit.

[0031] In a second embodiment, which geometry is sketched on figure 10, the elongation axes E are not coplanar but are, relative to the main plane PM, regularly rotated by an evolving angle A2, so forming a helical surface SH. In this second embodiment the elongation axis E of the inner cross section SI can also be inclined relative to the main plane PM at any angle. In particular, the helical surface SH can twist by a complete turn, 360°, or

even more. It is to be noted that the angle A2 of the elongation axis E at the exit can also be inclined relative to the main plane PM by any angle between 0° and 360°, for instance, the angle A2 at the entry can be 50° when the angle A2 at the exit is 30°.

[0032] In a third alternative, which geometry is sketched in figures 11, 12 and 13 the axis H of the spray hole and the main axis Z do not intersect. The two axes H, Z, are at a distance d from each other. Here is considered a main plane, still identified for simplicity as the main plane PM, defined as the plane that is parallel to and distant from the main axis Z and wherein the axis H of the spray hole 26 lies. The main axis Z is at the distance d from the main plane PM.

[0033] Similarly to the first embodiment and its alternative, the spray hole 26 can be a surface generated by a straight line evolving from the elongated inner cross section SI to the circular outer cross section SO, the elongation axis E having a constant angle A1, chosen between 0° and 90°, relative to the main plane PM - figures 11 and 12.

[0034] Similarly to the second embodiment, the spray hole 26 can also form a helical surface SH - figure 13 - with an elongated inner cross section SI being inclined relative to the main plane PM at any angle between 0° and 90°.

[0035] Indeed the alternatives of the third embodiment - figures 10, 11 and 12 - differ from the first and second embodiment by the distance d, which is non-zero while in the first and second embodiments it is zero. Still, the shape of the spray hole 26 is not affected by the distance d so, whatever choice is made for the shape, the profile, the elongation or the inclination angle, the choice can be duplicated in all alternatives.

[0036] In a preferred embodiment, but not limiting the invention to it, the spray holes 26 have a length L over diameter D ratio greater than 2.5. The length L is the distance from the entry 30 to the exit 32 while the diameter D is that of the outer cross section SO.

[0037] Furthermore, in order to avoid sharp edges, the entries 30 and exits 32 can be smoothed with a chamfer or a rounded toric surface.

[0038] Also, while the principles of the invention are applicable to any kind of fuel injector, the invention is primary intended for a diesel fuel injection system.

Claims

1. Nozzle body (16) of the nozzle (14) of a fuel injector (12), the body (16) having a bore (20) extending along a main axis (Z) toward a blind extremity which internally forms a seat (22) for receiving in circumferential contact a closing member, the tip portion of the bore (20) having a peripheral surface (28) ofrevolution about the main axis (Z) forming a sac chamber (24), the body (14) being further provided with at least one spray hole (26) axially (H) extending throughout the wall (18) of the body (16), between an entry (30) that is arranged in the peripheral surface (28) of the sac (24) and an exit (32) opening on the outer surface (38) of the wall (18), **characterized in that**
in the vicinity of its entry (30), the transversal section (SI) of the spray hole (26) is elongated along an elongation axis (E) or is triangular having its height along the elongation axis (E) and,
in the vicinity of the exit (32) the transversal section (SO) of the spray hole (26) is circular and,
the transversal section (S) of the spray hole (26) continuously and smoothly evolves from the entry (30) to the exit (32).

2. Nozzle body (16) as set in the previous claim further provided with a plurality of spray holes (26), the axis (H) of the spray holes (26) intersects the peripheral surface (28) of the sac (24) along a line (C) transversal to the main axis (Z) of the body (16).

3. Nozzle body (16) as set in any of the preceding claims where in the vicinity of its entry (30) the elongated section of the spray hole (26) is oval or elliptical or oblong.

4. Nozzle body (16) as set in any of claims 1 or 2 wherein the entries (30) are triangular and alternated upside-down one every two holes, so as to arrange said entries (30) in a complementary manner around the peripheral surface (28) of the sac (24).

5. Nozzle body (16) as set in any of the preceding claims wherein the axis (H) of the spray hole (26) is in a main plane (PM) that is parallel to the main axis (Z) and that is at a distance (d) from the main axis (Z), the elongation axis (E) of a transversal section (SI) taken in the close vicinity of the entry (30) being inclined relative to said main plane (PM) by an inclination angle (A1, A2) comprised between 0° and 360°.

6. Nozzle body (16) as set in claim 5 wherein the elongation axis (E) of the transversal section (SI) taken in the close vicinity of the entry (30) is in the main plane (PM), the inclination angle (A1, A2) being 0°.

7. Nozzle body (16) as set in claim 5 wherein the elongation axis (E) of the transversal section (SI) taken in the close vicinity of the entry (30) is inclined relative to the main plane (PM), the inclination angle (A1, A2) being comprised between 30° and 45°.

8. Nozzle body (16) as set in claims 5 to 7 wherein from the entry (30) to the exit (32) the inclination angle (A1) of the elongated axis (E) of any transversal section (S) is constant, the elongation axes (E) of the transversal sections (SI, S, SO) being coplanar.

9. Nozzle body (16) as set in claims 5 to 7 wherein from the entry (30) to the exit (32) the inclination angle (A2) of the elongated axis (E) of the transversal sections (S) evolves, the elongation axes (E) of the transversal sections (SI, S, SO) forming a helical surface (SH).

10. Nozzle body (16) as set in any of the claims 5 to 9 wherein the main axis (Z) and the spray hole axis (H) intersect, the distance (d) being zero.

11. Nozzle body (16) as set in any the preceding claims wherein the spray hole (26) has a ratio length (L) over diameter (D) equal to or greater than 2.5, the length (L) being the distance from the entry to the exit and the diameter (D) being that of the cross-section (SO) in the vicinity of the exit (32).

12. Nozzle body (16) as set in any the preceding claims wherein the spray hole (26) is tapered, the area of its cross section (S) diminishing from the entry (30) to the exit (32).

13. Nozzle body (16) as set in any the preceding claims wherein the entry (30) and the exit (32) of the spray hole (26) are rounded avoiding sharp edges.

14. Nozzle (14) of a fuel injector (12) having a nozzle body (16) as set in any of the preceding claims, a closing member, such as a needle, being axially arranged in the bore (20) and being able to cooperate with the seat (22).

15. Fuel injector (12) comprising a nozzle (14) as set in claim 14.

16. Fuel injector (12) as set in claim 15 specially made for diesel fuel.

17. Fuel injection system (10) for an internal combustion engine, the system (10) comprising a fuel injector (12) as set in any of the claims 15 or 16.

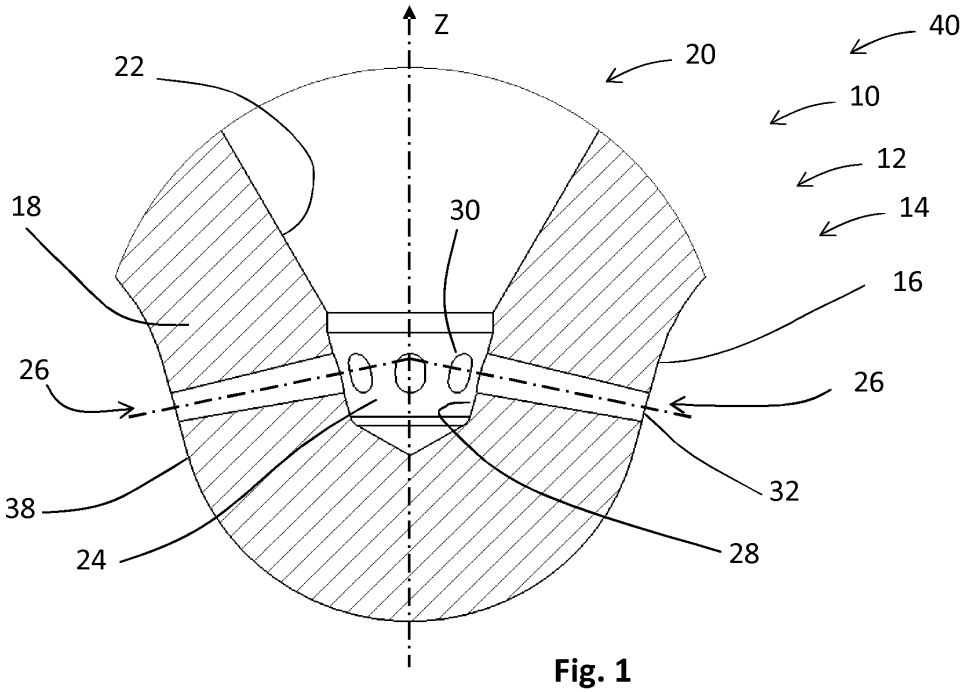
Z
40
22
20
10
12
18
30
14
16
26
26
32
38
24
28

Fig. 1

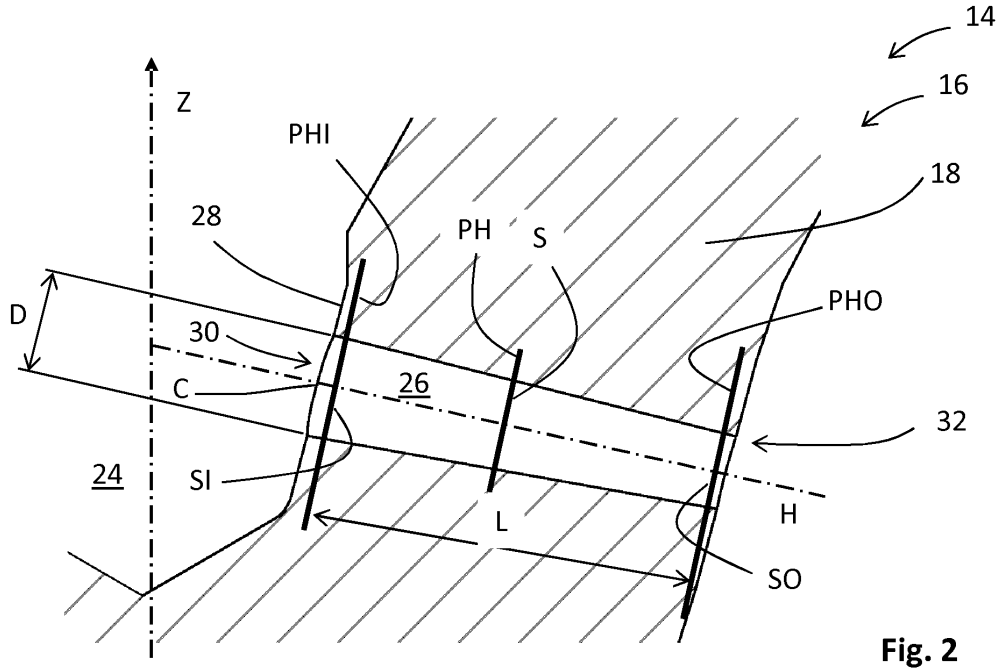
14
16
Z
PHI
18
28
PH
S
PHO
D
30
C
26
32
24
SI
L
H
SO

Fig. 2

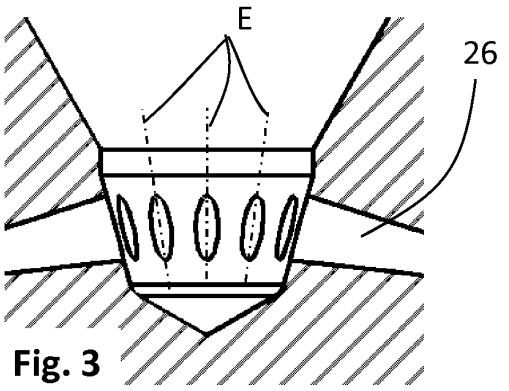

Fig. 3

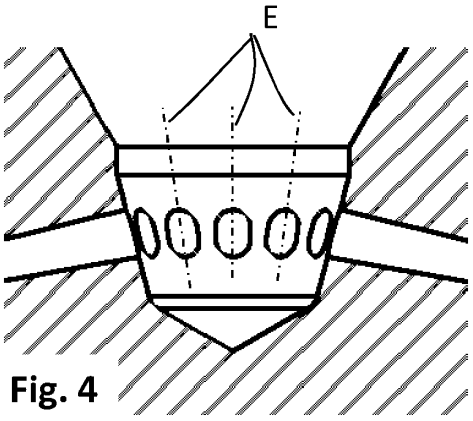

Fig. 4

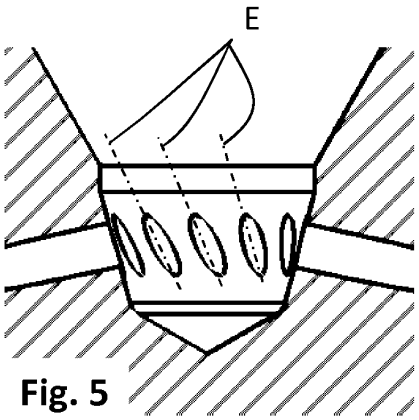

Fig. 5

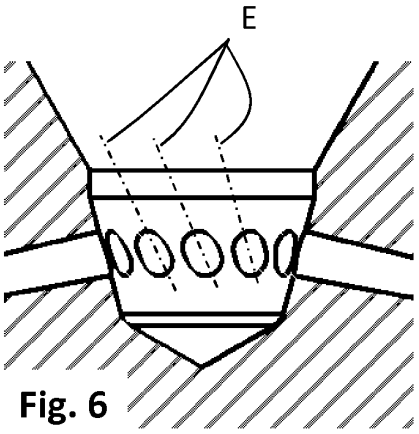

Fig. 6

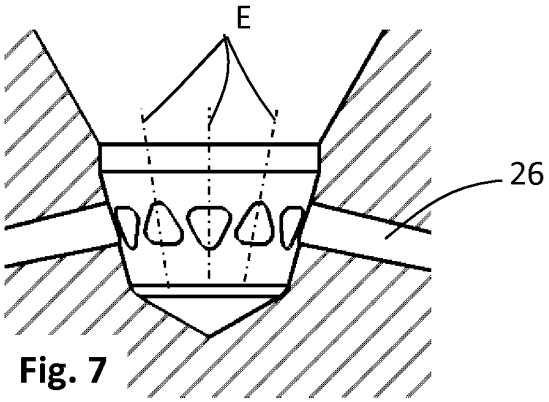

Fig. 7

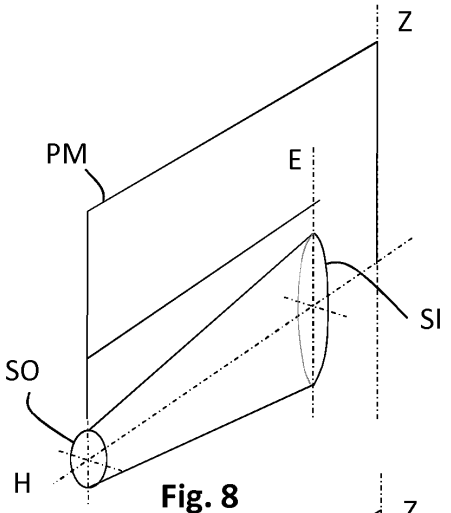

Fig. 8

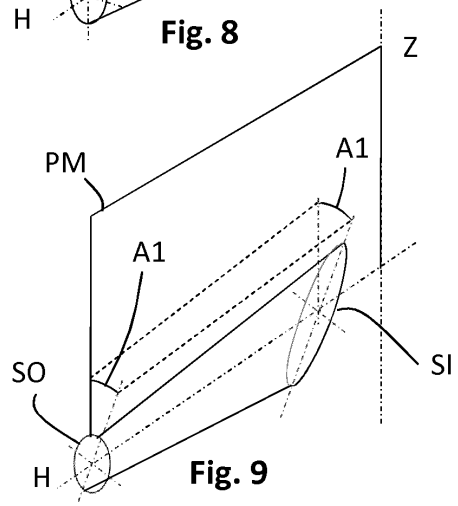

Fig. 9

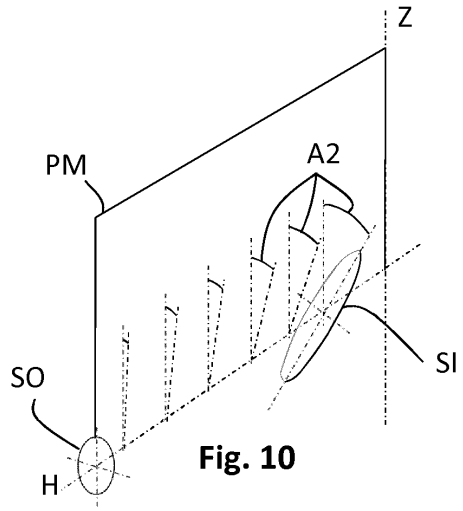

Fig. 10

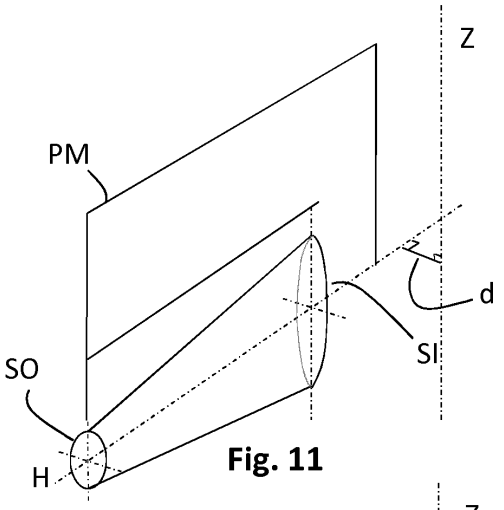

Fig. 11

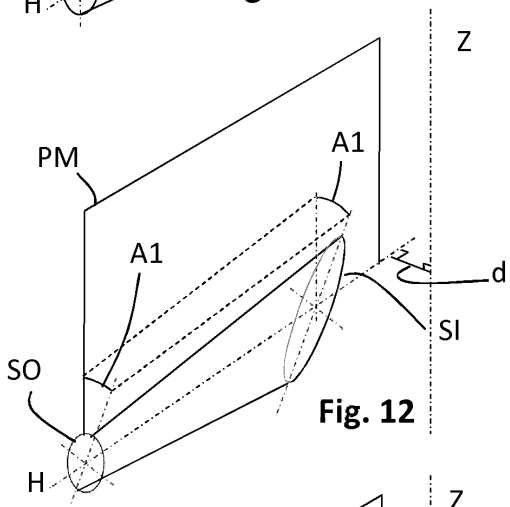

Fig. 12

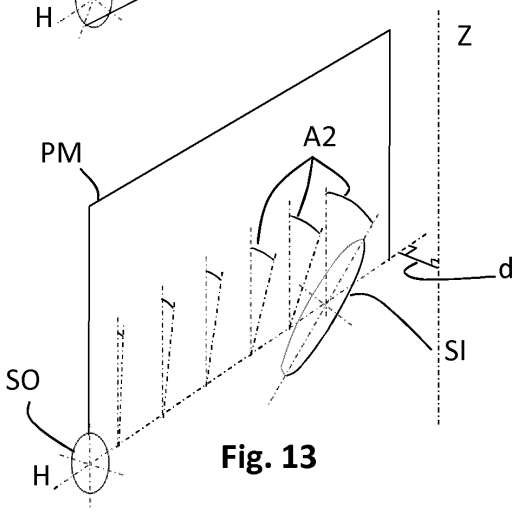

Fig. 13

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 16 9668

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 103 30 256 A1 (BOSCH GMBH ROBERT [DE]) 20 January 2005 (2005-01-20) * paragraphs [0017] - [0019]; figures *	1,2,5,6, 8,10-17 4,7,9	INV. F02M61/18
X	DE 199 31 890 A1 (SIEMENS AG [DE]) 18 January 2001 (2001-01-18) * figures *	1-3,5,6, 8,10,11, 13-17	
Y	DE 103 36 737 A1 (BOSCH GMBH ROBERT [DE]) 31 March 2005 (2005-03-31) * figure 2D *	4	
Y	WO 2012/106512 A2 (3M INNOVATIVE PROPERTIES CO [US]; CARPENTER BARRY S [US]; SHIRK RYAN C) 9 August 2012 (2012-08-09) * page 10, line 29 - page 11, line 2 * * page 11, line 10 - page 12, line 27 * * page 26, lines 3-28 * * figures 5,7,8,12,24,48 *	9	
			TECHNICAL FIELDS SEARCHED (IPC)
Y	WO 01/90571 A2 (BOSCH GMBH ROBERT [DE]; WUERFEL GERNOT [DE]) 29 November 2001 (2001-11-29)	7	F02M
A	* figures 5A,5B *	3	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 November 2013	Landriscina, V

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 13 16 9668

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.

04-11-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 10330256 A1	20-01-2005	DE 10330256 A1	20-01-2005
		EP 1644636 A1	12-04-2006
		WO 2005010350 A1	03-02-2005
DE 19931890 A1	18-01-2001	DE 19931890 A1	18-01-2001
		FR 2796104 A1	12-01-2001
		US 6443374 B1	03-09-2002
DE 10336737 A1	31-03-2005	NONE	
WO 2012106512 A2	09-08-2012	CA 2826443 A1	09-08-2012
		WO 2012106512 A2	09-08-2012
WO 0190571 A2	29-11-2001	CN 1380942 A	20-11-2002
		DE 10026324 A1	29-11-2001
		EP 1290339 A2	12-03-2003
		JP 2003534495 A	18-11-2003
		US 2002179039 A1	05-12-2002
		WO 0190571 A2	29-11-2001

EPO FORM P0459

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