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(54) METHOD OF MANUFACTURING A CYLINDER HEAD

(57) The invention relates to a method (3) for manufacturing a cylinder head (2) for an internal combustion engine. In the method (3), a pre-chamber insert (1) with an internal pre-chamber (4) is prefabricated and is arranged in the correct position in a cylinder head mould (11). A casting material is then filled into the cylinder head mould (11) with the arranged pre-chamber insert (1), and the cylinder head (2) with the materially bonded pre-chamber insert (1) is thereby manufactured for the internal combustion engine.

The invention also relates to the cylinder head (2) and the pre-chamber insert (1).

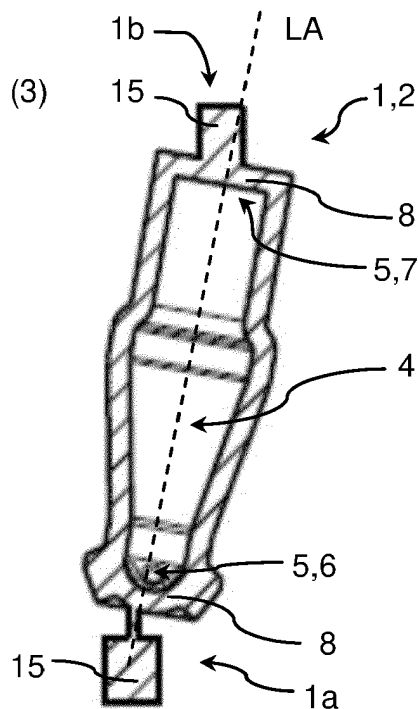


Fig. 1

Description

[0001] The invention relates to a method of manufacturing a cylinder head according to the generic term of claim 1. The invention also relates to the cylinder head and a pre-chamber insert for the cylinder head.

[0002] In an internal combustion engine, a fuel is ignited in a combustion chamber by means of a spark plug arranged in the cylinder head. Often a pre-chamber is also formed in the cylinder head and is arranged between the spark plug and the combustion chamber. Part of the fuel is then ignited in the pre-chamber and is ejected through nozzles into the combustion chamber. Then, the remaining fuel in the combustion chamber is ignited by the ejected part of the fuel. The pre-chamber requires a complex integral geometry and must be accurately positioned in the cylinder head. With current manufacturing methods, it is disadvantageously not possible to realize a complex geometry of the pre-chamber. Particularly problematic is the alignment of the individual nozzles, which directly influences ignition in the combustion chamber.

[0003] It is therefore the object of the invention to provide a method of manufacturing a cylinder head in which the disadvantages described are overcome.

[0004] This object is solved according to the invention by the object of the independent claims. Advantageous embodiments are the subject of the dependent claims.

[0005] The present invention is based on the general idea of prefabrication of a pre-chamber for a cylinder head with all the required internal features and then casting it into the cylinder head. The method according to the invention is provided for manufacturing a cylinder head for an internal combustion engine. In the method, a pre-chamber insert with an internal pre-chamber is prefabricated and arranged in the correct position in a cylinder head mould. Thereafter, a casting material is filled into the cylinder head mould with the arranged pre-chamber insert and thereby the cylinder head with the materially bonded pre-chamber insert for the internal combustion engine is casted.

[0006] In the internal combustion engine, the combustion chamber is not a part of the cylinder head but is partially limited to the outside by the cylinder head. However, the position of the combustion chamber can be seen on the cylinder head, so that here and after a reference is made to the combustion chamber.

[0007] In the method according to the invention, the pre-chamber insert can be manufactured independently of the cylinder head with all the required internal features and all the required external features. As a result, the pre-chamber can contain a configuration of almost any complexity. In particular, the nozzles leading from the pre-chamber into a combustion chamber can be asymmetrically shaped and/or different in size and/or different in shape. Moreover, the orientation of the nozzles can be adapted according to the requirements. Overall, this can improve the ignition in the internal combustion en-

gine. In addition, the pre-chamber insert is materially bonded to the cylinder head, so that a heat transfer between the cylinder head and the pre-chamber is also optimized. As a result, the temperature in the pre-chamber can be better controlled. The method according to the invention is applicable for manufacturing cylinder heads for differently designed internal combustion engines with a pre-chamber.

[0008] Advantageously, the pre-chamber insert can be prefabricated by means of 3D printing. 3D printing can be used for both passive and active applications. The pre-chamber insert can thereby be manufactured ready for use and further post-methoding - for example, for manufacturing internal features of the pre-chamber - can be avoided. Moreover, the nozzles leading from the pre-chamber into a combustion chamber can be shaped asymmetrically and/or differently in size and/or differently in shape. Moreover, with 3D printing, the orientation of the nozzles can also be adapted according to the requirements. Alternatively, the pre-chamber insert can be prefabricated by means of a casting method. Regardless of the manufacturing method, the pre-chamber insert can be made of steel or non-ferrous materials.

[0009] In one embodiment of the method, it can be provided that during the prefabrication of the pre-chamber insert, at least one opening closed to the outside by means of a protective region is prefabricated. After the materially bonding of the pre-chamber insert has been into the cylinder head, the protective region is removed and the at least one opening is opened to the outside. The protective region can thereby protect the pre-chamber from penetration of the casting material during casting of the cylinder head.

[0010] For example, the protective region can be integrally manufactured with the pre-chamber insert. In particular, this can be used by fabricating the pre-chamber insert by means of 3D printing. Alternatively, the protective region can be manufactured separately from the pre-chamber insert and can be attached to the prefabricated pre-chamber insert by material bonding, preferably by welding. In this case, the protective region can be prefabricated in the form of a cover cap. The material of the cover cap can be identical to the material of the pre-chamber insert or can differ therefrom.

[0011] Possible embodiments of the at least one opening are listed below. In principle, one or more openings can be formed in the pre-chamber insert in one or more embodiments. The embodiment and the number of the respective openings can thereby differ depending on the requirements. It is understood that this list is not exhaustive.

[0012] The at least one opening can be prefabricated in the form of a gas recirculation opening for introducing recirculated exhaust gas. The at least one opening can also be prefabricated in the form of a purge opening for introducing purge air into the pre-chamber. The at least one opening can be prefabricated in the form of a fuel opening for introducing a gaseous or alternative second-

ary fuel. To form the openings described above, a bore with a valve system can be formed in the pre-chamber insert. The valve system can then allow passive or active introduction of exhaust gas or purge air or secondary fuel. Alternatively or additionally, the at least one opening can be prefabricated in the form of an instrument opening for arranging of at least one additional instrument. Preferably, the at least one instrument can be a temperature sensor and/or a pressure sensor and/or a combustion air ratio sensor. The at least one opening can be prefabricated at an end of the pre-chamber insert facing a combustion chamber in the form of a nozzle leading into the combustion chamber. Thereby, a plurality of nozzles can be prefabricated, wherein the nozzles can differ from each other in shape and/or in size and/or in orientation. For example, the nozzles can have a different angle of inclination with respect to a longitudinal central axis of the pre-chamber insert and/or a different diameter and/or a cylindrical or conical or other shape. The at least one opening can be prefabricated at an end of the pre-chamber insert facing away from a combustion chamber in the form of a spark plug opening. The spark plug can then be inserted into the pre-chamber through the spark plug opening.

[0013] In an advantageous embodiment of the method, it can be provided that during prefabrication of the pre-chamber insert, a filling material is filled into the internal pre-chamber. After the pre-chamber insert has been materially bonded into the cylinder head, the filling material is removed from the internal pre-chamber. The filling material can be filled into the pre-chamber during prefabrication and the pre-chamber can be closed with the protective region described above. Preferably, the filling material is inert and does not affect the fabrication of the cylinder head. The filling material can be removed after removal of the respective protective region through the at least one opening thus opened. The filling material can protect the pre-chamber insert from internal pressure during casting, or at least reduce the internal pressure during casting.

[0014] During the prefabrication of the pre-chamber insert, at least one rotationally asymmetric positioning unit can be fabricated on an outer side of the pre-chamber insert. In this regard, the positioning unit can be fabricated at an end of the pre-chamber insert facing a combustion chamber or at an end of the pre-chamber insert facing away from a combustion chamber. When arranging the pre-chamber insert in the cylinder head mould, the pre-chamber insert can then be arranged in the correct position in the cylinder head mould by means of the at least one rotationally asymmetrical positioning unit. In particular, it is conceivable that at least two positioning units are provided at each end of the pre-chamber insert. Advantageously, the at least one positioning unit can be formed in the protective region or as the protective region and can be removed after the pre-chamber insert has been materially bonded into the cylinder head.

[0015] In an advantageous embodiment of the method,

it can be provided that during the prefabrication of the pre-chamber insert, at least one additional element is integrally manufactured on the pre-chamber insert. Possible embodiments of the element are listed below. In principle, several elements listed below can be combined in the pre-chamber insert according to the requirements. It is understood that this list is not exhaustive.

[0016] During the prefabricating the pre-chamber insert, an ignition source holder for receiving a secondary ignition source for a combustion chamber can be integrally fabricated on the pre-chamber insert. During the prefabricating the pre-chamber insert, an injector holder for receiving a fuel injector for a combustion chamber can also be integrally fabricated on the pre-chamber insert. Further, a cooling channel unit with a channel for cooling guidance can be integrally fabricated on the pre-chamber insert. During the prefabricating the pre-chamber insert, a preheating channel unit with a channel for preheating the pre-chamber can also be integrally manufactured on the pre-chamber insert. In principle, the cooling channel unit and the preheating channel unit can be implemented by a single or common unit. The cooling channel unit and the preheating channel unit enable cooling and preheating of the pre-chamber independently of the cylinder head. Further, during the prefabrication of the pre-chamber insert, at least one external retention unit can be integrally manufactured on the pre-chamber insert. In this regard, the retention unit can include a plurality of retention elements to enhance the retention i.e. materially binding of the pre-chamber insert in the cylinder head. Further, during the prefabrication of the pre-chamber insert, a holding unit for holding an electrical heating element can also be integrally manufactured on the pre-chamber insert.

[0017] By manufacturing the above elements with the pre-chamber insert, these elements can be closely coupled to each other. The cooling channel unit and/or the preheating channel unit closely coupled to the pre-chamber and optionally to further elements can significantly improve the cooling and/or the preheating of the pre-chamber and optionally of the further elements. Furthermore, the need for external housings for said elements is reduced. Overall, the manufacturing of the cylinder head is thereby simplified.

[0018] The invention also relates to a cylinder head for an internal combustion engine, wherein the cylinder head is manufactured by means of the method described above. The invention also relates to the pre-chamber insert for the cylinder head of an internal combustion engine, wherein the pre-chamber insert is adapted to manufacture the cylinder head by means of the method described above.

[0019] Other important features and advantages of the invention will be apparent from the sub-claims, from the drawings and from the accompanying figure description with reference to the drawings.

[0020] It is understood that the above features, and those to be explained below, can be used not only in the

combination indicated in each case, but also in other combinations or alone, without departing from the scope of the present invention.

[0021] Preferred embodiments of the invention are shown in the drawings and will be explained in more detail in the following description, wherein identical reference signs refer to identical or similar or functionally identical components.

[0022] It shows, schematically in each case

- Fig. 1 a sectional view of a pre-chamber insert according to the invention;
- Fig. 2 a sectional view of the pre-chamber insert according to the invention with indicative machined protective regions;
- Fig. 3 a sectional view of the pre-chamber insert according to the invention with an additional functional opening for passive purge;
- Fig. 4 a sectional view of the pre-chamber insert according to the invention in the region of a nozzle;
- Fig. 5 a view of a combustion chamber in a cylinder head for a method according to the invention;
- Figs. 6 to 9 partial views of the cylinder head mould with different mounted mould core elements;
- Figs. 10 and 11 sectional views of a cylinder head according to the invention on the pre-chamber insert according to the invention with additional close coupled pre-chamber and cooling channel unit;
- Fig. 12 a view of the pre-chamber insert according to the invention with an ignition source holder and an injector holder;
- Figs. 13 and 14 sectional views of the pre-chamber insert of Fig. 12 according to the invention in different sectional planes.

[0023] Fig. 1 shows a sectional view of a pre-chamber insert 1 for a cylinder head 2 of the internal combustion engine. A lower core of the cylinder head 2 is shown in Fig. 6. In a method 3, the pre-chamber insert 1 is prefabricated and is cast into the cylinder head 2 and thereby integrated in a materially bonded manner into the cylinder head 2. The pre-chamber insert 1 can be prefabricated,

for example, in a 3D printing method or in a casting method. The pre-chamber insert 1 contains an internal pre-chamber 4 and two ends 1a and 1b which are opposite one another with respect to a longitudinal central axis LA of the pre-chamber insert 1. If the pre-chamber insert 1 is cast in the cylinder head 2 - see Fig. 10 and Fig. 11 - the first end 1a faces a combustion chamber and the second end 1b faces away from the combustion chamber.

[0024] At the first end 1a of the pre-chamber insert 1, a plurality of openings 5 are formed in the form of nozzles 6. The respective nozzles 6 are directed outwardly from the pre-chamber 4 into the combustion chamber. At the second end 2a, an opening 5 is formed in the form of a spark plug opening 7. The spark plug opening 7 is provided for inserting a spark plug into the pre-chamber 4. In Fig. 1, the two openings 5 are closed each by a protective region 8. In the method 3, the protective regions 8 are removed after the pre-chamber insert 1 has been materially bonded into the cylinder head 2. Thereby, the openings 5 are exposed to the outside.

[0025] A positioning unit 15 is also formed on each end 1a and 1b of the pre-chamber insert 1. By means of the positioning units 15, the pre-chamber insert 1 can be arranged in a correct position in the cylinder head 2. The positioning units 15 are thereby in each case a part of the respective protective region 8 and are also removed when the respective protective region 8 is removed.

[0026] Fig. 2 shows a sectional view of the pre-chamber insert 1 according to the invention. In Fig. 2, cut lines for removing the protective regions 8 are marked separately with solid lines.

[0027] Fig. 3 shows a sectional view of the pre-chamber insert 1 according to the invention with a further opening 5. The further opening 5 can here be a purge opening 9a for introducing purge air, or a gas recirculation opening 9b for introducing recirculated exhaust gas, or a fuel opening 9c for introducing a gaseous or alternative secondary fuel into the pre-chamber 4. A valve system in the form of a check valve 10 is also provided at the opening 5.

[0028] Fig. 4 shows a sectional view of the pre-chamber insert 1 according to the invention in the region of the nozzles 6. The protective region 8 has already been removed here and the nozzles 6 are exposed to the outside. The nozzles 6 of the pre-chamber insert 1 can differ in shape, in size and in orientation.

[0029] Fig. 5 shows a view of a cylinder head mould 11 for the method 3 according to the invention. According to the method 3, the prefabricated pre-chamber insert 1 is arranged in the correct position in the cylinder head mould 11. Then, a casting material is poured into the cylinder head mould 11, thereby casting the cylinder head 2 with the materially bonded pre-chamber insert 1. The protective regions 8 described above protect the pre-chamber 4 from penetration of the casting material and are removed after the pre-chamber insert 1 has been materially bonded into the cylinder head 2.

[0030] Fig. 6 to Fig. 9 show partial views of the cylinder head mould 11. Fig. 6 shows the cylinder head mould 11 with the pre-chamber insert 1 arranged in the correct position. Fig. 7 shows the cylinder head mould 11 with a water jacket core 12. Fig. 8 shows the cylinder head mould 11 with an inlet core 13 and an exhaust core 14. Fig. 9 shows the cylinder head mould 11, wherein individual elements are aligned with each other inter alia by the positioning unit 15.

[0031] Fig. 10 shows a sectional view of the cylinder head 2 according to the invention on the pre-chamber insert 1. Fig. 11 shows a further sectional view of the cylinder head 2 on the pre-chamber insert 1 in a deviating sectional plane. Here, the cylinder head 2 contains the water jacket 12a formed therein by the water jacket core 12 and the pre-chamber insert 1 contains a cooling channel unit 16 formed therein. Thus, the cylinder head 2 and the pre-chamber 4 can be effectively cooled. The cooling channel unit 16 is arranged very close to the pre-chamber 4 of the pre-chamber insert 1 so that the temperature in the pre-chamber 4 can be better maintained. In addition, the wall of the cooling channel unit 16 can be small, thereby intensifying the heat transfer between the cooling channel unit 16 and the cylinder head 2.

[0032] Fig. 12 shows a view of the pre-chamber insert 1 according to the invention. Here, an ignition source holder 17 and an injector holder 18 are integrally manufactured on the pre-chamber insert 1. Here, the ignition source holder 17 contains an internal receiving space and is provided for receiving a secondary ignition source - for example, another spark plug - for the combustion chamber. The injector holder 18 similarly contains a receiving space and is provided for receiving a fuel injector for the combustion chamber.

[0033] The receiving space in the ignition source holder 17, the receiving space in the injector holder 18, the nozzles 6 at the first end 1a, and the spark plug opening 7 at the second end 1b are closed by protective regions 8 and are thereby protected from the penetration of the casting material during the casting of the cylinder head 2. After casting, the protective regions 8 are removed and the receiving spaces as well as the nozzles 6 and the spark plug opening 7 are exposed i.e. opened to the outside. The pre-chamber insert 1 can here be filled with a filling material to withstand the internal pressure during casting of the cylinder head 2.

[0034] Fig. 13 shows a sectional view of the pre-chamber insert 1 shown in Fig. 12. Fig. 14 shows a further sectional view of the pre-chamber insert 1 shown in Fig. 12. As can be seen particularly well in Fig. 13 and Fig. 14, the cooling channel unit 16 extends around the pre-chamber insert 1, whereby the cooling of the pre-chamber insert 1 is improved.

Claims

1. A method (3) of manufacturing a cylinder head (2)

for an internal combustion engine,

- wherein a pre-chamber insert (1) with an internal pre-chamber (4) is prefabricated and arranged in the correct position in a cylinder head mould (11);
- wherein a casting material is filled into the cylinder head mould (11) with the arranged pre-chamber insert (1) and thereby the cylinder head (2) with the materially bonded pre-chamber insert (1) for the internal combustion engine is casted.

2. Method according to claim 1,

characterized

in that the pre-chamber insert (1) is prefabricated by means of a 3D printing or casting method.

3. Method according to claim 1 or 2,

characterized

- in that during the prefabrication of the pre-chamber insert (1) at least one opening (5) is prefabricated, wherein the at least one opening (5) is closed to the outside by means of a protective region (8);
- in that after the materially bonding of the pre-chamber insert (1) into the cylinder head (2), the protective region (8) is removed and the at least one opening (5) is opened to the outside.

4. Method according to claim 3,

characterized

- in that the protective region (8) is manufactured integral with the pre-chamber insert (1); and/or
- in that the protective region (8) is manufactured separately from the pre-chamber insert (1) and is fastened to the prefabricated pre-chamber insert (1) by a materially bonding, preferably by welding.

5. Method according to claim 3 or 4,

characterized

- in that the at least one opening (5) is prefabricated at an end (1a) of the pre-chamber insert (1) facing a combustion chamber in the form of a nozzle (6) leading into the combustion chamber; and/or
- in that the at least one opening (5) is prefabricated at an end (1b) of the pre-chamber insert (1) facing away from a combustion chamber in the form of a spark plug opening (7); and/or
- in that the at least one opening (5) is prefabricated in the form of a purge opening (9a) for the introduction of purge air; and/or

- **in that** the at least one opening (5) is prefabricated in the form of a gas recirculation opening (9b) for the introduction of recirculated exhaust gas; and/or
 - **in that** the at least one opening (5) is prefabricated in the form of a fuel opening (9c) for the introduction of a gaseous or alternative secondary fuel; and/or
 - **in that** the at least one opening (5) is prefabricated in the form of an instrument opening for arranging of at least one additional instrument, preferably a temperature sensor and/or a pressure sensor and/or a combustion air ratio sensor.
6. Method according to any one of the preceding claims,
characterized
- **in that** during the prefabrication of the pre-chamber insert (1), a filling material is filled into the inner pre-chamber (4), and
 - **in that** after the materially bonding of the pre-chamber insert (1) into the cylinder head (2), the filling material is removed from the inner pre-chamber (4).
7. Method according to any one of the preceding claims,
characterized
- **in that** during the prefabrication of the pre-chamber insert (1), at least one rotationally asymmetrical positioning unit (15) is fabricated on an end (1a) of the pre-chamber insert (1) facing a combustion chamber or on an end (1b) of the pre-chamber insert (1) facing away from the combustion chamber on an outer side of the pre-chamber insert (1); and
 - **in that** when arranging the pre-chamber insert (1) in the cylinder head mould (11), the pre-chamber insert (1) is arranged in the correct position in the cylinder head mould (11) by means of the at least one rotationally asymmetrical positioning unit (15).
8. Method according to claim 3 and 7,
characterized
in that the at least one positioning unit is formed in the protective region (8) or as the protective region (8) and is removed after the pre-chamber insert (1) has been materially bonded into the cylinder head (2).
9. Method according to any one of the preceding claims,
characterized
- **in that** during the prefabrication of the pre-chamber insert (1), an ignition source holder (17) for receiving a secondary ignition source for a combustion chamber is integrally manufactured on the pre-chamber insert (1); and/or
 - **in that** during the prefabrication of the pre-chamber insert (1), an injector holder (18) for receiving a fuel injector for a combustion chamber is integrally manufactured on the pre-chamber insert (1); and/or
 - **in that** during the prefabrication of the pre-chamber insert (1), a cooling channel unit (16) with a channel for cooling guidance is integrally manufactured on the pre-chamber insert (1); and/or
 - **in that** during the prefabrication of the pre-chamber insert (1), a preheating channel unit with a channel for preheating the pre-chamber is integrally manufactured on the pre-chamber insert (1); and/or
 - **in that** during the prefabrication of the pre-chamber insert (1), at least one external retention unit is integrally manufactured on the pre-chamber insert (1); and/or
 - **in that** during the prefabrication of the pre-chamber insert (1), a holding unit for holding an electric heating element is integrally manufactured on the pre-chamber insert (1).
10. Method according to any one of the preceding claims,
characterized
in that during the prefabrication of the pre-chamber insert (1), a fuel injector seal is arranged in the inner pre-chamber (4).
11. A cylinder head (2) for an internal combustion engine, wherein the cylinder head (2) is manufactured by means of the method (3) according to any one of the preceding claims.
12. A pre-chamber insert (1) for a cylinder head (2) of an internal combustion engine, wherein the pre-chamber insert (1) is adapted to produce the cylinder head (2) by means of the method (3) according to any one of claims 1 to 10.

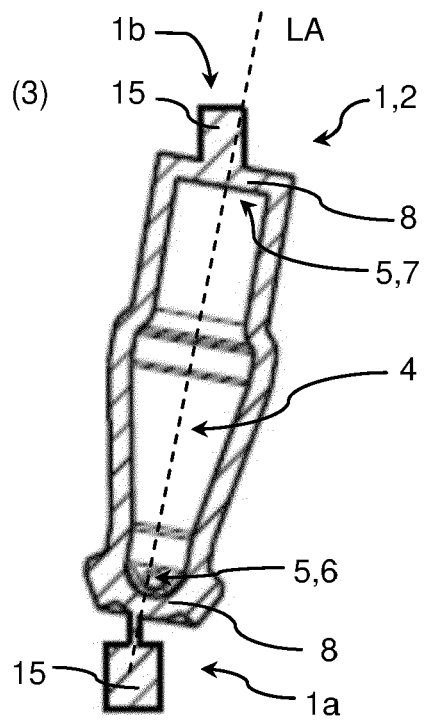


Fig. 1

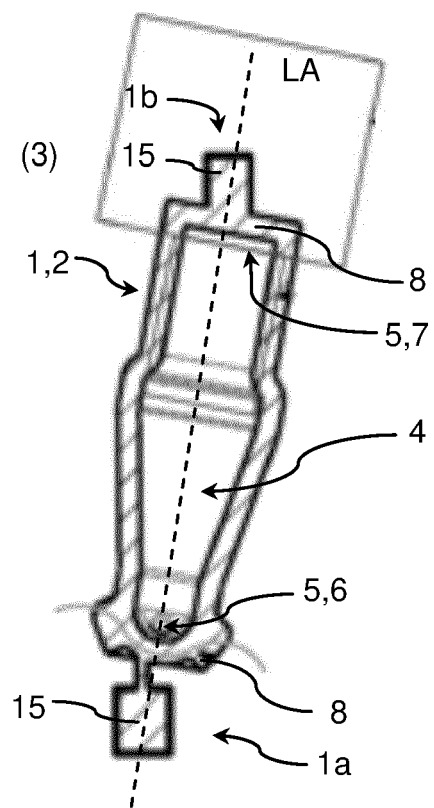


Fig. 2

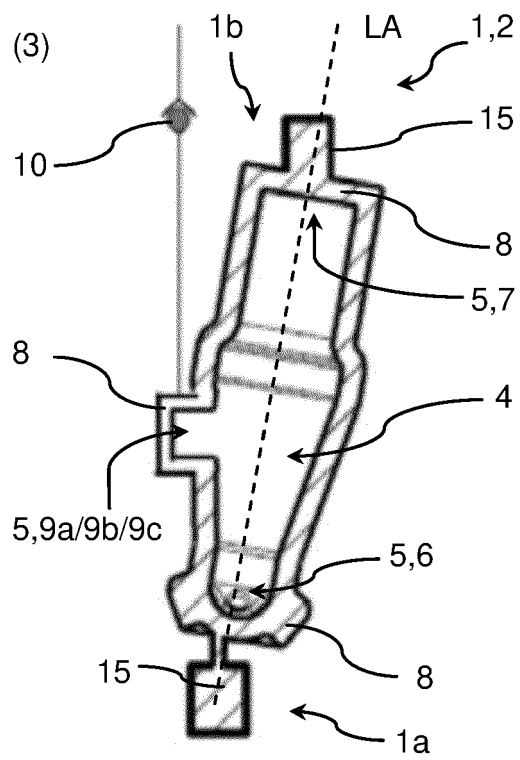


Fig. 3

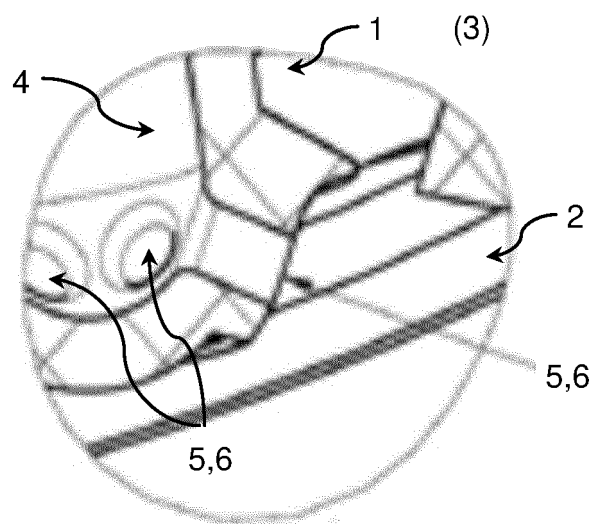


Fig. 4

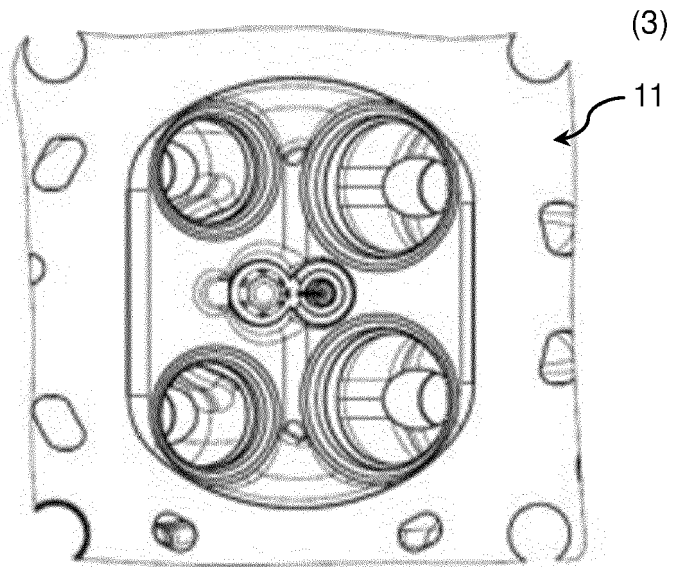


Fig. 5

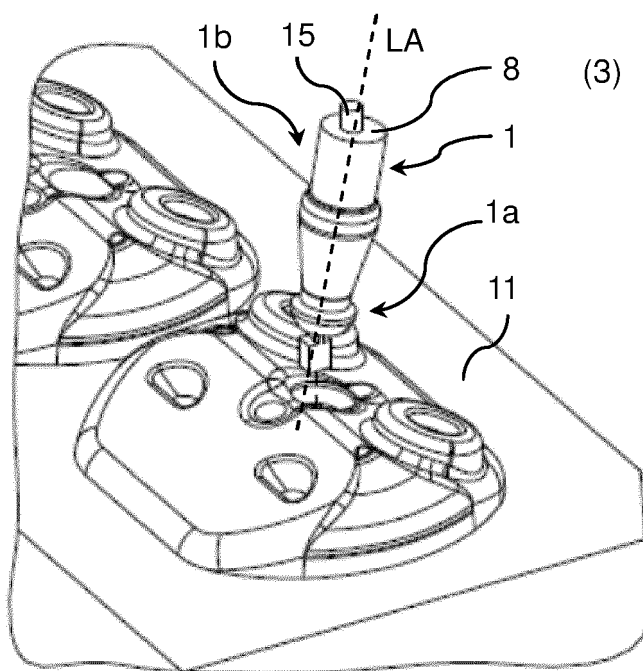


Fig. 6

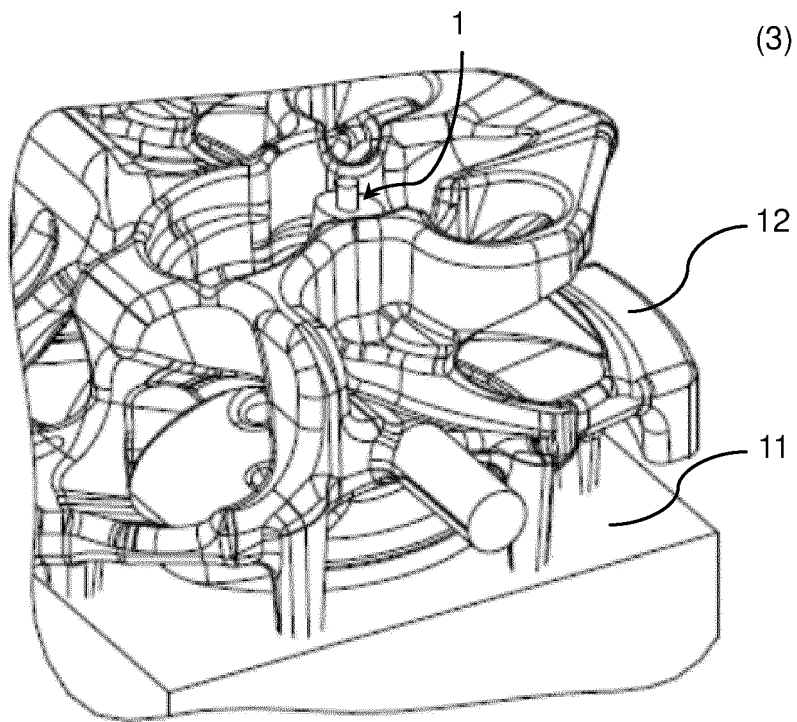


Fig. 7

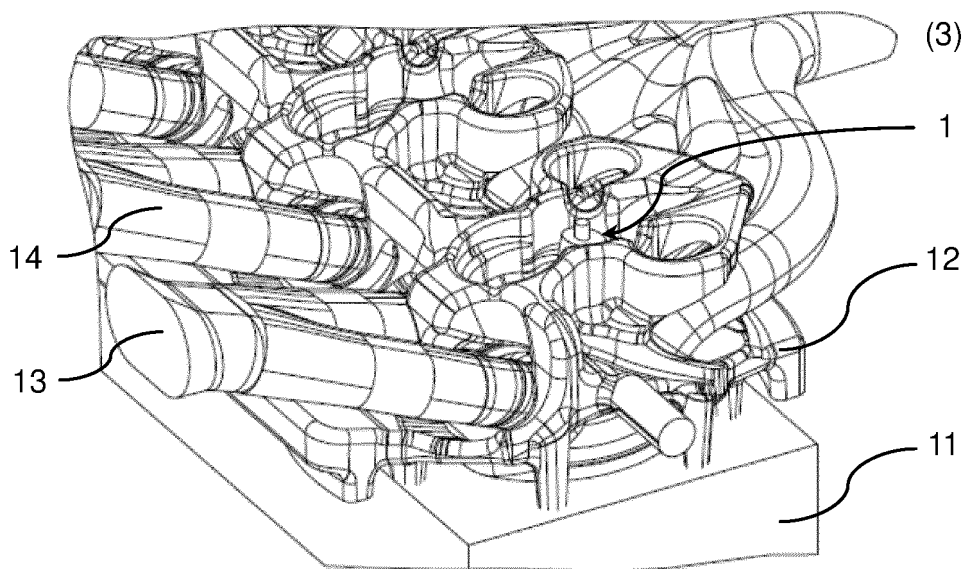


Fig. 8

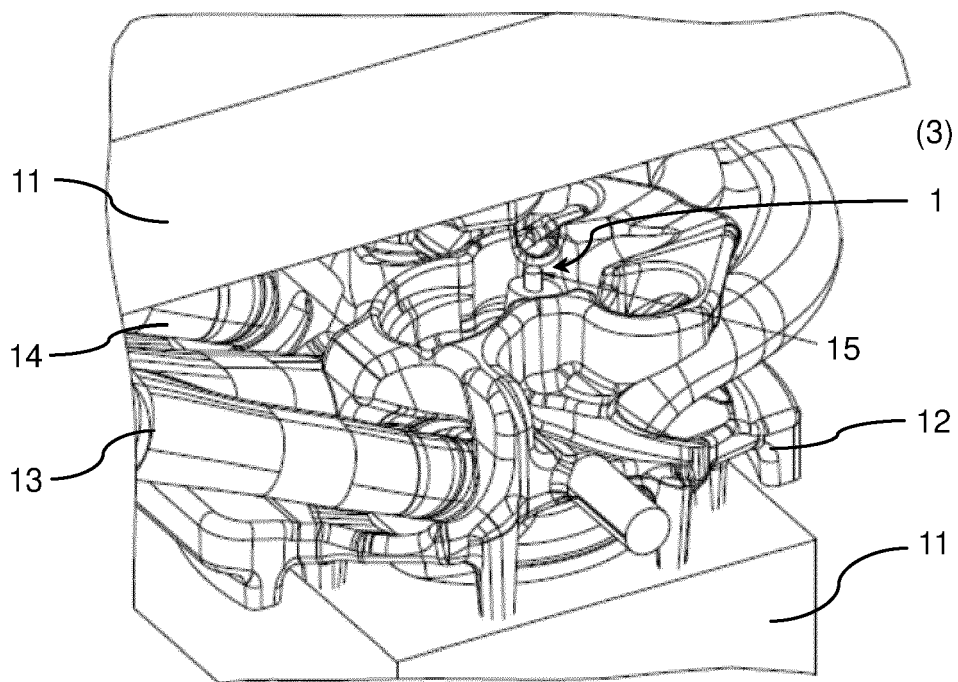


Fig. 9

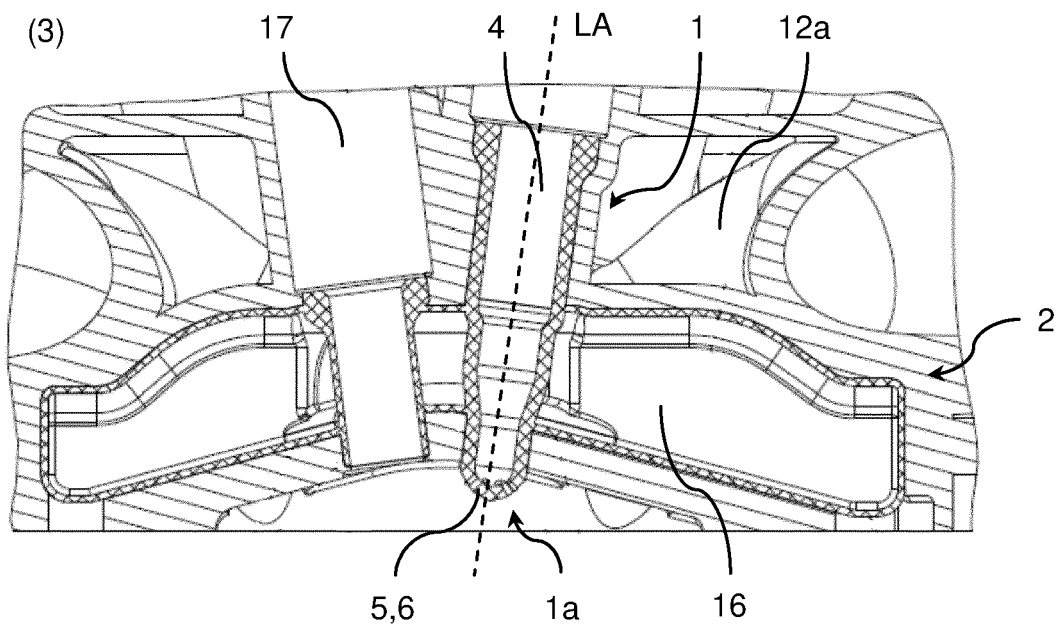


Fig. 10

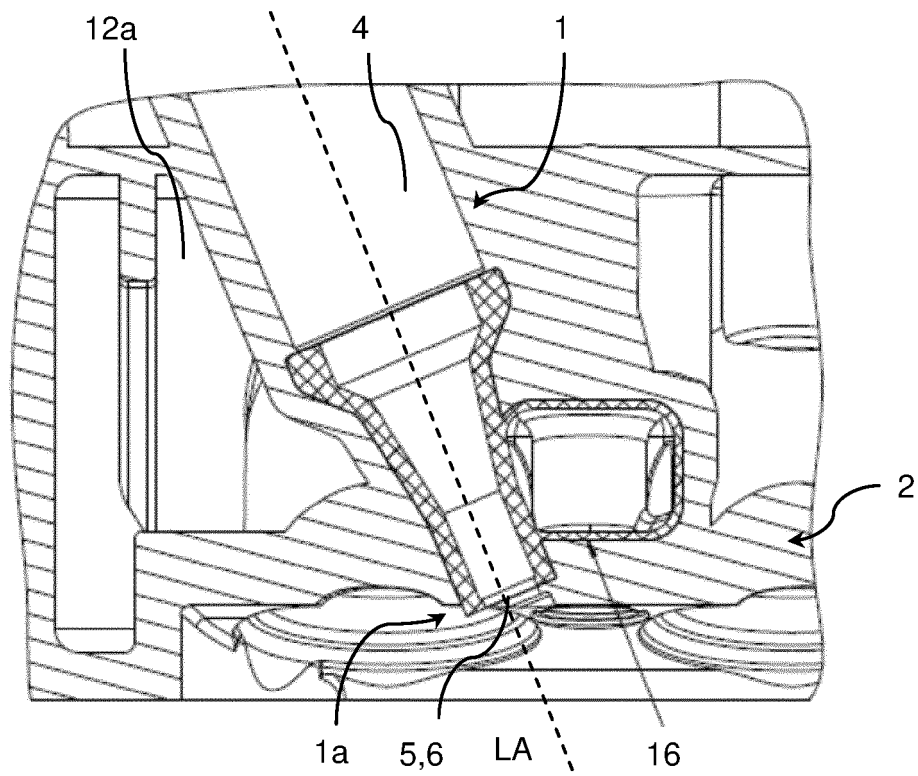


Fig. 11

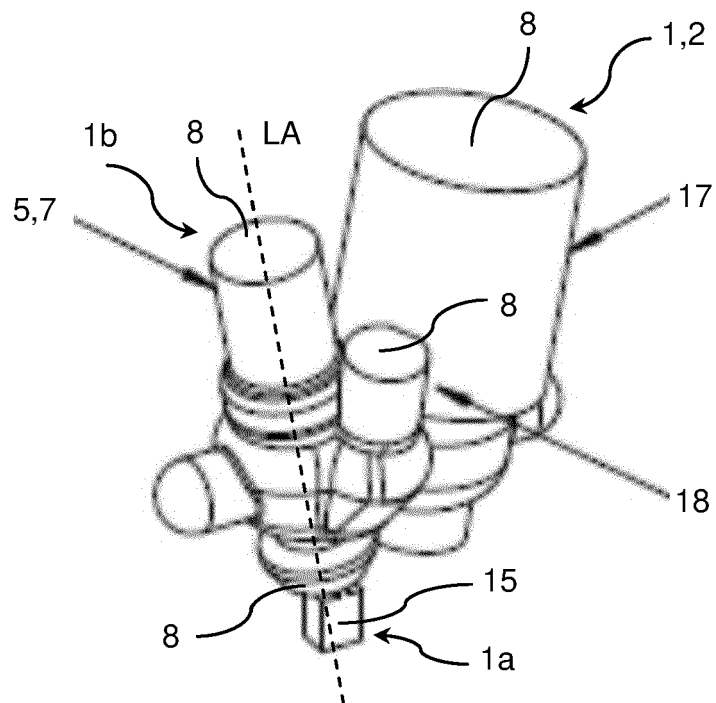


Fig. 12

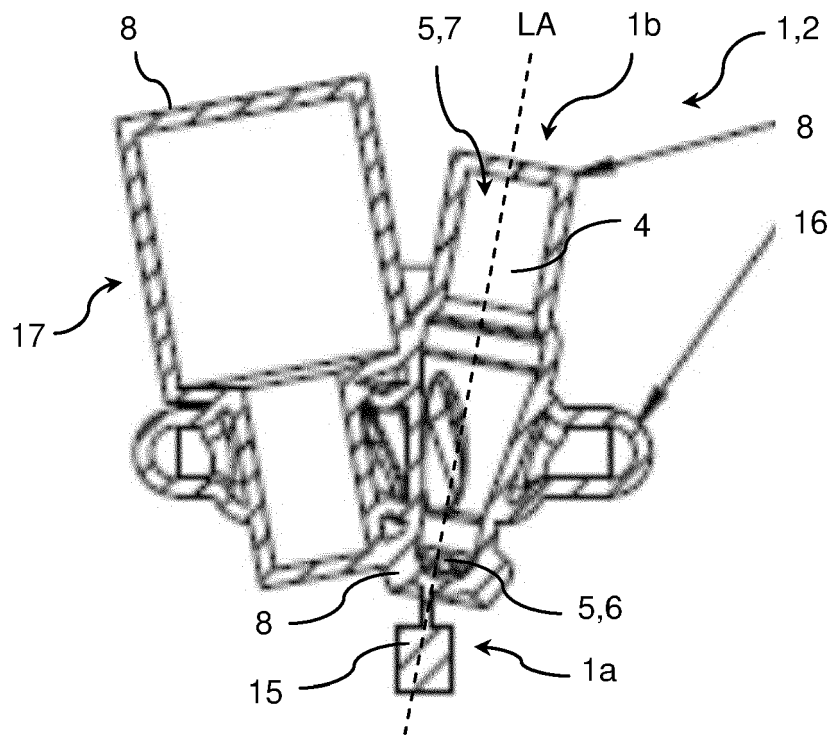


Fig. 13

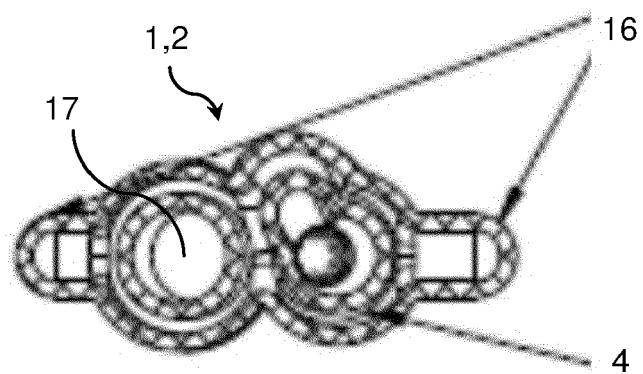


Fig. 14



EUROPEAN SEARCH REPORT

Application Number

EP 22 20 1681

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EPO FORM 1503 03.82 (P04C01)

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	DE 26 36 659 A1 (DAIMLER BENZ AG) 16 February 1978 (1978-02-16) * figure 1 * * page 17, paragraph 2 * -----	1-7, 9-12	INV. F02F1/24 B22D19/00 F02B19/00 B22D15/02
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