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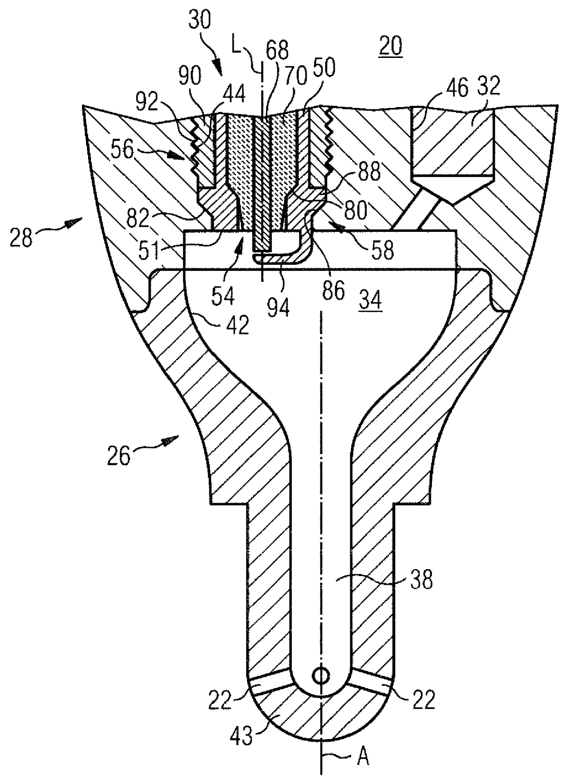
(54) SPARK PLUG FOR AN INTERNAL COMBUSTION ENGINE

(57) The present disclosure relates to a spark plug (30) for an internal combustion engine. The spark plug (30) is configured to be mounted in a spark plug bore (44) of the engine in such a manner that a length of a heat transfer path from a center electrode (68) and a ground electrode (94) is shortened. To this end, a sealing portion (58) through which the heat transfer is effected is provided closer to an end (51) of a housing (50) of the spark plug (30) than a mounting portion (56) for mounting the spark plug (30) in the spark plug bore (44). In this manner, the heat from the center electrode (68) and the ground electrode (94) can be transferred from the housing (50) to the inner surface of the spark plug bore (44) without having to flow through the mounting portion (56).

FIG 2



EP 3 460 929 A1

Description

Technical Field

[0001] The present disclosure generally relates to an internal combustion engine, and more particularly to a spark plug for an internal combustion engine.

Background

[0002] Internal combustion engines, for example, gaseous fuel internal combustion engines powered with a mixture of gaseous fuel and air, may comprise a spark plug per cylinder for ignition purposes. Particularly, large-bore gaseous fuel internal combustion engines may benefit from a spark plug disposed in a pre-combustion chamber (also referred to as a pre-chamber), as it is otherwise difficult to consistently achieve complete and thorough combustion of the gaseous fuel/air mixtures.

[0003] Typically, such a pre-chamber is fluidly connected to a main combustion chamber of a respective cylinder via a riser channel and a plurality of flow transfer channels. The flow transfer channels and the riser channel allow the flow of the mixture of gaseous fuel and air from the main combustion chamber into the pre-chamber during a compression stroke. Enrichment of the mixture in the pre-chamber may be effected by supplying a small quantity of (gaseous) fuel to the pre-chamber via a separate fuel supply passage, for example, during the intake stroke. The enriched mixture is ignited in the pre-chamber by the spark plug. The ignition of the enriched mixture causes a flame front of hot gases that propagates from the pre-chamber via the flow transfer channels into the main combustion chamber. Thus, the mixture in the main combustion chamber ignites and burns, and thereby expands against a movable piston that drives a crankshaft.

[0004] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0005] In one aspect, the present disclosure relates to a spark plug for an internal combustion engine. The spark plug comprises a center electrode extending along a longitudinal direction, an insulator disposed around the center electrode, and a housing mounted to the insulator. The housing is in thermal contact with the insulator at a first contact interface and has an opening at an end in the longitudinal direction through which the center electrode is exposed. A mounting portion is provided on an outer surface of the housing and configured to detachably mount the spark plug in a spark plug bore of the internal combustion engine. A sealing portion is provided on the outer surface of the housing and configured to sealingly engage an inner surface of the spark plug bore at a second contact interface when the spark plug is mounted in the spark plug bore. The sealing portion is disposed between the mounting portion and the opening in the longitudinal direction.

[0006] According to another aspect, the present disclosure relates to a pre-chamber assembly for an internal combustion engine. The pre-chamber assembly comprises a pre-chamber body defining a pre-chamber, and a spark plug according to the above aspect mounted in a spark plug bore formed in the pre-chamber body such that the sealing portion of the spark plug is sealingly engaged with the inner surface of the spark plug bore at the second contact interface.

[0007] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0008] The accompanying drawings, which are incorporated herein and constitute a part of the specification, illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure. In the drawings:

Fig. 1 shows a schematic cross-sectional view of a portion of an internal combustion engine equipped with a pre-chamber assembly in accordance with the present disclosure;

Fig. 2 shows a schematic cross-sectional view of a pre-chamber body including a spark plug in accordance with the present disclosure; and

Fig. 3 shows a partial cross-sectional view of a spark plug in accordance with the present disclosure.

Detailed Description

[0009] The following is a detailed description of exemplary embodiments of the present disclosure. The exemplary embodiments described herein 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.

[0010] The present disclosure is based in part on the realization that a known spark plug design has the disadvantage that the heat flow from the electrodes of the spark plug takes place over long distances, and therefore the electrodes may become very hot and be subjected to considerable wear. This applies especially when high pressures and a rich combustion are used. Further, even using materials like iridium, platinum and rhodium, this effect can only be reduced, but the problem cannot be overcome.

[0011] In view of the above, it has been realized that a new spark plug design is needed, which can significantly decrease the heat transfer distances from the electrodes to the part of the engine in which the spark plug is mounted. In this manner, the temperature of the electrodes can be reduced significantly, and the oxidation of the material of the electrodes can also be decreased.

[0012] The present disclosure is also based in part on the realization that proving additional insulation of the spark plug from the combustion chamber can further reduce the heat transferred from the combustion chamber and also enhances the heat transfer from the electrodes. In particular, it has been realized that materials having low thermal conductivity, such as Inconel or ceramics, can be advantageously employed.

[0013] Referring now to the drawings, Fig. 1 depicts a piston 2 arranged in a cylinder 4 of a portion of an internal combustion engine 1 (not shown in further detail). The cylinder 4 is covered by a cylinder head 6. The piston 2, the cylinder 4, and the cylinder head 6 together define a main combustion chamber 8 of the internal combustion engine 1. The piston 2 is reciprocatingly arranged in the cylinder 4 to move between a top dead center (TDC) and a bottom dead center (BDC) during operation of the internal combustion engine 1.

[0014] For the purpose of describing exemplary embodiments of the present disclosure, the internal combustion engine 1 is considered as a four-stroke stationary or marine internal combustion engine operating at least in part on gaseous fuel, for example, a gaseous fuel engine or a dual fuel engine. One skilled in the art will appreciate, however, that the internal combustion engine may be any type of engine (turbine, gas, diesel, natural gas, propane, two-stroke, etc.) that would utilize the pre-chamber assembly as disclosed herein, or that may not have the pre-chamber assembly. Furthermore, the internal combustion engine may be of any size, with any number of cylinders, and in any configuration (V-type, in-line, radial, etc.). Moreover, the internal combustion engine 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, pumps, stationary equipment, or other engine powered applications.

[0015] The cylinder head 6 includes at least one inlet valve 10, for example, a poppet valve. The inlet valve 10 is accommodated in an inlet channel 12 opening in a piston-side face 14 of the cylinder head 6 for supplying a mixture of gaseous fuel and air into the main combustion chamber 8. Similarly, at least one outlet valve 16, for example, also a poppet valve, is accommodated in an outlet channel 18 of the cylinder head 6 to guide exhaust gas out of the main combustion chamber 8.

[0016] The cylinder head 6 further comprises a pre-chamber assembly 20. A plurality of flow transfer channels 22 fluidly connect the main combustion chamber 8 with an interior of the pre-chamber assembly 20.

[0017] The pre-chamber assembly 20 is installed in the cylinder head 6 via a mounting body 24 as shown in Fig. 1. Alternatively, the pre-chamber assembly 20 may be installed in the cylinder head 6 in any other appropriate fashion.

[0018] Referring to Fig. 2, an exemplary embodiment of a pre-chamber assembly 20 is shown in a schematic cross-sectional view.

[0019] The pre-chamber assembly 20 includes a first pre-chamber body 26, a second pre-chamber body 28, a spark plug 30, and a fuel supply device 32. The first pre-chamber body 26 and the second pre-chamber body 28 are connected to one another. The spark plug 30 and the fuel supply device 32 are accommodated in the second pre-chamber body 28

[0020] The first pre-chamber body 26 includes and defines a pre-chamber 34, a riser channel 38 and the flow transfer channels 22. In an assembled state, the flow transfer channels 22 fluidly connect an interior of the pre-chamber body 26 (the pre-chamber 34 and the riser channel 38) and the main combustion chamber 8 (Fig. 1). As can be seen in Fig. 2, a diameter of the pre-chamber 34 is greater than a diameter of the riser channel 38, which in turn is greater than a diameter of the flow transfer channels 22.

[0021] The pre-chamber 34 extends along a longitudinal axis A of the first pre-chamber body 26, is funnel-shaped, and tapers towards the riser channel 38. Alternatively, the pre-chamber 34 may have any other shape such as a cylindrical shape, a pyramidal shape, a conical shape, and combinations thereof. For example, the pre-chamber 34 may have a volume within a range between 0,1 % and 10 % of the compression volume of the cylinder 4 (see Fig. 1).

[0022] A bottom section of the pre-chamber 34 smoothly transitions into the riser channel 38. The riser channel 38 longitudinally extends in the first pre-chamber body 26, and opens with one end in the pre-chamber 34. In the configuration shown in Fig. 2, the riser channel 38 is aligned with the pre-chamber longitudinal axis A. Alternatively, the riser channel 38 may run parallel to the pre-chamber longitudinal axis A, or may confine an angle with the pre-chamber longitudinal axis A. The riser channel 38 fluidly connects the pre-chamber 34 and the flow transfer channels 22.

[0023] To fluidly connect a bottom section of the riser channel 38 and a top section of the main combustion chamber 8 (see Fig. 1), the flow transfer channels 22 are provided. The flow transfer channels 22 extend through a tip portion 43 of the first pre-chamber body 26. In some embodiments, the flow transfer channels 22 may directly open in the pre-chamber 34. In other words, a riser channel fluidly interconnected between the pre-chamber and the flow transfer channels may be omitted.

[0024] The spark plug 30 is installed in the pre-chamber assembly 20 so that the spark plug 30 is operably coupled to the pre-chamber 34.

[0025] As used herein, "operably coupled" means that the spark plug 30 is configured and arranged to ignite an ignitable mixture in the pre-chamber 34. For example, the spark plug 30 may extend into the pre-chamber 34. Specifically, electrodes of the spark plug 30 may reach into the pre-chamber 34 so that a spark between the electrodes ignites a mixture in the pre-chamber 34. The spark plug 30 may be mounted in a spark plug bore 44 formed in the first and/or second pre-chamber body 26, 28.

[0026] The fuel supply device 32 is mounted in a fuel supply bore 46 extending through the second pre-chamber body 28. Alternatively, the fuel supply device 32 may be mounted in the first pre-chamber body 26. The fuel supply device 32 is configured to supply a fuel, for example, a gaseous fuel, or a rich mixture of fuel and air to the pre-chamber 34 for enriching the same.

[0027] As shown in Fig. 2, the spark plug 30 comprises a center electrode 68 extending along a longitudinal direction L. An insulator 70 is disposed around the center electrode 68 and is in thermal contact with the same. Further, a housing 50 is mounted to the insulator 70. The housing 50 is a substantially cylindrical body surrounding the insulator 70, and is in thermal contact with the insulator 70 at a first contact interface 80. As used herein, the term "contact interface" generally designates an interface between two members that are either directly or indirectly in contact with each other, in particular, in thermal contact with each other. Therefore, as used herein, the term "contact interface" includes a direct contact between surfaces of two members, or an indirect contact between the two members via an intermediate member. In particular, as used herein, the term "contact interface" designates an interface via which a heat transfer between two members occurs. The first contact interface 80 will be described in more detail below.

[0028] The housing 50 of the spark plug 30 further has an opening 54 at an end 51 in the longitudinal direction A. Through the opening 54, the center electrode 68 is exposed. In the example shown in Fig. 2, the center electrode 68 protrudes from the opening 54 into the pre-chamber 34. However, in other embodiments, the center electrode 68 may not protrude from the opening 54, and may be disposed in a recess formed in the end 51 of the housing 50. Therefore, as used herein, the term "exposed" is used to designate the accessibility of the center electrode 68 from the side of the pre-chamber 34 via the opening 54 formed in the housing 50.

[0029] As shown in Fig. 2, in one exemplary embodiment, the spark plug 30 further includes at least one ground electrode 94 mounted at the end 51 of the housing 50. In particular, the ground electrode 94, which may be a J-gap electrode, is arranged to face the center electrode 68 such that a spark can be generated between the center electrode 68 and the ground electrode 94 in a known manner. As will be described in more detail below, the at least one ground electrode 94 is configured to be in thermal contact with the inner surface of the spark plug bore 44 via the housing 50 and a second contact interface 82, which will also be described in more detail below.

[0030] A mounting portion 56 configured to detachably mount the spark plug 30 in the spark plug bore 44 is provided on an outer surface of the housing 50. In particular, as shown in Fig. 2, the mounting portion 56 includes a shoulder 88 formed in the outer surface of the housing 50. The shoulder 88 is formed, for example, as a substantially annular flange on the housing 50.

[0031] Further, as shown in Fig. 2, in the exemplary embodiment, the mounting portion 56 further comprises a mounting sleeve 90 configured to be mounted on the outer surface of the housing 50 to engage the shoulder 88 and bias the housing 50 towards the end 51 of the housing 50 in the longitudinal direction L. In particular, the mounting sleeve 90 includes a male threaded portion 92 configured to engage a corresponding female threaded portion formed in the inner surface of the spark plug bore 44. In this manner, the spark plug 30 is mounted in the spark plug bore 44 by tightening the mounting sleeve 90 to press the housing 50 of the spark plug 30 against the pre-chamber body 26, 28, which will be described in more detail below.

[0032] A sealing portion 58 is provided on the outer surface of the housing 50 and configured to sealingly engage an inner surface of the spark plug bore 44 at the second contact interface 82 when the spark plug 30 is mounted in the spark plug bore 44 in the above described manner.

[0033] With the above configuration, heat that is transferred to the center electrode 68 and the ground electrode 94 due to the combustion in the pre-chamber 34 can be transferred to the pre-chamber body 26, 28 via the first contact interface 80 and the second contact interface 82. In particular, the heat is transferred from the ground electrode 94 to the housing 50, in particular, the end 51 of the same at which the ground electrode 94 is connected to the housing 50, and from the end 51 of the housing 50 to the second pre-chamber body 28 via the second contact interface 82, at which the housing 50 is pressed against the inner surface of the spark plug bore 44. In addition, the heat is transferred from the center electrode 68 to the second pre-chamber body 28 via the insulator 70, the first contact interface 80, and the second contact interface 82.

[0034] In accordance with the present disclosure, the sealing portion 58 of the spark plug 30 is disposed between the mounting portion 56 and the opening 54 at the end 51 of the housing 50 in the longitudinal direction L. As shown in Fig. 2, this has the effect that the heat transfer from the housing 50 to the second pre-chamber body 28 occurs in close proximity to the end 51 where the center electrode 68 and the ground electrode 94 are heated due to the combustion in the pre-chamber 34. This is in contrast to known designs, in which the corresponding sealing portion is disposed further away from the end of the spark plug than the corresponding mounting portion, such that the heat transfer occurs over a significantly greater distance, i.e., results in significantly less effective cooling of the exposed portions of the center electrode 68 and the ground electrode 94.

[0035] Fig. 3 shows an exemplary configuration of a spark plug 30 in accordance with the present disclosure in more detail.

[0036] As shown in Fig. 3, the sealing portion 58 includes a conical sealing surface 84 formed in the outer surface of the housing 50 and configured to sealingly engage a mating sealing surface of the spark plug bore 44 (see Fig. 2). It will be readily appreciated, however, that the conical sealing surface 84 is only an example for the sealing portion 58 of the present disclosure, and other appropriate configurations can be used. For example, instead of a conical sealing surface, a shoulder or step can be formed in the outer surface of the housing 50, as long as an extended sealing surface is provided that can be pressed against a mating sealing surface of the spark plug bore 44 when the spark plug 30 is mounted in the same. Further, in other embodiments, the heat transfer between the housing 50 and the spark plug bore 44 may be effected by providing an intermediate member between the same, for example, an annular seal mounted to the outer surface of the housing 50 and configured to sealingly engage the inner surface of the spark plug bore 44.

[0037] In addition, while Fig. 3 shows an exemplary configuration in which the mounting portion 56 includes the shoulder 88 formed on the outer surface of the housing 50 and the mounting sleeve 90 described above, it will be readily appreciated that in other embodiments the mounting portion may be configured as a male threaded portion that is formed on the housing 50 and engages a female threaded portion formed in the inner surface of the spark plug bore to mount the spark plug inside the same such that the sealing portion 58 sealingly engages the inner surface of the spark plug bore 44 at the second contact interface 82. Clearly, in any of the above-mentioned configurations, the heat transfer path from both the center electrode 68 and the ground electrode 94 to the pre-chamber body 26, 28 or any other part of the engine in which the spark plug 30 is mounted can be shortened due to the sealing portion 58 being disposed closer to the end 51 of the housing 50 than the mounting portion 56.

[0038] As shown in Fig. 3, in the exemplary embodiment, the first contact interface 80 is formed between a conical outer surface of the insulator 70 and a corresponding conical inner surface of the housing 50, between which a seal 87 is disposed. When the spark plug 30 is assembled, the heat transfer between the insulator 70 and the housing 50 occurs primarily between the two conical surfaces mentioned above via the seal 87. Accordingly, the heat transfer from the center electrode 68 to the housing 50 also occurs primarily via the first contact interface 80. The heat that is transferred from the center electrode 68 to the housing 50 via the first contact interface 80 is then transferred to the second pre-chamber body 28 via the second contact interface 82 (see Fig. 2). The corresponding heat transfer path from the center electrode 68 is shown by a dashed line in Fig. 3.

[0039] Likewise, the heat from the ground electrode 94 is also transferred to the second pre-chamber body 28 from the housing 50 via the second contact interface 82, in particular, via the conical sealing surface 84 that is in thermal contact with a mating surface of the spark plug bore 44.

[0040] As shown in Fig. 3, in one embodiment, the at least one ground electrode 94 may be configured as a plurality of linear electrodes 96 protruding from the housing 50 with respect to the longitudinal axis L, for example, at an angle of between 0° and 15°. Further, in some embodiments, the plurality of linear electrodes 96, for example, three such linear electrodes, may be arranged at equal intervals in the circumferential direction. The heat transfer path from the linear electrodes 96 to the second contact interface 82 is also shown by a dashed line in Fig. 3.

[0041] It will be appreciated that the configurations of the ground electrode 94 shown in the drawings are only exemplary, and that any appropriate configuration for such ground electrodes can be used. Further, in some embodiments, the ground electrodes 94 may be omitted. In particular, in some cases, the housing 50 itself may serve as the "ground electrode" for generating the spark to ignite the combustion in pre-chamber 34. Clearly, the above-described advantageous effect of the short heat transfer path from the housing 50 to the second pre-chamber body 28 or a corresponding part of the engine can also be obtained in this case.

[0042] Fig. 3 also shows that, in order to increase the thermal insulation of the housing 50 from the combustion inside the pre-chamber 34, a shield member 98 that covers at least in part a front surface 53 of the housing 50 at the end 51 of the same can be provided. In particular, the shield member 98 may be formed as a cover that covers the front surface 53 of the housing 50, for example, a cap-like member that is attached to the end 51 of the housing 50 such that the plurality of linear electrodes 96 and the center electrode 68 protrude from the same. Advantageously, the shield member 98 is made from a material that has lower thermal conductivity than the material forming the housing 50. For example, the shield member 98 may be made from a material such as Inconel or ceramics to further reduce the amount of heat that is transferred from the side of the pre-chamber 34 to the housing 50. This further increases the amount of heat that can be transferred from the center electrode 68 and the plurality of linear electrodes 96 to the housing 50 and the pre-chamber body 26, 28. On the other hand, the housing 50 may be formed from a material with a high thermal conductivity, for example, aluminum alloy and/or copper alloy.

[0043] In accordance with some exemplary embodiments, the second contact interface 82 is disposed closer to the opening 54 than the first contact interface 80, or at substantially the same position along the longitudinal direction L. In this manner, the heat transfer from the housing 50 to the part of the engine to which the spark plug 30 is mounted can take place as close to the end 51 of the housing 50 as possible, to minimize the length of the heat transfer path from the center electrode 68 and the at least one ground electrode 94 to the part of the engine to which the spark plug 30 is mounted.

[0044] With the spark plug 30 in accordance with the present disclosure, the heat transfer distances for at least the center electrode 68 and, if present, the ground electrode 94 can be shortened to efficiently cool the electrodes. Further, the mounting portion 56 of the housing 50 is isolated from the side of the pre-chamber 34 by the sealing portion 58 that is disposed between the same. In particular, in case a male threaded portion is formed on an outer surface of the housing 50 or the mounting sleeve 90, it is not subjected to the heat generated by the combustion in the pre-chamber 34. In addition, the housing 50 itself can be thermally insulated from the pre-chamber 34 by providing the shield member 98, to further enhance the heat transfer from the electrodes.

Industrial Applicability

[0045] The spark plug 30 as exemplarily disclosed herein is particularly applicable to gaseous fuel internal combustion engines running on a mixture of gaseous fuel and air. However, as one skilled in the art will appreciate, the spark plug 30 as described herein may be used in other engine configurations and types as well.

[0046] Generally, a gaseous fuel internal combustion engine for use with the teachings of the present disclosure comprises a plurality of cylinders and a plurality of pre-chamber assemblies. Each pre-chamber assembly comprises a pre-chamber body defining a pre-chamber, a fuel supply device accommodated in the pre-chamber body and configured to supply gaseous fuel to the pre-chamber, and a spark plug in accordance with the present disclosure mounted in a spark plug bore formed in the pre-chamber body and configured to ignite the gaseous fuel in the pre-chamber. The plurality of pre-chamber assemblies configured as described above are respectively mounted to the cylinder heads of the plurality of cylinders of the gaseous fuel internal combustion engine.

[0047] It should be noted that, while the embodiments have been described with respect to a spark plug provided in a pre-chamber assembly, in other embodiments, the spark plug may also be provided in an engine that does not have a pre-chamber assembly. In other words, the spark plug disclosed herein may be mounted to a cylinder head of an internal combustion engine and may be arranged in a main combustion chamber of the engine. Further, while the present embodiments have been described with respect to the combustion of gaseous fuel, it will be appreciated that in some embodiments different types of fuel can be used, for example, liquid fuels and/or a mixture of gaseous fuel and/or liquid fuel.

[0048] Terms such as "about", "around", "approximately", or "substantially" as used herein when referring to a measurable value such as a parameter, an amount, a temporal duration, and the like, is meant to encompass variations of $\pm 10\%$ or less, preferably $\pm 5\%$ or less, more preferably $\pm 1\%$ or less, and still more preferably $\pm 0.1\%$ or less of and from the specified value, insofar as such variations are appropriate to perform in the disclosed invention. It is to be understood that the value to which the modifier "about" refers is itself also specifically, and preferably, disclosed. The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within the respective ranges, as well as the recited endpoints.

[0049] 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 spark plug (30) for an internal combustion engine (1), the spark plug (30) comprising:

   a center electrode (68) extending along a longitudinal direction (L);
   an insulator (70) disposed around the center electrode (68);
   a housing (50) mounted to the insulator (70), the housing (50) being in thermal contact with the insulator (70) at a first contact interface (80) and having an opening (54) at an end (51) in the longitudinal direction (L) through which the center electrode (68) is exposed;
   a mounting portion (56) provided on an outer surface of the housing (50) and configured to detachably mount the spark plug (30) in a spark plug bore (44) of the internal combustion engine (1); and
   a sealing portion (58) provided on the outer surface of the housing (50) and configured to sealingly engage an inner surface of the spark plug bore (44) at a second contact interface (82) when the spark plug (30) is mounted in the spark plug bore (44),
   wherein the sealing portion (58) is disposed between the mounting portion (56) and the opening (54) in the longitudinal direction (L).

2. The spark plug of claim 1, wherein the sealing portion (58) includes a conical sealing surface (84) configured to sealingly engage a mating sealing surface of the spark plug bore (44).

3. The spark plug of claim 1 or 2, wherein the sealing portion (58) includes an annular seal mounted to the outer surface of the housing (50) and configured to sealingly engage the inner surface of the spark plug bore (44).

4. The spark plug of any one of claims 1 to 3, wherein the mounting portion (56) includes a shoulder (88) formed in the outer surface of the housing (50).

5. The spark plug of claim 4, wherein the shoulder (88) is formed as a substantially annular flange on the housing (50).

6. The spark plug of claim 4 or 5, further comprising a mounting sleeve (90) configured to be mounted on the outer surface of the housing (50) to engage the shoulder (88) and bias the housing (50) towards the end (51) in the longitudinal direction (L).

7. The spark plug of claim 6, wherein the mounting sleeve (90) includes a male threaded portion (92) configured to engage a female threaded portion formed in the inner surface of the spark plug bore (44) to mount the spark plug (30) in the spark plug bore (44).

8. The spark plug of any one of claims 1 to 3, wherein the mounting portion (56) includes a male threaded portion formed on the housing (50) and configured to engage a female threaded portion formed in the inner surface of the spark plug bore (44) to mount the spark plug (30) inside the spark plug bore (44) such that the sealing portion (58) sealingly engages the inner surface of the spark plug bore (44) at the second contact interface (82).

9. The spark plug of any one of the preceding claims, further comprising at least one ground electrode (94) mounted at the end (51) of the housing (50) and arranged to face the center electrode (68), the at least one ground electrode being configured to be in thermal contact with the inner surface of the spark plug bore (44) via the housing (50) and the second contact interface (82).

10. The spark plug of claim 9, wherein the at least one ground electrode (94) includes a plurality of linear electrodes (96) protruding from the housing (50) at an angle with respect to the longitudinal direction (L), for example, at an angle of between 0° and 15°.

11. The spark plug of claim 10, wherein the plurality of linear electrodes (96), for example, three linear electrodes, are arranged at equal intervals in the circumferential direction.

12. The spark plug of any one of claims 1 to 11, further comprising a shield member (98) covering at least in part a front surface (53) of the housing (50) at the end (51) of the same.

13. The spark plug of claim 12, wherein the shield member (98) is made from a material that has lower thermal conductivity than the material forming the housing (50), for example, Inconel and/or ceramics.

14. The spark plug of any one of the preceding claims, wherein the second contact interface (82) is disposed closer to the opening (54) than the first contact interface (80), or at substantially the same position as the first contact interface (80) in the longitudinal direction (L).

15. A pre-chamber assembly (20) for an internal combustion engine (1), comprising:

a pre-chamber body (26, 28) defining a pre-chamber (34); and
a spark plug (30) according to any one of claims 1 to 14 mounted in a spark plug bore (44) formed in the pre-chamber body (26, 28) such that the sealing portion (58) of the spark plug (30) is sealingly engaged with the inner surface of the spark plug bore (44) at the second contact interface (82).

FIG 1

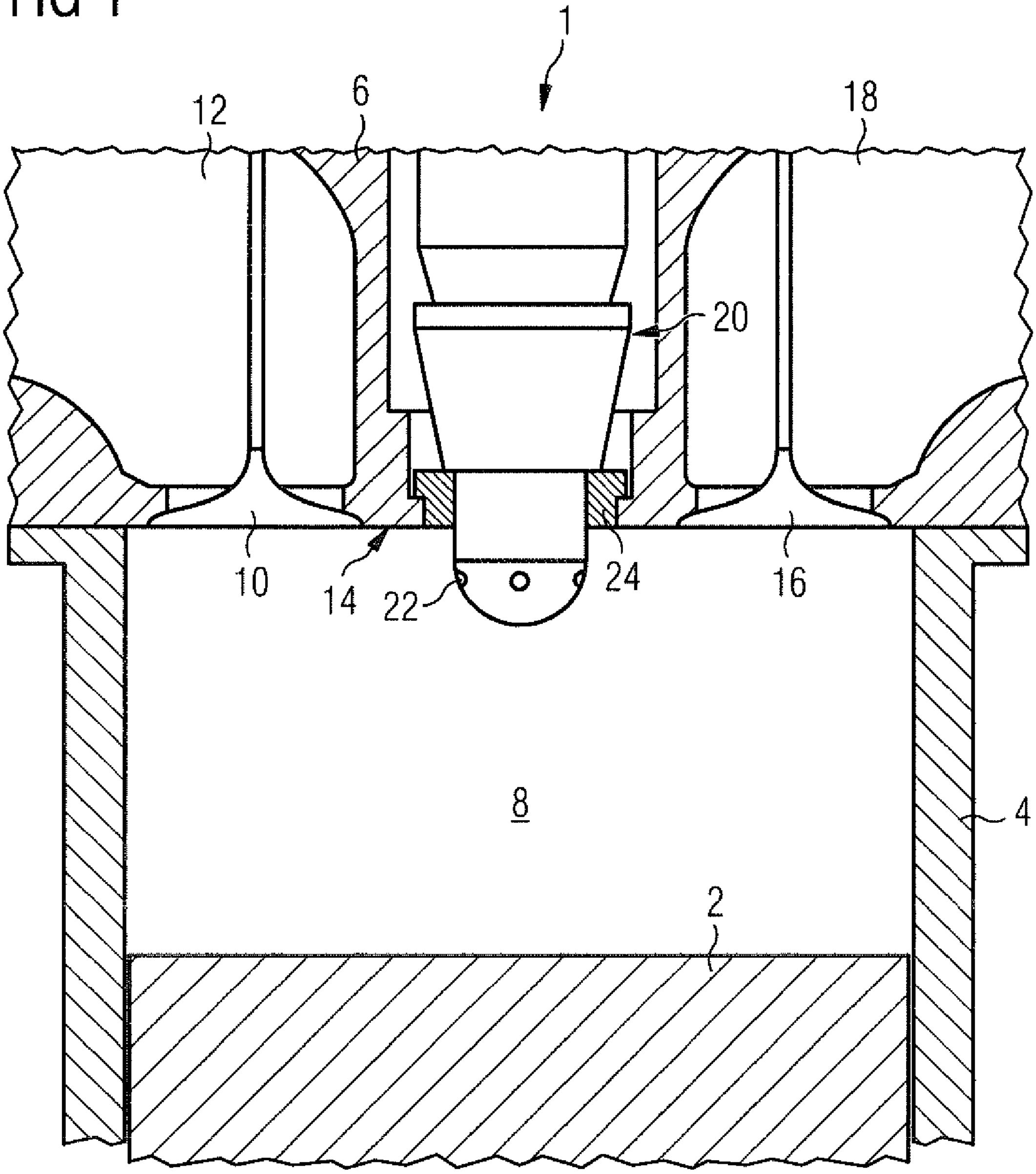


FIG 2

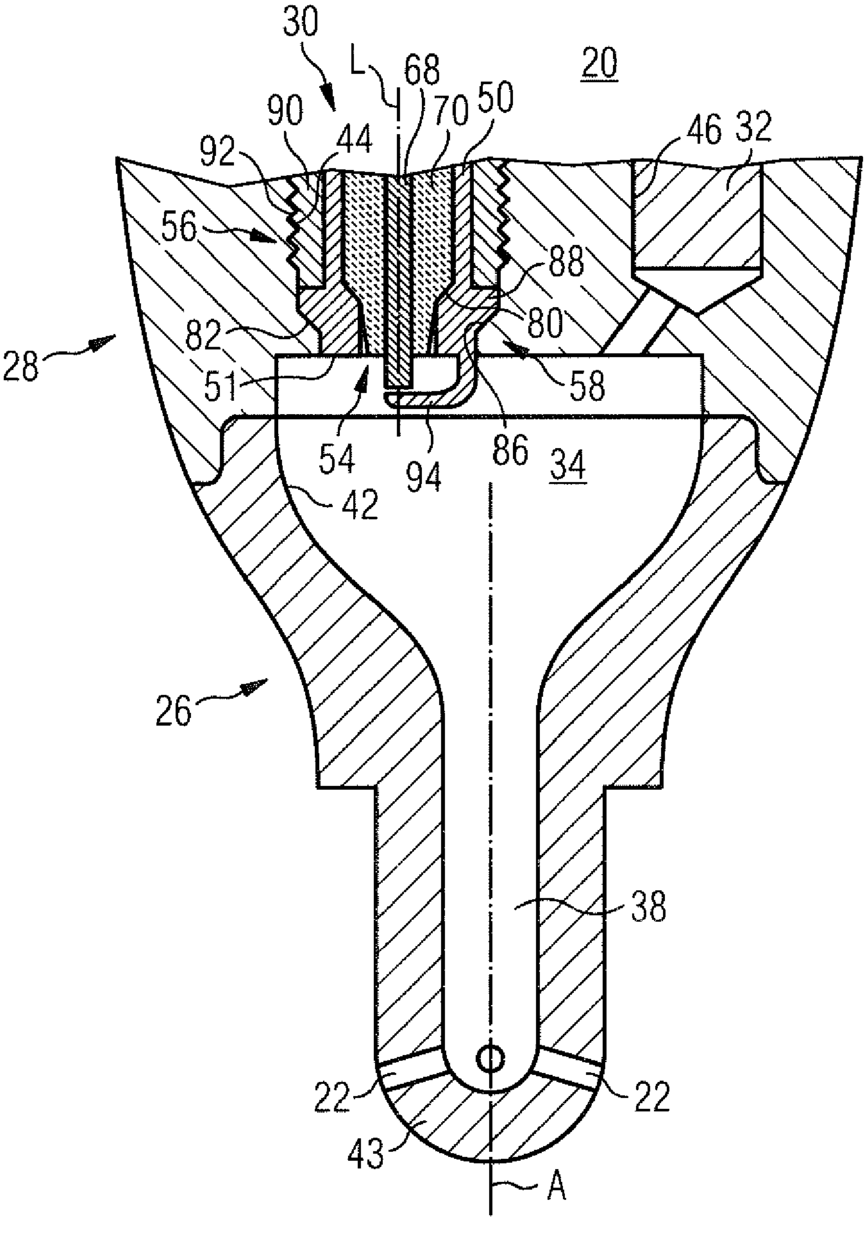

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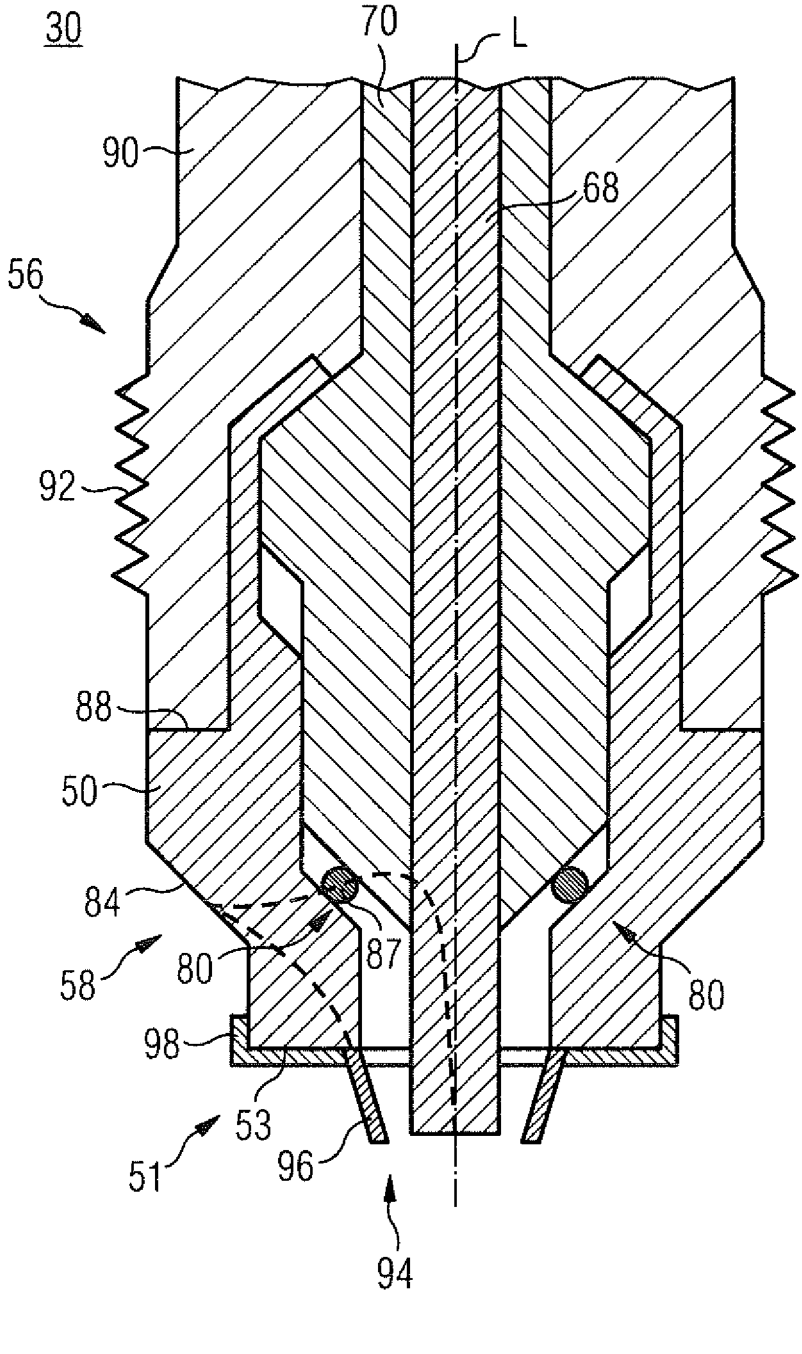
FIG 3



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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 2672

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search	Date of completion of the search	Examiner
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