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(54) SAPPHIRE SPARKING PLUG AND METHOD OF ITS MANUFACTURE

SAPHIRZÜNDKERZE UND HERSTELLUNGSVERFAHREN DAFÜR

BOUGIE D'ALLUMAGE À SAPHIR ET PROCÉDÉ DE FABRICATION CORRESPONDANT

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Description

TECHNICAL FIELD

[0001] The present invention relates to ignition spark plugs used preferably for internal combustion engines of different types - automobile, aircraft, etc.

[0002] The present invention also relates to improved methods of manufacture of such spark plugs.

BACKGROUND ART

[0003] It is known a sparking plug with the insulating body consisting if necessary of two parts, wherein at least the part of the insulating body adjacent to the spark gap consisting of fused aluminium oxide. This sparking plug is characterised by at least a part of the surface of the insulating body coming into contact with the gases of combustion being polished (see patent GB 302 893, 1929.01.31).

[0004] It is also known an ignition plug preferably for internal combustion engines, comprising an insulator arranged in the jacket cavity. A sapphire tip is fitted at the end of the insulator and a central electrode is located in the insulator (see Eurasian patent EA 002075 B1, 2001.12.24).

[0005] The known spark plug suffers from the disadvantage that the sapphire tip is not in contact with the plug jacket and cannot have any influence on heat sink from combustion chamber, it only prevents of settling of combustion products.

[0006] The main jacket of insulator is made from ceramic material, having drawbacks of relatively not too high electric resistance at high temperatures (10^3-10^4 Ω m^{-1} at 900 °C) and low thermal conductivity coefficient - cca 6 W m^{-1} K^{-1} even for very compact and dense ceramics.

[0007] These negative characteristics do not allow that such plug can in time react to steep changes in engine cylinder so that it cannot avoid its overheating.

[0008] It is also known an ignition plug for internal combustion engines, wherein the insulator is partly or completely made of sapphire monocrystal and the sapphire portion is extending always on one side beyond the plug metal jacket and is used for temperature measurement in the engine cylinder (see Eurasian patent EA 004493 B1, 2004.04.29).

[0009] This plug suffers from the disadvantage that in the portion, where the cables from ignition system are connected, the high temperatures can occur, what can cause, inter alia, inflammation of cable insulation and fire of the engine.

SUMMARY OF THE INVENTION

[0010] The present invention seeks to eliminate the above deficiencies and to provide a new ignition spark plug, wherein the sapphire portion of the insulator is made from sapphire monocrystal without any residual tension, stress and strain and with brightened glossy outer surface from the end entering the engine cylinder into area of connection with ceramic portion of insulator and plug jacket, where outer and inner portions of sapphire tip are only grinded on surface roughness till 10 μm, wherein on inner surface there is applied a layer of high-temperature adhesive with working temperature at least 1 000 °C and on outer surface the same layer of the same adhesive, comprising less than 3 % by volume of copper powder having particle size till 5 μm.

[0011] A method of manufacture of the ignition spark plug according to the present invention is characterized in that the connection of ceramic and sapphire portions of insulator to each other and to the plug jacket is carried out at normal temperature by pressing at pressure at least 20 atm, and then the insulator is completely rolled in the plug jacket at the same pressure and does not require any further heat treatment.

[0012] Advantageously, the ignition spark plug according to the present invention has the sapphire tip of combined insulator made in the form of elongated cone or cylinder with annular groove in lower portion in depth till 3 mm and is tightly without clearance arranged in the plug jacket at normal temperature, wherein the tip has the same length as that portion of the plug jacket entering the engine cylinder, and the central electrode extends from the sapphire tip for 1 to 2 mm, wherein a lateral electrode is missing, and a ring made from high-temperature corrosion-resistant material is placed in the plug jacket.

[0013] The ignition spark plug according to the present invention is further characterized in that in the inner portion of the central electrode there is on 90% of its length inserted a rod having thermal conductivity at least 150 W m^{-1} K^{-1}, preferably made of optical material having high translucency and melting temperature at least 950 °C.

[0014] The present sapphire ignition spark plug works as follows:

[0015] When an ignition system connects the central electrode with a high voltage supply, then an electric discharge occurs in the spark gap, which discharge will cause an ignition of the fuel mixture in the respective cylinder.

[0016] During the engine run the temperature in the cylinder is increased and rises steeply in particular in transient regimes, when the rotational speed rises in a short time up to the limit working speed.

[0017] During the engine run the electrodes and the insulator tip heat up, but they are protected against overheating by means of the heat sink thanks to the photoconductivity effect of sapphire.

[0018] Furthermore, the heat sink is realized owing to the internal heat transfer by radiation, i.e. without inertia, so that the plug can maintain constant temperature.

[0019] In other words, inherent regulation effect occurs that provides the protection of the engine against over-

heating in all its operational regimes.

[0020] Effective thermal conductivity of sapphire and other highly translucent optic materials can reach 250 to 400 W m^{-1} K^{-1}, what is by an order higher than in case of plug jacket.

[0021] The heat transfer from insulator to the plug jacket is facilitated by means of a thin layer of high-temperature adhesive with a little addition of copper powder. Therefore, the thermal resistance between insulator and plug jacket is considerably reduced.

[0022] Specific electric resistance of sapphire at the temperature of 900 °C is cca 10^8 Ω m^{-1} so that sparking trough of insulator at high temperatures in the cylinder is avoided, wherein its diameter can be lowered and the plug size can be miniaturized.

[0023] Moreover, the present invention allows to increase the combustion temperature in the cylinder and therefore to increase the engine efficiency and operation economy.

[0024] This applies in particular to the plug without lateral electrode. Use of such plug will improve gas dynamics during injection of each new portion of fuel mixture owing to the missing mechanical obstacle in the form of lateral electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These, as well as other objects and advantages of this invention, will be more completely understood and appreciated by careful study of the following more detailed description of the presently preferred exemplary embodiments of the invention taken in conjunction with the accompanying drawings, in which:

FIGURE 1 shows a schematic cross-sectional view of a spark plug according to the present invention;

FIGURE 2 shows a schematic cross-sectional view of a spark plug according to the present invention, but the lateral electrode is missing;

FIGURE 3 shows a cross-sectional view of a whole sapphire ignition spark plug according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0026] The ignition spark plug has a metal, mostly steal, jacket 1. In the cavity of the jacket 1 there is instaled an insulator, made of two portions - inner ceramic portion 2 and sapphire tip 3.

[0027] The inner ceramic portion 2 is made of high-temperature ceramics and the sapphire tip 3 is made of sapphire monocrystal without any residual tension, stress and strain.

[0028] In the inner cavity of the insulator there is arranged a metal central electrode 4, in which a rod 5 is placed, the rod 5 being made from high-temperature optical material or another material having a high-temperature conductivity, that is deliberately and several times higher that the thermal conductivity of the central electrode.

[0029] On inner surface of the sapphire tip 6 there is applied a layer of high-temperature adhesive, on outer surface 7 a layer of the same adhesive with addition of fine dispersive copper powder in amount maximally 3 % by volume and with the particle size less than 5 μm.

[0030] The seal 8 is made of soft material having a good electric conductivity, for example of copper.

[0031] A spark 9 occurs between the central electrode 4 and the lateral electrode, or between the central electrode 4 and a corrosion-resistant ring 10 arranged in the jacket and made of high-temperature material, for example of iridium.

[0032] The arrows 11 represent an exhaust of heat from the combustion chamber of the engine cylinder into its jacket cooled by water. The ignition spark plug is made so that the connection of the inner ceramic portion 2 and the insulator sapphire tip 3 is carried out at normal temperature by pressing at pressure at least 20 atm, and then the insulator is completely rolled in the plug jacket at the same pressure and does not require any further heat treatment.

INDUSTRIAL APPLICABILITY

[0033] The specific electric resistance of sapphire at the temperature 900 °C is cca 10^8 Ω m^{-1}, what avoids an insulator sparking through at high temperatures in the cylinder and allows to reduce its diameter - to miniaturize a plug size.

[0034] Moreover, the reliable work of the plug, proved experimentally, allows to raise the combustion temperature in the cylinder, and therefore to raise the efficiency and economy of the engine.

[0035] This is in particular true for the plug without any lateral electrode. The dynamics of the gases injected is improved owing to the missing mechanical obstacle in the form of the lateral electrode. Therefore, the more effective combustion and reduced amount of harmful residual combustion products are achieved.

[0036] It should be appreciated that sapphire is a monocrystal material having zero porosity and its polished surface does not absorb any combustion products, so that the insulator remains always clean.

[0037] The repeated starting of the engine is therefore facilitated considerably.

Claims

1. An ignition spark plug, preferably for internal combustion engines, comprising a jacket with working, connecting and outer portions, an insulator installed in the jacket cavity and made partly of sapphire monocrystal, and a central electrode located in the

insulator, **characterized in that** the sapphire portion of the insulator is made of sapphire monocrystal without any residual tension, stress and strain and with brightened glossy outer surface from the end entering the engine cylinder into area of connection with ceramic portion of insulator and plug jacket, where outer and inner portions of sapphire tip are only grinded on surface roughness till 10 μm, wherein on inner surface there is applied a layer of high-temperature adhesive with working temperature at least 1 000 °C and on outer surface the same layer of the same adhesive, comprising less than 3 % by volume of copper powder having particle size till 5 μm.

2. The ignition spark plug according to claim 1, **characterized in that** the sapphire tip of combined insulator is made in the form of elongated cone or cylinder with annular groove in lower portion in depth till 3 mm and is tightly without clearance arranged in the plug jacket at normal temperature, wherein the tip has the same length as that portion of the plug jacket entering the engine cylinder, and the central electrode extends from the sapphire tip for 1 to 2 mm, wherein a lateral electrode is missing, and a ring made from high-temperature corrosion-resistant material is placed in the plug jacket.

3. The ignition spark plug according to claim 1 and 2, **characterized in that** in the inner portion of the central electrode there is on 90% of its length inserted a rod having thermal conductivity at least 150 W m^{-1} K^{-1}, preferably made of optical material having high translucency and melting temperature at least 950 °C.

4. A method of manufacture of the ignition spark plug according to claims 1 through 3, **characterized in that** the connection of ceramic and sapphire portions of insulator to each other and to the plug jacket is carried out at normal temperature by pressing at pressure at least 20 atm, and then the insulator is completely rolled in the plug jacket under the same pressure and does not require any further heat treatment.

Patentansprüche

1. Zündkerze insbesondere für Brennkraftmaschinen, enthaltend einen Mantel mit einem Arbeits-, einem Verbindungs- und einem Außenabschnitt, einen in einem Hohlraum des Mantels angebrachten und teilweise aus einem Saphirmonokristall hergestellten kombinierten Isolator, sowie eine in dem Isolator angebrachte Zentralelektrode, **dadurch gekennzeichnet, dass** der Saphirteil des Isolators aus einem Saphirmonokristall ohne jedweden Resttemperaturspannungen und -tensionen sowie mit einer polierten Außenoberfläche von einem in einen Motorzylinder hineinragenden Ende bis in den Bereich von Verbindung mit dem Keramikteil des Isolators und dem Kerzemantel, wo der Außen- und der Innenteil der Saphirspitze lediglich auf eine Oberflächenrauhigkeit bis zu 10 μm geschliffen sind, wobei auf die Innenoberfläche eine Hochtemperatur-Kleberschicht mit einer Arbeitstemperatur mindestens von 1000 °C angebracht ist und auf die Außenoberfläche die gleiche Kleberschicht gleiches Klebers, enthaltend weniger als 3 Volumenprozente Kupferpulver mit einer Partikelgröße bis zu 5 μm, angebracht ist.

2. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass** die Saphirspitze des Isolators in Form von einem verlängerten Kegel oder Zylinder mit einer Ringnut in einem unteren Teil bis zu der Tiefe von 3 mm hergestellt und bei einer Normaltemperatur eng spielfrei in dem Kerzemantel angebracht ist, und wobei die Spitze eine gleiche Länge wie ein in den Motorzylinder hineinragender Teil des Metallkerzemantels aufweist, und die Zentralelektrode aus der Saphirspitze bis zu 1 bis 2 mm herausragt, wobei eine Seitenelektrode fehlt, und in dem Kerzenmantel ein Ring aus einem korrosionsbeständigen Hochtemperatur-Material angebracht ist.

3. Zündkerze nach Anspruch 1 und 2, **dadurch gekennzeichnet, dass** in dem inneren Teil der Zentralelektrode auf 90% ihrer Länge eine Stange mit einer Temperaturleitfähigkeit von mindestens 150 W m^{-1} K^{-1} eingeführt ist, vorzugsweise aus einem optischen Material mit einer hohen Transluzenz und einer Schmelztemperatur von mindestens 950 °C.

4. Verfahren zur Herstellung einer Zündkerze nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** ein Verbinden von einem Keramikteil und einem Saphirteil des Isolators miteinander sowie mit einem Kerzemantel bei einer Normaltemperatur durch Pressen bei einem Druck von mindestens 20 atm erfolgt, wonach der Isolator in einen Kerzemantel unter einem gleichen Druck völlig eingewalzt wird und keine weitere Temperaturbehandlung erfordert.

Revendications

1. Bougie d'allumage, notamment pour machines à combustion interne; comprenant une gaine ayant une partie de travail, une partie de liaison et une partie extérieure, un isolateur combiné localisé dans une cavité de la gaine réalisé en partie d'un monocristal de saphir et une électrode centrale installée dans ledit isolateur **caractérisée en ce que** la partie de saphir de l'isolateur est est réalisé en monocristal de saphir sans quelconques tensions résiduelles thermiques et sans contraintes ayant une surface

extérieure adoucie depuis l'extrémité débouchant dans le cylindre du moteur en zone de liaison avec la partie céramique de l'isolateur et la douille de la bougie dans laquelle la partie extérieure et intérieure de la pointe de saphir sont polies à rugosité de la surface jusqu'au 10mm et la surface intérieure est munie d'une couche d'un adhésif supportant haute température avec température de travail au moins 1000°C et la partie extérieure est munie d'une même couche de l'adhésif identique contenant moins que 3 % de volume de la poudre de cuivre avec grandeur des particules jusqu'au 5 μm.

2. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** la pointe de saphir de l'isolateur combiné est réalisée en forme d'un cône ou cylindre allongé avec une rainure annulaire ayant une profondeur jusqu'au 3mm en partie inférieure qui est placé d'une façon étanche sans aucun jeu dans la douille de la bougie à la température normale et la pointe a la même longeur comme la partie de la douille métallique de la bougie débouchant dans le cylindre du moteur et l'électrode centrale dépasse la pointe de saphir de 1 à 2 mm, tandisque l'électrode latérale y manque et une bague d'un matériau à haute température résistant à la corrosion est placé dans la gaine de la bougie.

3. Bougie d'allumage selon les revendications 1 et 2, **caractérisé en ce qu'**une barre d'une conductivité thermique au moins 150 W m^{-1} K^{-1}, preférentiellement réalisée en matériau optique d'une transparence haute et d'une température de fusion au moins 950°C est inséré dans la partie intérieure de l'électrode centrale sur 90% de sa longeur.

4. Procédé de fabrication d'une bougie d'allumage selon les revendications 1 à 3, **caractérisé en ce que** le couplage mutuel de la partie céramique avec la partie de saphir de l'isolateur et avec la gaine de la bougie est réalisé à température normale par formage à la pression d'au moins 20 atm. et que l'isolateur est ensuite totalement renflé dans la douile de la bougie sous même pression ce qui ne revendique d'autre traitement à chaud.

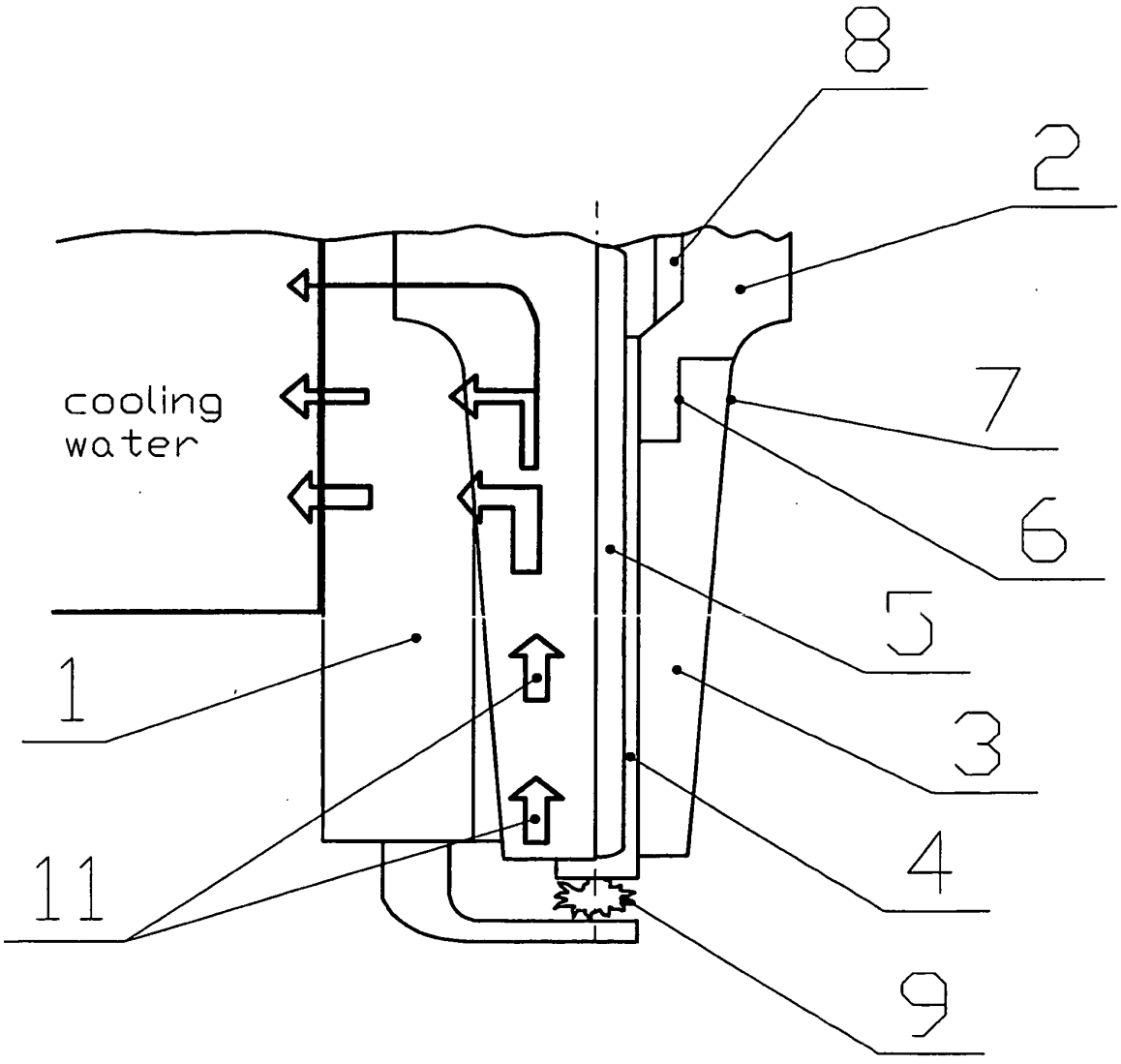

FIG. 1

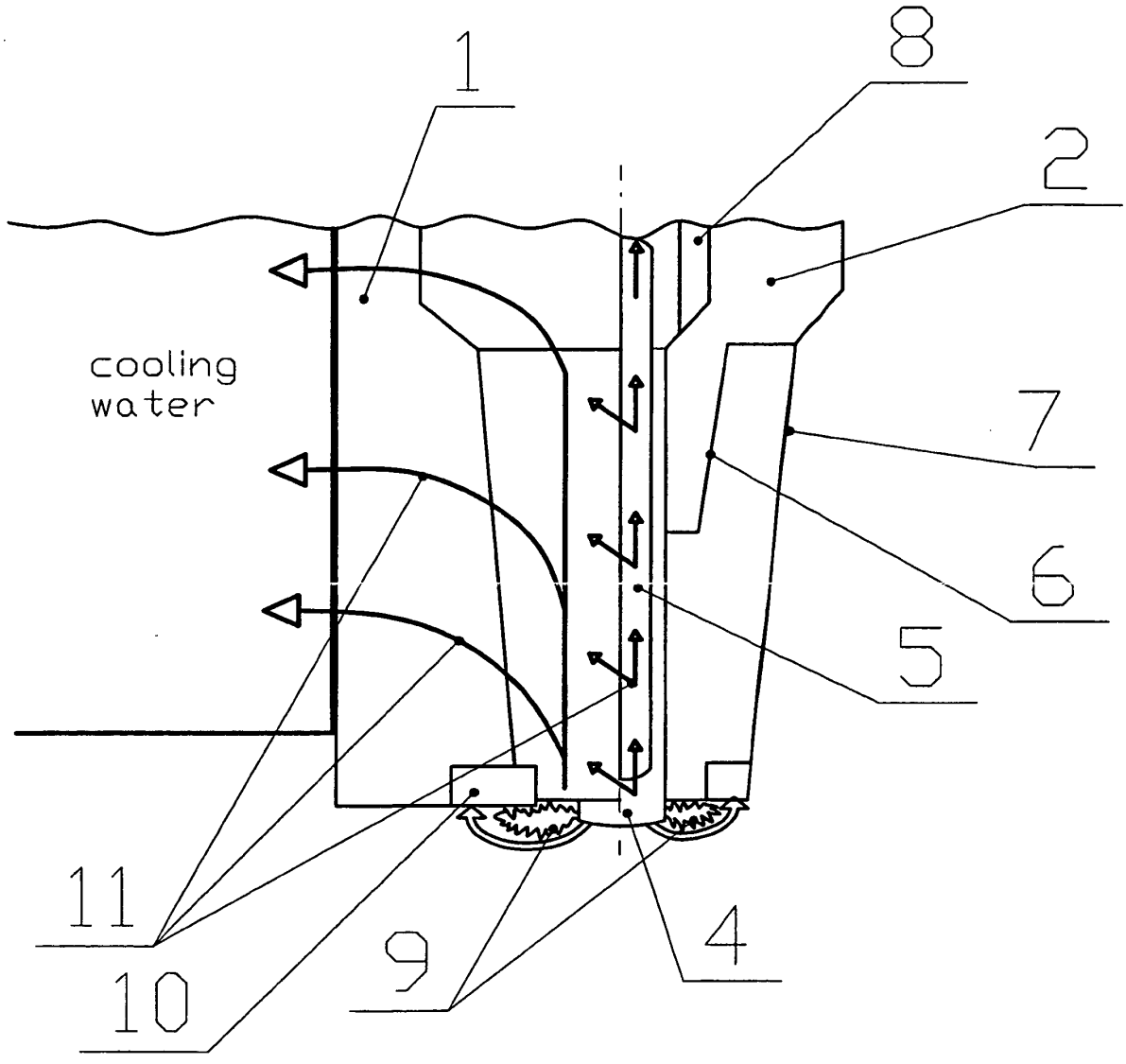

FIG. 2

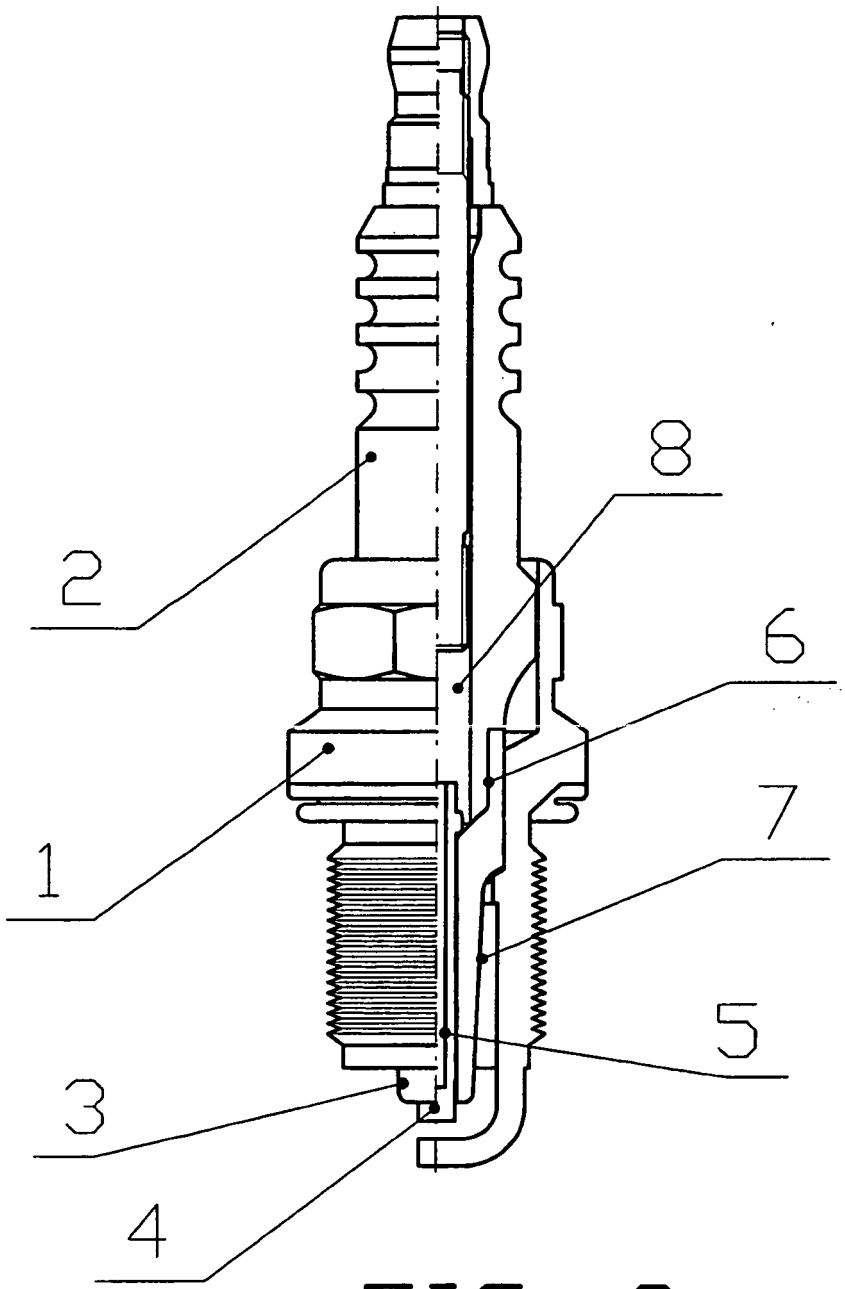

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

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- EA 002075 B1 **[0004]**
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