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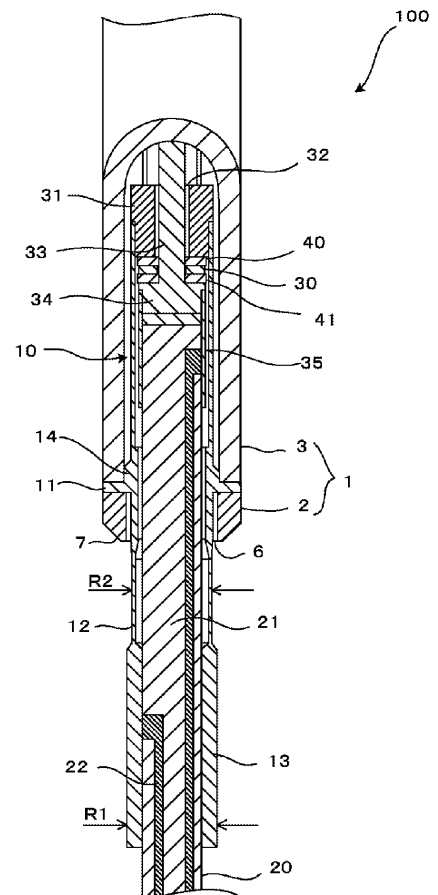
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(54) **Glow plug having combustion pressure sensor**

(57) A glow plug (100) is provided having a combustion pressure sensor capable of detecting combustion pressure with high accuracy over a long period of time. A heater support member (10) for supporting a heater (20) has a movable or elastically deformable portion (12), which is located forward of a seat face (7); i.e. the movable or elastically deformable portion (12) is substantially exposed forward of a housing (1). The movable portion (12) has the function to allow axial displacement of the heater (20) through elastic deformation in response to combustion pressure applied to the pressure-receiving surface of a forward end of the heater (20).

Fig. 1



Description

[0001] The present invention relates to a glow plug having a combustion sensor for use in an internal combustion engine, such as an automobile engine.

[0002] Conventional glow plugs for use in internal combustion engines, such as automotive diesel engines, include a glow plug having a combustion pressure sensor for detecting the combustion pressure of an internal combustion engine. Such a known glow plug having a combustion pressure sensor is configured, for example, as follows (refer to, for example, Japanese Patent Application Laid-Open (*kokai*) No. 2007-120939). A support tube having axial extensibility is provided within a housing and supports a heater to the housing in such a manner that the heater can be displaced in an axial direction. The support tube allows the heater to be displaced backward in the axial direction in response to combustion pressure applied to a pressure-receiving surface of a forward end of the heater. The thus-displaced heater presses the pressure sensor.

[0003] The above-mentioned conventional glow plug having a combustion pressure sensor involves the following problem. Soot generated within a combustion chamber clogs a clearance between the housing and the axially extensible support tube for supporting the heater, thereby preventing displacement of the heater. Also, heat of combustion causes a change in axial extensibility of the support tube. Accordingly, in the course of use over a long period of time, the detection of combustion pressure with high accuracy gradually becomes difficult.

[0004] The present invention has been conceived to solve the above-mentioned problem. An object of the present invention is to provide a glow plug having a combustion pressure sensor capable of detecting combustion pressure with high accuracy over a long period of time.

[0005] A glow plug having a combustion pressure sensor of the present invention comprises a housing assuming a tubular form and having a seat face at an axially forward end for close contact with an engine, and an externally threaded portion formed on an outer circumferential surface located axially rearward of the seat face and adapted to mount the glow plug to the engine; a pressure detection element; a heater having a forward portion projecting from a forward end portion of the housing and a rear portion housed within the housing, and transmitting combustion pressure to the pressure detection element with a forward end surface of the heater serving as a pressure-receiving surface; and a heater support member adapted to support the heater to the housing and having a movable or elastically deformable portion assuming a tubular form, located forward of the seat face, and axially displacing the heater through elastic deformation in response to combustion pressure applied to the pressure-receiving surface, a heater connection portion located forward of the movable or elastically deformable portion and connected to the heater, and a

housing connection portion located rearward of the seat face and connected to the housing.

[0006] In the glow plug having a combustion pressure sensor of the present invention, the heater support member for supporting the heater to the housing has the movable or deformable portion, which assumes a tubular form, is substantially located forward of the seat face, and is arranged to allow axial displacement of the heater through elastic deformation in response to combustion pressure applied to the pressure-receiving surface. That is, at least a major part of the movable or deformable portion, which can also be referred to as flexible portion, is located externally of the housing. This avoids a drop in combustion pressure detection accuracy, which could otherwise result from a hindrance to axial displacement of the heater caused by soot clogging a clearance between the movable portion and the housing. Therefore, accurate combustion pressure detection can be performed for a long period of time.

[0007] Preferably, in the above-configured glow plug having a combustion pressure sensor, the pressure detection element is disposed rearward of the housing connection portion of the heater support member. This can restrain deterioration of the pressure detection element caused by thermal influence of combustion gas. Generally, in a glow plug having a combustion pressure sensor, combustion gas enters the housing up to the housing connection portion of the heater support member, thereby greatly exercising thermal influence on the pressure detection element. Thus, by means of the pressure detection element being disposed rearward of the housing connection portion of the heater support member, the thermal influence of combustion gas on the pressure detection element can be mitigated.

[0008] Preferably, in the above-configured glow plug having a combustion pressure sensor, the movable portion is positioned such that, as viewed from an axially forward side, a member (e.g. the heater connection portion) disposed forward of the movable or elastically deformable portion conceals the movable portion from view. This configuration can restrain direct imposition of heat generated within the combustion chamber on the movable or elastically deformable portion, thereby restraining deterioration of the movable portion caused by thermal influence.

[0009] In the above-configured glow plug having a combustion pressure sensor, the movable portion of the heater support member can be a thin-walled portion whose wall thickness is thinner than that of the remaining portion of the heater support member. Also, the movable portion of the heater support member can be formed of bellows. Furthermore, preferably, the movable portion of the heater support member is formed of a member whose Young's modulus is lower than that of the remaining portion of the heater support member. This configuration facilitates the axial displacement of the heater, and enables improved transmission of combustion pressure to the pressure sensor.

[0010] The glow plug having a combustion pressure sensor of the present invention can detect combustion pressure with high accuracy over a long period of time.

[0011] An embodiment of the present invention will next be described with reference to the drawings which show in

Figure 1 the configuration of portions of a glow plug having a combustion pressure sensor according to an embodiment of the present invention; and
Figure 2 the overall configuration of the glow plug having a combustion pressure sensor according to the embodiment of the present invention.

[0012] Figures 1 and 2 show the configuration of a glow plug 100 having a combustion pressure sensor according to the embodiment of the present invention. Figure 1 is a sectional view showing, on an enlarged scale, a forward end portion of the glow plug 100 having a combustion pressure sensor. Figure 2 is a partially cutaway side view showing the entire configuration of the glow plug 100 having a combustion pressure sensor.

[0013] As shown in Figures 1 and 2, the glow plug 100 having a combustion pressure sensor has a housing 1. The housing 1 assumes a substantially tubular form and is formed of a high-strength metal, such as carbon steel (S45C, etc.) or stainless steel (e.g., SUS430 or SUS630). The housing 1 is configured such that a forward housing 2 and a rear housing 3 are connected together.

[0014] As shown in Figure 2, the rear housing 3 has an externally threaded portion 4 formed on its outer circumferential surface. The externally threaded portion 4 is adapted to mount the glow plug 100 having a combustion pressure sensor to an unillustrated engine. The rear housing 3 also has a tool engagement portion 5 formed on its outer circumferential surface and located rearward of the externally threaded portion 4. When the housing 1 is to be mounted to the engine, a tool, such as a spanner or a wrench, is engaged with the tool engagement portion 5.

[0015] As shown in Figure 1, the forward housing 2 has an opening portion 6 for allowing a heater 20 to project from the forward end of the housing 1. The opening portion 6 has a seat face (taper face) 7 at its axially forward end for close contact with the engine, such as an automotive diesel engine. A heater support member 10 extends through the opening portion 6. The heater support member 10 assumes a substantially tubular form and is formed of a metal, such as stainless steel (e.g., SUS430 or SUS630). The heater 20 is provided within the heater support member 10. The heater 20 is a ceramic heater (formed of silicon nitride, alumina, or the like) configured, for example, such that a conductive ceramic 22 is embedded in an insulating ceramic 21, or is a metal glow heater (formed of a coil, a stainless steel tube, an insulating powder, or the like). A forward end surface 23 of the heater 20 shown in Figure 2 serves as a pressure-receiving surface which receives combustion

pressure generated within a combustion chamber.

[0016] As shown in Figure 1, the heater support member 10 has a housing connection portion 11, which is formed at its intermediate region and assumes the form of a flange projecting radially outward. The housing connection portion 11 is sandwiched between the forward housing 2 and the rear housing 3 and is joined thereto by welding or the like, whereby the heater support member 10 is connected to the housing 1.

[0017] The heater support member 10 has a movable or elastically deformable portion 12, also referred to as axially flexible or axially elastically deformable portion, which is located forward of the seat face 7; i.e., which is exposed forward of the housing 1. The movable portion 12 has a function of axially displacing the heater 20 through elastic deformation in response to combustion pressure applied to the pressure-receiving surface of the heater 20. In the present embodiment, the movable portion 12 is a thin-walled portion whose wall thickness is thinner than that of the remaining portion of the heater support member 10. Preferably, in the case where the movable portion 12 is such a thin-walled portion, the movable portion 12 has a wall thickness of, for example, about 0.2 ± 0.1 mm (the remaining portion (e.g., a heater connection portion 13, which will be described later) has a wall thickness of about 0.4 mm) and an axial length of, for example, about 5 mm. Preferably, the movable portion is formed of a material which is resistant to repeated stress and has a low Young's modulus; for example, stainless steel (e.g., SUS430 or SUS630), maraging steel, pure titanium, a titanium alloy (Ti-6Al-4V or the like). The movable portion 12 may be embodied in the form of bellows. Alternatively, instead of having a thinner wall thickness or assuming the form of bellows or the like, the movable portion 12 may be formed of a member which has a profile similar to that of the remaining portion of the heater support member 10 and has a Young's modulus lower than that of the remaining portion of the heater support member 10.

[0018] The heater support member 10 has a heater connection portion 13 located forward of the movable portion 12. The inner circumferential surface of the heater connection portion 13 is connected with the heater 20 by means of press-fitting or brazing. The heater connection portion 13 is thicker (e.g., about 0.4 mm) in wall thickness than the movable portion 12.

[0019] In the present embodiment, as shown in Figure 1, an outside diameter R1 of the heater connection portion 13 is greater than an outside diameter R2 of the movable portion 12; i.e., $R1 > R2$. As a result, when a forward end portion of the heater connection portion 13 is viewed from the axially forward side, the heater connection portion 13 conceals the movable portion 12 from view. The employment of the configuration prevents direct transmission of heat generated within a combustion chamber to the movable portion 12, thereby restraining deterioration of the movable portion 12 caused by the heat. In order to yield such an action, the employment of

the relation $R1 \geq R2$ suffices. Since the heater connection portion 13 is thick-walled as mentioned above and thus has an associated large volume, the thermal capacity of the heater connection portion 13 is increased, thereby enhancing the effect of shielding the movable portion 12 from heat.

[0020] A portion of the heater support member 10 located rearward of the housing connection portion 11 extends rearward in the form of a cylinder. An element retainer 31 is fixedly attached to an end portion of the rearward extending portion of the heater support member 10. A pressure detection element 30 is disposed within the rearward extending portion of the heater support member 10 and is located forward of the element retainer 31 with an insulating member 40 sandwiched therebetween. The pressure detection element 30 can be, for example, a piezoelectric element. The element retainer 31 is formed of a high-strength metal; for example, carbon steel (S45C, etc.) or stainless steel (e.g., SUS430 or SUS630).

[0021] The above-mentioned element retainer 31 has a through-hole 32 extending therethrough at its center. A conductive axial rod 33 extends through the through-hole 32. The axial rod 33 has a large-diameter flange portion 34 formed at its forward end and is disposed such that the flange portion 34 intervenes between the pressure detection element 30 and the heater 20. The heater 20 transmits combustion pressure to the pressure detection element 30 via the flange portion 34 and an insulating member 41, which is sandwiched between the flange portion 34 and the pressure detection element 30. The axial rod 33 is electrically connected to the conductive ceramic 22 of the heater 20 via a conductive ring member 35, whereby power is supplied to the heater 20 via the axial rod 33. As shown in Figure 2, the axial rod 33 is electrically connected to a heater power line 8, and the pressure detection element 30 is electrically connected to a signal output line 9, whereby the axial rod 33 and the pressure detection element 30 are electrically led out to the exterior of the housing 1.

[0022] As mentioned above, in the present embodiment, the pressure detection element 30 is disposed rearward of the housing connection portion 11 of the heater support member 10. This can restrain deterioration of the pressure detection element 30 caused by thermal influence of combustion gas. Specifically, in the glow plug 100 having a combustion pressure sensor, combustion gas generated in the combustion chamber enters a clearance between the heater support member 10 and the housing 1 and reaches the forward end of the housing connection portion 11. Thus, a region located forward of the housing connection portion 11 is severely affected by heat of combustion gas, whereas a region located rearward of the housing connection portion 11 is less affected by heat of combustion gas. By means of disposing the pressure detection element 30 in the region which is located rearward of the housing connection portion 11 and thus is less affected by heat of combustion gas, the thermal influence of combustion gas on the pressure de-

tection element 30 can be mitigated.

[0023] In Figure 1, a portion 14 of the heater support member 10 integral with the rear end of the housing connection portion 11 is a press-fit portion whose wall thickness and outside diameter are greater than those of the remaining portion of the rearward extending portion of the heater support member 10. The press-fit portion 14 is press-fitted into the rear housing 3 of the housing 1, whereby the rear housing 3 and the heater support member 10 are fixed together such that the axis of the rear housing 3 (housing 1) and the axis of the heater support member 10 coincide with each other.

[0024] In the above-configured glow plug 100 having a combustion pressure sensor, as shown in Figure 2, a forward end portion of the heater 20 projects from a forward end portion of the housing 1. The glow plug 100 is airtightly mounted to an unillustrated engine by the following procedure: the glow plug 100 is inserted into a plug-mounting hole of the engine, and the externally threaded portion 4 is engaged with mounting threads of the engine so as to bring the seat face 7 in contact with the engine. By this procedure, the glow plug 100 is mounted to the internal combustion engine such that a forward end portion of the heater 20 is located within a combustion chamber. When the heater 20 is energized, the heater 20 generates heat, thereby assisting the start-up of the internal combustion engine.

[0025] When combustion pressure is applied to the forward end surface (pressure-receiving surface) 23 of the heater 20, the movable portion 12 elastically deforms (flexes), whereby the heater 20 is displaced rearwardly along the axial direction and presses the pressure detection element 30. As a result, a pressure detection signal is detected. An internal space of the housing 1 located rearward of the pressure detection element 30 accommodates an electronic circuit (not shown) for processing an output signal from the pressure detection element 30. A signal output from the electronic circuit is input to a control unit, such as an ECU, through the signal output line 9, whereby variation of combustion pressure within the engine is detected.

[0026] In the course of use of the glow plug 100 having a combustion pressure sensor in the above-mentioned state over a long period of time, soot generated in the combustion chamber may clog a clearance between the inside of the housing 1 and the outside of the heater support member 10. However, in the glow plug 100 having a combustion pressure sensor, the movable portion 12, which is elastically deformed, is completely located outside the housing 1, thereby being free from impairment of its movability caused by clogging of soot. Therefore, the glow plug 100 can detect combustion pressure with high accuracy over a long period of time. Only a small (insubstantial) part of the movable portion 12 could be arranged inside the housing 1, so long as the above-mentioned effect is not substantially deteriorated.

[0027] Also, the movable portion 12, and the forward housing 2 having the seat surface 7, which comes in air-

tight contact with the engine, are of separate members. Thus, even when the forward housing 2 is flexingly deformed as a result of the externally threaded portion 4 being engaged with the mounting threads of the engine, and the seat surface 7 coming into close contact with the engine, the influence of the flexure on the result of pressure detection can be mitigated. Furthermore, the influence of the strain of a head portion of the engine caused by combustion on the result of pressure detection can be mitigated. Therefore, combustion pressure can be detected with high accuracy.

[0028] The pressure detection element 30 can be an element other than a piezoelectric element. For example, an Si element or an SOI element may be used as the pressure detection element 30. Such an element outputs an electric signal corresponding to strain associated with application of pressure. The pressure detection element 30 can be configured such that an element, such as an Si element or an SOI element, is joined to a substrate of glass, metal, or the like. A piezoresistor is formed on the surface of the element. Pressure is detected from variation of resistance at the time of the element being pressed.

[0029] While the present invention has been described with reference to the above embodiment, the present invention is not limited thereto, but may be modified as appropriate without departing from the gist of the invention.

DESCRIPTION OF REFERENCE NUMERALS

[0030]

1:	housing	
2:	forward housing	
3:	rear housing	
4:	externally threaded portion	
5:	tool engagement portion	
6:	opening portion	
7:	seat face	
8:	heater power line	
9:	signal output line	
10:	heater support member	
11:	housing connection portion	
12:	movable or elastically deformable portion	
13:	heater connection portion	
14:	press-fit portion	
20:	heater	
21:	insulating ceramic	
22:	conductive ceramic	
23:	forward end surface (pressure-receiving surface)	
30:	pressure detection element	
31:	element retainer	
32:	through-hole	
33:	axial rod	
34:	flange portion	
35:	ring member	

40, 41:	insulating member
100:	glow plug having a combustion pressure sensor

Claims

1. A glow plug having a combustion pressure sensor comprising:

a housing (1) assuming a tubular form and having a seat face (7) at an axially forward end for close contact with an engine, and an externally threaded portion (4) formed on an outer circumferential surface located axially rearward of the seat face (7) and adapted to mount the glow plug (100) to the engine;

a pressure detection element (30);

a heater (20) having a forward portion projecting from a forward end portion of the housing (1) and a rear portion housed within the housing (1), and transmitting combustion pressure to the pressure detection element (30) with a forward end surface (23) of the heater (20) serving as a pressure-receiving surface; and

a heater support member (10) adapted to support the heater (20) to the housing (1) and having a movable or elastically deformable portion (12) assuming a tubular form, substantially located forward of the seat face (7), and being arranged to allow axial displacement of the heater (20) through elastic deformation in response to combustion pressure applied to the pressure-receiving surface (23), a heater connection portion (13) located forward of the movable or elastically deformable portion (12) and connected to the heater (20), and a housing connection portion (11) located rearward of the seat face (7) and connected to the housing (1).

2. The glow plug having a combustion pressure sensor according to claim 1, wherein the pressure detection element (30) is disposed rearward of the housing connection portion (11) of the heater support member (10).

3. The glow plug having a combustion pressure sensor according to claim 1 or 2, wherein the movable or elastically deformable portion (12) is positioned such that, as viewed from an axially forward side, a member (13) disposed forward of the movable or elastically deformable portion (12) conceals the movable or elastically deformable portion (12) from view.

4. The glow plug having a combustion pressure sensor according to any one of claims 1 to 3, wherein the movable or elastically deformable portion (12) of the heater support member (10) is a thin-walled portion

whose wall thickness is thinner than that of the remaining portion of the heater support member (10).

5. The glow plug having a combustion pressure sensor according to any one of claims 1 to 4, wherein the movable or elastically deformable portion (12) of the heater support member (10) is formed of bellows. 5
6. The glow plug having a combustion pressure sensor according to any one of claims 1 to 5, wherein the movable or elastically deformable portion (12) of the heater support member (10) is formed of a member whose Young's modulus is lower than that of the remaining portion of the heater support member (10). 10

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Fig. 1

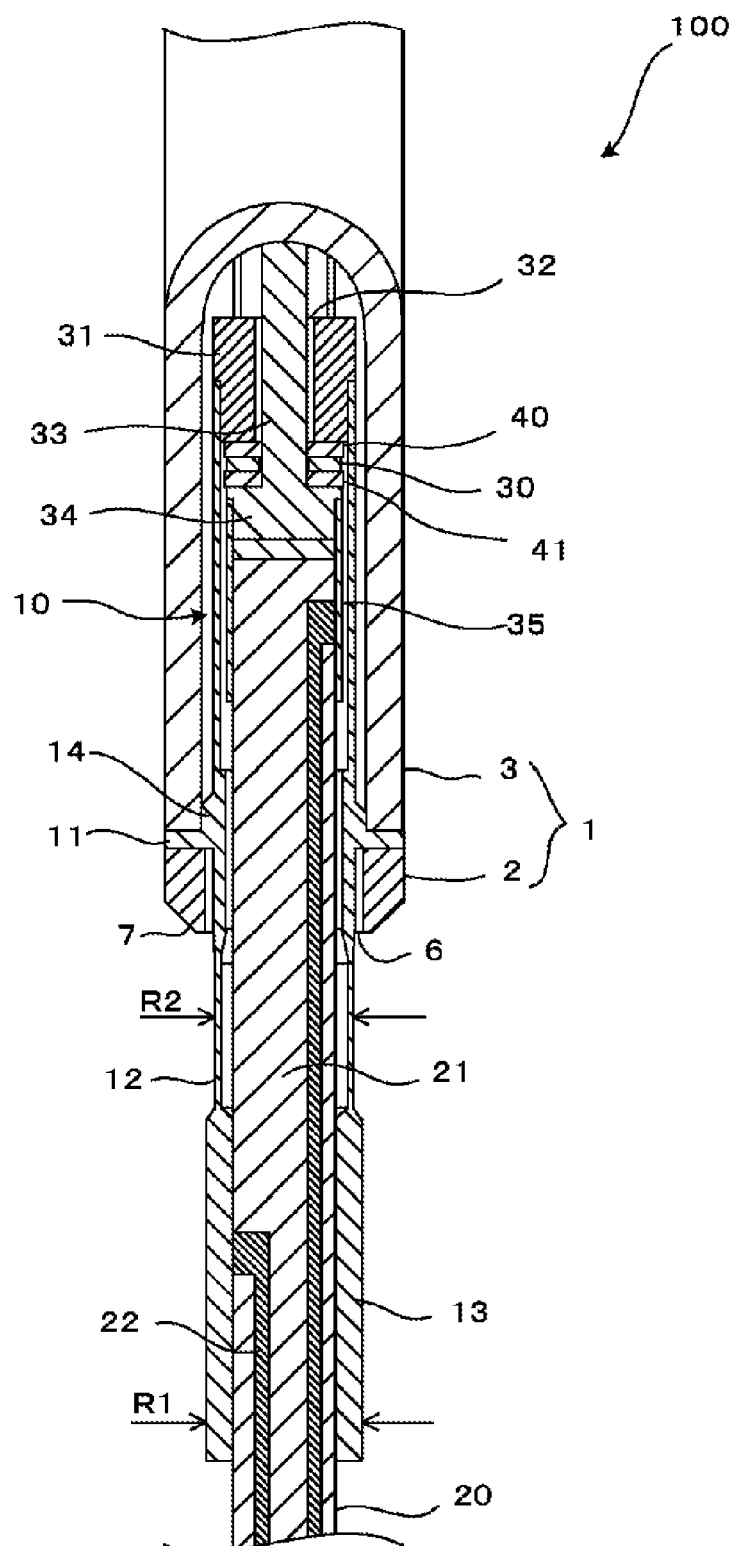
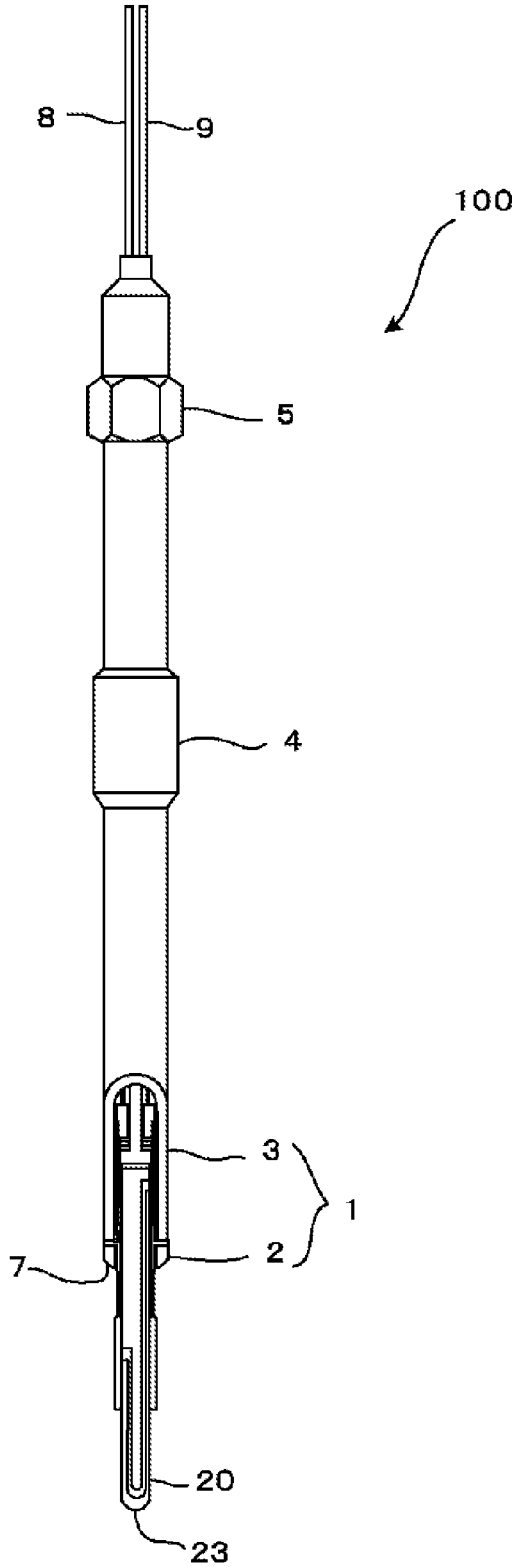


Fig. 2





EUROPEAN SEARCH REPORT

Application Number
EP 08 17 2468

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 5 May 2009	Examiner Rohr, Peter
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 08 17 2468

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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