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(54) **Method for manufacturing a spark plug and corresponding spark plug**

Herstellungsverfahren einer Zündkerze und übereinkommende Zündkerze

Procédé de fabrication de bougie d'allumage et bougie correspondante

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EP 1 304 783 B1

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Description

Prior art

[0001] The present invention relates to a method for manufacturing a spark plug to be mounted in a combustion chamber and to a corresponding spark plug. It is already known a method for manufacturing a spark plug, wherein a ceramic insulator is placed in a through hole of a metal housing, wherein the rotational axis of the insulator and the rotational axis of the housing are parallel. The insulator is placed in the housing so, that a first washer seat of the insulator is adjacent to an inner washer seat of the housing. The first washer seat of the insulator and the inner washer seat of the housing form a first seal. After placing of the insulator in the through hole of the housing a force consisting of axial and radial components is applied to the rim of the housing. Using a curling tool in order to deform the rim and to press it against a shoulder of the collar of the insulator. So, the curled rim and the shoulder of the collar of the insulator form a second seal. After this step a section of the housing between the first seal and the second seal is heated and during heating an axial force is applied to the housing. The heating temperature is far above 500°C. After cooling the housing down to room temperature the housing is shrunk related to the ceramic insulator so that there is a tension between the first seal and the second seal leading to a spark plug, which is gas tight.

[0002] The known spark plug manufactured by above mentioned method comprises a insulator made of ceramic. It also comprises a metal housing. This ceramic insulator is placed in a through hole of the housing, wherein the rotational axis of the insulator and the rotational axis of the housing are parallel. A first seal is formed by a first washer seat of the insulator and a adjacent inner washer seat of the housing and a second seal is formed by a curled rim of the housing adjacent to a shoulder of the collar of the insulator. The shrinking zone, which is heated to temperatures far above 500°C, comprises a curved surface in the direction of the insulator at the inner surface of the housing and also a curved surface in the direction away from the insulator at the outer surface of the housing.

[0003] In US 3,594,883 a spark plug with a steel shell and a ceramic insulator is described. An inwardly deformed portion is formed in the interior surface of the shell. The insulator is pressed into a radial interference fit with said portion of the shell. The radial interference fit produces a permanent elastic stress at said portion.

[0004] A method of manufacturing this spark plug is also disclosed, whereby the deformed portion is formed before insertion of the insulator into the shell.

Advantages of the invention

[0005] The method for manufacturing a spark plug to be mounted in a combusting chamber and a corre-

sponding spark plug according to claim 1 and claim 7 resp. of the present invention has the advantage, that for the manufacturing of the spark plug lower temperatures can be used. This has the advantage, that coatings for the housing or the insulator can be used which would be destroyed by higher temperatures known for the conventional technique. A further advantage is that the required gas tightness of the spark plug is achieved.

[0006] Further advantageous embodiments of the method for manufacturing a spark plug and the corresponding spark plug cited in the main claim are realised by the further specifications and steps of the sub claims. The application of a force consisting of radial and axial components during the application of the radial force using a radial force tool prevents the deformation of the seal consisting of the curled rim of the housing and the shoulder of the collar of the insulator. Removing the radial force tool and the curling force tool after applying the radial force tool to at least one section of the housing has the advantage that the spark plug can easily be handled by further manufacturing steps. In order to meet the requirements of the standards for spark plug it is advantageous that the section of the housing applying the radial force is situated behind the hexagon and the direction of the combustion chamber. A further advantage is achieved by heating the housing before placing the insulator or the insulator assembly in the through hole of the housing. After cooling down the housing an additional tension between the first seal and the second seal is achieved which improves the gas tightness of the seals. A further advantage is achieved by using an additional sealing washer forming the first washer seat improving the gas tightness.

Drawings

[0007] Exemplary embodiments of the invention are represented in drawings and are described in greater detail below with reference to the drawings.

Figure 1 shows schematically the components of a spark plug, the insulator assembly, the housing, and the sealing washer in the exterior view (left side) and in the view of the longitudinal section (right side),

Figures 2 to 5 show the exterior view (left side) and the view of the longitudinal section (right side) of a spark plug respectively according to different manufacturing steps.

Description of exemplary embodiments

[0008] Figure 1 shows three pieces which becoming the spark plug assembly. The resulting spark plug is to be mounted in a combustion chamber. The three pieces, the sealing washer 3, the housing 5, and the insulator assembly 10 are shown in an exterior view and in a longitudinal section schematically. The sealing washer 3

consists of steel. Alternatively, it may consist of rubber or other synthetic material. The housing 5 consists of metallic material. The housing has, as the person skilled in the art knows, a complicate form on its inner and outer surface. The housing 5 comprises for instance a hexagon 8, a barrel 9 and fixed to its rim pointing to the direction of the combustion chamber a mass electrode 7. The rotational axis of the housing 5 is depicted by the reference sign 6. Furthermore, the housing 5 comprises a rim 52 at its end in the direction pointing away from the combustion chamber. The inner surface of the housing 5 has a bulge like section, wherein the shoulder pointing to the direction away from the combustion chamber is called inner washer seat 51, as the person skilled in the art knows.

[0009] In figure 1 the insulator assembly is depicted by reference sign 10. The insulator assembly 10 consists of the ceramic insulator 12 and different components which are arranged within a cylindrical through hole of the insulator 12. The shown arrangement in figure 1 is only one example for the arrangement of different components in the through hole of the insulator 12. Other arrangements of the components are also possible and known to the person skilled in the art. In this exemplary embodiment a center electrode 13 is arranged within the through hole of the insulator at the end pointing in the direction of the combustion chamber. Behind the center electrode 13 in the direction pointing away from the combustion chamber a contact packet 15, a resistive packet 14 and again a contact packet 15 and following in the same direction an electrode shank 16 are arranged within the through hole of the insulator 12. The five components, center electrode 13, resistant packet 14, first and second contact packet 15 and electrode shank 16 are fixed within the through hole of the insulator 12. The center electrode 13 is in electrical contact with the electrode shank 16 via the contact packets 15 and the resistive packet 14. The rotational axis of the insulator and also of the insulator through hole is depicted by reference sign 11. The insulator 12 has a complicated form concerning its outer surface. A step like transition from a section with lower diameter to a section with higher diameter at the end of the insulator 12 pointing to the combustion chamber is called washer seat 121. The section with the biggest diameter of the insulator is called collar 123. The transition shoulder of the collar 123 to a section with the lower diameter pointing in the direction away from the combustion chamber is called collar shoulder 122. The collar shoulder 122 can also be called washer seat, because it has the same function when interacting with the housing.

[0010] Using a spark plug mounted in a combustion chamber of an internal combustion engine by a high voltage between the center electrode 13 and the mass electrode 7 a spark is generated in the combustion chamber causing the burning of the air/fuel-mixture within the combustion chamber.

[0011] In a first manufacturing step now the insulator

assembly 10 enclosing the components within the through hole of the insulator 12 is arranged in the through hole of the housing 5 so that the inner washer seat 51 of the housing 5 is placed adjacent to the washer seat 121 of the insulator 12. In a further exemplary embodiment a sealing washer 3 can additionally be placed at the same position. The cooperation of the inner washer seat 51 and the washer seat 121, and eventually the additional sealing washer 3, form a first sealing at the end of the spark plug which is located close to the combustion chamber.

[0012] The arrangement of the insulator 12 and the insulator assembly 10, respectively, can be seen in figure 2. In figure 2 and in the following figures the same reference signs refer to the same components.

[0013] Figure 2 shows the next step of the manufacturing of the spark plug. An annular curling tool 41 is moved in the axial direction from the end pointing away from the combustion chamber of the spark plug in the direction of the rim 52 of the housing. At the side of the annular curling tool 41 which is faced to the rim 52 of the housing the curling tool 41 has a curved form, so that the rim 52 is deformed (bent) and pressed against the collar shoulder 121 of the insulator 12. This deformation is also called curling. The curled rim 52 of the housing 5 and the collar shoulder 122 of the insulator 12 form a second sealing. The forces which are put on the rim 52 of the housing 5 by the curling tool 41 are depicted by the arrows 32 and 31 in figure 2. It can easily be seen, that these forces have axial and radial components, wherein with reference sign 31 axial components and with reference sign 32 radial components are depicted. In order to prevent moving of the spark plug a fixing tool 42 is arranged at a ledge of the housing 5. This ledge is located preferably at the shoulder of the transition from a section with a smaller diameter of the housing to the section of the barrel 9, wherein this shoulder points to the direction of the combustion chamber.

[0014] In figure 3 the next manufacturing step of the spark plug with respect to the present invention is shown. Leaving the curling tool 41 and the fixing tool 42 at its place of the previous step a radial force tool 43 is applied additionally to a section of the housing 5 between the first seal and the second seal. The section is located preferably between the hexagonal 8 and the barrel 9. Using the radial force tool 43 a force is applied in the radial direction which is indicated by the reference sign 33 to the housing 5 in order to deform the housing. The deformation of the housing by the radial force tool 43 causes a tension between the first seal and the second seal in order to achieve gas tightness of both seals. The gas tightness of both seals guarantees that there is no gas escaping from the combustion chamber to the outer space. Also, there is no gas entering the space between the insulator 12 and the housing 5.

[0015] In figure 4 the next manufacturing step for the spark plug is shown, wherein the radial force tool 43 is removed. It is removed in a radial direction away from

the spark plug, wherein the direction is visualised in figure 4 by the arrow 35. It can be now clearly seen, that there is a dent 55 in the housing 5 at the place where the radial force tool 43 was located. In the next step, which is shown in figure 5, the curling tool 51 is removed from the rim 52 of the housing 5. It is removed in an axial direction away from the combustion chamber. This direction is visualised in figure 5 by the arrow 36. In figure 5 it can be clearly seen, that the rim 52 of the housing 5 is curled against the shoulder of the collar 122.

[0016] In an further embodiment in a next step also the fixing tool 42 can be removed, for instance in the direction pointing to the combustion chamber.

[0017] In a further embodiment of the present invention the housing 5 can additionally be heated before the insulator 12 is placed in the through hole of the housing 5. The temperatures used for this heating step depend on the material of the housing and on the material of the coating of the housing 5. If one uses a zink coating, the temperature should be in a range below 420°C, the melting temperature of zink. If one uses a coating consisting of a zink/nickel alloy, especially 90wt% of zink and 10wt% of nickel, one should choose the temperature in a range below 490°C, the melting point of such alloy. If one uses a coating consisting of a zink/copper alloy, especially 95wt% of zink and 5wt% of copper, one should choose the temperature in a range below 500°C, the melting point of such alloy. If the housing is made of steel with or without coating one should use a temperature range below approximately 500°C, that means below the recrystallisation boundary of the steel depending on the steel type.

Claims

1. A method for manufacturing a spark plug to be mounted in a combustion chamber, wherein said spark plug comprises a ceramic insulator (12) and a metal housing (5), comprising the steps of:

- a) placing said insulator in a through hole of said housing, wherein a rotational axis (11) of said insulator and a rotational axis (6) of said housing are parallel, wherein a first washer seat (121) of said insulator is placed adjacent to an inner washer seat (51) of said housing thereby forming a first seal,
- b) applying a force consisting of axial and radial components to a rim (52) of said housing using a curling tool (41) in order to deform said rim and to press it against a second washer seat (122) of said insulator thereby forming a second seal,
- c) applying a radial force to at least one section of said housing between said first seal and said second seal using a radial force tool (43) causing a dent (55) in said housing.

2. The manufacturing method in accordance with claim 1, wherein during application of said radial force to said at least one section of said housing the curling tool (41) is still applying said force consisting of axial and radial components.

3. The manufacturing method in accordance with claim 2, wherein after applying said radial force to at said least one section of said housing said curling tool and said radial force tool are removed.

4. The manufacturing method in accordance with claim 1, wherein said at least one section of said housing is situated behind the hexagon in the direction of said combustion chamber.

5. The manufacturing method in accordance with claim 1, wherein said housing is heated to a temperature lower than 500°C before said insulator is placed in said through hole of said housing.

6. The manufacturing method in accordance with claim 1, wherein said first seal is formed additionally by a sealing washer (3) placed between said inner washer seat of said housing and said first washer seat of said insulator.

7. Spark plug for use in a combustion chamber, comprising:

- a) a metal housing (5),
- b) a ceramic insulator (12), wherein said insulator is placed in a through hole of said housing, wherein the rotational axis (11) of said insulator and the rotational axis (6) of said housing are parallel,
- c) a first seal formed by a first washer seat (121) of said insulator and an adjacent inner washer seat (51) of said housing and a second seal formed by a curled rim of said housing adjacent to second washer seat (122) of said insulator,
- d) a dent (55) at at least one section of said housing between said first seal and said second seal caused by a radial force applied by a radial force tool (43), wherein said dent (55) is arranged at a distance from said insulator (12).

8. Spark plug in accordance with claim 7, wherein said first seal comprises additionally a sealing washer (3) placed between said inner washer seat of said housing and said first washer seat of said insulator.

Patentansprüche

1. Verfahren zur Herstellung einer in einem Brennraum zu montierenden Zündkerze, wobei die Zündkerze einen Keramikisoliertkörper (12) und ein Me-

tallgehäuse (5) umfaßt, wobei das Verfahren folgende Schritte umfaßt:

- a) Einsetzen des Isolierkörpers in ein durchgehendes Loch des Gehäuses, wobei eine Rotationsachse (11) des Isolierkörpers und eine Rotationsachse (6) des Gehäuses parallel verlaufen, wobei ein erster Unterlegscheibensitz (121) des Isolierkörpers angrenzend an einen inneren Unterlegscheibensitz (51) des Gehäuses eingesetzt wird, so daß dadurch eine erste Dichtung gebildet wird; 5
- b) Ausüben einer aus axialen und radialen Komponenten bestehenden Kraft auf einen Rand (52) des Gehäuses unter Verwendung eines Kräuselungswerkzeugs (41), um den Rand zu verformen und ihn gegen einen zweiten Unterlegscheibensitz (122) des Isolierkörpers zu pressen, so daß dadurch eine zweite Dichtung gebildet wird; 10
- c) Ausüben einer radialen Kraft auf mindestens einen Bereich des Gehäuses zwischen der ersten und der zweiten Dichtung unter Verwendung eines Radialkraftwerkzeugs (43), um eine Einbeulung (55) im Gehäuse zu bewirken. 15
2. Herstellungsverfahren in Übereinstimmung mit Anspruch 1, bei dem während der Ausübung der radialen Kraft auf den mindestens einen Bereich des Gehäuses das Kräuselungswerkzeug (41) noch die 20
3. Herstellungsverfahren in Übereinstimmung mit Anspruch 2, bei dem nach Ausübung der radialen Kraft auf den mindestens einen Bereich des Gehäuses das Kräuselungswerkzeug und das Radialkraftwerkzeug entfernt werden. 25
4. Herstellungsverfahren in Übereinstimmung mit Anspruch 1, bei dem sich der mindestens eine Bereich des Gehäuses hinter dem Sechskant in der Richtung des Brennraums befindet. 30
5. Herstellungsverfahren in Übereinstimmung mit Anspruch 1, bei dem das Gehäuse auf eine unter 500°C liegende Temperatur erwärmt wird, bevor der Isolierkörper in das durchgehende Loch des Gehäuses eingesetzt wird. 35
6. Herstellungsverfahren in Übereinstimmung mit Anspruch 1, bei dem die erste-Dichtung zusätzlich durch eine Dichtungsunterlegscheibe (3) gebildet wird, die zwischen dem inneren Unterlegscheibensitz des Gehäuses und dem ersten Unterlegscheibensitz des Isolierkörpers eingesetzt wird. 40
7. Zündkerze zur Verwendung in einem Brennraum, 45

die folgendes umfaßt:

- a) ein Metallgehäuse (5);
- b) einen Keramikisoliertkörper (12), wobei sich der Isolierkörper in einem durchgehenden Loch des Gehäuses befindet, wobei die Rotationsachse (11) des Isolierkörpers und die Rotationsachse (6) des Gehäuses parallel verlaufen;
- c) eine durch einen ersten Unterlegscheibensitz (121) des Isolierkörpers und einen angrenzenden inneren Unterlegscheibensitz (51) des Gehäuses gebildete erste Dichtung sowie eine durch einen gekräuselten Rand des Gehäuses angrenzend an den zweiten Unterlegscheibensitz (122) des Isolierkörpers gebildete zweite Dichtung;
- d) eine Einbeulung (55) in mindestens einem Bereich des Gehäuses zwischen der ersten Dichtung und der zweiten Dichtung, wobei die Einbeulung durch eine durch ein Radialkraftwerkzeug (43) ausgeübte radiale Kraft bewirkt wird, wobei die Einbeulung (55.) in einer Distanz vom Isolierkörper (12) vorgesehen ist.

8. Zündkerze in Übereinstimmung mit Anspruch 7, wobei die erste Dichtung zusätzlich eine zwischen dem inneren Unterlegscheibensitz des Gehäuses und dem ersten Unterlegscheibensitz des Isolierkörpers befindliche Dichtungsunterlegscheibe (3) umfaßt. 50

Revendications

1. Procédé de fabrication d'une bougie d'allumage destinée à être montée dans une chambre de combustion, cette la bougie d'allumage comportant un isolant en céramique (12) et une enveloppe métallique (5), et le procédé comprend les étapes suivantes à : 55
- a) placer l'isolant dans un orifice traversant de l'enveloppe, un axe de rotation (11) de l'isolant et un axe de rotation (6) de l'enveloppe étant parallèles, et un premier siège de rondelle (121) de l'isolant est placé de façon adjacente à un siège de rondelle intérieur (51) de l'enveloppe, formant ainsi un premier joint,
- b) appliquer une force présentant des composantes axiales et radiales sur un rebord (52) de l'enveloppe à l'aide d'un outil de bordage (41) afin de déformer le rebord et de le presser contre un second siège de rondelle (122) de l'isolant, formant ainsi un second joint,
- c) appliquer une force radiale sur au moins une section de l'enveloppe entre le premier joint et le second joint à l'aide d'un outil à force radiale (43) afin de former un renforcement (55) dans

l'enveloppe.

d'étanchéité (3) placée entre le siège de rondelle intérieur de l'enveloppe et le premier siège de rondelle de l'isolant.

2. Procédé de fabrication selon la revendication 1, **caractérisé en ce que**
pendant l'application de la force radiale sur l'au moins une section de l'enveloppe, l'outil de bordage (41) continue d'appliquer la force présentant des composants axiaux et radiaux. 5

3. Procédé de fabrication selon la revendication 2, **caractérisé en ce qu'**
après l'application de la force radiale sur l'au moins une section de l'enveloppe, l'outil de bordage et l'outil à force radiale sont retirés. 10
15

4. Procédé de fabrication selon la revendication 1, **caractérisé en ce qu'**
au moins une section de l'enveloppe est située derrière l'hexagone dans la direction de la chambre de combustion. 20

5. Procédé de fabrication selon la revendication 1, **caractérisé en ce que**
l'enveloppe est chauffée à une température inférieure à 500 °C avant de placer dans l'orifice traversant de l'enveloppe. 25

6. Procédé de fabrication selon la revendication 1, **caractérisé en ce que**
le premier joint est formé en outre par une rondelle d'étanchéité (3) placée entre le siège de rondelle intérieur de l'enveloppe et le premier siège de rondelle de l'isolant. 30

7. Bougie d'allumage destinée à être utilisée dans une chambre de combustion, comprenant : 35
 - a) une enveloppe métallique (5),
 - b) un isolant en céramique (12), placé dans un orifice traversant de l'enveloppe, l'axe de rotation (11) de l'isolant et l'axe de rotation (6) de l'enveloppe étant parallèles, 40
 - c) un premier joint formé par un premier siège de rondelle (121) de l'isolant et par un siège de rondelle intérieur adjacent (51) de l'enveloppe et un second joint formé par une bordure roulée de l'enveloppe de façon adjacente au second siège de rondelle (122) de l'isolant, 45
 - d) un renforcement (55) au niveau d'au moins une section de l'enveloppe entre le premier joint et le second joint, produit par une force radiale appliquée par un outil à force radiale (43), ce renforcement (55) étant disposé à une certaine distance de l'isolant (12). 50
55

8. Bougie d'allumage selon la revendication 7, dans laquelle
le premier joint comprend en outre une rondelle

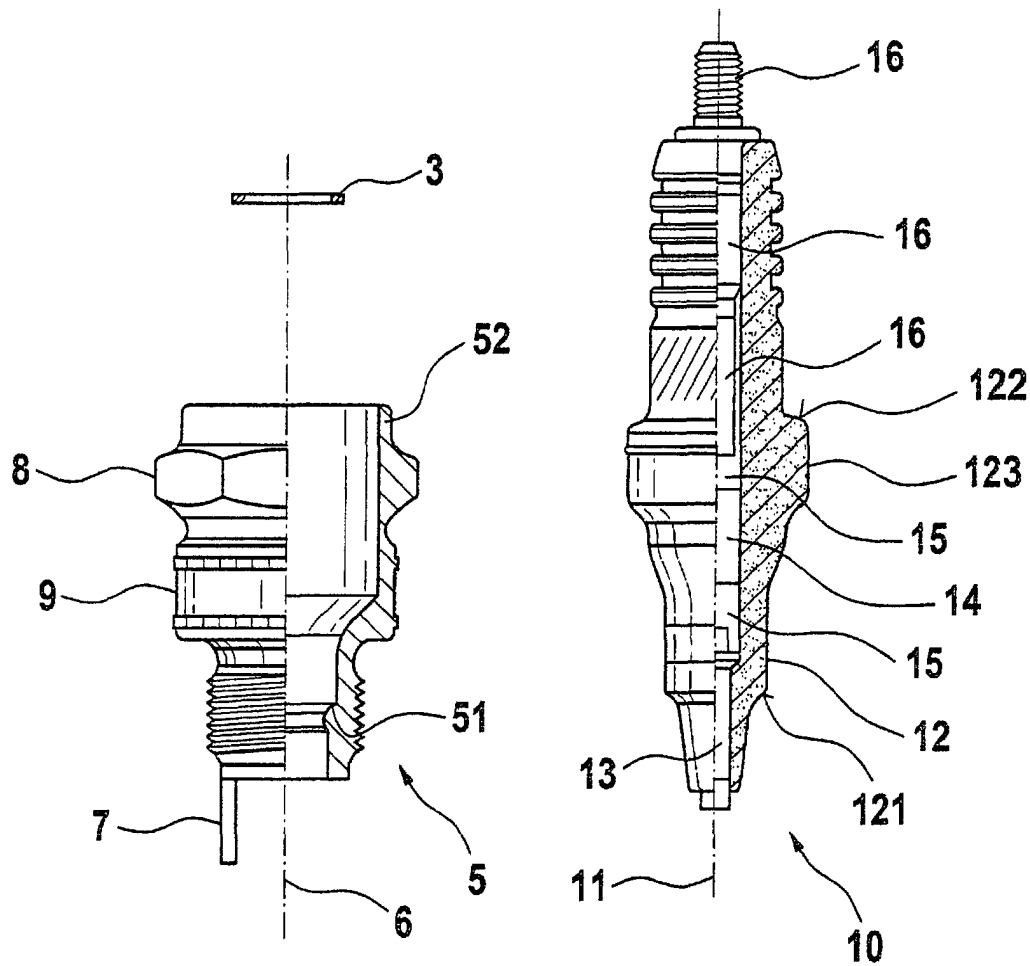


Fig. 1

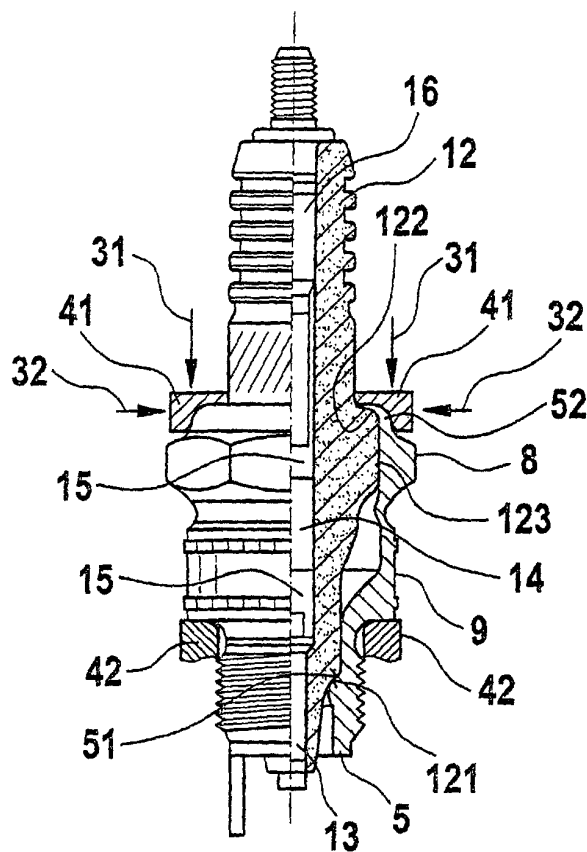


Fig. 2

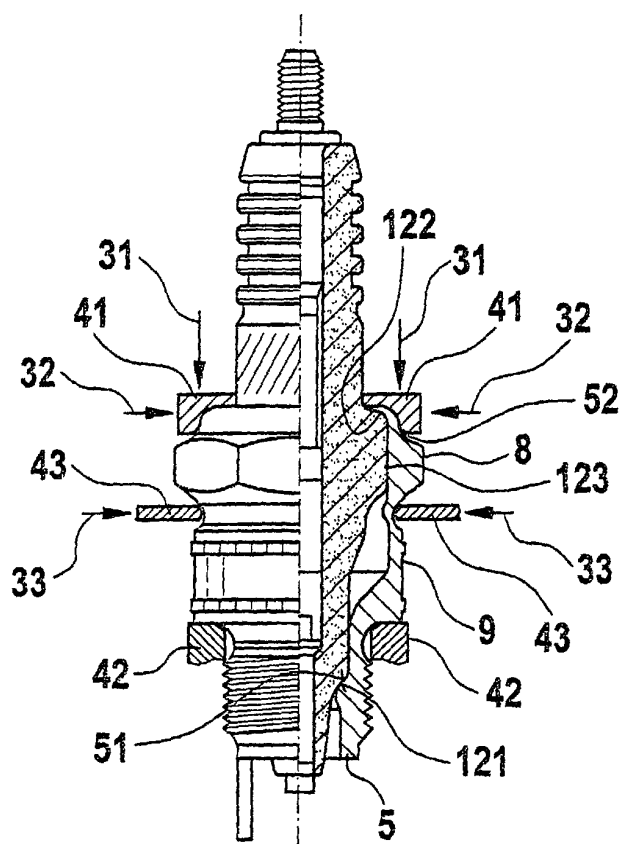


Fig. 3

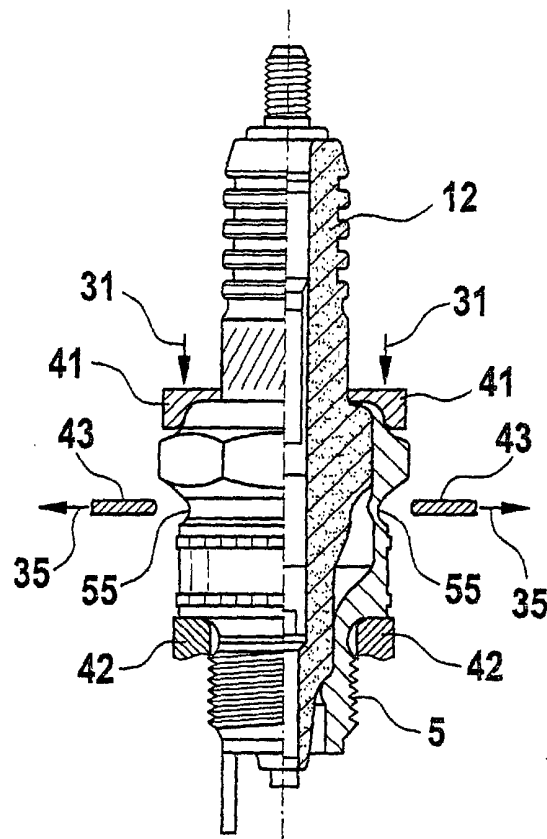


Fig. 4

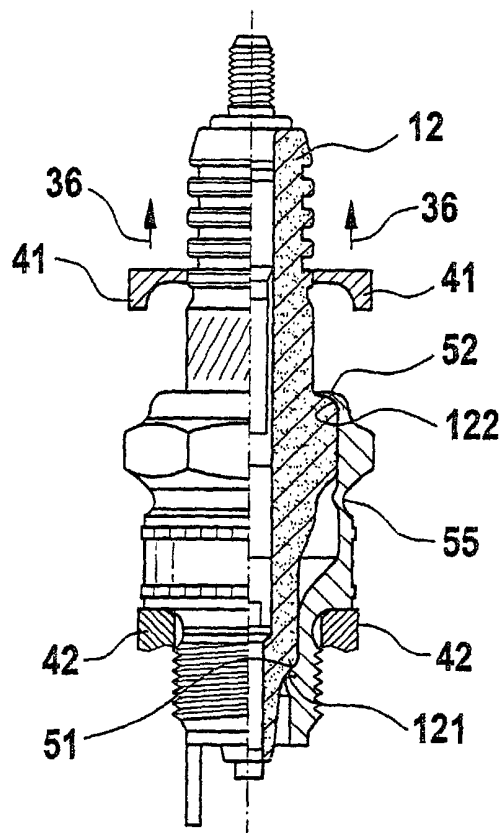


Fig. 5