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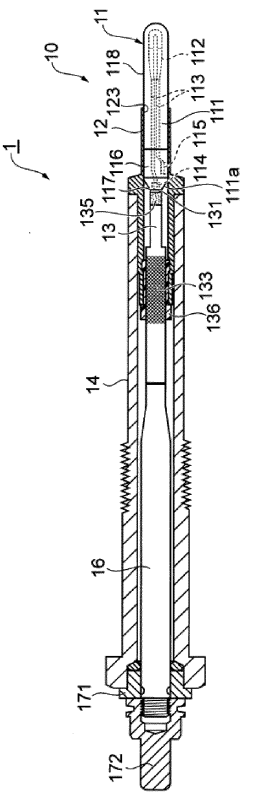
(54) METHOD FOR MANUFACTURING CERAMIC-HEATER-TYPE GLOW PLUG, AND CERAMIC-HEATER-TYPE GLOW PLUG

(57) To simplify a structure and a manufacturing process of a ceramic heater-type glow plug so as to cut manufacturing cost.

A manufacturing method of a ceramic heater-type glow plug (1) including: a ceramic heater (11); and a metallic outer cylinder (12), one end of which holds the ceramic heater and the other end of which is fixed to a housing (14) has: a step of forming a metallized layer (116) on at least a portion of a surface region in the ceramic heater that is held by the outer cylinder (12); a step of press-inserting at least the metallized layer of the ceramic heater in the outer cylinder; and a step of heating the ceramic heater and the outer cylinder at a temperature at which a material for forming the metallized layer becomes a semi-molten state and performing joining by mass transfer between the outer cylinder and a solid layer of the metallized layer.

Fig.1



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Description

Technical Field

[0001] The invention relates to a manufacturing method of a ceramic heater-type glow plug and to a ceramic heater-type glow plug that is used to assist in starting of a diesel engine.

Background Art

[0002] A ceramic heater-type glow plug that is used to assist in starting of a diesel engine has been known. The ceramic heater-type glow plug includes: a ceramic heater that has a heat generating section; and a metallic outer cylinder that holds one end side of the ceramic heater in a state where the heat generating section is projected to the outside. In such a glow plug, one end side of the outer cylinder is inserted in and fixed to a housing as a mounting fixture to a cylinder head of the engine (for example, see PTL 1).

[0003] In addition, manufacturing cost of the glow plug largely depends on length of the ceramic heater. Thus, a glow plug in which the length of the ceramic heater is reduced to cut the manufacturing cost has also been suggested (for example, see PTL 2).

[0004] A holding method of the ceramic heater by the outer cylinder will specifically be described. First, an outer cylinder that is made of stainless steel and has a step at a tip is prepared, and nickel-plated layers are formed on an outer surface and an inner surface of this outer cylinder. Next, a ceramic heater that is formed with a metallized layer on a portion of a surface is inserted and positioned in the outer cylinder, and a brazing material is placed on the step portion in the inner surface of the outer cylinder. Then, these are heated to a temperature at which the brazing material is melted, and the molten brazing material flows between a surface of the ceramic heater and the inner surface of the outer cylinder by using gravity and surface tension. Thereafter, the ceramic heater and the outer cylinder are joined when being cooled, and the ceramic heater is thereby held by the outer cylinder (for example, see PTL 3).

Citation List

Patent Literature

[0005]

[PTL 1] Japanese Patent No. 4,555,508
[PTL 2] Japanese Patent No. 4,172,486
[PTL 3] JP-A-2005-315447

Summary of Invention Technical Problem

[0006] However, in the case where a joining method as described above is used to hold the ceramic heater by the outer cylinder, the step on which the brazing material is placed has to be formed in the outer cylinder, and it takes time and effort to produce the outer cylinder. As a result, even when the length of the ceramic heater is reduced, a structure of the outer cylinder becomes complicated, and it is thus difficult to cut the manufacturing cost.

[0007] In addition, the brazing material for joining the outer cylinder and the ceramic heater is located at a position near the heat generating section of the ceramic heater after joining. Accordingly, a copper component that is contained in the brazing material is oxidized by heat of the ceramic heater, and joining strength between the ceramic heater and the outer cylinder may not sufficiently be held.

[0008] The invention has been made in view of the above problem and therefore has a purpose of providing a manufacturing method of a ceramic heater-type glow plug and a ceramic heater-type glow plug capable of simplifying a structure thereof to cut manufacturing cost and capable of sufficiently holding joining strength between a ceramic heater and an outer cylinder. Solution to Problem

[0009] In order to solve the above problem, the invention is a manufacturing method of a ceramic heater-type glow plug including: a ceramic heater; and a metallic outer cylinder, one end of which holds the ceramic heater and the other end of which is fixed to a housing, characterized by having: a step of forming a metallized layer on at least a portion of a surface region in the ceramic heater that is held by the outer cylinder; a step of press-inserting at least the metallized layer of the ceramic heater in the outer cylinder; and a step of heating the ceramic heater and the outer cylinder at a temperature at which a material for forming the metallized layer becomes a semi-molten state and performing joining by mass transfer between the outer cylinder and a solid layer of the metallized layer.

[0010] As one aspect of the invention, it is preferred to have a step of applying silver plating to a region in the outer cylinder that is joined to the metallized layer before joining the outer cylinder and the ceramic heater.

[0011] As one aspect of the invention, it is preferred to form the metallized layer by using silver paste containing: copper that occupies 30% or lower; and titanium that occupies 10% or lower, with respect to total weight of the metallized layer.

[0012] As one aspect of the invention, it is preferred to form an oxidation resistant layer by a material having an oxidation resistance property on a connection portion in lead wire, which energizes the ceramic heater, to the ceramic heater.

[0013] As one aspect of the invention, it is preferred that the material having the oxidation resistance property is silver or nickel.

[0014] As one aspect of the invention, it is preferred to braze the lead wire, which energizes the ceramic heater, and the ceramic heater at the same time as joining by

the mass transfer between the outer cylinder and the solid layer of the metallized layer.

[0015] As one aspect of the invention, it is preferred to caulk the outer cylinder and fix the lead wire to the outer cylinder after the lead wire and the ceramic heater are brazed.

[0016] As one aspect of the invention, it is preferred to caulk the outer cylinder in a state where the lead wire, which energizes the ceramic heater, is pressed against the ceramic heater, fix the lead wire to the outer cylinder, and connect the lead wire to the ceramic heater.

[0017] As one aspect of the invention, it is preferred to provide a heat resistant resin on a surface of the lead wire that opposes a caulked portion of the outer cylinder.

[0018] As one aspect of the invention, it is preferred to knurl a surface of the lead wire that opposes the caulked portion of the outer cylinder.

[0019] In addition, the invention is a ceramic heater-type glow plug including: a ceramic heater; and a metallic outer cylinder, one end of which holds the ceramic heater and the other end of which is fixed to a housing, characterized in that the ceramic heater has a metallized layer on at least a portion of a surface region that is held by the outer cylinder and that the ceramic heater and the outer cylinder are joined by press-inserting the metallized layer of the ceramic heater in the outer cylinder and heating the ceramic heater and the outer cylinder at a temperature at which a material for forming the metallized layer becomes a semi-molten state, so as to achieve mass transfer between the outer cylinder and a solid layer of the metallized layer.

[0020] As one aspect of the invention, it is preferred to apply silver plating to a region in the outer cylinder that is joined to the metallized layer.

[0021] As one aspect of the invention, it is preferred to form the metallized layer from silver paste containing: copper that occupies 30% or lower; and titanium that occupies 10% or lower, with respect to total weight of the layer.

[0022] As one aspect of the invention, it is preferred to have an oxidation resistant layer by a material having an oxidation resistance property on a connection portion at a tip of lead wire, which energizes the ceramic heater, to the ceramic heater.

[0023] As one aspect of the invention, it is preferred that the material having the oxidation resistance property is silver or nickel.

[0024] As one aspect of the invention, it is preferred to include the lead wire, which energizes the ceramic heater, and fix the lead wire to the outer cylinder by caulking of the outer cylinder.

[0025] As one aspect of the invention, it is preferred to provide a heat resistant resin on a surface of the lead wire that opposes a caulked portion of the outer cylinder.

[0026] As one aspect of the invention, it is preferred to knurl the surface of the lead wire that opposes the caulked portion of the outer cylinder.

Advantageous Effects of Invention

[0027] According to the invention, by simplifying the structure, manufacturing cost can be cut, and joint strength between the ceramic heater and the outer cylinder can sufficiently be held. Brief Description of Drawings

[0028]

[Fig. 1] Fig. 1 is a vertical cross-sectional view of a ceramic heater-type glow plug according to a first embodiment of the invention.

[Fig. 2] Fig. 2 is a vertical cross-sectional view of the ceramic heater-type glow plug in which a portion near a ceramic assembly in Fig. 1 is enlarged.

[Fig. 3] Fig. 3 is a view for explaining a manufacturing method of the ceramic heater-type glow plug according to the first embodiment of the invention.

[Fig. 4] Fig. 4 is a vertical cross-sectional view of a ceramic heater-type glow plug according to a second embodiment of the invention in which a portion near a ceramic assembly in the ceramic heater-type glow plug is enlarged.

[Fig. 5] Fig. 5 is a view for explaining a manufacturing method of the ceramic heater-type glow plug according to the second embodiment of the invention.

[Fig. 6] Fig. 6 is a vertical cross-sectional view of a ceramic heater-type glow plug according to a third embodiment of the invention.

Description of Embodiments

[0029] A description will be made on preferred embodiments of the invention with reference to the drawings. Noted that the embodiments, which will be described below, are merely illustrative and various embodiments can be adopted within the scope of the invention.

[First Embodiment]

[0030] Fig. 1 is a vertical cross-sectional view of a ceramic heater-type glow plug 1 for a diesel engine according to a first embodiment of the invention. Fig. 2 is a vertical cross-sectional view of the ceramic heater-type glow plug in which a portion near a ceramic assembly in Fig. 1 is enlarged. As depicted in Figs. 1, 2, the glow plug 1 includes a ceramic heater assembly 10, a housing 14, a lead rod 16, and the like. Noted that a lateral cross section, which will be used below, means a cross section that is perpendicular to an axis of the ceramic heater-type glow plug 1 in a longitudinal direction. In addition, a vertical cross section, which will be used below, means a cross section that includes the axis of the ceramic heater-type glow plug 1 in the longitudinal direction.

<Configuration of Ceramic Heater-Type Glow Plug>

(Ceramic heater-type assembly)

[0031] The ceramic heater assembly 10 includes a ceramic heater 11, a metallic outer cylinder (sheath) 12, a large-diameter lead section 13, and the like.

[0032] The ceramic heater 11 is a portion that is heated by energization. In the ceramic heater 11, a ceramic heat generating body 112 that is formed in a U shape is embedded in a ceramic insulation substrate 111 that constitutes a main body section thereof. On both end sides of this ceramic heat generating body 112, a positive electrode 114 and a negative electrode 115 are provided via metal leads 113. The negative electrode 115 is exposed on an outer circumferential surface of the ceramic insulating substrate 111, and a negative electrode side metalized section 116 as a metalized layer is formed on the outer circumferential surface of the ceramic insulating substrate 111 that includes the negative electrode 115.

[0033] The negative electrode side metalized section 116 is, for example, formed of silver paste that contains: copper (Cu) of 30% by weight or lower; and titanium (Ti) of 10% by weight or lower, with respect to total weight of the negative electrode side metalized section 116.

[0034] In the ceramic heater 11, at least the negative electrode side metalized section 116 is joined to an inner surface on one end side of the outer cylinder 12, and the negative electrode 115 is electrically connected to the outer cylinder 12. That is, the outer cylinder 12 is formed of a metal material having electrical conductivity. The outer cylinder 12 is formed such that an inner diameter thereof is in size to allow press-insertion of the ceramic heater 11, and is also formed such that a large clearance is hardly formed between an inner circumferential surface 123 of the outer cylinder 12 and an outer circumferential surface 118 of the ceramic heater 11 when the ceramic heater 11 is press-inserted in the outer cylinder 12.

[0035] More specifically, the ceramic heater 11 and the outer cylinder 12 are joined by heating the ceramic heater 11 and the outer cylinder 12 at a temperature at which a material for forming the negative electrode side metalized section 116 becomes a semi-molten state in a state where the negative electrode side metalized section 116 of the ceramic heater 11 is press-inserted in and fixed to the outer cylinder 12, so as to achieve mass transfer between the outer cylinder 12 and a solid layer of the negative electrode side metalized section 116.

[0036] On a rear end side that is opposite from a tip side on which the ceramic heat generating body 112 is embedded, the positive electrode 114 is exposed on an outer surface of the ceramic insulating substrate 111. A positive electrode side metalized section 117 is formed in a rear end surface of the ceramic insulating substrate 111 that includes the positive electrode 114. This positive electrode side metalized section 117 is joined to a tip surface 131 of the large-diameter lead section 13 by brazing or the like, and the positive electrode 114 and the large-diameter lead section 13 are electrically connected.

[0037] Here, a chamfered section 111a is formed in the rear end surface of the ceramic insulating substrate 111. In this way, a distance between the ceramic insulating substrate 111 and the outer cylinder 12 can be increased around a joined section between the ceramic insulating substrate 111 and the large-diameter lead section 13. Accordingly, in the case of brazing, an insulating property between a brazing material and the outer cylinder 12 can be enhanced. Thus, a chance of insulation breakdown can be reduced.

[0038] During an actuation of the glow plug 1, a large current (for example, 4 to 30 amperes) that causes generation of a high temperature flows through the large-diameter lead section 13. Accordingly, in the case where a diameter of the large-diameter lead section 13 is excessively small, such as being less than 1 mm, in combination with self-generating heat, the large-diameter lead section 13 is possibly oxidized in a short time. Thus, the large-diameter lead section 13 is, for example, formed as a lead rod (lead wire for energization of the ceramic heater) whose lateral cross-sectional area is 20% or larger of a lateral cross-sectional area of the ceramic insulation substrate 111 and which has a relatively large diameter.

[0039] On the contrary, in the case where the diameter of the large-diameter lead section 13 is excessively large, a sufficient distance cannot be secured between the large-diameter lead section 13 and the outer cylinder 12, which possibly leads to the insulation breakdown. Thus, the lateral cross-sectional area of the large-diameter lead section 13 is preferably 40% or smaller of the lateral cross-sectional area of the ceramic insulating substrate 111, for example. In addition, the large-diameter lead section 13 is preferably at least twice as long as the diameter of the large-diameter lead section 13.

[0040] The large-diameter lead section 13 is formed of a material that has lower rigidity and higher electrical conductivity than the lead rod 16 (the lead wire for energization of the ceramic heater) that functions an external connection terminal. As such a material, copper (Cu), aluminum (Al), or alloys of those can be raised, for example. Alternatively, an iron alloy or cast iron having low rigidity and high electrical conductivity can also be used.

[0041] A tip that includes the tip surface 131 of the large-diameter lead section 13 is coated with the silver paste as an oxidization resistant layer 135 so as to improve an oxidation resistance property. Noted that the oxidization resistant layer 135 is not limited to the silver paste but a material having the oxidation resistance property, such as nickel, may be baked thereon. In addition, the large-diameter lead section 13 may be nickel (Ni) plated or the like in order to improve a heat resistance property.

[0042] A whole circumference of a surface at a central portion of the large-diameter lead section 13 in the axial direction is knurled, and a heat resistant resin 136 is filled

between this knurled section 133 and the outer cylinder 12. Here, as the heat resistant resin 136, a polyphenylene sulfide (PPS) resin, a polyether ether ketone (PEEK) resin, or the like is preferably used.

[0043] The heat resistant resin 136 is caulked with the outer cylinder 12, and the diameter of a caulked portion of the outer cylinder 12 is reduced when compared to rest thereof. Due to caulking of the outer cylinder 12, the outer cylinder 12 and the heat resistant resin 136 are pressed against the knurled section 133 of the large-diameter lead section 13. Thus, the large-diameter lead section 13 can be fixed to the outer cylinder 12. That is, a surface of the large-diameter lead section 13 that opposes the caulked portion of the outer cylinder 12 is formed with the knurled section 133 and provided with the heat resistant resin 136.

(Housing)

[0044] The housing 14 is a mounting fixture to a cylinder head of the engine, which is not depicted, and houses the outer cylinder 12 and the large-diameter lead section 13. The housing 14 is formed in a cylindrical shape, for example, and the ceramic heater assembly 10 that is configured as described above is fixed thereto by brazing or the like. In an example of Fig. 1, the other end side of the outer cylinder 12 is fixed to the inside of the housing 14 by brazing or the like. However, as another mode, the outer cylinder 12 is fixed to the inside of a metal pipe or the like (not depicted) by brazing or the like, the metal pipe and a member that constitutes a housing body are welded, and the integrated housing 14 can thereby be formed.

(Lead rod)

[0045] The lead rod 16 is housed in the housing 14 and is joined to a rear end of the large-diameter lead section 13 by welding.

[0046] The lead rod 16 is held by an insulator 171 on a rear end side of the housing 14, and a rear end thereof is exposed to the outside of the housing 14 and is connected to a round pin 172.

[0047] That is, the tip side of the lead rod 16 is held by and fixed to the outer cylinder 12 via the large-diameter lead section 13 by caulking, and the rear end side thereof is held by and fixed to the insulator 171.

<Manufacturing Method>

[0048] Based on Fig. 3, a manufacturing method of the glow plug 1 for the diesel engine will be described.

[0049] Fig. 3 is a view for explaining the manufacturing method of the ceramic heater-type glow plug according to the embodiment of the invention.

[0050] First, the ceramic heater 11 and the outer cylinder 12 are prepared. Here, the negative electrode side metalized section 116 is formed on the outer circumferential surface near one end (a rear end side after assembly) of the ceramic heater 11.

[0051] Next, as depicted in Fig. 3(a), the ceramic heater 11 is press-inserted in an inner hole 121 of the outer cylinder 12. During the press-insertion, as depicted in Fig. 3(b), the ceramic heater 11 is press-inserted in the outer cylinder 12 to a position where at least an entire region of the negative electrode side metalized section 116, which is formed in the ceramic heater 11, is housed in the outer cylinder 12.

[0052] Next, as depicted in Fig. 3(b), the tip surface 131 of the large-diameter lead section 13 that is knurled is placed on the positive electrode side metalized section 117 of the ceramic heater 11. At this time, a brazing material 175 is placed between the positive electrode side metalized section 117 and the large-diameter lead section 13. In addition, the heat resistant resin 136 is filled between the knurled section 133 of the large-diameter lead section 13 and the inner circumferential surface of the outer cylinder 12.

[0053] Thereafter, in a state where the outer cylinder 12, the ceramic heater 11, and the large-diameter lead section 13 are temporarily assembled, this assembly is heated to 800 to 900°C under a vacuum environment or an environment of inert gas. Here, the temperature of 800 to 900°C is a temperature at which the silver paste for forming the negative electrode side metalized section 116 becomes the semi-molten state. Accordingly, the negative electrode side metalized section 116 becomes the semi-molten state by heating, and joining is performed by the mass transfer between the inner circumferential surface of the outer cylinder 12 and the solid layer of the negative electrode side metalized section 116. In this way, the outer cylinder 12 and the ceramic heater 11 are joined. At the same time as this joining, the ceramic heater 11 and the large-diameter lead section 13 are brazed by the brazing material 175.

[0054] Next, as depicted in Fig. 3(c), the outer cylinder 12 is caulked, and the large-diameter lead section 13 is fixed to the outer cylinder 12. In addition, the lead rod 16 and the large-diameter lead section 13 are joined by welding (for example, spot welding) and are fixed.

[0055] Noted that a fixing method of the large-diameter lead section 13 to the outer cylinder 12 and connecting the large-diameter lead section 13 and the ceramic heater 11 by caulking the outer cylinder 12 in a state where the end of the large-diameter lead section 13 is pressed against the end of the ceramic heater 11 with a specified magnitude of a force may be used.

[0056] Next, as depicted in Fig. 3(d), the housing 14 is lowered until a tip surface 141 of the housing 14 abuts against a rear end surface 125 of a projected section 124 of the outer cylinder 12. In such an abutment state, the tip surface 141 of the housing 14 and the rear end surface 125 of the projected section 124 of the outer cylinder 12 are welded. Noted that the housing 14 and the outer cylinder 12 may be fixed by brazing an inner circumferential surface of the housing 14 and an outer circumferential

surface of the outer cylinder 12.

[0057] Finally, as depicted in Fig. 3(e), a rear end of an inner hole 143 of the housing 14 is sealed by the insulator 171, and the round pin 172 is connected to the rear end of the lead rod 16. At this time, an O-ring 177 is provided between the insulator 171 and the housing 14.

[0058] According to the above configuration, at least the negative electrode side metalized section 116 of the ceramic heater 11 is press-inserted in the outer cylinder 12, and the ceramic heater 11 and the outer cylinder 12 are heated at the temperature, at which the silver paste for forming the negative electrode side metalized section 116 becomes the semi-molten state, so as to be joined by the mass transfer between the outer cylinder 12 and the solid layer of the negative electrode side metalized section 116. Accordingly, there is no need to place the brazing material on the inside of the outer cylinder 12 when the outer cylinder 12 and the ceramic heater 11 are joined. In this way, there is no need to form a step on which the brazing material is placed on the inside of the outer cylinder 12, either. Thus, a configuration of the outer cylinder 12 can be simplified. In addition, when the ceramic heater 11 and the outer cylinder 12 are joined by using the brazing material that is placed on the inside of the outer cylinder 12, plated layers need to be formed on an outer surface and the inner surface of the outer cylinder 12 in order to improve wettability of the molten brazing material. However, formation of such plated layers is no longer needed. Thus, a process for forming the plated layers can be omitted, and a manufacturing process can be simplified.

[0059] Therefore, a structure and a manufacturing process of the ceramic heater-type glow plug 1 can be simplified, and manufacturing cost thereof can thereby be cut.

[0060] The outer cylinder 12 can be fixed to the large-diameter lead section 13 by caulking the outer cylinder 12. Thus, there is no need to fix the large-diameter lead section 13 by filling a filler between the large-diameter lead section 13 and the outer cylinder 12, or the like. In addition, because the large-diameter lead section 13 can be fixed to the outer cylinder 12 by a single task of caulking, this process can easily be performed in a short time.

[0061] Because the positive electrode side metalized section 117 of the ceramic heater 11 is connected to the lead rod 16 by using the large-diameter lead section 13, resistance of the large-diameter lead section 13 can be reduced, and a configuration thereof can be simplified. In addition, even in the case where the large current that causes the generation of the high temperature flows, the self-generating heat can be suppressed, and a temperature of the large-diameter lead section 13 can thereby be prevented from reaching an upper temperature limit thereof or higher. Thus, degradation of the large-diameter lead section 13 that is caused by oxidation can be prevented for a long time period. Furthermore, by using the large-diameter lead section 13, modes of the other components can also be simplified, and thus the manufacturing process can also be simplified.

[0062] The large-diameter lead section 13 is likely to be deflected by reducing rigidity of the large-diameter lead section 13 to be lower than that of the lead rod 16. In this way, stress concentration on a joined section between the large-diameter lead section 13 and the positive electrode side metalized section 117 of the ceramic heater 11can be alleviated. More specifically, even in the case where bending stress is generated in the joined section due to vibrations during driving of the engine or due to stress that is applied to a periphery of each of joined sections during the assembly of the glow plug 1, the large-diameter lead section 13 is deflected, and concentration of the bending stress on the joined section can thereby be avoided.

[0063] Because the large-diameter lead section 13 is made of copper, the copper alloy, aluminum, the aluminum alloy, or cast iron, the large-diameter lead section 13 having the relatively low rigidity and the high electrical conductivity can be formed. By increasing the electrical conductivity, an effect of suppressing the self-generating heat, which is realized by increasing the diameter of the lead wire, can further be enhanced.

[0064] When the diameter of the large-diameter lead section 13 is set as 1.0, axial length of the large-diameter lead section 13 is set to have a value of 2.0 or larger. In this way, the large-diameter lead section 13 can sufficiently be deflected. Accordingly, even in the case where the bending stress is generated in the joined section due to the vibrations during driving of the engine or due to the stress that is applied to the periphery of each of the joined sections during the assembly of the glow plug 1, the large-diameter lead section 13 is deflected, and the concentration of the bending stress on the joined section can thereby be avoided.

[0065] When a lateral cross-sectional area of the ceramic heater 11 is set as 1.0, the lateral cross-sectional area of the large-diameter lead section 13 is set to have a value within a range from 0.2 to 0.4. In this way, joint strength of a joined section between the large-diameter lead section 13 and the positive electrode side metalized section 117 can be enhanced. Accordingly, it is possible to obtain the joint strength capable of enduring vibrations that are generated in the case where the glow plug 1 is fixed to the engine of the vehicle or the like for use, stress applied thereto during manufacturing, and the like. Furthermore, an electrical insulation property between the large-diameter lead section 13 and the outer cylinder 12 can be secured.

[0066] The heat resistance property of the large-diameter lead section 13 can further be enhanced by applying the nickel (Ni) plating or the like to the large-diameter lead section 13. In addition, heat that is transferred from the ceramic heater 11 can efficiently be transferred to the lead rod 16 by further increasing thermal conductivity of the large-diameter lead section 13. In this way, the heat resistance property of the large-diameter lead section 13 can further be enhanced.

[0067] Furthermore, durability (especially, the oxidation resistance property) of the large-diameter lead section 13 can be improved by coating the large-diameter lead section 13 with silver (Ag).

[0068] Moreover, the large-diameter lead section 13 is provided with the silver paste as the oxidization resistant layer 135. In this way, the tip of the large-diameter lead section 13 becomes flexible, and a contact area thereof with the positive electrode side metalized section 117 is increased. As a result, contact resistance can be reduced.

[Second Embodiment]

[0069] Fig. 4 is a vertical cross-sectional view of a ceramic heater-type glow plug according to a second embodiment of the invention in which a portion near a ceramic assembly in the ceramic heater-type glow plug is enlarged. Fig. 5 is a view for explaining a manufacturing method of the ceramic heater-type glow plug according to the second embodiment of the invention. Noted that, in Fig. 4 and Fig. 5, the same configuration as that of the first embodiment is denoted by the same reference numerals and the description thereon will not be repeated.

[0070] In the second embodiment, silver-plated layers 122 are formed on the inner circumferential surface and the outer circumferential surface at the tip of the outer cylinder 12, in which the ceramic heater 11 is inserted. Here, the silver-plated layer 122 only needs to be formed in a region that opposes the negative electrode side metalized section 116 when at least the ceramic heater 11 is inserted in the outer cylinder 12.

[0071] Based on Fig. 5, the manufacturing method of a glow plug 2 for the diesel engine will be described.

[0072] Fig. 5 is the view for explaining the manufacturing method of the ceramic heater-type glow plug according to the embodiment of the invention.

[0073] First, the ceramic heater 11 and the outer cylinder 12 are prepared. Here, the negative electrode side metalized section 116 is formed on the outer circumferential surface near the one end (the rear end side after the assembly) of the ceramic heater 11. In addition, the silver-plated layers 122 are formed across the inner circumferential surface and the outer circumferential surface of the outer cylinder 12 that include a joined surface to the negative electrode side metalized section 116.

[0074] Next, as depicted in Fig. 5(a), the ceramic heater 11 is press-inserted in the inner hole 121 of the outer cylinder 12. During the press-insertion, as depicted in Fig. 5(b), the ceramic heater 11 is press-inserted in the outer cylinder 12 to a position where at least the entire region of the negative electrode side metalized section 116, which is formed in the ceramic heater 11, is housed in the outer cylinder 12 and where the negative electrode side metalized section 116 opposes the silver-plated layer 122 of the outer cylinder 12.

[0075] Next, as depicted in Fig. 5(b), the tip surface 131 of the large-diameter lead section 13 that has been knurled is placed on the positive electrode side metalized section 117 of the ceramic heater 11. At the time, the brazing material 175 is placed between the positive electrode side metalized section 117 and the large-diameter lead section 13. In addition, the heat resistant resin 136 is filled between the knurled section 133 of the large-diameter lead section 13 and the inner circumferential surface of the outer cylinder 12.

[0076] Thereafter, in the state where the outer cylinder 12, the ceramic heater 11, and the large-diameter lead section 13 are temporarily assembled, this assembly is heated to 800 to 900°C under the vacuum environment or the environment of the inert gas. Here, the temperature of 800 to 900°C is the temperature at which the silver paste for forming the negative electrode side metalized section 116 becomes the semi-molten state. Accordingly, the negative electrode side metalized section 116 becomes the semi-molten state by heating, and joining is performed by the mass transfer between the silver-plated layer 122 that is formed on the inner circumferential surface of the outer cylinder 12 and the solid layer of the negative electrode side metalized section 116. In this way, the outer cylinder 12 and the ceramic heater 11 are joined. At the same time as this joining, the ceramic heater 11 and the large-diameter lead section 13 are brazed by the brazing material 175.

[0077] Next, as depicted in Fig. 5(c), the large-diameter lead section 13 is fixed to the outer cylinder 12 by caulking the outer cylinder 12. In addition, the lead rod 16 and the large-diameter lead section 13 are joined by welding (for example, spot welding) and are fixed.

[0078] Next, as depicted in Fig. 5(d), the housing 14 is lowered until the tip surface 141 of the housing 14 abuts against the rear end surface 125 of the projected section 124 of the outer cylinder 12. In such an abutment state, the tip surface 141 of the housing 14 and the rear end surface 125 of the projected section 124 of the outer cylinder 12 are welded. Noted that the housing 14 and the outer cylinder 12 may be fixed by brazing the inner circumferential surface of the housing 14 and the outer circumferential surface of the outer cylinder 12.

[0079] Finally, as depicted in Fig. 5(e), the rear end of the inner hole 143 of the housing 14 is sealed by the insulator 171, and the round pin 172 is connected to the rear end of the lead rod 16. At this time, the O-ring 177 is provided between the insulator 171 and the housing 14.

[0080] In such a configuration, similar to the first embodiment, there is no need to place the brazing material on the inside of the outer cylinder 12 when the outer cylinder 12 and the ceramic heater 11 are joined. In this way, there is no need to form the step on which the brazing material is placed on the inside of the outer cylinder 12, either. Thus, the configuration of the outer cylinder 12 can be simplified. Therefore, the structure and the manufacturing process of the ceramic heater-type glow plug 1 can be simplified, and the manufacturing cost thereof can thereby be cut.

[0081] In addition, instead of the brazing material for

joining the outer cylinder 12 and the ceramic heater 11, the silver-plated layer 122 is formed on the inner circumferential surface of the outer cylinder 12, and the ceramic heater 11 is press-inserted. Accordingly, the copper component that is contained in the brazing material is not oxidized by heat generation of the ceramic heater 11, and the joint strength between the ceramic heater 11 and the outer cylinder 12 can sufficiently be held. Furthermore, cost of the silver-plated layer 122 is lower than that of the conventional nickel-plated layer and that of the brazing material. Therefore, the manufacturing cost can be cut.

[Third Embodiment]

[0082] Fig. 6 is a vertical cross-sectional view of a ceramic heater-type glow plug for a diesel engine according to a third embodiment of the invention. Noted that, in Fig. 6, the same configuration as that of the first embodiment is denoted by the same reference numerals and the description thereon will not be repeated.

[0083] In the third embodiment, fixation of the large-diameter lead section 13 in the housing 14 is configured as depicted in Fig. 6.

[0084] In a glow plug for a diesel engine 3, instead of fixing the large-diameter lead section 13 to the outer cylinder 12, the lead rod 16 is fixed to the inner surface of the housing 14, and the large-diameter lead section 13 that is joined to the lead rod 16 is also fixed to the inside of the housing 14.

[0085] More specifically, the lead rod 16 is housed in the housing 14 and is fixed by a filler 173 and a seal ring 174, the filler 173 being made of a resin, a low melting point glass, or the like that is filled between the lead rod 16 and the housing 14.

[0086] In such a configuration, while the filler 173 and the seal ring 174 need to be provided, there is no need to caulk the outer cylinder 12. Thus, there is no need to fill the heat resistant resin 136 between the outer cylinder 12 and the large-diameter lead section 13. In addition, there is no need to form the knurled section 133 in the large-diameter lead section 13.

[0087] The glow plug that has been described so far merely illustrates one aspect of the invention and thus does not limit this invention. Each of the embodiments can arbitrarily be changed within the scope of the invention.

Claims

1. A manufacturing method of a ceramic heater-type glow plug including: a ceramic heater; and a metallic outer cylinder, one end of which holds the ceramic heater and the other end of which is fixed to a housing, the manufacturing method of the ceramic heater-type glow plug **characterized by** comprising:
   a step of forming a metallized layer on at least a portion of a surface region in the ceramic heater that is held by the outer cylinder;
   a step of press-inserting at least the metallized layer of the ceramic heater in the outer cylinder; and
   a step of heating the ceramic heater and the outer cylinder at a temperature at which a material for forming the metallized layer becomes a semi-molten state and performing joining by mass transfer between the outer cylinder and a solid layer of the metallized layer.

2. The manufacturing method of the ceramic heater-type glow plug according to claim 1 **characterized by** comprising
   a step of applying silver plating to a region in the outer cylinder that is joined to the metallized layer before joining the outer cylinder and the ceramic heater.

3. The manufacturing method of the ceramic heater-type glow plug according to claim 1 or 2 **characterized by**
   forming the metallized layer by using silver paste containing: copper that occupies 30% or lower; and titanium that occupies 10% or lower, with respect to total weight of the metallized layer.

4. The manufacturing method of the ceramic heater-type glow plug according to any one of claims 1 to 3 **characterized by**
   forming an oxidation resistant layer by a material having an oxidation resistance property on a connection portion in lead wire, which energizes the ceramic heater, to the ceramic heater.

5. The manufacturing method of the ceramic heater-type glow plug according to claim 4 **characterized in that**
   the material having the oxidation resistance property is silver or nickel.

6. The manufacturing method of the ceramic heater-type glow plug according to any one of claims 1 to 5 **characterized by**
   brazing the lead wire, which energizes the ceramic heater, and the ceramic heater at the same time as joining by the mass transfer between the outer cylinder and the solid layer of the metallized layer.

7. The manufacturing method of the ceramic heater-type glow plug according to claim 6 **characterized by**
   caulking the outer cylinder and fixing the lead wire to the outer cylinder after brazing the lead wire and the ceramic heater.

8. The manufacturing method of the ceramic heater-type glow plug according to any one of claims 1 to 5 **characterized by**
caulking the outer cylinder in a state where the lead wire, which energizes the ceramic heater, is pressed against the ceramic heater, fixing the lead wire to the outer cylinder, and connecting the lead wire to the ceramic heater.

9. The manufacturing method of the ceramic heater-type glow plug according to claim 7 or 8 **characterized by**
providing a heat resistant resin on a surface of the lead wire that opposes a caulked portion of the outer cylinder.

10. The manufacturing method of the ceramic heater-type glow plug according to any one of claims 7 to 9 **characterized by**
knurling the surface of the lead wire that opposes the caulked portion of the outer cylinder.

11. A ceramic heater-type glow plug including: a ceramic heater; and a metallic outer cylinder, one end of which holds the ceramic heater and the other end of which is fixed to a housing, the ceramic heater-type glow plug **characterized in that**
the ceramic heater has a metallized layer on at least a portion of a surface region that is held by the outer cylinder,
and
the ceramic heater and the outer cylinder are joined by press-inserting the metallized layer of the ceramic heater in the outer cylinder and heating the ceramic heater and the outer cylinder at a temperature at which a material for forming the metallized layer becomes a semi-molten state, so as to achieve mass transfer between the outer cylinder and a solid layer of the metallized layer.

12. The ceramic heater-type glow plug according to claim 11 **characterized in that**
silver plating is applied to a region in the outer cylinder that is joined to the metallized layer.

13. The ceramic heater-type glow plug according to claim 11 or 12 **characterized in that**
the metallized layer is formed of silver paste containing: copper that occupies 30% or lower; and titanium that occupies 10% or lower, with respect to total weight of the layer.

14. The ceramic heater-type glow plug according to any one of claims 11 to 13 **characterized in that**
an oxidation resistant layer by a material having an oxidation resistance property is provided on a connection portion at a tip of lead wire, which energizes the ceramic heater, to the ceramic heater.

15. The ceramic heater-type glow plug according to claim 14 **characterized in that**
the material having the oxidation resistance property is silver or nickel.

16. The ceramic heater-type glow plug according to any one of claims 11 to 15 **characterized in that**
the lead wire, which energizes the ceramic heater, is provided, and
the lead wire is fixed to the outer cylinder by caulking of the outer cylinder.

17. The ceramic heater-type glow plug according to claim 16 **characterized in that**
a heat resistant resin is provided on a surface of the lead wire that opposes a caulked portion of the outer cylinder.

18. The ceramic heater-type glow plug according to claim 16 or 17 **characterized in that**
a surface of the lead wire that opposes the caulked portion of the outer cylinder is knurled.

Fig.1

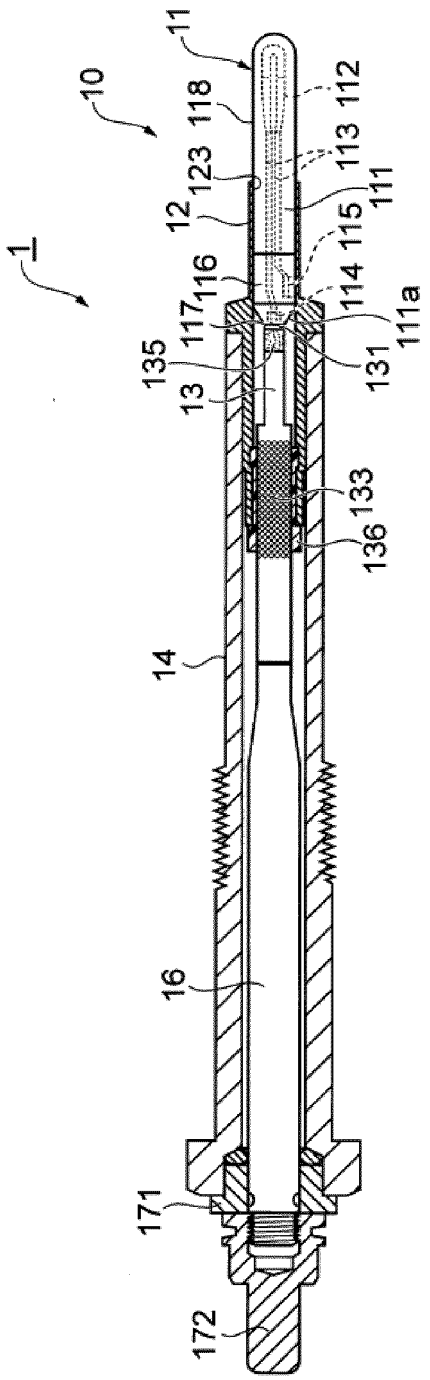
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Fig.2

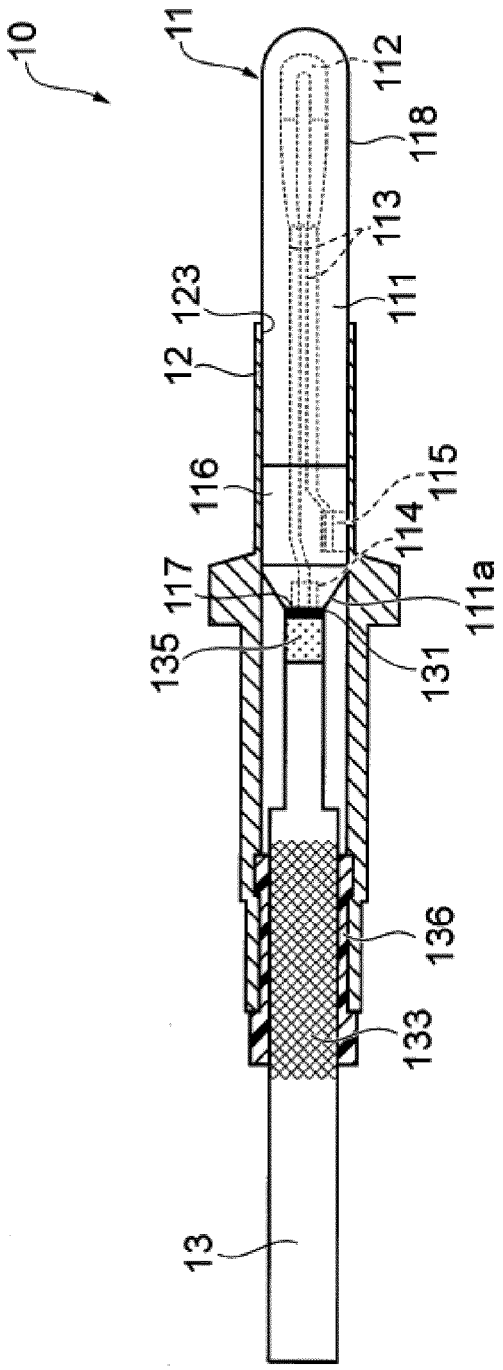
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Fig.3

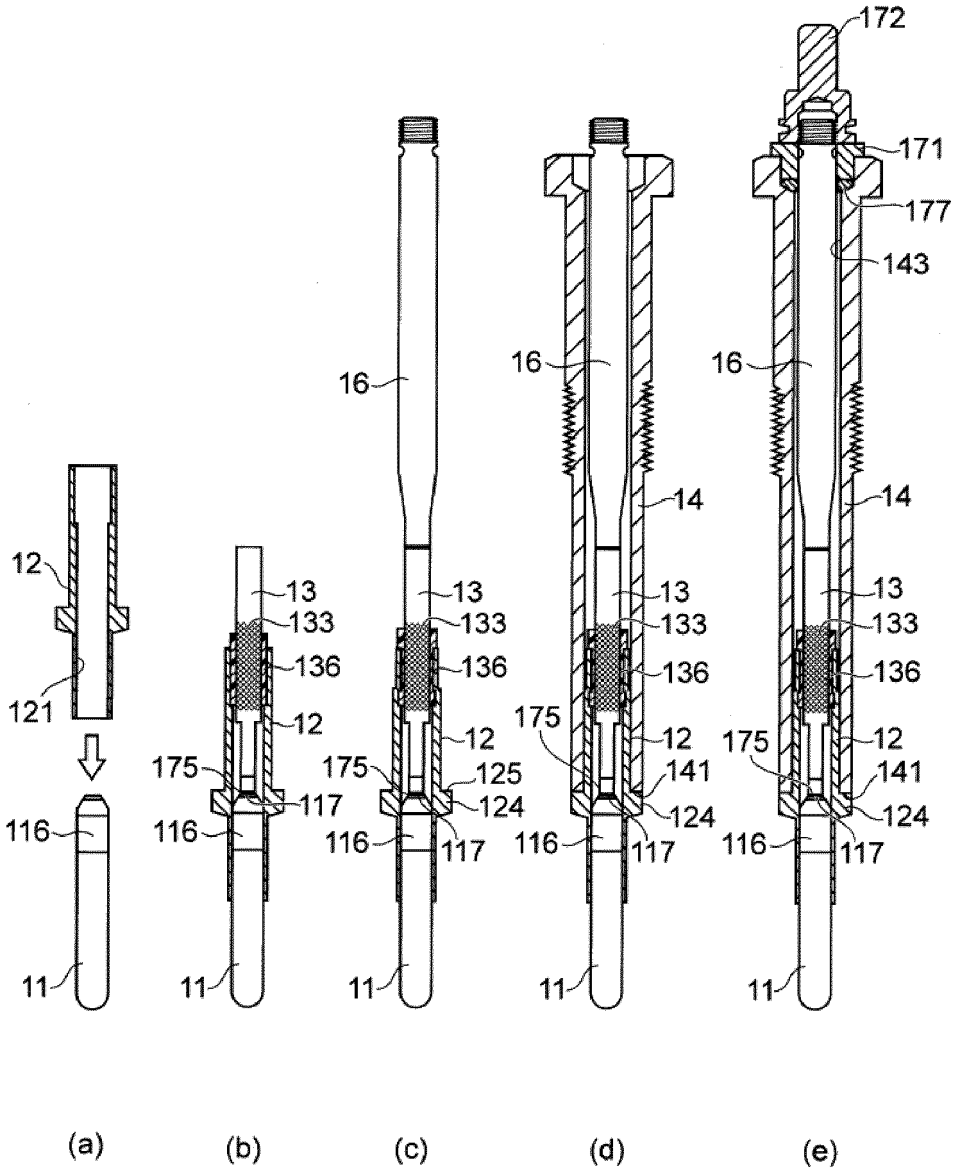
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Fig.4

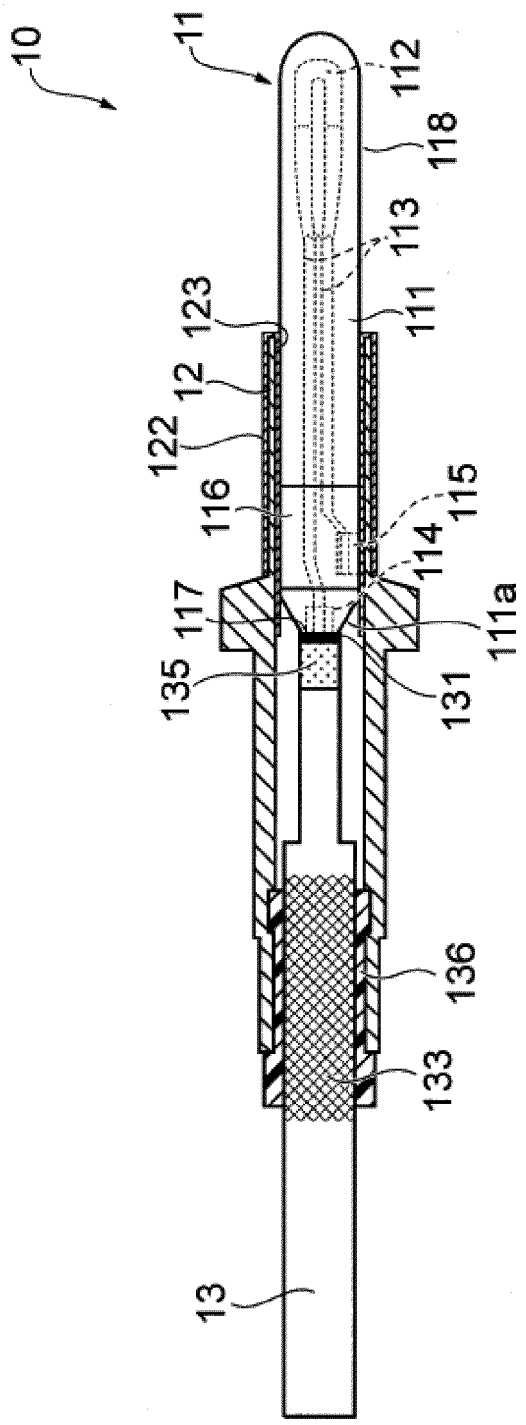
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Fig.5

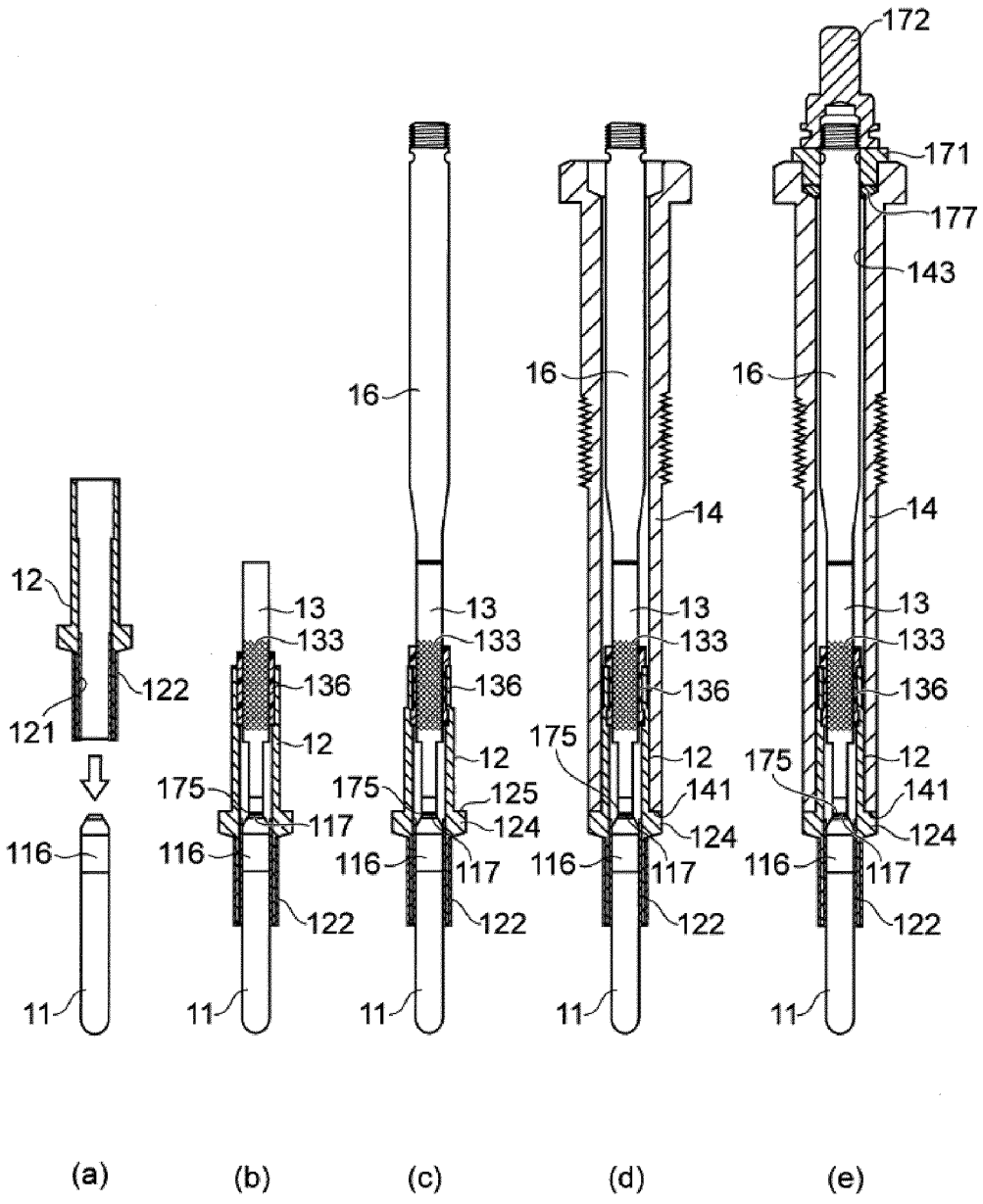
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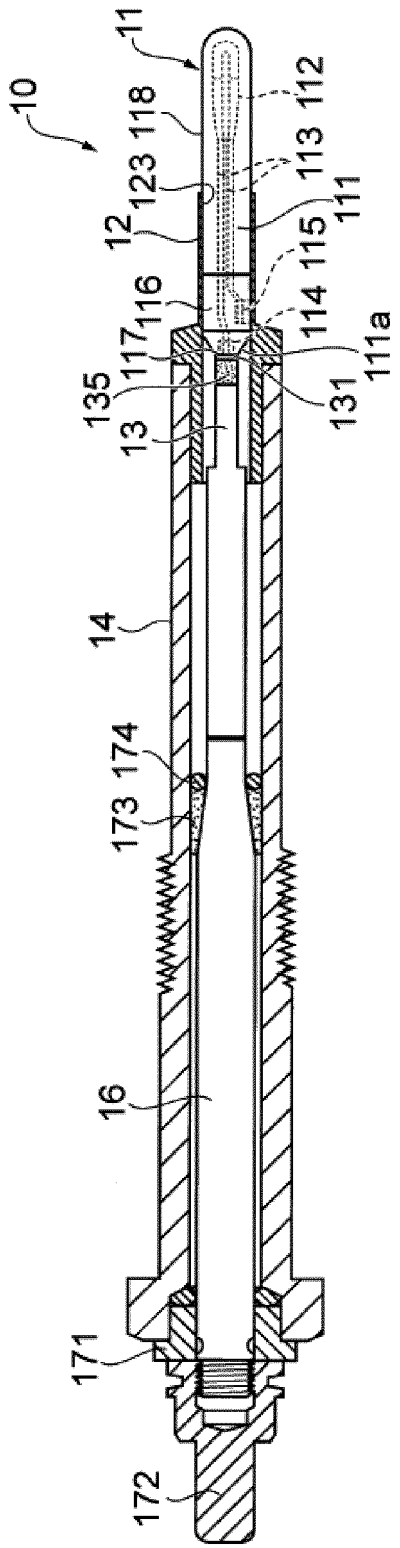
Fig.6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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/060546

A. CLASSIFICATION OF SUBJECT MATTER
F23Q7/00(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)
F23Q7/00

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.
Y	WO 2007/013497 A1 (Kyocera Corp.), 01 February 2007 (01.02.2007), paragraphs [0015] to [0051]; fig. 2 to 3 & JP 4751392 B & US 2010/0006557 A1 & US 2013/0157075 A1 & EP 1916480 A1 & CN 101228396 A & KR 10-2008-0031314 A & KR 10-1016977 B	11,13
Y	WO 2005/117492 A1 (Kyocera Corp.), 08 December 2005 (08.12.2005), paragraphs [0066] to [0067], [0085] & US 2008/0302776 A1 & US 2011/0031231 A1 & US 7935912 B2 & EP 1768456 A1 & CN 1957641 A & KR 10-2007-0027561 A & KR 10-0915576 B1	11,13

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 June 2015 (05.06.15)	16 June 2015 (16.06.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/060546

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 4555508 B2 (NGK Spark Plug Co., Ltd.), 06 October 2010 (06.10.2010), paragraphs [0041] to [0050] & JP 2002-364842 A	1-18
A	JP 4172486 B2 (Bosch Corp.), 29 October 2008 (29.10.2008), paragraphs [0020] to [0030] & WO 2005/061963 A1	1-18
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P,A	WO 2014/083913 A1 (Bosch Corp.), 05 June 2014 (05.06.2014), entire text; all drawings (Family: none)	1-18

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REFERENCES CITED IN THE DESCRIPTION

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- JP 4555508 B **[0005]**
- JP 4172486 B **[0005]**
- JP 2005315447 A **[0005]**