



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 1 207 349 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

22.05.2002 Bulletin 2002/21

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

(21) Application number: 01126433.0

(22) Date of filing: 08.11.2001

(84) Designated Contracting States:

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR

Designated Extension States:

AL LT LV MK RO SI

(30) Priority: 13.11.2000 JP 2000345654

03.08.2001 JP 2001236926

(71) Applicant: Bosch Automotive Systems
Corporation
Tokyo (JP)

(72) Inventors:

- Tanaka, Arihito,
Bosch Automotive Systems Corp.
Higashimatsuyama-shi, Saitama-ken (JP)

- Aota, Takashi, Bosch Automotive Systems Corp.
Higashimatsuyama-shi, Saitama-ken (JP)
- Zhao, Jian, Bosch Automotive Systems Corp.
Higashimatsuyama-shi, Saitama-ken (JP)
- Miura, Toshitsugu,
Bosch Automotive Systems Corp.
Higashimatsuyama-shi, Saitama-ken (JP)

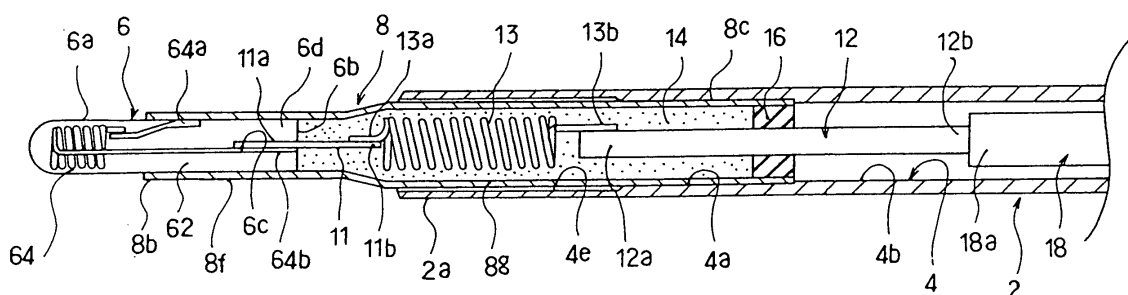
(74) Representative: HOFFMANN - EITLE
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) Ceramics glow plug and method of manufacturing same

(57) Toward an end 6d of a ceramics heater 6, a coiled heating element 64 formed of a high melting point metal and a control coil 13 having a greater positive temperature coefficient of resistance than the heating element 64 are connected together through a lead wire 11, and the other end 13b of the control coil is connected to an electrode fitting 12. The ceramics heater 6 is cemented within a reduced diameter portion 8f of a metallic outer sleeve 8 by brazing while the control coil 13 and its junction 12a, 13b with the electrode fitting 12 are contained within an increased diameter portion 8g of the

metallic outer sleeve 8. A heat resistant insulating powder 14 is filled into a space 15 located within the increased diameter portion 8g of the metallic outer sleeve 8, a seal member 16 is fitted into an opening 4d, and an end 8e is caulked before applying a swaging operation to the metallic outer sleeve. Subsequently, the electrode fitting 12 is welded to an external connection terminal 18, and a resulting assembly is assembled into a housing 2. An ease of assembly of a self-controlled ceramics glow plug 1 is improved while allowing a reduction in the cost.

FIG.2



Description

Background of the invention

[0001] The invention relates to a glow plug which is used as a startup aid for a diesel engine, and in particular, a self controlled ceramics glow plug with a self-temperature controlling coil (or brake coil) and a ceramics glow plug which allows for a correction of a deviation in the resistance of a ceramics heater in a facilitated manner.

[0002] A ceramics glow plug is known in the art which comprises a ceramics heater provided as a compound of an insulating ceramics material and a heating element in the form of an inorganic conductor, as may be obtained by embedding a coil of a high melting point metal, such as tungsten, for example, or a heating element formed of electrically conductive ceramics in electrically insulating ceramics or by partly exposing the conductive ceramics heating element, a metallic outer sleeve in which the ceramics heater is secured by brazing, a lead wire associated with a negative electrode of the heating element and extending through a lateral side of the insulating ceramics to be electrically connected to the internal surface of the outer sleeve, a lead wire associated with a positive electrode of the heating element and extending through an end face of the insulating ceramics which is located opposite from the end which contains the heating element to be connected to one end of an electrode fitting, and an external terminal connected to the other end of the electrode fitting.

[0003] A self-temperature controlling ceramics glow plug is heretofore extensively used which includes a control coil or a coil of a high melting point metal which has a greater positive temperature coefficient of resistance than the heating element in the ceramics glow plug and connected in series with the heating element. In the self-controlled ceramics glow plug, the heating element is disposed in the distal end of the glow plug while the control coil is disposed rearwardly thereof.

[0004] With the self-controlled ceramics glow plug, both the heating element and the control coil have small resistances at low temperatures, and accordingly, a high current flows through the heating element and the control coil and there occurs a rapid temperature rise. The resistance of the control coil increases rapidly with the temperature rise, thus reducing a current flow through the heating element and suppressing a further temperature rise. This self-control of the temperature avoids the need for an expensive controller for purpose of temperature control and hence provides a low cost device.

[0005] A variety of arrangements are known for self-controlled ceramics glow plug. For example, Japanese Laid-Open Patent Application No. 170,620/1974 discloses an arrangement in which a ceramics heater having a heating element (or a heating coil) embedded therein is received in a metallic outer sleeve, which is secured in an internal bore of a housing (an engine fit-

ting), with a control coil (brake coil) and an external connection terminal connected to the ceramics heater through an electrode fitting and with the internal bore of the housing and the metallic outer sleeve being filled with a heat resistant insulating filler (glass) to secure the control coil therein.

[0006] Japanese Laid-Open Utility Model Application No. 196,164/1985 discloses an arrangement in which a ceramics heater having a heating element (or heating coil) embedded therein is received in a metallic outer sleeve, which is then secured in an internal bore of a housing toward its one end while a sheath having a control coil and a distal end of an external connection terminal embedded therein is secured in the internal bore of the housing toward the other end and where the heater and the sheath are connected together by connection leads.

[0007] In addition, Japanese Laid-Open Patent Application No. 257,615/1992 discloses an arrangement in which a ceramics heater having a heating element of conductive ceramics and a control coil connected in series and embedded in an insulating ceramics is received in a metallic outer sleeve, which is secured to a housing.

[0008] Finally, Japanese Laid-Open Patent Application No. 217,623/1986 discloses an arrangement in which a heating element of conductive ceramics and a control element are connected in series and each of these heating and control elements is centrally formed with an opening in which an external connection terminal is inserted through an interposed insulating member to be connected to the heating element.

[0009] When a ceramics heater and a control coil are separate from each other as in self-controlled ceramics glow plugs disclosed in the first and the second citation (namely, Japanese Laid-Open Patent Application No. 170,620/1984 and Japanese Laid-Open Utility Model Application No. 196,164/1985), a difficulty is experienced when positioning the control coil and the external connection terminal as they are assembled into the housing and a difficulty is also experienced in assuring their connections. Because an increased number of parts are assembled into the housing, there remains a disadvantage that there is a problem in the ease of assembly and reliability, thus leading to an increased cost.

[0010] When a heating element (heating coil) and a control element (control coil) are disposed inside a ceramics heater as in self-controlled ceramics glow plugs disclosed in the third and the fourth citation (namely, Japanese Laid-Open Patent Applications No. 257,615/1992 and No. 217,623/1986), a sufficient distance cannot be secured between the heating element and the control element, and a poor self-temperature controllability and a complex structure of the ceramics heater result, thus requiring a complicated molding process. The length of the ceramics heater must be increased for the disposition of the control coil, and this reduces the mechanical strength of the ceramics heater, presenting problems in respects of productivity, the

strength and the cost.

The present invention

[0011] Above problems are overcome by the present invention which intends to provide a self-controlled ceramics glow plug which provides an ease of assembly and an excellent reliability while allowing a reduction in the cost, by integrally coupling a control coil with a ceramics heater. It is also an object of the present invention to provide a self-controlled ceramics glow plug which allows the structure of the ceramics heater to be simplified and its length reduced to reduce the manufacturing cost while improving the productivity and the strength.

[0012] It is very important for a ceramics glow plug to restrict the resistance of a heating element in a required range for the purpose of controlling the temperature, in particular, a maximum attainable temperature of the ceramics heater. In the ceramics heater, the resistance is adjusted by blending an inorganic conductor and an inorganic insulator, but it is not a simple matter to achieve a desired resistance because of factors including a difficulty of preparing raw material powders, a variation in the sintered density and an unbalance with the surrounding insulating materials during the sintering operation.

[0013] These parameters are not inherent to the ceramics glow plug, but are common issues to the ceramics heater in general. In particular, for the ceramics glow plug, the severity of service temperature condition, the limitation of a voltage available from a vehicle which is usually limited to about 12V, and the demanded compactness which limits the freedom impose a difficulty in the design of a resistor, and the difficulty is even more aggravated in suppressing a change in the resistance which results from a variation of resistors.

[0014] In the prior art practice, a special sintering technique referred to as hot press technique is used to manufacture the ceramics glow plug. When using the hot press technique, the sintering operation proceeds with the assistance of an external force, which contributes to minimizing many factors which causes variations. In this manner, a variation in the sintered density or the unbalance during the sintering operation can be greatly alleviated to a point where a variation in the resistance can be suppressed to a degree which presents no problems for practical purposes. However, the hot press technique requires a very expensive equipment, is not readily adaptable to a near net shaping process and involves a high grinding cost, and is therefore not preferred from the view point of a mass production. This represents a principal reason for a high cost of a ceramics glow plug in comparison to a metal glow plug. In addition, if the hot press technique is employed, a very strict quality control is necessary in order to obtain a given resistance, adding to a further cost increase.

[0015] Accordingly, it is another object of the invention to provide a ceramics glow plug which overcomes above

problems by enabling an adjustment for a variation in the resistance of a ceramics heater to provide the manufacture of a ceramics glow plug having a heating characteristic that is free from objectionable faults for practical purposes at a low cost without using the expensive hot press technique.

[0016] A self-controlled ceramics glow plug according to the invention defined in Claim 1 comprises a ceramics heater formed by an insulating ceramics material and an inorganic conductor serving as a heating element, a metallic outer sleeve having one end in which the ceramics heater is secured and the other end which is adapted to be secured in an internal bore of a housing, a control coil connected to one of electrodes of the heating element and having a greater positive temperature coefficient of resistance than the heating element, and an electrode fitting connected to the other end of the control coil wherein the electrode fitting is formed of a rigid body and the control coil and its junction with the electrode fitting are contained within the metallic outer sleeve while securing the control coil and the electrode fitting within the metallic outer sleeve with an insulator interposed therebetween.

[0017] With the ceramics glow plug according to the invention defined in Claim 1, the control coil can be unified with the ceramics heater to facilitate the assembly, thus allowing the cost to be reduced. In addition, the ceramics glow plug has a structure similar to a conventional self-controlled metal glow plug, and thus can be assembled with a conventional equipment.

[0018] The invention defined in Claim 2 is characterized in that the insulator comprises a heat resistant insulating powder which fills the metallic outer sleeve and which is densified by a swaging operation. With the ceramics glow plug according to the invention defined in Claim 2, the control coil is secured within the metallic outer sleeve with the interposition of the densified heat resistant insulating powder, whereby the durability of the control coil is improved. This also facilitates a hermetic seal around the control coil.

[0019] The invention defined in Claim 3 is characterized in that the metallic outer sleeve has a stepped configuration including a reduced diameter portion in which the ceramics heater is secured, and an increased diameter portion which is adapted to be secured in the housing, the control coil being disposed within the increased diameter portion.

[0020] The invention defined in Claim 4 is characterized in that the control coil is disposed inwardly of a distal end of the housing.

[0021] With the ceramics glow plug according to the invention defined in Claim 4, the heating element of the ceramics heater can be spaced from the control coil, thus improving the temperature controllability. This permits the ceramics heater in a compact form to be formed, reducing an overall cost.

[0022] The invention defined in Claim 5 is characterized in that one electrode of the ceramics heater is con-

nected with the control coil through a lead wire.

[0023] The invention defined in Claim 6 is characterized in that the electrode fitting has an insertion opening which is formed in an end face thereof, through which one end of the control coil is inserted for connection.

[0024] The invention defined in Claim 7 is characterized in that the insertion opening is a through-opening which axially extends through the electrode fitting and through which the control coil is passed, the outer periphery of the electrode fitting being subject to a plastic deformation for achieving a connection with the control coil.

[0025] The invention defined in Claim 8 is characterized in that a lateral side of a distal end of the control coil is disposed in abutment against a lateral side of a distal end of the electrode fitting for purpose of connection.

[0026] The invention defined in Claim 9 is characterized in that the distal end of the control coil is shaped into a coil, into which the distal end of the electrode fitting is inserted for purpose of connection.

[0027] According to the invention described in either one of Claims 5 to 9, the electrical connection between the control coil and the electrode fitting is facilitated and is reliably achieved.

[0028] The invention defined in Claim 10 relates to a ceramics glow plug comprising a ceramics heater formed by an insulating ceramics material and an inorganic conductor serving as a heating element, a metallic outer sleeve having one end in which the ceramics heater is secured and having the other end which is adapted to be secured in a internal bore of a housing, a resistor connected to one electrode of the heating element, and an electrode fitting connected to the other end of the resistor in which said resistor is selected to have a resistance which depends on the resistance of the ceramics heater and is connected in series therewith, thereby allowing for a correction of the resistance of the ceramics heater to achieve a substantially uniform heating characteristic of the glow plug.

[0029] The invention defined in Claim 10 allows a variation in the heating characteristic which is caused by an individual deviation of the resistance of the ceramics heater to be reduced to enable the ceramics heater to be manufactured by a process other than the hot press technique. If the hot press technique is employed, the yield of the products can be increased and/or items which are subject to quality control can be reduced, thus contributing to a reduction in the cost.

[0030] The invention defined in Claim 11 relates to a ceramics glow plug comprising a ceramics heater formed by an insulating ceramics material and an inorganic conductor serving as a heating element, a metallic outer sleeve having one end in which the ceramics heater is secured and having the other end which is adapted to be secured in an internal bore of a housing, a resistor connected to one electrode of the heating element, and an electrode fitting connected to the other end of the

resistor wherein an end of the resistor located toward the electrode fitting is shaped into a coil while a distal end of the electrode fitting is formed with a screw formation, which is screwed into the coil to complete an electrical connection between the resistor and the electrode fitting, and the location where the electrode fitting is screwed into the coil being adjustable and being adjusted in accordance with the resistance of the combination of the ceramics heater and the resistor which are connected in series, thereby allowing for a correction of the resistance of the ceramics heater to provide a substantially uniform heating characteristic of the glow plug.

[0031] The invention defined in Claim 11 achieves the similar effect as achieved by the invention defined in Claim 10, and also enables an automation of the entire manufacturing process.

[0032] The invention defined in Claim 12 relates to a ceramics glow plug as defined in Claim 10 or 11 and is characterized in that the electrode fitting is formed of a rigid body, the resistor and its junction with the electrode fitting are contained in the metallic outer sleeve and are secured therein with an interposed heat resistant insulating powder which is to become dense by a swaging operation.

[0033] The invention defined in Claim 13 relates to a method of manufacturing a self-controlled ceramics glow plug according to one of Claims 1 to 9, comprising the steps of connecting one end of a control coil to one end of an electrode fitting which is formed of a rigid body and connecting the other end of the control coil to one electrode of a ceramics heater; securing the ceramics heater within a metallic outer sleeve; filling a heat resistant insulating powder into the metallic outer sleeve through an opening formed therein; and subjecting a portion of the metallic outer sleeve which is adjacent to the outer periphery thereof where the junction between the control coil and the electrode fitting is contained to a swaging operation to reduce the diameter, thereby securing the control coil and the electrode fitting to the metallic outer sleeve.

[0034] A manufacturing method according to the invention defined in Claim 14 comprises the steps of connecting one end of the control coil to one electrode of a ceramics heater and securing the ceramics heater in one end of a metallic outer sleeve; connecting the other end of the control coil to one end of an electrode fitting; filling a heat resistant insulating powder into the metallic outer sleeve through an opening formed therein; and subjecting a portion of the metallic outer sleeve adjacent to the outer periphery thereof where the junction between the control coil and the electrode fitting is contained to a swaging operation to reduce the diameter thereof, thereby securing the control coil and the electrode fitting to the metallic outer sleeve.

[0035] The manufacturing method according to the invention defined in Claim 15 is characterized in that a portion of the metallic outer sleeve where the ceramics heater is secured has a reduced diameter while a por-

tion of the metallic outer sleeve where the control coil and its junction with the electrode fitting are contained has an increased diameter, which is then subject to a swaging operation to reduce its diameter.

[0036] The invention defined in any one of the Claims 13 to 15 allows a self-controlled ceramics glow plug to be manufactured in a facilitated manner.

Brief Description of the Drawings

[0037]

Fig. 1 is a longitudinal section of a self-controlled ceramics glow plug according to one embodiment of the invention;

Fig. 2 is a longitudinal section, to an enlarged scale, of part of the ceramics glow plug shown in Fig. 1; Figs. 3A to 3D are respectively a series of diagrams illustrating a first half of a procedure of assembling the self-controlled ceramics glow plug;

Figs. 4A to 4C are respectively a series of similar diagrams illustrating a second half of the assembling procedure;

Fig. 5 is a diagram illustrating an assembling procedure of the self-controlled ceramics glow plug, specifically showing a sub-assembly being assembled;

Figs. 6A to 6D are respectively a series of diagrams illustrating a first half of a procedure for assembling a self-controlled ceramics glow plug according to a second embodiment of the present invention;

Figs. 7A to 7C are respectively a series of diagrams illustrating the second half of the procedure shown in Fig. 6;

Fig. 8 is a diagram illustrating the procedure of assembling the self-control ceramics glow plug, specifically showing a sub-assembly being assembled;

Figs. 9A and 9B are respectively a series of diagrams illustrating a first half of a procedure of assembling a self-control ceramics glow plug according to a third embodiment of the invention;

Figs. 10A and 10B are respectively a series of diagrams illustrating a first half of a procedure of assembling a self-controlled ceramics glow plug according to a fourth embodiment of the invention;

Fig. 11 is a longitudinal section of a self-controlled ceramics glow plug according to a fifth embodiment of the invention;

Fig. 12 is an illustration of several combinations of ceramics heaters and resistors to be used in a ceramics glow plug according to a sixth embodiment of the invention; and

Figs. 13A to 13F are respectively a series of diagrams illustrating a first half of a procedure of assembling a ceramics glow plug according to a seventh embodiment.

Detailed Description of the preferred embodiment

[0038] The present invention will now be described in connection with several embodiments shown in the attached drawings. Referring to Fig. 1, a ceramics glow plug 1 has a substantially cylindrical housing 2 which is internally formed with a stepped axial bore 4. The internal bore 4 within the housing 2 includes a central portion 4b of a reduced diameter, which continues to an intermediate diameter portion 4a located to the left of and having a diameter slightly greater than the diameter of the reduced diameter portion 4b and where a ceramics heater is secured therein as will be described later. The internal bore 4 has an opening 4e, located to the left of the intermediate diameter 4a where the ceramics heater is secured and having an internal diameter which is slightly greater than the diameter of the intermediate diameter portion 4a. Toward the right end, as viewed in Fig. 1, the internal bore includes an increased diameter portion 4c in which an external connection terminal and an insulating member are secured.

[0039] A ceramics heater 6 is cemented by silver brazing to a metallic outer sleeve 8 having a rear end 8c, which is disposed as a press fit into the intermediate diameter portion 4a of the internal bore 4 in the housing 2 or inserted therein and secured by brazing.

[0040] The ceramics heater 6 includes a heating assembly 6a including a heating wire element 64 in the form of a coil of a high melting metal point such as tungsten (W), for example, which is embedded within a ceramic insulator 62 which forms the body of the ceramics heater. The heating assembly 6a projects externally beyond a front end 8b of the metallic outer sleeve 8, while the rear end of the heating assembly 6a is inserted into the metallic outer sleeve 8 with its rear end face 6b located within the sleeve 8. In this embodiment, the heating element 64 comprises a high melting point metal, but it may comprise conductive ceramics or a heating element in the form of a sheet. Alternatively, the ceramics heater 6 may comprise a compound of an insulating ceramics material and an inorganic conductor serving as a heating element, as by exposing part of the heating element formed of conductive ceramics out of insulating ceramics material.

[0041] The coiled heating wire 64 which is embedded within the ceramics heater 6 has one end 64a which corresponds to a negative electrode exposed outside the ceramics insulator 62 within the metallic outer sleeve 8 to be electrically connected to the internal surface of the sleeve 8 by brazing. On the other hand, an end 64b of the coiled heating wire 64 which corresponds to a positive electrode extends to the rear end face 6b to be connected to one end 11a of a positive lead wire 11 within the ceramics heater 6. The positive lead wire 11 comprises a nickel (Ni) wire or a nickel plated soft steel wire.

[0042] In this instance, that is, when the end 11a of the positive lead wire 11 is connected to the positive end 64b of the coiled heating wire 64, a rear end 6d of the

ceramics heater 6 is formed with a lead wire receiving opening 6c, in which a lateral side of the end 64b of the coiled heating wire 64 is exposed. The front end 11a of the positive lead wire 11 is inserted into the opening 6c and brazed thereto with silver, thus electrically connecting the end 64b of the coiled heating wire 64 and the positive lead wire 11.

[0043] The other end 11b of the positive lead wire 11 which extends through the end face 6b of the ceramics heater 6 is connected to one end 13a of a control coil 13. The control coil 13 comprises a coil of a wire of a metal having a relatively high temperature coefficient of resistance, in particular, having a positive temperature coefficient of resistance which is greater than that of the heating element or the coiled heating wire 64. Its one end 13a is cemented to the positive lead wire 11 as by spot welding while its other end 13b is cemented, at its lateral side, with a lateral side of one end 12a of an electrode fitting 12 which comprises a rigid body as by spot welding. Alternatively, the control coil 13 and the positive lead wire 11 may be formed together in an integral manner.

[0044] The metallic outer sleeve 8 has a stepped structure including a forwardly located reduced diameter portion 8f in which the ceramics heater 6 is secured and a rearwardly located increased diameter portion 8g having a rear end 8c which is secured within the internal bore 4 of the housing 2. As described, the ceramics heater 6 is secured within the reduced diameter portion 8f of the metallic outer sleeve 8 while the control coil 13 and its junction 12a, 13b with the electrode fitting 12 are received within the increased diameter portion 8g. In a region where the control coil 13 and the electrode fitting 12 are contained, the metallic outer sleeve 8 is filled with a heat resistant insulating powder which is then densified by a swaging operation to provide an insulator 14. In this manner, the control coil 13 and the electrode fitting 12 are secured within the metallic outer sleeve 8 by means of the insulator 14. A seal member 16 is fitted around the electrode fitting 12 to seal between the internal surface of the metallic outer sleeve 8 and the electrode fitting 12 at the rear opening of the sleeve.

[0045] It will be noted that the control coil 13 is disposed within the increased diameter portion 8g of the metallic outer sleeve 8 at a location close to the reduced diameter portion 8f, and when the metallic outer sleeve 8 is secured within the housing 2, the control coil 13 is located within the housing 2 adjacent to the front end 2a thereof.

[0046] The other end 12b of the electrode fitting 12 which has its one end 12a secured to the control coil 13 within the metallic outer sleeve 8 projects externally of the metallic outer sleeve 8 and is connected to a front end 18a of an external connection terminal 18 as by butt welding.

[0047] As mentioned previously, the ceramics heater 6 and the metallic outer sleeve 8 are secured to the housing 2, and under this condition, threads 18b formed

on the terminal end (or the right end as viewed in Fig. 1) of the external connection terminal 18 projects externally of the housing 2 for connection with a battery. A seal member (O-ring) 20 and a cylindrical insulating bushing 22 are passed over the thread 18b to be inserted into the increased diameter portion 4c of the internal bore 4 within the housing 2. Subsequently, an insulating member 24 in the form of a washer is fitted over the external connection terminal 18, and a nut 26 which is formed of aluminum is tightened to secure the insulating bushing 22 in place. The increased diameter portion 4c of the internal bore 4 has a tapered surface 4f toward the reduced diameter portion 4b, and the seal member 20 is clamped between the tapered surface 4f and the insulating bushing 22 to maintain a hermetic seal of the housing 2. It is to be noted that the seal member 20 and the insulating bushing 22 can be secured in place by caulking a corresponding end of the housing 2, but the use of the nut 26 formed of aluminum to secure these members in place dispenses with a caulking step, which is advantageous in consideration of the cost.

[0048] However, it should be understood that the external connection terminal 18 may be secured by a structure other than that described above. For example, as disclosed in Japanese Laid-Open 084,659/2000, an insulated fixing member may be provided between the internal surface of the housing 2 and the external surface of the external connection terminal 18 to apply a clamping torque thereto.

[0049] In the self-controlled ceramics glow plug 1 mentioned above, the positive lead wire 11 taken out of the ceramics heater 6 and the control coil 13 are connected together and the control coil and the electrode fitting 12 are connected together inside the metallic outer sleeve 18, and the control coil 13 and the electrode fitting 12 are fixed within the metallic outer sleeve 8 by the insulator 14 which fills the latter. Because the control coil 13 is unified with the ceramic heater 6, the assembly of the glow plug 1 is greatly facilitated, and because the number of parts which are assembled into the housing 2 is reduced, the efficiency of operation is improved to allow a reduction in the cost.

[0050] Although the ceramics heater 6 and the control coil 13 are unified, a required distance can be secured between the heating element 64 and the control coil 13 in distinction to a conventional arrangement in which the control coil 13 is assembled into the ceramics heater 6, providing an excellent temperature control. In addition, the length of the ceramics heater 6 can be reduced, contributing to a reduction in the overall cost.

[0051] In addition, because the metal sheath is filled with a heat resistant insulating powder which is then subject to a swaging operation in a similar manner as in a conventional self-controlled metal glow plug in which the heating coil and the control coil are secured, an equipment which presses the metallic outer sleeve 8 into the housing 2 which have been used in the prior art practice can be utilized. Since the control coil 13 is fixed

in the insulator 14 which is provided by making the heat resistant insulating powder dense in density by the swaging operation, providing a hermetic seal around the control coil is facilitated.

[0052] Referring to Figs. 1, 2 and 3 to 5, a procedure of assembling a self-controlled ceramics glow plug 1 constructed in the manner mentioned above will now be described. Initially, one end 11a of the positive lead wire 11 (a nickel wire or a nickel plated soft steel wire) which is spot welded to one end 13a of the control coil 13 is inserted into the positive lead wire receiving opening 6c formed in the end face 6b of the ceramics heater 6 and is then silver brazed to the positive lead wire 64b, and the electrode fitting 12 which comprises a rigid body is welded to the other end 13b of the control coil 13 to form an assembly (see Fig. 3A). In this embodiment, the lateral side of the end 13b of the control coil 13 is disposed in abutment against a lateral side of the front end 12a of the electrode fitting 12 and is then spot welded thereto for purpose of fixture.

[0053] The ceramics heater 6 formed as the assembly is inserted into the reduced diameter portion 8f of the metallic outer sleeve 8 while the heating assembly 6a is externally exposed, and is silver brazed to the metallic outer sleeve 8 for purpose of fixture. When the ceramics heater 6 and the metallic outer sleeve 8 are cemented together by the silver brazing, the control coil 13 is positioned within the increased diameter portion 8g of the metallic outer sleeve 8 at a location toward the reduced diameter portion 8f, as indicated in Fig. 3B. The junction 12a, 13b of the control coil 13 with the electrode fitting 12 is also disposed within the metallic outer sleeve 8.

[0054] A procedure of assembling which is used when securing the ceramics heater 6 within the metallic outer sleeve 8 by silver brazing will now be briefly described. Initially, the metallic outer sleeve 8 is set up in a brazing fixture (not shown). It is to be understood that a plurality of assemblies each comprising the metallic outer sleeve 8 and the ceramics heater 6 are prepared and are simultaneously subject to a brazing operation. A silver alloy (brazing material) in the form of a wire coil is then placed on the end face 6b of the ceramics heater 6 assembly (an assembly as shown in Fig. 3A) formed by connecting the positive lead wire 11, the control coil 13 and the electrode fitting 12 together, and the assembly is then fitted into the metallic outer sleeve 8 to position the metallic outer sleeve 8 and the ceramics heater 6 relative to each other. Subsequently, the assembly is heated to melt the brazing material to braze the ceramics heater 6 and the metallic outer sleeve 8 together.

[0055] After the ceramics heater 6 is secured by the silver brazing within the metallic outer sleeve 8 having a stepped configuration, the heat resistant insulating powder 14 such as magnesia (MgO) or the like, for example, is filled into a space 15 in which the control coil 13 and one end of the electrode fitting 12 are contained, through the opening 8d of the increased diameter portion 8g of the metallic outer sleeve 8 (see Fig. 3C). After

filling the powder 14, an amount of the powder which is located near the opening 8d of the sleeve 8 is removed to secure a space 17, into which the seal member 16 is to be inserted (see Fig. 3D).

[0056] Subsequently, the seal member 16 formed of rubber such as silicone rubber or flouoring contained rubber is inserted into the space 17 secured within the opening 8d of the metallic outer sleeve 8 (see Fig. 4A). By inserting the seal member 16 into the opening 8d of the metallic outer sleeve 8, any spilling of the heat resistant insulating powder 14 can be prevented during a swaging operation which takes place subsequently, also preventing the electrode fitting 12 from contacting the internal surface of the metallic outer sleeve 8. The end of the metallic outer sleeve 8 is then caulked (see character 8e shown in Fig. 4B) to prevent the disengagement of the seal member 16.

[0057] After the heat resistant insulating powder 14 fills the metallic outer sleeve 8, the seal member 16 is inserted and the end 8e of the metallic outer sleeve 8 is caulked, the increased diameter portion 8g of the metallic outer sleeve 8 in which the control coil 13 and its junction 12a, 13b with the electrode fitting 12 are contained is subject to a swaging operation, thus reducing its diameter to a value which is slightly greater than the diameter of the reduced diameter portion 8f in which the ceramics heater 6 is secured. By reducing the external diameter of the increased diameter portion 8g of the metallic outer sleeve 8 by the swaging operation, the heat resistant insulating powder 14 is densified to secure the control coil 13 and the electrode fitting 12 in place within the metallic outer sleeve 8 (see Fig. 4C). It should be understood that the swaged external diameter may be approximately equal to the external diameter of the reduced diameter portion 8f where the ceramics heater 6 is secured.

[0058] One end 18a of the external connection terminal 18 is secured to the outer end 12b of the electrode fitting 12 which is fixed in position within the metallic outer sleeve 8 by the swaging operation, as by butt welding (see Fig. 5). An assembly shown in Fig. 5, comprising the ceramics heater 6, the metallic outer sleeve 8, the control coil 13, the electrode fitting 12 and the external connection terminal 18, is then inserted into the internal bore 4 of the housing 2 through the left end as viewed in Fig. 1, with the thread 18b on the external connection terminal 18 inserted first, and the rear portion 8c of the metallic outer sleeve 8 is fixed by a press fit or by silver brazing.

[0059] When the assembly is fixed in the housing 2, the thread 18b on the end of the external connection terminal 18 is projecting externally of the housing 2. As mentioned previously, the seal member (O-ring) 20 and the cylindrical insulating bushing 22 are passed over the thread 18b to be inserted into the increased diameter portion 4c of the internal bore 4 within the housing, and then the insulating member 24 in the form of the washer is fitted and clamped by the nut 26 to fix these members,

thus completing the assembly of the self-controlled ceramics glow plug 1 shown in Fig. 1.

[0060] By performing the swaging operation under the condition that the control coil 13 is contained within the metallic outer sleeve 8, the ceramics heater 6 and the control coil 13 can be unified in a facilitated manner. The unified ceramics heater 6 control coil 13 and electrode fitting 12 are assembled into the housing 2, thus greatly facilitating the operation. Because the number of parts assembled into the housing 2 is reduced, the ease of assembly and reliability are improved while allowing a reduction in the cost.

[0061] Figs. 6 to 8 show a procedure of assembling a self-controlled ceramics glow plug 1 according to a second embodiment of the invention. In the second embodiment, the ceramics heater 6 and the metallic outer sleeve 8 are brazed together at the same time as the positive end 64b of the coiled heating wire 64 of the ceramics heater 6 is brazed with the end 13a of the control coil 13, and then the electrode fitting 12 is connected to the other end 13c of the control coil. The swaging operation then takes place to fix these members and to achieve an electrical connection between them. In this embodiment, the end 13a of the control coil 13 which is to be secured to the ceramics heater 6 has an extended length while omitting the positive lead wire 11 used in the first embodiment, and thus the control coil 13 is directly connected to the positive end 64b of the coiled heating element 64 of the ceramics heater 6.

[0062] When brazing the ceramics heater 6, the control coil 13 and the metallic outer sleeve 8 together, the lower portion (reduced diameter portion 8f) of the metallic outer sleeve 8 which is formed with the increased diameter portion 8g toward the end which is to be secured to the housing 2 (or the top end as viewed in Fig. 6) is fitted over the ceramics heater 6, and this assembly is set up in a brazing fixture (not shown); a brazing material in the form of a wire coil is placed on the end face 6b of the ceramics heater 6; the front end 13a of the control coil 13 is inserted into the opening which is formed in the end face 6b and through which the positive end 64b of the coiled heating wire 64 is exposed, and the assembly is heated to a given temperature which may be 900° C, for example, thus melting the brazing material. Molten brazing material flows into the interstices between the inner surface of the metallic outer sleeve 8 and the external surface of the ceramics heater 6 and between the inner surface of the opening formed in the ceramics heater 6 and the external surface of the control coil 13 to achieve a brazing operation simultaneously (see Fig. 6A).

[0063] In this embodiment, the electrode fitting 12 has a front end 12c (or lower end as viewed in Fig. 6) of a reduced diameter, as shown in Fig. 6B), and the other end 13c (or top end as viewed in Fig. 6) of the control coil 13 is formed into a coil of an internal diameter comparable to the external diameter of the reduced diameter end 12c of the electrode fitting 12 so that the end 12c of

the electrode fitting 12 can be inserted into the coil 13c formed at the end of the control coil 13.

[0064] Subsequently, similar steps take place as in the first embodiment. Specifically, the top space 15 in the increased diameter portion 8g of the metallic outer sleeve 8 (see Fig. 6B) is filled with a heat resistant insulating powder 14 (see Fig. 6C), an amount of the heat resistant insulating powder 14 is removed from the entrance of the opening 8d of the metallic outer sleeve 8 to define a space 17 (see Fig. 6D). Subsequently, the seal member 16 is inserted into the opening 8d of the metallic outer sleeve 8 (see Fig. 7A) and then the end 8e of the metallic outer sleeve 8 is caulked to prevent the disengagement of the seal member 16 (see Fig. 7B). The swaging operation is then applied to the increased diameter portion 8g of the metallic outer sleeve 8 to reduce its diameter to a value which is slightly greater than the diameter of the reduced diameter portion 8f in which the ceramics heater 6 is secured (see Fig. 7C).

[0065] One end 18a of the external connection terminal 18 is secured, as by butt welding, to the outer end 12b of the electrode fitting 12 which is secured within the metallic outer sleeve 8 by the swaging operation (see Fig. 8). The assembly thus formed including the ceramics heater 6, the metallic outer sleeve 8, the control coil 13, the electrode fitting 12 and the external connection terminal 18 is inserted into and secured in the housing 2, thus completing the assembly of the self-controlled ceramics glow plug 1. The self-controlled ceramics glow plug 1 prepared according to this embodiment is capable of achieving a similar effect as the glow plug mentioned above in connection with the first embodiment. The front end 12c of a reduced diameter of the electrode fitting 12 may be provided with a step so that it can not be simply disengaged once it is inserted into the coil 13c of the control coil 13. This prevents the disengagement of the front end 12c of the electrode fitting 12 from the coil 13c of the control coil 13 which might occur otherwise during some subsequent steps.

[0066] The assembling procedure of the second embodiment provides manufacturing merits in comparison to the first embodiment. In the first embodiment, the electrode fitting 12 is connected to the coil 13 which is already secured to the ceramics heater 6 before the ceramics heater 6 is brazed to the metallic outer sleeve 8. Accordingly, during the brazing operation, the ceramics heater assembly has an increased entire length, presenting a difficulty in achieving a number of brazing operations simultaneously. In addition, the weight of the electrode fitting 12 may cause a bending in the control coil 13 during the brazing operation, and a correction may be required. In addition, the electrode fitting 12 may stand in the way to placing the brazing material in the form of a wire coil. Finally, such placement may be prevented if the electrode fitting has an external diameter which is greater than the internal diameter of the metallic outer sleeve 8. In addition, a brazing between the ceramics heater 6 and the control coil 13 or the positive

lead wire 11 connected to the control coil 13 and a brazing between the ceramics heater 6 and the metallic outer sleeve 8 take place separately, thus requiring two separate brazing steps.

[0067] By contrast, in the second embodiment, the brazing between the ceramics heater 6 and the metallic outer sleeve 8 and the brazing between the ceramics heater 6 and the control coil 16 take place in a single step, and then the connection with the electrode fitting 12 takes place (this connection may be a temporary connection) before the swaging operation takes place. Accordingly, difficulties and inconveniences mentioned above in connection with the first embodiment are all eliminated.

[0068] Fig. 9 shows an arrangement and an assembling procedure of essential parts of a self-controlled ceramics glow plug 1 according to a third embodiment of the invention. In the third embodiment, the front end 12d of the electrode fitting 12 has a reduced diameter and is formed with an opening 12e, into which the end 13b of the control coil 13 is inserted (see Fig. 9B). Parts not shown are constructed in an identical manner as the previously mentioned embodiments, and are designated by like reference numerals as used before in the description to follow.

[0069] In the third embodiment, the positive lead wire 11 is previously welded to the end 13a of the control coil 13, and the ceramics heater 6 is fitted into the reduced diameter portion 8f of the metallic outer sleeve 8. The end 11a of the positive lead wire 11 is inserted into a corresponding opening formed in the ceramics heater 6. The ceramics heater 6 and the metallic outer sleeve 8 are brazed simultaneously as the ceramics heater 6 and the control coil 13 (or the positive lead wire 11 thereof) are brazed together (a condition shown in Fig. 9A).

[0070] The end 13b of the control coil 13 is then inserted into the opening 12e formed in the front end 12d of a reduced diameter of the electrode fitting 12. Subsequently, a procedure similar to that mentioned above is employed until the swaging operation is completed. While the swaging step for the third embodiment is not illustrated, this will be explained using reference characters used in the description of the previous embodiments. The heat resistant insulating powder fills the metallic outer sleeve 8, the heat resistant insulating powder 14 is removed from a portion adjacent to the opening 8d of the metallic outer sleeve 8, the seal member 16 is inserted, the end 8e of the metallic outer sleeve 8 is caulked and the swaging operation takes place in a sequential manner. When the swaging operation is performed to reduce the diameter of the increased diameter portion 8g of the metallic outer sleeve 8, the front end 12d of a reduced diameter of the electrode fitting 12 is deformed to be more strongly fixed to the control coil 13, achieving a reliable electrical connection. In this embodiment, similar effects as mentioned above in connection with the previous embodiments can be achieved.

[0071] Fig. 10 shows an arrangement of essential

parts and an assembling procedure of a self-controlled ceramics glow plug 1 according to a fourth embodiment of the invention. In the fourth embodiment, a portion 13d of the control coil 13 which is to be connected to the electrode fitting 12 has a considerably extended length and extends externally through the opening 8d of the metallic outer sleeve 8 (see Fig. 10A) when the other end (or lower end as viewed in Fig. 10) of the control coil 13 is connected through the positive lead wire 11 to the coiled heating wire 64 of the ceramics heater 6.

[0072] In this embodiment, during the assembly, the positive lead wire 11 is previously welded to one end 13a of the control coil 13, and the ceramics heater 6 is fitted into the reduced diameter portion 8f of the metallic outer sleeve 8 as the end 11a of the positive lead wire 11 is inserted into the receiving opening formed in the ceramics heater 6, thus brazing the ceramics heater 6 and the metallic outer sleeve 8 together and brazing the ceramics heater 6 and the control coil 13 simultaneously, in the similar manner as in the third embodiment.

[0073] It is to be noted that the electrode fitting 12 of the fourth embodiment is formed with an axially extending through-opening 12f through which the extended end 13d of the control coil 13 extends (see Fig. 10B), and the electrode fitting 12 and the control coil 13 are electrically connected together by caulking them.

[0074] As mentioned previously, one end 13a of the control coil 13 is connected through the positive lead wire 11 to the ceramics heater 6 while its other end 13d extends externally of the metallic outer sleeve 8, and the electrode fitting 12 is connected to this end 13d which is extending outside the sleeve 8. Subsequently, in the similar manner as in the previous embodiments, the space 15 in the increased diameter portion 8g of the metallic outer sleeve 8 is filled with the heat resistant insulating powder 14, a fraction thereof which is disposed near the opening 8d is removed to form the space 17, into which the seal member 16 is inserted. After caulking the end 8e, the metallic outer sleeve 8 is subject to the swaging operation. The swaging operation is effective to forge the electrode fitting 12, assuring an electrical connection between the control coil 13 and the electrode fitting 12. Accordingly, an electrical connection which is achieved between the control coil 13 and the electrode fitting 12 before the swaging operation takes place may only be a temporary one. Alternatively, the electrical connection between the control coil 13 and the electrode fitting 12 may be accomplished by merely caulking the outer periphery of the electrode fitting 12 either before or after the swaging operation. Subsequently, a portion of the control coil 13 which projects through the electrode fitting 12 is cut off.

[0075] The end 18a of the external connection terminal is then connected to the end 12g of the electrode fitting 12 by butt welding, and the resulting assembly is inserted into and secured in the housing 2, thus completing the assembly of the self-controlled ceramics glow plug 1.

[0076] The assembling procedure used in the fourth embodiment is similar to the assembling procedure used in the third embodiment (Fig. 9) in that one end 13d of the control coil 13 is inserted into the through-opening 12f of the electrode fitting 12 to be secured therein. However, it is to be noted that in the third embodiment, the end 13b of the control coil 13 is inserted into the opening 12e formed in the electrode fitting 12 within the metallic outer sleeve 8, and this involves a difficulty in the insertion of the control coil 13 and also involves a difficulty to confirm whether or not the coil end has been successfully inserted, leaving a likelihood that a failure of connection may result. However, in the fourth embodiment, the length of the end 13d of the control coil 13 is increased to pass through the through-opening 12f of the electrode fitting 12 outside the metallic outer sleeve 8, facilitating the insertion and also the confirmation that the coil end has been successfully inserted and thus avoiding the likelihood that a failure of connection may result, contributing to improving the quality control.

[0077] In the fourth embodiment, the end 13d of the control coil 13 is extended long enough to be brought to the outside of the metallic outer sleeve 8, but instead of lengthening the control coil 13 itself, a separate lead wire may be welded to the end of the control coil 13.

[0078] Fig. 11 is a longitudinal section of a self-controlled ceramics glow plug 1 according to a fifth embodiment of the invention where the metallic outer sleeve 8 shown in the first embodiment has its length increased to extend to nearly the center of the housing 2 so that the control coil 13 is located within the housing 2.

[0079] In the fifth embodiment, the internal bore 4 of the housing 2 includes the intermediate diameter portion 4a where the metallic outer sleeve 8 is secured centrally along the length thereof. The end 8c of the increased diameter portion 8g of the metallic outer sleeve 8 which has its length considerably increased is disposed as a press fit into the intermediate diameter portion 8a or inserted therein and then secured. One end 11b of an elongate positive lead wire 11 is secured to one end 13a of the control coil 13 as by welding, while the other end 11a of the positive lead wire 11 is connected to the coiled heating element 64 of the ceramics heater 6. In this manner, the control coil 13 is centrally located within the housing 2. Other aspects of the arrangement and the assembling procedure remain similar as described above in connection with the first embodiment.

[0080] It will be noted that in the first embodiment, the control coil 13 is located toward the front end 2a of the housing 2, allowing the length of the metallic outer sleeve 8 to be shortened to improve the effectiveness of the swaging operation. However, because the control coil 13 is located close to the heating assembly 6a of the ceramics heater 6, it is influenced by a small temperature change of the heating assembly 6a and thus is liable to degrade the controllability or stability of the temperature control. By contrast, in the fifth embodiment where the metallic outer sleeve 8 has an increased

length, the control coil 13 can be further spaced from the heating assembly 6a of the ceramics heater 6 to improve the temperature controllability even though the effectiveness of the swaging operation is somewhat influenced. In addition, in the fifth embodiment, it is possible to prevent the heating of the control coil 13 from influencing upon the brazed portions between the ceramics heater 6 and the metallic outer sleeve 8. Specifically, if the brazed portions assume an elevated temperature, a degradation in the mechanical strength and the hermetic seal can be prevented.

[0081] Fig. 12 is a schematic illustration of an essential part of a ceramics glow plug 1 according to a sixth embodiment of the invention. While the ceramics glow plug is not shown entirely, it is to be understood that the general arrangement is similar to that of the first embodiment shown in Figs. 1 to 5. Accordingly, parts not shown will be described below using reference characters which are used in the description of the first embodiment. In the described embodiments, a self-temperature control takes place by the interposition of the control coil 13 between one electrode (positive electrode) of the heating element 64 of the ceramics heater 6 and the electrode fitting 12. However, in the sixth embodiment, an arrangement is made such that if individual ceramics heaters 6 have different resistances, a variation in the heating characteristic which results from such resistance deviations can be alleviated while retaining the structure of each embodiment in which the control coil 13 is connected in series between the ceramics heater 6 and the electrode fitting 12 and is secured within the metallic outer sleeve 8 by the swaging operation.

[0082] In the sixth embodiment, a plurality of resistors 113 having different resistances $R'1$, $R'2$, $R'3$, ... $R'n$ are previously provided as indicated in the upper portion of Fig. 12 and one of these resistors which has an appropriate resistance is selected in accordance with the particular resistance ($R1$, $R2$, $R3$, ... Rn) of the ceramics heater 6 to form a series connection so that a variation in the heating characteristic of the combination of the ceramics heater 6 and the resistor 113 can be minimized. In this embodiment, the resistor 113 is in the form of a coil and has a connection 113a at one end which is to be connected with the positive pole of the heating element of the ceramics heater 6 and another connection 113b at its other end which is to be connected to the electrode fitting 12.

[0083] A ceramics glow plug 1 including the combination of the ceramics heater 6 and the resistor 113 can be assembled by a similar procedure as used in assembling the ceramics glow plug 1 of the first embodiment or any other procedure. By way of example, one of the resistors 113 having an optimum resistance (one of $R'1$, $R'2$, $R'3$, ... $R'n$) is selected in accordance with the particular resistance (one of $R1$, $R2$, $R3$, ... Rn) of the ceramics heater 6. One end 113a of the selected resistor 113 is inserted into the opening 6c of the ceramics heater 6, and is connected to the positive electrode of the

heating element (not shown in Fig. 12) of the ceramics heater 6 by silver brazing while the other end 113b of the selected resistor 113 is welded to the electrode fitting 12 which comprises a rigid body, thus forming an assembly. The assembly including the ceramics heater 6 is inserted into the metallic outer sleeve 8 and is secured therein by silver brazing.

[0084] Subsequently, the heat resistant insulating powder 14 fills the interior of the metallic outer sleeve 8, the seal member 16 is inserted into the opening thereof, and the sleeve is subject to the swaging operation to reduce the external diameter of the sleeve, thus densifying the heat resistant insulating powder 14 to secure the resistor 113 and the electrode fitting 12 in the metallic outer sleeve 8. The external connection terminal 18 is secured to the external end 12b of the electrode fitting 12. The assembly including the ceramics heater 6, the metallic outer sleeve 8, the resistor 113 and the external connection terminal 18 is secured in the internal bore 4 of the housing 2.

[0085] Thus it will be seen that a variation in the heating characteristic which may result from a resistance variation of the ceramics heater 6 can be alleviated by using a substantially similar structure as the first embodiment, by selecting one of the resistors 113 having different resistances ($R'1$, $R'2$, $R'3$, ... $R'n$) in accordance with an individual resistance deviation of the particular ceramics heater 6 and connecting it in series with the ceramics heater 6. It is to be recognized that while there has been a need in the art to manufacture the ceramics heater 6 with the hot press technique in order to suppress a variation in the resistance ($R1$, $R2$, $R3$, ... Rn) of the ceramics heater 6, a simple technique which can be implemented with a lower cost than the hot press technique may be used to manufacture the ceramics heater 6.

[0086] If the hot press technique is used to manufacture the ceramics heater 6, the structure provided by the present invention enables an improvement in the yield of the product and a reduction in the cost as a result of a reduction in the items being controlled. Since what is required is to connect the resistor 113 in series between the positive electrode of the ceramics heater 6 and the electrode fitting 12 within the metallic outer sleeve 8 and to unify them by the swaging operation, any increase in the cost which may be required to implement the structure of the sixth embodiment is minimal.

[0087] Fig. 13 shows part of a procedure of assembling a ceramics glow plug 1 according to a seventh embodiment of the invention. In the embodiment shown in Fig. 12, a plurality of coiled resistors 113 having different resistances ($R'1$, $R'2$, $R'3$, ... $R'n$) are provided to allow one of them to be selected in accordance with a resistance deviation of an individual ceramics heater 6 to be connected in series therewith. However, in the seventh embodiment, a single resistor (control coil) 213 is used, and the location where the electrode fitting 212 is connected to the resistor 213 is adjusted to optimize the

external resistance.

[0088] The resistor 213 used in the ceramics glow plug 1 of the seventh embodiment includes a connection terminal 213a at one end of a coiled portion 213e which is to be connected to the positive electrode of the heating element (not shown) of the ceramics heater 6, and the other end of the resistor which is to be connected with the electrode fitting 212 remains to be the coiled portion 213e. On the other hand, the end of the electrode fitting 212 which is to be connected to the resistor 213 is formed with threads 212a (see Fig. 13B), which are threadably engaged with the coiled portion 213e of the resistor 213, thus mechanically and electrically connecting the resistor 213 and the electrode fitting 212 together.

[0089] When assembling the ceramics glow plug 1 of this embodiment, one end 213a of the resistor 213 is inserted into the opening 6c formed in the end face of the ceramics heater 6, which is then fitted into the reduced diameter portion 8f of the metallic outer sleeve 8 and brazed thereto to connect the resistor 213 and the positive electrode of the heating element of the ceramics heater 6 together while simultaneously cementing the ceramics heater 6 and the metallic outer sleeve 8 together. Under this condition, a total resistance presented by the ceramics heater 6 and the resistor 213 is measured (see Fig. 13A).

[0090] The threads 212a of the electrode fitting 212 are then inserted through the opening of the metallic outer sleeve 8 (indicated by an arrow shown in Fig. 13B), causing the threads 212a to be threadably engaged with the coiled portion 213e of the resistor 213. The position to which the electrode fitting 212 is screwed into the resistor 213 is adjusted in accordance with the measured total resistance determined by the step indicated in Fig. 13A, thus optimizing the external resistance (see Figs. 13C and 13D). After adjusting the screwed position of the electrode fitting 212, the heat resistant insulating powder 14 is admitted through the opening of the metallic outer sleeve 8 to fill it, and the seal member 16 is inserted into the opening (see Fig. 13E), followed by the swaging operation (see Fig. 13F). The swaging operation reduces the diameter of the increased diameter portion 8g of the metallic outer sleeve 8, whereby the heat resistance insulating powder 14 is densified to secure the resistor 213 and the electrode fitting 212 within the metallic outer sleeve 8.

[0091] If there is a variation in the resistance of individual ceramics heaters 8, this embodiment allows the external resistance to be optimized by adjusting the screwed position of the electrode fitting 212, and thus it is possible to manufacture the ceramics heater 6 using a simple low cost technique without resort to the hot press technique which has been used in the prior art. If the hot press technique is used to manufacture the ceramics heater 6, the described structure of this embodiment enables an improvement in the yield of the product and a reduction in the cost as a result of reduction of

items being controlled. Because what is required is to connect the resistor 213 in series between the positive electrode of the ceramics heater 6 and the electrode fitting 112 within the metallic outer sleeve 8, any increase in the cost which is required to achieve the structure of this embodiment is minimal.

[0092] Since the electrode fitting 212 is connected to the coil portion 213e of the resistor 213 which is connected to the ceramics heater 6 as it is threadably engaged, the entire process can be automated. Since the electrode fitting 212 and the resistor 213 are connected together within the metallic outer sleeve 8 by the insulator 14 which is to become dense in density by the swaging operation, the cementation between the fitting 212 and the resistor 113 can be reliably achieved at any desired position. In the self-controlled ceramics glow plug according to the first to the fifth embodiment, the control coil having a greater positive temperature coefficient of resistance than the heating element of the ceramics heater is connected between the ceramics heater and the electrode fitting. By contrast, the sixth and the seventh embodiment are intended to provide an adjustment for a variation in the resistance of an individual ceramics heater, by connecting a separate resistor in series therewith to provide a substantially uniform total resistance for the combination of the ceramics heater and the resistor, and there is no need to satisfy the requirement for the control coil.

Claims

1. A self-controlled ceramics glow plug including a ceramics heater formed by an insulating ceramics material and an inorganic conductor serving as a heating element, a metallic outer sleeve having one end in which the ceramics heater is secured and having other end which is adapted to be secured in an internal bore of a housing, a control coil connected to one of electrodes of the heating element and having a greater positive temperature coefficient of resistance than the heating element, and an electrode fitting connected to the other end of the control coil;
characterized in that the electrode fitting is formed by a rigid body, and the control coil and its junction with the electrode fitting are contained within the metallic outer sleeve and are secured therein through an insulator.
2. A self-controlled ceramics glow plug according to Claim 1 in which the insulator comprises a heat resistant insulating powder which fills the metallic outer sleeve and which is densified by a swaging operation.
3. A self-controlled ceramics glow plug according to Claim 1 or 2 in which the metallic outer sleeve has a stepped configuration including a reduced diam-

eter in which the ceramics heater is secured and an increased diameter portion which is adapted to be secured to the housing, the control coil being disposed within the increased diameter portion.

4. A self-controlled ceramics glow plug according to one of Claims 1 to 3 in which the control coil is disposed inwardly of a front end of the housing.
5. A self-controlled ceramics glow plug according to one of Claims 1 to 4 in which one electrode of the ceramics heater is connected with the control coil through a lead wire.
6. A self-controlled ceramics glow plug according to one of Claims 1 to 5 in which the electrode fitting is formed with an insertion opening which opens into its end face, the control coil having its one end inserted into the insertion opening to be connected thereto.
7. A self-controlled ceramics glow plug according to Claim 6 in which the insertion opening comprises a through-opening which axially extends through the electrode fitting, the control coil passing through the through-opening, the outer periphery of the electrode fitting being subject to a plastic deformation to achieve a connection with the control coil.
8. A self-controlled ceramics glow plug according to one of Claims 1 to 5 in which a lateral side of an end of the control coil is disposed in abutment against a lateral side of a front end of the electrode fitting for purpose of an electrical connection therebetween.
9. A self-controlled ceramics glow plug according to one of Claims 1 to 5 in which the end of the control coil is formed into a coil, into which the front end of the electrode fitting is inserted for purpose of an electrical connection therebetween.
10. A self controller ceramics glow plug including a ceramics heater formed by an insulating ceramics material and an inorganic conductor serving as a heating element, a metallic outer sleeve having one end in which the ceramics heater is secured and having other end which is adapted to be secured in an internal bore of a housing, a resistor connected to one electrode of the heating element, and an electrode fitting connected to the other end of the resistor;
characterized in that one from a plurality of resistors having different resistances is selected in accordance with the resistance of the ceramics heater to be connected in series therewith, thereby providing a correction for the resistance of the ceramics heater to achieve a substantially uniform heating characteristic as a whole.

11. A ceramics glow plug including a ceramics heater formed by an insulating ceramics material and an inorganic conductor serving as a heating element, a metallic outer sleeve having one end in which the ceramics heater is secured and having other end 5 which is adapted to be secured in an internal bore of a housing, a resistor connected to one electrode of the heating element, and an electrode fitting connected to the other end of the resistor;

characterized in that the end of the resistor 10 which is to be connected with the electrode fitting is formed into a coil while the end of the electrode fitting which is to be connected with the resistor is formed with threads, which are screwed into the coil to achieve an electrical connection between the resistor and the electrode fitting, the screwed position 15 of the electrode fitting being adjustable, a total resistance presented by the ceramics heater and the resistor connected in series being measured, and the screwed position of the electrode fitting being 20 adjusted in accordance with the measured total resistance, thereby correcting for a resistance of the ceramics heater to provide a substantially uniform heating characteristic as a whole.

12. A ceramics glow plug according to Claim 10 or 11 in which the electrode fitting is formed of a rigid body, the resistor and its junction with the electrode fitting being contained within the metallic outer sleeve and are secured therein through a heat resistant insulating powder which is densified by a 30 swaging operation.

13. A method of manufacturing a self-controlled ceramics glow plug according to one of Claims 1 to 9, comprising the steps of 35

connecting one end of the coil to one end of the electrode fitting which is formed of a rigid body and connecting the other end of the control coil 40 to one electrode of the ceramics heater; securing the ceramics heater within the metallic outer sleeve; filling a heat resistant insulating powder into the metallic outer sleeve through an opening thereof; 45 and subjecting the outer periphery of the metallic outer sleeve in which the junction between the control coil and the electrode fitting is contained to a swaging operation to reduce the diameter thereof, thereby securing the control coil and the electrode fitting in the metallic outer sleeve. 50

14. A method of manufacturing a self-controlled ceramics glow plug according to one of Claims 1 to 9, comprising the steps of 55

connecting one end of the control coil to one electrode of the ceramics heater and securing the ceramics heater within one end of the metallic outer sleeve; connecting the other end of the control coil with one end of the electrode fitting; filling a heat resistant insulating powder into the metallic outer sleeve through an opening thereof; and subjecting the outer periphery of the metallic outer sleeve in which the junction between the control coil and the electrode fitting is contained to a swaging operation to reduce the diameter thereof, thereby securing the control coil and the electrode fitting in the metallic outer sleeve.

15. A method of manufacturing a self-controlled ceramics glow plug according to Claim 13 or 14 in which the metallic outer sleeve has a reduced diameter in a region where the ceramics heater is secured and has an increased diameter in a region where the control coil and its junction with the electrode fitting are contained, the portion of an increased diameter being reduced in diameter by the swaging operation.

FIG.1

1

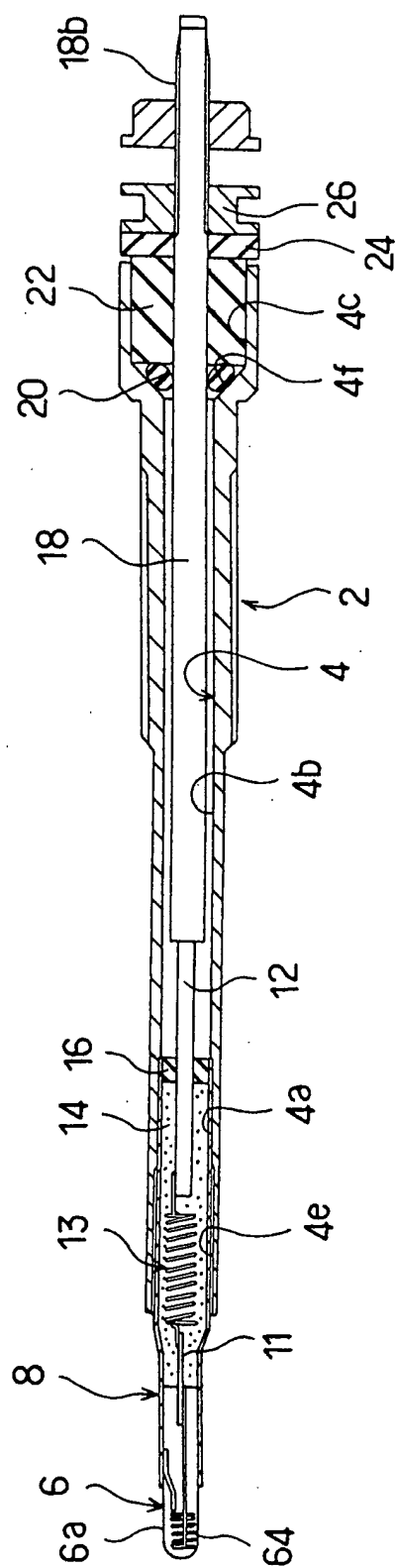
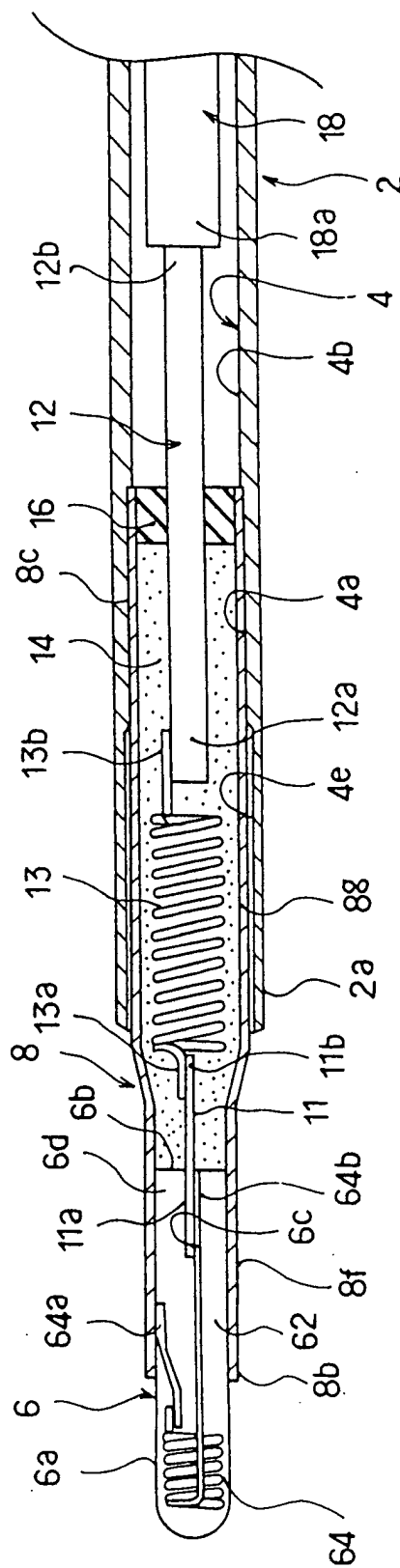


FIG.2



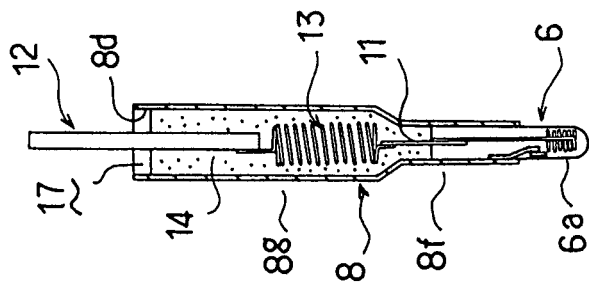


FIG. 3D

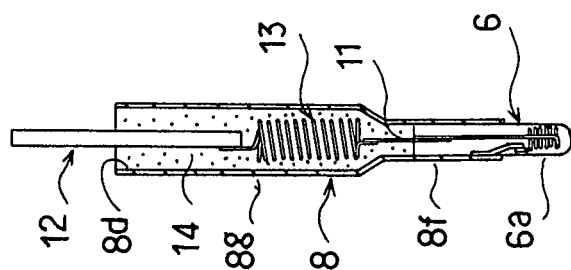


FIG. 3C

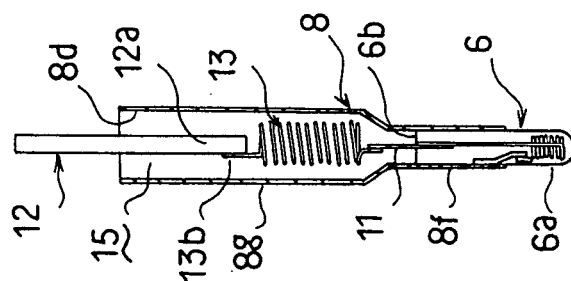


FIG. 3B

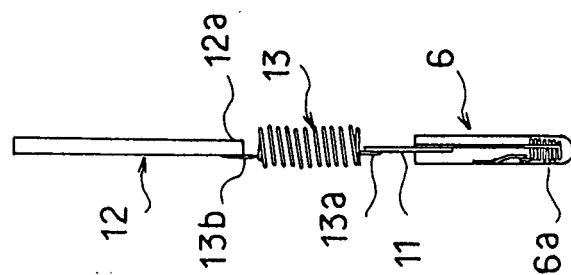


FIG. 3A

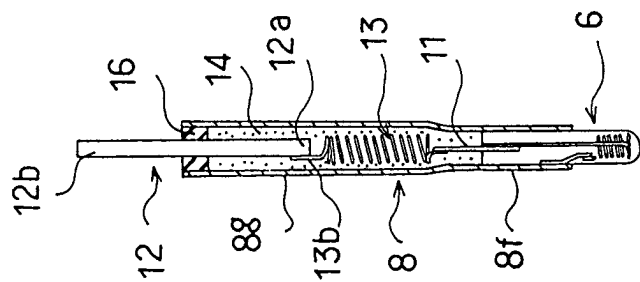


FIG. 4C

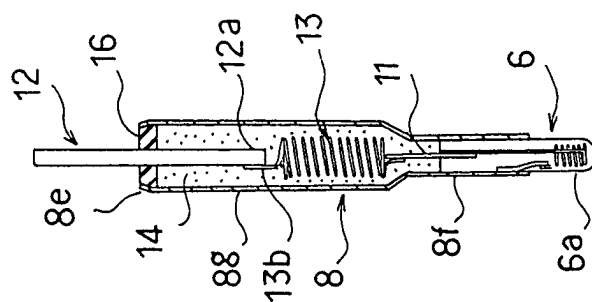


FIG. 4B

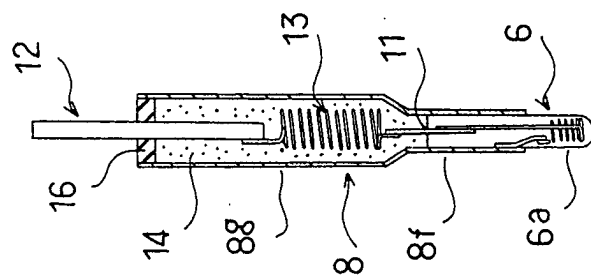
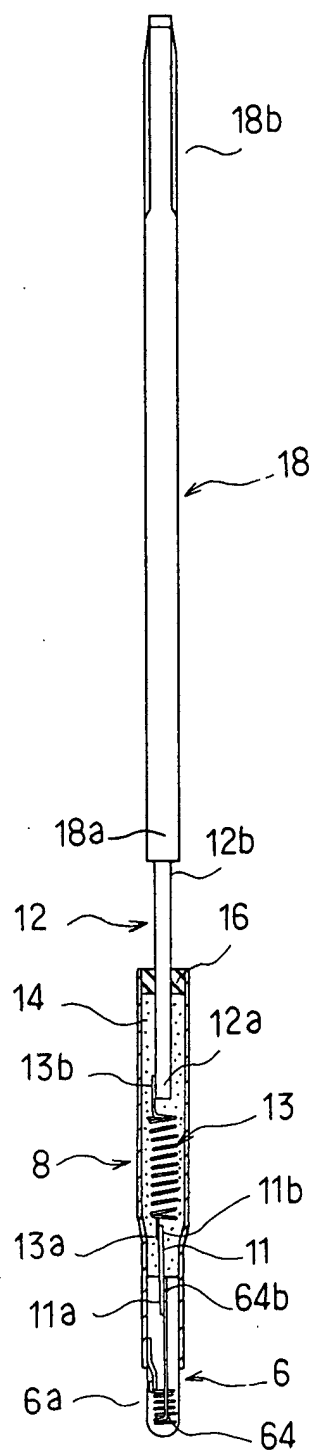


FIG. 4A

FIG.5



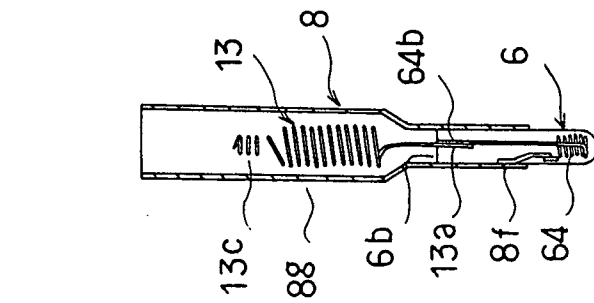


FIG. 6A

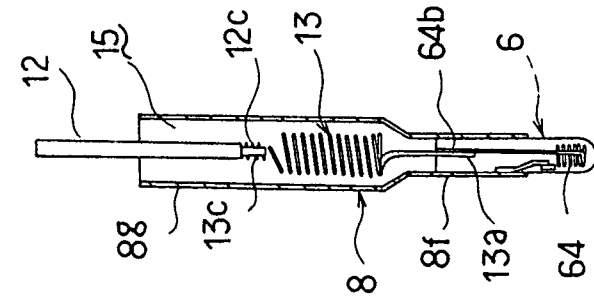


FIG. 6B

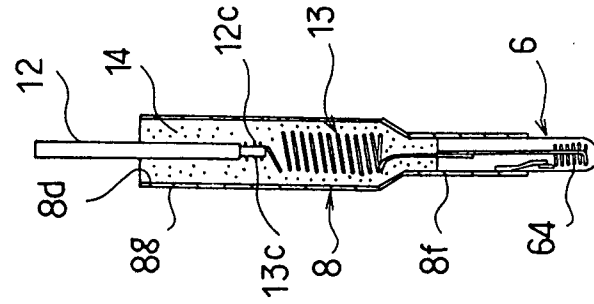


FIG. 6C

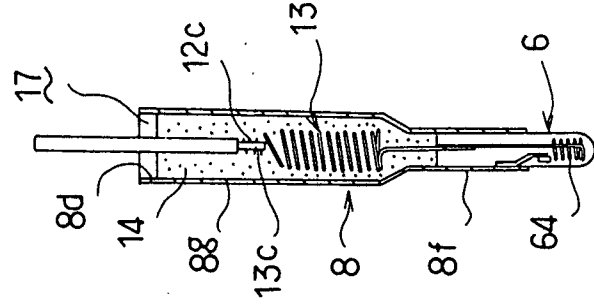


FIG. 6D

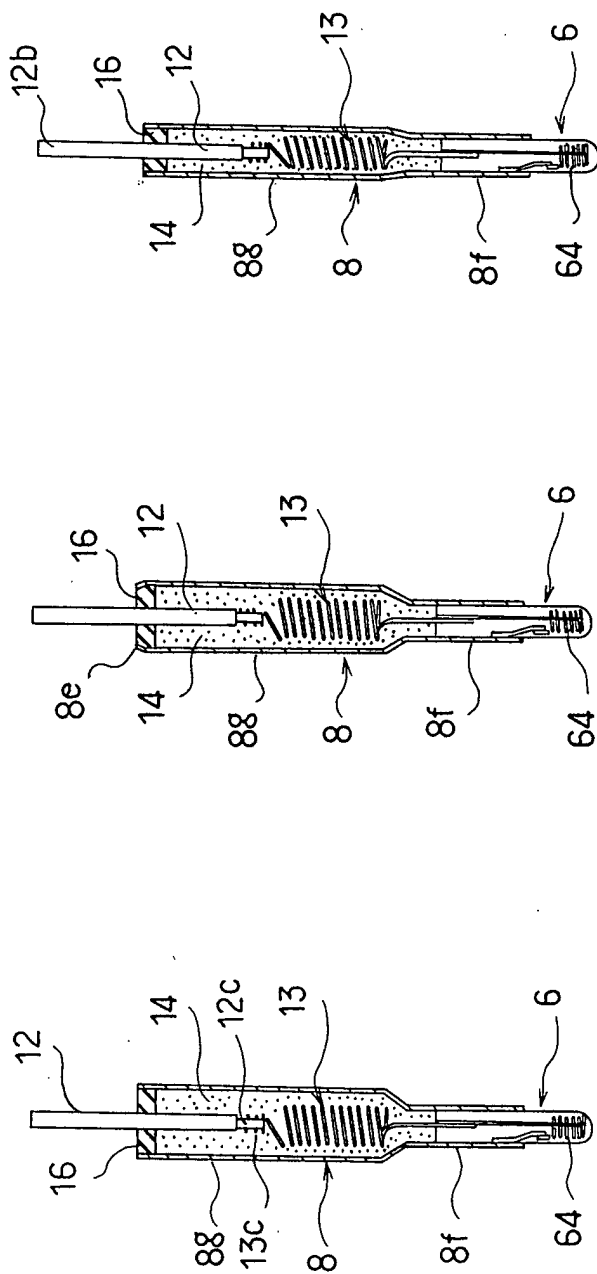


FIG. 7A

FIG. 7B

FIG. 7C

FIG.8

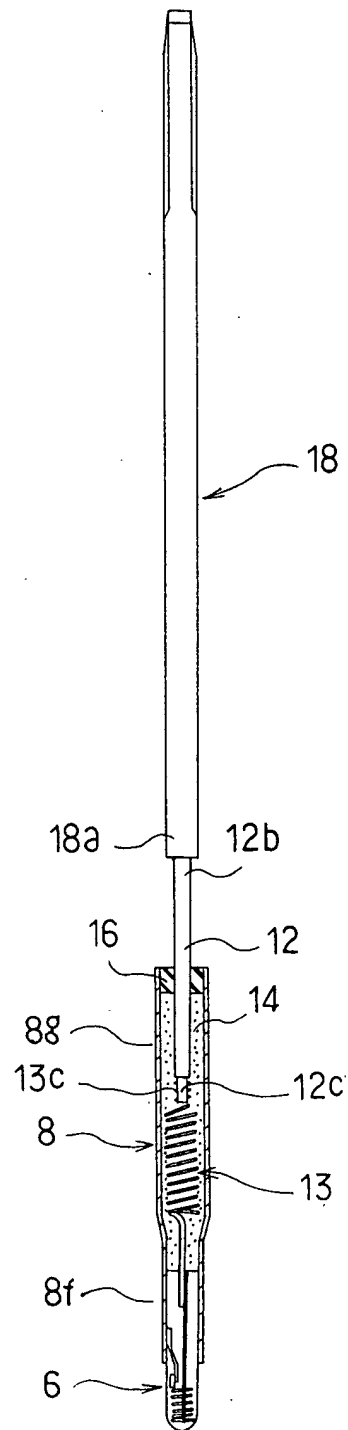


FIG.9A

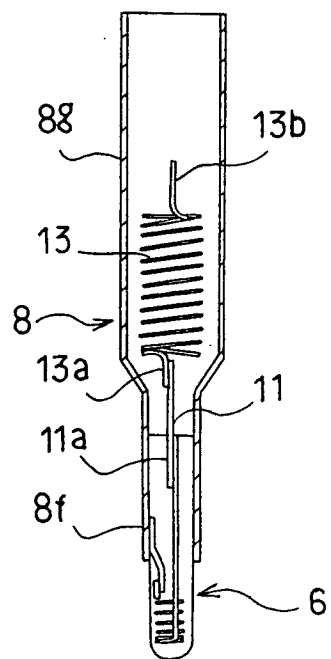


FIG.9B

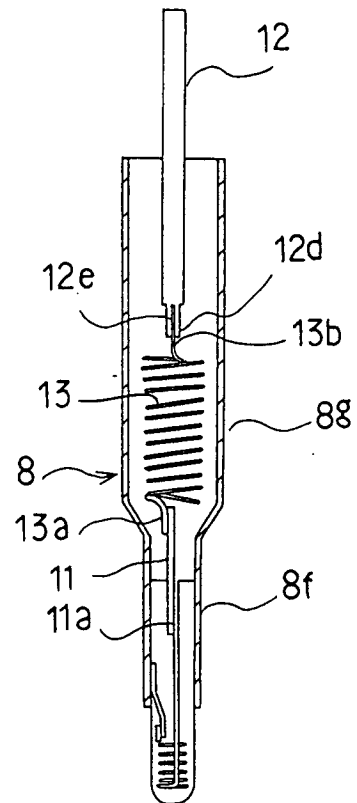


FIG.10A

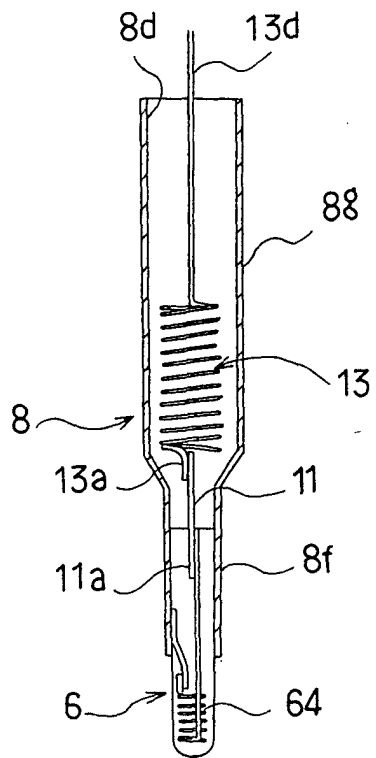


FIG.10B

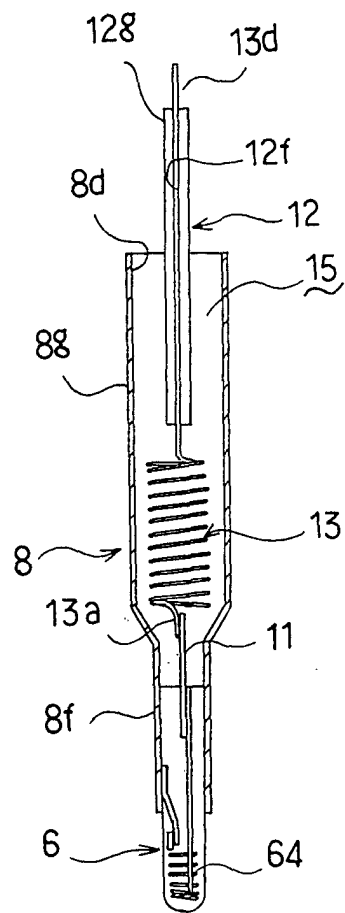


FIG.11

1

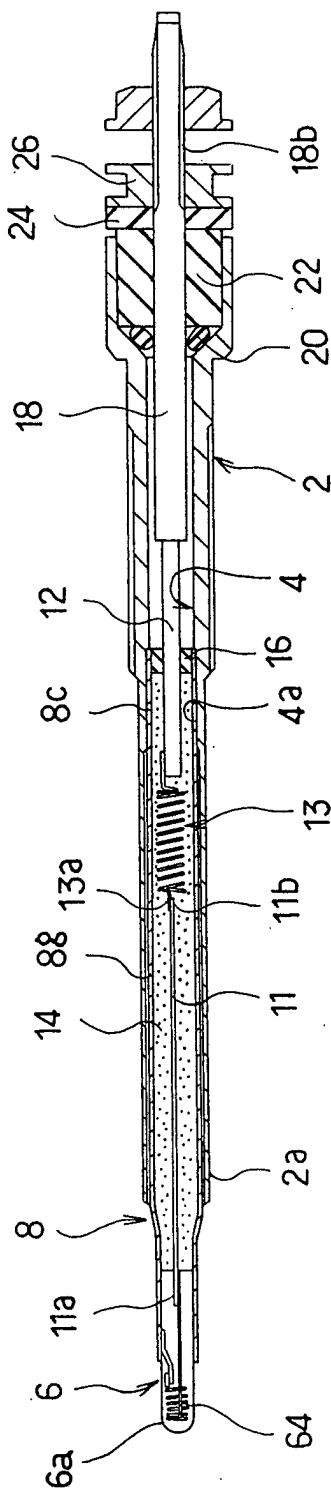
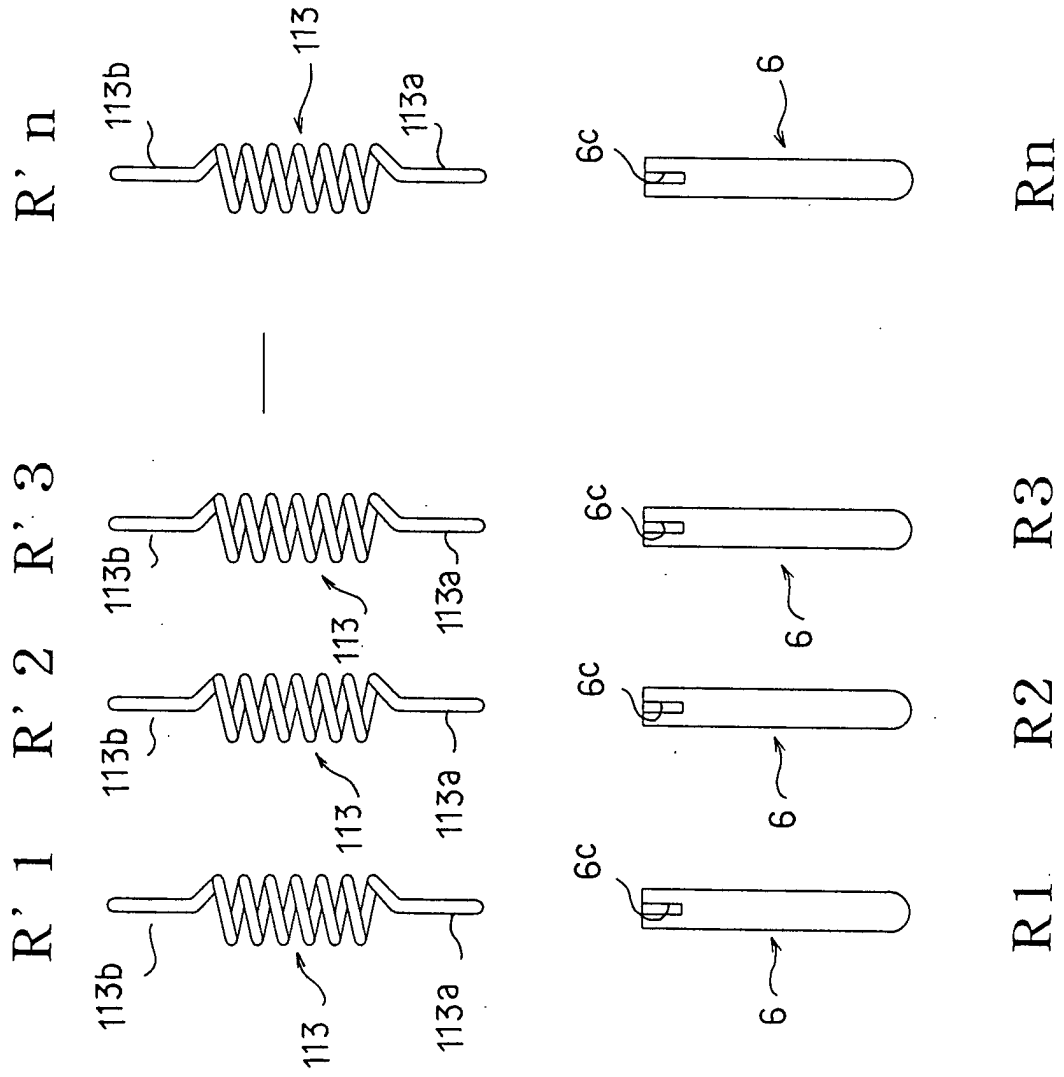


FIG.12



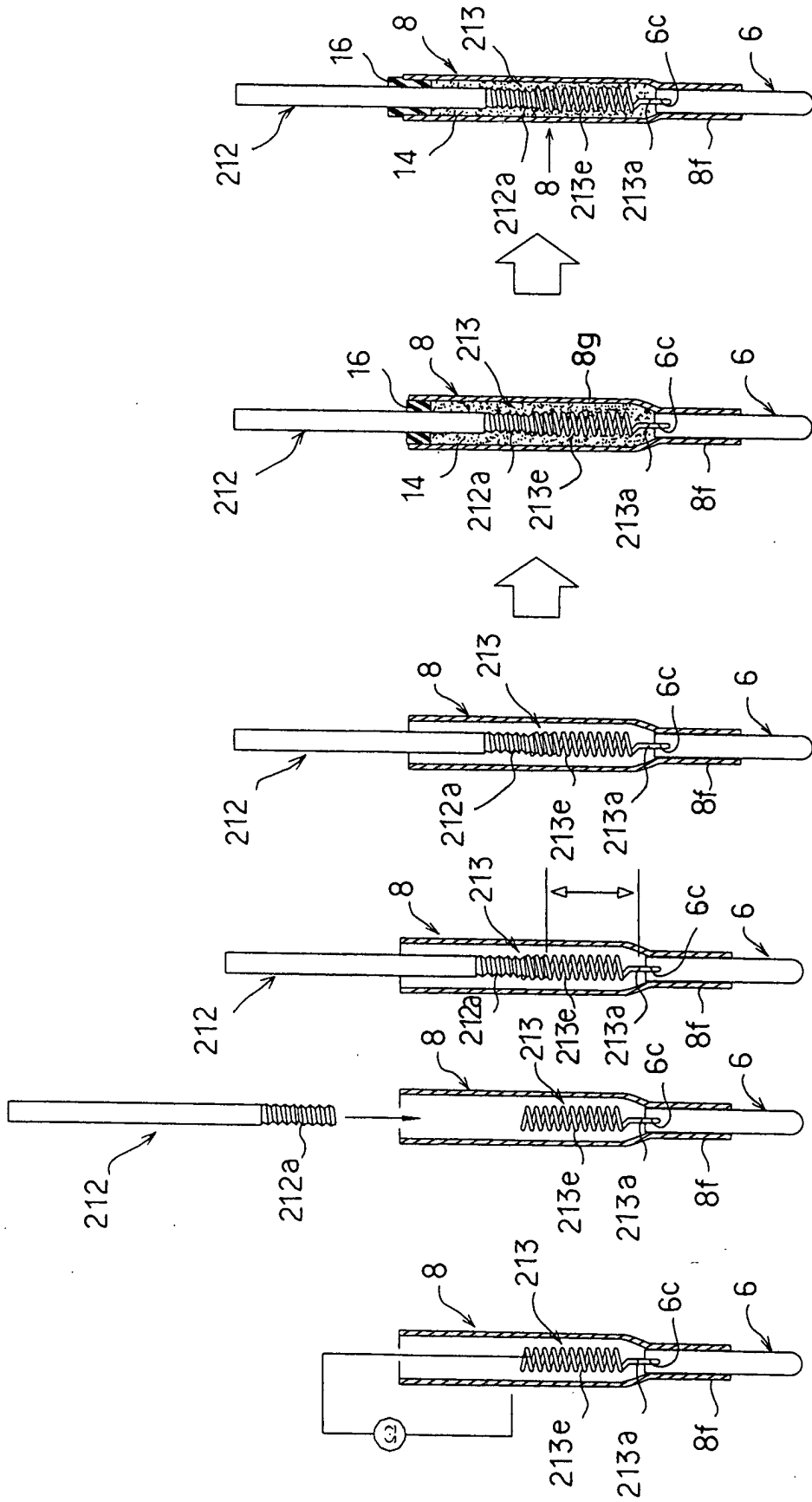


FIG. 13F

FIG. 13E

FIG. 13D

FIG. 13C

FIG. 13B

FIG. 13A