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(54) **HEATER AND GLOW PLUG EQUIPPED WITH SAME**

(57) A heater of the present disclosure includes a ceramic body having a rod shape, and a heating resistor provided in an interior of the ceramic body. The heating resistor includes a fold-back portion and a projection hav-

ing a wire shape and extending across an entirety of an outer periphery of the fold-back portion in a folding-back direction.

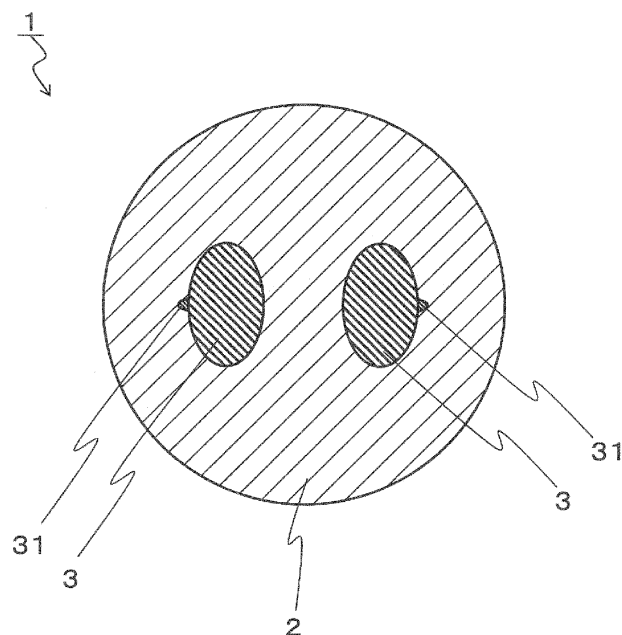


FIG. 3

Description

Technical Field

[0001] The present disclosure relates to a heater utilized as, for example, a heater for ignition or flame detection in a combustion-type vehicle-mounted heating device, a heater for ignition for various combustion equipment such as an oil fan heater, a heater for a glow plug of a diesel engine, a heater for various sensors such as an oxygen sensor, a heater for heating measuring equipment, and a glow plug equipped with such a heater.

Background Art

[0002] As a heater, there have been known ceramic heaters such as that described in JP 2007-240080 A (hereinafter referred to as Patent Document 1), for example. The ceramic heater described in Patent Document 1 includes a base having a rod shape and made of ceramic, and a heating element embedded in this base. The heating element includes a pair of electrically conductive portions each having a rod shape and extending in an axis direction, and has a circular shape when the electrically conductive portions are viewed in a cross section perpendicular to the axis direction.

Summary of Invention

[0003] A heater of an aspect of the present disclosure includes a ceramic body having a rod shape, and a heating resistor provided in an interior of the ceramic body. The heating resistor includes a fold-back portion, and a projection having a wire shape and extending across an entirety of an outer periphery of the fold-back portion in a folding-back direction.

Brief Description of Drawings

[0004]

FIG. 1 is a vertical cross-sectional view illustrating an example of a heater.
 FIG. 2 is a horizontal cross-sectional view of the heater illustrated in FIG. 1 taken along line A-A'.
 FIG. 3 is a horizontal cross-sectional view illustrating another example of a heater.
 FIG. 4 is a vertical cross-sectional view illustrating another example of a heater.
 FIG. 5 is a vertical cross-sectional view illustrating another example of a heater.
 FIG. 6 is a vertical cross-sectional view illustrating an example of an embodiment of a glow plug.
 FIG. 7 is a horizontal cross-sectional view illustrating another example of a heater.
 FIG. 8 is a schematic view illustrating a front surface of a heating resistor of a heater of another example.

Description of Embodiment

[0005] As illustrated in FIG. 1, a heater 1 includes a ceramic body 2, a heating resistor 3 embedded in the ceramic body 2, and leads 4 connected to the heating resistor 3 and drawn to a front surface of the ceramic body 2.

[0006] The ceramic body 2 of the heater 1 is formed into a rod shape having a longitudinal direction, for example. The heating resistor 3 and the leads 4 are embedded in this ceramic body 2. Here, the ceramic body 2 includes ceramic. As a result, it is possible to provide the heater 1 having high reliability under rapid temperature rise. Examples of the ceramic include ceramic having an electrical insulating property such as oxide ceramic, nitride ceramic, or carbide ceramic. Particularly, the ceramic body 2 may include silicon nitride ceramic. This is because silicon nitride, which serves as a primary component of silicon nitride ceramic, is excellent in terms of strength, toughness, electrical insulating property, and thermal resistance. The ceramic body 2 including silicon nitride ceramic is obtained by, for example, mixing from 3 to 12 mass% of rare earth element oxide such as Y_2O_3 , Yb_2O_3 , or Er_2O_3 as a sintering aid, from 0.5 to 3 mass% of Al_2O_3 , and from 1.5 to 5 mass% of SiO_2 in terms of an amount of SiO_2 contained in the sintered body into silicon nitride, which is the primary component, forming the mixture into a predetermined shape, and subsequently subjecting the mixture to hot press firing at a temperature of from 1650 to 1780°C. The length of the ceramic body 2 is set to from 20 to 50 mm, for example, and the diameter of the ceramic body 2 is set to from 3 to 5 mm, for example.

[0007] Note that, when the ceramic body 2 including silicon nitride ceramic is used, $MoSiO_2$, WSi_2 , or the like may be mixed and dispersed into the ceramic body 2. In this case, a coefficient of thermal expansion of the silicon nitride ceramic serving as a base material can be made approximate to a coefficient of thermal expansion of the heating resistor 3, thus enhancing a durability of the heater 1.

[0008] The heating resistor 3 is provided in an interior of the ceramic body 2. The heating resistor 3 is provided on a leading end side (first end side) of the ceramic body 2. The heating resistor 3 is a member that generates heat by the flow of electrical current therethrough. The heating resistor 3 includes linear portions 32 extending in the longitudinal direction of the ceramic body 2, and a fold-back portion 30 connecting the linear portions 32. As the heating resistor 3, a heating resistor containing carbide, nitride, silicide or the like of W, Mo, Ti or the like as a primary component can be used. When the ceramic body 2 includes silicon nitride ceramic, from a viewpoint that a difference in the coefficients of thermal expansion of the heating resistor 3 and the ceramic body 2 is small and from a viewpoint that the heating resistor 3 exhibits high thermal resistance, tungsten carbide (WC) is excellent as the material of the heating resistor 3 among the

materials described above.

[0009] Further, when the ceramic body 2 includes silicon nitride ceramic, the heating resistor 3 may contain WC, which is an inorganic electrically conductive material, as a primary component, and the content of silicon nitride to be added to WC may be 20 mass% or greater. For example, in the ceramic body 2 including silicon nitride ceramic, electrically conductive elements that form the heating resistor 3 have large coefficients of thermal expansion compared to the coefficient of thermal expansion of silicon nitride, and thus the heating resistor 3 is usually in a state where a tensile stress is applied to the heating resistor 3. In contrast, with the addition of silicon nitride into the heating resistor 3, the coefficient of thermal expansion of the heating resistor 3 can be brought close to the coefficient of thermal expansion of the ceramic body 2, and thus stress caused by the difference in coefficients of thermal expansion between a time where a temperature of the heater 1 is elevated and a time where a temperature of the heater 1 is lowered can be alleviated.

[0010] Further, when the content of silicon nitride contained in the heating resistor 3 is 40 mass% or less, a variation of a resistance value of the heating resistor 3 can be reduced. Accordingly, the content of silicon nitride contained in the heating resistor 3 may be from 20 to 40 mass%. Preferably, the content of silicon nitride is from 25 to 35 mass%. Further, as an additive to be added into the heating resistor 3 in the same manner as silicon nitride, from 4 to 12 mass% of boron nitride may be added in place of silicon nitride. A total length of the heating resistor 3 can be set to from 3 to 15 mm, and the cross-sectional area may be set to from 0.15 to 0.8 mm².

[0011] The leads 4 are members for electrically connecting the heating resistor 3 and an external power supply. The leads 4 are connected to the heating resistor 3 and drawn to the front surface of the ceramic body 2. Specifically, the leads 4 are bonded to both end portions of the heating resistor 3, one lead 4 is connected to a first end of the heating resistor 3 on one end and led from a side surface near a rear end of the ceramic body 2 on the other end, and the other lead 4 is connected to a second end of the heating resistor 3 on one end and led from the rear end portion of the ceramic body 2 on the other end.

[0012] The leads 4 are formed using the same material as that of the heating resistor 3, for example. The leads 4 include WC, for example. The leads 4 have a greater cross-sectional area than that of the heating resistor 3, a lower content of the formation materials of the ceramic body 2 than that of the heating resistor 3, and thus a low resistance value per unit length. Further, the leads 4 may contain WC, which is an inorganic electrically conductive material, as a primary component, and the content of silicon nitride to be added to WC may be 15 mass% or greater. Along with the increase in content of silicon nitride, the coefficient of thermal expansion of the leads 4 can be brought close to the coefficient of thermal expansion of the silicon nitride constituting the ceramic body

2. Further, when the content of silicon nitride is 40 mass% or less, a resistance value of the leads 4 decreases and becomes stable. Accordingly, the content of silicon nitride may be from 15 to 40 mass%. Further, the content of silicon nitride may be from 20 to 35 mass%.

[0013] Here, the heater 1 of the present embodiment, as illustrated in FIG. 1, includes the ceramic body 2 having a rod shape, and the heating resistor 3 provided in the interior of the ceramic body 2, with the heating resistor 3 including the fold-back portion 30 and a projection 31 having a wire shape and extending across an entirety of an outer periphery of the fold-back portion 30 in a folding-back direction. The projection 31 projects outward and extends along an entirety of the fold-back portion 30 along the fold-back portion 30. In this way, with the provision of the projection 31 having a wire shape and extending across the entirety of the outer periphery of the fold-back portion 30 of the heating resistor 3 in the folding-back direction, the heat can be readily dispersed from the projection 31 having a wire shape to the ceramic body 2. This makes it possible to reduce the amount of heat momentarily trapped in the heating resistor 3 and thus reduce the thermal stress between the heating resistor 3 and the ceramic body 2. Thus, the possibility of the occurrence of cracks in the heating resistor 3 can be reduced. As a result, a long-term reliability of the heater 1 can be improved.

[0014] Further, as illustrated in FIG. 2, the projection 31 may be positioned on an outermost periphery of the fold-back portion 30. In this way, the heat can be more readily dispersed to the outer peripheral side of the ceramic body 2, making it possible to further reduce the amount of heat momentarily trapped in the heating resistor 3. In the heater 1 illustrated in FIG. 2, the cross-section shape of the fold-back portion 30 is elliptical. The fold-back portion 30 folds back on an imaginary plane. The cross-section shape of the fold-back portion 30 has a major axis in the direction perpendicular to the imaginary plane on which the fold-back portion 30 folds back. The projection 31 is positioned on an extended line of a minor axis of the elliptical shape.

[0015] While the projection 31 has a triangular shape in FIG. 2, the shape is not limited thereto. For the projection 31, various shapes can be used. For example, the shape may be semicircular or semi-elliptical. The length (height) of the projection 31 in the direction of projection can be set to from 5 to 30 μm, for example.

[0016] Further, as illustrated in FIG. 3, a tip of the projection 31 when viewed in a cross section perpendicular to an extending direction of the projection 31 may have a smooth curved shape. In this way, the possibility of the occurrence of cracks in the ceramic body 2 caused by a contact portion that comes into contact with the projection 31 can be reduced.

[0017] Further, as illustrated in FIG. 4, the heating resistor 3 may include the fold-back portion 30 and the linear portions 32 connected to the fold-back portion 30, with the projection 31 extending to the linear portions 32.

In this way, heat can be more readily transmitted from the heating resistor 3 to the ceramic body 2. This makes it possible to further reduce the trapping of heat in the heating resistor 3.

[0018] Further, with the projection 31 continuously formed from the fold-back portion 30 to the linear portions 32, end portions of the projection 31 are positioned on the linear portions 32 and not on the fold-back portion 30. Because the heat tends to become trapped particularly in the fold-back portion 30, the heating resistor 3 including the fold-back portion 30 may be subjected to a large concentration of thermal stress at the end portions of the projection 31 when the end portions of the projection 31 are positioned in the middle of the fold-back portion 30. By positioning the end portions of the projection 31 on the linear portions 32 as illustrated in FIG. 4, it is possible to reduce the possibility of concentration of thermal stress in the end portions of the projection 31.

[0019] Further, as illustrated in FIG. 5, the heating resistor 3 may further include a second projection 33 having a wire shape and extending across an entirety of an inner periphery of the fold-back portion 30 in the folding-back direction. In this way, heat can be more readily transmitted from the heating resistor 3 to the ceramic body 2. For the second projection 33, various shapes can be used. For example, the shape may be semicircular or semi-elliptical. The length (height) of the second projection 33 in the direction of projection can be set to from 5 to 30 μm , for example. Further, a tip of the projection 33 when viewed in a cross section perpendicular to an extending direction of the projection 33 may have a smooth curved shape. In this way, the possibility of the occurrence of cracks in the ceramic body 2 caused by a contact portion that comes into contact with the second projection 33 can be reduced.

[0020] As illustrated in FIG. 6, a glow plug 10 includes the heater 1 described above, and a metal tube 5 having a tubular shape and attached so as to cover a rear end side (second end side) of the heater 1. The glow plug 10 further includes an electrode fitting 6 disposed on an inner side of the metal tube 5 and attached to the rear end of the heater 1. According to the glow plug 10, because the heater 1 described above is used, durability is improved.

[0021] The metal tube 5 is a member for holding the ceramic body 2. The metal tube 5 is a tubular member, and is attached so as to surround the rear end side of the ceramic body 2. That is, the ceramic body 2 having a rod shape is inserted into the inner side of the metal tube 5 having a tubular shape. The metal tube 5 is provided to a side surface on the rear end side of the ceramic body 2, and is electrically connected to the exposed portions of the leads 4. The metal tube 5 includes, for example, stainless steel or iron (Fe) - nickel (Ni) - cobalt (Co) alloy.

[0022] The metal tube 5 and the ceramic body 2 are bonded by a brazing material. The brazing material is provided so as to surround the rear end side of the ceramic body 2, between the metal tube 5 and the ceramic

body 2. With the brazing material provided, the metal tube 5 and the leads 4 are electrically connected.

[0023] As the brazing material, a silver (Ag) - copper (Cu) brazing material, a silver brazing material, or a copper brazing material containing glass components in an amount from 5 to 20 mass% or the like can be used. The glass components have favorable wettability with the ceramic of the ceramic body 2 and a high friction coefficient, making it possible to improve a bonding strength between the brazing material and the ceramic body 2 or a bonding strength between the brazing material and the metal tube 5.

[0024] The electrode fitting 6 is positioned on the inner side of the metal tube 5, and attached to the rear end of the ceramic body 2 so as to be electrically connected to the leads 4. As the electrode fitting 6, various forms may be used. In the example illustrated in FIG. 9, the electrode fitting 6 is configured by connecting a cap portion attached to the rear end of the ceramic body 2 so as to cover the rear end including the leads 4, and a coil-shaped portion electrically connected to an external connecting electrode, by a wire-shaped portion. This electrode fitting 6 is kept separated from an inner peripheral surface of the metal tube 5 so as to not cause a short with the metal tube 5.

[0025] The electrode fitting 6 is a metal wire having a coil-shaped portion provided to alleviate stress in the connection with the external power supply. The electrode fitting 6 is electrically connected to the leads 4, and electrically connected to the external power supply. Voltage is applied between the metal tube 5 and the electrode fitting 6 by the external power supply, making it possible to allow electrical current to flow to the heating resistor 3 via the metal tube 5 and the electrode fitting 6. The electrode fitting 6 includes, for example, nickel or stainless steel. The heater 1 can be formed by, for example, injection molding or the like which uses metal molds having shapes of the heating resistor 3, the leads 4, and the ceramic body 2, respectively, of the configuration described above.

[0026] Further, as illustrated in FIG. 7, the heater 1 may include the ceramic body 2 having a rod shape, and the heating resistor 3 provided in the interior of the ceramic body 3, with the heating resistor 3 including the fold-back portion 30 and a stepped portion 34 having a wire shape and extending across the entirety of the outer periphery of the fold-back portion 30 in the folding-back direction. In this way, with the provision of the stepped portion 34 having a wire shape and extending across the entirety of the outer periphery of the fold-back portion 30 of the heating resistor 3 in the folding-back direction, the heat can be readily dispersed from the stepped portion 34 having a wire shape to the ceramic body 2. This makes it possible to reduce the amount of heat momentarily trapped in the heating resistor 3 and thus reduce the thermal stress between the heating resistor 3 and the ceramic body 2. Thus, the possibility of the generation of cracks in the heating resistor 3 can be reduced. As a result, the

long-term reliability of the heater 1 can be improved.

[0027] Further, as illustrated in FIG. 7, the stepped portion 34 may be positioned on the outermost periphery of the fold-back portion 30. In this way, the heat can be more readily dispersed to the outer peripheral side of the ceramic body 2, making it possible to further reduce the amount of heat momentarily trapped in the heating resistor 3.

[0028] Further, the heating resistor 3 may further include a second stepped portion 35 having a wire shape and extending across the entirety of the inner periphery of the fold-back portion 30 in the folding-back direction. In this way, heat can be more readily transmitted from the heating resistor 3 to the ceramic body 2, making it possible to further reduce the trapping of the heat in the heating resistor 3.

[0029] Further, as illustrated in FIG. 8, the heating resistor 3 may further include a third projection 36 having a wire shape and extending across the inner periphery and the outer periphery. Note that, in FIG. 8, the focus is on the third projection 36 and thus the projection 31 or the stepped portion 34 is omitted. With the third projection 36 provided, heat can be more readily transmitted from the heating resistor 3 to the ceramic body 2.

[0030] In FIG. 8, the third projection 36 extends diagonally in the folding-back direction of the fold-back portion 30. In this way, the heat can be more readily dispersed to the inner peripheral side and the outer peripheral side across a wider range of the ceramic body 2, making it possible to further reduce the amount of heat momentarily trapped in the heating resistor 3 under rapid temperature rise. Note that the third projection 36 may extend diagonally in the folding-back direction, or may extend in a direction perpendicular to the folding-back direction. When extended in a direction perpendicular to the folding-back direction, the third projection 36 may be provided across the entire periphery of the fold-back portion 30. In other words, the third projection 36 may be formed into an annular shape and provided across the entire periphery of the fold-back portion 30.

Reference Signs List

[0031]

- 1 Heater
- 2 Ceramic body
- 3 Heating resistor
- 30 Fold-back portion
- 31 Projection
- 32 Linear portion
- 33 Second projection
- 34 Stepped portion
- 35 Second stepped portion
- 36 Third projection
- 4 Lead
- 5 Metal tube
- 6 Electrode fitting

10 Glow plug

Claims

1. A heater comprising:

a ceramic body having a rod shape; and
a heating resistor provided in an interior of the ceramic body,
wherein
the heating resistor comprises a fold-back portion and a projection having a wire shape and extending across an entirety of an outer periphery of the fold-back portion in a folding-back direction.

2. The heater according to claim 1, wherein the projection is positioned on an outermost periphery of the fold-back portion.

3. The heater according to claim 1 or 2, wherein a tip of the projection when viewed in a cross section perpendicular to an extending direction of the projection has a smooth curved shape.

4. The heater according to any one of claims 1 to 3, wherein the heating resistor comprises the fold-back portion and a linear portion connected to the fold-back portion, and the projection extends to the linear portions.

5. The heater according to any one of claims 1 to 4, wherein the heating resistor further comprises a second projection having a wire shape and extending across an entirety of an inner periphery of the fold-back portion in the folding-back direction.

6. A heater comprising:

a ceramic body having a rod shape; and
a heating resistor provided in an interior of the ceramic body,
wherein
the heating resistor comprises a fold-back portion and a stepped portion having a wire shape and extending across an entirety of an outer periphery of the fold-back portion in a folding-back direction.

7. The heater according to claim 6, wherein the stepped portion is positioned on an outermost periphery of the fold-back portion.

8. The heater according to claim 6 or 7, wherein the heating resistor further comprises a second stepped portion having a wire shape and extending across

an entirety of an inner periphery of the fold-back portion in the folding-back direction.

9. The heater according to any one of claims 1 to 8, wherein the heating resistor further comprises a third projection having a wire shape and extending across an inner periphery and an outer periphery. 5

10. A glow plug comprising: 10
- the heater according to any one of claims 1 to 9 including the heating resistor positioned on a first end side of the ceramic body; and
- a metal tube attached covering a second end side of the ceramic body. 15

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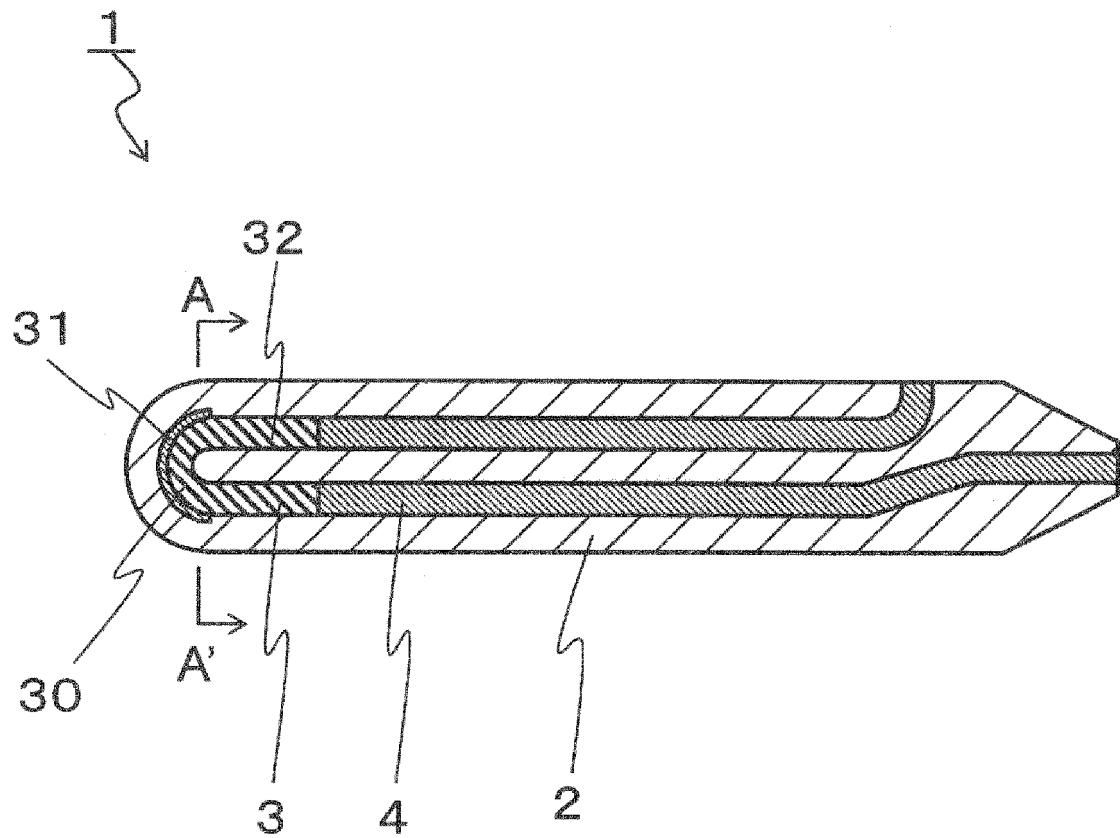


FIG. 1

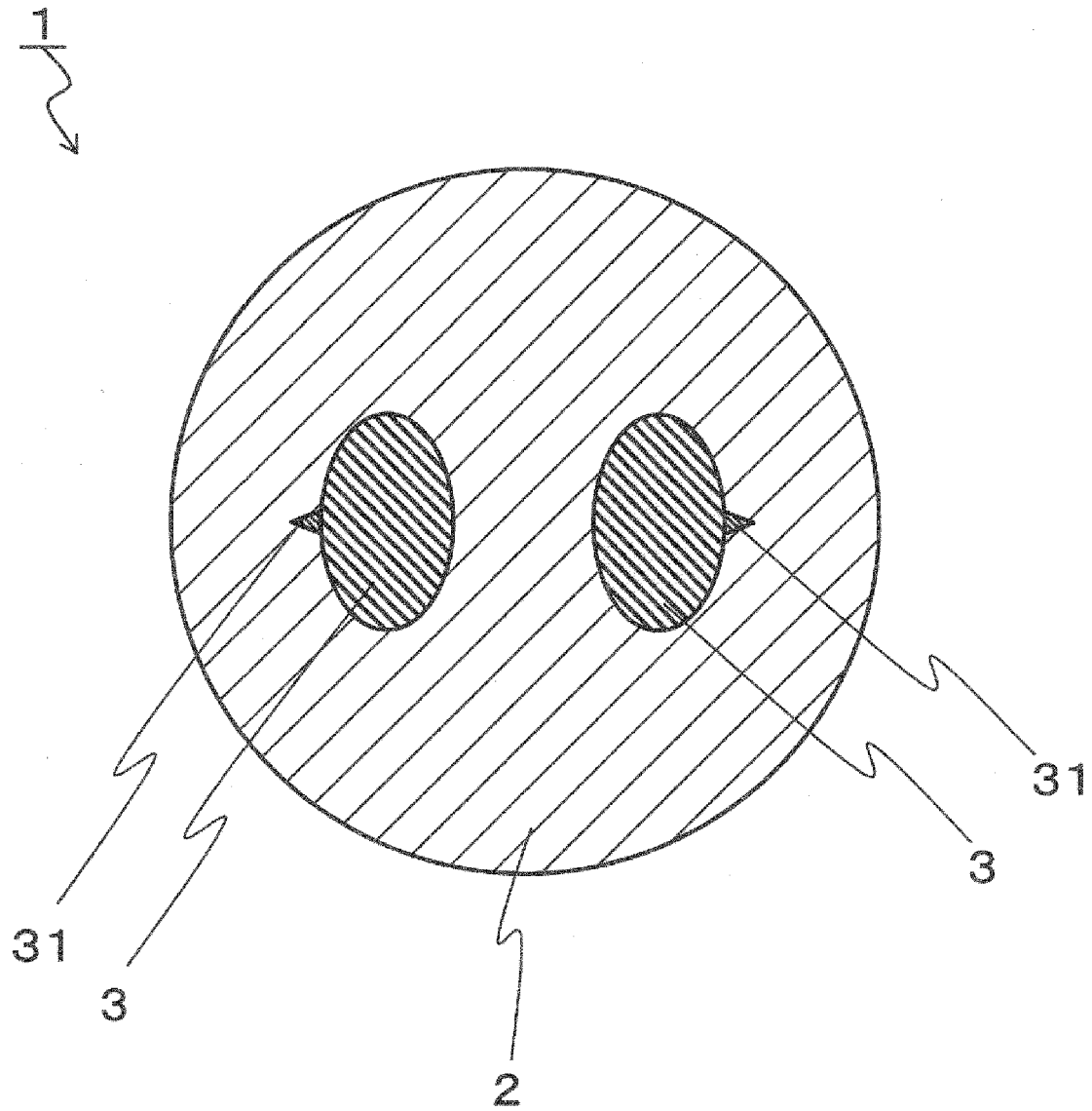


FIG. 2

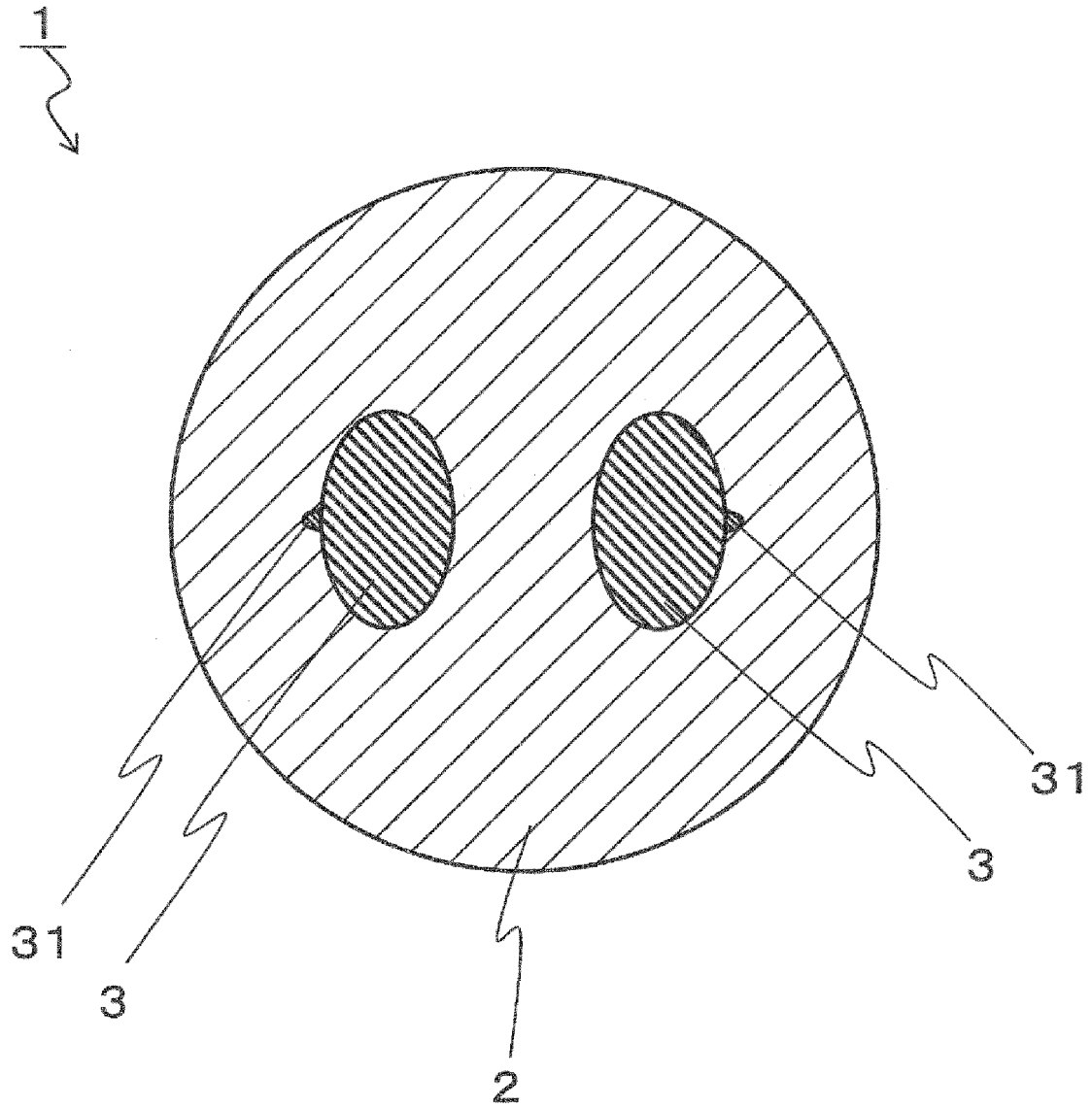


FIG. 3

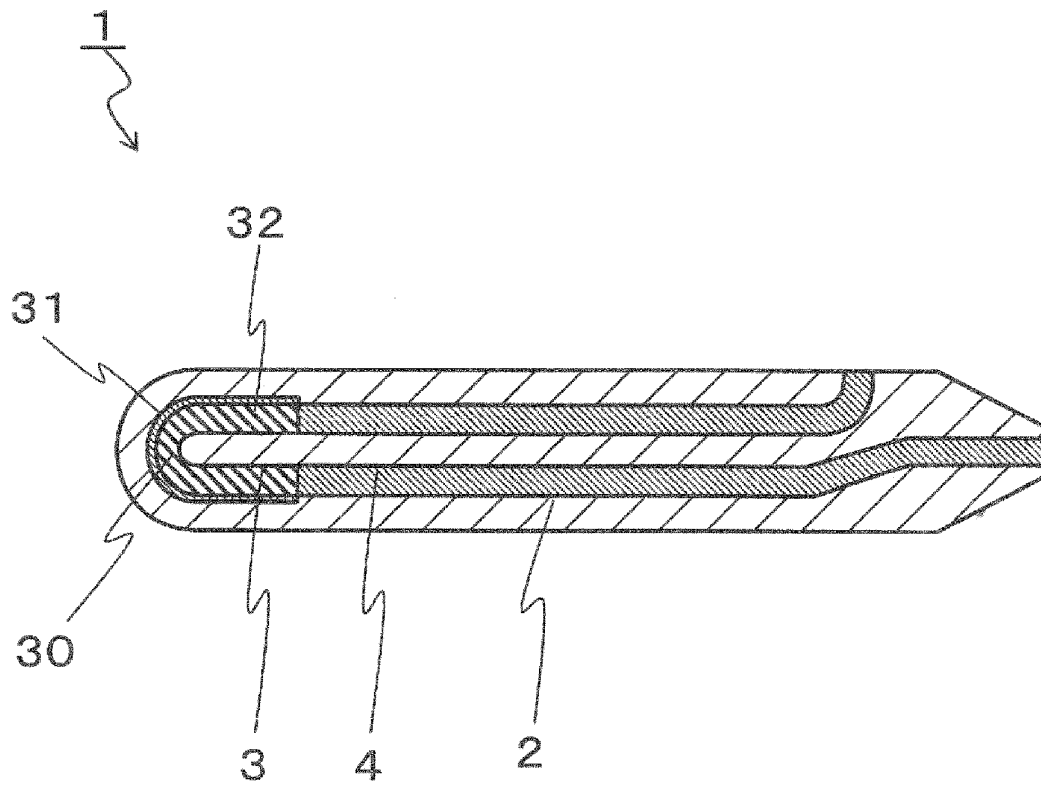


FIG. 4

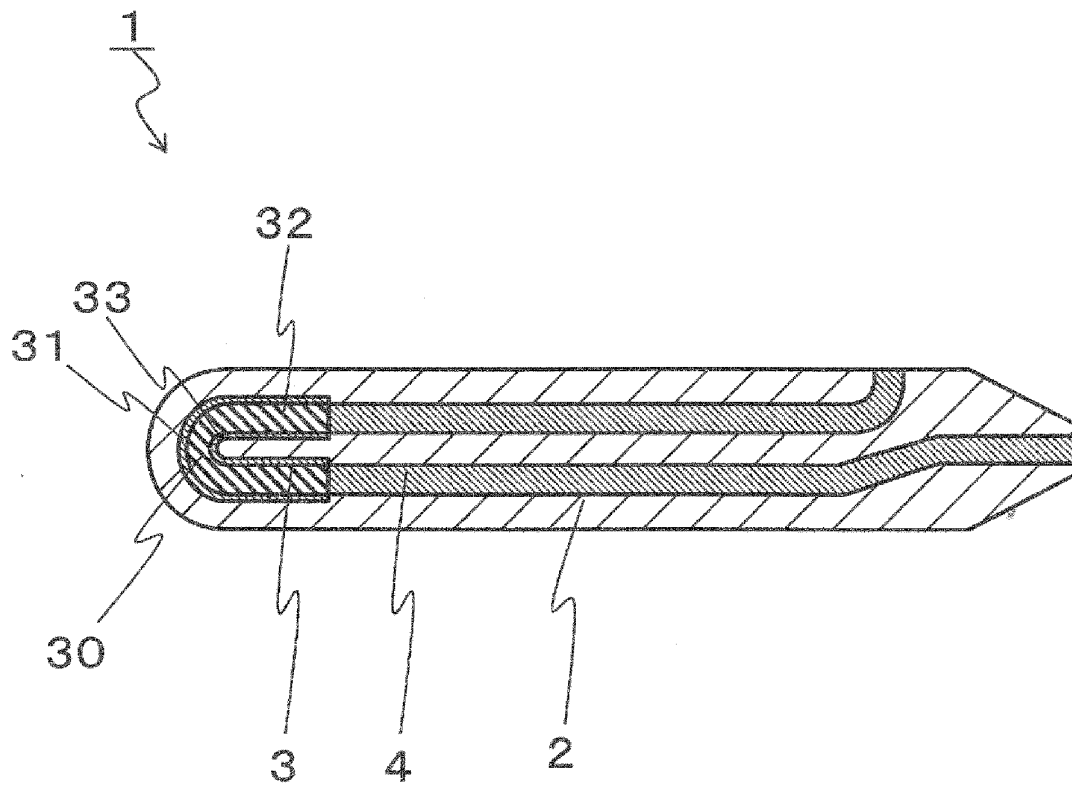


FIG. 5

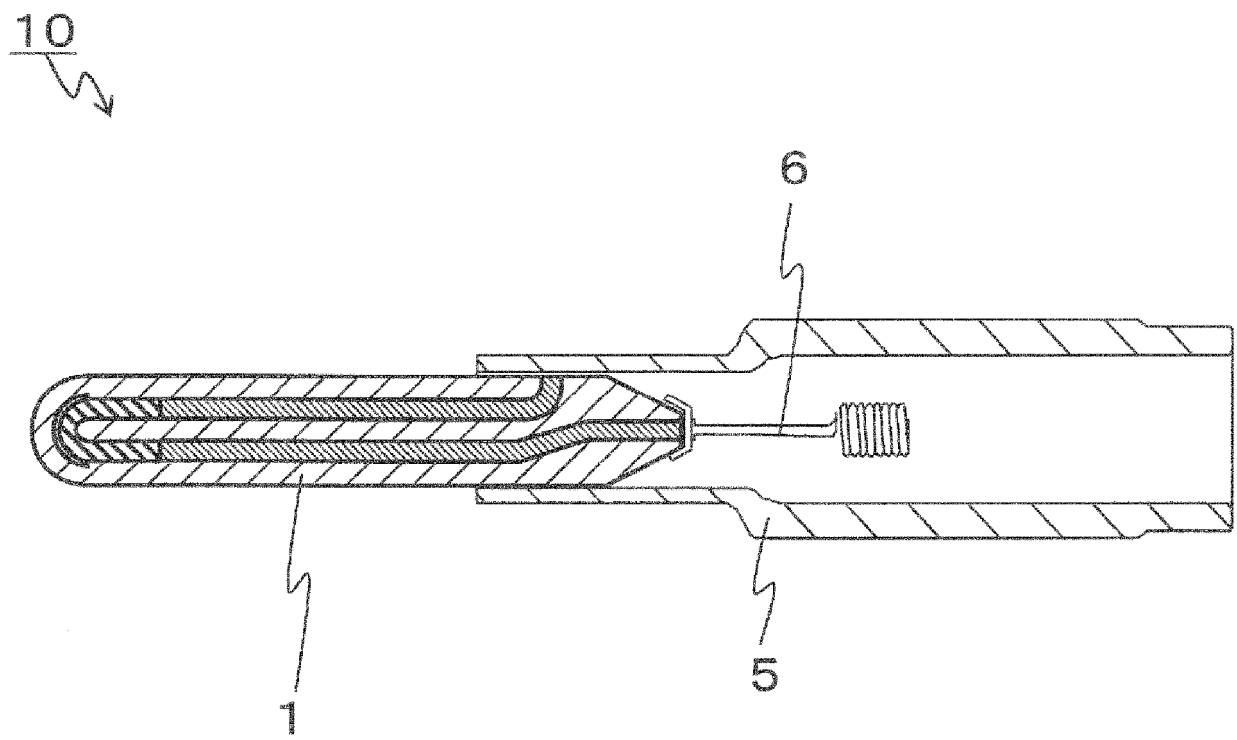


FIG. 6

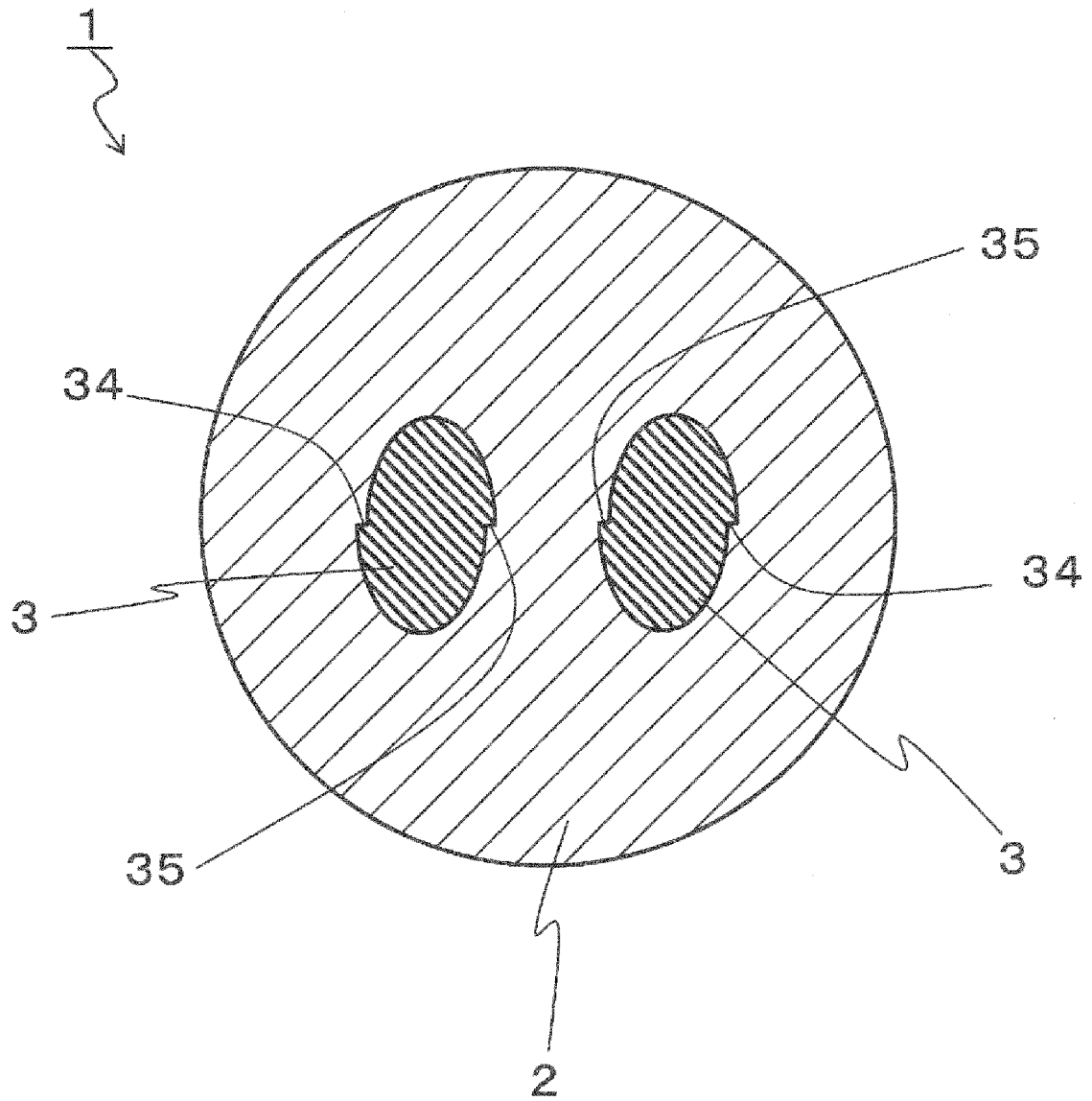


FIG. 7

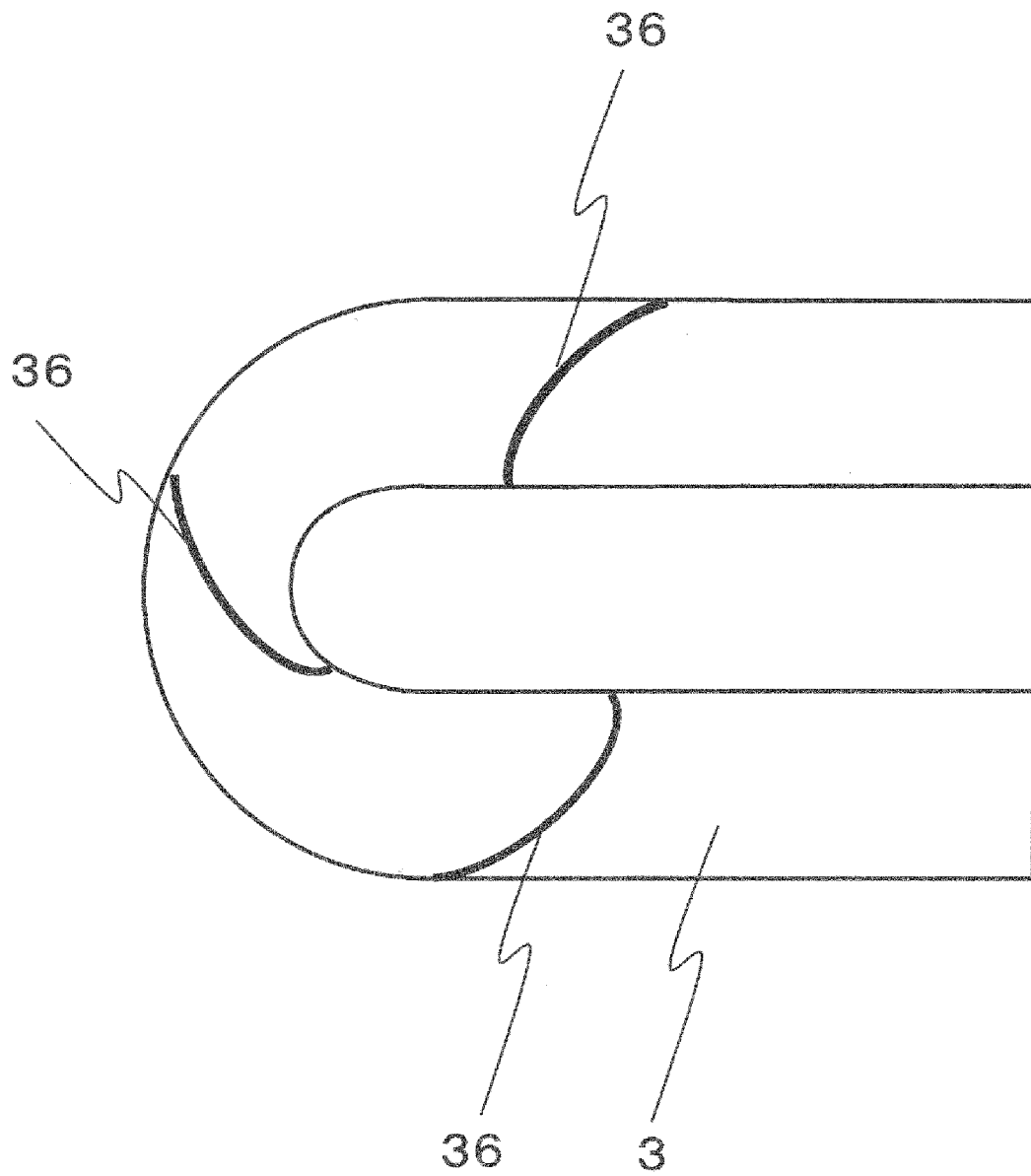


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/016347

A. CLASSIFICATION OF SUBJECT MATTER

H05B3/10(2006.01)i, F23Q7/00(2006.01)i, F23Q7/22(2006.01)i, H05B3/14
(2006.01)i, H05B3/18(2006.01)i, H05B3/48(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)

H05B3/10, F23Q7/00, F23Q7/22, H05B3/14, H05B3/18, H05B3/48

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 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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.
X A	WO 2011/065366 A1 (Kyocera Corp.), 03 June 2011 (03.06.2011), paragraphs [0019], [0022], [0025], [0031] to [0034], [0044] to [0046]; fig. 1 to 4 & JP 5409806 B2	1-4, 6-7, 10 5, 8-9
A	JP 2015-103469 A (NGK Spark Plug Co., Ltd.), 04 June 2015 (04.06.2015), entire text; all drawings (Family: none)	1-10
A	JP 2015-103470 A (NGK Spark Plug Co., Ltd.), 04 June 2015 (04.06.2015), entire text; all drawings (Family: none)	1-10

☒ 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
06 June 2017 (06.06.17)

Date of mailing of the international search report
20 June 2017 (20.06.17)

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/JP2017/016347

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 2010-108606 A (Kyocera Corp.), 13 May 2010 (13.05.2010), entire text; all drawings & US 2011/0253704 A1 entire text; all drawings & WO 2010/050380 A1 & EP 2343951 A1 & CN 102204404 A & KR 10-2011-0075000 A	1-10

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007240080 A [0002]