(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 285 004 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
21.02.2018 Bulletin 2018/08

(21) Application number: **16779858.6**

(22) Date of filing: **14.03.2016**

(51) Int Cl.:
F23Q 7/00 *(2006.01)*

(86) International application number:
PCT/JP2016/058027

(87) International publication number:
WO 2016/167066 (20.10.2016 Gazette 2016/42)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **15.04.2015 JP 2015083780**

(71) Applicant: **Bosch Corporation**
Tokyo 150-8360 (JP)

(72) Inventor: **TAKATSU, Katsumi**
Higashimatsuyama-shi
Saitama 355-8603 (JP)

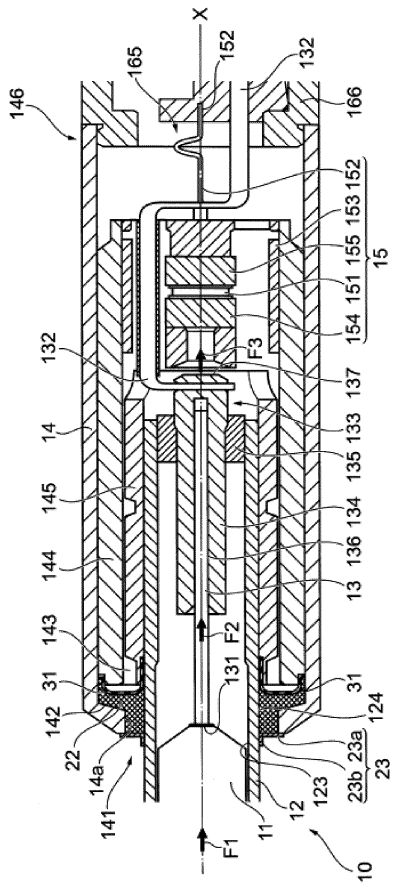
(74) Representative: **Bee, Joachim**
Robert Bosch GmbH, C/IPE
P.O. Box 30 02 20
70442 Stuttgart (DE)

(54) GLOW PLUG

(57) Breakage in a short period is suppressed by improving a heat dissipation property.

In a glow plug that includes: a heater element (10) that is inserted in a combustion chamber of an internal combustion engine; a housing (14) that supports the heater element in a state where a heating section of the heater element is projected; a resilient body (31) that couples the heater element and the housing to divide a space between the heater element and the housing into a tip side and a rear end side of the housing; and a pressure sensor (15) that is provided in a space on the rear end side of the resilient body in the housing to detect a pressure in the combustion chamber from displacement of the heater element, a space (142) on the tip side of the resilient body in the housing is filled with a heat transfer material (22) that is melted by heat transferred from the heater element.

[FIG. 2]



EP 3 285 004 A1

Description

Technical Field

[0001] The invention relates to a glow plug that is used to assist a start-up of an internal combustion engine such as a diesel engine, the glow plug including a pressure sensor that detects a pressure in a combustion chamber.

Background Art

[0002] A glow plug that is used to assist a start-up of an internal combustion engine such as a diesel engine and that includes a pressure sensor detecting a combustion pressure in a combustion chamber of the internal combustion engine has been in practical use (for example, see PTL 1).

[0003] In the glow plug described in PTL 1, a heater element, which is heated by energization, is accommodated in a housing in a displaceable manner, the heater element is displaced in an axial direction of the housing by a pressure change in the combustion chamber, and said displacement is transmitted to the pressure sensor and is detected as the combustion pressure in the combustion chamber of the internal combustion engine.

[0004] Here, the heater element is attached to the housing by a metal diaphragm and is thereby brought into a displaceable state with respect to the housing.

Citation List

Patent Literature

[0005] [PTL 1] JP-T-2009-527748

Disclosure of Invention

Technical Problem

[0006] However, in the glow plug that includes the pressure sensor as described above, the heater element and the housing are joined only by the diaphragm, and heat transferred from the heater element is mainly transferred to the housing side through a path via the thin diaphragm. Accordingly, compared to a general glow plug in which the heater element is fixed to the housing by a brazing material, transfer efficiency of the heat that is transferred from the heater element to the housing is low, and a heat dissipation property is low. Thus, temperatures of the heater element and an inside of the housing are likely to be increased. As a result, temperatures of an extraction electrode of a heat generation body in the heater element and the brazing material each exceed a limit temperature, which possibly results in breakage of the glow plug in a short period.

[0007] The invention has been made in view of the above problem and therefore has a purpose of providing a glow plug that can improve a heat dissipation property and can thereby suppress breakage thereof in a short period.

Solution to Problem

[0008] In order to solve the above problem, the invention is a glow plug that includes: a heater element that is inserted in a combustion chamber of an internal combustion engine; a housing that supports the heater element in a state where a heating section of the heater element is projected; a resilient body that couples the heater element and the housing to divide a space between the heater element and the housing into a tip side and a rear end side of the housing; and a pressure sensor that is provided in a space on the rear end side of the resilient body in the housing to detect a pressure in the combustion chamber from displacement of the heater element, and is characterized in that a space on the tip side of the resilient body in the housing is filled with a heat transfer material that is melted by heat transferred from the heater element.

[0009] The housing preferably has an opening at a tip thereof, in which the heater element is inserted, and preferably includes a sealing member that seals a clearance between the heater element, which is inserted from the opening, and an opening edge.

[0010] The heat transfer material is preferably metal that is melted at 100 °C or lower.

[0011] A step is preferably formed on an inner surface on the tip side of the resilient body in the housing. Advantageous Effects of Invention

[0012] According to the invention, breakage in a short period can be suppressed by improving a heat dissipation property.

Brief Description of Drawings

[0013]

Fig. 1 is a vertical cross-sectional view in which a part of a glow plug according to an embodiment of the invention is seen in a cross section.

Fig. 2 is a vertical cross-sectional view in which a portion near a tip of a housing of the glow plug in Fig. 1 is enlarged.

Fig. 3 includes views that depict a manufacturing method of the glow plug according to the embodiment of the invention.

Fig. 4 includes vertical cross-sectional views in each of which a portion near a tip of a housing of a glow plug according to another embodiment of the invention is enlarged.

Description of Embodiments

[0014] A description will be made on a preferred embodiment of the invention with reference to the drawings. Note that the embodiment, which will be described below,

is merely one example and various embodiments can be implemented within the scope of the invention.

[0015] Fig. 1 is a vertical cross-sectional view of a glow plug. Fig. 2 is a vertical cross-sectional view of the glow plug in which a portion near a tip of a housing is enlarged in Fig. 1. Hereinafter, a lateral cross section means a cross section that is perpendicular to a longitudinal axis of the glow plug, and a vertical cross section means a cross section that includes the longitudinal axis of the glow plug.

[0016] As depicted in Fig. 1, Fig. 2, a glow plug 1 includes a heater element 10, a housing 14, a pressure sensor module 15, an electronic module 16, and the like.

(Heater Element)

[0017] The heater element 10 assists a start-up of an internal combustion engine, is inserted in a combustion chamber (a precombustion chamber in a case of the internal combustion engine of a precombustion type, the combustion chamber of the internal combustion engine in a case of the internal combustion engine of a direct-injection type), and is fixed. The heater element 10 is constructed of ceramics, for example. Note that the heater element 10 is not limited to the ceramics but may be constructed of metal.

[0018] As depicted in Fig. 1, Fig. 2, the heater element 10 includes a ceramic heater 11, a metallic outer cylinder (sheath) 12, a lead section 13, and the like.

[0019] The ceramic heater 11 is a portion that is heated by energization, and a ceramic heat generation body 112 formed in a U-shape is embedded in a ceramic insulating base 111 that constitutes a body of the ceramic heater 11 therein. A positive electrode 114 and a negative electrode 115 are respectively provided on both end sides of this ceramic heat generation body 112 via metal leads 113. The negative electrode 115 is taken out on an outer peripheral surface of the ceramic insulating base 111, and a negative-electrode side metallized section 116 is formed on the outer peripheral surface of the ceramic insulating base 111 that includes the negative electrode 115.

[0020] Of the ceramic heater 11, at least the negative-electrode side metallized 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. The outer cylinder 12 is formed of a metallic material with electrical conductivity and thermal conductivity. The outer cylinder 12 is formed to have an inner diameter in such extent that the ceramic heater 11 can be inserted therein and is formed in such extent that a slight clearance is formed between an inner peripheral surface 123 of the outer cylinder 12 and an outer peripheral surface 118 of the ceramic heater 11 when the ceramic heater 11 is inserted in the outer cylinder 12.

[0021] The ceramic heater 11 and the outer cylinder 12 are joined by brazing or the like in a state where the negative-electrode side metallized section 116 of the ceramic heater 11 is inserted in and fixed to an inside of the outer cylinder 12. That is, the negative-electrode side metallized section 116 of the ceramic heater 11 is joined to the inner surface of the outer cylinder 12 by the brazing material and is thereby electrically connected thereto. The negative-electrode side metallized section 116 is formed of silver paste that contains 30 wt% or less of copper (Cu) and 10 wt% or less of titanium (Ti) with respect to total weight of the negative-electrode side metallized section 116, for example.

[0022] The positive electrode 114 is taken out on an outer surface of the ceramic insulating base 111 on a base end side that is opposite from a tip side where the ceramic heat generation body 112 is embedded. A positive-electrode side metallized section 117 is formed on a rear end surface of the ceramic insulating base 111, which includes the positive electrode 114. This positive-electrode side metallized section 117 is joined to a tip surface 131 of the lead section 13 by brazing, and the positive electrode 114 and the lead section 13 are electrically connected.

[0023] A chamfered section 111a is formed on the rear end surface of the ceramic insulating base 111. In this way, a distance can be secured between the ceramic insulating base 111 and the outer cylinder 12 around a joined section between the ceramic insulating base 111 and the lead section 13. Accordingly, in the case of brazing, an insulation property between the brazing material and the outer cylinder 12 is improved, and a chance of occurrence of dielectric breakdown can be reduced.

[0024] The lead section 13 is electrically connected to the positive electrode 114 of the ceramic heater 11. A large current (for example, 4 to 30 amperes) at a high temperature flows through the lead section 13 during actuation of the glow plug 1. Accordingly, when a diameter of the lead section 13 is too small as being smaller than 1 mm, for example, in addition to self-heating, the lead section 13 is possibly oxidized in a short time. For this reason, the lead section 13 is formed as a lead rod with a relatively large diameter having a cross-sectional area that is 20% or more of a cross-sectional area of the ceramic insulating base 111, for example.

[0025] Meanwhile, when the diameter of the lead section 13 is too large, a distance between the lead section 13 and the outer cylinder 12 cannot sufficiently be secured, which possibly results in the dielectric breakdown. Accordingly, the cross-sectional area of the lead section 13 is preferably 40% or less of the cross-sectional area of the ceramic insulating base 111, for example. In addition, length of the lead section 13 is preferably at least twice as long as the diameter of the lead section 13.

[0026] The lead section 13 is formed of a material with high electrical conductivity. As such a material, for example, copper (Cu), aluminum (Al), or alloys of those can be exemplified. Alternatively, iron alloy or cast iron with low rigidity and the high electrical conductivity may be used.

[0027] Note that nickel (Ni) plating or the like may be

applied to the lead section 13 to improve thermal resistance or the lead section 13 may be covered with silver (Ag) to improve oxidation resistance.

[0028] The lead section 13 is guided to the pressure sensor module 15 side, and, at the rear end 133 on the pressure sensor module 15, is retained in the outer cylinder 12 by a retaining member 134 and a positioning member 135. In this way, the rear end 133 of the lead section 13 is positioned such that a certain distance is kept between the lead section 13 and the inner peripheral surface 123 of the outer cylinder 12 and that displacement of the heater element 10 is appropriately transmitted to the pressure sensor module 15. Here, the positioning member 135 is installed in a manner to contact the inner peripheral surface 123 of the outer cylinder 12, and retains the lead section 13 via the retaining member 134. The retaining member 134 is formed to cover an outer peripheral surface 136 of the lead section 13 on the rear end 133 side of the lead section 13 and can favorably contact the pressure sensor module 15 by increasing an area of an end surface 137 on the pressure sensor module 15 side. The retaining member 134 is electrically connected to the lead section 13. The lead section 13 is electrically connected to a lead cable 132 as an external connection terminal via the retaining member 134, and the lead cable 132 is pulled out of the housing 14 of the glow plug 1.

(Housing)

[0029] As depicted in Fig. 1, Fig. 2, the housing 14 is an attachment jig to a cylinder head of the engine, which is not depicted, and accommodates the heater element 10, the pressure sensor module 15, and the like. The housing 14 is formed of a metallic material with the thermal conductivity and superior heat dissipation property. The housing 14 is formed in a cylindrical shape, for example, and the heater element 10 is supported by the housing 14 via a diaphragm 31 (a resilient body) in states where a base end side thereof is partially arranged in the housing 14 and a tip side thereof is projected to an outside of the housing 14 from an opening 141 on a tip side of the housing 14. The tip of the heater element 10, which is projected from the housing 14, is inserted in the combustion chamber of the internal combustion engine.

[0030] The diaphragm 31 is a thin film body that is formed in a ring shape in a plan view, and is formed of metal that can elastically be deformed. The outer cylinder 12 of the heater element 10 is inserted through a hole formed at a center of the diaphragm 31, and the diaphragm 31 and the outer cylinder 12 are accommodated in the housing 14 together. An inner edge side of the diaphragm 31 is attached to an outer peripheral surface 124 of the outer cylinder 12, and an outer edge side thereof is attached to a sleeve 144 provided on an inner surface of the housing 14. In this way, a space between the inner surface of the housing 14 and an outer surface of the outer cylinder 12 is divided into a space 142 on a tip side (the heater element 10 side) and a space 143 on a rear end side (the pressure sensor module 15 side) by the diaphragm 31.

[0031] The sleeve 144 is fixed to the housing 14 and accommodates a part of the heater element 10 and the pressure sensor module 15.

[0032] On the inside of the sleeve 144, a positioning member 145 is arranged on the same axis as the sleeve 144, and the positioning member 145 is fixed to the sleeve 144. The outer cylinder 12 is inserted in this positioning member 145 in a freely slidable manner. That is, while the outer peripheral surface 124 of the outer cylinder 12 is in contact with the positioning member 145, the outer cylinder 12 is not restrained.

[0033] A step 14a is formed on an inner wall of the space 142 on the tip side of the housing 14. Note that the step 14a is not limited to that formed of plural planes but design thereof can freely be changed as long as being in such a shape that a contact area between the housing 14 and a heat transfer material 22 is increased.

[0034] The space 142 on the tip side of the housing 14 is filled with the heat transfer material 22, which is melted by the heat transferred from the heater element 10, in a solid state. The heat transfer material 22 is preferably a material with the high thermal conductivity so as to efficiently transfer the heat, which is transferred from the heater element 10, to the housing 14. Furthermore, because a contact section thereof with the heater element 10 is exposed to a relatively high temperature, the heat transfer material 22 is preferably constructed of a material that can retain a liquid phase at a high temperature (about 500 °C) in a relatively stable manner (a change such as decomposition, or evaporation, of constituents does not occur) . Moreover, because the glow plug 1 is repeatedly used, the heat transfer material 22 is preferably constructed of a material that can reversibly be changed between a solid phase and the liquid phase depending on a temperature change in a use environment. As such a material, for example, a low-melting-point alloy is exemplified, and preferably, an alloy that is melted at a temperature of 100 °C or below is exemplified. As such a low-melting-point alloy, for example, an alloy that contains two types or more of metal selected from Sn, Bi, In, Zn, Pb, and Cd. Note that the low-melting-point alloy that does not contain Pb and Cd is further preferred from a perspective of reducing an environmental load. As such a low-melting-point alloy, for example, an Sn-Bi-In alloy or the like is exemplified.

[0035] The opening 141 of the space 142 on the tip side of the housing 14 is sealed by a seal material (a sealing member) 23. The seal member 23 is located near the combustion chamber and a heat generating section of the heater element 10, is exposed to the relatively high temperature, and thus is constructed of a material with the high thermal resistance. As such a material, metal, a resin, an elastomer, or the like with the high thermal resistance is exemplified. When sealing the opening 141 of the space 142 on the tip side of the housing 14, the

seal member 23 is connected to both of the housing 14 and the heater element 10. However, in order not to restrain movement of the heater element 10 at a time when the heater element 10 is pressurized by a pressure in the combustion chamber, the seal member preferably has flexibility. As such a member with the superior flexibility, a metallic material that is processed to be thin, fluororubber, silicone rubber, or the like is exemplified.

[0036] The seal member 23 is sealed by a fastener as depicted in Fig. 2, for example. The seal member (a fastener) 23 has: a base section 23a in a ring shape in the plan view; and a cylindrical flange 23b on an inner edge side of this base section 23a, and an inner peripheral surface of the cylindrical flange 23b is joined to the outer peripheral surface 124 of the outer cylinder 12 in the heater element 10 by brazing or the like.

(Pressure Sensor Module)

[0037] The pressure sensor module 15 is provided in the space 143 on the rear end side of the housing 14. The pressure sensor module 15 includes a pressure sensor 151, sensor cable 152, and a sensor housing 153. The pressure sensor 151 can be configured as a piezoelectric sensor element, for example. This piezoelectric sensor element generates electric charge when receiving a mechanical load, and this electric charge can be detected in contact regions 154, 155 of the pressure sensor 151. The detected electric charge is led out of the housing 14 of the glow plug 1 by the sensor cable 152. The sensor housing 153 accommodates the pressure sensor 151 and the contact regions 154, 155 and is supported in the sleeve 144. On a rear end 146 side of the housing 14 that is a far side from the ceramic heater 11, the pressure sensor module 15 is supported by the sleeve 144 that is included in the housing 14.

[0038] In a state where the glow plug 1 is assembled, a force that is applied to the heater element 10 is generated on the basis of the pressure in the combustion chamber of the internal combustion engine. This force is applied to the heater element 10 in an axial direction F1, that is, a direction along an axis x. This force is transmitted to the pressure sensor 151 along a force transmission path indicated by arrows F2, F3. In accordance with the transmitted force, the pressure sensor 151 outputs a detection signal via the sensor cable 152, and the pressure generated in the combustion chamber is detected using this detection signal.

(Electronic Module)

[0039] The electronic module 16 has a contact unit 161, and the contact unit 161 includes: a support body 163 that accommodates a signal processing unit 162; and a connector housing 164. On an end surface side 165 of the support body 163 on the pressure sensor module side, the contact unit 161 has an interface for contact connection with the heater element 10 and the pressure sensor module 15. The interface is implemented via the sensor cable 152 and the lead cable 132 that are pulled out of the housing 14 of the glow plug 1. Note that the contact unit 161 is at least partially surrounded by a tubular electronic module housing 166 and, in this case, the support body 163 is completely surrounded by the electronic module housing 166. In addition, the electronic module housing 166 is partially surrounded by the connector housing 164.

<Manufacturing Method of Glow Plug>

[0040] A description will be made on a manufacturing method of the glow plug 1 of a pressure-sensor integrated type on the basis of Fig. 3.

[0041] As depicted in Fig. 3(a), the ceramic heater 11 is inserted in an inner hole 121 of the outer cylinder 12. The ceramic heater 11 is inserted in the outer cylinder 12 until reaching a position where a specified positional relationship (see Fig. 3(b)) in which the positive-electrode side metallized section 117 of the ceramic heater 11 is sufficiently covered with the outer cylinder 12 is established.

[0042] Next, as depicted in Fig. 3(b), brazing materials 175 are placed on the chamfered section 111a of the ceramic heater 11. In addition, the tip surface 131 of the lead section 13 is placed on the positive-electrode side metallized section 117 of the ceramic heater 11. At this time, another brazing material 176, which differs from the brazing materials 175 placed on the chamfered section 111a, is placed between the positive-electrode side metallized section 117 and the lead section 13.

[0043] Next, in a state where the outer cylinder 12, the ceramic heater 11, and the lead section 13 are temporarily assembled, this heater element 10 is heated to 800 to 900 °C. In this way, the ceramic heater 11 and the outer cylinder 12 as well as the ceramic heater 11 and the lead section 13 are simultaneously brazed.

[0044] Next, as depicted in Fig. 3(c), the housing 14, in which the pressure sensor module 15 is installed, is inserted from a rear end side of the heater element 10 to a specified position, and then the space 142 on the tip side in the housing 14 is filled with the heat transfer material 22 from the opening 141. Thereafter, the opening 141 is sealed by the seal member 23.

[0045] Lastly, as depicted in Fig. 3(d), the electronic module 16 that is assembled in advance is connected from a rear end of the housing 14, and the glow plug 1 is thereby assembled.

<Effects of Embodiment>

[0046] According to the above-described configuration, the space 142 on the tip side of the housing 14 from the diaphragm 31 is filled with the heat transfer material 22, which is melted by the heat transferred from the heater element 10. Thus, the heat can also be dissipated from the heat transfer material 22 toward the housing 14. In

addition, because the heat transfer material 22 is melted, the movement of the heater element 10, which is caused by a pressure fluctuations in the combustion chamber of the internal combustion engine, is not restrained. In this way, the heat transferred from the heater element 10 can efficiently be transferred to the housing 14. Thus, the heat dissipation property is improved, and breakage in a short period is suppressed.

[0047] In the conventional glow plug, a foreign substance such as soot, unburned gas, or oil, that is produced in association with an operation of the internal combustion engine or the like enters the space 142 in the housing 14 from the opening 141 of the housing 14, causes clogging due to accumulation of the foreign substance, or deteriorates performance of the diaphragm 31 due to the foreign substance. As a result, movability of the heater element 10 by the combustion pressure or the like is hindered, which possibly deteriorates pressure detection sensitivity. However, according to the above configuration, the space 142 on the tip side from the diaphragm 31 has already been filled with the heat transfer material 22. Thus, entry of the foreign substance in the space 142 can be prevented, and performance deterioration of the diaphragm 31 and deterioration of the pressure detection sensitivity can be prevented. As a result, performance deterioration of the glow plug in a case of being attached to the inside of the combustion chamber for the long period can be alleviated.

[0048] The opening 141 between the housing 14 on the tip side from the diaphragm 31 and the heater element 10 is sealed by the seal member 23. Thus, even when the heat transfer material 22 is liquefied by the heat transferred from the heater element 10 during the operations of the glow plug and the internal combustion engine, the heat transfer material 22 is favorably retained in the space 142. In addition, because the opening 141 is sealed by the seal member 23, the entry of the foreign substance in the space 142 can be suppressed.

[0049] Furthermore, because the step 14a is formed on the inner wall that faces the space 142 on the tip side of the housing 14, the contact area between the heat transfer material 22 and the housing 14 can be increased, and a heat dissipation effect can further be enhanced.

<Others>

[0050] The glow plug that has been described so far only illustrates one aspect of the invention and thus do not limit the invention. Each embodiment can arbitrarily be changed within the scope of the invention.

[0051] For example, the opening 141 may be sealed by a different seal member from that in Fig. 2. More specifically, as depicted in Fig. 4(A), the opening 141 may be sealed by a filler 25 as the seal material. Alternatively, as depicted in Fig. 4(B), the opening 141 may be sealed by the filler 25 as the seal material and a fastener 26.

[0052] After the space 142 is filled with the heat transfer material 22, a clearance between the housing 14 on the opening 141 side and the heater element 10 is filled with the filler 25. As such a filler 25, for example, the fluororubber or the silicone rubber is available.

[0053] One end of the fastener 26 is fixed to an outer peripheral surface on the tip side of the housing 14 by brazing or the like. Meanwhile, because the other end thereof does not have to be joined to an outer peripheral surface of the heater element 10, the heater element 10 is not restrained to the housing 14 by the fastener 26. Accordingly, the fastener 26 does not always have to be constructed of a material with the flexibility and can be constructed of metal or a resin with the thermal resistance, for example. As such a fastener 26, for example, a member such as a gasket is exemplified.

Claims

1. A glow plug **characterized by** comprising:

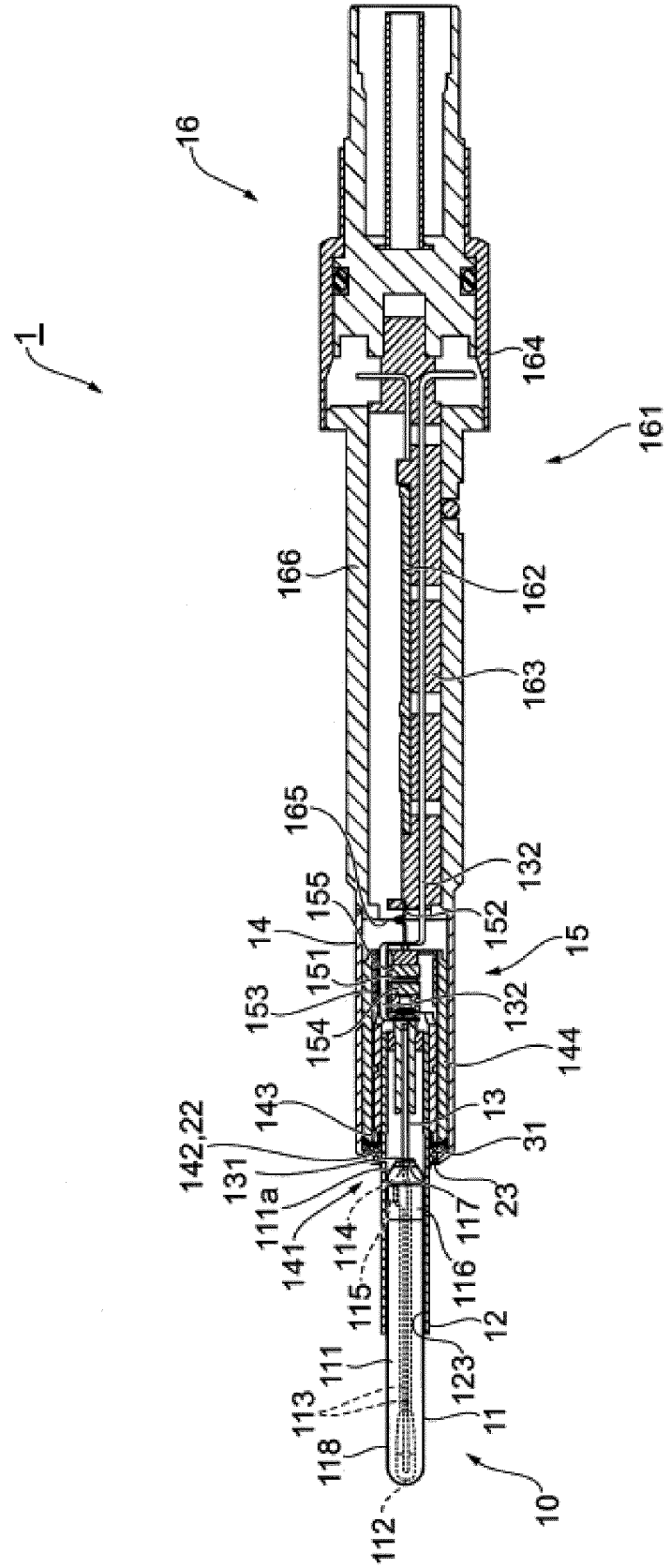
   a heater element that is inserted in a combustion chamber of an internal combustion engine;
   a housing that supports the heater element in a state where a heating section of the heater element is projected;
   a resilient body that couples the heater element and the housing and divides a space between the heater element and the housing into a tip side and a rear end side of the housing; and
   a pressure sensor that is provided in a space on the rear end side of the resilient body in the housing to detect a pressure in the combustion chamber from displacement of the heater element, in that
   the space on the tip side of the resilient body in the housing is filled with a heat transfer material that is melted by heat transferred from the heater element.

2. The glow plug according to claim 1 **characterized in that**
   the housing has an opening at a tip thereof, in which the heater element is inserted, and
   includes a sealing member that seals a clearance between the heater element, which is inserted from the opening, and an opening edge.

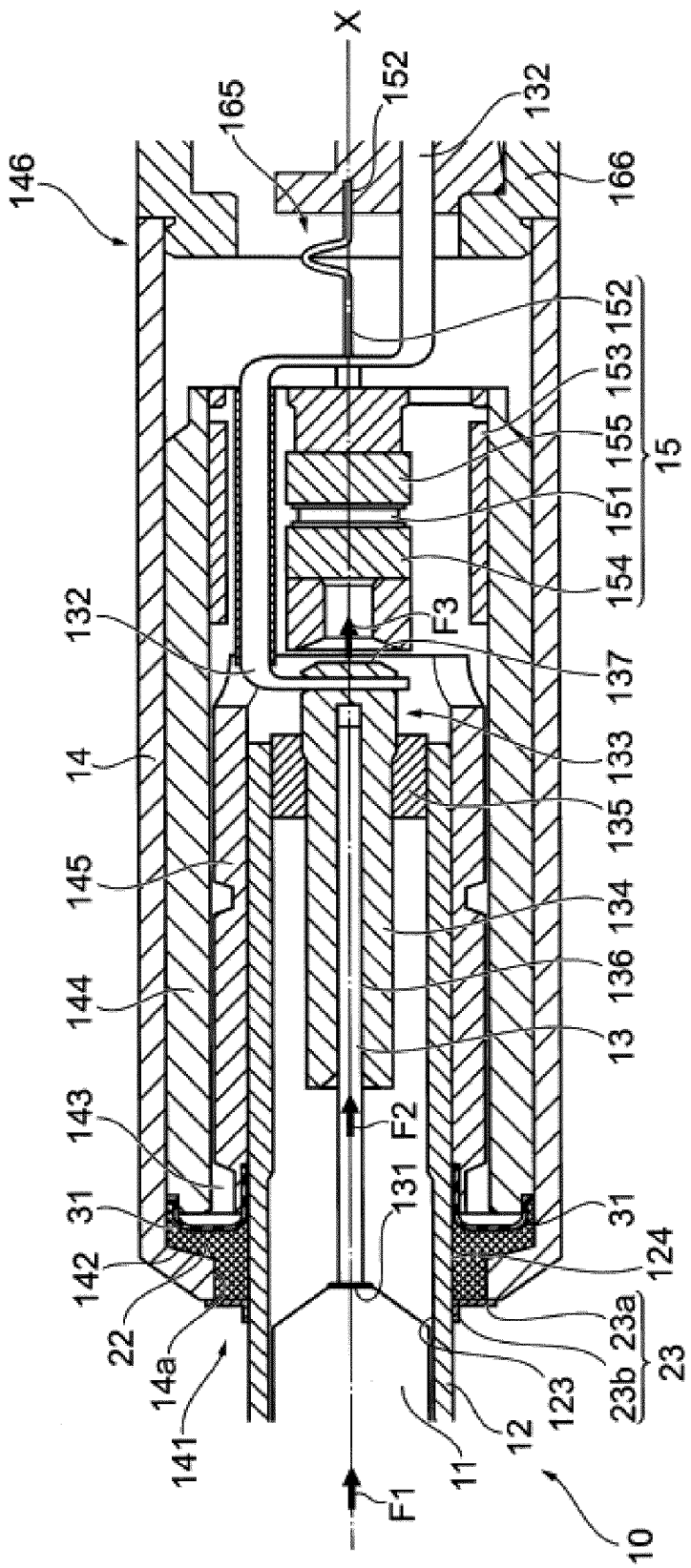
3. The glow plug according to claim 1 or 2 **characterized in that** the heat transfer material is metal that is melted at 100 °C or lower.

4. The glow plug according to any one of claims 1 to 3 **characterized in that** a step is formed on an inner surface on the tip side of the resilient body in the housing.

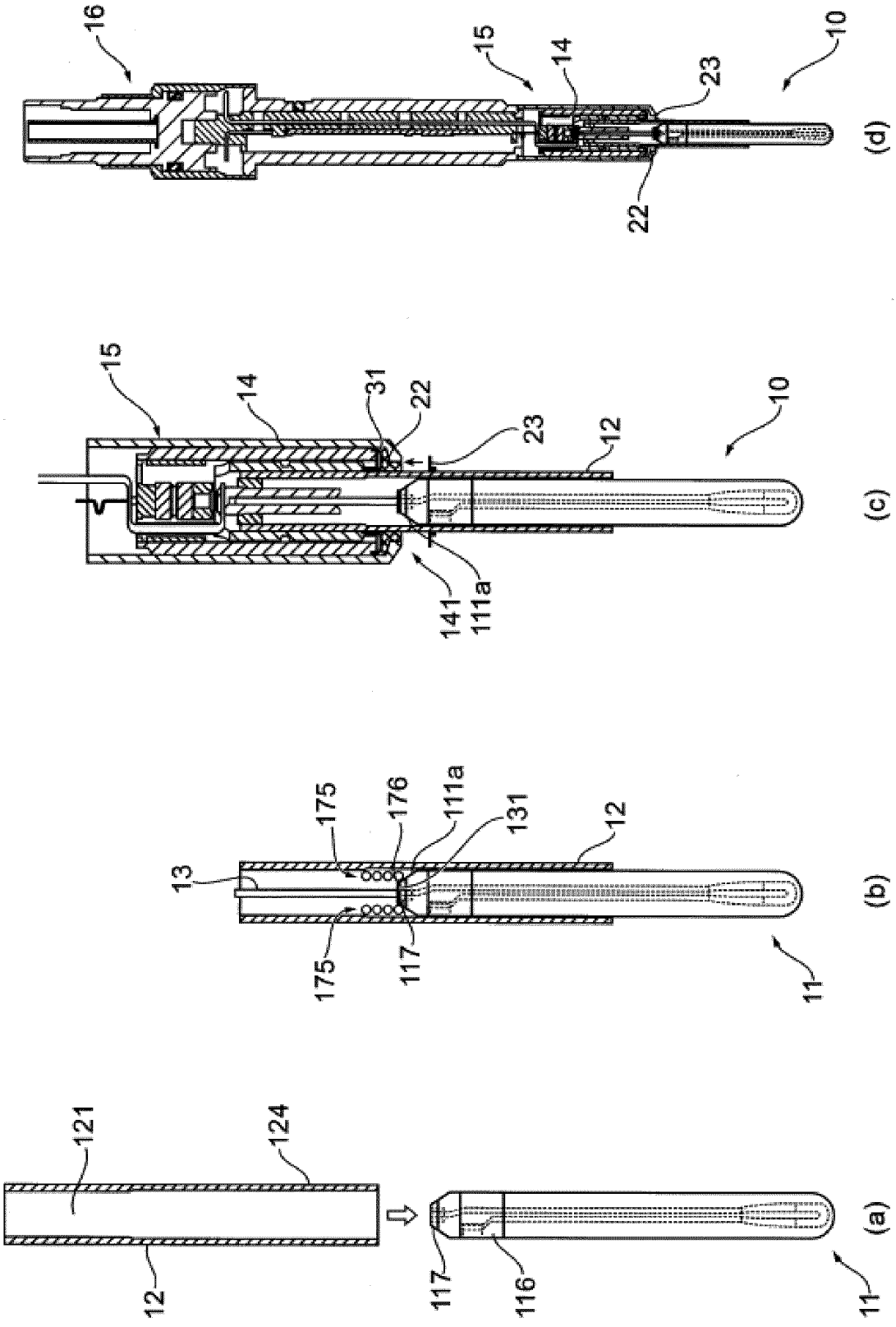
[FIG. 1]


1
16
164
161
166
162
163
165
132
155
152
14
15
151
153
132
154
144
143
13
142,22
31
131
23
111a
117
141
114
116
115
12
111
123
113
11
118
10
112

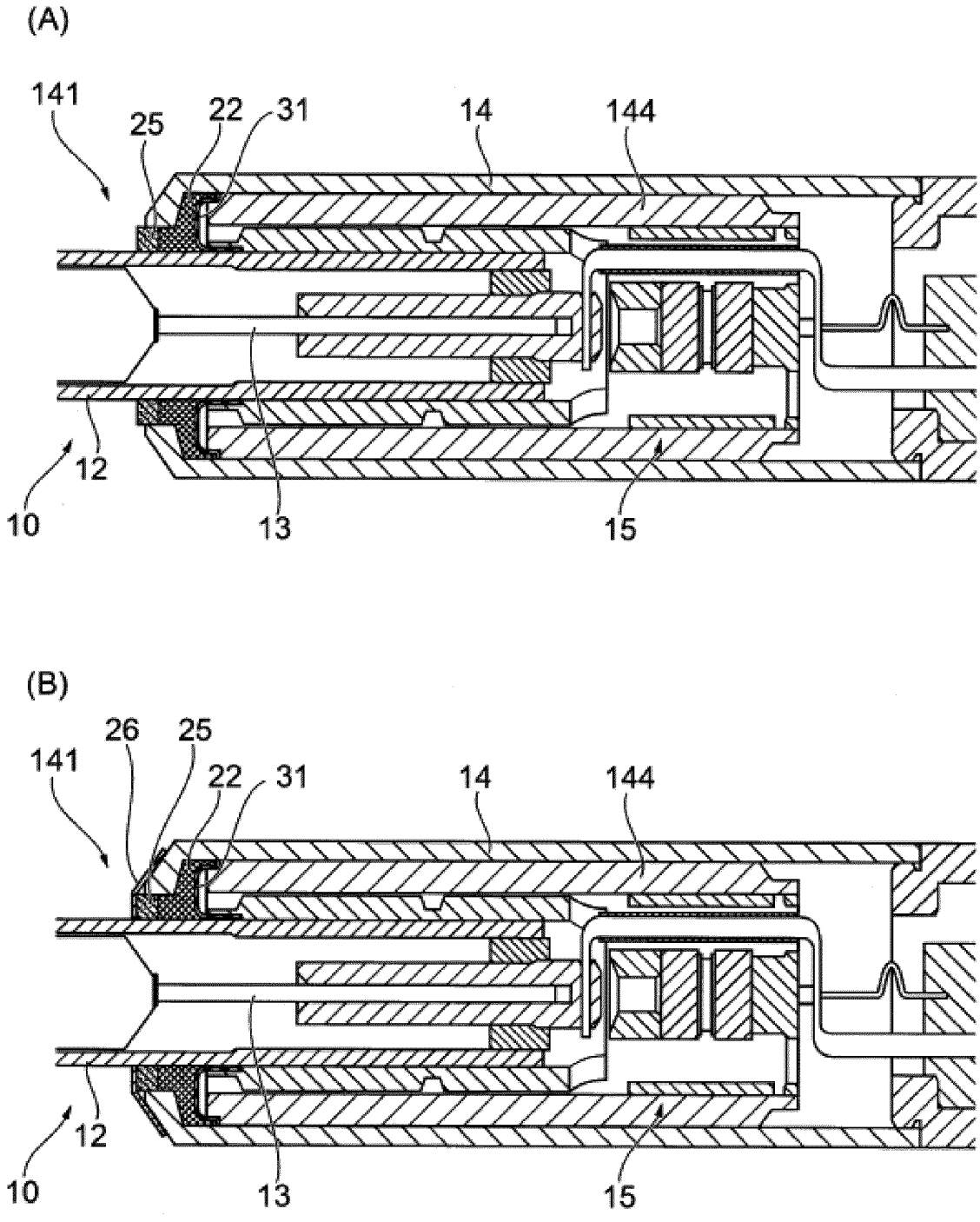
[FIG. 2]


X
165
152
132
146
166
152
153
155
151
154
15
132
F3
137
14
133
135
145
134
144
136
13
143
F2
131
31
31
142
124
22
23a
14a
23b
23
123
141
12
11
F1
10

[FIG. 3]


16
15
14
23
10
22
(d)
15
14
31
22
23
12
10
141
111a
(c)
175
176
111a
131
12
13
175
117
11
(b)
121
124
12
117
116
11
(a)

[FIG. 4]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/058027

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 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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	JP 2007-177782 A (NGK Spark Plug Co., Ltd.), 12 July 2007 (12.07.2007), paragraph [0034]; all drawings (Family: none)	1-4
A	JP 2007-309916 A (Denso Corp.), 29 November 2007 (29.11.2007), claim 6; all drawings & US 2007/0245806 A1 & EP 1847776 A2	1-4
A	JP 2013-40751 A (NGK Spark Plug Co., Ltd.), 28 February 2013 (28.02.2013), claim 1; all drawings (Family: none)	1-4

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 June 2016 (01.06.16)	14 June 2016 (14.06.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/058027

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 2015-4463 A (NGK Spark Plug Co., Ltd.), 08 January 2015 (08.01.2015), paragraph [0039]; all drawings (Family: none)	1-4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2009527748 T **[0005]**