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Office européen des brevets



(11) **EP 1 328 138 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
16.07.2003 Bulletin 2003/29

(51) Int Cl.7: **H05B 3/44**

(21) Application number: **01976690.6**

(86) International application number:
PCT/JP01/09043

(22) Date of filing: **15.10.2001**

(87) International publication number:
WO 02/033149 (25.04.2002 Gazette 2002/17)

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR**

(30) Priority: **17.10.2000 JP 2000317079**
27.07.2001 JP 2001228361

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

(72) Inventors:
• **TANAKA, Arihito**
C/O BOSCH AUTOMOTIVE SYST. CORP.
Higashimatsuyama-shi Saitama 355-8603 (JP)

- **AOTA, Takashi**
C/O BOSCH AUTOMOTIVE SYST. CORP.
Higashimatsuyama-shi Saitama 355-8603 (JP)
- **ZHAO, Jian**
C/O BOSCH AUTOMOTIVE SYST. CORP.
Higashimatsuyama-shi Saitama 355-8603 (JP)
- **MIURA, Toshitsugu**
C/O BOSCH AUTOMOTIVE SYST. CORP.
Higashimatsuyama-shi Saitama 355-8603 (JP)
- **SUGIMOTO, Hitoshi**
C/O BOSCH AUTOMOTIVE SYST. CORP.
Higashimatsuyama-shi Saitama 355-8603 (JP)

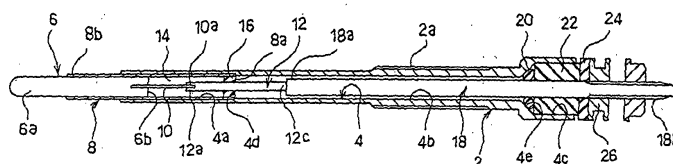
(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) **CERAMIC HEATER TYPE GLOW PLUG AND METHOD OF MANUFACTURING THE GLOW PLUG**

(57) A ceramics heater 6 includes a heating element which is carried by an insulating ceramics material. A negative pole lead wire extends from the heating element and is externally exposed on a lateral surface of the ceramics heater to be electrically connected to a metallic outer sleeve 8. The ceramics heater 6 also has a positive pole lead wire 10 which is taken out through an end face of the ceramics heater disposed remote from the heating element to be connected to an electrode fitting 12. The ceramics heater is cemented to the metallic outer sleeve toward one end thereof so that a junction

between the lead wire and the electrode fitting is situated within the metallic outer sleeve. A refractory insulating powder 14 is filled into the space within the metallic outer sleeve, which is then subject to a swaging operation to densify the refractory insulating powder, thereby securing the electrode fitting within the metallic outer sleeve. The swaged portion of the metallic outer sleeve is secured within an internal bore 4 of a housing. A structure which supports the lead wire and the electrode fitting is simplified, and a tightening torque applied to an external connection terminal 18 can be resisted by the metallic outer sleeve which is secured to the housing.

FIG. 1.



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 ceramics heater glow plug which uses a ceramics heater as a heating element and a method of manufacturing same.

BACKGROUND ART

[0002] A ceramics heater is known in the art which includes a heating element formed by a coil of high melting metal (such as tungsten) or a conductive ceramics material or a film shaped heating element embedded in an insulating ceramics material. Where the conductive ceramics material is used as the heating element, it is partly exposed outside the insulating ceramics so that a lead wire connected to the negative electrode of the heating element can be taken out through the side of the insulating ceramics material for connection with a metallic outer sleeve, while a lead wire connected to the positive electrode of the heating element is taken out through an end face of the insulating ceramics material which is located remote from the heating element for connection with one end of an electrode fitting, the other end of which is connected to an external connection terminal.

[0003] When the positive electrode lead wire which projects through the end face of the ceramics heater is to be connected with the heating element within the insulating ceramics material, a mounting hole is opened into the end face of the insulating ceramics material so that the lead wire can be connected with the heating element within the mounting hole. However, the size of the mounting hole is limited, preventing the diameter of the lead wire from being increased and also preventing the lead wire from being formed with a sufficient rigidity. Also, for the connection between the lead wire and the heating element on the end face of the ceramics heater, it is difficult to achieve a sufficient strength for the connection. It will be seen that the insulating ceramics material is brittle in nature and cannot stand an increased force applied. For this reason, when a power supply (battery) is connected to the external connection terminal, a tightening torque applied cannot be resisted by the lead wire alone. As a consequence, in order to allow a tightening torque which is applied when connecting the battery to the ceramics heater to be resisted, there results a tendency that the connection with the electrode fitting or the external connection terminal or a construction which fixes them to a housing becomes complex and leads to an increased size.

[0004] It is also necessary that the resulting construction be capable of withstanding vibrations of an engine, again resulting in a tendency toward an increased size of the construction which fixes the electrode fitting or the external connection terminal.

[0005] Recently, to accommodate for regulatory requirements on exhaust gases, a combustion scheme of a diesel engine is shifting toward a direct injection type, whereby a reduced diameter and an increased overall length are demanded for an associated glow plug. To meet with these demands, it is necessary that a part of the ceramics heater which is passed through a housing during the assembly be reduced in diameter and the housing itself be also reduced in diameter while securing the strength thereof so that a sufficient strength can be secured to withstand the tightening torque applied when connecting a battery terminal to the external connection terminal or to withstand vibrations of an engine.

[0006] With a sheath heater which is extensively used in the art for a heating element of a glow plug for a diesel engine, the electrode fitting is swaged to be secured within the sheath so that the electrode fitting provides a strength which resists a tightening torque applied to the external connection terminal or vibrations of an engine. By contrast, with the ceramics heater as mentioned above, there remains a problem in securing the required strength because the lead wire which is taken out of the end face of the ceramics heater is reduced in diameter.

[0007] The present invention has been made to solve such problems, and has for its object the provision of a glow plug including a ceramics heater having a simplified construction which supports the lead wire taken out from the end face of the ceramics heater and the electrode fitting connected to the lead wire with respect to the housing while securing a sufficient strength to resist the tightening torque applied to the external connection terminal and vibrations of an engine.

DISCLOSURE OF THE INVENTION

[0008] A ceramics heater glow plug according to the present invention comprises a ceramics heater formed by an insulating ceramics material and an inorganic conductor, a metallic outer sleeve having one end in which the ceramics heater is secured and having the other end which is secured in an internal bore of a housing, and an electrode fitting connected to one of lead wires which projects through an end face of a heating element of the ceramics heater which is located inside the metallic outer sleeve. In particular, the electrode fitting is formed as a rigid body, and the junction between the electrode fitting and the lead wire from the heating element is contained within the metallic outer sleeve. The electrode fitting is secured within the metallic outer sleeve through an insulator interposed therebetween.

[0009] According to the present invention, the lead wire extending from the electrode of the heating element and the electrode fitting are secured to the metallic outer sleeve through the interposed insulator, allowing the electrode fitting to be insulated in a reliable manner and simplifying the construction which support them with respect to the housing and thus reducing the manufacturing cost. The tightening torque applied to the external

connection terminal is transmitted to a region of the housing where the metallic outer sleeve is disposed as a press fit through the interposed electrode fitting which is formed as a rigid body, thus allowing the construction which fixes the external connection terminal to be simplified. A likelihood of a wire breakage occurring due to vibrations or an ingress of water is avoided and there is no likelihood that the ceramics heater may be deformed under the influence of vibrations, thermal cycle or internal cylinder pressure or may be damaged under the influence of external force. If an external force of an excessively high magnitude is applied to the external connection terminal, such force cannot be transmitted to the ceramics heater, thus avoiding any damage thereof. The lead wire extending from the electrode of the heating element can be reduced in length, thus suppressing a self-heating of the lead wire and the resulting power dissipation. Finally, the ceramics heater glow plug can be constructed in substantially identical manner as a sheath glow plug, allowing parts and an assembling equipment to be used in common to reduce the manufacturing cost.

[0010] The invention defined in Claim 2 is characterized in that in the arrangement of the invention defined in Claim 1, an insertion opening is formed in the end face of the electrode fitting to receive one end of the lead wire for purpose of connection therewith.

[0011] The invention defined in Claim 3 is characterized in that in the arrangement of the invention defined in Claim 2, the insertion opening comprises an through-opening axially extending through the electrode fitting to receive the lead wire, and the outer periphery of the electrode fitting is subject to a plastic deformation for connection with the lead wire.

[0012] The invention defined in Claim 4 is characterized in that in the arrangement of the invention defined in Claim 1, a lateral surface of the lead wire at its distal end is disposed in abutment against a lateral surface of the electrode fitting at the distal end thereof for purpose of connection therebetween.

[0013] The invention defined in Claim 5 is characterized in that in the arrangement of the invention defined in Claim 4, the distal end of the electrode fitting is formed with a step, against which the lateral surface of the lead wire at its distal end abuts for purpose of connection therebetween.

[0014] The invention defined in Claim 6 is characterized in that in the arrangement of the invention defined in Claim 1, a connection member is used to connect between the lead wire and the electrode fitting.

[0015] The invention defined in Claim 7 is characterized in that in the arrangement of the invention defined in Claim 1, a hollow pipe member is used as the lead wire extending from the electrode of the heating element.

[0016] The invention defined in Claim 8 is characterized in that in the arrangement of the invention defined in Claim 1, a slitted hollow pipe member is used as the

lead wire extending from the electrode of the heating element.

[0017] According to the inventions defined in Claims 7 and 8 where a hollow pipe is used as the lead wire extending from the electrode of the heating element, when the hollow pipe is inserted into the mounting hole formed in the end of the ceramics heater and is cemented therewith by brazure, air remaining within the mounting hole can be exhausted smoothly, thus reducing air bubbles which may be generated therein.

[0018] The invention defined in Claim 9 is characterized in that in the arrangement of either invention defined in Claim 1, 7 or 8, the distal end of the lead wire is coiled, and the distal end of the electrode fitting is inserted into the coiled end for purpose of connection therebetween.

[0019] The invention defined in Claim 10 is characterized in that in the arrangement of the invention defined in either Claim 7 or 8, the hollow pipe member which is used as a lead wire is formed at its end with a cup-shaped juncture, into which the distal end of the electrode fitting fits. The invention defined in Claim 10 permits the electrode fitting and the lead wire to be connected together in a simple and reliable manner from outside the metallic outer sleeve, in addition to the advantages achieved by the inventions defined in Claims 7 and 8.

[0020] The invention defined in Claim 11 is characterized in that in the arrangement of the invention defined either one of Claims 1, 7 and 8, the end of the lead wire extending from the electrode of the heating element is helically coiled, while the distal end of the electrode fitting is formed with a plurality of steps, which are engaged with an unevenness in the helical coil to achieve a connection therebetween.

[0021] The invention defined in Claim 12 is characterized in that in the arrangement of the invention defined in either Claim 7 or 8, the end of the lead wire extending from the electrode of the heating element is helically coiled, while the distal end of the electrode fitting is threaded for threadable engagement with the helical coil to provide a connection therebetween.

[0022] The inventions defined in Claims 11 and 12 allow the electrode fitting and the lead wire extending from the electrode of the heating element to be connected together in a reliable manner while preventing a disengagement therebetween, thus achieving a reliable electrical connection.

[0023] The invention defined in Claim 13 is characterized in that in the arrangement of the ceramics heater glow plug according to one of the above Claims, an elastic seal member is fitted into an opening formed in the metallic outer sleeve which is located toward the electrode.

[0024] The invention defined in Claim 14 is characterized in that in the ceramics heater glow plug according to one of the above Claims, the metallic outer sleeve comprises a stepped pipe including a portion of a reduced diameter and another portion of a greater diam-

eter, and an end face of the ceramics heater which is located within the metallic outer sleeve is disposed within the portion of a greater diameter.

[0025] The invention defined in Claim 15 relates to a method of manufacturing a ceramics heater according to one of the above Claims, comprising the sequential steps of connecting a lead wire which projects from the end face of the ceramics heater with the electrode fitting, securing the ceramics heater in one end of the metallic outer sleeve, filling a refractory insulating powder into the other end of the metallic outer sleeve, and subjecting the outer periphery of the metallic sleeve in which the lead wire and the electrode fitting are contained to a swaging operation to reduce the diameter thereof, thereby securing the electrode fitting to the metallic outer sleeve.

[0026] The invention defined in Claim 16 relates to a method of manufacturing a ceramics heater according to one of the above Claims, comprising the sequential steps of securing the ceramics heater in one end of the metallic outer sleeve, connecting the lead wire projecting from an end face of the ceramics heater with the electrode fitting, filling a refractory insulating powder into the other end of the metallic outer sleeve, and subjecting the outer periphery of the metallic outer sleeve in which the lead wire and the electrode fitting are contained to a swaging operation to reduce the diameter thereof, thereby securing the electrode fitting to the metallic outer sleeve.

[0027] According to the method of the invention defined in either Claim 15 or 16, a portion of the metallic outer sleeve which is disposed as a press fit in a housing is formed by a swaging operation, and accordingly, a dimensional accuracy can be maintained to stabilize the press fit. This permits a welding or caulking operation which is intended to connect between the lead wire extending from the electrode of the heating element and the electrode fitting to be dispensed with, thus improving the ease of assembly and productivity while reducing the manufacturing cost.

[0028] The invention defined in Claim 17 is characterized in that in the method defined in Claim 16, at the same time as the ceramics heater is secured in one end of the metallic outer sleeve, one end of the lead wire is connected to the ceramics heater.

[0029] The invention defined in Claim 18 is characterized in that in the manufacturing method mentioned above, a portion of the metallic outer sleeve which is subject to the swaging operation assumes an outer diameter before the swaging operation takes place which is greater than the outer diameter of a portion thereof where the ceramics heater is secured.

[0030] The invention defined in Claim 19 is characterized in that in the manufacturing method mentioned above, subsequent to the step of filling a refractory insulating powder into the other end of the metallic outer sleeve, an elastic seal member is fitted into an opening of the metallic outer sleeve which is located toward the

electrode fitting.

[0031] The invention defined in Claim 20 is characterized in that in the manufacturing method defined in either Claim 15 or 16, an end of the lead wire extending from the electrode of the heating element is helically coiled while the distal end of the electrode fitting is formed with a plurality of steps, and the electrode fitting is axially urged to drive the steps into the helical coil for engagement therebetween, thus achieving a connection therebetween.

[0032] The invention defined in Claim 21 is characterized in that in the manufacturing method defined in either Claim 15 or 16, an end of the lead wire extending from the electrode is helically coiled while the distal end of the electrode fitting is threaded, and the electrode fitting is rotated to cause the threads to be threadably engaged with the helical coil to provide a connection therebetween.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

Fig. 1 is a longitudinal section of a ceramics heater glow plug according to one embodiment of the present invention;

Fig. 2 illustrates an exemplary construction of connecting between a lead wire of a ceramics heater and an electrode fitting;

Fig. 3 shows a sequence of steps for assembling the ceramics heater glow plug;

Fig. 4 shown an example of sub-assembly at a point where a lead wire from the ceramics heater is connected to a external connection terminal;

Fig. 5 shows other examples of a construction connecting between a lead wire of the ceramics heater and the electrode fitting;

Fig. 6 shows a sequence of assembling steps for a ceramics heater glow plug according to a second embodiment of the invention.

Fig. 7 shows another example of a sub-assembly at a point where a lead wire of the ceramics heater is connected to an external connection terminal;

Fig. 8 shows steps in a first half of a sequence of assembling steps for a ceramics heater glow plug according to a third embodiment of the invention;

Fig. 9 shows steps in the sequence of assembling steps for the ceramics heater glow plug according to the third embodiment which follow the steps shown in Fig. 8;

Fig. 10 shows a third example of a sub-assembly at a point where a lead wire from the ceramics heater is connected with an external connection terminal;

Fig. 11 shows steps in a first half of sequence of assembling steps for a ceramics heater glow plug according to a fourth embodiment;

Fig. 12 shows steps in the sequence of assembling steps for the ceramics heater glow plug according

to the fourth embodiment which follow the steps shown in Fig. 11;

Fig. 13 shows a fourth example of a sub-assembly at a point where a lead wire of the ceramics heater is connected with an external connection terminal;

Fig. 14 shows steps in a first half of the sequence of assembling steps for a ceramics heater glow plug according to a fifth embodiment;

Fig. 15 shows steps in the sequence of assembling steps for the ceramics heater glow plug according to the fifth embodiment which follow the steps shown in Fig. 14;

Fig. 16 shows a fifth example of a sub-assembly at a point where a lead wire of the ceramics heater is connected with the external connection terminal;

Fig. 17 shows steps in a first half of a sequence of assembling steps for a ceramics heater glow plug according to a sixth embodiment;

Fig. 18 shows steps in the sequence of assembling for the ceramics heater glow according to the sixth embodiment which follow the steps shown in Fig. 17;

Fig. 19 shows a sixth example of a sub-assembly where a lead wire of the ceramics heater is connected with the external connection terminal;

Fig. 20 shows steps in a first half of a sequence of assembling steps for a ceramics heater glow plug according to a seventh embodiment;

Fig. 21 shows steps in the sequence of assembling steps for the ceramics heater glow plug according to the seventh embodiment which follow the steps shown in Fig. 20;

Fig. 22 shows a seventh example of a sub-assembly at a point where a lead wire of the ceramics heater is connected with the external connection terminal;

Fig. 23 is a longitudinal section illustrating a status in the course of assembling a ceramics heater glow plug according to an eighth embodiment;

Fig. 24 shows an example of an lead wire extending from the electrode of the heating element, Fig. 24 (a) being a front view of a hollow pipe, Fig. 24(b) a side elevation, Fig. 24(c) a front view of a slitted hollow pipe and Fig. 24(d) a side elevation;

Fig. 25 is a longitudinal section showing a status in the course of assembling a ceramics heater glow plug according to a ninth embodiment;

Fig. 26 shows a status in the course of assembling a ceramics heater glow plug according to a tenth embodiment, Fig. 26 (a) showing a status before a connection between the lead wire extending from the electrode of the heating element and the electrode fitting and Fig. 26(b) a status after the connection is completed;

Fig. 27 shows a status in the course of assembling a ceramics heater glow plug according to an eleventh embodiment, Fig. 27(a) showing a status before the connection between the lead wire extend-

ing from the electrode of the heating element and the electrode fitting and Fig. 27(b) a status after the connection is completed;

Fig. 28 shows sequential steps in the course of assembling a ceramics heater glow plug according to a twelfth embodiment;

Fig. 29 shows sequential steps in the course of assembling a ceramics heater glow plug according to a thirteenth embodiment;

Fig. 30 shows sequential steps in the course of assembling a ceramics heater glow plug according to a fourteenth embodiment;

Fig. 31 shows sequential steps in the course of assembling a ceramics heater glow plug according to a fifteenth embodiment;

Fig. 32 shows sequential steps in the course of assembling a ceramics heater glow plug according to a sixteenth embodiment;

Fig. 33 shows sequential steps in the course of assembling a ceramics heater glow plug according to a seventeenth embodiment; and

Fig. 34 shows sequential steps in the course of assembling a ceramics heater glow plug according to an eighteenth embodiment.

BEST MODES OF CARRYING OUT THE INVENTION

[0034] Several embodiments of the present invention will now be described with reference to the drawings. Fig. 1 is a longitudinal section of a ceramics heater glow plug according to one embodiment of the present invention. The glow plug has a cylindrical housing 2 having an internal bore 4 which is a stepped axial bore including a portion of a medium diameter 4a which is located to the left and in which a ceramics heater is secured, a portion of a greater diameter 4c which is located to the right and in which an external connection terminal is secured, and a portion of a reduced diameter 4b which is disposed between the portions 4a and 4c.

[0035] A ceramics heater 6 is cemented, as by being disposed as a press fit or by brazure, to a metallic outer sleeve 8, which is in turn inserted into the portion 4a of a medium diameter of the internal bore 4 in the housing 2. The outer periphery of the metallic outer sleeve 8 is partly secured to the housing 2 as by being disposed as a press fit or by brazure.

[0036] Since the ceramics heater 6 is generally known in construction, its interior will not be specifically shown or described. However, briefly, the ceramics heater 6 comprises a body which is formed by a ceramics insulating material in which a coil of a high melting material such as tungsten (W), for example, is embedded as a heating wire to provide a heating element 6a, which projects externally through a distal end 8b of the metallic outer sleeve 8. An end face 6b of the ceramics heater 6 which is located remote from the heating element 6a is situated inside the metallic outer sleeve 8. In this embodiment, the heating element comprises a high melting

metal, but it may be in the form of a heating element formed by conductive ceramics or a sheet-like heating element. In sum, the ceramic heater 6 may be a composite structure of an insulating ceramics material and an inorganic conductor which serves as a heating element, as may be provided by exposing part of a heating element of conductive ceramics outside the insulating ceramics material.

[0037] A negative pole lead wire is connected to one end of the coiled heating wire which is embedded within the ceramics heater 6, while a positive pole lead wire is connected to the other end thereof. The negative pole lead wire is exposed externally of the ceramics insulating material inside the metallic outer sleeve 8 and is electrically connected to the internal surface of the metallic outer sleeve 8 as by brazure. On the other hand, the positive pole lead wire extends toward the end face 6b, and is connected to an electrode connection lead wire 10 within the end of the ceramics heater 6. A structure which connects the electrode connection lead wire 10 with the positive pole lead wire disposed within the ceramics insulating material and taken out of the ceramics heater is disclosed in Japanese Patent Applications No. 173,877/1999, No. 143,994/2000 and the like, but any other technique maybe applied.

[0038] The electrode connection lead wire 10 which is taken out through the end face 6b of the ceramics heater 6 has a distal end 10a, which is connected to an electrode fitting 12 inside the metallic outer sleeve 8. It should be noted that the electrode connection lead wire 10 is a wire of a reduced diameter, but the electrode fitting 12 comprises a rigid material. The electrode fitting 12 has an end 12a, in which an insertion opening 12b (which will be described later with reference to Fig. 2) is formed, and the distal end 10a of the electrode connection lead wire 10 is inserted into the insertion opening 12b and is connected thereto as by brazing or by caulking the end 12a of the electrode fitting 12.

[0039] A refractory insulating powder which is swaged to provide a densified insulator 14 is filled into the metallic outer sleeve 8 around a junction between the electrode connection lead wire 10 and the electrode fitting 12, whereby the electrode connection lead wire 10 and the electrode fitting 12 are secured in the metallic outer sleeve 8 through the interposed insulator 14. A seal member 16 is fitted between an opening of the metallic outer sleeve 8 and the external surface of the electrode fitting 12.

[0040] The electrode fitting 12 which has its end 12a secured within the metallic outer sleeve 8 has its other end 12c projecting externally of the metallic outer sleeve 8, and a distal end 18a of an external connection terminal 18 is connected to the end 12c as by butt welding. A sub-assembly including the ceramics heater 6, the metallic outer sleeve 8, the electrode fitting 12 and the external connection terminal 18 is inserted into the internal bore 4 through the end of the housing 2 which is located toward the ceramics heater (or the left end as

viewed in Fig.1) with a threaded portion 18b of the external connection terminal 18 which is used for connection with a battery disposed foremost and is secured when the metallic outer sleeve 8 is disposed as a press fit at a given position or secured at a given position by brazure (brazure using a silver brazing material). When the sub-assembly is secured in the housing 2, the threaded portion 18b of the external connection terminal 18 projects externally of the housing 2.

[0041] After the ceramics heater 6 and the metallic outer sleeve 8 have been secured to the housing 2 in the manner mentioned above, a seal member 20 (O-ring 20) and a cylindrical insulating bushing 22 are fitted over the end adjacent to the threaded portion 18b of the external connection terminal 18 which projects externally of the housing, and are inserted into the portion 4c of a greater diameter of the internal bore 4 in the housing 2. Subsequently, a washer-like insulating member 24 is fitted over the threaded end, and an aluminum nut is clamped to the threaded end. The portion 4c of a greater diameter of the internal bore 4 in the housing 2 has a tapered surface 4e toward the portion 4b of a reduced diameter, and when the seal member 20 is pressed between the tapered surface 4e and the insulating bushing 22, a hermetic seal of the interior of the housing 2 is maintained. While the seal member 20 and the insulating bushing 22 can be secured in place by caulking the end of the housing 2, clamping the aluminum nut 26 dispenses with the caulking step and is advantageous in respect of the cost required.

[0042] However, it should be understood that the external connection terminal may be secured in place by any other construction. For example, as disclosed in Japanese Patent Application No. 084, 659/2000, an insulating securing member may be provided between the internal surface of the housing 2 and the external surface of the external connection terminal 18 so that a tightening torque may be applied to the external connection terminal 18.

[0043] In the ceramics heater glow plug constructed in the manner mentioned above, the electrode connection lead wire 10 extending from the ceramics heater 6 and the electrode fitting 12 which is connected to the external connection terminal 18 are connected together inside the metallic outer sleeve 8, and both of them are secured in the metallic outer sleeve 8 by the insulator 14 which fills the interior of the metallic outer sleeve 8. Accordingly, there is no need to provide an insulating support for the electrode connection lead wire 10 and the electrode fitting 12, and the construction which supports them with respect to the housing 2 is simplified, reducing the manufacturing cost. The tightening torque which is applied to the external connection terminal is resisted by the electrode fitting 12 and the insulator 14, thus simplifying the construction which secures the external connection terminal 18.

[0044] Referring to Figs. 2 to 5, an assembling procedure which is used when securing an electrode connec-

tion lead wire 10 extending from the ceramics heater 6 and the electrode fitting 12 to the metallic outer sleeve 8 will be described. Initially, one end 12a of the electrode fitting 12 which comprises a rigid body is connected to the distal end 10a of the electrode connection lead wire 10 which extends through the end face 6b of the ceramics heater 6. The lead wire 10 comprises a nickel (Ni) wire or a nickel plated soft steel wire having a thickness ϕ on the order of 0.5 to 1.0 mm. The electrode fitting 12 has a thickness ϕ on the order of 2.2 to 2.4 mm where the external diameter of the threaded portion 2a (see Fig. 1) of the housing 2 is M8 and has a thickness ϕ on the order of 2.8mm for M10.

[0045] As shown to an exaggerated scale in Fig. 2, the connecting construction between the electrode connection lead wire 10 and the lead wire 12 is formed by forming an insertion opening 12b in the end 12a of the electrode fitting 12, and inserting the distal end 10a of the electrode connection lead wire 10 into the insertion opening 10b and connected thereto by brazure or by caulking. However, the connection is not limited to this construction. As illustrated in Fig. 5(a), one side of the distal end 12a of the electrode fitting 12 may be notched to form a notched area 12d, and the lateral surface of the distal end 10a of the electrode connection lead wire 10 may be disposed in abutment against the notched area 12d for purpose of connection. Alternatively, as shown in Fig. 5(b), a lateral surface of the distal end 10a of the electrode connection lead wire 10 may be disposed in contact with a lateral surface of the distal end 12a of the electrode fitting 12, and the both members may be welded together. As a further alternative, as shown in Fig. 5(c), the distal end 12a of the electrode fitting 12 may be inserted into one end of a pipe-shaped connection member 30 while the distal end 10a of the electrode connection lead wire 10 may be inserted into the other end of the connection member 30, which is then caulked to connect the both members together. Instead, the both members may be disposed into the opposite ends of the connection members 30 as a press fit for purpose of connection.

[0046] After the electrode connection lead wire 10 extending from the ceramics heater 6 and the electrode fitting 12 are connected together, the ceramics heater 6 may be secured in the end of the metallic outer sleeve 8 which is located toward the ceramics heater by brazure or by being disposed as a press fit therein. Obviously, at this time, the heating element 6a of the ceramics heater 6 must be exposed externally of the metallic outer sleeve 8. The metallic outer sleeve 8 in which the ceramics heater 6 is secured is stepped to define the portion 8c of a greater diameter on the side opposite from the end where the ceramics heater 6 is secured and where the electrode fitting 12 is secured, and the junction between the electrode connection lead wire 10 and the electrode fitting 12 is disposed within the portion 8c of a greater diameter (see Fig. 3(a)).

[0047] An exemplary assembling procedure which is

used when securing the ceramics heater 6 to the metallic outer sleeve 8 by brazure will be described briefly. An assembly (see Fig. 2) of the ceramics heater 6 having the electrode connection lead wire 10 and the electrode fitting 12 connected together is set up on a brazure jig, not shown. It should be noted that a plurality of ceramics heater assemblies are set up on the brazure jig for performing a brazing operation simultaneously. A wire of brazing filler material (brazing silver) which is coiled is set up on the end face of the ceramics heater 6 which is located inside the metallic outer sleeve 8. The metallic outer sleeve 8 is then fitted over the ceramics heater 6. The brazing filler material is then heated to melt to complete a brazing between the ceramics heater 6 and the metallic outer sleeve 8.

[0048] After the ceramics heater 6 has been secured inside the stepped metallic outer sleeve 8, a refractory insulating powder (such as magnesia (MgO) or the like, for example) 14 is filled into a space in which the junction between the electrode connection lead wire 10 and the electrode fitting 12 is contained through an opening 8d of the metallic outer sleeve 8 which is located at the end of the portion 8c of a greater diameter (see Fig. 3(b)). Subsequently, a seal member of rubber (such as silicone rubber or fluorine containing rubber) is inserted into the opening 8d of the metallic outer sleeve 8 (see Fig. 3(c)). The insertion of the seal member 16 into the opening 8d of the metallic outer sleeve 8 is effective to prevent a spillage of the refractory insulating powder 14 from occurring when the swaging operation takes place subsequently and also prevents the electrode fitting 12 from contacting the metallic outer sleeve 8. The end of the metallic outer sleeve 8 is then caulked (indicated by reference numeral 8e shown in Fig. 3(d)), preventing the seal member 16 from being disengaged.

[0049] When the refractory insulating powder 14 is filled into the metallic outer sleeve 8, the seal member 16 is inserted and the end 8e of the metallic outer sleeve 8 is caulked as indicated in Fig. 3(d), the portion 8c of a greater diameter of the metallic outer sleeve 8 in which the junction between the electrode connection lead wire 10 and the electrode fitting 12 is contained is subject to a swaging operation, whereby the diameter of the sleeve 8 is reduced to be comparable to the diameter of the portion of the metallic outer sleeve 8 in which the ceramics heater 6 is secured. In this manner, by reducing the external diameter of the metallic outer sleeve 8 by means of the swaging operation, the refractory insulating powder 14 is densified to secure the electrode fitting 12 within the metallic outer sleeve 8 (see Fig. 3(e)). It should be understood that the external diameter of the swaged portion may be slightly greater than or less than the external diameter of the portion of the sleeve 8 in which the ceramics heater 6 is secured.

[0050] One end 18a of the external connection terminal 18 is secured to the outer end 12c of the electrode fitting 12 which is secured within the metallic outer sleeve 8 by the swaging operation mentioned above

(see Fig. 4). The sub-assembly shown in Fig. 4 including the ceramics heater 6, the metallic outer sleeve 8, the electrode fitting 12 and the external connection terminal 18 is inserted into the housing 2 and secured in the manner mentioned above, thus assembling a ceramics heater glow plug.

[0051] With the ceramics heater glow plug constructed in the manner mentioned above, a portion of the metallic outer sleeve 8 which is disposed as a press fit into the housing 2 is formed by the swaging operation, and accordingly, a dimensional accuracy can be maintained to stabilize the press fit. Since the electrode connection lead wire 10 of the ceramics heater 6 is embedded in the refractory insulating powder 14, there is no likelihood of a wire breakage due to vibrations, and has a resistance to the ingress of water. In addition, the presence of the refractory insulating powder 14 is effective in suppressing a penetration of the ceramics heater 6 into the metallic outer sleeve 8 as a result of vibration, thermal cycle, internal cylinder pressure or the like. If an external force of an excessively high magnitude is applied to the external connection terminal 18, such force is not transmitted to the ceramics heater 6, thus effectively preventing any damage of the ceramics heater 6 from occurring. In addition, the length of the electrode connection lead wire 10 can be reduced, allowing a self-heating of the lead wire 10 to be suppressed and the power dissipation to be reduced. Finally, since the ceramics heater glow plug can be formed to a construction which is substantially same as a sheath glow plug, parts or an assembling equipment can be used in common to reduce the manufacturing cost.

[0052] In the described embodiment, the seal member 16 is inserted into the opening 8b of the metallic outer sleeve 8 before the swaging operation takes place, but the use of the seal member 16 may be omitted. In this instance, when molding the metallic outer sleeve 8, the end adjacent to the opening can be molded to be inwardly tapered or the end adjacent to the opening may be caulked before the swaging operation takes place so as to be inwardly tapered. When the opening 8b of the metallic outer sleeve 8 is narrowed in this manner, a spillage of the refractory insulating powder 14 during the swaging operation can be effectively prevented.

[0053] In the above description, a tightening torque applied to the external connection terminal 18 is resisted by the electrode fitting 12, the refractory insulating powder 14, the metallic outer sleeve 8 and the housing 2. This arrangement provides a sufficient strength for the diameter of the mounting threads 2a of the housing 2 which is equal to M10, for example, since various members may have greater diameters. However, for a diameter of mounting threads 2a which is equal to M8, for example, the electrode fitting 12 becomes thinner in diameter, and may be incapable of resisting the tightening torque. In this instance (see para. 0042), the external connection terminal 18 may be secured to the housing by using an insulating securing member as mentioned

above.

[0054] In the above description, the metallic outer sleeve 8 is configured before the swaging operation to be stepped to provide the portion 8c of the greater diameter in the region where the electrode fitting 12 is contained, and the swaging operation reduces the diameter of this portion to be comparable to the diameter of the metallic outer sleeve in a portion where the ceramics heater is secured. However, it is also possible to use a metallic outer sleeve which has a uniform diameter over the entire length before the swaging operation takes place.

[0055] An assembling procedure for a second embodiment which employs a metallic outer sleeve 108 having a uniform diameter over the entire length will now be described with reference to Figs. 6 and 7. Since parts other than the metallic outer sleeve 8 are similar to those used in the first embodiment, corresponding parts are designated by like reference characters as used before. After connecting an electrode connection lead wire 10 of a ceramics heater 6 with an electrode fitting 12 (see Fig. 2), the ceramic heater 6 is secured to a portion of the metallic outer sleeve 108 in a region which is located toward the ceramics heater by brazure (Fig. 6(a)). It should be understood that the connection between the electrode connection lead wire 10 of the ceramics heater 6 and the electrode fitting may take place by using other constructions (see Figs. 5(a), 5(b) and 5(c)) as in the first embodiment.

[0056] A refractory insulating powder 14 is filled into the portion of the metallic outer sleeve 108 disposed around the electrode fitting 12 through an opening 108d (see Fig. 6(b)), and a seal member 16 is inserted into the opening 108d (see Fig. 6(c)). The opening 108d of the metallic outer sleeve 108 is caulked from the outside (as indicated by character 108e shown in Fig. 6(d)), thus preventing the seal member 16 from being disengaged. Subsequently, a portion 108f of the metallic outer sleeve 108 which is filled with the refractory insulating powder 14 is subject to a swaging operation to reduce a diameter thereof, thus densifying the refractory insulating powder 14 to secure the electrode fitting 12 within the metallic outer sleeve 108.

[0057] It will be seen that subsequent to the swaging operation, the portion 108f of the metallic outer sleeve 108 in which the electrode fitting 12 is contained will be reduced in diameter as compared with the portion thereof in which the ceramics heater 6 is secured, but the diameter of the portion 108f should be greater than the external diameter of the external connection terminal 18. Since the swaged portion 108f of the metallic outer sleeve represents a portion which is disposed as a press fit into an internal bore 4 of a housing 2, if the portion 108f has an external diameter which is less than the external connection terminal 18, it becomes impossible to pass the external connection terminal 18 through the internal bore 4 of the housing. For this reason, the swaged external diameter of the metallic outer sleeve 108 must

be greater than the external diameter of the external connection terminal 18.

[0058] After the swaging operation of the portion of the metallic outer sleeve 108 which is located around the electrode fitting 12 to densify the filled refractory insulating powder 14 to secure the electrode fitting 12 within the metallic outer sleeve 108, one end 18a of the external connection terminal 18 is connected to the outer end 12c of the electrode fitting 12 as by butt welding (see Fig. 7). The sub-assembly shown in Fig. 7 is assembled with the housing 2 by similar steps as used in the first embodiment, thus completing a ceramics heater glow plug.

[0059] Although the use of the metallic outer sleeve 108 (see Fig. 6) having a straight configuration or a uniform diameter over the entire length is advantageous over the use of the stepped metallic outer sleeve 8 having the portion 8c of a greater diameter as in the first embodiment in respect to the manufacturing cost, the use of the stepped metallic outer sleeve 8 becomes necessary depending on the diameter (M8 or M10) of the mounting threads 2a of the housing 2, the external diameter of the ceramics heater 6 which influences upon a temperature rise characteristic of the glow plug or the external diameter of the external connection terminal 18. Accordingly, the configuration of the metallic outer sleeve 8 or 108 may be suitably chosen as required. Where the metallic outer sleeve 108 having a straight configuration is used, a reduced clearance between the internal surface of the sleeve 108 and the external surface of the electrode fitting 12 results in a reduced amount of the refractory insulating powder 32 which fills the clearance, leading to a difficulty in performing the swaging operation. In such instance, it is necessary to use the stepped metallic outer sleeve 8. Also where the metallic outer sleeve 108 having a straight configuration is used, there arises a likelihood of a short circuit occurring between the electrode fitting 12 and the metallic outer sleeve 108, but such likelihood of a short circuit can be prevented by inserting an insulating hose or the like.

[0060] In the described embodiments, after connecting the ceramics heater 6 and the electrode connection lead wire 10 and the electrode fitting 12, the ceramics heater 6 is cemented to the metallic outer sleeve 8 as by brazure and subsequently the refractory insulating powder 14 is filled into the metallic outer sleeve 8 in preparation to the swaging operation. However, other steps may also be used to manufacture a ceramics heater glow plug.

[0061] Figs. 8 to 10 show a procedure of assembling a ceramics heater glow plug according to a third embodiment. In this instance, a brazure initially takes place between the ceramics heater 6 and the metallic outer sleeve 8 and between the lead wire connected to the positive pole of the ceramics heater 6 (not shown, but contained inside the ceramics heater 6) and the electrode connection lead wire 10 concurrently to provide an integral assembly, whereupon the electrode fitting 12

is connected to the distal end of the lead wire 10, followed by the swaging operation to secure and electrically connect the electrode fitting.

[0062] As shown in Fig. 8(a), when brazing the ceramics heater 6, the electrode connection lead wire 10 and the metallic outer sleeve 8, the metallic outer sleeve 8 is set up on a brazure jig (not shown) such that a portion 8c of a greater diameter which is to be secured to the housing 2 is disposed at the top, as viewed in Fig. 8, while a bottom portion of the sleeve 8 is fitted around the ceramics heater 6. The distal end 10b of the electrode connection lead wire 10 is inserted into an insertion opening formed in the end face 6b of the ceramics heater 6 and in which the positive pole lead wire is exposed, and a wire of brazing silver which is coiled is placed on top of the end face 6b of the ceramics heater 6 which is situated inside the metallic outer sleeve 8 and heated to a given temperature such as 900°C, for example, to melt the brazing silver. The molten brazing silver flows into a clearance between the internal surface of the metallic outer sleeve 8 and the external surface of the ceramics heater 6 and a clearance between the internal surface of the insertion opening formed in the ceramics heater 6 and the external surface of the electrode connection lead wire 10, thus completing a brazure.

[0063] The electrode fitting 12 is provided with a narrowed end 12e in which an insertion opening 12f is formed, and the distal end 10a of the electrode connection lead wire 10 is then inserted into the insertion opening 12f as shown in Fig. 8(b). Then steps used in the first embodiment (refer Figs. 3(b) to (e)) are performed. Specifically, a refractory insulating powder 14 is filled into a top space in the metallic outer sleeve 8 around the portion 8c of a greater diameter (see Fig. 9(a)), a seal member 16 is inserted into the opening 8d of the metallic outer sleeve 8 (see Fig. 9(b)), and the end 8e of the metallic outer sleeve 8 is caulked to prevent the seal member 16 from being disengaged (see Fig. 9(c)). Subsequently, the portion 8c of a greater diameter of the metallic outer sleeve 8 is subject to a swaging operation to reduce its diameter to a value substantially comparable to the diameter of a portion of the sleeve in which the ceramics heater 6 is secured (see Fig. 9(d)). The swaging operation deforms the narrowed end 12e at the distal end of the electrode fitting 12 to secure it and electrically connect it with the lead wire 10 in a reliable manner.

[0064] One end 18a of the external connection terminal 18 is secured, as by butt welding, to the outer end 12c of the electrode fitting 12 which is now secured within the metallic outer sleeve 8 as a result of the swaging operation (see Fig. 10). The sub-assembly which is thus assembled (including the ceramics heater 6, the metallic outer sleeve 8, the electrode connection lead wire 10, the electrode fitting 12 and the external connection terminal 18) is now inserted into and secured in the housing 2 in the manner mentioned previously, thus assembling a ceramics heater glow plug. It will be seen that the ce-

ramics heater glow plug of this embodiment can achieve a similar effect as the glow plugs of the previous embodiments.

[0065] It will be appreciated that the assembling procedure of this embodiment provides merits over the embodiments first mentioned. In the first mentioned embodiment, the electrode fitting 12 is initially connected to the electrode connection lead wire 10 of the ceramics heater 6 before the ceramics heater 6 is brazed to the metallic outer sleeve 8, resulting in an increased overall length of the ceramics heater assembly, and it is difficult to achieve a brazure for a plurality of ceramics heater assemblies. In addition, in the course of the brazing operation, the electrode connection lead wire 10 may become flexed under the influence of the weight of the electrode fitting 12, which must be corrected. In addition, the presence of the electrode fitting 12 may stand in the way to placing a coil of brazing filler material and if the clearance between the external surface of the electrode fitting 12 and the internal diameter of the metallic outer sleeve 8 is reduced, a difficulty may be experienced in placing the coil of the brazing filler material. Since the brazure between the ceramics heater 6 and the electrode connection lead wire 10 is separate from the brazure between the ceramics heater 6 and the metallic outer sleeve 8, two independent brazures are required.

[0066] By contrast, in the third embodiment, the brazure between the ceramics heater 6 and the metallic outer sleeve 8 and the brazure between the ceramics heater 6 and the electrode connection lead wire 10 take place in one step, followed by the connection of the electrode fitting 12 (such connection may be only temporary) and the swaging operation, thus eliminating all of inconveniences and difficulties experienced during the assembling procedure of the first embodiment.

[0067] Figs. 11 to 13 show a procedure of assembling a ceramics heater glow plug according to a fourth embodiment. In this embodiment, the electrode fitting 12 has a distal end 12a of a reduced diameter (see Fig. 11(b) which will be described later), and the electrode connection lead wire 10 has one end 10c which is coiled so as to have an internal diameter substantially equal to the external diameter of the distal end 12a of the electrode fitting 12. The ceramics heater 6 and the metallic outer sleeve 8 are set up on a brazure jig, not shown, and an end 10b of the lead wire 10 which is located at the opposite end from the coil 10c is inserted into a mounting hole formed in the ceramics heater 6, and a brazing operation takes place concurrently between the ceramics heater 6 and the metallic outer sleeve 8 and between the ceramics heater 6 and the lead wire 10 (see Fig. 11(a)).

[0068] Subsequently, the distal end 12a of a reduced diameter of the electrode fitting 12 is then inserted into the coiled end 10c of the lead wire 10 (see Fig. 11(b)). Subsequently, similar steps as used in the previous embodiments follow, including filling the refractory insulating powder 14 into a top space within the metallic outer

sleeve 8 around the portion 8c of a greater diameter (see Fig. 12(a)), inserting a seal member 16 into the opening 8b of the metallic outer sleeve 8 (see Fig. 12(b)), caulking the end 8e of the metallic outer sleeve 8 (see Fig. 12(c)) and swaging the portion 8c of a greater diameter of the metallic outer sleeve (see Fig. 12(d)).

[0069] In this embodiment, the portion 8c of a greater diameter of the metallic outer sleeve 8 has a slightly greater diameter than the portion thereof in which the ceramics heater 6 is secured even after the swaging operation, as will be noted from Fig. 12(d). However, it should be understood that the portion 8c may be reduced in diameter to a comparable diameter as a portion of the metallic outer sleeve in which the ceramics heater 6 is contained. The distal end 12a of a reduced diameter of the electrode fitting 12 may be formed with an unevenness. The unevenness on the electrode fitting 12 allows it to be more firmly bonded with the coiled end 10c of the lead wire 10, eliminating any likelihood of disengagement therebetween from occurring.

[0070] Subsequently, one end 18a of the external connection terminal 18 is secured to the outer end 12c of the electrode fitting 12 (see Fig. 13), and the sub-assembly is assembled into the housing 2 to complete a ceramics heater glow plug.

[0071] Figs. 14 to 16 show a procedure of assembling a ceramics heater glow plug according to a fifth embodiment. In the embodiments described above, the electrode connection lead wire 10 of a short length is connected to a positive pole lead wire situated within the ceramics heater 6 and is taken out of the ceramics heater 6, and the electrode fitting 12 is connected to the end 10a, 10c of the lead wire 10 within the metallic outer sleeve 8. However, in the fifth embodiment, one end 10b of the electrode connection lead wire 10 having an increased length which is long enough to extend to the outside of the metallic outer sleeve 8 is inserted into a mounting pole through which a lateral surface of a positive pole lead wire of the ceramics heater 6 is exposed and is connected thereto (see Fig. 14(a)). It is to be noted that the steps of brazing between the ceramics heater 6 and the metallic outer sleeve 8 and between the ceramics heater 6 and the electrode connection lead wire 10 are similar to corresponding steps in the third and the fourth embodiment.

[0072] In addition, in the fifth embodiment, the electrode fitting 12 is formed with an axially extending through-opening 12g, into which the electrode connection lead wire 10 is passed and is secured to and electrically connected to the electrode fitting 12 as by caulking (see Fig. 14(b)).

[0073] As mentioned previously, the electrode connection lead wire 10 which is taken out of the ceramics heater 6 is connected to the electrode fitting 12, and as in the described embodiments, the refractory insulating powder 14 is filled into the space in the metallic outer sleeve 8 around the portion 8c of a greater diameter (see Fig. 15(a)), the seal member 16 is inserted into the open-

ing 8d (see Fig. 15(b)), the end 8e of the metallic outer sleeve 8 is caulked (see Fig. 15(c)), and the portion 8c of a greater diameter is swaged (see Fig. 15(d)) in a sequential manner. It is to be understood that the step of caulking the electrode fitting 12 in order to secure it with the electrode connection lead wire 10 may take place immediately after the lead wire 10 is inserted into the through-opening 12g formed in the electrode fitting 12, or may be performed upon completion of the swaging operation. Subsequently, any fragment of the lead wire 10 which project through the electrode fitting 12 is cut off (see Fig. 15(e)).

[0074] Subsequently, the end 18a of the external connection terminal 18 is connected to the end 12g of the electrode fitting 12 (see Fig. 16), and the sub-assembly shown in Fig. 16 is inserted into and secured to the housing 2 to complete a ceramics heater glow plug.

[0075] The assembling procedure of the fifth embodiment is similar to the third embodiment (shown in Figs. 8 to 10) in that the electrode connection lead wire 10 is inserted into and secured to the through-opening 12g formed in the electrode fitting 12, but in the third embodiment, the operation of inserting the lead wire 10 into the electrode fitting 12 takes place within the metallic outer sleeve 8, and accordingly, a difficulty may be experienced in inserting the lead wire 10 and in confirming whether or not the lead wire has been inserted, leading to a failure of connection. However, in the fifth embodiment, the length of the electrode connection lead wire 10 is increased and the lead wire is inserted into the through-opening 12g in the electrode fitting 12 outside the metallic outer sleeve 8, thus facilitating the insertion and the confirmation that it has been inserted, thus eliminating the likelihood of a failure of connection to improve a quality control.

[0076] Figs. 17 to 19 shows a procedure of assembling a ceramics heater glow plug according to a sixth embodiment. In this embodiment, an electrode connection lead wire 110 which is to be connected to a positive pole lead wire located within the ceramics heater 6 is thick enough to exhibit a certain degree of rigidity.

[0077] In this embodiment, the electrode connection lead wire 110 and the ceramics heater 6 as well as the ceramics heater 6 and the metallic outer sleeve 8 are secured and connected together by a brazure (see Fig. 17(a)). Subsequently, a distal end 110a of the electrode connection wire 110 is inserted into one end of a pipe-shaped connection member 30 which is secured to the distal end 12a of the electrode fitting 12 by being caulked (which is indicated by reference character 30a) (see Fig. 17(b)). Thus, the electrode connection wire 110 requires a degree of rigidity which can be inserted and fitted into the connection member 30.

[0078] After the connection member 30 which is secured to the electrode fitting 12 is fitted over the distal end 110a of the electrode connection wire 110, the refractory insulating powder 14 is filled into the space within the metallic outer sleeve 8 around the portion 8c of a

greater diameter (see Fig. 18(a)), the seal member 16 is fitted into the opening 8d (see Fig. 18(b)), the end 8e of the metallic outer sleeve 8 is caulked (see Fig. 18(c)), and the portion 8c of a greater diameter of the metallic outer sleeve 8 is swaged (see Fig. 18(d)). Subsequently, the end 18a of the external connection terminal 18 is connected to the outer end 12c of the electrode fitting 12 by a butt welding (see Fig. 19), and the resulting sub-assembly is secured in the housing 2 to complete a ceramics heater glow plug.

[0079] Figs. 20 to 22 shows a procedure of assembling a ceramics heater glow plug according to a seventh embodiment. In this embodiment, an electrode connection wire 110 which is to be connected to a positive pole lead wire located within the ceramics heater 6 has sufficient rigidity which allows it to urge the electrode fitting 12, as will be described below.

[0080] In this embodiment, the metallic outer sleeve 8 and the ceramics heater 6 as well as the ceramics heater 6 and the electrode connection wire 110 are connected together concurrently by a brazure (see Fig. 20(a)). A heat shrinkable tube 32 is mounted on the distal end 12a of the electrode fitting 12 (see Fig. 20(b)). It is to be noted that at this point, the tube 32 has not yet been shrunk.

[0081] Subsequently, the end 12a of the electrode fitting 12 is urged against the end 110a of the electrode connection wire 110 to have the heat shrunk tube 32 fitted around the electrode connection wire 110. The heat shrinkable tube 32 is then caused to shrink under heat to be secured thereon (see Fig. 20(c)).

[0082] The refractory insulating powder 14 is filled into the space in the metallic outer sleeve 8 around the portion 8c of a greater diameter (see Fig. 21(a)), the seal member 16 is inserted into the opening 8d (see Fig. 21(b)), the end 8e is caulked (see Fig. 21(c)), and the portion 8c of the greater diameter is swaged (see Fig. 21(d)). Subsequently, the end 18a of the external connection terminal 18 is secured to the end 12c of the electrode fitting 12 as by a butt welding (Fig. 22), and the resulting sub-assembly is inserted into and secured in the housing 2 to complete a ceramics heater glow plug. In the sixth and the seventh embodiment, the electrode connection wire 110 and the electrode fitting 12 are connected together using either the connection member 30 or the heat shrinkable tube 32, thus achieving a reliable connection between the wire 110 and the electrode fitting 12.

[0083] In the third to the seventh embodiment shown in Figs. 8 to 22, the ceramics heater 6 and the metallic outer sleeve 8 as well as the positive pole lead wire located within the ceramics heater 6 and the electrode connection lead wire 10 (or the electrode connection wire 110) are secured together in one brazing operation, and then the electrode fitting 12 is connected to the electrode connection lead wire 10 (or the electrode connection wire 110) (this connection may be a temporary connection), followed by the swaging operation to secure

the electrode fitting to achieve an electrical connection in a reliable manner, and accordingly, there is no need for a welding or caulking step to take place between the electrode connection lead wire 10 or 110 and the electrode fitting 12, allowing a reduction in the number of steps required. A number of ceramics heaters 6 and metallic outer sleeves 8, which are greater in number than in the first and second embodiment, can be concurrently brazed together while avoiding any influence of the weight of the electrode fitting 12 upon the electrode connection lead wire 10 during the brazing operation to avoid a deformation of the lead wires. During the brazing operation, placement of a brazing filler material is facilitated and the result of the brazing operation can be more easily observed, adding an advantage to the quality control. The ease of assembly is not detracted if an electrode fitting 12 of a greater diameter than the ceramics heater 6 is used, allowing a free choice of sizes. In addition, a heat treatment of the electrode fitting 12 is permitted, enabling a torque accommodation in a glow plug of a thin diameter (for example M8) while allowing an expensive working such as glass fusing to be avoided. The brazure can be completed in one step with an improved assembly and productivity, leading to an economical advantage.

[0084] Fig. 23 is a longitudinal section showing a status of a ceramics heater glow plug according to an eighth embodiment in the course of assembly thereof. In this embodiment, an electrode connection lead wire 210 which is connected to a positive pole lead wire is coiled at its end 210c which is to be connected with an electrode fitting, in the similar manner as in the fourth embodiment shown in Figs. 11 to 13. However, in this embodiment, a hollow pipe member is used for the electrode connection lead wire 210.

[0085] In the similar manner as in the fourth embodiment, the ceramics heater 6 and the metallic outer sleeve 8 are set on a brazure jig, and an end 210b of the electrode connection lead wire 210 which is opposite from the coiled end 210c is inserted into a mounting hole 6c formed in the end of the ceramics heater 6, and a brazing operation takes place concurrently between the ceramics heater 6 and the metallic outer sleeve 8 and between the ceramics heater 6 and the electrode connection lead wire 210.

[0086] Since the electrode connection lead wire 210 which is inserted into and secured in the mounting hole 6c of the ceramics heater 6 is hollow, any air which remains in the mounting hole 6 is exhausted externally through a hollow passage 210d (see Figs. 24 (a) and (b)) during the brazing operation, thus allowing bubbles which may be generated during the brazing operation to be reduced, with consequence that an increase in the resistance of brazed parts is suppressed, permitting a variation in the performance of the glow plug to be prevented. The hermetic seal of brazed parts is also improved, allowing the ingress of moisture or oil content into the heating element of the ceramics heater to be

prevented and also allowing cracks which may result from the evaporation of such contents within the ceramics heater to be prevented. In addition, a variety of advantages result including a reduction in the number of voids and pores within the brazed parts and an increase in the strength of connection of the electrode fitting.

[0087] After cementing the ceramics heater 6 and the metallic outer sleeve 8 as well as the ceramics heater 6 and the electrode connection lead wire 210, a portion of a reduced diameter which is located at the distal end of the electrode fitting is inserted into the coiled end 210c of the electrode connection lead wire 210, in the similar manner as shown in Figs. 11 to 13. The refractory insulating powder is filled into the top space within the metallic outer sleeve 8 around the portion 8c of a greater diameter, the seal member is inserted into the opening of the sleeve 8, the end of the sleeve 8 is caulked and then the sleeve is swaged. One end of the external connection terminal is secured to the outer end of the electrode fitting as by a butt welding, and the resulting sub-assembly is assembled into the housing to complete a ceramics heater glow plug.

[0088] In this embodiment, the hollow pipe 210 having a circular through-passage 210d formed therein is used as the electrode connection lead wire 210 (see Fig. 24 (a) and (b)), but the present invention is not limited to the use of such a hollow pipe 210. By way of example, a hollow pipe 310 having a slit 310e formed therein which communicates the internal through-passage 310d with the exterior, as indicated in Figs. 24(c) and (d), may also be used. In any event, any member having a passage 210d or 310d which allows the air within the mounting hole 6c to be led externally of the ceramics heater 6 may be used when it is inserted into the mounting hole 6c of the ceramics heater 6 and the brazing operation takes place.

[0089] Fig. 25 shows an essential part of a ceramics heater glow plug according to a ninth embodiment. In this embodiment, a hollow pipe member 410 is used as an electrode connection lead wire, in the same manner as in the eighth embodiment. The electrode connection lead wire 410 includes a straight pipe section 410f of a reduced diameter having an end which is formed with a cup-shaped connector 410 while the opposite end 410b is inserted into a mounting hole 6c formed in the ceramics heater 6 to be secured therein by a brazure. The distal end of the electrode fitting is inserted into the cup-shaped connector 410g for purpose of electrical connection.

[0090] In this embodiment, the distal end of the electrode fitting is sized to be a close fit with the internal diameter of the connector 410g of the lead wire 410, and after the electrode fitting and the end 410g of the lead wire 410 are fitted together, sequential steps of filling a refractory insulating powder into a top space within the metallic outer sleeve 8 around the portion 8c of a greater diameter, inserting a seal member into the , opening of the metallic outer sleeve 8, caulking the end of the me-

tallic outer sleeve 8 and swaging the portion 8c take place in the similar manner as in the previous embodiments. This embodiment uses the hollow pipe member 410 for the electrode connection lead wire, and thus achieves a similar effect as achieved in the eighth embodiment.

[0091] Fig. 26 shows part of an assembling step for a glow plug according to a tenth embodiment, in particular, illustrating a unique connection between an electrode connection lead wire 510 and an electrode fitting 112. Again, a hollow pipe-shaped member is used for the electrode connection lead wire 510 in the similar manner as in the eighth and the ninth embodiment. Although the end 210c of the lead wire 210 which is located toward the electrode fitting is coiled in the manner of a spring having spaced successive turns, in the tenth embodiment, the end 510h of the lead wire 510 which is located toward the electrode fitting is in the form of a helical coil having successive turns which are in close contact with each other.

[0092] The electrode fitting 112 has a distal end 112e which is to be connected with the helical coil 510h of the electrode connection lead wire 510. The distal end 112e is in the form of a stack of umbrella or fungi having a maximum diameter (indicated by reference character 112ea) which is slightly greater than the internal diameter of the helical coil 510h of the lead wire 510.

[0093] When assembling a ceramics heater glow plug according to this embodiment, a straight end 510b of the electrode connection lead wire 510 which comprises a hollow pipe member is inserted into a mounting hole 6c formed in the ceramics heater 6, and a brazure takes place between the ceramics heater 6 and the metallic outer sleeve 8 and between the ceramics heater 6 and the electrode connection lead wire 510. It will be seen that when the brazing operation takes place, the use of the hollow pipe member for the electrode connection lead wire 510 allows an air which remains in the mounting hole 6c to be exhausted in a similar manner as described above in connection with the eighth and the ninth embodiment.

[0094] After the ceramics heater 6 and the metallic outer sleeve 8 as well as the ceramics heater and the electrode connection lead wire 510 have been cemented together by the brazing operation, the distal end 112e of the electrode fitting 112 is placed against the helical coil 510h of the lead wire 510, and is urged axially (or in the vertical direction as viewed in Fig. 26), as indicated by an arrow A shown in Fig. 26(a) to connect the lead wire 510 and the electrode fitting 112 together (see Fig. 26(b)). The helical coil 510h of the lead wire 510 is internally formed with an unevenness which is engaged with a plurality of bases of the umbrella or the fungi having the maximum diameter 112ea formed on the distal end 112e of the electrode fitting 112 to prevent their disengagement, thus connecting the lead wire 510 and the electrode fitting 112 mechanically and electrically in a reliable manner. While the distal end 112e of the elec-

trode fitting 112 is formed with a stack of umbrella or fungi-shaped heads, it should be understood that the invention is not limited to such configuration, but the distal end 112e may be formed with a stack of steps of any other configuration which are engageable with the internal surface of the helical coil 510h of the lead wire 510.

[0095] After the lead wire 510 and the electrode fitting 112 are connected together, the swaging operation takes place in the similar manner as mentioned above, and the resulting sub-assembly is assembled into the housing to complete a ceramics heater glow plug. While the connection of the electrode connection lead wire 510 with the electrode fitting 512 which is formed by a hollow pipe member has been described, the arrangement of Fig. 26 can be used to connect the electrode connection lead wire and the electrode fitting together if an electrode connection lead wire other than a hollow pipe member is used.

[0096] Fig. 27 shows part of an assembling step for a ceramics heater glow plug according to an eleventh embodiment. In this embodiment, an electrode connection lead wire 510 having a helical coil 510h formed on an end of the pipe-shaped member is used as in the tenth embodiment. However, the electrode fitting 212, to which the lead wire 510 is to be electrically connected, has a distal end 212f which is in the form of threads having an external diameter which is slightly greater than the internal diameter of a convex portions formed as an unevenness on the internal surface of the helical coil 510h of the lead wire 510.

[0097] In this embodiment, the electrode fitting 212 is turned around its axis, as indicated by an arrow B in Fig. 27 (a), to cause the threads 212f formed on the distal end of the electrode fitting 212 to be threadably engaged with the helical coil 510h of the lead wire 510, thus connecting the lead wire 510 and the electrode fitting 512 together. This construction also achieves a reliable mechanical and electrical connection between the lead wire 510 and the electrode fitting 512. After the lead wire 510 and the electrode fitting 212 are connected together in this manner, the swaging operation takes place as mentioned above, and the resulting sub-assembly is assembled to the housing to complete a ceramics heater glow plug.

[0098] Fig. 28 shows a procedure of assembling a ceramics heater glow plug according to a twelfth embodiment, in particular, the manner of securing the ceramics heater 6 and the electrode fitting 12 through a metallic outer sleeve 208. In this embodiment, the ceramics heater 6 and the electrode connection lead wire 10 are constructed in the similar manner as shown in the fourth embodiment (Figs. 11 to 13), but the configuration of the metallic outer sleeve 208 in which the ceramics heater 6 is secured and the relative positions of the ceramics heater 6 and the metallic outer sleeve 208 are different from the fourth embodiment.

[0099] In this embodiment, the metallic outer sleeve 208 comprises a stepped pipe including a straight por-

tion 208a having a minimum diameter, a portion 208b of a greater or a medium diameter and a portion 208c having a maximum diameter. The ceramics heater 6 is secured within the straight portion 208a having the minimum diameter. In the fourth embodiment, the end face 6b of the ceramics heater 6 through which the electrode connection lead wire 10 is taken out is situated within the straight portion having the minimum diameter of the metallic outer sleeve 8, but in the twelfth embodiment, the end face 6b of the ceramics heater 6 is situated within the portion 208b having a medium diameter rather than within the straight portion 208a having the minimum diameter.

[0100] In this embodiment, one end 10c of the electrode connection lead wire 10 which is located toward the electrode fitting 12 is formed into a coil having an internal diameter which is comparable to the external diameter of the distal end 12a having a reduced diameter of the electrode fitting 12. The ceramics heater 6 and the metallic outer sleeve 8 are set up on a brazure jig, not shown, and the other end 10b of the lead wire 10 is inserted into a mounting hole 6c formed in the ceramics heater 6 to be brazed therewith (see Fig. 28(a)). It should be noted that the ceramics heater 6 may be cemented with the electrode connection lead wire 10 and the metallic outer sleeve 208, respectively, by two separate brazing steps.

[0101] After the ceramics heater 6, the electrode connection lead wire 10 and the metallic outer sleeve 208 are connected together by the brazing operation, the portion 12a of a reduced diameter which is formed at the distal end of the electrode fitting 12 is inserted into the coiled end 10c of the lead wire 10 (see Fig. 28(b)). It is to be noted that in this embodiment, the portion 12a of a reduced diameter of the electrode fitting 12 is formed with a portion 12h of an increased diameter at its tip, which is engaged with the coiled end 10c to prevent the disengagement thereof from the coil.

[0102] Subsequently, a refractory insulating powder 14 is filled into the portion 208b of a medium diameter and the portion 208c of a maximum diameter of the metallic outer sleeve 208, a seal member 16 is inserted into the opening of the metallic outer sleeve 208 (see Fig. 28(c)), and the portion 208c of the metallic outer sleeve is subject to a swaging operation (see Fig. 28(d)). The swaging operation reduces the diameter of the portion 208c of the metallic outer sleeve 208 to a value which is comparable to the diameter of the portion 208b. In this embodiment, the junction between the coiled end 10c of the lead wire 10 and the electrode fitting 12 is situated within the portion 208c of a maximum diameter of the metallic outer sleeve 208, and accordingly, when the portion 208c is swaged, the lead wire 10 and the electrode fitting 12 are cemented together in a reliable manner to provide an electrical connection therebetween. One end 18a of the external connection terminal 18 is secured to the outer end 12c of the electrode fitting 12 as by a butt welding, and the resulting sub-assembly is

assembled into the housing 2 to complete a ceramics heater glow plug.

[0103] It is to be noted that the swaging operation achieves a firm connection between the ceramics heater 6 and the electrode fitting 12 through the metallic outer sleeve 208 interposed. The end face 6b of the ceramics heater 6 through which the positive pole lead wire is taken out is not located within the straight portion 208a having a minimum diameter to which the negative pole lead wire is connected, but is situated within the portion 208b having a medium diameter, thus improving the insulation between the positive and the negative pole and facilitating the placement of a brazing silver in preparation to the brazing operation.

[0104] Fig. 29 shows an assembling procedure for a ceramics heater glow plug according to a thirteenth embodiment. In this embodiment, an end of the electrode connection lead wire 10 which is located toward the ceramics heater 6 is formed with a cap-shaped connector 10j which is fitted over a positive pole lead connection end 6d of the ceramics heater 6. A positive pole lead wire extending from a heating element is exposed on the external surface of the end 6d of the ceramics heater 6 so that when the connector 10j of the lead wire 10 is fitted over the end 6d of the ceramics heater 6, an electrical connection is achieved at the same time as the ceramics heater 6 and the electrode connection lead wire 10 are mechanically secured together.

[0105] In this embodiment, the portion 12a of a reduced diameter which is formed on the distal end of the electrode fitting 12 is inserted into the coiled end 10c of the lead wire 10 to be connected therewith (see Fig. 29(b)), a refractory insulating powder is filled into the portion 208a of a medium diameter and the portion 208c of a maximum diameter of the metallic outer sleeve 208, a seal member 16 is inserted into the opening of the metallic outer sleeve 208 (see Fig. 29(c)), and the portion 208c is swaged (see Fig. 29(d)). The swaging operation achieves a reliable cementation between the ceramics heater 6 and the connector 10j of the lead wire 10 and between the coiled end 10c of the lead wire 10 and the electrode fitting 12. Subsequently, one end 18a of the external connection terminal 18 is secured to the outer end 12c of the electrode fitting 12 as by a butt welding, and a resulting sub-assembly is assembled into the housing 2 to complete a ceramics heater glow plug.

[0106] Fig. 30 shows an assembling procedure according to a fourteenth embodiment. In this embodiment, an end of the electrode connection lead wire 10 which is to be connected to the ceramics heater 6 is formed with a coil 10k of a reduced diameter. On the other hand, the opposite end of the ceramics heater 6 which is connected to the positive pole is formed with a portion 6e of a reduced diameter, and a positive pole lead wire extending from a heating element is disposed as exposed around the portion 6e of a reduced diameter. When the coil 10k of the lead wire 10 is fitted over the portion 6e of a reduced diameter of the ceramics heater

6 to be secured, an electrical connection is achieved between the ceramics heater 6 and the electrode connection lead wire 10.

[0107] Subsequently, after the ceramics heater 6 is cemented with the metallic outer sleeve 108 and the ceramics heater 6 is connected with the electrode connection lead wire 10 (see Fig. 30(a)), the electrode fitting 12 is fitted into the coiled end 10c of the lead wire to be connected therewith. A refractory insulating powder is filled into the metallic outer sleeve 208, a seal member 16 is inserted into the opening of the metallic outer sleeve 208 (see Fig. 30(c)), and the swaging operation takes place (see Fig. 30(d)).

[0108] Fig. 31 shows an assembling procedure according to a fifteenth embodiment, and the ceramics heater 6 and the electrode connection lead wire 10 are connected together with a similar construction as used in the fourteenth embodiment. However, in this embodiment, a construction which takes out a negative pole wire from a heating element 36 of the ceramics heater 6 is different from the embodiments described above. In the described embodiments, an end of a negative pole lead wire is exposed to a portion of either metallic outer sleeve 8, 108 or 208 where a ceramics heater 6 is cemented (namely, the straight portion 208a having the minimum diameter), whereby it is electrically connected to the internal surface of either metallic outer sleeve 8, 108 or 208. By contrast, in the fifteenth embodiment, the negative pole lead wire 38 extending from the heating element 36 extends through the ceramics heater 6 to a point which is situated within the portion 208b of having a medium diameter of the metallic outer sleeve 108, and has an end 38a which is electrically connected to the metallic outer sleeve 208 through a conductive ring 40.

[0109] In this embodiment, the ceramics heater 6 is cemented to the metallic outer sleeve 208 and the electrode connection lead wire 10 is fitted over the portion 6e of a reduced diameter formed at the distal end of the ceramics heater 6 to be connected therewith (see Fig. 31(a)), the distal end 12a of the electrode fitting 12 is inserted into the coil 10c of the lead wire 10 to be connected therewith (see Fig. 31(b)), a refractory insulating powder 14 is filled into the metallic outer sleeve 208 and a seal member 16 is inserted into the opening of the metallic outer sleeve 208 (see Fig. 31(c)), whereupon the metallic outer sleeve is swaged to secure the ceramics heater 6 and the electrode fitting 12 (see Fig. 31(d)).

[0110] Since the negative pole lead wire 38 is cemented to the metallic outer sleeve 108 inside the metallic outer sleeve 208 (or within the portion 208b having a medium diameter), it will be seen that as compared with the described embodiments where the negative pole lead wire is connected to the straight portion having a minimum diameter of either metallic outer sleeve 8, 108 or 208, the location where the lead wire 38 is cemented is further removed from the heating element 6a and thus assumes a lower temperature and thus is less susceptible to the influence of a difference in the coefficient of

linear expansion between the ceramics and the metallic outer sleeve, thus improving the reliability of cementations.

[0111] Fig. 32 shows an assembling procedure for a ceramics heater glow plug according to a sixteenth embodiment. In this embodiment, the configuration of a ceramics heater 106 differs from the described embodiments. Specifically, the ceramics heater 106 includes a portion 106f of an increased diameter toward an end through which a positive pole lead wire is taken out. The portion 106f is configured to be in substantial conformity to a shift in the internal surface of the metallic outer sleeve 208 from the portion 208b having a medium diameter to the portion 208a having a minimum diameter.

[0112] In this embodiment, the portion 106f having an increased diameter of the ceramics heater 106 is formed with a distal end 106e of a reduced diameter, and the end of a positive pole lead wire 142 extending from a heating element 136 is exposed on the lateral surface of the end 106e. Accordingly, when a coil 10k of a reduced diameter at one end of the electrode connection lead wire 10 is fitted over the end 106e to be secured therewith, the lead wire is electrically connected with the lead wire 142. The negative pole lead wire 138 is taken out of the ceramics heater 106 at a point which is located within the portion 208a having a minimum diameter of the metallic outer sleeve 208, but located toward the portion 106f of an increased diameter, where it is cemented to the internal surface of the metallic outer sleeve 208 to be electrically connected therewith.

[0113] The ceramics heater 106 which is configured in the manner mentioned above is inserted into the portion 208c having a maximum diameter of the metallic outer sleeve 208 to be secured within the portion 208b of a medium diameter and a straight portion 208a of the minimum diameter of the metallic outer sleeve 208. The coil 10k of the electrode connection lead wire 10 is fitted over the ceramics heater 106 to be connected therewith (see Fig. 32(a)), the electrode fitting 12 is connected to the coil 10c located at the other end of the lead wire 10 (see Fig. 32(b)), a refractory insulating powder 14 is filled into the metallic outer sleeve 208, a seal member 16 is inserted into the opening of the metallic outer sleeve 208 (see Fig. 32(c)), and the swaging operation of the metallic outer sleeve takes place (see Fig. 32(d)). By using the ceramics heater 106 having the portion 106f of an increased diameter formed on the end which is disposed inside the metallic outer sleeve 208, the positioning when brazing the ceramics heater 106 and the metallic outer sleeve 208 is facilitated. In the event an abnormal combustion occurs during the use of the glow plug, the ceramics heater 106 which is thus positioned can not be displaced relative to the metallic outer sleeve 208, thus improving the reliability.

[0114] Fig. 33 shows an assembling procedure for a ceramics heater glow plug according to a seventeenth embodiment. A ceramics heater 106 of this embodiment differs in configuration from the described embodi-

ments. The ceramics heater 206 has a greater diameter in its portion which projects externally of the metallic outer sleeve 208 or a heater portion 206a in which a heat element 236 is embedded. The heater portion 206a has an external diameter which substantially matches the external diameter of the portion 208a of the metallic outer sleeve 208 which has a minimum diameter.

[0115] In this embodiment, the ceramics heater 206 is inserted into the straight portion 208a having a minimum diameter of the metallic outer sleeve 208, and after the ceramics heater 206 is cemented with the sleeve 208 and the portion 206e of a reduced diameter which is located at the distal end of the ceramics heater 206 is connected with a coil 10k of a reduced diameter of the electrode connection lead wire 10 (see Fig. 33(a)), the electrode fitting 22 is connected to the coil 10c of the lead wire 10 (see Fig. 33(b)), a refractory insulating powder 14 is filled into the metallic outer sleeve 208, a seal member 16 is inserted into the opening of the metallic outer sleeve 208 (see Fig. 33(c)), and the swaging operation takes place (see Fig. 33(d)).

[0116] As a result of providing the heater portion 206a of an increased diameter for a portion of the ceramics heater 206 which projects externally of the metallic outer sleeve 208, the relative positioning between the ceramics heater 206 and the metallic outer sleeve 208 is facilitated when the brazing operation takes place. This also prevents a displacement of the ceramics heater 206 relative to the metallic outer sleeve 208.

[0117] Fig. 34 shows an assembling procedure for a ceramics heater glow plug according to an eighteenth embodiment. In the described embodiments, a wire material of a reduced diameter is used for the electrode connection lead wire 10 which connects the positive pole of either heating element 36, 136 or 236 of the ceramics heater 6, 106 or 206 to the electrode fitting 12. However, in the eighteenth embodiment, the positive pole lead wire (not shown) extending from the heating element of the ceramics heater 6 is cemented with the electrode fitting 12 through a cylindrical hardware 50 to provide an electrical connection therebetween.

[0118] The cylindrical hardware 50 has a connector 50a of an increased diameter for connection with the ceramics heater 6 and another connector 50b of an increased diameter for connection with the electrode fitting 12. The connector 50a has an internal diameter which substantially matches or is slightly greater than the external diameter of the end 6d of the ceramics heater 6. The connector 50b has an internal diameter which substantially matches or is slightly greater than the external diameter of the distal end 12a of the electrode fitting 12.

[0119] In this embodiment, the ceramics heater 6 is inserted into the metallic outer sleeve 208 and is positioned such that the heating element 6a projects externally of the sleeve while the end 6d is disposed within the portion 208b having a medium diameter of the sleeve, and the sleeve 208 and the ceramics heater 6

are cemented together by a brazing operation. The connector 50a of the cylindrical hardware 50 is fitted over the end 6d of the ceramics heater 6 which remains within the metallic outer sleeve 208 (see Fig. 34(a)). Also, the distal end 12a of the electrode fitting 12 is inserted into the other connector 50b of the cylindrical hardware 50 (see Fig. 34(b)).

[0120] Subsequently, a refractory insulating powder 14 is filled into the metallic outer sleeve 208, a seal member 16 is inserted into the opening of the sleeve 208 (see Fig. 34(c)), and a swaging operation takes place (see Fig. 34(d)). The swaging operation reduces the diameter of the portion 208(c) of the sleeve 208, and also reduces the diameter of the cylindrical hardware disposed within the sleeve 208 through the refractory insulating powder 14, thus firmly cementing the ceramics heater 6 and the electrode fitting 12 together.

CAPABILITY OF INDUSTRIAL EXPLOITATION

[0121] As discussed above, a ceramics heater glow plug according to the invention is used as a start aid for a diesel engine. The glow plug has a reduced diameter and an increased length, and thus is suitable for use in a diesel engine of direct injection type having an increased number of valves.

Claims

1. A ceramics heater glow plug including a ceramics heater formed by an insulating ceramics material and an inorganic conductor, a metallic outer sleeve having one end in which the ceramics heater is secured and the other end which is adapted to be secured within an internal bore of an housing, and an electrode fitting connected to one of lead wires extending from a heating element of the ceramics heater which projects through an end face disposed within the metallic outer sleeve;
wherein the electrode fitting is formed as a rigid body and a junction between the electrode fitting and the lead wire extending from the heating element is received within the metallic outer sleeve, and the electrode fitting is secured to the metallic outer sleeve through an insulator interposed.
2. A ceramics heater glow plug according to Claim 1 in which the electrode fitting has an end face which is formed with an insertion opening, into which one end of the lead wire is inserted for purpose of connection therebetween.
3. A ceramics heater glow plug according to Claim 2 in which the insertion opening represents a through-opening axially extending through the electrode fitting, the lead wire being passed through the through-opening and then the outer periphery of the

electrode fitting being subject to a plastic deformation to complete a connection between the lead wire and the electrode fitting.

4. A ceramics heater glow plug according to Claim 1 in which a lateral surface of the distal end of the lead wire is disposed in abutment against a lateral surface of the distal end of the electrode fitting for purpose of connection therebetween.
5. A ceramics heater glow plug according to Claim 4 in which the distal end of the electrode fitting is formed with a step, against which a lateral surface of the distal end of the lead wire is disposed in abutment for purpose of connection therebetween.
6. A ceramics heater glow plug according to Claim 1 in which the electrode fitting and the lead wire are connected together through a connection member.
7. A ceramics heater glow plug according to Claim 1 in which a hollow pipe member is used for the lead wire which is connected with the electrode of the heating element.
8. A ceramics heater glow plug according to Claim 1 in which a slitted hollow pipe member is used for the lead wire which is connected with the electrode of the heating element.
9. A ceramics heater glow plug according to one of Claims 1, 7 and 8 in which the distal end of the lead wire is formed into a coil, into which the distal end of the electrode fitting is inserted for purpose of an electrical connection therebetween.
10. A ceramics heater glow plug according to Claim 7 or 8 in which the lead wire formed by the hollow pipe member has an end which is formed with a cup-shaped connector into which the distal end of the electrode fitting is fitted.
11. A ceramics heater glow plug according to one of Claims 1, 7 and 8 in which the lead wire has an end which is helically coiled while the distal end of the electrode fitting is formed with a plurality of steps, which are engaged with an unevenness formed by the helical coil to connect the lead wire and the electrode fitting together.
12. A ceramics heater glow plug according to one of Claims 1, 7 and 8 in which the lead wire has an end which is helically coiled while the distal end of the electrode fitting is formed with threads, which are threadably engaged with the helical coil to connect the lead wire and the electrode fitting together.
13. A ceramics heater glow plug according to one of

Claims 1 to 12 in which an elastic seal member is fitted into an opening of the metallic outer sleeve which is formed toward the electrode fitting.

14. A ceramics heater glow plug according to one of Claims 1 to 13 in which the metallic outer sleeve comprises a stepped pipe including a portion of a reduced diameter and another portion of a greater diameter and an end face of the ceramics heater which is situated within the metallic outer sleeve is disposed within the portion of a greater diameter.
15. A method of manufacturing a ceramics heater glow plug according to one of Claims 1 to 14, comprising sequential steps of
 - connecting a lead wire projecting from an end face of the ceramics heater with the electrode fitting;
 - securing the ceramics heater within one end of the metallic outer sleeve;
 - filling a refractory insulating powder into the metallic outer sleeve through the other end thereof;
 - and subjecting the outer periphery of the metallic outer sleeve in a region in which the lead wire and the electrode fitting are received to a swaging operation to reduce the diameter thereof; thereby securing the electrode fitting within the metallic outer sleeve.
16. A method of manufacturing a ceramics heater glow plug according to one of the claims 1 to 14, comprising sequential steps of
 - securing the ceramics heater in one end of the metallic outer sleeve;
 - connecting a lead wire which projects from an end face of the ceramics heater to the electrode fitting;
 - filling a refractory insulating powder into the metallic outer sleeve through the other end thereof;
 - and subjecting the outer periphery of the metallic outer sleeve in a region in which the lead wire and the electrode fitting are received to a swaging operation to reduce the diameter thereof, thereby securing the electrode fitting within the metallic outer sleeve.
17. A method of manufacturing a ceramics heater glow plug according to Claim 16 in which securing the ceramics heater in one end of the metallic outer sleeve takes place concurrently with connecting one end of the lead wire to the ceramics heater.
18. A method of manufacturing a ceramics heater glow plug according to one of Claims 15 to 17 in which a region of the metallic outer sleeve which is subject to the swaging operation has an external diameter prior to the swaging operation which is greater than an external diameter of the portion of the metallic outer sleeve in which the ceramics heater is se-

cured.

19. A method of manufacturing a ceramics heater glow plug according to one of Claims 15 to 18 in which after the step of filling a refractory insulating powder into the metallic outer sleeve through the other end thereof, an elastic seal member is fitted into an opening of the metallic outer sleeve disposed toward the electrode fitting. 5 10
20. A method of manufacturing a ceramics heater glow plug according to one of Claims 15 and 16 in which the lead wire connected to the electrode of the heating element has an end which is helically coiled while the distal end of the electrode fitting is formed with a plurality of steps, and in which the electrode fitting is axially urged to force the steps into the helical coil for engagement therebetween, thus connecting the lead wire and the electrode fitting together. 15 20
21. A method of manufacturing a ceramics heater glow plug according to one of Claims 15 and 16 in which the lead wire connected to the electrode of the heating element has an end which is helically coiled while the distal end of the electrode fitting is formed with threads and in which the electrode fitting is turned about its axis to force the threads into threadable engagement with the helical coil, thereby connecting the lead wire and the electrode fitting together. 25 30

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FIG. 1

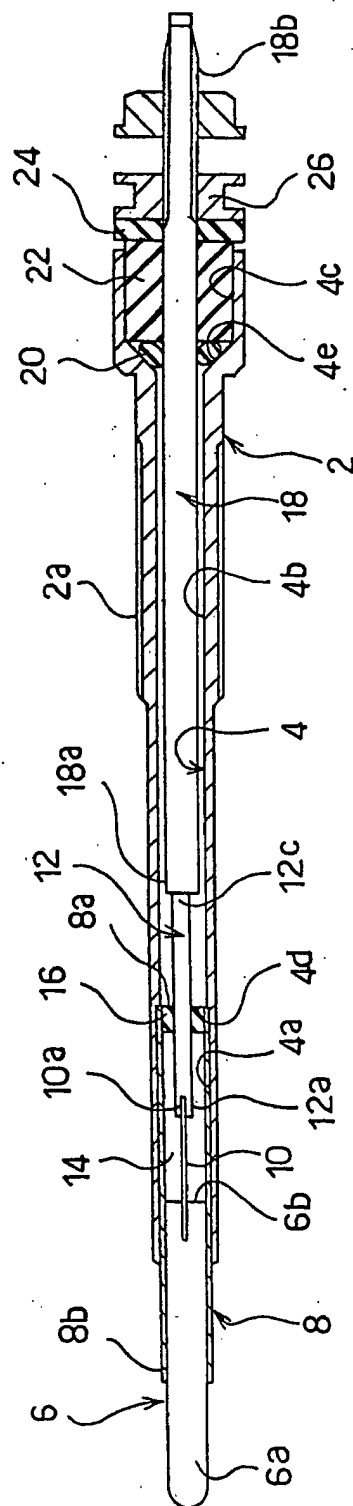


FIG. 2

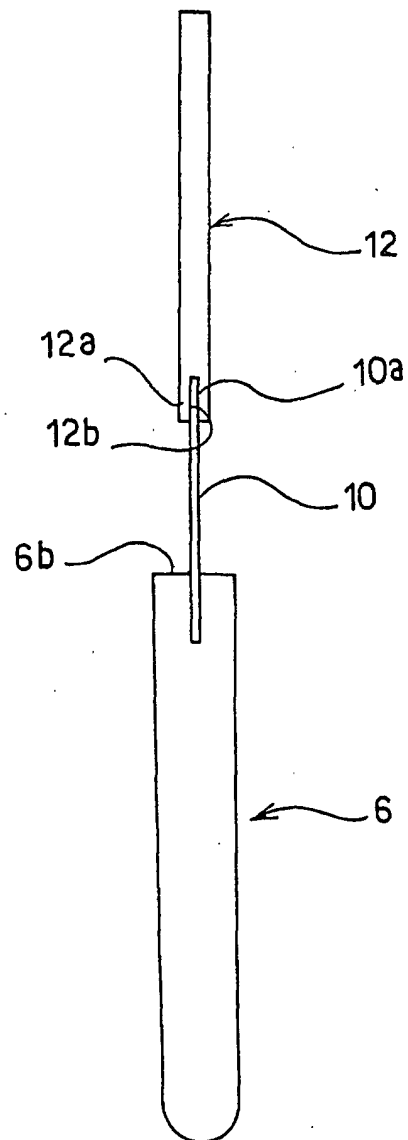


FIG. 3

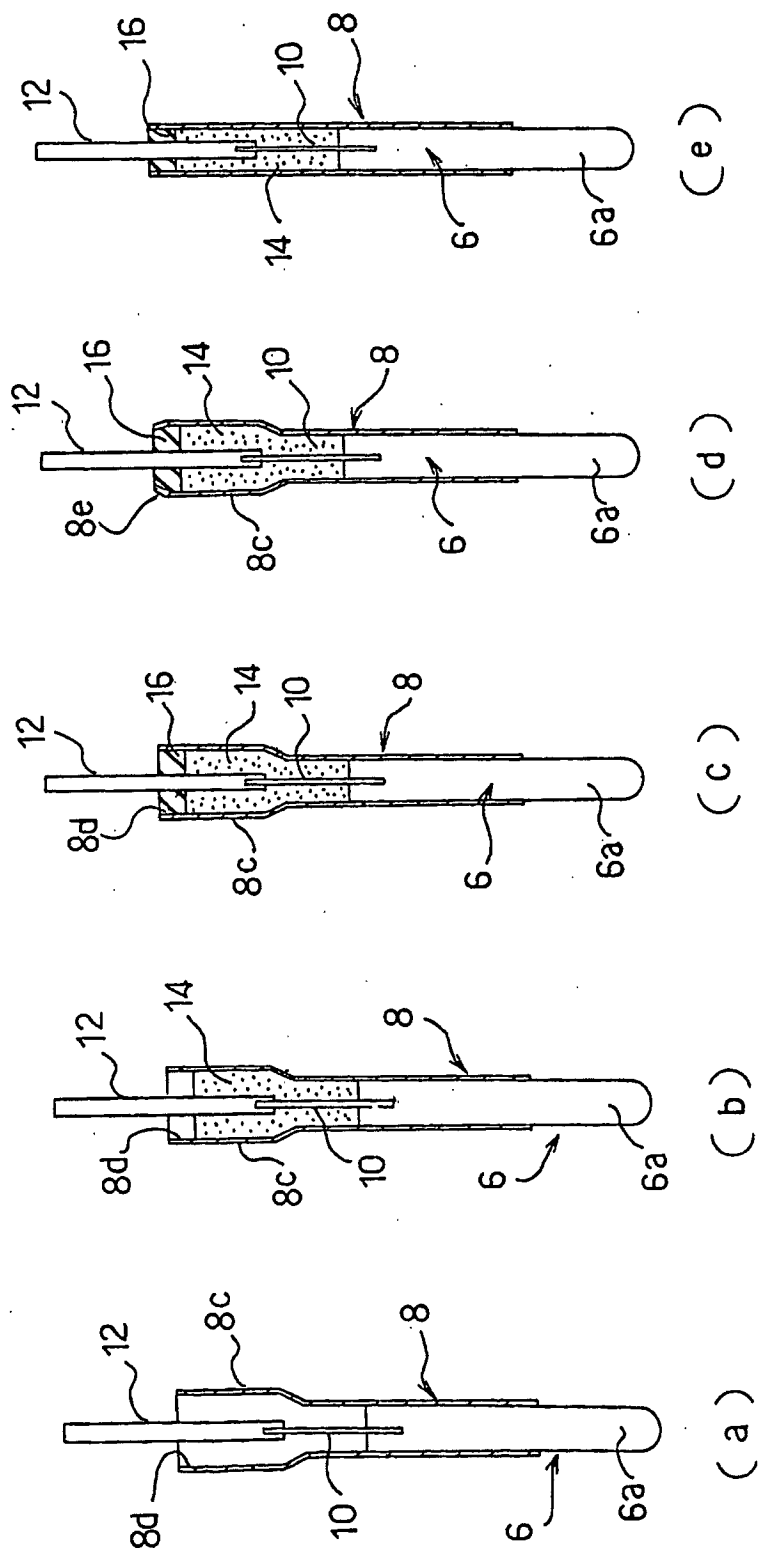


FIG. 4

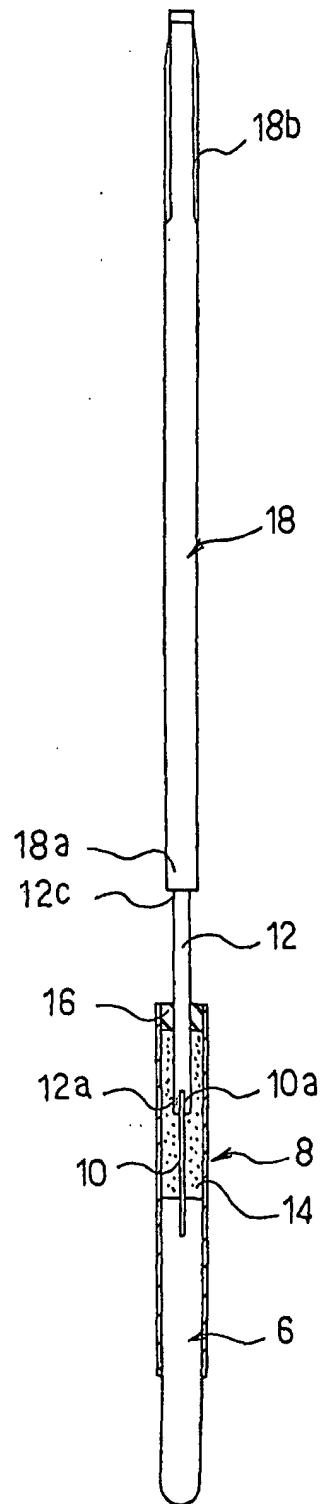


FIG. 5

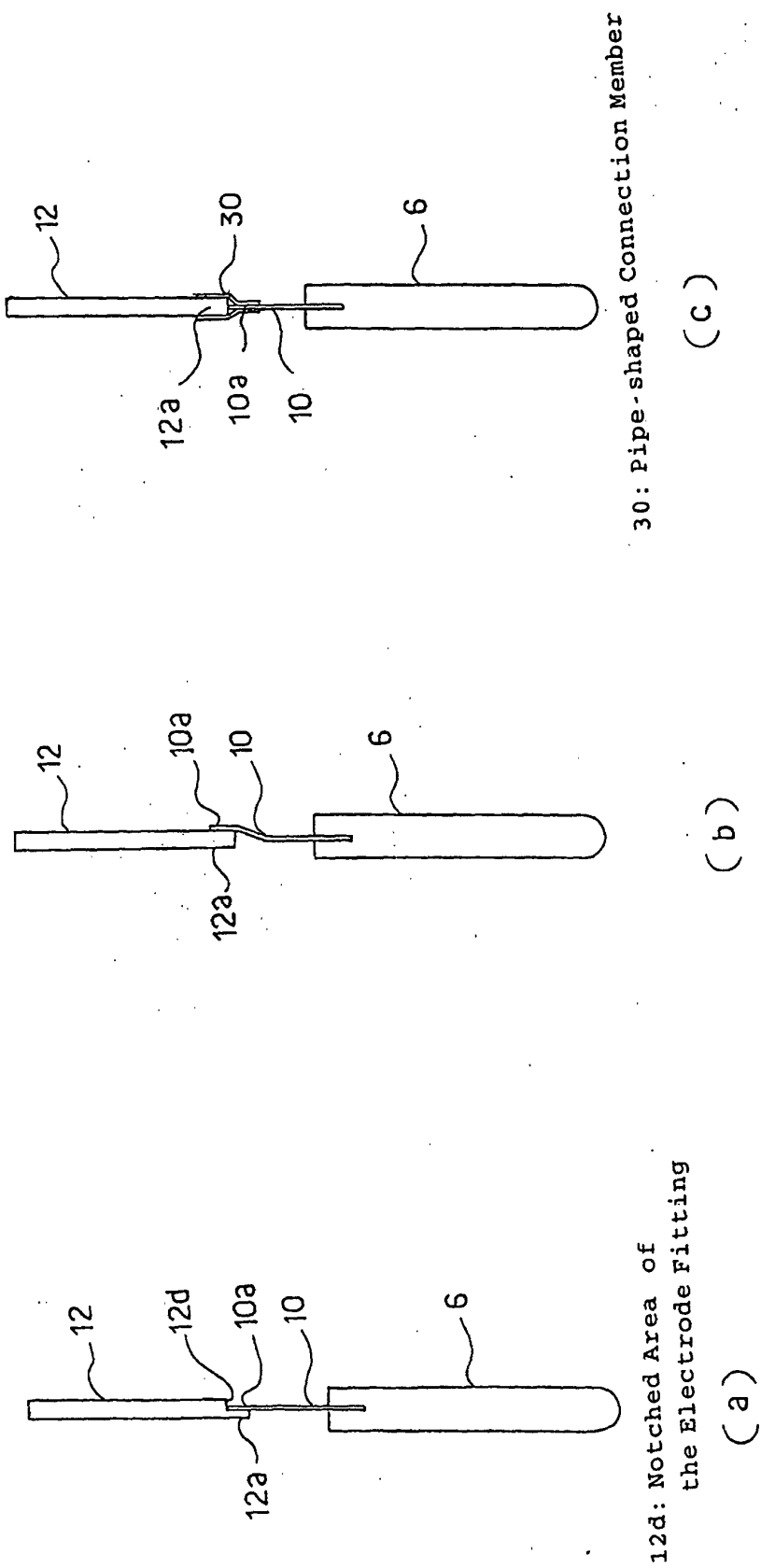


FIG. 6

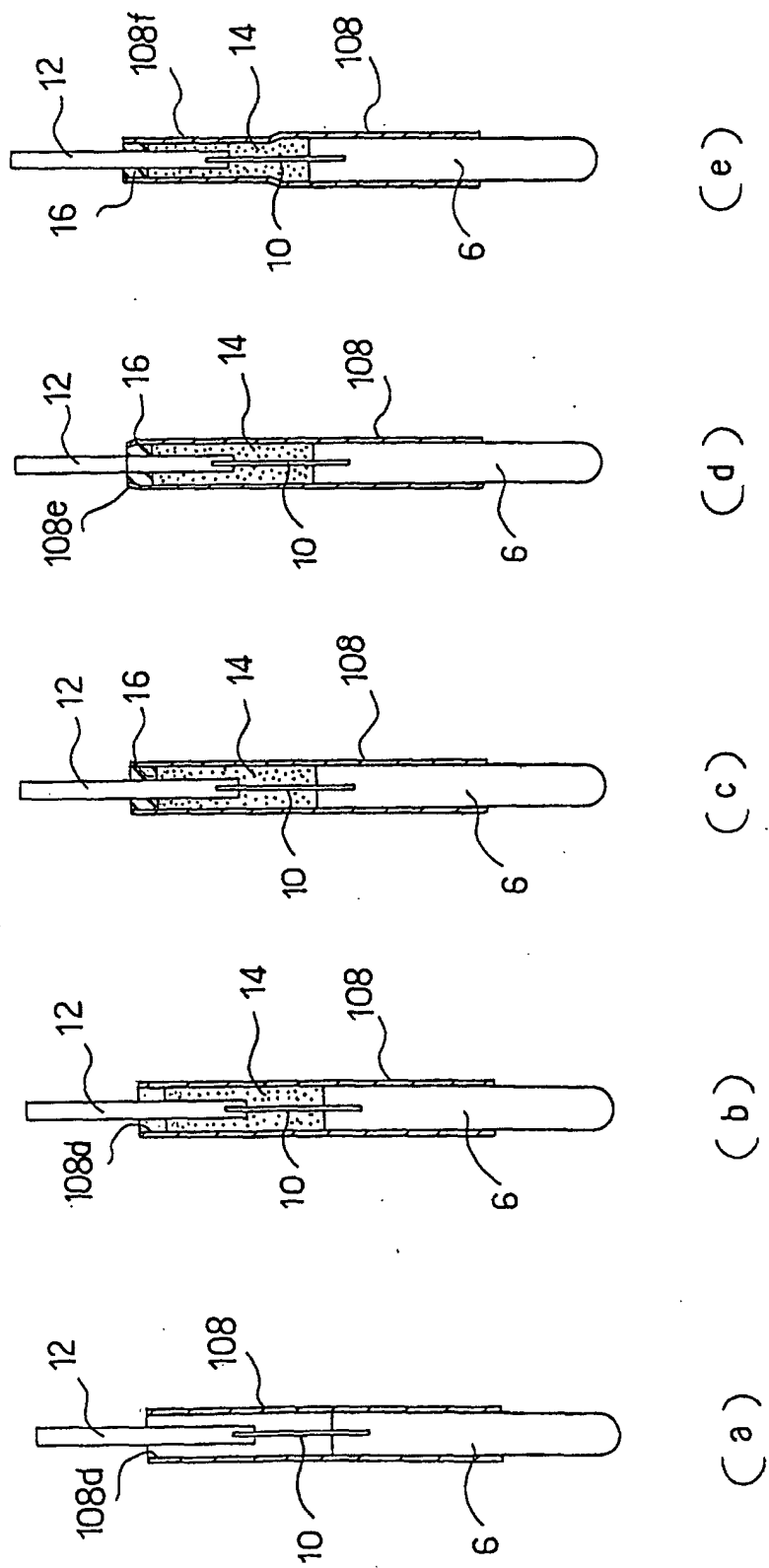


FIG. 7

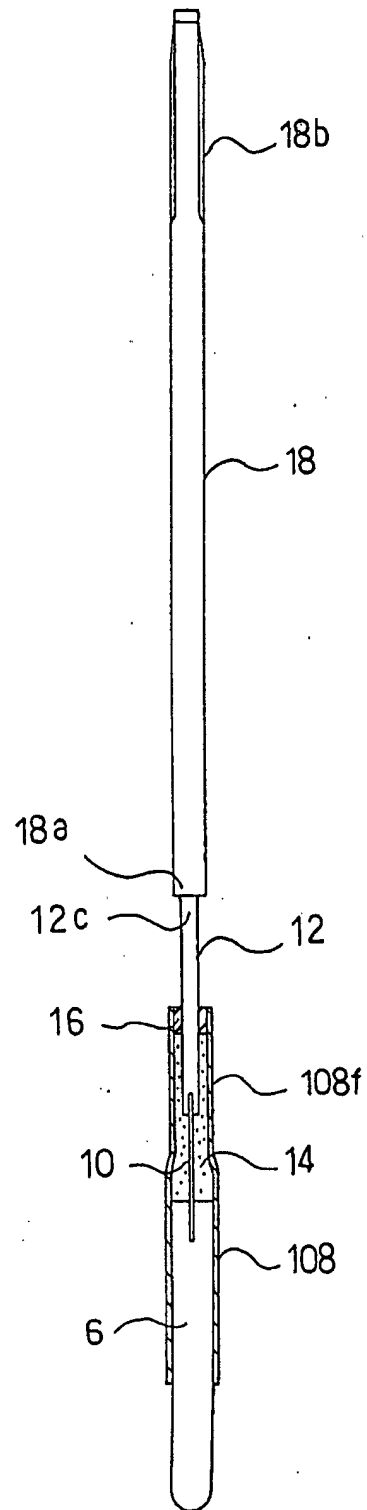


FIG. 8

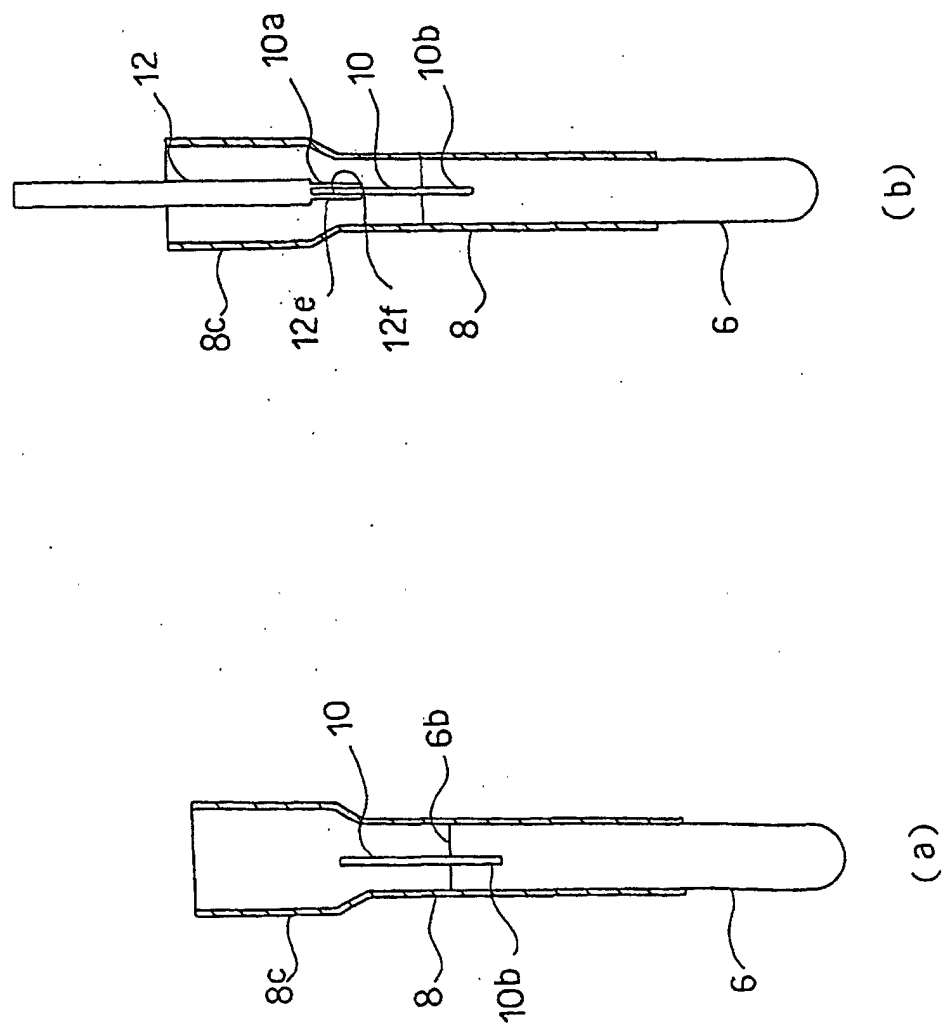


FIG. 9

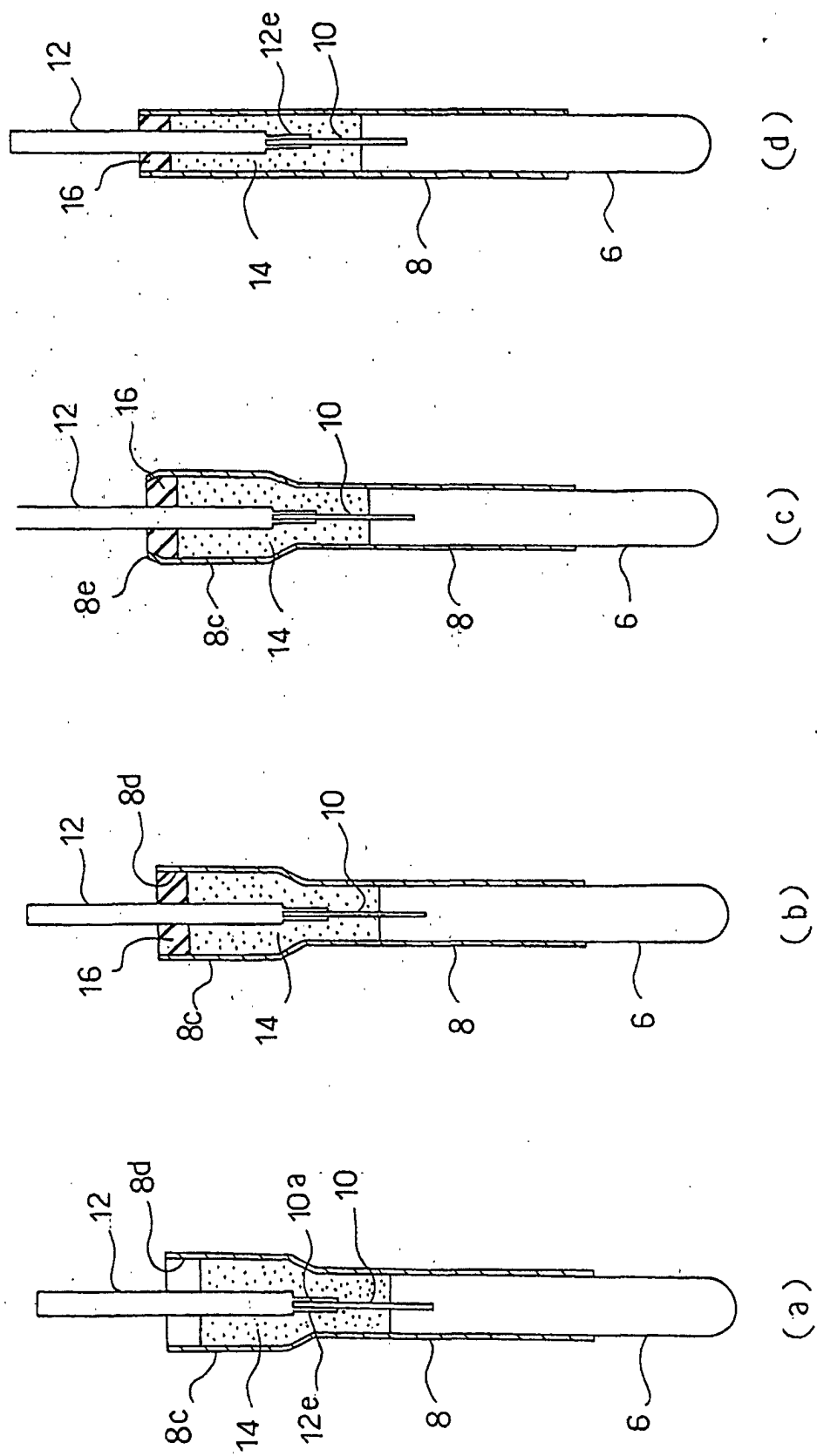


FIG. 10

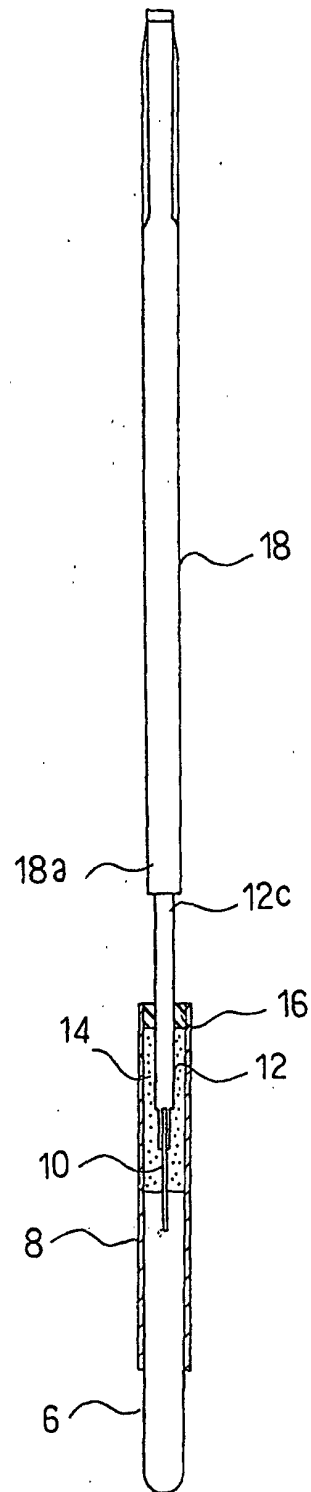


FIG. 11

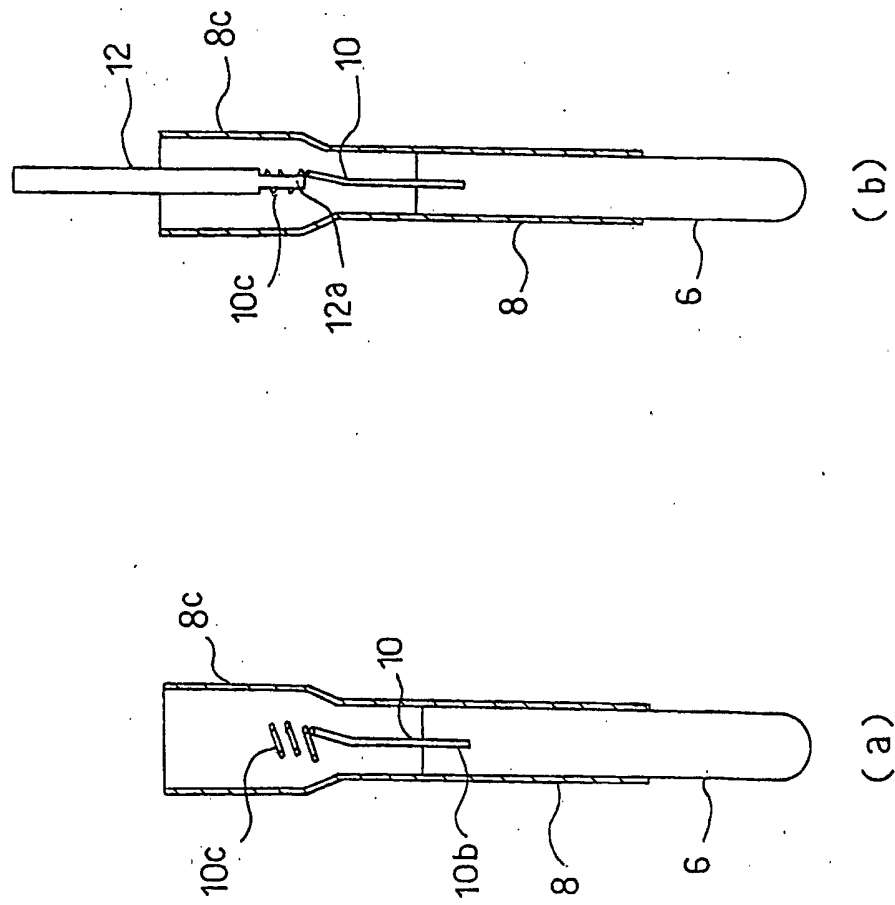


FIG. 12

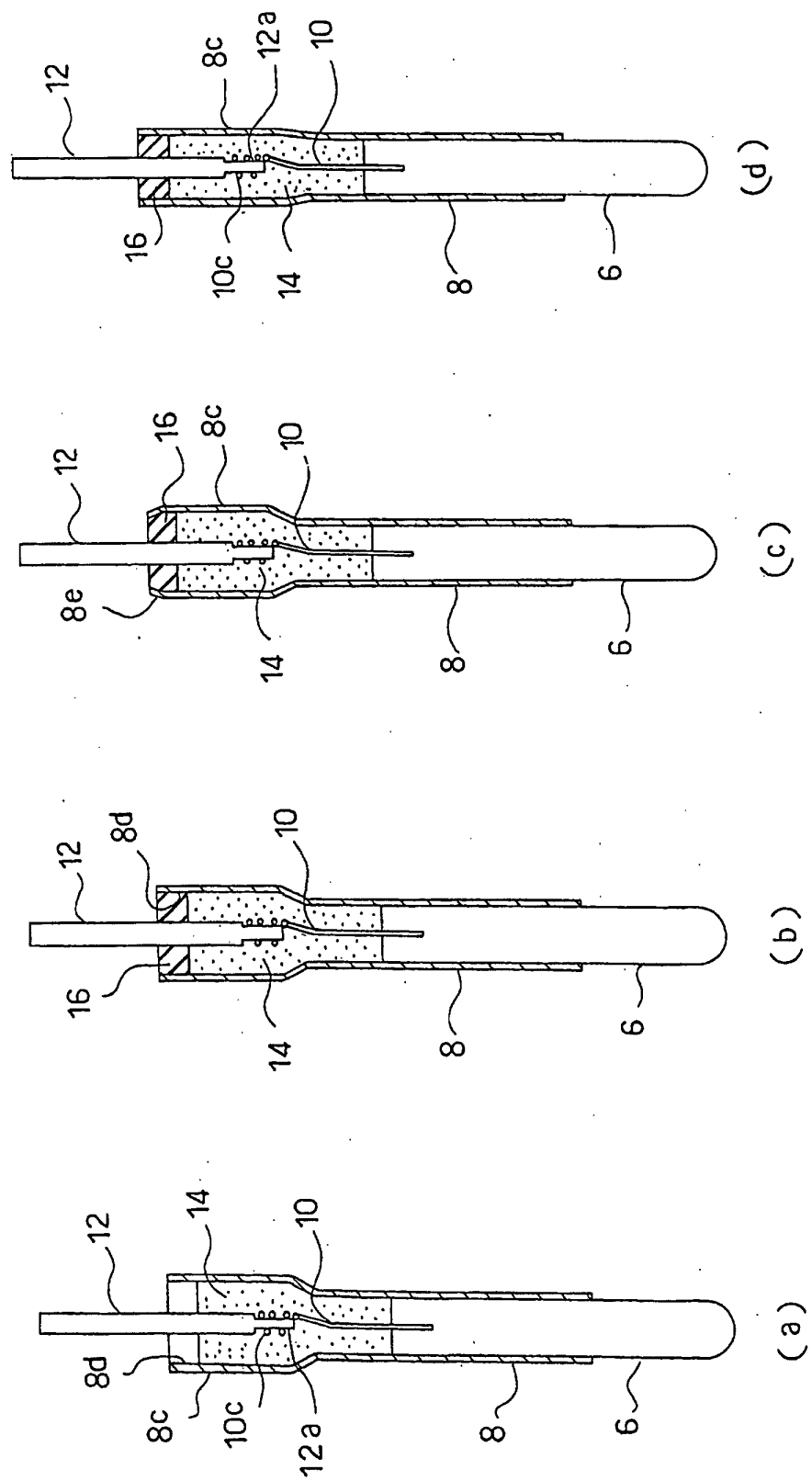


FIG. 13

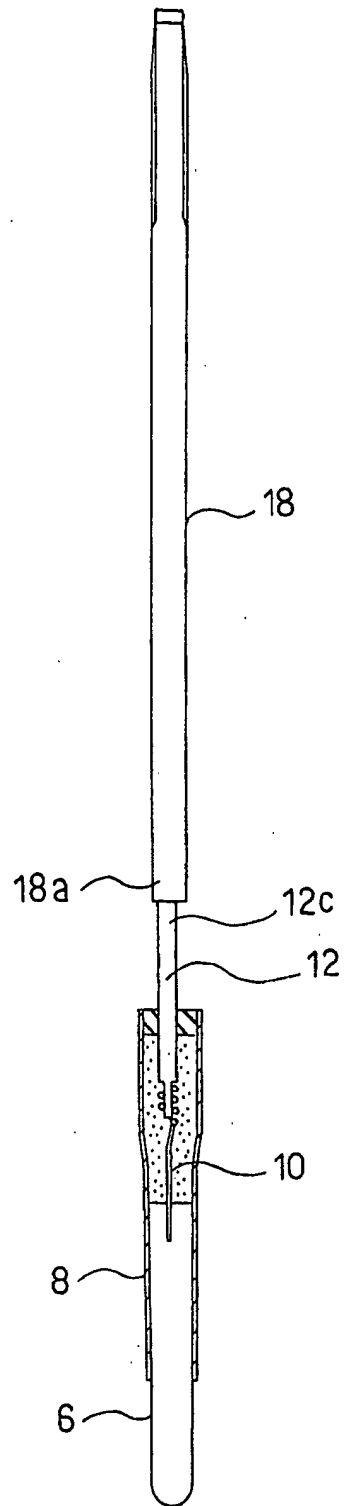


FIG. 14

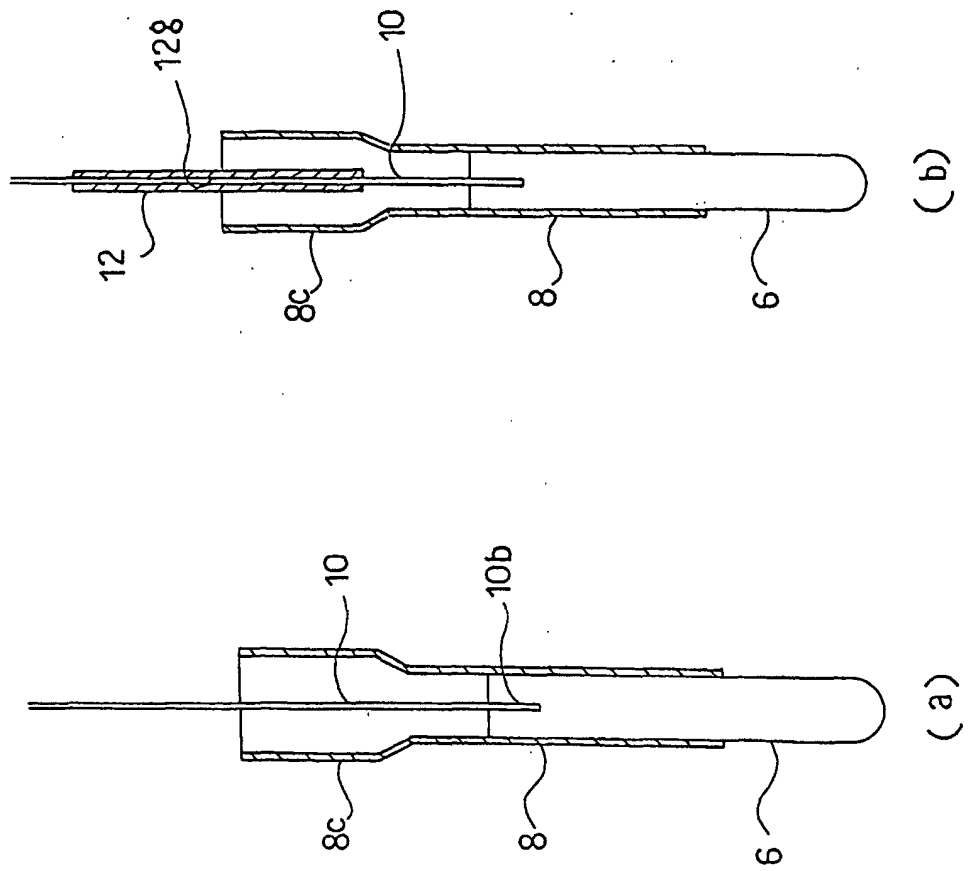


FIG. 15

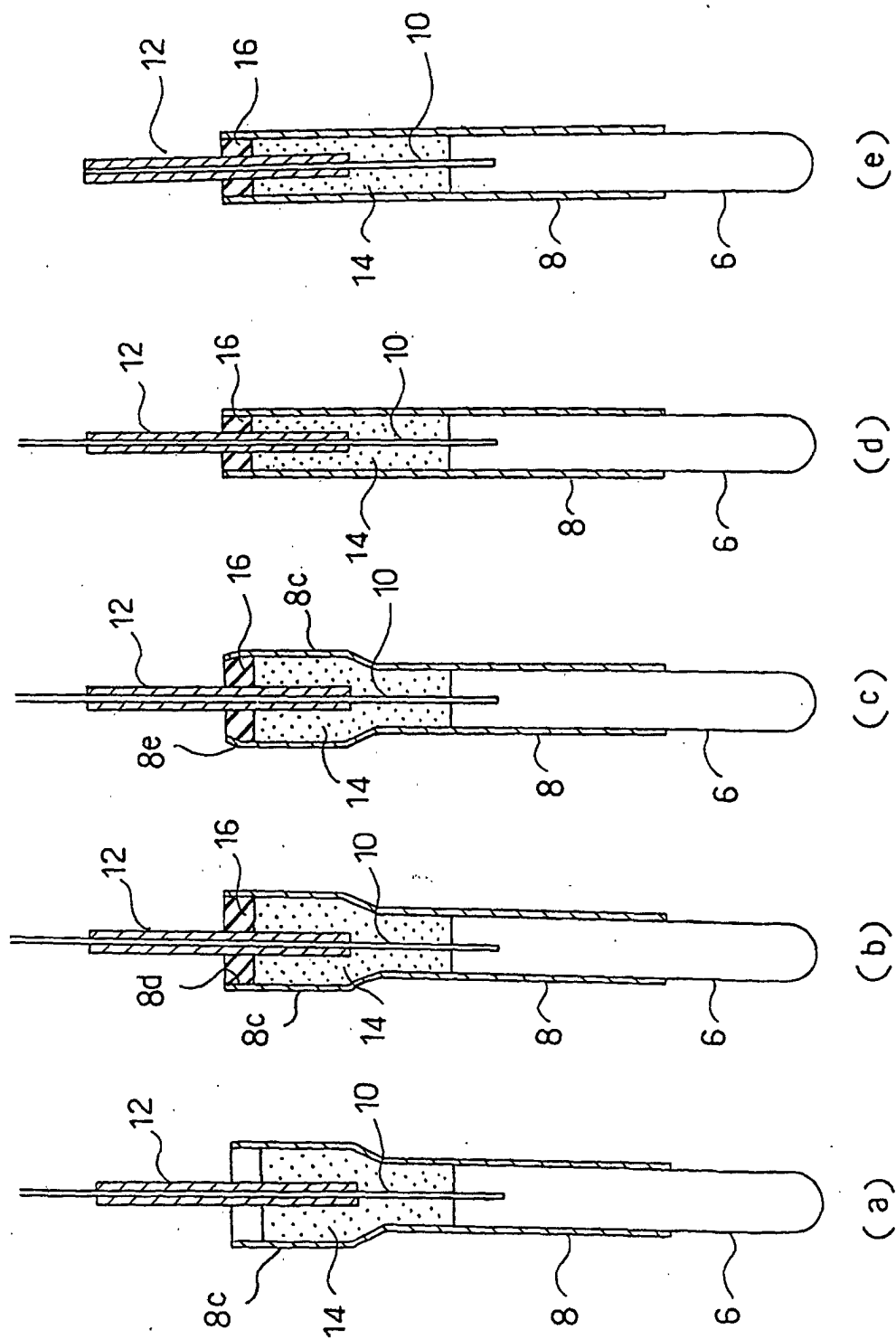


FIG. 16

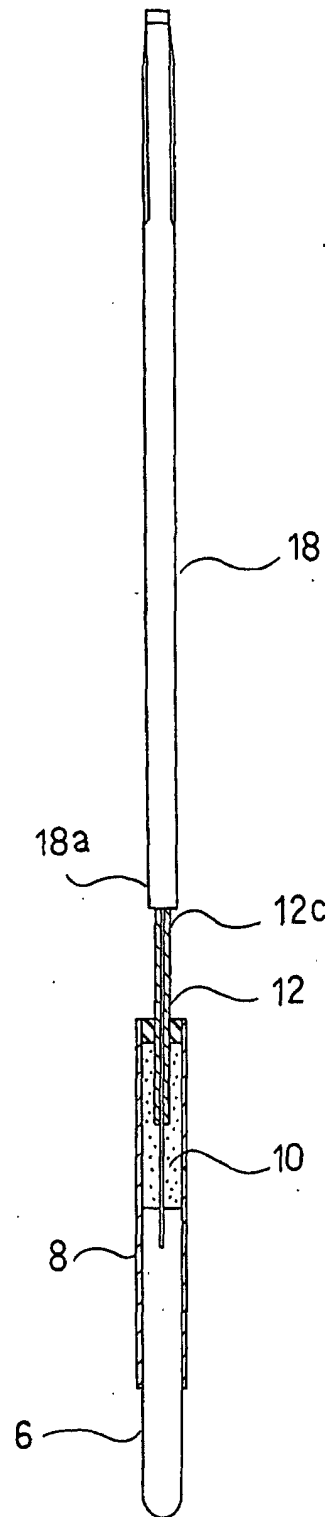


FIG. 17

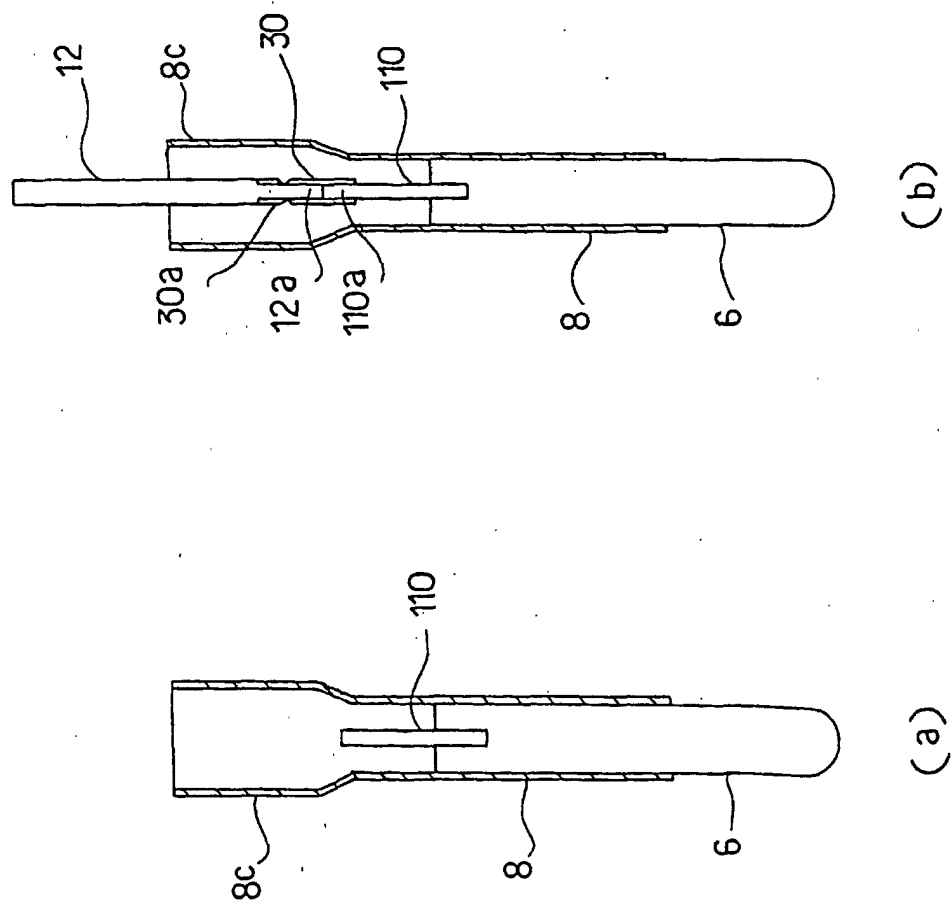


FIG. 18

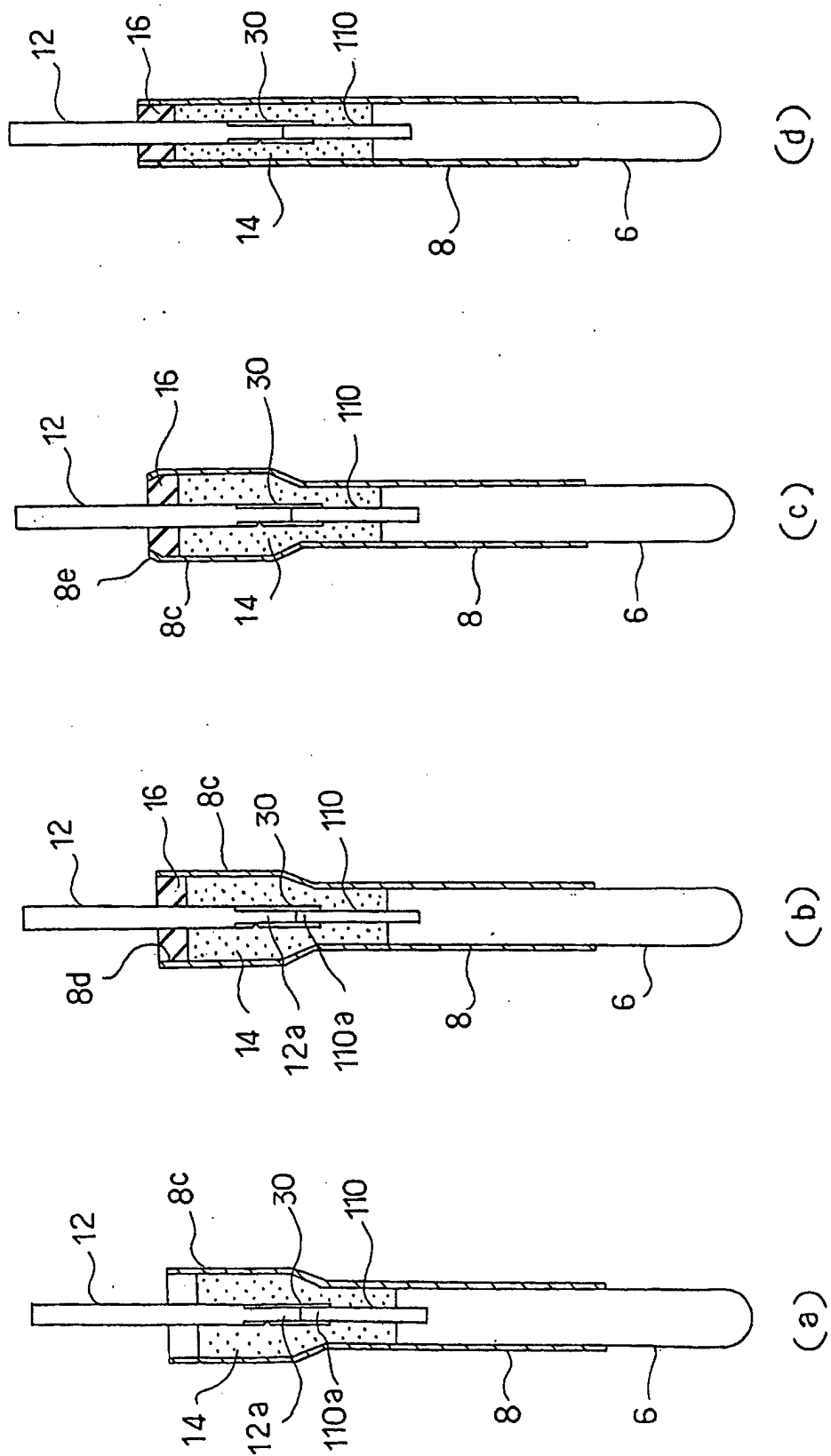


FIG. 19

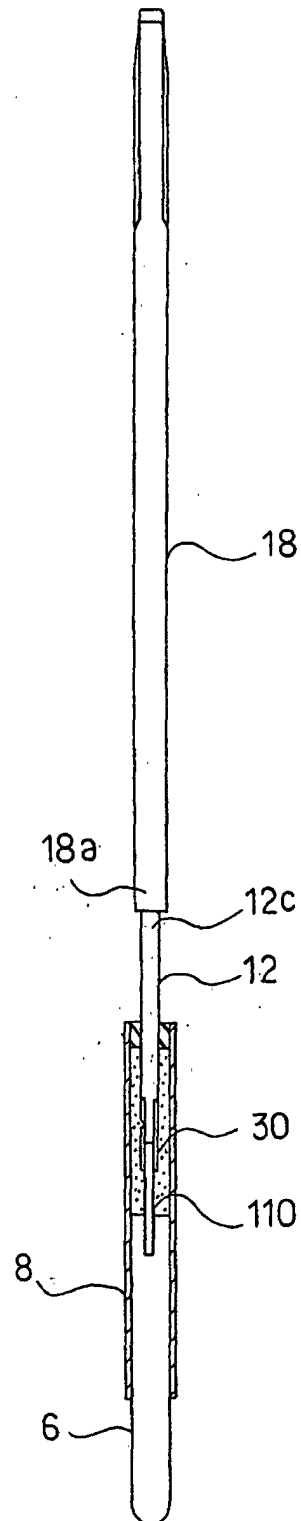


FIG. 20

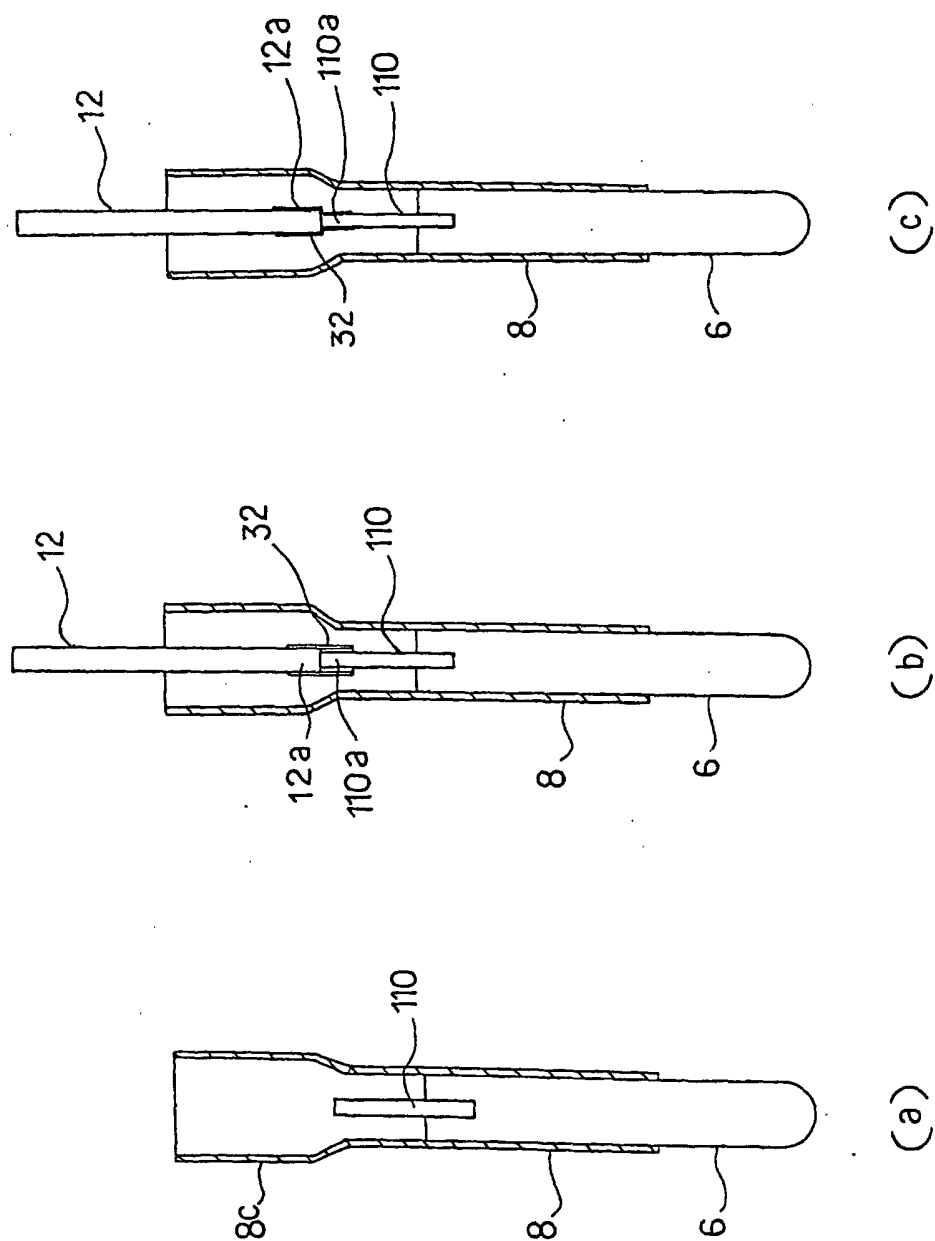


FIG. 21

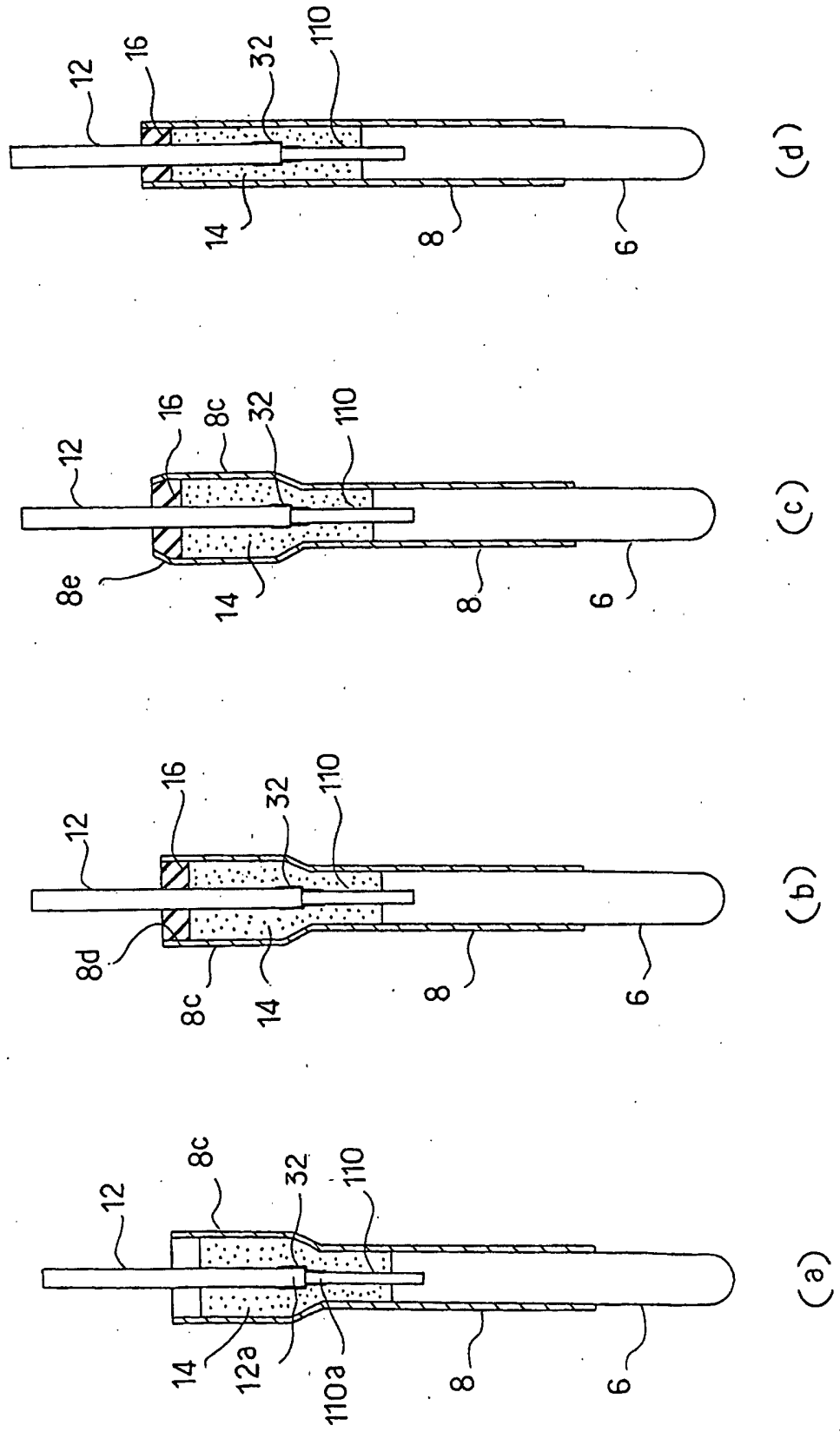


FIG. 22

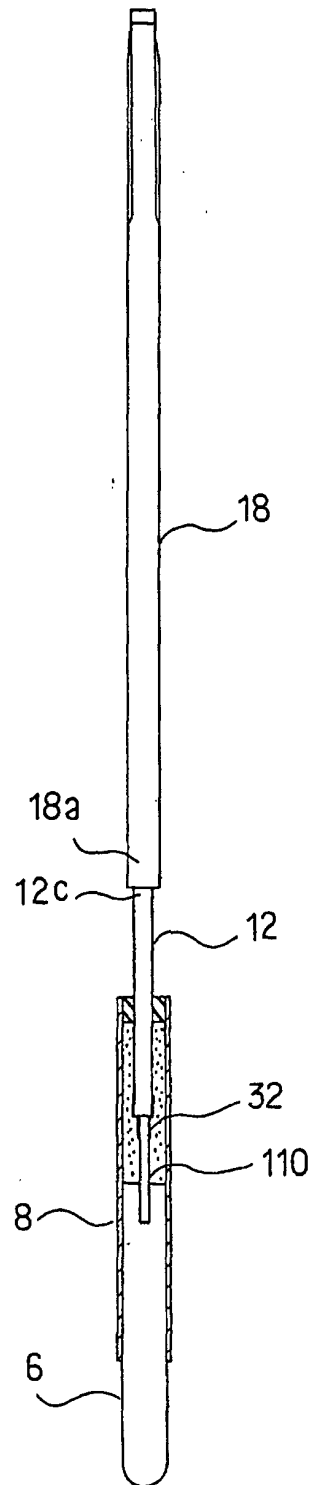


FIG. 23

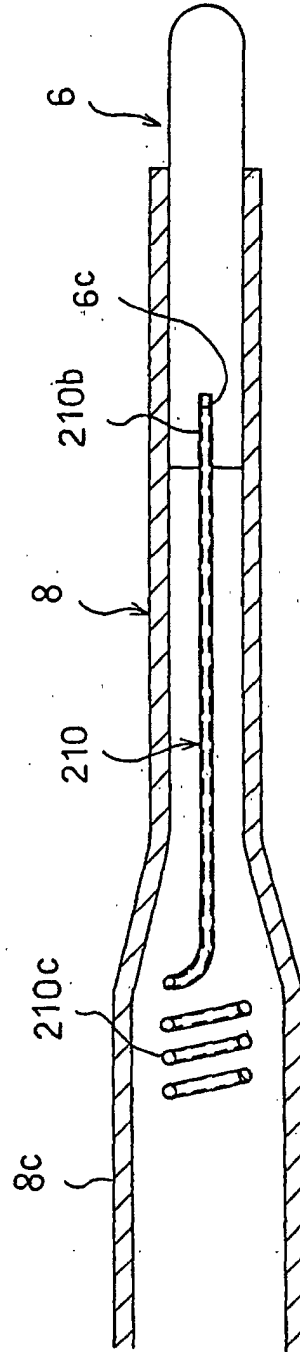


FIG. 24

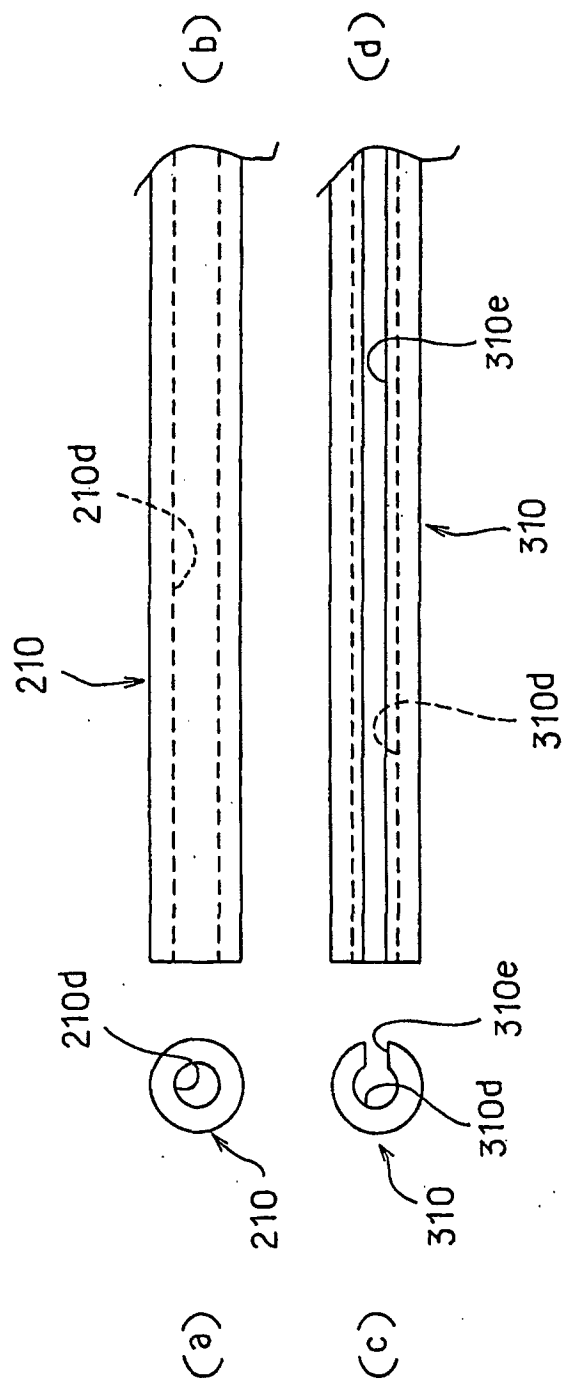


FIG. 25

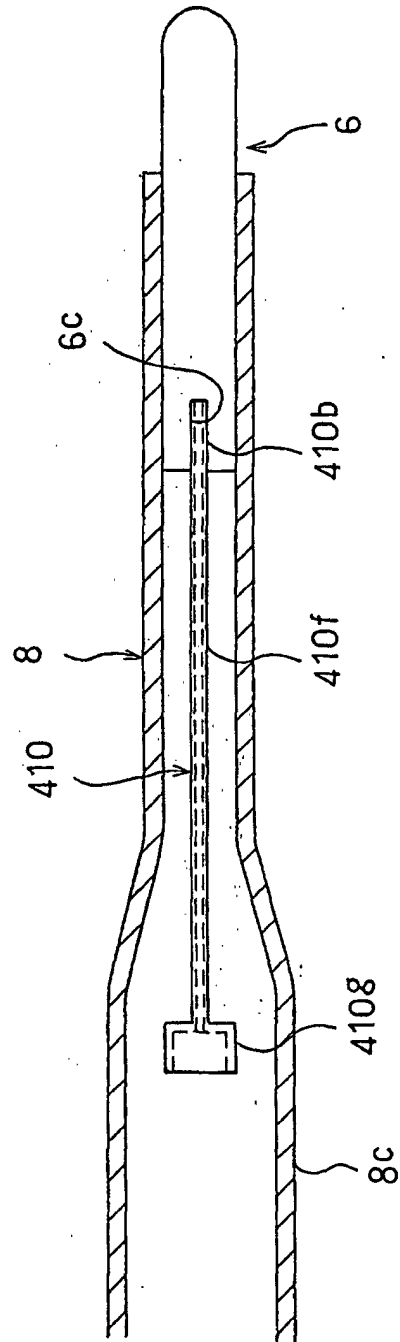


FIG. 26

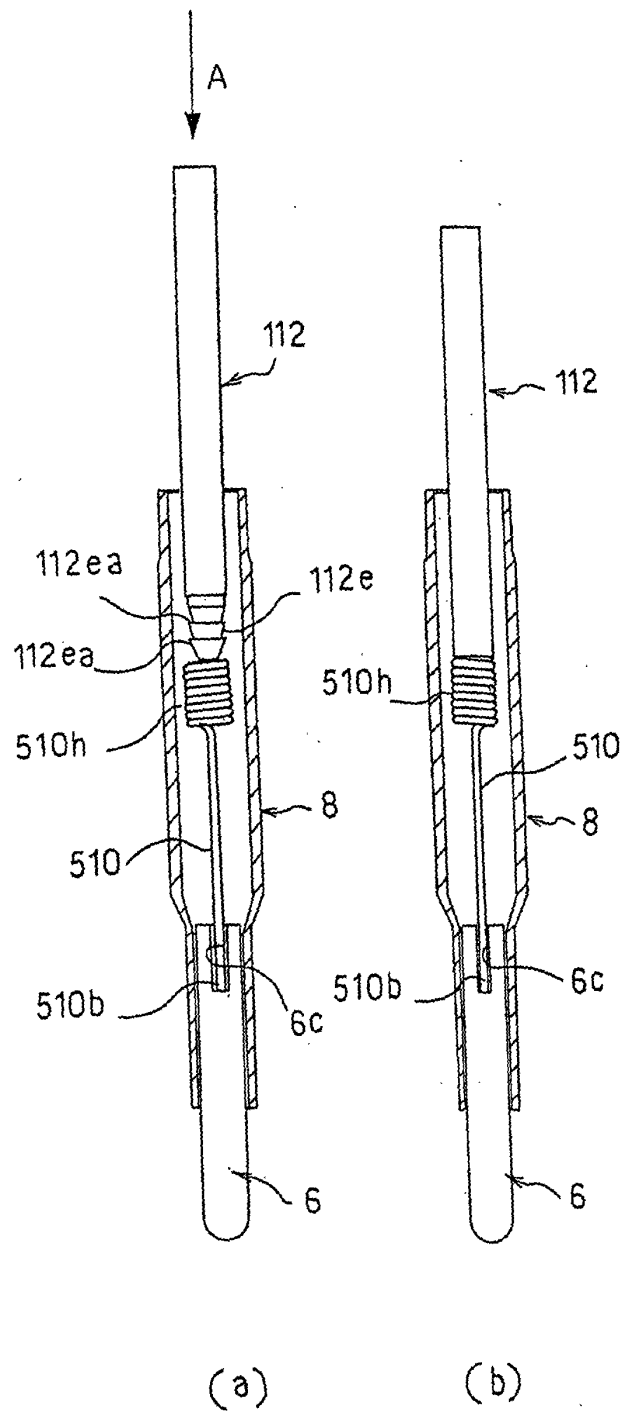


FIG. 27

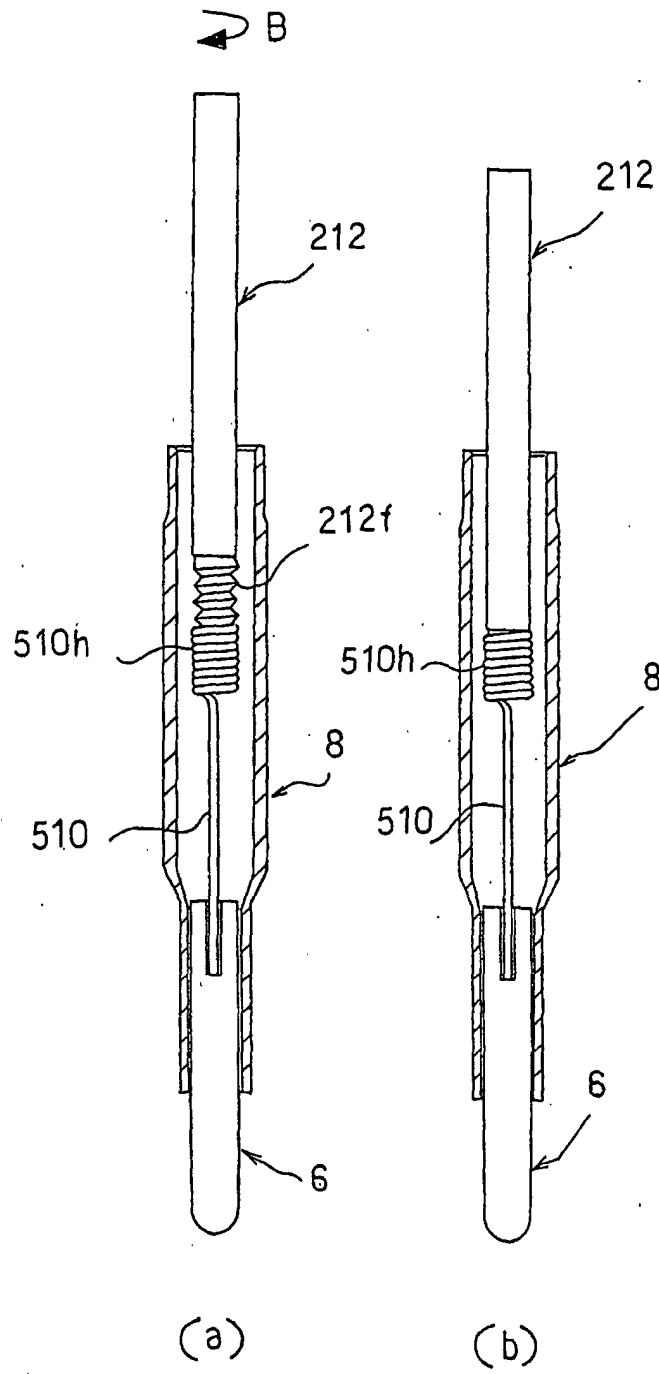


FIG. 28

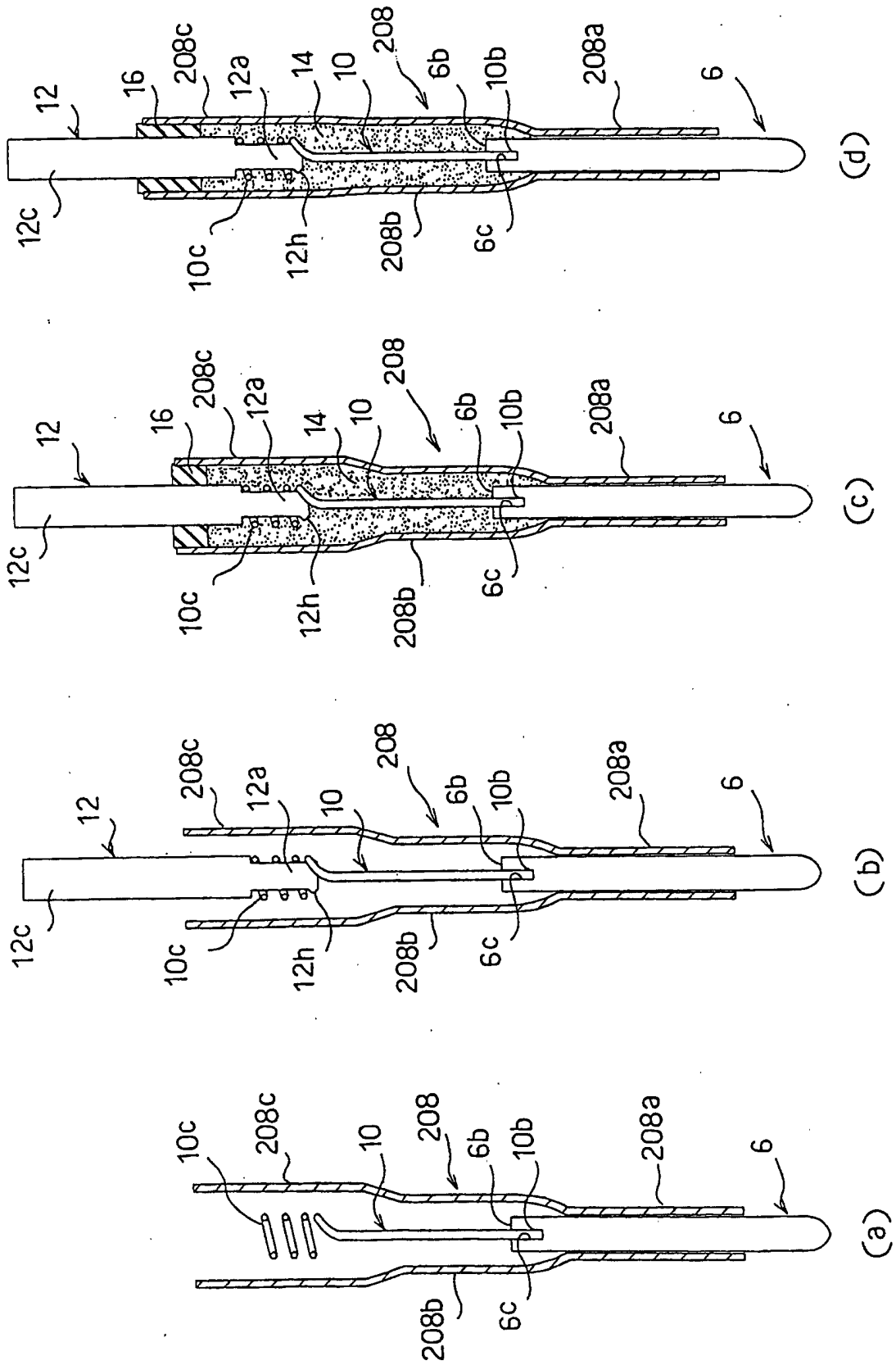


FIG. 29

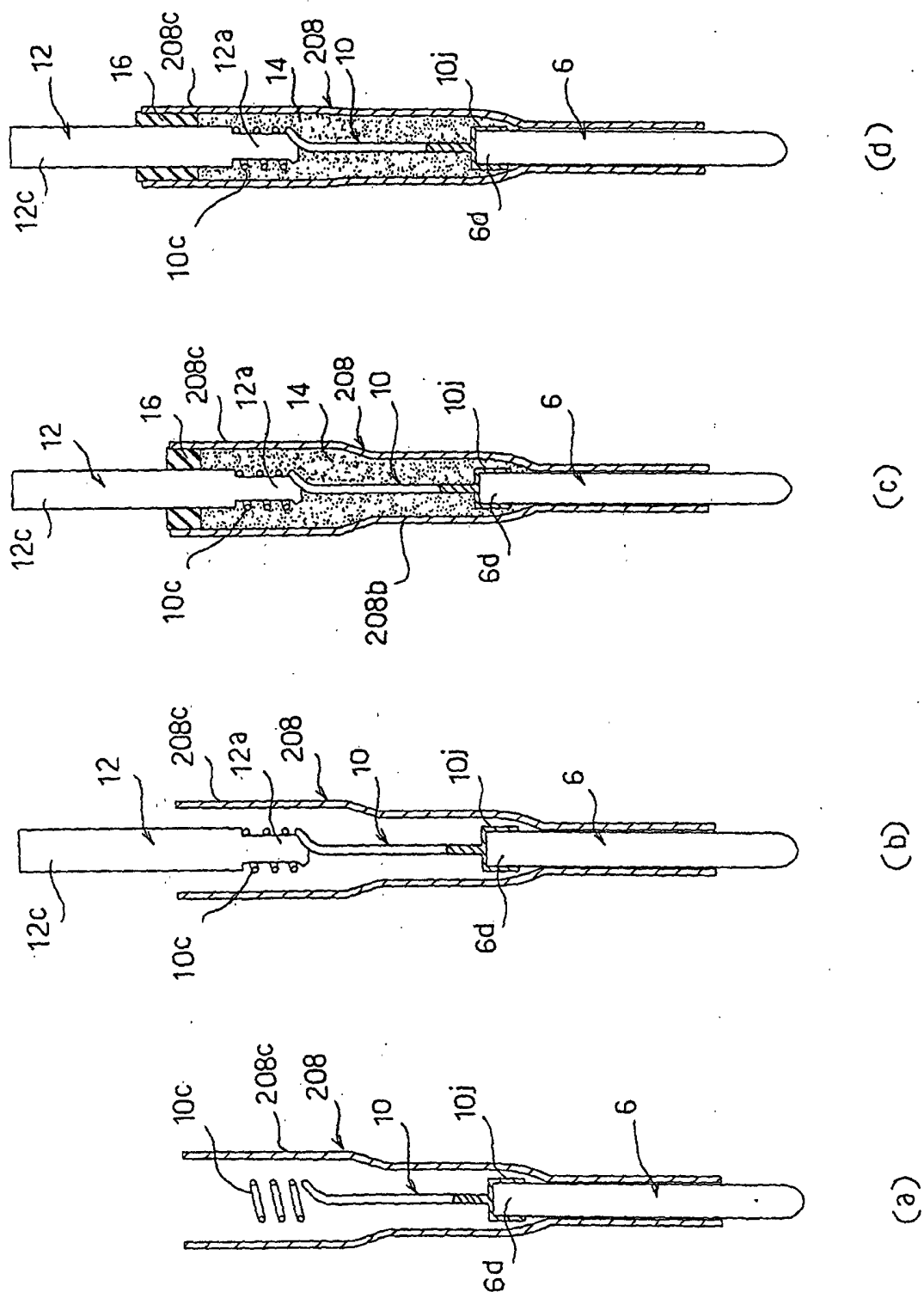
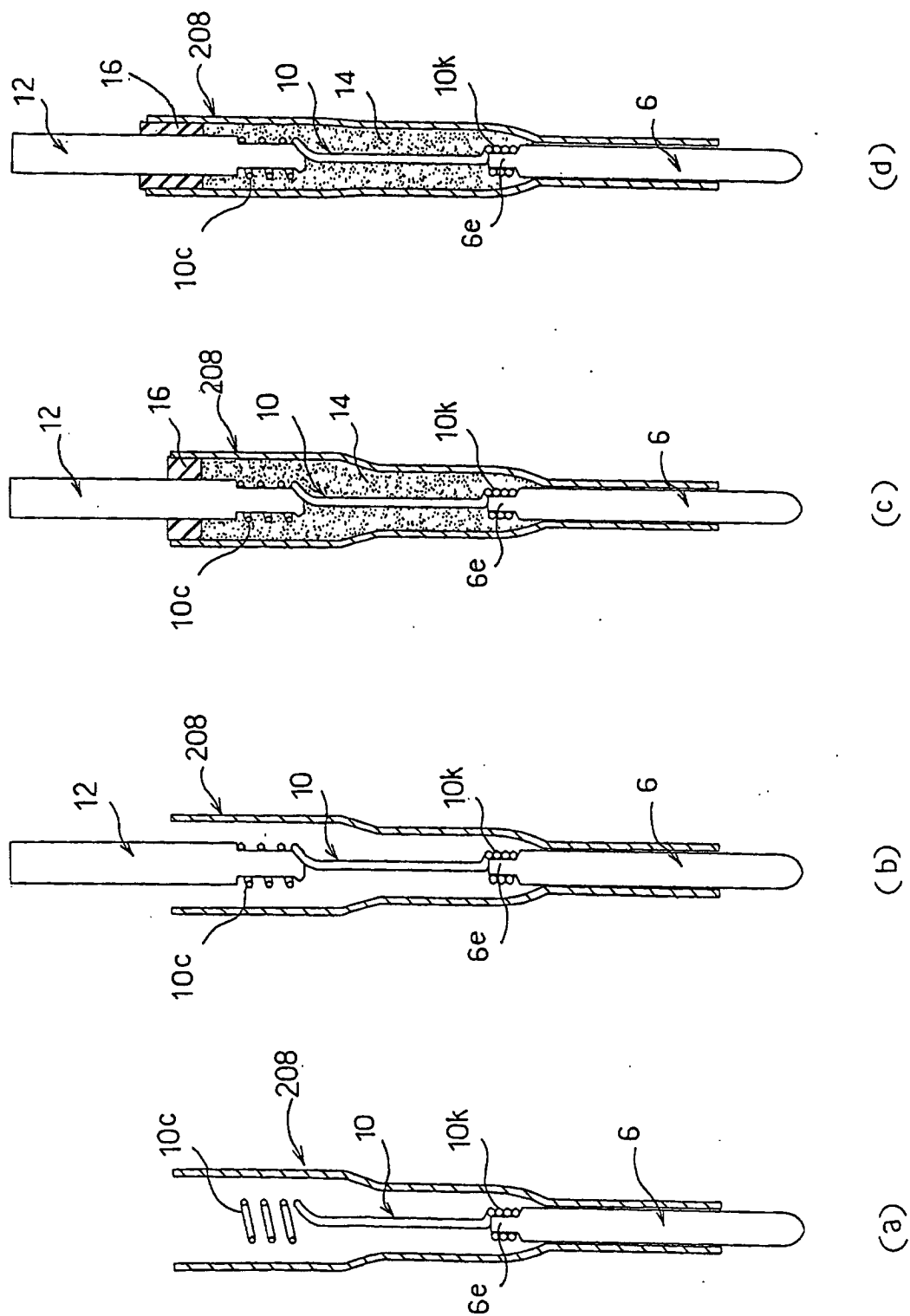


FIG. 30



F I G. 31

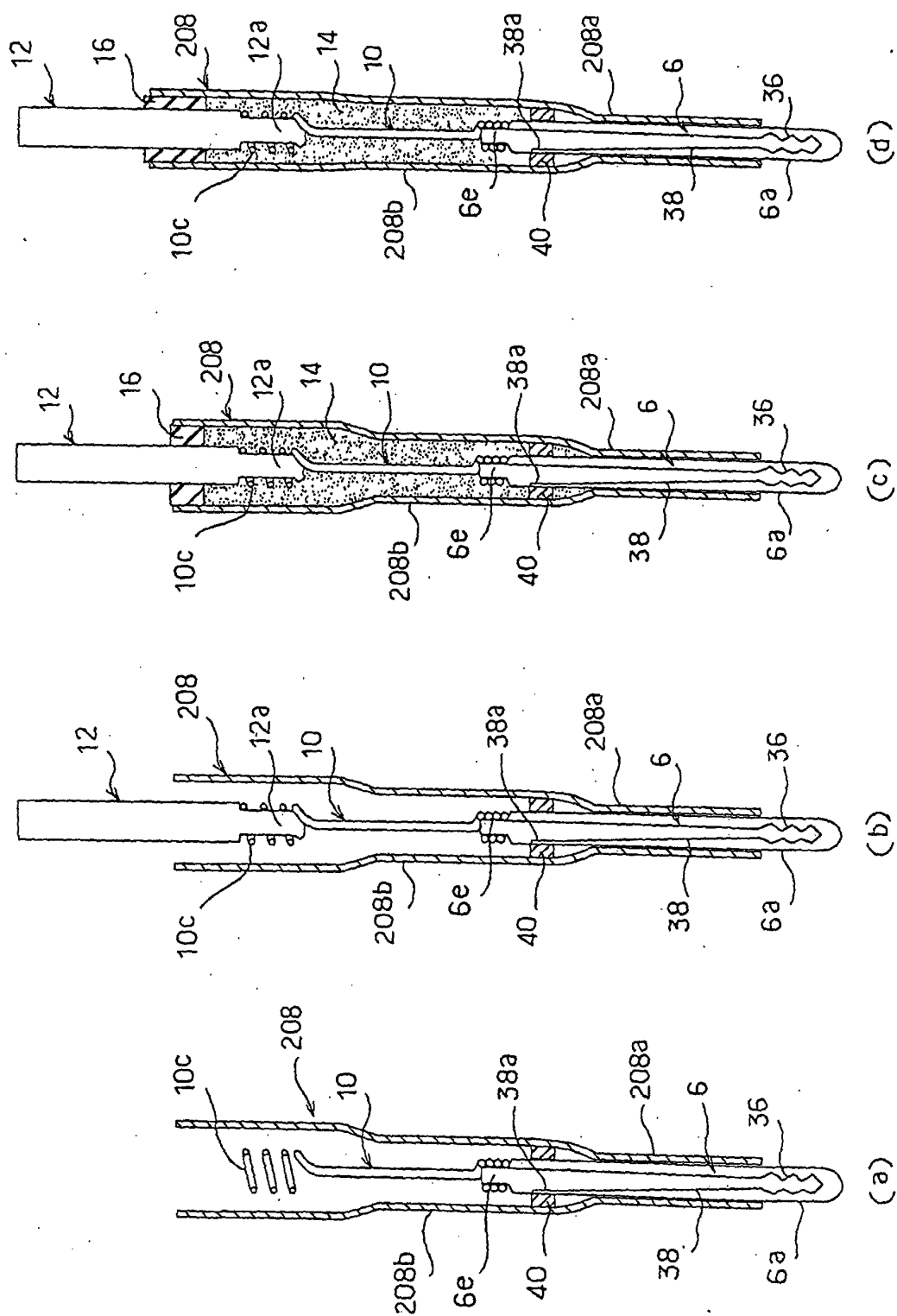


FIG. 32

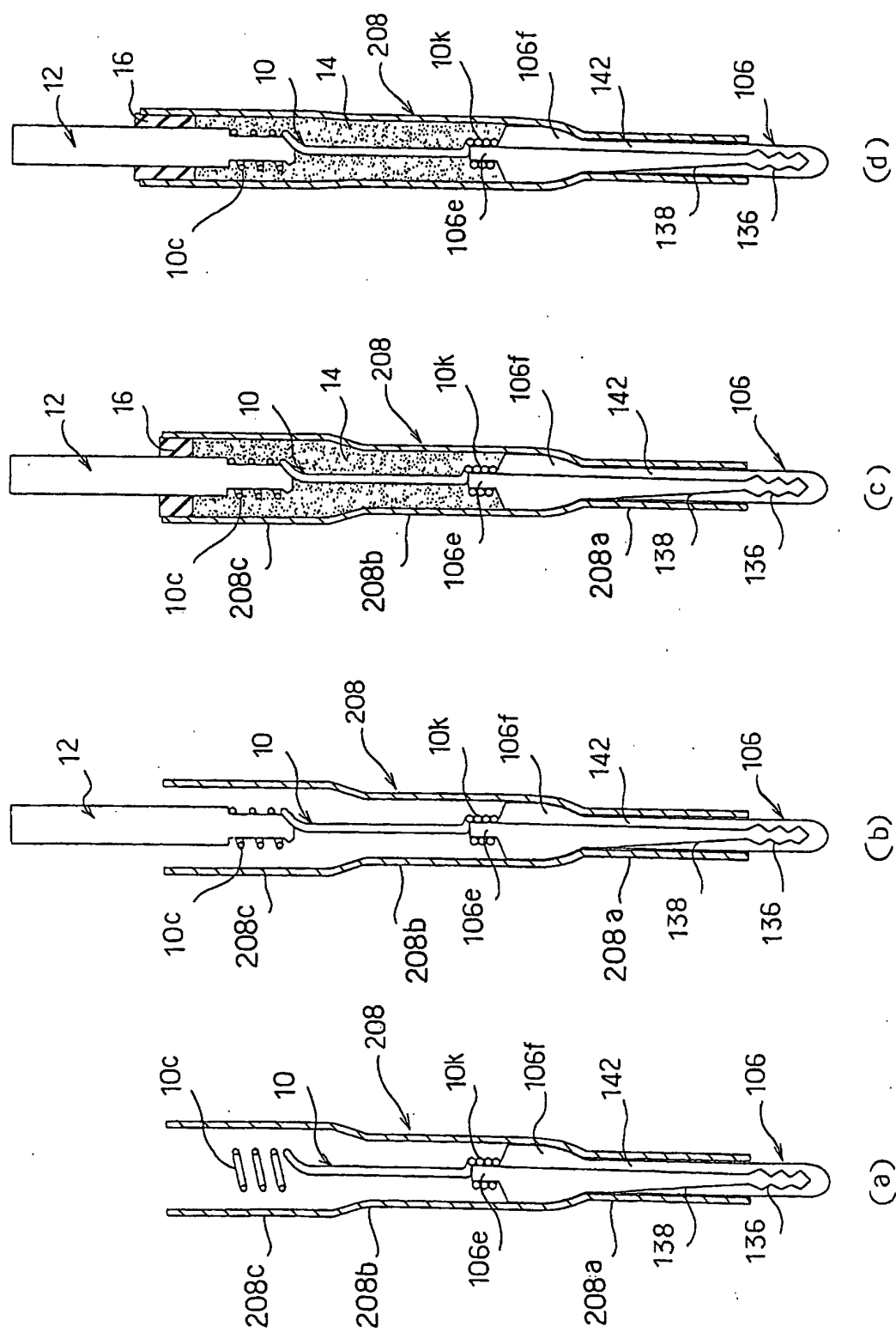


FIG. 33

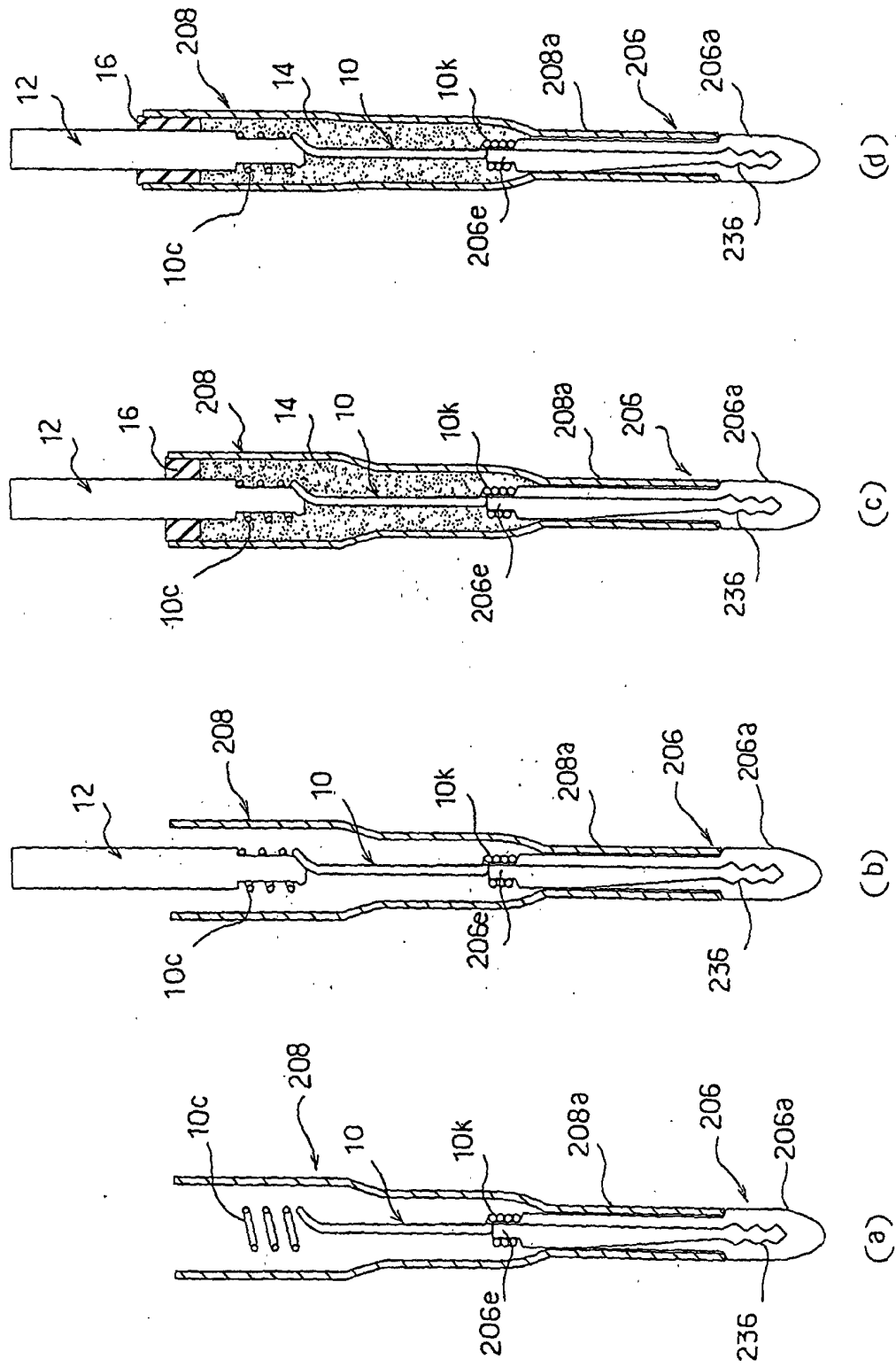
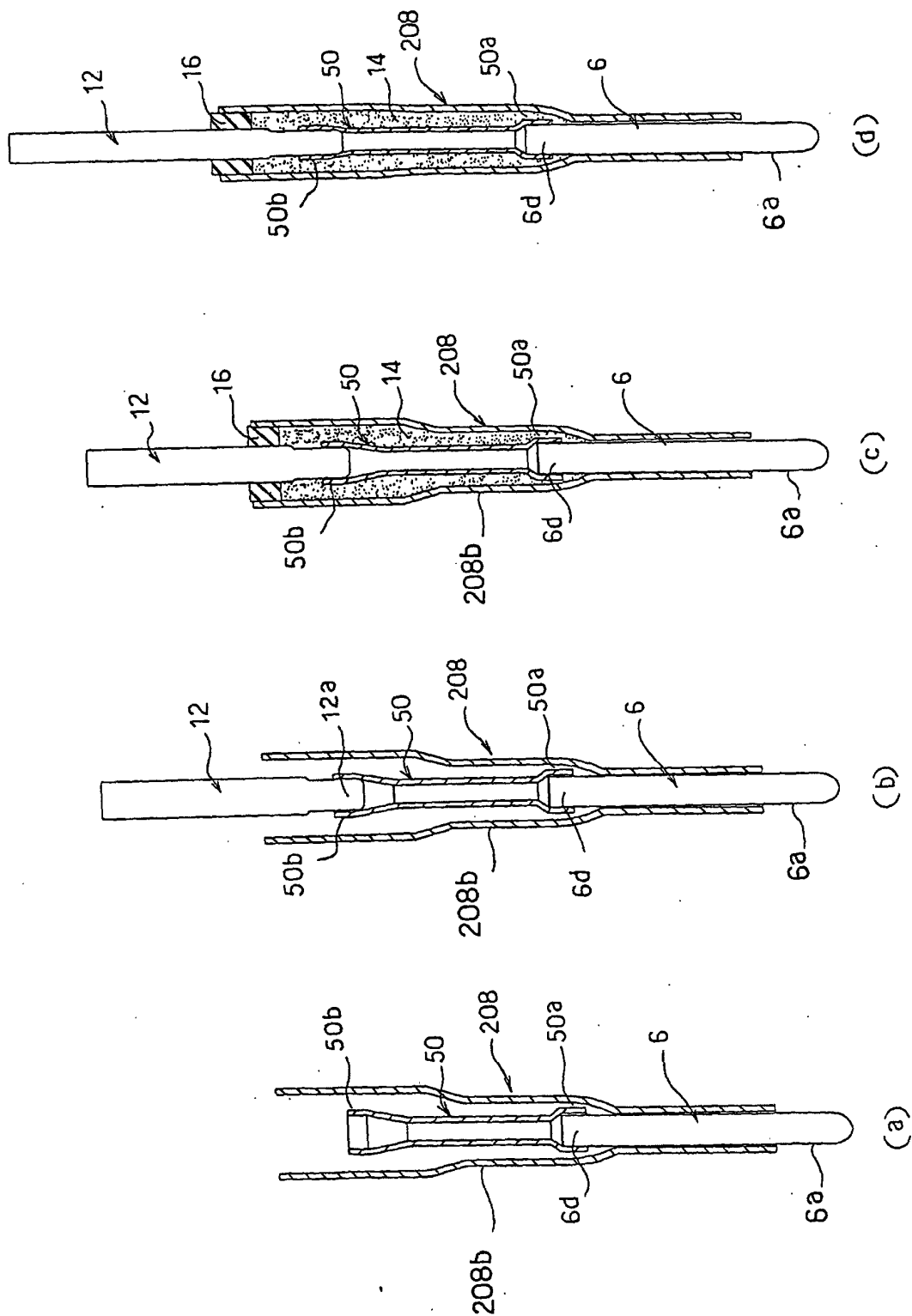


FIG. 34



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/09043

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, H05B3/40-3/52														
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 1994-2002 Kokai Jitsuyo Shinan Koho 1971-2002 Jitsuyo Shinan Toroku Koho 1996-2002														
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)														
C. DOCUMENTS CONSIDERED TO BE RELEVANT														
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.												
A	JP 63-311022 A (NGK Spark Plug Co., Ltd.), 19 December, 1988 (19.12.88), Full text; Figs. 1 to 3 (Family: none)	1-21												
A	JP 11-94251 A (Denso Corporation), 09 April, 1999 (09.04.99), Full text; Figs. 1 to 8 & EP 000903541 A	1-21												
A	JP 62-34651 U1 (NGK Spark Plug Co., Ltd.), 28 February, 1987 (28.02.87), Full text; Figs. 1 to 3 (Family: none)	1-21												
A	JP 8-210638 A (Jidosha Kiki Co., Ltd.), 20 August, 1996 (20.08.96), Full text; Figs. 1 to 6 (Family: none)	1-21												
A	JP 62-26419 A (NGK Spark Plug Co., Ltd.), 04 February, 1987 (04.02.87), Full text; Figs. 1 to 3 (Family: none)	1-21												
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.														
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>"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</td> </tr> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"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</td> </tr> <tr> <td>"E" earlier document but published on or after the international filing date</td> <td>"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</td> </tr> <tr> <td>"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)</td> <td>"&" document member of the same patent family</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td></td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>			* Special categories of cited documents:	"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	"A" document defining the general state of the art which is not considered to be of particular relevance	"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	"E" earlier document but published on or after the international filing date	"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	"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)	"&" document member of the same patent family	"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	
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"P" document published prior to the international filing date but later than the priority date claimed														
Date of the actual completion of the international search 08 January, 2002 (08.01.02)		Date of mailing of the international search report 29 January, 2002 (29.01.02)												
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/JP01/09043

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 9-112904 A (Jidosha Kiki Co., Ltd.), 02 May, 1997 (02.05.97), Full text; Figs. 1 to 8 (Family: none)	1-21

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