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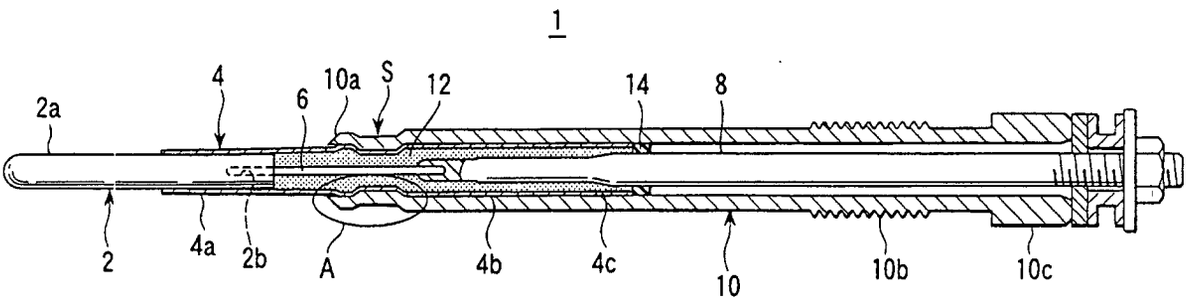
# (54) GLOW PLUG FOR DIESEL ENGINE AND METHOD OF MANUFACTURING THE GLOW PLUG

(57) One end of a ceramics heater 2 is secured to one end of a metallic outer sleeve 4. The negative pole of the heater 2 is electrically connected to the metallic outer sleeve while the positive pole is connected to an external connection terminal 8 through an electrode fitting 8. The metallic outer sleeve 8 in which the heater 2 and the external connection terminal 8 are mounted is inserted into an internal bore 16 of a housing 10. After positioning the distal end of the heater 2 and a sheet surface 10a on the housing 10, the outer periphery of the housing 10 is subject to a swaging operation. An annular projection 10d is formed on the inner peripheral surface of the housing 10, and an annular recess 4c, in which the angular projection 10d is fitted, is concurrently formed in the outer peripheral surface of the metallic outer sleeve 4. The mechanic outer sleeve 4 which carries the heater 2 and the housing 10 can be secured together firmly without requiring a high precision in the internal diameter of the housing 10, allowing a reduction in the manufacturing cost.

FIG.1

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a glow plug which is used as a starting aid for a diesel engine, and in particular, to a glow plug for a diesel engine which is characterized in the technique to secure a sheath which carries a heater to a housing which serves as a fitting hardware to a cylinder head of an engine and a method of manufacturing such glow plug.

### BACKGROUND ART

**[0002]** A glow plug for a diesel engine is generally constructed such that a heater is carried within a metallic sheath, one end of which is inserted into a front end of a fitting hardware (cylindrical housing) to a cylinder head of an engine to be secured therein and one of the electrodes of the heater is electrically connected to the sheath while the other electrode is taken outside through an electrode fitting to be electrically connected to an external connection terminal which is secured to the other end of the housing with an insulator interposed therebetween.

**[0003]** In the described glow plug for a diesel engine, a silver brazing or a press fit is used as a technique to secure the sheath which carries the heater and the housing together. When the sheath and housing are secured together by a brazing operation, a small clearance is previously formed between the inner peripheral surface of the housing and the outer peripheral surface of the sheath, and a molten brazing material is cast into the clearance to bond the housing and the sheath together. When a press fit is used, the internal bore of the housing is formed with an area of a diameter which is slightly less than the outer diameter of the sheath so that the sheath can be placed as a press fit into this area to be secured therein.

**[0004]** When the sheath which carries the heater is to be secured within the housing by the brazing operation, there must be provided a clearance between the inner peripheral surface of the housing and the outer peripheral surface of the sheath into which the brazing material can flow. Accordingly, this arrangement is liable to a misalignment, and there remains a problem that it is difficult to achieve an accurate alignment between the housing and the heater. In addition, repeated application of high heat may give rise to a likelihood that the sheath which carries the heater may slide into the housing or may move out of the housing.

**[0005]** Where the sheath is secured within the housing by the press fit technique, it is necessary to machine the internal diameter and the length of the portion of the housing into which the sheath is to be placed to a high precision. Normally, the internal bore of the housing is machined by a cutting operation, and accordingly, this requires an expensive machining cost of the housing. In addition, in order to change the distance from the distal end of the heater to the sheet surface formed on the front end of the housing which is to be placed in abutment against the cylinder head in accordance with the performance demanded, the portion inside the internal bore of the housing where the sheath is to be placed must be formed at different locations, requiring a variety of housings which must be machined according to the specifications, which result in high costs. If a scoring occurs in the portion of the housing where the sheath is to be placed, the load which must be applied to place the sheath as a press fit into the housing increases, with consequence that the heater or the housing may be damaged.

**[0006]** The present invention has been made to overcome described problems and has for its object the provision of a glow plug for a diesel engine which is free from the likelihood of a misalignment occurring between a sheath which carries a heater and a housing as when the both members are secured together by a brazing operation and which provides a strong axial retention and a method of manufacturing such glow plug.

**[0007]** It is another object of the present invention to provide a glow plug for a diesel engine which allows a housing to be machined inexpensively and which is free from the likelihood of damaging a heater when a sheath is placed as a press fit and a method of manufacturing such glow plug.

### DISCLOSURE OF THE INVENTION

**[0008]** A glow plug for a diesel engine according to the invention defined in Claim 1 includes a cylindrical housing having an internal bore into which one end of a sheath which carries a heater is inserted to be secured therein and wherein a plastic working is applied to the outer peripheral surface of the housing to form an annular projection on the internal surface thereof and an annular recess in the outer surface of the sheath as a result of the plastic working applied through the housing, the annular projection and the annular recess fitting each other to secure the housing and the sheath together.

**[0009]** In the glow plug for a diesel engine according to the present invention, the annular projection on the housing and the annular recess in the sheath which are formed by the application of the plastic working are firmly in engagement with each other, avoiding the likelihood that the sheath may move axially relative to the housing or that the sheath may slide into or out of the housing. There is no likelihood of a misalignment occurring between the housing and the sheath. There is no need to machine the internal bore of the housing to a high precision, which can be machined with a low cost.

**[0010]** According to the invention defined in Claim 2, the annular projection and the annular recess which are formed by the application of the plastic working are characterized by surfaces which run parallel to the axis of

the housing.

**[0011]** According to the invention defined in Claim 3, the angular projection and the annular recess which are formed by the application of the plastic working are characterized by surfaces which are disposed at angles with respect to the axis of the housing.

**[0012]** According to the invention defined in Claim 3, the annular projection and the annular recess have diameters which continuously change from a larger diameter to a smaller diameter, allowing a hermetic seal to be maintained between the housing and the sheath in a facilitated manner than when they have a uniform diameter along the entire axial length.

**[0013]** According to the invention defined in Claim 4, the annular projection and the annular recess which are formed by the application of the plastic working are provided at a plurality of axially spaced locations.

**[0014]** The invention defined in Claim 5 relates to a method of manufacturing a glow plug for a diesel engine including a cylindrical housing having an internal bore, into which one end of a sheath which carries a heater is inserted to be secured therein, comprising the steps of inserting one end of the sheath into the internal bore of the housing, positioning a front end of the heater which is carried by the sheath and a sheet surface on the housing which is to be placed in abutment against the cylinder head, and then applying a plastic working to the outer peripheral surface of the housing to form an annular projection on the inner surface of the housing and an annular recess in the outer surface of the sheath which receives the annular projection as a fitting engagement, thus securing the sheath to the housing.

**[0015]** According to the method of the present invention, the annular projection on the housing and the annular recess in the sheath which are formed by the application of the plastic working are firmly in engagement with each other in the glow plug for a diesel engine manufactured, and accordingly, there is no likelihood that the sheath may move axially relative to the housing or that a misalignment between the sheath and the housing may occur. There is no need for the housing to be machined to a high precision, and thus the housing can be machined at a low cost. When the heater and the housing are joined together, a distance between the distal end of the heater and the sheet surface on the housing can be chosen as desired, allowing glow plugs having different performances to be manufactured using a housing and a heater of a single size.

**[0016]** A method of manufacturing a glow plug for a diesel engine according to the invention defined in Claim 6 is characterized in that when one end of the sheath is inserted into the internal bore of the housing and the plastic working is applied to the outer peripheral surface of the housing, an annular proj ection is formed on the inner surface of the housing and an annular recess which receives the annular projection as a fitting engagement is formed in the outer surface of the sheath, thus securing the sheath to the housing while simultaneously forming a sheet surface which is to be disposed in abutment against the cylinder head on the distal end surface of the housing.

**[0017]** According to the method of the invention defined in Claim 6, when the housing and the heater are joined together by the application of the plastic working, the sheet surface is simultaneously formed on the housing, allowing the dimensional accuracy of a distance between the distal end of the heater to the sheet surface of the housing to be further improved.

**[0018]** A method of manufacturing a glow plug for a diesel engine according to the invention defined in Claim 7 comprises the steps of inserting one end of a sheath into a internal bore of a housing, interposing an insulator between the inner surface of the housing and the outer surface of the sheath and positioning the distal end of a heater which is carried by the sheath and a sheet surface on the housing which is to be disposed in abutment against a cylinder head, and then applying a plastic working to the outer surface of the housing to form an angular projection on the inner surface of the housing, thereby allowing the sheath to be secured to the housing through the interposed insulator.

**[0019]** In the glow plug for a diesel engine which is manufactured according to the method defined in Claim 7, the insulator is interposed between the inner surface of the housing and the outer surface of the sheath to secure them together while maintaining them insulated from each other, and accordingly, the glow plug can be directly used as an ion sensor.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0020]**

Fig. 1 is a longitudinal section of a glow plug for a diesel engine according to one embodiment of the present invention;

Fig. 2 is an enlarged view of an essential part (part A shown in Fig. 1) of the glow plug;

Fig. 3 is a longitudinal section illustrating an assembling step of the glow plug;

Fig. 4 is a longitudinal section which illustrates a next following step;

Fig. 5 is a longitudinal section illustrating a step which follows the step shown in Fig. 4;

Fig. 6 is a longitudinal section of a glow plug for a diesel engine according to a second embodiment of the present invention;

Fig. 7 is a longitudinal section illustrating an assembling step of the glow plug of the second embodiment;

Fig. 8 is a longitudinal section illustrating a step which follows the step shown in Fig. 7; and

Fig. 9 is a circuit diagram showing an electrical circuit operating the glow plug of the second embodiment.

BEST MODES OF CARRYING OUT THE INVENTION

**[0021]** Several embodiments of the present invention will now be described with reference to the drawings. Fig. 1 is a longitudinal section of a glow plug for a diesel engine, generally indicated by numeral 1, according to one embodiment of the present invention, and Fig. 2 is an enlarged view of an essential part (part A shown in Fig. 1) thereof. The glow plug 1 of this embodiment represents a ceramics heater glow plug which employs a ceramics heater 2 as a heating element. The construction of the ceramics heater 2 is well known in the art, and therefore is not shown in detail. Briefly, the ceramics heater 2 includes a body portion comprising a ceramics insulator, in which a heating wire in the form of a coil of a high melting metal (such as tungsten W) is embedded. One end of the heating wire is connected to a negative pole lead wire while the other end is connected to a positive pole lead wire. The negative pole lead wire is taken to the outer side of the ceramics insulator, and is electrically connected by being joined by a brazing operation to the internal surface of a sheath (metallic outer sleeve) 4 which will be described later. On the other hand, the positive pole lead wire extends to the opposite end from the position where the heating wire is embedded (left end as viewed in Fig. 1) and is electrically connected by a brazing operation to the distal end of an electrode fitting 6 within a mounting hole 2b which is formed in the opposite end face. The other end of the electrode fitting 6 is secured to the distal end of an external connection terminal 8.

**[0022]** The ceramics heater 2 constructed in the manner mentioned above is joined inside the sheath (metallic outer sleeve) 4 by a brazing operation, and is then secured to a cylindrical housing 10 which serves as a fitting hardware to a cylinder head through the metallic outer sleeve 4. In this embodiment, the metallic outer sleeve 4 has a front end 4a which is slightly reduced in diameter and which is followed rearwardly by a portion 4b of a greater diameter. A rear portion of the ceramics heater 2 is inserted into the portion 4a of a reduced diameter and is joined thereto as by brazing. At its front end (left end as viewed in Fig.1), the housing 10 is formed with a sheet surface 10a which is to be disposed in abutment against a cylinder head of an engine, and the housing 10 is also formed with threads 10b which are used in mounting the housing on the cylinder head toward the rear end where a tightening nut 10c is formed.

**[0023]** The external connection terminal 8 which is electrically connected to the positive pole lead wire of the ceramics heater 2 through the electrode fitting 6 is swaged at its one end, whereby it is secured within the metallic outer sleeve 4. This swaging step which secures the external connection terminal 8 will be briefly described. Initially, the electrode fitting 6 is inserted into the mounting hole 2b formed in the ceramics heater 2 and is joined together with the positive pole lead wire of the ceramics heater 2 by a brazing operation, and the ceramics heater 2 is secured by a brazing operation to the end of the metallic outer sleeve 4 which is located toward the portion 4a of a reduced diameter 4. It should be understood that at this time, the heater portion 2a toward the distal end of the ceramics heater 2 where the heating wire is embedded is exposed outside the metallic outer sleeve 4.

**[0024]** After the ceramics heater 2 is secured within the portion 4a of a reduced diameter of the metallic outer sleeve 4, the distal end of the external connection terminal 8 is inserted into an opening 4c formed in the portion 4b of a greater diameter of the metallic outer sleeve 4 to be joined to the other end of the electrode fitting 6. Subsequently, a refractory insulating powder (such as magnesia MgO, for example) 12 is filled through the opening 4c in the metallic outer sleeve 4 into a space where a junction between the electrode fitting 6 and the external connection terminal 8 is contained. Subsequently, a seal member formed of rubber (silicone rubber or flourine-contained rubber) is fitted into the opening 4c of the metallic outer sleeve 4. When the seal member 14 is fitted into the opening 4c of the metallic outer sleeve 4, a spilling of the refractory insulating powder 12 can be prevented during a swaging operation which takes place at a subsequent step, and the electrode fitting 6 can be prevented from moving into contact with the metallic outer sleeve 4.

**[0025]** The portion 4b of a greater diameter of metallic outer sleeve 4 where the junction between the electrode fitting 6 and the external connection terminal 8 is contained is then subject to a swaging operation to reduce the outer diameter of the metallic outer sleeve 4 while densifying the refractory insulating powder 12 to secure the external connection terminal 8 within the metallic outer sleeve 4.

**[0026]** The metallic outer sleeve 4 in which the ceramics heater 2, the electrode fitting 6 and the external connection terminal 8 are secured has its rear portion 4b of a greater diameter placed into the cylindrical housing 10 to be secured therein. In this embodiment, a portion of the housing 10 which is located short of the distal end is located around the outer periphery of part of the portion 4b of a greater diameter of the metallic outer sleeve 4 which is disposed toward the portion 4a of a reduced diameter and this portion is subject to the swaging operation from the outer periphery of the housing 10 (portion being swaged being indicated by a character S), whereby an annular projection 10d (see Fig. 2 which illustrates the part A shown in Fig. 1 to an enlarged scale) is formed on the inner periphery of the housing and an annular recess 4c is formed in the outer periphery of the metallic outer sleeve 4 simultaneously. It will be seen that the annular projection 10d on the housing 10 and the annular recess 4c in the metallic outer sleeve 4 fit each other. In this manner, the annular projection 10d and the annular recess 4d which are formed by the application of the swaging operation fit each other in close

contact with each other, thus securing the housing 10 and the metallic outer sleeve 4 together and also maintaining a hermetic seal therebetween.

**[0027]** When the swaging operation is applied to the outer periphery of the housing 10 in the manner mentioned above, the housing 10 and the metallic outer sleeve 4 are secured together and are perfectly in close contact with each other, thus preventing any likelihood of a misalignment occurring therebetween. A hermetic seal between the housing 10 and the metallic outer sleeve 4 is reliably maintained. Since the annular projection 10d and the annular recess 4c are firmly in engagement with each other, there is obtained a strong axial retention, preventing the ceramics heater 2 which is carried within the metallic outer sleeve 4 from moving out of the housing 10 or moving deeper into the housing 10.

**[0028]** Steps to assemble the glow plug 1 constructed in the manner mentioned above will now be described with reference to Figs. 1, 2 and 3 to 5. First of all, an assembly including the ceramics heater 2, the electrode fitting 6 and the external connection terminal 8 which are secured within the metallic outer sleeve 4 is inserted into an internal bore of the housing 10 at its distal end (which is located toward the sheet surface 10a), with the threads 8a on the external connection terminal 8 placed first (see Fig. 3). Before the assembly, the entire internal bore 16 of the housing 10 has an internal diameter which allows the portion 4b of a greater diameter of the metallic outer sleeve 4 to pass therethrough.

**[0029]** As mentioned above, the external connection terminal 8 is inserted into the internal bore 16 of the housing 10 with the threads 8a first, and the portion 4b of a greater diameter of the metallic outer sleeve 4 is then inserted into the internal bore 16 of the housing 10. The distal end of the housing 10 is formed with the sheet surface 10a which is to be disposed in abutment against the cylinder head of the engine, and the sheet surface 10a and the ceramics heater 2 are positioned so that a distance L1 between the sheet surface 10a and the distal end of the ceramics heater 2 has a given value (see Fig. 4).

**[0030]** Under this condition, a swaging operation is applied to the outer periphery of the housing 10 at a location which is short of the distal end thereof (indicated by character S in Fig. 5). As illustrated to an enlarged scale in Fig. 2, the application of the swaging operation depresses the outer peripheral surface of the housing 10, forming the annular projection 10d on the inner surface thereof. The swaging operation acts through the plastic deformation of the housing 10 to form the annular recess 4c in the outer surface of the metallic outer sleeve 4. Thus, the swaging operation results in the housing 10 and the metallic outer sleeve 4 being engaged firmly in close contact with each other and joined together.

**[0031]** In this embodiment, it is sufficient that the internal bore 16 of the housing 10 has an internal diameter which is slightly greater than the outer diameter of the portion 4b of the metallic outer sleeve 4 so that such portion can pass through the internal bore 16, and any further accuracy of machining is not required. Accordingly, this machining operation can be achieved with a very low cost as compared with the cost required when the sheath is disposed as a press fit in the housing. Since the distance L1 between the sheet surface 10a on the housing 10 and the distal end of the ceramics heater 2 can be chosen as desired when they are joined together, it follows that a housing 10 and a ceramics heater 2 of a given single size may be used to manufacture glow plugs 1 of various performances, thus reducing the cost of manufacturing the glow plug. In addition, there is no likelihood of damaging the ceramics heater 2 which would be the case if the heater is secured by the press fit technique.

**[0032]** In the embodiment described above, the outer peripheral surface of the housing 10 has been swaged to cause both the housing 10 and the metallic outer sleeve 4 to be deformed simultaneously to be secured together, but the plastic working is not limited to the swaging operation mentioned above. For example, a thread rolling operation may also be used to form an annular projection 10d and an annular recess 4c which fit each other on the housing 10 and the metallic outer sleeve 4, respectively. In the prior art practice, a solid steel material has been used to manufacture a housing having an internal bore by a cutting operation, but no machining of an internal bore 16 to any particular precision is required in the housing 10 in the present embodiment, and accordingly, an inexpensive pipe material may be used and threads 10b which are used in mounting the glow plug on the engine, the rear end nut 10c and the front end sheet surface 10a may be formed thereon as by thread rolling operation, allowing a further reduction in the cost required.

**[0033]** In the glow plug 1 of the embodiment described above, the deformed portion which is formed by the plastic working is formed by a surface which runs parallel to the axis of the housing 10. Specifically, the swaged portion S has a uniform diameter lengthwise of the housing 10. However, the annular projection 10a and the annular recess 4c are not limited to such ones which have a uniform diameter lengthwise, but the diameter may change continuously, thus forming the annular projection 10a and the annular recess 4c by surfaces which are disposed at angles with respect to the axis of the housing 10.

**[0034]** As mentioned above, the distal end of the housing 10 is formed with the sheet surface 10a which is used in mounting the glow plug to the cylinder head of the engine. However, rather than forming the sheet surface previously on the housing 10 as described above in connection with the embodiment, it is also possible to form the sheet surface 10a at the same time as the housing 10 and the metallic outer sleeve 4 are secured together by the application of the plastic working

such as the swaging or thread rolling operation. When the sheet surface 10a is concurrently formed on the housing 10, the dimensional accuracy between the distal end of the ceramics heater 2 and the sheet surface 10a on the housing 10 can be improved.

**[0035]** It is also to be noted that the exfoliation of the antirust plating on the housing 10 can be prevented during the swaging operation by providing a smooth curvature between the swaged portion and adjacent portions of the housing 10.

**[0036]** In the above description, the interior of the metallic outer sleeve 4 is filled with the refractory insulating powder 12 before the swaging operation takes place in order to fix the external connection terminal 8 which is connected to the electrode fitting 6 within the metallic outer sleeve 4, but this swaging operation can be dispensed with, and the swaging operation which takes place for purpose of applying the plastic working may also serve the swaging operation which is used to fix the housing 10 and the metallic outer sleeve 4 together. In this instance, because there is no demand on the hermetic seal, and what is required is that the positive pole electrode be reliably secured, there is no problem in dispensing with this swaging operation, contributing to a further cost down.

**[0037]** Fig. 6 is a longitudinal section of a glow plug 101 for a diesel engine according to a second embodiment of the present invention. The glow plug 101 comprises the glow plug 1 mentioned above which is integrally combined with an ion sensor which detects an ion current to detect a condition of combustion of the engine.

**[0038]** The glow plug 101 includes a ceramics heater 102 including a ceramics insulator 102a in which a heating element 102b is embedded. One end of the heating element 102b is connected to a negative pole lead wire 102c while the other end is connected to a positive pole lead wire 102d. To serve as an ion detecting electrode, the heating element 102b has a distal end 102ba which is exposed outside the ceramics insulator 102a.

**[0039]** The negative pole lead wire 102c is taken out through the lateral side of the ceramics insulator 102a to be electrically connected to the inner surface of a sheath (metallic outer sleeve) 104 while the positive pole lead wire 102d is electrically connected to one end of an electrode fitting 106 inside the ceramics insulator 102a. The other end of the electrode fitting 106 is connected to an external connection terminal 108.

**[0040]** In contradistinction to the first embodiment, the metallic outer sleeve 104 in which the ceramics heater 102 is secured has a greater overall length than a housing 110, and has an end 104e which is opposite from a distal end 104d in which the ceramics heater 102 is secured and which extends to the rear end of the housing 10 when the metallic outer sleeve is secured to the housing 110. The interior of the metallic outer sleeve 104 is filled with a refractory insulating powder 112, which is swaged to be densified, thus securing the external connection terminal 108 and insulating the external connection terminal 108 which is connected to the positive pole from the metallic outer sleeve 104 which is connected to the negative pole.

**[0041]** The metallic outer sleeve 104 having the ceramics heater 102 secured in its one end 104d and having the external connection terminal 108 which extends toward the other end 104e is inserted into an internal bore 116 of the cylindrical housing 110 to be secured therein. An insulator 118 is inserted between the inner surface of the housing 110 at a location toward its distal end and the outer surface of the metallic outer sleeve 104 to provide an electrical insulation between the housing 110 and the metallic outer sleeve 104. In this embodiment, in a region which is filled with the insulator 118, the outer periphery of the housing 110 is subject to a swaging operation (indicated by character S in Fig. 6) to form an annular projection 110d on the inner periphery. The metallic outer sleeve 104 is secured within the housing 110 in the region S where the swaging operation has taken place.

**[0042]** Steps to assemble the glow plug 101 which is integrally provided with the ion sensor will now be describe with reference to Figs. 6, 7 and 8. An assembly integrally including the ceramics heater 102, the electrode fitting 106 and the external connection terminal 108 which are carried within the metallic outer sleeve 104 is inserted into the distal end of the housing 110 (or the end located toward the ceramics heater 102) with threads 108a on the external connection terminal 108 placed first (see Fig. 7).

**[0043]** After positioning the ceramics heater 102 and the housing 110 so that the distal end of the ceramics heater 102 is spaced by a given distance L2 from a sheet surface 110a formed on the distal end of the housing 110 and which is to be disposed in abutment against the cylinder head, a seal member 120 is fitted between the distal end of the housing 110 and the outer periphery of the metallic outer sleeve 104, and the refractory insulating powder 118 is filled into the housing 110 through a rear opening thereof, and a seal member 122 is fitted (see Fig. 8). Subsequently, the outer periphery of the housing is subject to a swaging operation in a region which is filled with the refractory insulating powder 118 to cause a plastic deformation of the housing 110, thus forming an annular projection 110d on its inner peripheral surface and densifying the refractory insulating powder 118 to secure the metallic outer sleeve 104 in place (a condition shown in Fig. 6).

**[0044]** In the glow plug 101 which integrally incorporates the ion sensor, the metallic outer sleeve 104 which is electrically connected to the negative pole lead wire 102c of the ceramic house 102 is connected to a negative terminal 124 at the rear end of the housing 110 while the external connection terminal 108 which is electrically connected to the positive pole lead wire 102d through the electrode fitting 106 is connected to a positive terminal 126. An insulating ring 128 is interposed between

the negative terminal 124 which is electrically connected to the metallic outer sleeve 104 and the housing 110, and an insulator 130 is interposed between the negative terminal 124 and the positive terminal 126 to provide an electrical insulation.

**[0045]** As shown in Fig. 9, the positive terminal 126 is connected to a positive pole of a battery 132 through a first relay 134A, and the negative terminal 124 is connected to the negative pole of the battery 132 through a second relay 134B. In this manner, an electrical circuit for the glow plug is formed by the positive pole of the battery 132, the first relay 134A, the positive terminal 126, the external connection terminal 108, the electrode fitting 106, the positive pole lead wire 102d of the ceramics heater 102, the heating element 102b, the negative pole lead wire 102c, the metallic outer sleeve 104, the negative terminal 124, the second relay 134 and the negative pole of the battery 132.

**[0046]** The housing 110 is secured to the cylinder head 136 of the engine, and the negative pole of the battery 132 is connected to the cylinder head 136 as the electrical ground. Current detecting means 138 and a sensor relay 140 are connected between the positive pole of the battery 132 and the positive terminal 126 of the glow plug 101. In this manner, an electrical circuit for the ion sensor is completed by the positive pole of the battery 132, the current detecting means 138, the sensor relay 140, the positive terminal 126, the external connection terminal 108, the electrode fitting 106, the heating element 102b which serves as an ion detecting electrode and the ground connection to the cylinder head 136.

**[0047]** When the glow plug 101 integrally incorporating the ion sensor is to function as the glow plug, the first and the second relay 134A and 134B are turned on while the sensor relay 140 is turned off. There occurs a current flow through the electrical circuit for the glow plug, causing a heating of the heating element 102b to preheat the engine.

**[0048]** When the glow plug 101 is to function as the ion sensor, the glow plug relays 134A and 134B are turned off while the ion sensor relay 140 is turned on. A voltage is generated between the heating element 102b of the ceramics heater 102 which functions as an ion detecting electrode and the cylinder head 136, causing ions within a combustion chamber which are generated during the combustion of the engine to produce a current flow through the sensor electrical circuit. The current detecting means 138 detects this current flow to provide a feedback control of the engine.

**[0049]** With the glow plug 101 for a diesel engine according to the second embodiment, the construction of the housing 110 is simplified in the similar manner as in the first embodiment, allowing the housing 110 to be manufactured inexpensively. Also, the distance L2 between the sheet surface 110a on the housing 110 which is to be disposed in abutment against the cylinder head 136 and the distal end of the ceramics heater 102 can be chosen as desired without requiring a modification in the configuration of the housing 110, allowing a significant cost-down.

**[0050]** It is to be noted that the insulator interposed between the housing 110 and the metallic outer sleeve 104 is not limited to the refractory insulating powder 118 which is densified by the swaging operation, but may comprise a resin or any other insulator.

**[0051]** While the embodiments have been described above in connection with ceramics heater glow plugs 1, 101 using ceramics heaters 2, 102 as heating elements, it should be understood that the invention is not limited to the use of a ceramics heater, but is equally applicable to a glow plug which uses a metallic heater.

## Claims

1. A glow plug for a diesel engine including a cylindrical housing having an internal bore, into which one end of a sheath which carries a heater is inserted to be secured therein;

   wherein a plastic working is applied to the outer peripheral surface of the housing to form an annular projection on the inner surface of the housing and an annular recess in the outer surface of the sheath, the annular projection and the annular recess fitting each other, whereby the housing and the sheath are secured together.

2. A glow plug for a diesel engine according to Claim 1 in which the annular proj ection and the annular recess which are formed by the application of the plastic working are formed by surfaces which run parallel to the axis of the housing.

3. A glow plug for a diesel engine according to Claim 1 in which the annular proj ection and the annular recess which are formed by the application of the plastic working are formed by surfaces which are disposed at angles with respect to the axis of the housing.

4. A glow plug for a diesel engine according to Claim 1 in which the annular projection and the annular recess which are formed by the application of the plastic working are provided at a plurality of axial locations.

5. A method of manufacturing a glow plug for a diesel engine including a cylindrical housing having an internal bore, into which one end of a sheath which carries a heater is inserted to be secured therein;

   comprising the steps of

   inserting one end of the sheath into the internal bore of the housing;

   positioning a distal end of the heater which is carried by the sheath and a sheet surface on the

housing which is to be disposed in abutment against a cylinder head;

subsequently applying a plastic working to the outer peripheral surface of the housing to form an angular proj ection on the inner surface of the housing and an annular recess in the outer surface of the sheath, the annular projection fitting in the annular recess to secure the sheath to the housing.

**6.** A method of manufacturing a glow plug for a diesel engine including a cylindrical housing having an internal bore, into which one end of a sheath which carries a heater is inserted to be secured therein;

comprising the steps of

inserting one end of the sheath into the internal bore of the housing;

and applying a plastic working to the outer peripheral surface of the housing to form an angular projection on the inner surface of the housing and an annular recess in the outer surface of the sheath which is fitted by the annular projection to thereby secure the sheath to the housing and concurrently to form a sheet surface on the housing which is to be disposed in abutment against a cylinder head.

**7.** A method of manufacturing a glow plug for a diesel engine including a cylindrical housing having an internal bore, into which one end of a sheath which carries a heater is inserted to be secured therein;

comprising the steps of

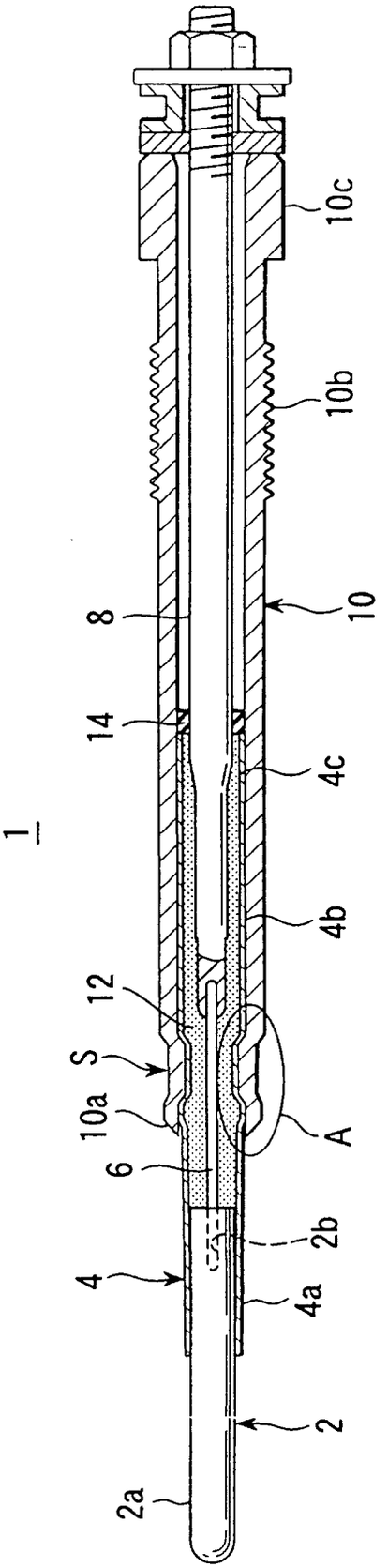
inserting one end of the sheath into the internal bore of the housing;

interposing an insulator between the inner surface of the housing and the outer surface of the sheath;

positioning a distal end of the heater which is carried by the sheath and a sheet surface on the housing which is to be disposed in abutment against a cylinder head;

and applying a plastic working to the outer peripheral surface of the housing to form an annular projection on the inner surface of the housing, thereby causing the sheath to be secured to the housing through the insulator.

FIG.1


1
10c
10b
8
10
14
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4b
12
S
10a
A
6
2b
4
4a
2
2a

FIG.2

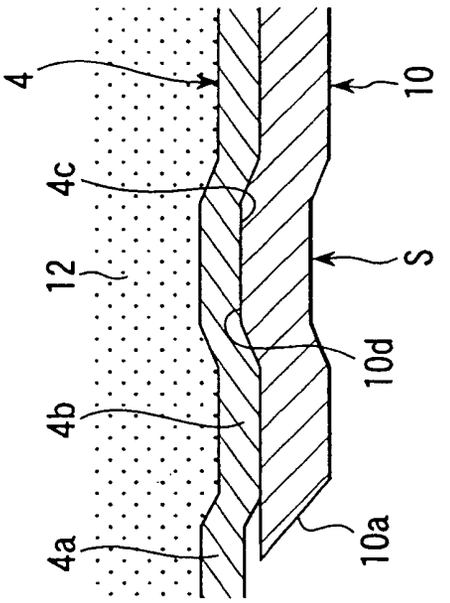

4
10
4c
12
S
10d
4b
4a
10a

FIG.3

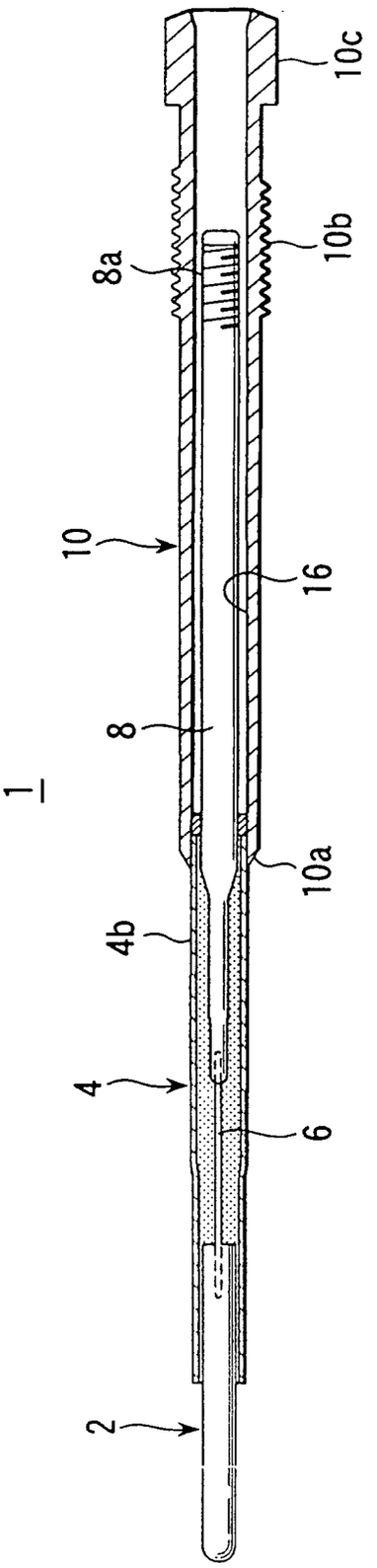



FIG.4

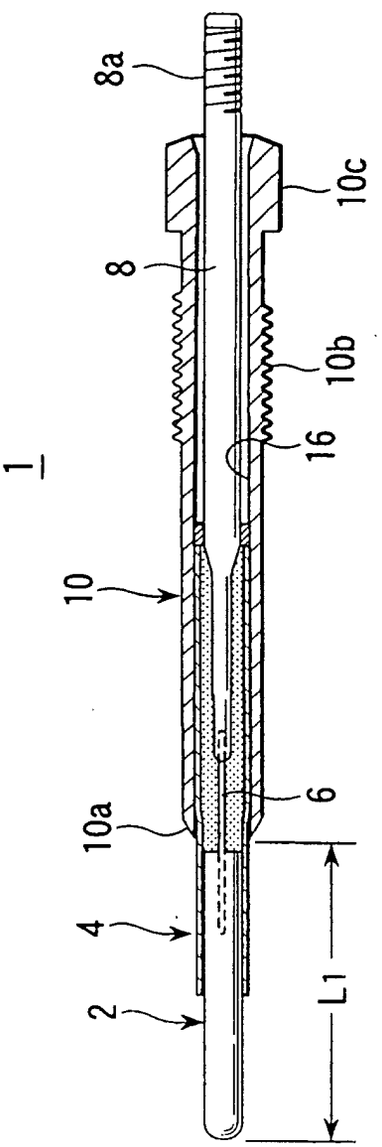
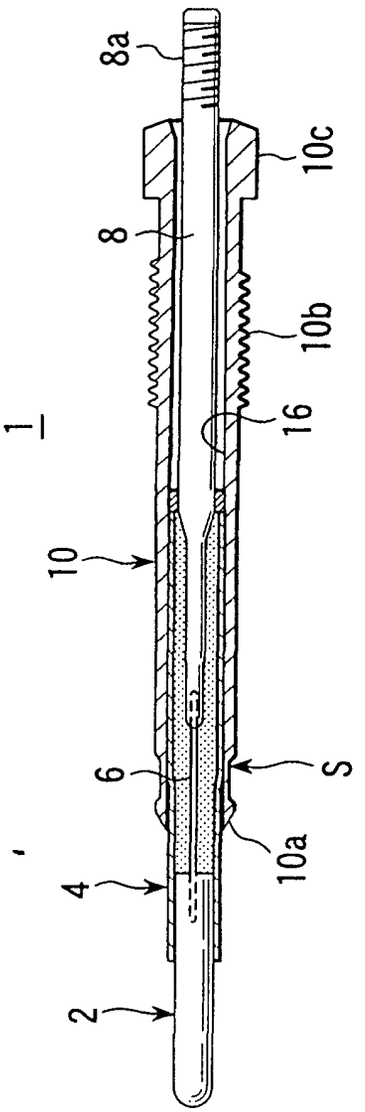


FIG.5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8a
10c
8
10b
16
10
6
S
10a
4
2

FIG.6

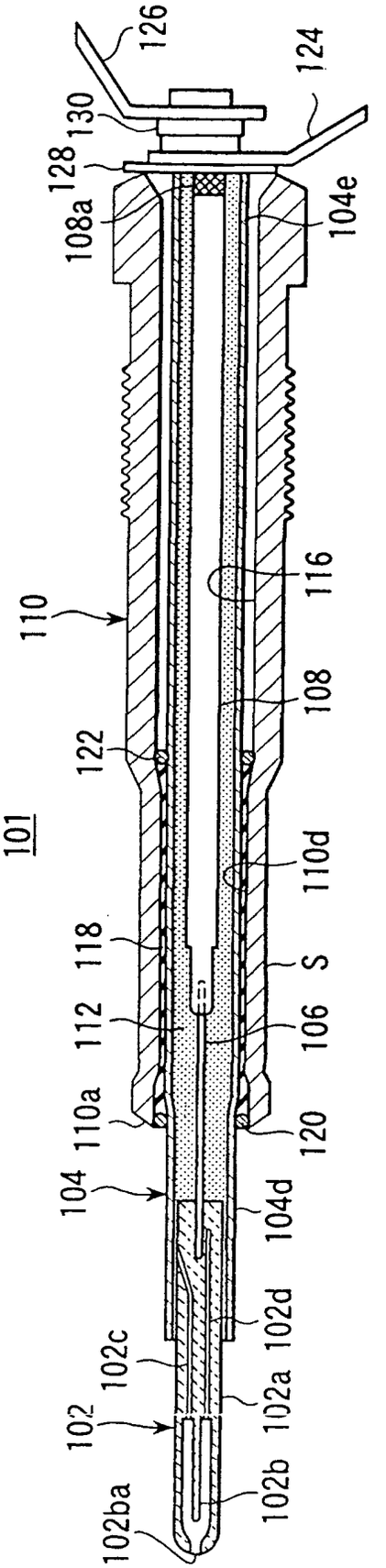
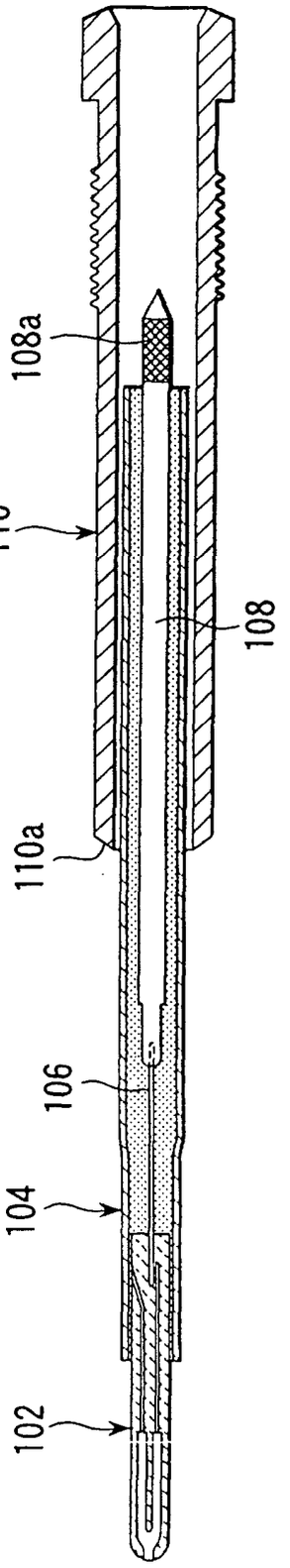

126
124
130
128
108a
104e
110
116
108
122
101
110d
118
S
112
106
110a
120
104
104d
102d
102c
102a
102
102b
102ba

FIG.7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102
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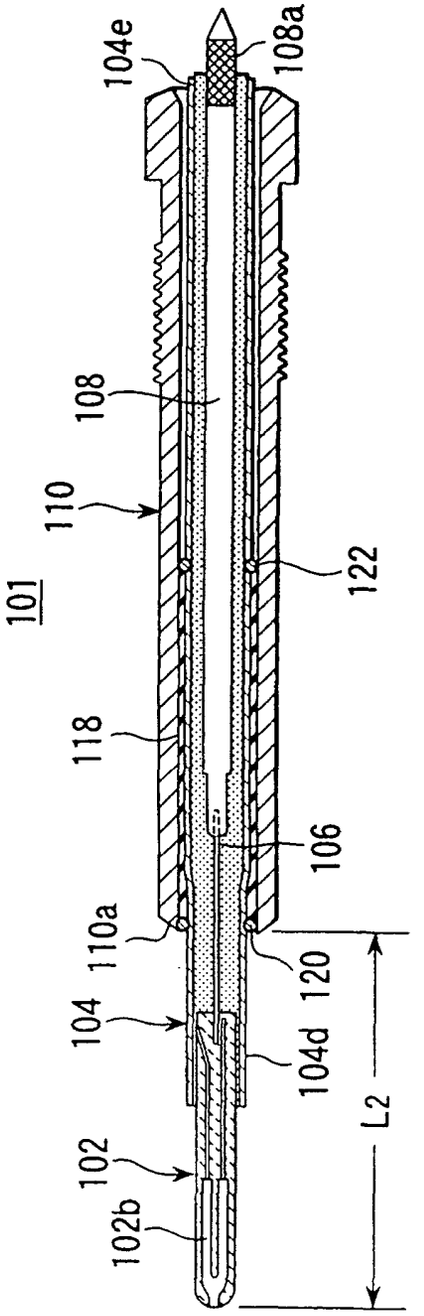
108
108a
110
110a

FIG.8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102b
104
104d
104e
106
108
108a
110
110a
118
120
122
L2

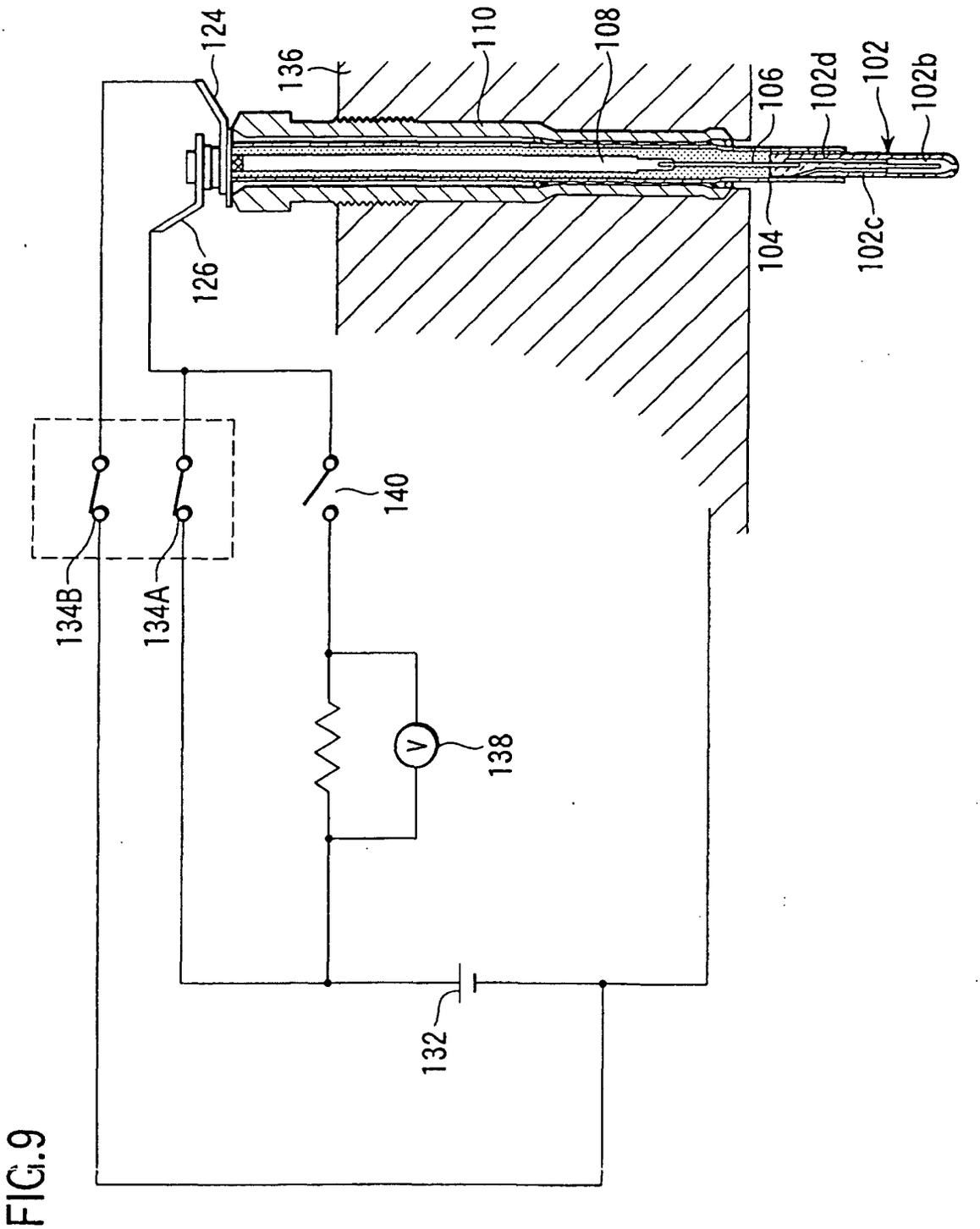
124
136
110
108
106
102d
102
102b
126
104
102c
140
134B
134A
138
132

FIG.9

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/11146

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F23Q7/00, H05B3/44

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)
Int.Cl[7] F23Q7/00, H05B3/44

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

| | | | |
|---|---|---|---|
| Jitsuyo Shinan Koho | 1940-1996 | Toroku Jitsuyo Shinan Koho | 1994-2003 |
| Kokai Jitsuyo Shinan Koho | 1971-2003 | Jitsuyo Shinan Toroku Koho | 1996-2003 |

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 | JP 58-000022 A (NGK Spark Plug Co., Ltd.), 05 January, 1983 (05.01.83), Full text; Figs. 1 to 4 (Family: none) | 1-7 |
| Y | EP 1055878 A2 (DENSO CORP.), 29 November, 2000 (29.11.00), Full text; Figs. 1 to 8 & JP 2001-041452 A Full text; Figs. 1 to 8 | 1-7 |
| Y | JP 2001-108236 A (NGK Spark Plug Co., Ltd.), 20 April, 2001 (20.04.01), Full text; Figs. 1 to 7 (Family: none) | 1-7 |

☒ 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
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"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 |
|---|---|
| 28 January, 2003 (28.01.03) | 12 February, 2003 (12.02.03) |
| Name and mailing address of the ISA/ Japanese Patent Office | Authorized officer |
| Facsimile No. | Telephone No. |

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## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/11146

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | JP 57-040866 U (NGK Spark Plug Co., Ltd.),<br>05 March, 1982 (05.03.82),<br>Full text; Figs. 1 to 2<br>(Family: none) | 1-7 |

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