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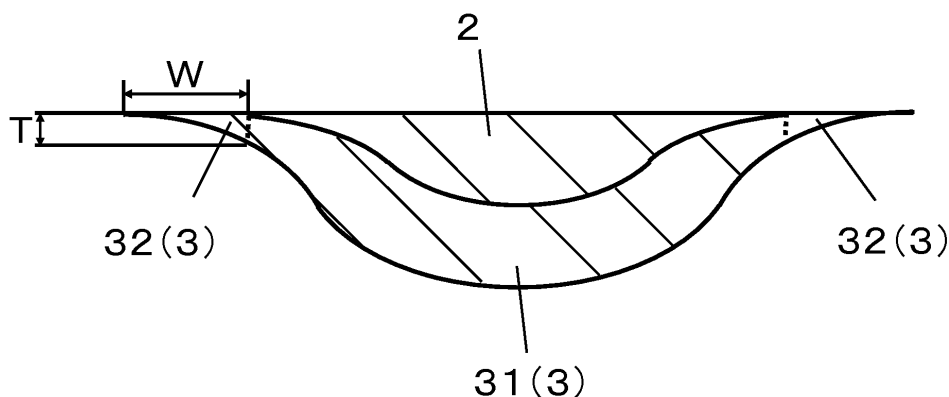
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(54) **CERAMIC HEATER AND IGNITION DEVICE PROVIDED WITH SAME**

(57) A ceramic heater includes a ceramic body; a heat-generating resistor embedded in the ceramic body and having a belt shape; and a lead embedded in the ceramic body, connected to an end portion of the heat-generating resistor, and having a belt shape. The lead includes a first portion covering the end portion of

the heat-generating resistor at a connection portion between the lead and the heat-generating resistor, and second portions extending sideways from both sides of the end portion. A thickness of each of the second portions is smaller than a thickness of the first portion.

FIG 3



Description

Technical Field

[0001] The present invention relates to a ceramic heater and an ignition device provided with the ceramic heater.

Background Art

[0002] A ceramic heater is known as an example of a heater for use in a gas stove, an on-vehicle heating device, a kerosene fan heater, a glow plug of an automobile engine, a heater for preheating of fuel, or the like. An example of a ceramic heater is disclosed in Japanese Unexamined Patent Application Publication No. 2000-156275 (hereinafter referred to as Patent Document 1).

[0003] The ceramic heater disclosed in Patent Document 1 includes a ceramic structure, a heat-generating resistor embedded in the ceramic structure, and feeder lines connected to the heat-generating resistor and extending to a surface of the ceramic structure.

[0004] The ceramic heater disclosed in Patent Document 1 has a risk that cracks will be formed in connection portions between the feeder lines and the heat-generating resistor as a thermal stress is generated in the feeder lines and the heat-generating resistor when the ceramic heater is repeatedly used in a high-temperature environment. Thus, it is difficult to increase the long-term reliability when the ceramic heater is repeatedly used in a high-temperature environment.

Summary of Invention

[0005] A ceramic heater includes a ceramic body; a heat-generating resistor embedded in the ceramic body and having a belt shape; and a lead embedded in the ceramic body, connected to an end portion of the heat-generating resistor, and having a belt shape. The lead includes a first portion covering the end portion of the heat-generating resistor at a connection portion between the lead and the heat-generating resistor, and second portions extending sideways from both sides of the end portion. A thickness of each of the second portions is smaller than a thickness of the first portion.

[0006] An ignition device includes the ceramic heater, and a channel through which fuel gas flows to the ceramic body included in the ceramic heater.

Brief Description of Drawings

[0007]

Fig. 1 is a longitudinal sectional view of a ceramic heater.

Fig. 2 is a cross-sectional view of the ceramic heater illustrated in Fig. 1 taken along line A-A'.

Fig. 3 is an enlarged view of a resistor and a lead of the ceramic heater illustrated in Fig. 2.

Fig. 4 is a perspective view of an ignition device including the ceramic heater illustrated in Fig. 1. Description of Embodiments

[0008] A ceramic heater 10 will be described with reference to the drawings.

[0009] As illustrated in Fig. 1, the ceramic heater 10 includes a ceramic body 1, a heat-generating resistor 2 disposed in the ceramic body 1, and leads 3 disposed in the ceramic body 1 and connected to the heat-generating resistor 2. The ceramic heater 10 may be used, for example, in a glow plug of an automobile engine, for preheating a fuel, or for igniting a gas stove.

[0010] The ceramic body 1 is a member in which the leads 3 and the heat-generating resistor 2 are embedded. The durabilities of the leads 3 and the heat-generating resistor 2 can be increased by placing the leads 3 and the heat-generating resistor 2 in the ceramic body 1. The ceramic body 1 is a member having, for example, a rod shape or a plate shape (each of which may be regarded as a columnar shape). The ceramic body 1 includes, for example, a plurality of ceramic layers 11. In the example described below, the ceramic body 1 of the ceramic heater 10 is a multilayer body including the plurality of ceramic layers 11. However, the ceramic body 1 is not limited to this. That is, the ceramic body 1 may be integrally formed. Examples of a method for integrally forming the ceramic body 1 include injection molding.

[0011] The ceramic body 1 is made of an electrically insulative ceramic, such as an oxide ceramic, a nitride ceramic, or a carbide ceramic. More specifically, the ceramic body 1 is made of, for example, an alumina ceramic, a silicon nitride ceramic, an aluminum nitride ceramic, or a silicon carbide ceramic.

[0012] The ceramic body 1 made of a silicon nitride ceramic may be obtained by the following method. For example, silicon nitride, which is the main component, is mixed with 5 to 15 mass% of rare earth oxide, such as Y₂O₃, Yb₂O₃, or Er₂O₃, which functions as a sintering additive; 0.5 to 5 mass% of Al₂O₃; and SiO₂, the amount of which is adjusted so that the amount of SiO₂ in the sintered body is 1.5 to 5 mass%. The thus-obtained material is formed in a predetermined shape, and is then fired at a temperature of 1650°C to 1780°C. Thus, the ceramic body 1 made of a silicon nitride ceramic is obtained. A hot press method, for example, may be used in the firing process.

[0013] When the ceramic body 1 has a rod shape, more specifically, a rectangular-prism shape, the length of the ceramic body 1 is set to, for example, 20 to 100 mm. The cross-sectional shape of the ceramic body 1 is set to, for example, a rectangle having a thickness of 1 to 6 mm and a width of 2 to 40 mm.

[0014] The heat-generating resistor 2 is a member that has a belt shape and that generates heat when a voltage is applied thereto. The heat-generating resistor 2 is em-

bedded between two ceramic layers 11 of the ceramic body 1 adjacent to each other. When a voltage is applied to the heat-generating resistor 2, a current flows through the heat-generating resistor 2, and the heat-generating resistor 2 generates heat. The generated heat is transferred through the ceramic body 1, so that the temperature of the surface of the ceramic body 1 increases. The heat is transferred from the surface of the ceramic body 1 to an object to be heated, thereby providing the function of the ceramic heater 10. The object to be heated that receives the heat from the surface of the ceramic body 1 is, for example, diesel oil to be supplied to a fuel injection device of an automobile diesel engine.

[0015] The heat-generating resistor 2 is disposed in a region near the front end of the ceramic body 1. The heat-generating resistor 2 has, for example, a bent shape in longitudinal cross section (cross section parallel to the length direction of the heat-generating resistor 2). More specifically, the heat-generating resistor 2 includes two parallel linear portions 21 and a connecting portion 22 that has substantially semicircular or substantially semielliptical inner and outer peripheries and that is bent so as to connect the two linear portions 21. The heat-generating resistor 2 is bent at a location near the front end of the ceramic body 1. The length from the front end of the heat-generating resistor 2 (the front end of the connecting portion 22) to the rear end of the heat-generating resistor 2 (the rear end of each of the linear portions 21) is set to, for example, 2 to 15 mm in the length direction of the heat-generating resistor 2.

[0016] The heat-generating resistor 2 is made of, for example, a material having a carbide, nitride, silicide, etc., of tungsten (W), molybdenum (Mo), titanium (Ti), etc., as the main component. When the ceramic body 1 is made of a silicon nitride ceramic, the heat-generating resistor 2 is preferably made of a material having tungsten carbide as the main component. In this case, the coefficient of thermal expansion of the ceramic body 1 and that of the heat-generating resistor 2 can be made close to each other.

[0017] Each of the leads 3 is a member that has a belt shape, that is embedded in the ceramic body 1, and one end of which is at a corresponding one of side surfaces of the ceramic body 1. The leads 3 are located between two ceramic layers 11 adjacent to each other. The leads 3 are electrically connected to the heat-generating resistor 2. The leads 3 are used to electrically connect the heat-generating resistor 2 to an external electric power source.

[0018] The number of the leads 3 is two. The two leads 3 extend in the length direction of the ceramic body 1 so as to correspond to the two linear portions 21 of the heat-generating resistor 2. Each of the leads 3 is bent in a rear end portion of the ceramic body 1 so as to extend to a corresponding one of side surfaces of the ceramic body 1. The lead 3 is bent in the rear end portion of the ceramic body 1 by an angle of 90° so as to extend to the corresponding one of side surfaces of the ceramic body 1.

[0019] The leads 3 are made of, for example, a highly heat-resistant metal material, such as W or Mo. In particular, preferably, the leads 3 are made of tungsten carbide, which is the same as the heat-generating resistor 2, in consideration of the coefficient of thermal expansion. For example, the width of each of the leads 3 is set to about 1 to 20 mm; the length of a part of the lead 3 extending in the length direction of the heat-generating resistor 2 is set to about 10 to 80 mm; the length of a part of the lead 3 extending, in a direction perpendicular to the heat-generating resistor 2, to a corresponding one of the side surfaces of the ceramic body 1 is set to about 2 to 30 mm; and the thickness the lead 3 is set to about 10 to 50 μm .

[0020] Fig. 2 is a cross-sectional view of the ceramic heater 10 illustrated in Fig. 1 taken along line A-A', which passes through connection portions between the heat-generating resistor 2 and the leads 3. Fig. 2 illustrates a cross section perpendicular to the main surface of the heat-generating resistor 2. In Fig. 2, the boundaries between the plurality of ceramic layers 11 are shown by dotted lines. Fig. 3 is an enlarged view of the resistor 2 and one of the leads 3 illustrated in Fig. 2. As illustrated in Figs. 2 and 3, each of the leads 3 includes a first portion 31, covering a corresponding end portion of the heat-generating resistor 2, and second portions 32, extending sideways from both sides of the end portion. The boundary between the lead 3 and the heat-generating resistor 2 is not planar, since the lead 3 covers the end portion of the heat-generating resistor 2 and extends sideways from both sides of the end portion in this way. Therefore, cracks are not easily formed in the boundary between the lead 3 and the heat-generating resistor 2. In particular, preferably, the sideways length W of each of extending portions (each of the second portions 32) is greater than the thickness T (shown by a broken line in Fig. 3) of the lead 3 at the end portion of an overlapping portion (the first portion 31) in which the lead 3 and the heat-generating resistor 2 overlap. Thus, the end portion of the lead 3 can be located sufficiently far from the heat-generating resistor 2. Therefore, if cracks are formed at an end of the second portion 32, the risk that the cracks will extend into a space between the lead 3 and the heat-generating resistor 2 can be reduced. In particular, the sideways length W of the second portion 32 may be greater than or equal to twice the thickness T of the lead 3 at the end portion of the first portion 31. In this case, the second portion 32 can extend thinly in the ceramic body 1. As a result, a thermal stress generated in the ceramic body 1 when the second portion 32 thermally expands can be reduced.

[0021] The thickness of each of the extending portions (each of the second portions 32) of the lead 3 is smaller than the thickness of the overlapping portion (the first portion 31) of the lead 3 overlapping the heat-generating resistor 2. Thus, when a thermal stress is generated in the heat-generating resistor 2, the thermal stress is easily concentrated on the extending portion.

[0022] Therefore, the possibility that cracks will be formed in the overlapping portion (the first portion 31) of the lead 3 overlapping the heat-generating resistor 2 can be reduced. As a result, the long-term reliability when the ceramic heater 10 is repeatedly used in a high-temperature environment can be increased. For example, the thickness of the first portion 31 of the lead 3 is set to 5 to 50 μm , and the thickness of the second portion 32 of the lead 3 is set to 0.5 to 10 μm .

[0023] The thickness of the first portion 31 and the thickness of the second portion 32 can be compared with each other by, for example, comparing the average thickness of the first portion 31 and the average thickness of the second portion 32 with each other. The average thicknesses of the first portion 31 and the second portion 32 can be obtained by using, for example, the following method. To be specific, three imaginary lines that quarter each of the first portion 31 and the second portion 32 are drawn in each of the first portion 31 and the second portion 32. Then, the averages of the thicknesses of the first portion 31 and the second portion 32 at positions where the three imaginary lines are drawn are calculated. The averages can be regarded as the average thickness of the first portion 31 and the average thickness of the second portion 32.

[0024] Preferably, as illustrated in Figs. 2 and 3, the thickness of each of the second portions 32 gradually decreases as further it gets sideways from the lead 3 at the connection portion between the lead 3 and the heat-generating resistor 2. In this case, a thermal stress is easily concentrated on a part of the second portion 32 near the end thereof, since the thickness of each of the second portions 32 gradually decreases as further it gets sideways. Thus, even when a thermal stress is generated in the lead 3, the positions where cracks may be formed in the lead 3 can be located away from the heat-generating resistor 2 and the first portion 31. Therefore, the risk that the connection reliability between the lead 3 and the heat-generating resistor 2 will decrease can be reduced.

[0025] As illustrated in Figs. 2 and 3, the heat-generating resistor 2 and the lead 3 may be disposed between two ceramic layers 11 adjacent to each other. Thus, cracks that may be formed in the ceramic body 1 can be reduced. In the ceramic body 1, in particular, a stress is easily concentrated on a region between the ceramic layers 11. The second portion 32 can absorb the stress generated between the ceramic layers 11 by disposing the heat-generating resistor 2 and the lead 3, which can concentrate the stress on the second portion 32 as described above, between the ceramic layers 11. Therefore, the risk that cracks will be formed between the ceramic layers 11 in the ceramic body 1 can be reduced.

[0026] The heat-generating resistor 2 and each of the second portions 32 may be in contact with one surface of one of the two ceramic layers 11 in the connection portion between the lead 3 and the heat-generating resistor 2. In this case, both the heat-generating resistor 2

and the lead 3 can absorb a force when a thermal stress is generated in the ceramic body 1, since the heat-generating resistor 2 and each of the second portions 32 are in contact with the same surface. In other words, the risk that a force will be applied to only the heat-generating resistor 2 or only the lead 3 can be reduced. Therefore, for example, the risk that cracks will be formed at the interface between the heat-generating resistor 2 and the lead 3 can be reduced.

[0027] The heat-generating resistor 2 and each of the second portions 32 may be continuous on one surface. The phrase "continuous on one surface" means that, when a cross section passing through the heat-generating resistor 2 and the lead 3 is viewed, the heat-generating resistor 2 and the lead 3 are in contact with each other on one surface of one of two ceramic layers 11 adjacent to each other. Thus, gaps from which cracks may develop can be reduced at the interface between the heat-generating resistor 2 and each of the second portions 32, and therefore the risk that cracks will be formed at the interface between the heat-generating resistor 2 and the lead 3 can be reduced.

[0028] As illustrated in Figs. 2 and 3, one of main surfaces of each of the second portions 32 of the lead 3 and the heat-generating resistor 2 may be in contact with one surface of one of two ceramic layers 11 adjacent to each other, and the other main surface of the second portion 32 may be convexly curved inward. In this case, stress can be more easily concentrated on the end portion of the second portion 32. As a result, even when a thermal stress is generated in the second portion 32, positions where cracks may be formed in the lead 3 can be located away from the first portion 31. Therefore, the reliability of connection between the lead 3 and the heat-generating resistor 2 can be increased.

[0029] The lead 3 and the heat-generating resistor 2 may be made of a metal material and a ceramic material mixed in the metal material. Examples of the metal material include WC. Examples of the ceramic material include Si_3N_4 and BN. In this case, the ceramic material content of the second portion 32 may be greater than the ceramic material content of the first portion 31. Thus, when a stress is applied to the entirety of the lead 3, cracks can be allowed to be formed more easily in the second portion 32 than in the first portion 31. This is because, the second portion 32 can be elastically deformed less easily than the first portion 31 when the metal material content of the second portion 32 is smaller than that of the first portion 31 and the ceramic material content of the second portion 32 is greater than that of the first portion 31. Examples of a method for making the compositions of the first portion 31 and the second portion 32 differ from each other include a method of forming the first portion 31 and the second portion 32 from different green sheets.

[0030] The thermal expansion coefficient of the heat-generating resistor 2 may be smaller than that of the lead 3. In this case, after firing, a residual stress remains in

such a way that the lead 3 cramps the heat-generating resistor 2. Therefore, the risk that peeling will occur between the heat-generating resistor 2 and the lead 3 can be reduced. The thermal expansion coefficient of the heat-generating resistor 2 can be made smaller than that of the lead 3 by using, for example, the following method. To be specific, WC is used as the main component of the lead 3 and the heat-generating resistor 2, and Si₃N₄, which has a smaller thermal expansion coefficient than WC, is added as a subcomponent. In this case, by adding a larger amount of Si₃N₄ to the heat-generating resistor 2 than to the lead 3, the thermal expansion coefficient of the heat-generating resistor 2 can be made smaller than that of the lead 3.

[0031] The ceramic heater 10 described above can be made, for example, by using a hot press method. To be specific, a paste, which is to become the heat-generating resistor 2 and the leads 3, is stacked on a green sheet, which is to become a part of the ceramic layer 11. In doing so, in order to make the second portions 32 of the lead 3 to extend sideways from both sides of the heat-generating resistor 2, a part of the paste to become the second portions 32 of the lead 3 and a green paste are made to closely contact each other by applying a small pressure to the part to become the second portion 32. Subsequently, another green sheet is stacked on the green sheet so that the heat-generating resistor 2 and the lead 3 are disposed between the green sheets, thereby obtaining a multilayer body. Subsequently, the ceramic heater 10 is produced by firing the multilayer body by using a hot-press method.

[0032] The ceramic heater 10 is used in, for example, an ignition device 100 illustrated in Fig. 4. The ignition device 100 includes the ceramic heater 10 and a channel 20 through which a fuel gas is supplied to the ceramic heater 10. The channel 20 includes, for example, a gas valve 21 and a gas flow pipe 22 having ejection holes 23. The gas valve 21 has a function of controlling the flow rate of the fuel gas. The fuel gas supplied from the gas valve 21 is, for example, natural gas or propane gas. The gas flow pipe 22 ejects the fuel gas, which is supplied from the gas valve 21, toward the ceramic heater 10 through the ejection holes 23. The ejected fuel gas can be ignited by heating the fuel gas with the heater 10. The ignition device 100, which includes the ceramic heater 10 having improved long-term reliability, has improved fuel-gas ignition stability.

Reference Signs List

[0033]

- 1 ceramic body
- 11 ceramic layer
- 2 heat-generating resistor
- 21 linear portion
- 22 connecting portion
- 3 lead

- 31 first portion
- 32 second portion
- 10 ceramic heater
- 100 ignition device

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Claims

1. A ceramic heater comprising:

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a ceramic body;
a heat-generating resistor embedded in the ceramic body and having a belt shape; and
a lead embedded in the ceramic body, connected to an end portion of the heat-generating resistor, and having a belt shape,
wherein the lead comprises:

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a first portion covering the end portion of the heat-generating resistor at a connection portion between the lead and the heat-generating resistor; and
second portions extending sideways from both sides of the end portion, and

a thickness of each of the second portions is smaller than a thickness of the first portion.

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2. The ceramic heater according to Claim 1, wherein the thickness of each of the second portions gradually decreases as further it gets sideways from the lead at the connection portion between the lead and the heat-generating resistor.

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3. The ceramic heater according to Claim 1 or 2, wherein a sideways length of the each of the second portions is greater than a thickness of the first portion at an end portion thereof.

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4. The ceramic heater according to any one of Claims 1 to 3, wherein the ceramic body is a multilayer body comprising a plurality of ceramic layers.

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5. The ceramic heater according to Claim 4, wherein the heat-generating resistor and the lead are disposed between two ceramic layers adjacent to each other.

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6. The ceramic heater according to Claim 5, wherein the heat-generating resistor and each of the second portions are in contact with one surface of one of the two ceramic layers.

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7. The ceramic heater according to Claim 6, wherein the heat-generating resistor and each of the second portions are continuous on the one surface.

8. An ignition device comprising:

the ceramic heater according to any one of Claims 1 to 7; and
a channel through which fuel gas flows to the ceramic body included in the ceramic heater.

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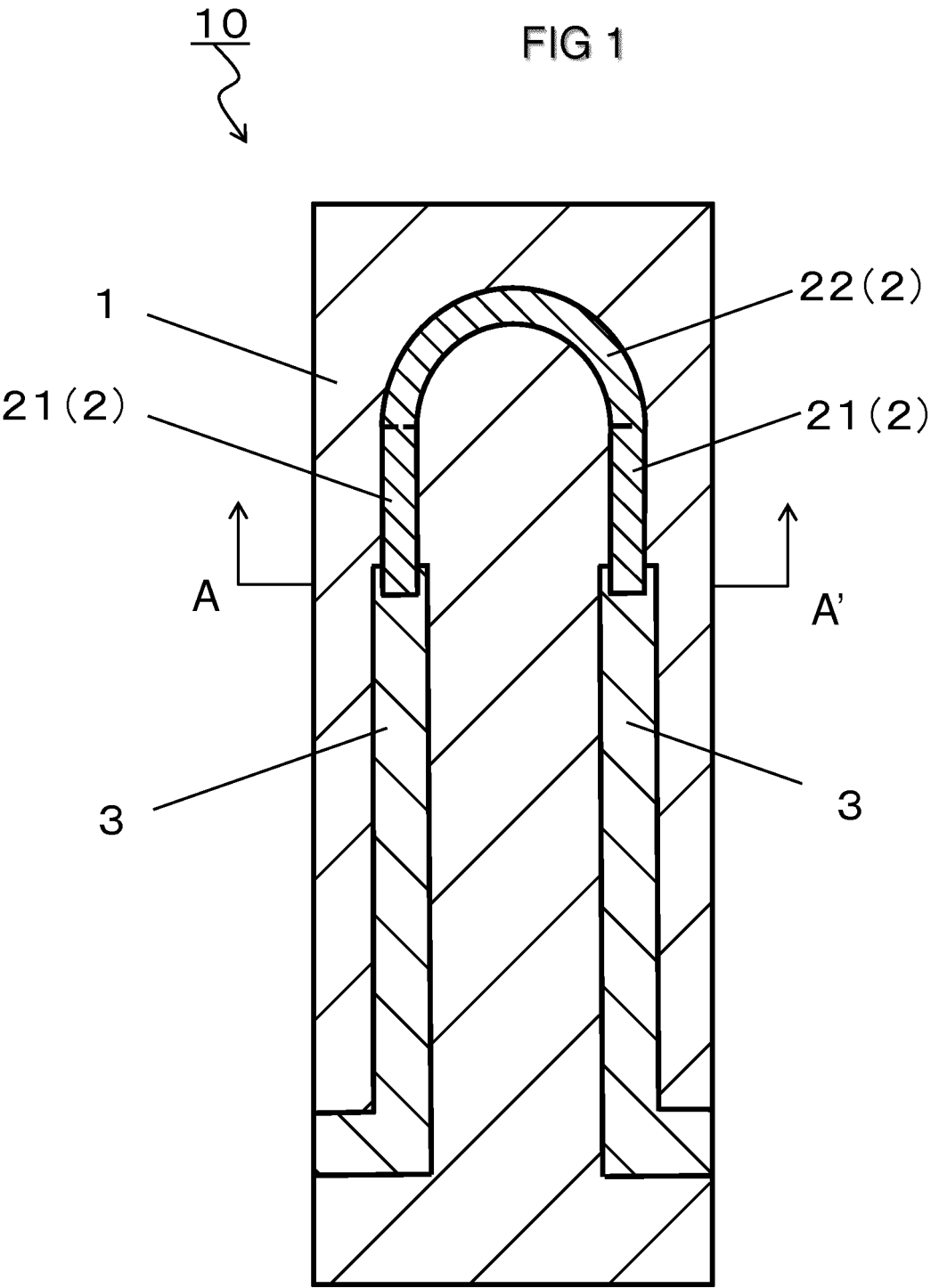
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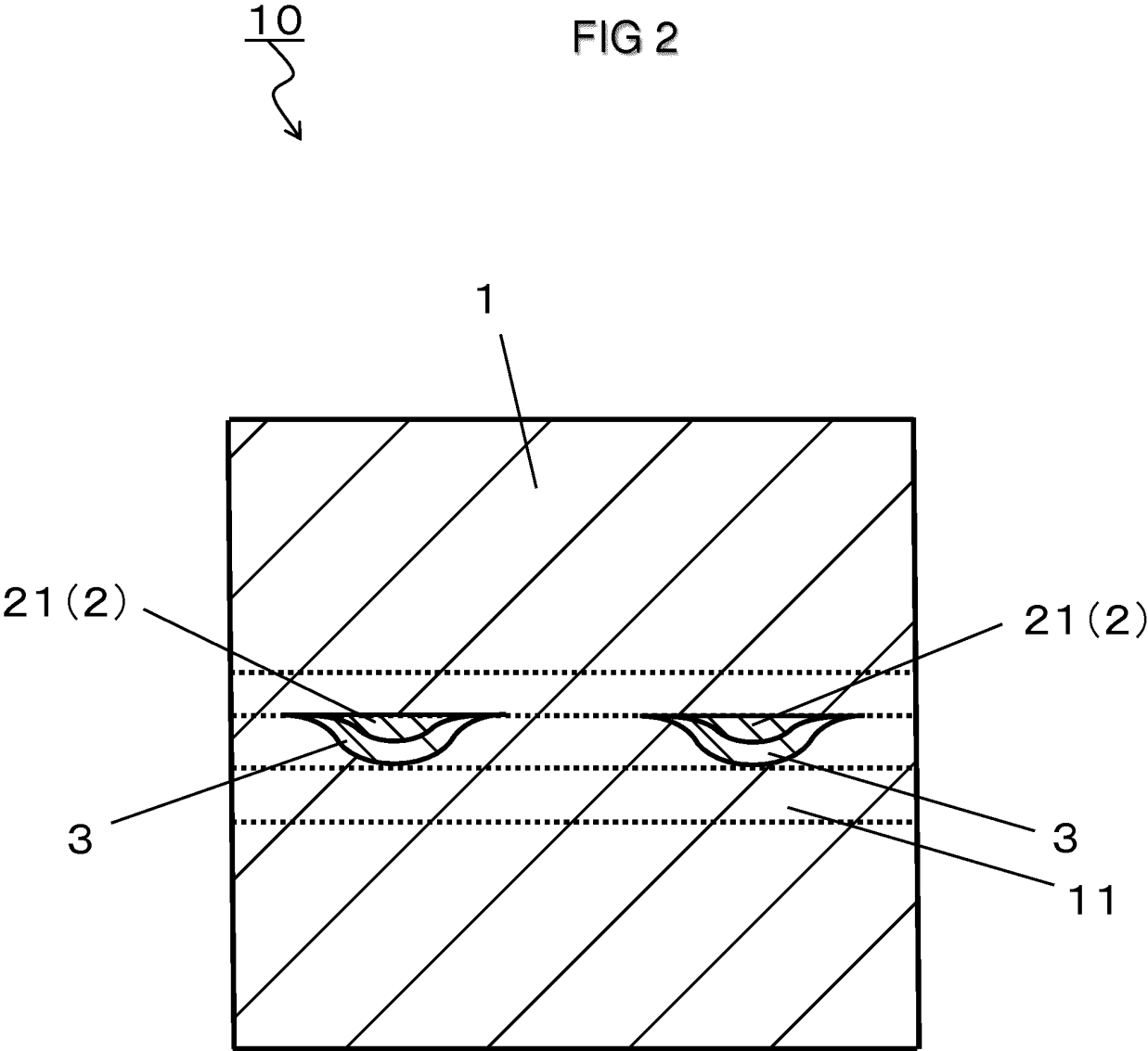


FIG 3

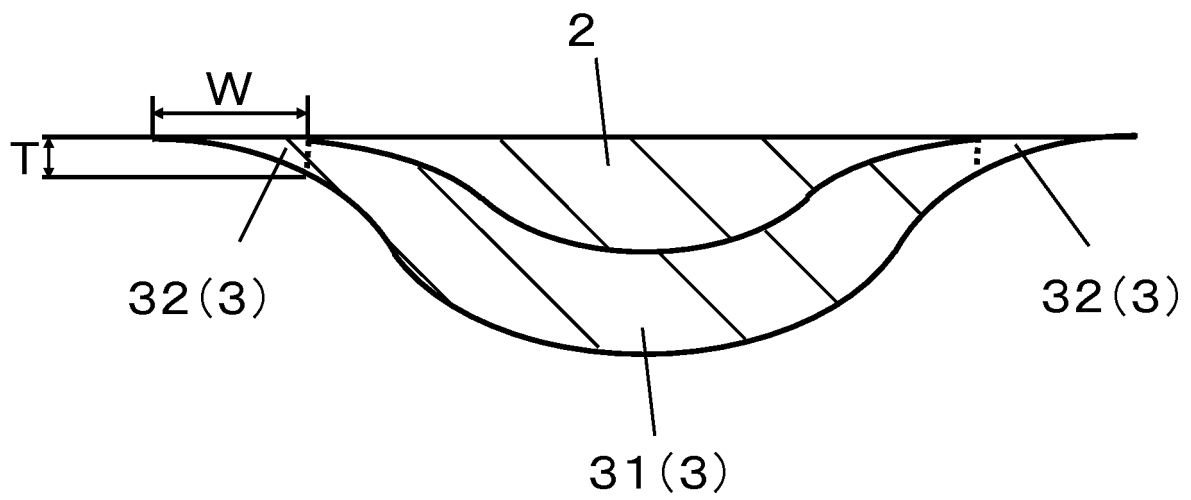
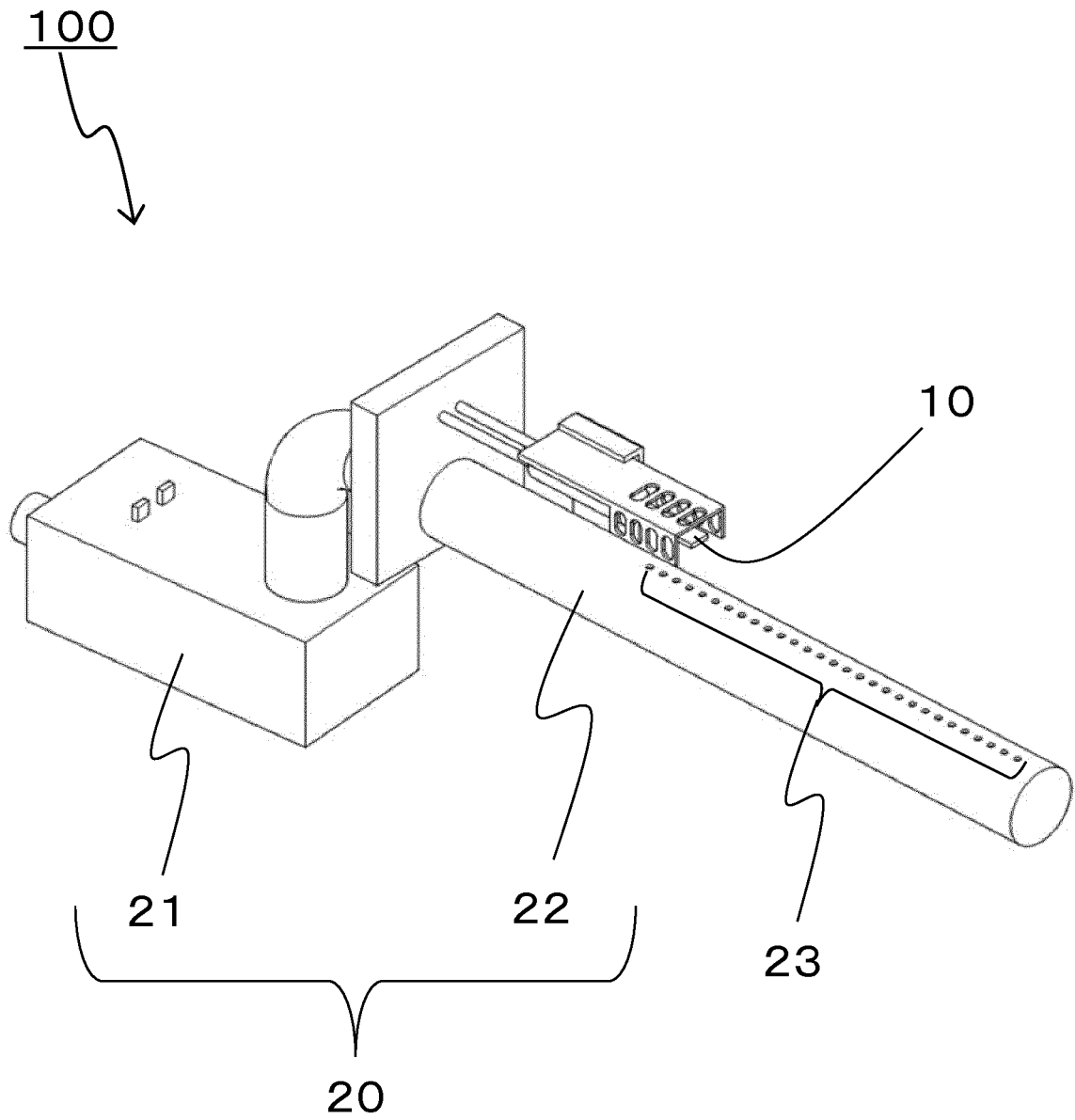


FIG 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/064851

A. CLASSIFICATION OF SUBJECT MATTER

H05B3/02(2006.01)i, H05B3/18(2006.01)i, H05B3/28(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H05B3/02, H05B3/18, H05B3/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 70436/1990 (Laid-open No. 29192/1992) (NGK Spark Plug Co., Ltd.), 09 March 1992 (09.03.1992), entire text; all drawings (Family: none)	1-8
A	JP 3-149791 A (NGK Spark Plug Co., Ltd.), 26 June 1991 (26.06.1991), entire text; all drawings (Family: none)	1-8

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search
14 August 2015 (14.08.15)Date of mailing of the international search report
25 August 2015 (25.08.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/064851

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-42615 A (Kyocera Corp.), 15 February 2007 (15.02.2007), claims 1, 9; paragraphs [0024] to [0040], [0055]; fig. 1 to 4 (Family: none)	1-8
A	JP 5-182746 A (Rohm Co., Ltd.), 23 July 1993 (23.07.1993), entire text; all drawings (Family: none)	1-8
A	JP 2005-135869 A (Kyocera Corp.), 26 May 2005 (26.05.2005), paragraphs [0020] to [0028]; fig. 1 to 3 (Family: none)	1-8
A	JP 1-272078 A (Rinnai Corp.), 31 October 1989 (31.10.1989), page 2, upper left column, line 18 to page 2, lower right column, line 14; fig. 1 to 2 (Family: none)	8

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000156275 A [0002]