

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 400 950 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

09.02.2000 Bulletin 2000/06

(51) Int. Cl.⁷: **H01T 21/02**, H01T 13/39

(21) Application number: **90305797.4**

(22) Date of filing: **29.05.1990**

(54) **Spark plug**

Zündkerze

Bougie d'allumage

(84) Designated Contracting States:
DE FR GB

(30) Priority: **29.05.1989 JP 13276089**

(43) Date of publication of application:
05.12.1990 Bulletin 1990/49

(73) Proprietor:
NGK SPARK PLUG CO., LTD
Nagoya-shi (JP)

(72) Inventors:
• **Oshima, Takafumi**
Takatsuji-cho - Mizuho-ku, Nagoya-cho (JP)
• **Kozuka, Kazuhiko**
Takatsuji-cho - Mizuho-ku, Nagoya-shi (JP)

(74) Representative:
Senior, Alan Murray et al
J.A. KEMP & CO.,
14 South Square,
Gray's Inn
London WC1R 5LX (GB)

(56) References cited:

EP-A- 0 353 196	DE-A- 1 941 979
DE-A- 3 038 649	FR-A- 1 490 828
GB-A- 1 099 387	US-A- 3 466 158
US-A- 4 427 915	

Remarks:

The file contains technical information submitted
after the application was filed and not included in
this specification

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 400 950 B1

Description

[0001] This invention relates to spark plugs, in particular the improvements of their resistance to spark erosion.

[0002] Due to a demand for high power outputs from internal combustion engines, the need has arisen for the spark erosion resistance of spark plugs to be improved. To meet this demand, firing tips have been manufactured individually from precious metals such as platinum or platinum-iridium based alloys. These firing tips may be columnar or laminar, and respectively bonded to a center electrode and an outer electrode by welding. The columnar tip, however, requires a great amount of precious metal thus raising manufacturing costs. On the other hand, the use of a laminar tip leads to a waste of precious metal because the tip is punched from a sheet of the metal thus reducing the yield by 30 percent. Further, a tip which is made of a Pt-Ir alloy has a melting point of more than 2300 degrees Celsius, so that it is difficult to machine the tip unless it is at an extremely high temperature. The Pt-Ir tip, which is alloyed by means of a metallurgical process, is ductile but fragile, and cracks readily occur on the tip at the time of machining, thus making it very difficult to machine the tip into a complex shape. The tip may also be shaped by means of electric discharge machining, but this takes a long time to finish because of its high melting point.

[0003] US-A-3 466 158 discloses a method of manufacturing a spark plug for an internal combustion engine, comprising the steps of providing a cylindrical metallic shell and placing a tubular ceramic insulator concentrically therein, placing a centre electrode concentrically within the tubular insulator, forming a firing tip from iridium material, and metallurgically bonding the firing tip to the front end of the centre electrode to form a spark gap between the firing tip and an outer electrode which extends from the metallic shell.

[0004] FR-A-1,490,828 discloses a method of making a spark plug firing tip by sintering a compact of ruthenium powder.

[0005] FR-A-1 490 828 further discloses a method of manufacturing a spark plug for an internal combustion engine, comprising the steps of preparing a ruthenium-iridium powder compact, forming a firing tip from the ruthenium-iridium powder compact, and sintering the ruthenium-iridium powder in a reducing atmosphere at a temperature of 1500°C to impart a density of 89% of theoretical to the ruthenium-iridium powder compact so as to provide spark-erosion resistance.

[0006] DE-A-3,038,649 discloses a method of making a spark plug firing tip but using a compact of platinum powder.

[0007] Therefore, it is an object of the present invention to reduce the above drawbacks, and provide a firing tip structure which has improved spark-erosion resistance for a long service life at a reduced cost.

[0008] According to the present invention, there is provided a method of manufacturing a spark plug for an internal combustion engine, the method comprising the steps of:

providing a cylindrical metallic shell and placing a tubular ceramic insulator concentrically therein; and placing a centre electrode concentrically within the tubular insulator; characterised by the further steps of:

preparing an iridium powder compact;

forming a firing tip from the iridium powder compact;

sintering the iridium powder compact in a vacuum, or a non-oxidizing or reducing atmosphere at a temperature in the range of from 2000 to 2200°C to impart a density of at least 90% of theoretical to the iridium powder compact so as to provide spark-erosion resistance; and

metallurgically bonding the firing tip to the front end of the centre electrode to form a spark gap between the firing tip and an outer electrode which extends from the metallic shell.

[0009] The present invention also provides a spark plug comprising:

a cylindrical metallic shell;

a tubular ceramic insulator positioned concentrically within the shell; and

a centre electrode concentrically placed in the insulator; characterised by

a firing tip metallurgically bonded to the centre electrode, the firing tip being formed from a sintered iridium powder compact and having a density greater than 90% of theoretical.

[0010] The firing tip is made from an iridium powder compact which may be compressed by means of metallic die press, thus lending itself to simple mass production, at reduced costs, with minimal waste of precious metal. Further, the use of powder metallurgy makes it possible to form firing tips of complex shapes which metallurgical processes may be unable to achieve.

[0011] These and other aspects of the present invention will be more readily understood from the following description, when taken with the attached drawings, which are given by way of example only, and in which:

Fig. 1 is a view of a spark plug according to a first embodiment of the invention, with the lower half of the spark plug

in section;

Fig. 2 is an enlarged cross sectional view of the firing tip of Fig. 1;

Fig. 3 is a schematic view showing a dimensional relationship of the firing tip;

Fig. 4 is a view similar to Fig. 1, of a second embodiment of the invention;

Fig. 5 is an enlarged cross sectional view of a firing tip of Fig. 4; and

Fig. 6 is a graph showing the comparison between the erosion of a sintered compact body and an equivalent conventionally produced iridium tip at different extents of sintering.

[0012] Referring to Fig. 1, there is shown a spark plug 1 which is to be incorporated into an internal combustion engine. The spark plug 1 has a cylindrical metallic shell 3 having a nut portion 3a and a thread portion 5 at its outer surface. Within the metallic shell 3, a tubular insulator 2 is concentrically enclosed which is made of alumina and nitride based ceramics such as aluminum nitride (AlN) and silicon nitride (Si₃N₄). The interior of the insulator 2 has as an axial bore 8 in which a terminal electrode 10 and a center electrode 7 are concentrically enclosed. These electrodes 10, 7 are linearly aligned by way of an electrically conductive glass sealant 9 which is encapsulated into the axial bore 8. The center electrode 7 is made of a metallic material, but may be made of an electrically conductive ceramic powder or a metal-coated ceramic body.

[0013] A front end of the center electrode 7 is terminated somewhat short of the front end of the insulator 2. Into the front end of the insulator 2, a firing tip 6 is inserted and sintered simultaneously at the insulator, and metallurgically bonded to the front end of the centre electrode 7 by means of an electrical resistant welding (Wd) as shown in Fig. 2.

[0014] In this instance, a front end of the firing tip 6 extends somewhat beyond the front end of the insulator 2 so as to provide a spark gap (Ga) between the tip 6 and an outer electrode 4 mounted on the metallic shell 5. The firing tip 6 is made from an iridium powder compact body by means of a metallic die press, C.I.P., extrusion or injection. Then, the compact body is degreased, and sintered at a temperature of more than 2000 degrees Celsius in a vacuum, or an inert reductive atmosphere, so that the density of the powder compact is more than 90 percent, thus improving the spark-erosion resistance. The firing tip 6 has a frusto-conically shaped stem 11 at a side in which the tip 6 is metallurgically bonded to the insulator 2. As shown in Fig. 3, the firing tip 6 measures 2.0 mm in length (C), and measures 0.8 mm, and 1.2 mm at its diameters (a), (b) at its stem 11. The stem 11 measures 0.5 mm in height (d) with a 45 degree taper of its stem 11. Now, Table 1 shows a relationship between relative press forming density, sintering atmosphere, sintering conditions and density of a sintered compact body. If the sintered compact body is placed in air at the time of sintering, the iridium of the compact body is oxidized to produce a black iridium oxide leading to volatilization. In order to protect the compact body against over-volatilization, it is necessary to sinter the compact body in a vacuum, or an inert atmosphere.

[0015] The compact body is then sintered at a temperature ranging from 1700 to 2200 degrees Celsius, and preferably sintered at more than 2000 degrees Celsius.

[0016] When the density of the sintered compact body is low, the number of pores in the compact body is high, which causes a temperature rise, quickly eroding the firing tip due to the high energy released when a spark discharge occurs. In order to reduce erosion, it is necessary to ensure that the density of the sintered compact body is more than 90 percent, as shown in Fig. 6 which is a graph showing the comparative erosion between a sintered compact body and a metallurgically processed ingot iridium tip at different densities of sintered compact. The value 100 is taken to be the erosion of a metallurgically processed iridium tip. As shown in Fig. 5, the comparative erosion of the firing tip decreases with the increase of the density of the sintered compact body.

[0017] In the meantime, it is desirable to sinter the compact body a second time to increase its density again as shown at Table 2.

[0018] A spark erosion experiment is carried out with the sample (K) at Table 2 employed. The sample is an iridium powder compact which is compressed by means of a die press, so that the press forming density ratio is 66.3 percent. Then, the compact body, thus compressed, is primarily sintered at 2200 degrees Celsius in a hydrogen atmosphere for 60 minutes, so that the density of the compact body is 92.5 percent. The compact body is secondarily sintered at 1400 degrees Celsius in an argon atmosphere for 60 minutes, and shaped as shown in Fig. 3 by means of a hot isostatic hydraulic press.

[0019] The result shows that the erosion of sample (K) is substantially identical to that of a Pt-Ir tip which is metallurgically processed to impart an increased erosion-resistant property.

TABLE 1

sample	press forming density ratio (%)	primary sintering atmosphere	sintering condition °C × min.	density of compact body (%)
A	66.4	vacuum	1300 × 30	75.6

TABLE 1 (continued)

sample	press forming density ratio (%)	primary sintering atmosphere	sintering condition °C × min.	density of compact body (%)
B	66.4	ditto	1700 × 60	86.7
C	67.3	hydrogen	1700 × 60	87.7
D	66.4	ditto	1800 × 60	87.9
E	66.4	ditto	1900 × 60	89.0
F	66.4	ditto	2000 × 60	92.1
G	66.3	ditto	2200 × 60	92.5

TABLE 2

sample	secondary sintering	sintering condition °C × min.	density of compact body (%)
H	corresponding to sample D	vacuum 1700 × 60	91.6
I	corresponding to sample E	ditto	91.8
J	corresponding to sample F	argon 1400 × 60 under hot isostatic hydraulic press	94.4
K	corresponding to sample G	ditto	95.6

[0020] Referring to Fig. 4 which shows a spark plug (1A) according to a second embodiment of the invention, the firing tip 6a is formed into a columnar shape, and measures 0.5 mm in diameter (e), and 1.5 mm in length (f).

[0021] In this embodiment, like reference numerals in Fig. 1 are identical to those in Fig. 4. A center electrode 12 is made of a copper core clad by a nickel alloy. The center electrode 12 is encapsulated in the axial bore 8 with the glass sealant 9, and has a flanged head 14 at its upper end to engage against a stepped portion 2a of the inner wall of the insulator 2. The front end face of the center electrode 12 has a recess 13 into which the firing tip 6a is fitted and securely attached at the center electrode 12 by means of a metallurgical bond (L) such as an electron beam welding or a laser welding. It is noted that the firing tip 6a may also be used in igniter plugs in general.

[0022] Various other modifications and changes may be also made without departing from the scope of the appended claims.

Claims

1. A method of manufacturing a spark plug for an internal combustion engine, the method comprising the steps of:

providing a cylindrical metallic shell and placing a tubular ceramic insulator concentrically therein; and placing a centre electrode concentrically within the tubular insulator; characterised by the further steps of: preparing an iridium powder compact; forming a firing tip from the iridium powder compact; sintering the iridium powder compact in a vacuum, or a non-oxidizing or reducing atmosphere at a temperature in the range of from 2000 to 2200°C to impart a density of at least 90% of theoretical to the iridium powder compact so as to provide spark-erosion resistance; and metallurgically bonding the firing tip to the front end of the centre electrode to form a spark gap between the firing tip and an outer electrode which extends from the metallic shell.

2. A method according to claim 1 comprising the step of:

inserting the firing tip into the front end of the tubular insulator, wherein said sintering of the firing tip is simultaneously carried out on the insulator, the firing tip having a stem for placing the firing tip in position when

inserting the firing tip into the tubular insulator.

3. A method according to claim 1 wherein the front end face of the centre electrode is provided with a recess into which the firing tip is fitted, and said metallurgically bonding step is performed using electron beam welding or laser welding.

4. A method according to claim 1 wherein said sintering of the iridium powder compact is performed at about 2000°C for 60 minutes, and the method comprises the further sintering step of the iridium powder compact at about 1400°C for 60 minutes in an argon atmosphere by means of a hot isostatic press procedure.

5. A spark plug comprising:

a cylindrical metallic shell;
a tubular ceramic insulator positioned concentrically within the shell; and
a centre electrode concentrically placed in the insulator; characterised by
a firing tip metallurgically bonded to the centre electrode, the firing tip being formed from a sintered iridium powder compact and having a density greater than 90% of theoretical.

6. A spark plug according to claim 5 in which a front end face of the centre electrode has a recess into which the firing tip is to be fitted and secured to the centre electrode by means of metallurgical bond such as electron beam welding or laser welding.

Patentansprüche

1. Verfahren zur Herstellung einer Zündkerze für einen Verbrennungsmotor, wobei das Verfahren die folgenden Schritte umfaßt:

Vorsehen eines zylinderförmigen Metallgehäuses und Anordnen eines rohrförmigen Keramikisolators konzentrisch darin; und
Anordnen einer Mittelelektrode konzentrisch in dem rohrförmigen Isolator; gekennzeichnet durch die weiteren Schritte:
Herstellen eines Iridium-Pulver-Preßlings;
Bilden einer Zündspitze aus dem Iridium-Pulver-Preßling;
Sintern des Iridium-Pulver-Preßlings in einem Vakuum oder in einer nicht oxidierenden oder reduzierenden Atmosphäre bei einer Temperatur in dem Bereich von 2000 bis 2200°C, um dem Iridium-Pulver-Preßling eine Dichte von mindestens 90% der theoretischen Dichte zu verleihen, um diesen mit einem Funkenerosionswiderstand zu versehen, und
metallurgisches Verbinden der Zündspitze mit dem vorderen Ende der Mittelelektrode zur Bildung einer Funkenstrecke zwischen der Zündspitze und einer Außenelektrode, die sich ausgehend von dem Metallgehäuse erstreckt.

2. Verfahren nach Anspruch 1, mit dem folgenden Schritt:

Einführen der Zündspitze in das vordere Ende des rohrförmigen Isolators, wobei das Sintern der Zündspitze gleichzeitig an dem Isolator durchgeführt wird, wobei die Zündspitze einen Schaft aufweist, damit die Zündspitze an der richtigen Stelle angeordnet wird, wenn die Zündspitze in den rohrförmigen Isolator eingeführt wird.

3. Verfahren nach Anspruch 1, wobei die vordere Endfläche der Mittelelektrode mit einer Aussparung versehen ist, in die die Zündspitze eingepaßt wird, und der metallurgische Verbindungsschritt unter Verwendung des Elektronenstrahlschweißens oder des Laserschweißens durchgeführt wird.

4. Verfahren nach Anspruch 1, wobei das Sintern des Iridium-Pulver-Preßlings bei etwa 2000°C über einen Zeitraum von 60 Minuten durchgeführt wird und das Verfahren den weiteren Schritt des Sinterns des Iridium-Pulver-Preßlings bei etwa 1400°C über einen Zeitraum von 60 Minuten in einer Argonatmosphäre mit Hilfe eines isostatischen Heißpressvorgangs umfaßt.

5. Zündkerze mit:

einem zylinderförmigen Metallgehäuse;

einem rohrförmigen Keramikisolator, der konzentrisch in dem Gehäuse angeordnet ist, und einer Mittelelektrode, die konzentrisch in dem Isolator angeordnet ist, gekennzeichnet durch

eine Zündspitze, die metallurgisch mit der Mittelelektrode verbunden ist, wobei die Zündspitze aus einem gesinterten Iridium-Pulver-Preßling hergestellt ist und eine Dichte aufweist, die größer als 90% der theoretischen Dichte ist.

6. Zündkerze nach Anspruch 5, bei der eine vordere Endfläche der Mittelelektrode eine Aussparung aufweist, in der die Zündspitze eingepaßt und mit Hilfe des metallurgischen Verbindens, wie z.B. Elektronenstrahlschweißen oder Laserschweißen, an der Mittelelektrode befestigt werden soll.

Revendications

1. Procédé de fabrication de bougie d'allumage pour moteur à combustion interne, le procédé comprenant les étapes consistant à:

réaliser une enveloppe métallique cylindrique et placer dans celle-ci, d'une manière concentrique, un isolateur tubulaire en céramique; et

placer d'une manière concentrique une électrode centrale dans l'isolateur tubulaire; caractérisé en outre par les étapes consistant à:

réaliser un comprimé de poudre d'iridium;

former une pointe d'allumage à partir du comprimé de poudre d'iridium;

fritter le comprimé de poudre d'iridium sous vide, ou sous une atmosphère non oxydante ou réductrice, à une température comprise entre 2000 et 2200°C, pour donner au comprimé de poudre d'iridium une densité au moins égale à 90% de la densité théorique, afin d'assurer une résistance à l'électro-érosion; et

fixer la pointe d'allumage par une liaison métallurgique à l'extrémité avant de l'électrode centrale pour former un intervalle de décharge entre la pointe d'allumage et une électrode extérieure qui s'étend depuis l'enveloppe métallique.

2. Procédé selon la revendication 1, comprenant l'étape consistant à:

insérer la pointe d'allumage dans l'extrémité avant de l'isolateur tubulaire, ledit frittage de la pointe d'allumage étant effectué simultanément sur l'isolateur, la pointe d'allumage ayant une tige pour mettre en place la pointe d'allumage lors de l'insertion de la pointe d'allumage dans l'isolateur tubulaire.

3. Procédé selon la revendication 1, dans lequel la face d'extrémité avant de l'électrode centrale comporte un évidement dans lequel la pointe d'allumage est logée, et ladite étape de fixation par liaison métallurgique est effectuée par soudage par faisceau d'électrons ou par soudage au laser.

4. Procédé selon la revendication 1, dans lequel ledit frittage du comprimé de poudre d'iridium est effectué pendant 60 minutes à environ 2000°C, et le procédé comprend une autre étape de frittage du comprimé de poudre d'iridium pendant 60 minutes à environ 1400°C sous une atmosphère d'argon à l'aide d'un procédé utilisant une presse isostatique à chaud.

5. Bougie d'allumage, comprenant:

une enveloppe métallique cylindrique;

un isolateur tubulaire en céramique dispose d'une manière concentrique dans l'enveloppe; et

une électrode centrale placée d'une manière concentrique dans l'isolateur; caractérisée par

une pointe d'allumage fixée à l'électrode centrale par une liaison métallurgique, la pointe d'allumage étant formée à partir d'un comprimé de poudre d'iridium frittée et ayant une densité supérieure à 90% de la densité théorique.

6. Bougie d'allumage selon la revendication 5, dans laquelle une face d'extrémité avant de l'électrode centrale a un évidement dans lequel la pointe d'allumage est destinée à se loger et à être fixée à l'électrode centrale à l'aide d'une liaison métallurgique telle que le soudage par faisceau d'électrons ou le soudage au laser.

Fig. 1

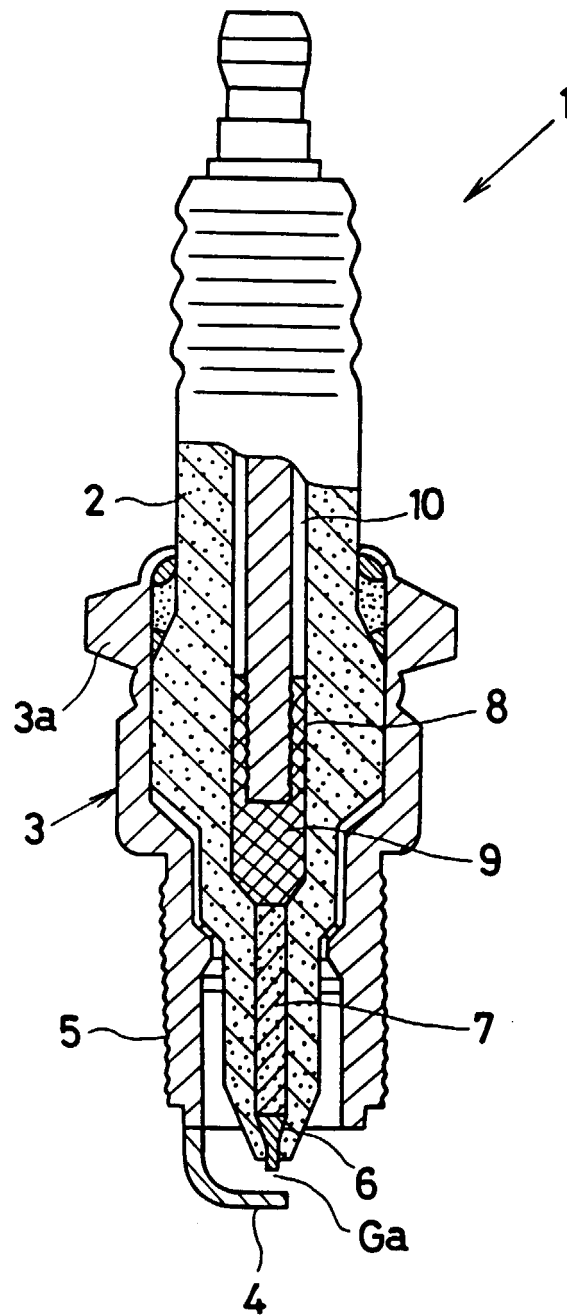


Fig. 2

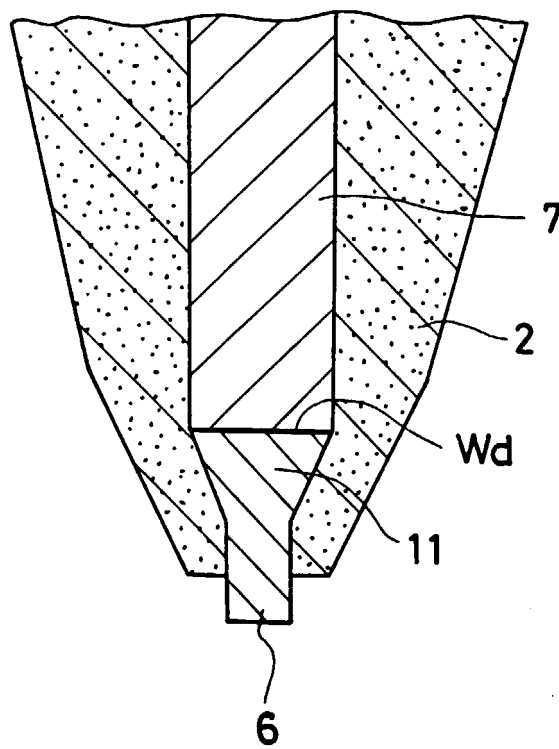


Fig. 3

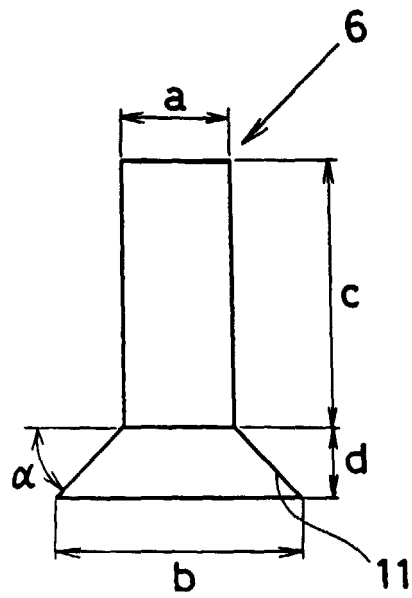


Fig. 5

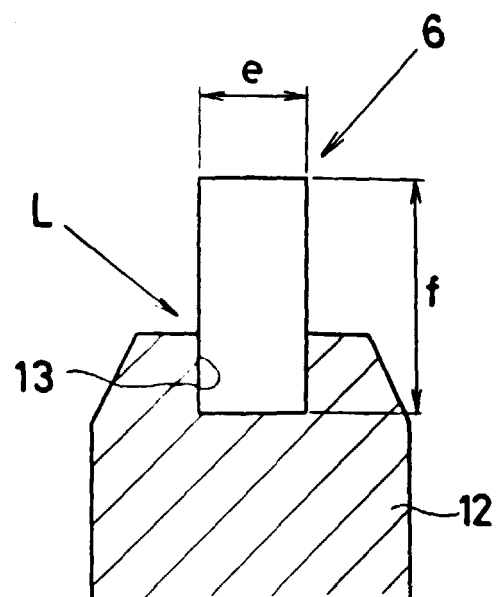


Fig. 4

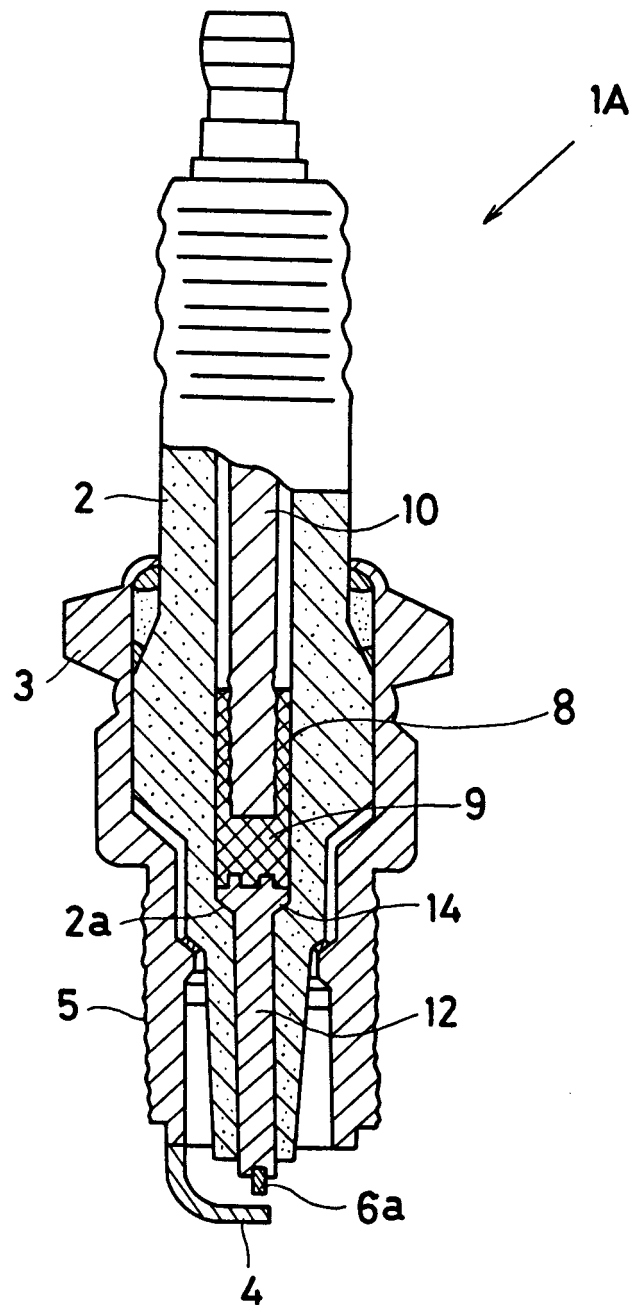


Fig. 6

