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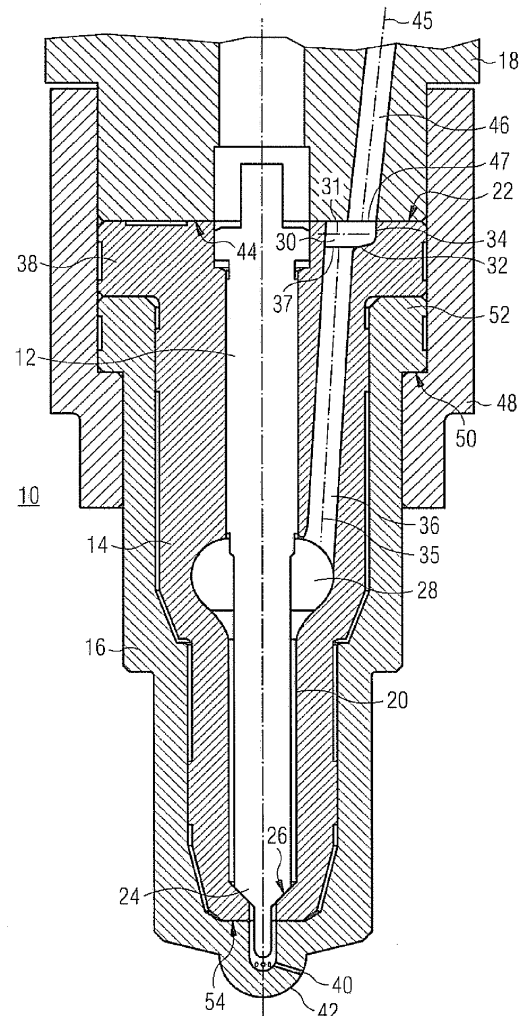
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(54) **Needle guide member**

(57) The disclosure relates to a needle guide member (14) of a fuel injection system (10) for internal combustion engines. A needle guide member (14) for forming the fuel injection system (10) may comprise an elongate fuel redirecting groove (30) provided within a needle guide member sealing face (22). The needle guide member (14) may further comprise a needle guide member fuel channel (36) fluidly interconnecting the elongate fuel redirecting groove (30) with a high pressure fuel chamber (28) of the needle guide member (14).

FIG 2



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Description

Technical Field

[0001] The present disclosure generally refers to fuel injection systems of internal combustion engines, and more particularly to a needle guide member of a fuel injection system for an internal combustion engine.

Background

[0002] Recently, use of alternative fuels to power internal combustion engines is subject of ongoing interest. Alternative fuels include first generation biofuels (for example palm oil, canola oil, oils based on animal fat) and second generation biofuels (for example oils made of non food crops, waste biomass)

[0003] Examples of second generation biofuels include "pyrolysis oils" obtained from the pyrolysis of, for example, wood or agricultural wastes, such as the stalks of wheat or corn, grass, wood, wood shavings, grapes, and sugar cane. In general, pyrolysis oil is predominantly produced by the "Fast Pyrolysis" technology, which comprises rapid pyrolysis of biomass in a fluidized bubbling sand bed reactor, wherein the solid heat-carrying medium is circulated and, therefore, the residence time of solids is well-controlled and high heating rates (up to 1000 °C/second) are obtained.

[0004] As the chemical composition and/or the physical properties of alternative fuels can differ significantly from those of commonly used fuels such as diesel fuel, light fuel oil (LFO), and heavy fuel oil (HFO), care has to be taken when alternative fuels are used as substitutes.

[0005] For example, the use of alternative fuels in internal combustion engines affects in particular the supply path of the alternative fuel to a combustion chamber. The supply path includes usually an injection pump systems and an injection nozzle system.

[0006] For an injection nozzle system, WO 2011/157375 discloses a two piece fuel injector formed by a needle guide member surrounded by a ceramic hood for the use with alternative fuels.

[0007] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of the related prior art and particularly improving an injection nozzle system.

Summary of the Disclosure

[0008] According to a first aspect of the present disclosure, a needle guide member for forming an injection nozzle system of an internal combustion engine, the fuel injection system may further comprise a needle and a nozzle holder, the needle guide member may comprise a needle guide member sealing face for providing a sealed connection to the nozzle holder, an elongate fuel redirecting groove provided within the needle guide member sealing face, and a needle guiding bore for guid-

ing the needle between a fuel injection state and a sealed state of the fuel injection system. The needle guiding bore may extend from the needle guide member sealing face into the needle guide member and may comprise a high pressure fuel chamber. The needle guide member may further comprise a fuel channel fluidly interconnecting the elongate fuel redirecting groove with the high pressure fuel chamber.

[0009] According to another aspect of the present disclosure, a fuel injection system for an internal combustion engine may comprise a needle and a needle guide member as exemplarily disclosed herein, and being adapted to guide the needle within the needle guiding bore between a fuel injection state and a sealed state of the fuel injection system. The fuel injection system may further comprise a nozzle holder comprising a nozzle holder sealing face for providing a sealed connection to the needle guide member, the nozzle holder comprising a nozzle holder fuel channel having a fuel outlet provided in the nozzle holder sealing face, wherein the needle guide member is mounted onto the nozzle holder, and the fuel outlet of the nozzle holder opens into the elongate fuel redirecting groove.

[0010] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0011]

Fig. 1 shows a schematic block diagram of an exemplary internal combustion engine system;

Fig. 2 shows a sectional view of an exemplary fuel injector; and

Fig. 3 shows a top view of an exemplary needle guide member of the fuel injector shown in Fig. 2.

Detailed Description

[0012] The following is a detailed description of exemplary embodiments of the present disclosure. The exemplary embodiments described therein and illustrated in the drawings are intended to teach the principles of the present disclosure, enabling those of ordinary skill in the art to implement and use the present disclosure in many different environments and for many different applications. Therefore, the exemplary embodiments are not intended to be, and should not be considered as, a limiting description of the scope of patent protection. Rather, the scope of patent protection shall be defined by the appended claims.

[0013] The disclosure may be based in part on the realisation that alternative fuels such as pyrolysis oil may cause an increased mechanical stress on the fuel injection system compared to commonly used fuels. In particular, alternative fuels may tend to strongly cavitate within the fuel channels of the fuel injection system due

to a high water content.

[0014] Accordingly, an exemplary fuel injector is disclosed that may combine both a cavitation reducing design of fuel channels as well as the possibility of mounting the fuel injector to a conventional nozzle holder of a fuel injection system.

[0015] Fig. 1 shows a non-limiting example of an internal combustion engine system with an injection nozzle system. The internal combustion engine system may include, for example, an engine with a cam injection pump for a conventional pump-line-nozzle injection or an engine with a common rail injection, which may be operated more flexible, for example, to adjust an injection pressure, a rail pressure, the injection timing, the number and type of injections (for example, pre- and post-injections). The internal combustion engine system includes a reservoir 1 for an alternative fuel such as pyrolysis oil and an internal combustion engine 5. Internal combustion engine 5 is configured to operate, for example, with a mixture of the pyrolysis oil with additives such as mineral oil, synthetic oil, natural oil, and/or a lubricant. Accordingly, the internal combustion engine system may optionally include one or more of reservoirs 2, 3 for the additives. The internal combustion engine system may further include a homogenizer 4. An inlet 4A of homogenizer 4 may be connected via corresponding lines 1A, 2A, and 3A with reservoirs 1, 2, and 3, respectively.

[0016] Internal combustion engine 5 includes at least one fuel injection pump 5A connected via one or more lines 4C with an outlet 4B of homogenizer 4, at least one nozzle system 5B and at least one combustion chamber 5C. Nozzle system 5B is supplied with the pressurized alternative fuel by fuel injection pump 5A and is configured to spray, for example, a mixture of the pyrolysis oil, the mineral oil, the synthetic oil, the natural oil, and/or the lubricant into combustion chamber 5C.

[0017] The number of fuel injection pumps 5A, nozzle systems 5B, and combustion chambers 5C of internal combustion engine 5 is not specifically restricted. For example, a stationary or mobile power system may include for inline configurations 4, 6, 7, 8, or 9 combustion chambers with one or more associated fuel injection pumps and respective nozzle systems, while a V-configuration of an internal combustion engine may include, for example, 12 or 16 combustion chambers with one or more fuel injection pumps and respective nozzle systems.

[0018] Generally, internal combustion engine 5 may include features not shown, such as air systems, cooling systems, peripheries, drivetrain components, etc. Furthermore, internal combustion engine 5 may be of any size, with any number of cylinders, and in any configuration (e.g., "V," in-line, radial, etc.). Internal combustion engine 5 may be used to power any machine or other device, including locomotive applications, on-highway trucks or vehicles, off-highway trucks or machines, earth moving equipment, generators, aerospace applications, marine applications, offshore applications, pumps, stationary equipment, or other engine powered applications.

[0019] Examples of internal combustion engines that are suitable for adaptation to alternative fuels include medium speed internal combustion diesel engines, like in-line and V-type engines of the series M20, M25, M32, M43 manufactured by Caterpillar Motoren GmbH & Co. KG, Kiel, Germany, operated in a range of 500 to 1000 rpm.

[0020] Fig. 2 shows a sectional view of an exemplary embodiment of an fuel injection system 10 adapted for injecting an alternative fuel such as pyrolysis oil into a combustion chamber. Fuel injection system 10 includes a needle 12, a needle guide member 14, a ceramic hood 16, and a nozzle holder 18. Needle guide member 14 and ceramic hood 16 form a two-piece injector body.

[0021] Needle 12 is reciprocatingly disposed within a needle guiding bore 20 extending through needle guide member 14 from a needle guide member sealing face 22 at a nozzle holder side to an injection side. Needle 12 is guided by needle guide member 14 between a fuel injection (open) state and a sealed (closed) state of fuel injection system 10. In the fuel injection state, a tip section 24 of needle 12 and a needle seat 26 of needle guiding bore 20 are spaced from each other to define a high pressure fuel path therebetween. In contrast, in the sealed state, tip section 24 engages needle seat 26. The sealed state is shown in Fig. 2.

[0022] During injection, tip section 24 of needle 12 is lifted from needle seat 26 and nozzle spray holes 40 are exposed to the pressurized fuel present in high pressure fuel chamber 28 and entering blind hole section 42 through a gap between tip section 24 and needle seat 26.

[0023] Needle guide member 14 comprises a high pressure fuel chamber 28. High pressure fuel chamber 28 is disposed in a middle section of needle guide member 14. Alternatively, high pressure fuel chamber 28 may be disposed closer to a nozzle holder side or to an injection side.

[0024] An elongate fuel redirecting groove 30 is provided within needle guide member sealing face 22 of needle guide member 14. Elongate fuel redirecting groove 30 is formed in an elongate shape along a second axis 31. Further, elongate fuel redirecting groove 30 is defined by a ground wall 32 and a side wall 34. Ground wall 32 forms a bottom of elongate fuel redirecting groove 30 and comprises a fuel inlet 37 to needle guide member fuel channel 36 in a radial inner section of elongate fuel redirecting groove 30. Side wall 34 extends from needle guide member sealing face 22 into needle guide member 14 and defines a depth of elongate fuel redirecting groove 30. The depth may be within a range from 2.5 mm to 4.5 mm.

[0025] Ground wall 32 and side wall 34 smoothly transition into each other. Said smooth transition may have a radius within the range from 0.5 mm to 2 mm. Additionally, in the shown configuration, elongate fuel redirecting groove 30 may have a length within the range from 6 mm to 9 mm, and a width within the range from 2.5 mm to 5 mm.

[0026] Needle guide member fuel channel 36 extends along first longitudinal axis 35 through needle guide member 14, and fluidly interconnects elongate fuel redirecting groove 30 and high pressure fuel chamber 28. Further, needle guide member fuel channel 36 at least partly smoothly transitions into ground wall 32. In Figs. 2 and 3, needle guide member fuel channel 36 transitions into a radial inner section of ground wall 32 of elongate fuel redirecting groove 30. Additionally, an inner channel wall of needle guide member fuel channel 36 linearly extends into a wall of high pressure fuel chamber 28.

[0027] Ceramic hood 16 essentially surrounds needle guide member 14 with the exception of a collar 38 of needle guide member 14 at a nozzle holder side of needle guide member 14 and an associated needle guide member sealing face 22 of needle guide member 14. At an injection side of fuel injection system 10, ceramic hood 16 provides a blind hole partly enclosing a blind hole section 42 and comprises nozzle spray holes 40 in the wall of the blind hole.

[0028] A nozzle holder fuel channel 46 extends along a third axis 45 through nozzle holder 18 to a fuel outlet 47 in nozzle holder sealing face 44 of nozzle holder 18. Fuel outlet 47 is disposed adjacent to a radial outer section of elongate fuel redirecting groove 30. In other words, fuel outlet 47 opens into a radial outer section of elongate fuel redirecting groove 30. In this way, elongate fuel redirecting groove 30 fluidly interconnects nozzle holder fuel channel 46 of nozzle holder 18 to needle guide member fuel channel 36 of needle guide member 14. As fuel inlet 37 of needle guide member fuel channel 36 is spaced from fuel outlet 47 of nozzle holder fuel channel 46, elongate fuel redirecting groove 30 is arranged to bridge a distance between fuel outlet 47 and fuel inlet 37. For example, elongate fuel redirecting groove 30 may comprise a length-width ratio within the range from 1.2:1 to 2.5:1.

[0029] Said distance between fuel outlet 47 and fuel inlet 37 results from various factors. For example, in the shown configuration, a favourable minimum wall thickness of needle guide member 14 in a section around needle guide member fuel channel 36 affects a course of needle guide member fuel channel 36 extending through needle guide member 14. In addition, it may be desired that nozzle holder 18 may be a conventional nozzle holder of a conventional fuel injection system. That is, a position of nozzle holder fuel channel 46 and fuel outlet 47 may be fixed and should not be changed if it is desired the facilitate mounting of needle 12, needle guide member 14, and ceramic hood 16 to a conventional interface of fuel injection systems.

[0030] A mount 48 interacts with nozzle holder 18, for example, via a thread connection (not shown). Mount 48 is configured to pull ceramic hood 16 towards nozzle holder 18. For example, mount 48 may be a one-sided threaded nut such as a sleeve nut. In the embodiment of Fig. 2, mount 48 acts onto a mount contact face 50 of a collar 52 of ceramic hood 16.

[0031] If mount 48 is moved towards nozzle holder 18, ceramic hood 16 contacts a second needle guide member sealing face 54 of needle guide member 14 at first at a first sealing zone and then at another sealing zone at the nozzle holder side of fuel injection system 10. Collar 38 of needle guide member 14 extends between collar 52 of ceramic hood 16, and nozzle holder 18. Applying a force onto collar 38 via collar 52 towards nozzle holder 18 allows forming a seal by tightly contacting opposing surfaces of needle guide member 14 and nozzle holder 18 to form aforementioned second sealing zone. In addition, needle guide member sealing face 22 of needle guide member 14 provides a sealed connection with nozzle holder sealing face 44 of nozzle holder 18 in a mounted state of mount 48.

[0032] Referring to Fig. 3, a top view on needle guide member sealing face 22 of an exemplary needle guide member 14 accommodating a needle 12 is shown. In addition, in Fig. 3 cutting plane line I-I indicates the location of the section cut of sectional view of Fig. 2. It is noted that Fig. 2 additionally shows ceramic hood 16, nozzle holder 18 and mount 48, which are omitted in Fig. 3 for purpose of clarity.

[0033] As can be seen, in the shown embodiment, two elongate fuel redirecting grooves 30 are provided in needle guide member sealing face 22. Each elongate fuel redirecting groove 30 is elongated in radial direction of needle guide member 14, and is formed of a side wall 34 and ground wall 32. Alternate embodiments may include different quantities of elongate fuel redirecting grooves 30 with a corresponding quantity of fuel channels 36, 46.

[0034] Each elongate fuel redirecting groove is elongated in radial direction of needle guide member 14. Alternatively, elongate fuel redirecting groove 30 may be elongated in an alternate direction depending on canal courses of nozzle holder fuel channel 46 of nozzle holder 18 and needle guide member fuel channel 36 of needle guide member 14. In this way, both fuel channels 46, 36 may be fluidly connected via elongate fuel redirecting groove 30.

[0035] As shown in the top view of needle guide member 14 of Fig. 3, two blind holes 56 may be provided in the needle guide member sealing face 22 of needle guide member 14 to hold bolts that ensure the proper relative position between needle guide member 14 and nozzle holder 18.

Industrial Applicability

[0036] The disclosed fuel injection systems may allow maintaining an outer shape of a conventional nozzle system. Thus, the disclosed nozzle systems may thereby simplify the modification of injection systems adapted, for example, for use with alternative fuels such as pyrolysis oil. The disclosed nozzle system may fulfill geometric boundary conditions of known nozzle systems, thereby simplifying a replacement of a conventional nozzle system with the herein disclosed nozzle systems.

[0037] In addition, the disclosed fuel injection system provides a high pressure fuel path that may reduce cavitation of strongly cavitating alternative fuels such as pyrolysis oils. One reason for the higher tendency to cavitate may be found in the high water content of alternative fuels. For example, pyrolysis oils contain a water content of up to 20 %, which is considerably higher than the water content of conventional fuels such as diesel fuel having a water content of up to 0.2 %.

[0038] Specifically, elongate fuel redirecting groove 30 facilitates retrofit of a conventional nozzle system with the herein disclosed nozzle system as the conventional interface, namely nozzle holder 18, is used. Moreover, elongate fuel redirecting groove 30 may participate in homogenisation of the fuel flow through fuel injection system 10 to reduce cavitation. In detail, the smooth transition between side wall 34 and ground wall 32 as well as the smooth transition between ground wall 32 and needle guide member fuel channel 36 of needle guide member 14 may help to reduce turbulences within the fuel flow if redirected.

[0039] Furthermore, the orientation of elongate fuel redirecting groove 30 in radial direction of needle guide member 14 in combination with a correspondingly arranged needle guide member fuel channel 36 fluidly connecting the elongate fuel redirecting groove 30 with high pressure fuel chamber 28 may reduce the amount of redirections of the fuel flow. For example, fuel flowing from fuel channel is slightly redirected a first time at the smooth transition between side wall 34 and ground wall 32, and slightly redirected a second time when entering needle guide member fuel channel 36 through fuel inlet 37. In other words, first, second, and third axes 35, 31, 45 of needle guide member fuel channel 36, elongate fuel redirecting groove 30 and nozzle holder fuel channel 46, respectively, are in the same plane, which helps to reduce the degree of redirection of the fuel flow.

[0040] In alternate embodiments, at least one of first, second, and third axes 35, 31, 45 may be not in the same plane with the other axes as the other cavitation reducing features of the present disclosure such as the smooth transitions already reduce cavitation of alternative fuels to a desired amount.

[0041] Further, needle guide member fuel channel 36 smoothly transitions into high pressure fuel chamber 28. Moreover, high pressure fuel chamber 28 may be formed in a drop-like shape, which also participates in homogenisation of the fuel flow.

[0042] It is noted that the present disclosure describes various features aiming to reduce cavitation of fuel flowing through fuel injection system 10, while at the same time facilitating a retrofit of the two piece injector body to a conventional nozzle system as geometric boundary conditions are fulfilled. One skilled in the art will recognize that not all disclosed cavitation reducing features may have to be used to considerably reduce cavitation. Accordingly, other embodiments may not include all those features without departing from the scope of the present

disclosure. For example, in one embodiment, high pressure fuel chamber 28 may be not drop-like shaped.

[0043] It is further noted that although as, an example, a two-piece injector formed of a needle guide member and a ceramic hood is disclosed in connection with Figs. 2 and 3, similarly the disclosed needle guide member configuration allows mounting retrofitted one-piece injectors (a needle guide member without hood) to nozzle holders with preset fuel outlet positions.

[0044] One skilled in the art will appreciate that an elongate fuel redirecting groove as disclosed herein may be arranged to bridge a distance between a fuel outlet of a nozzle holder and a fuel inlet of a needle guide member. The fuel outlet may open in a radial inner section of the elongate fuel redirecting groove, and the fuel inlet may be disposed in a radial outer section of the elongate fuel redirecting groove. In other words, a nozzle holder fuel channel may open into a radial inner section of the elongate fuel redirecting groove and the needle guide member fuel channel may open into a radial outer section of the elongate fuel redirecting groove. Additionally or alternatively, an elongate fuel redirecting groove may fluidly interconnect two fuel outlets of a nozzle holder with at least one fuel inlet disposed in the elongate fuel redirecting groove. In still another embodiment, at least two elongate fuel redirecting grooves may intersect to fluidly connect at least one fuel outlet with at least one fuel inlet disposed in the fuel redirecting grooves. Further, elongate fuel redirecting groove may have any orientation and/or elongate course (such as straight, curved, zigzag) for fluidly interconnecting a fuel outlet of a nozzle holder fuel channel and a fuel inlet of a needle guide member fuel channel.

[0045] Those configurations may, for example, further include a drop-like shaped high pressure fuel chamber and/or the smooth transitions as disclosed herein, in particular for strongly cavitating fuels such as pyrolysis oils.

[0046] Although the preferred embodiments of this invention have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

Claims

1. A needle guide member (14) for forming a fuel injection system (10) of an internal combustion engine (5), the fuel injection system (10) further comprising a needle (12) and a nozzle holder (18), the needle guide member (14) comprising:

a needle guide member sealing face (22) for providing a sealed connection to the nozzle holder (18);

an elongate fuel redirecting groove (30) provided within the needle guide member sealing face (22);

a needle guiding bore (20) for guiding the needle

- (12) between a fuel injection state and a sealed state of the fuel injection system (10), the needle guiding bore (20) extending from the needle guide member sealing face (22) into the needle guide member (14) and comprising a high pressure fuel chamber (28);
a needle guide member fuel channel (36) fluidly interconnecting the elongate fuel redirecting groove (30) with the high pressure fuel chamber (28).
2. The needle guide member (14) of claim 1, wherein the elongate fuel redirecting groove (30) is elongated in radial direction of the needle guide member (14).
 3. The needle guide member (14) of claim 1 or claim 2, wherein the needle guide member fuel channel (36) extends along a first axis (35), and the elongate fuel redirecting groove (30) is elongated along a second axis (31), the first axis (35) and the second axis (31) being in the same plane.
 4. The needle guide member (14) of any one of the preceding claims, wherein the elongate fuel redirecting groove (30) comprises a length-width ratio within the range from 1.2:1 to 2.5:1.
 5. The needle guide member (14) of any one of the preceding claims, wherein the elongate fuel redirecting groove (30) comprises:
 - a side wall (34); and
 - a ground wall (32) smoothly transitioning into the side wall (34).
 6. The needle guide member (14) of any one of the preceding claims, wherein the smooth transition between the side wall (34) and the ground wall (32) has a radius within the range from 0.5 mm to 2 mm.
 7. The needle guide member (14) of any one of the preceding claims, wherein the needle guide member fuel channel (36) opens into a radial inner section of the elongate fuel redirecting groove (30); or the needle guide member fuel channel (36) opens into a radial outer section of the elongate fuel redirecting groove (30).
 8. The needle guide member (14) of any one of the preceding claims, wherein the elongate fuel redirecting groove (30) has a length within the range from 6 mm to 9 mm ; and/or the elongate fuel redirecting groove (30) has a width within the range from 2.5 mm to 5 mm; and/or the elongate fuel redirecting groove (30) has a depth within the range from 2.5 mm to 4.5 mm.
 9. The needle guide member (14) of any one of the preceding claims, wherein an inner channel wall of the needle guide member fuel channel (36) linearly extends into a wall of the high pressure fuel chamber (28).
 10. The needle guide member (14) of any one of the preceding claims, wherein the high pressure fuel chamber (28) is disposed in a middle section of the needle guide member (14), and/or the high pressure fuel chamber (28) is formed in a drop-like shape.
 11. A fuel injection system (10) for an internal combustion engine (5), comprising:
 - a needle (12);
 - a needle guide member (14) according to any one of the preceding claims, being adapted to guide the needle (12) within the needle guiding bore (20) between a fuel injection state and a sealed state of the fuel injection system (10);
 - a nozzle holder (18) comprising a nozzle holder sealing face (44) for providing a sealed connection to the needle guide member (14), and a nozzle holder fuel channel (46) having a fuel outlet (47) provided in the nozzle holder sealing face (44);
 - wherein the needle guide member (14) is mounted onto the nozzle holder (18), and the fuel outlet (47) of the nozzle holder (18) opens into the elongate fuel redirecting groove (30).
 12. The fuel injection system (10) of claim 11, wherein the elongate fuel redirecting groove (30) is arranged to bridge a distance between the fuel outlet (47) of the nozzle holder (18) and the fuel inlet (37) of the needle guide member (14).
 13. The fuel injection system (10) of claim 11 or claim 12, wherein the nozzle holder fuel channel (46) opens into a radial outer section of the elongate fuel redirecting groove (30) and the needle guide member fuel channel (36) opens into a radial inner section of the elongate fuel redirecting groove (30); or the nozzle holder fuel channel (46) opens into a radial inner section of the elongate fuel redirecting groove (30) and the needle guide member fuel channel (36) opens into a radial outer section of the elongate fuel redirecting groove (30).
 14. The fuel injection system (10) of any one of claim 11 to claim 13, wherein the needle guide member fuel channel (36) extends along a first axis (35), the elongate fuel redirecting groove (30) extends along a second axis (31), and the nozzle holder fuel channel (46) extends along a third axis (45), the first axis (35), the second axis (31) and the third axis (45) being in the same plane.

15. The fuel injection system (10) of any one of claim 11 to claim 14, further comprising a ceramic hood (16) adapted to essentially surround the needle guide member (14) with the exception of the needle guide member sealing face (22) and a collar (38) of the needle guide member (14), wherein the needle guide member (14) and the ceramic hood (16) are mounted onto the nozzle holder (18).

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FIG 1

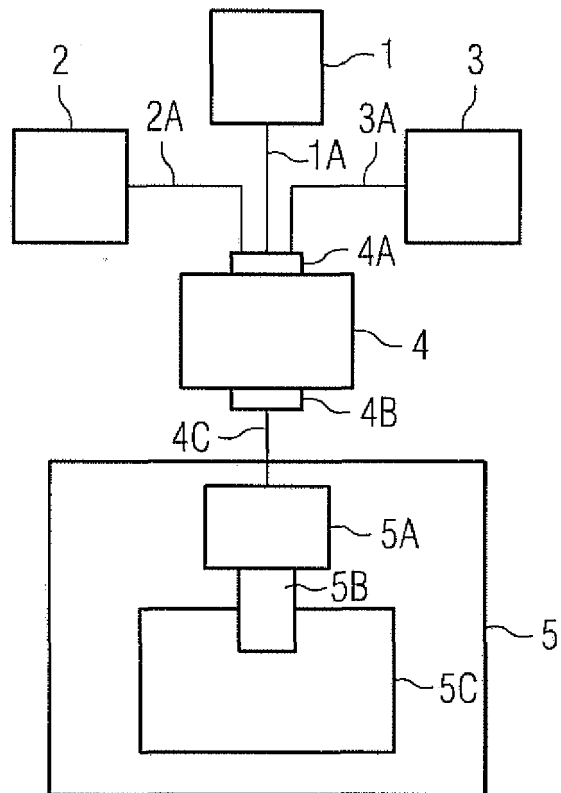


FIG 2

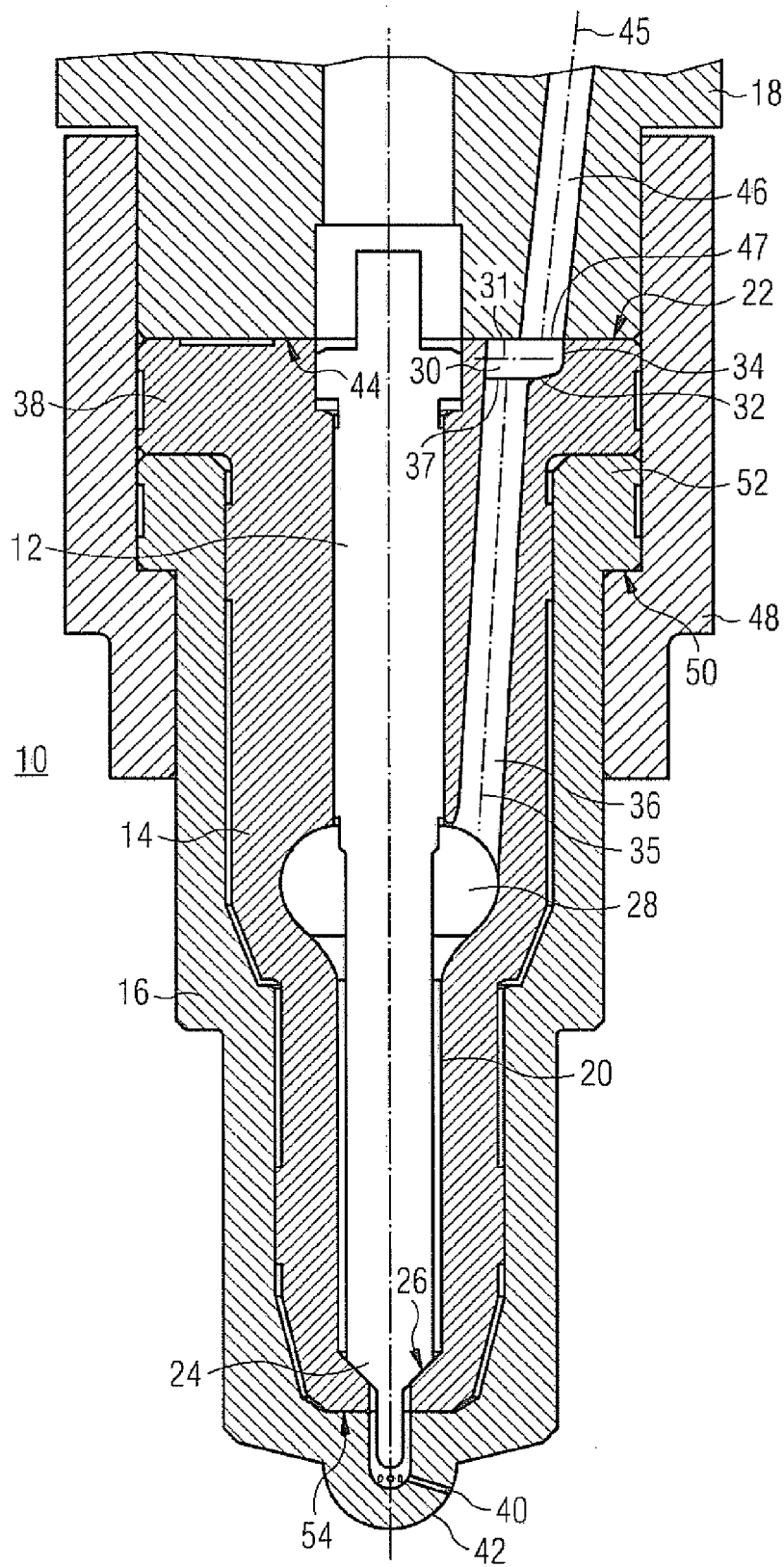
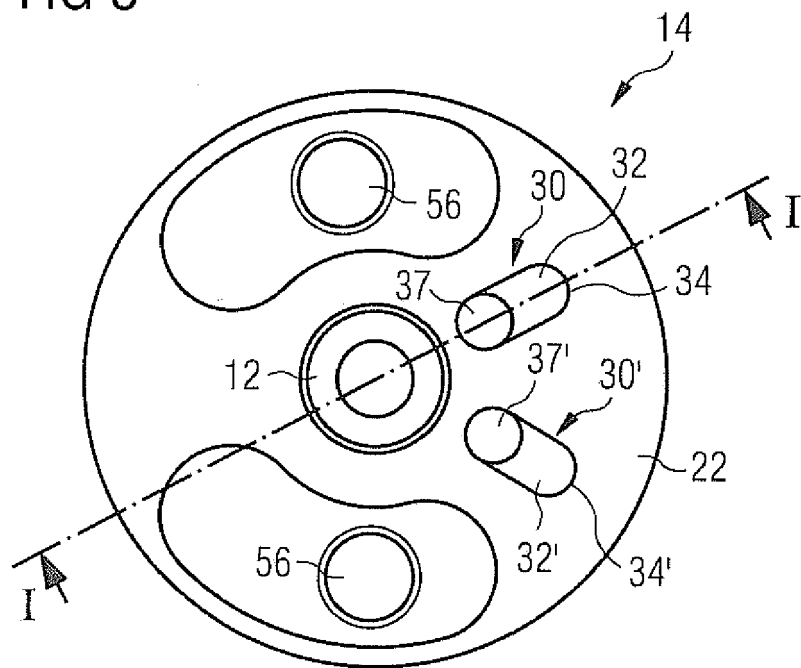


FIG 3





EUROPEAN SEARCH REPORT

Application Number
EP 12 19 3208

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	US 2008/173734 A1 (TOJO SENTA [JP] ET AL) 24 July 2008 (2008-07-24)	1-4,6, 8-11,14	INV. F02M55/00 F02M61/12
Y	* page 2, paragraph 0025; figures 1,4 *	15	
X	US 4 005 826 A (WOODWARD HENRY EDWIN) 1 February 1977 (1977-02-01)	1,4-6,8, 10-12	
Y	* abstract; figure 1 *	15	
X	GB 2 335 000 A (LUCAS IND PLC [GB]) 8 September 1999 (1999-09-08)	1,3,4, 6-8,11, 13	
Y	* abstract; figure 1 *	15	
X	WO 03/029642 A1 (SIEMENS AG [DE]; KRUEGER GRIT [DE]; ASTACHOW ANDREJ [DE]) 10 April 2003 (2003-04-10)	1-4,6-8, 11	TECHNICAL FIELDS SEARCHED (IPC)
Y	* abstract; figure 1 *	15	
X	CH 285 899 A (DUREX S A [CH]) 30 September 1952 (1952-09-30)	1-4,6,8, 11,14	
Y	* page 2, lines 25-38; figure 1 *	15	
Y,D	WO 2011/157375 A1 (CATERPILLAR MOTOREN GMBH & CO [DE]; NAGEL JUERGEN [DE]) 22 December 2011 (2011-12-22)	15	F02M
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 28 February 2013	Examiner Etschmann, Georg
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			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 19 3208

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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28-02-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008173734 A1	24-07-2008	CN 1648439 A	03-08-2005
		DE 102005003663 A1	25-08-2005
		FR 2865505 A1	29-07-2005
		JP 4066959 B2	26-03-2008
		JP 2005214023 A	11-08-2005
		US 2005161536 A1	28-07-2005
		US 2008173734 A1	24-07-2008

US 4005826 A	01-02-1977	US B541501 I5	13-04-1976
		US 4005826 A	01-02-1977

GB 2335000 A	08-09-1999	NONE	

WO 03029642 A1	10-04-2003	DE 10147792 A1	24-04-2003
		DE 50205062 D1	29-12-2005
		EP 1430218 A1	23-06-2004
		JP 2005504226 A	10-02-2005
		US 2004195350 A1	07-10-2004
		WO 03029642 A1	10-04-2003

CH 285899 A	30-09-1952	NONE	

WO 2011157375 A1	22-12-2011	NONE	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2011157375 A [0006]