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

KERAMISCHE GLÜHKERZE UND VERFAHREN ZUR HERSTELLUNG DAFÜR

BOUGIE LUISANTE DE CHAUFFAGE EN CERAMIQUE ET PROCEDE DE FABRICATION DE
CETTE BOUGIE

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(73) Proprietor: **Bosch Automotive Systems
Corporation
Tokyo 150-8360 (JP)**

(72) Inventors:

- **TANAKA, Arihito,**
Bosch Automotive Systems Corp.
Higashimatsuyama-shi Saitama-ken355-8603
(JP)
- **AOTA, Takashi**
Bosch Automotive Systems Corporation
Higashimatsuyama-shi Saitama-ken355-8603
(JP)
- **ZHAO, Jian**
Bosch Automotive Systems Corporation
Higashimatsuyama-shi Saitama-ken355-8603
(JP)

- **MIURA, Toshitsugu**
Bosch Automotive Systems Corp.
Higashimatsuyama-shi Saitama-ken355-8603
(JP)

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

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Description

Technical Field

[0001] The invention relates to a glow plug which is used as a starting aid for a diesel engine at cold times, and in particular, to a glow plug incorporating a ceramic heater as a heating element, and a method of manufacturing same.

Description of the Related Art

Background Art

[0002] To accommodate for regulatory requirements on exhaust gases, a combustion scheme of a diesel engine is shifting from a type using sub-combustion chambers to a so-called direct injection type and also toward a multiplication of valves. A glow plug which is used in a diesel engine of direct injection type is disposed in facing relationship with a main combustion chamber through the wall of an interposed cylinder head, and thus requires an increased overall length and a reduced diameter as compared with one which has been used to preheat sub-combustion chambers.

[0003] The thickness of the cylinder head must be increased in order to secure the strength thereof, and this results in an opening of a smaller diameter and a greater length which is formed therein to receive the glow plug, which thus must be formed into an elongate configuration in a corresponding manner.

[0004] Fig. 4 illustrates schematically an example of conventional glow plug for a diesel engine which is designed to meet the requirements for a greater length and a reduced diameter. A conventional glow plug incorporating a ceramic heater as a heating element for a diesel engine will be described below with reference to Fig. 4.

[0005] A ceramic heating element 6 is cemented as by brazing inside a metallic outer sleeve 8 and has an electrode fitting 14, which is integrally connected, as by welding, brazing or caulking, to an end of an external connection terminal 10, the outer periphery of which is integrally formed with an insulating member of bushing 12 which may be molded from resin. The integral assembly comprising the ceramic heating element 6, the metallic outer sleeve 8, the external connection terminal 10 and the insulating bushing 12 is inserted into an internal bore 4 of a housing 2 through an opening thereof, which is an upper end thereof as viewed in Fig. 4, which is later used to secure the external connection terminal, and the metallic outer sleeve 8 is secured, as by brazing, to the other end or lower end as viewed in Fig. 4 of the housing 2. Subsequently the end of the housing 2 is caulked at a location toward the insulating bushing 12, thus securing the external connection terminal 10 and the insulating bushing 12 to the housing 2.

[0006] In the conventional ceramic heater glow plug, one end, or an upper end as viewed in Fig. 4, of a coiled

heating wire, not shown, disposed within the ceramic heating element 6 is taken out thereof to be electrically connected with the electrode fitting 14. The metallic outer sleeve 8 is fitted around and cemented with the outer periphery of the ceramic heating element 6 intermediate its length. Accordingly, an increased strength is required of the ceramic heating element 6 and the electrode fitting 14. The increased length of the ceramic heating element results in an increased cost. To accommodate for this, a ceramic heater is now available which is structured such that the heater 6 and the sleeve 8 are cemented together under a condition that the heating wire of the element 6 is connected to the electrode fitting 14 within the element 6 and the end of the element 6 connected to the electrode fitting 14 is contained inside the sleeve 8.

[0007] In the ceramic heater thus structured, the connection between the internal heating wire of the heating element 6 and the electrode fitting 14 as well as the cementation between the heating element 6 and the sleeve 8 generally both take place by brazing. Steps taken to braze these members 6, 8 and 14 will now be described with reference to Figs. 2 (a), (b) and (c). Initially, the ceramic heating element 6 and the metallic outer sleeve 8 are mounted on a brazing jig 20 to adjust their relative positions. One end of the electrode fitting 14 is passed through an attachment opening 6b formed in an upper end 6a of the heating element 6. A given quantity of silver brazing filler metal 22 in the form of a coiled wire is placed on the face of the upper end 6a of the ceramic heating element 6 (see Fig. 2(a)), and is then heated to 900°C in hydrogen ambient.

[0008] When heated to 900°C, the silver brazing filler metal 22 on the upper end face 6a of the ceramic heating element 6 melts (see Fig. 2(b)) to flow into interstices between the element 6 and the sleeve 8 and between the opening 6b in the element 6 and the electrode fitting 14, cementing them together (see Fig. 2(c)). When the silver brazing takes place properly to achieve a cementation, no silver brazing filler metal 22 is left on the upper end face 6a of the element 6, but it flows into the interstices in its entirety.

[0009] However, when the silver brazing does not take place properly, if the coiled silver brazing filler metal 22 placed on the upper end face 6a (see Fig. 3a) melts (see Fig. 3b), it does not flow into the interstices between the element 6 and the sleeve 8 and between the opening 6b and the electrode fitting 14, but remains on the upper end face 6a (see Fig. 3c). If the silver brazing filler metal 22 remains on the heating element 6 in this manner, there is a likelihood of causing an electrical short-circuit between the electrode fitting 14 and the metallic outer sleeve 8. The present invention is made to avoid such likelihood.

[0010] EP 0 869 698 discloses a glow plug according to the preamble of claim 1.

Disclosure of Invention

[0011] It is an object of the invention to provide a ceramic heater glow plug which is free from the likelihood of causing an electrical short-circuit between an electrode fitting and a metallic outer sleeve, by choosing optimum conditions which assure that during a silver brazing operation, a molten silver brazing filler metal flows into interstices between the ceramic heater and the metallic outer sleeve and between an attachment opening in the ceramic heater and the electrode fitting. It is, also an object of the invention to provide a method of manufacturing the ceramic heater glow plug mentioned above.

[0012] A ceramic heater glow plug according to the present invention comprises the features of claim 1.

[0013] A method of manufacturing a ceramic heater glow plug according to the invention is defined in Claim 10 or 11.

Brief Description of Drawings

[0014]

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

Figs. 2a, 2b and 2c illustrate steps of assembling a ceramic heater of a ceramic heater glow plug by brazing operations, illustrating a brazing operation which takes place normally;

Figs. 3a, 3b and 3c show steps of assembling a ceramic heater of the ceramic heater glow plug, illustrating an unsuccessful brazing operation;

Fig. 4 is a longitudinal section of an example of a conventional ceramic heater glow plug;

Fig. 5 is a chart showing results of a first confirmation test;

Fig. 6 graphically shows results of the first confirmation test;

Fig. 7 is a chart showing results of a second confirmation test;

Fig. 8 is a chart showing results of a third confirmation test;

Fig. 9 is a chart showing results of a fourth confirmation test; and

Fig. 10 is a chart showing results of a fifth confirmation test.

Best Mode for Carrying Out the Invention

[0015] Referring to the drawings, an embodiment of the invention will now be described. Fig. 1 shows a glow plug for a diesel engine incorporating a ceramic heater according to one embodiment of the invention. The glow plug includes a cylindrical housing 2 having an internal bore 4, which is a stepped axial opening including a portion 4a of a medium diameter located to the left as

viewed in Fig. 1, and representing a region where a ceramic heating element is secured, a portion 4c of a greater diameter located to the right as viewed in Fig. 1 and representing a region where an external connection terminal is later secured, and a portion 4b of a smaller diameter disposed between the portion 4a of a medium diameter and the portion 4c of a greater diameter. In the present embodiment, the portion 4c of a greater diameter has different diameters for an inner portion 4ca and an outer portion 4cb.

[0016] A ceramic heating element 6 is contained inside a metallic outer sleeve 8, both of which are silver brazed together to define a ceramic heater 9, which is inserted into the portion 4a of a medium diameter of the housing 2. Part of the outer peripheral surface of the metallic outer sleeve 8 is secured to the housing 2 by being a press fit therein or by brazing. The metallic outer sleeve 8 has an inner end face 8a, which is positioned by abutment against the step 4d defined between the portion 4a of a medium diameter and the portion 4b of a smaller diameter of the internal bore 4, which is a stepped axial opening.

[0017] An external connection terminal 10 has an insulating member or bushing 12 which is integrally molded with the outer periphery of the terminal 10, and the insulating member 12 is inserted into the portion 4c of a greater diameter of the internal bore 4, or more specifically, into the outer portion 4cb, and is secured therein by caulking an end 2a of the housing. The outer periphery of the external connection terminal 10 is knurled, and an insulating resin is integrally molded therearound to form the insulating bushing 12. The external connection terminal 10 is formed with an axial through-opening 10a in alignment with the axis thereof, and an electrode fitting 14 of the ceramic heating element 6 is passed through the through-opening and has a distal end 14a, which is electrically connected to an outer end face 10b of the external connection terminal, located at the right end, as viewed in Fig. 1, either by brazing or by caulking.

[0018] Assembly steps for the glow plug incorporating the ceramic heater for a diesel engine will now be described with reference to Figs 1, 2a, 2b and 2c. The ceramic heating element 6 has a coiled heating wire 16 embedded therein, which is externally exposed, intermediate the length of the heating element 6, at its one end 16a to be electrically connected to the internal surface of the metallic outer sleeve 8. The other end 16b of the heating wire 16 is exposed within an electrode fitting attachment opening 6b formed in an end face 6a of the ceramic heating element 6, which is a right-hand end face as viewed in Fig. 1 or an upper end face as viewed in Figs. 2a-2c, to be electrically connected to an end 14b of the electrode fitting 14.

[0019] When the ceramic heating element 6, the metallic outer sleeve 8 and the electrode fitting 14 are cemented together to assemble the ceramic heater 9, the ceramic heating element 6 is initially inserted into the metallic outer sleeve 8, and they are mounted in a braz-

ing jig 20 to adjust their relative positions. When the ceramic heating element 6 and the metallic outer sleeve 8 are positioned, a heating area 6c located at the inner end of the ceramic heating element 6 projects outside the metallic outer sleeve while the opposite end 6a or

[0020] One end 14b of the electrode fitting 14 is inserted into the attachment opening 6b which is formed in the upper end 6a of the ceramic heating element 6 and where the end 16b of the coiled heating wire is exposed. Subsequently, a wire-shaped silver brazing filler metal 22 is coiled to exhibit an external diameter substantially comparable to the internal diameter of the metallic outer sleeve 8, and is inserted into the sleeve 8 to be placed on the upper end face 6a of the ceramic heating element 6 (see Fig. 2a). Upon being heated to 900°C in a hydrogen ambient, the silver brazing filler metal 22 melts (see Fig. 2b) to flow into interstices between the outer peripheral surface of the ceramic heating element 6 and the inner peripheral surface of the metallic outer sleeve 8 and between the attachment opening 6b in the upper end face 6a of the ceramic heating element 6 and the external surface of the electrode fitting 14, thus achieving a brazing operation (see Fig. 2c).

[0021] Because the affinity or wettability between the silver brazing filler metal 22 and the ceramic material is very low, there remains no silver brazing filler metal 22 on the upper end face 6a of the ceramic heating element 6. It is to be noted that in the regions where the silver brazing filler metal is applied between the ceramic heating element 6 and the metallic outer sleeve 8 and between the ceramic heating element 6 and the electrode fitting 14, the surfaces of these members are treated to increase the affinity with the silver brazing filler metal 22 in order to facilitate spreading the silver brazing filler metal 22 extensively. At this end, a surface treatment by Ni plating is applied to the metallic outer sleeve 8 and the electrode fitting 14, for example, and a surface treatment which provides an Ni metallization is applied to the surface of the ceramic heating element 6 which is to be brazed, for example. Accordingly, the upper end face 6a of the ceramic heating element 6 which is not subject to a brazing operation is not provided with a surface treatment and thus has a very low level of wettability with respect to the silver brazing filler metal 22.

[0022] As mentioned previously, the ceramic heating element 6 is inserted into the metallic outer sleeve 8, and after the ceramic heating element 6, the metallic outer sleeve 8 and the electrode fitting 14 are secured together by brazing, the distal end 14a of the electrode fitting 14 which is now connected to the ceramic heating element 6 is passed through the axial bore 4 in the housing 2 through an opening thereof which is later used to secure the ceramic heating element or the left opening as viewed in Fig. 1 while one end of the metallic outer sleeve is inserted into the portion 4a of a medium diameter of the housing 2 and is secured in place by brazing

or by being a press fit therein. At this time, the inner end face 8a of the metallic outer sleeve 8 is positioned in abutment against the step 4d defined between the portion 4a of a medium diameter and the portion 4b of a smaller diameter of the internal bore 4. Under the condition that the metallic outer sleeve 8 is secured, the distal end 14a of the electrode fitting 14 extends to the outside of the portion 4c of a greater diameter of the housing 2.

[0023] The insulating bushing 12 and the external connection terminal 10 are inserted into the portion 4c of the housing 2 while allowing the distal end 14a of the electrode fitting 14 to pass through the axial through-opening 10a formed in the external connection terminal 12 which is integral with the insulating bushing 12. Subsequently, the end 2a of the housing 2 is caulked to secure the external connection terminal in place. The electrode fitting 14 is electrically connected to the external connection terminal 10 at an outer end 10b of the external connection terminal as by brazing or by caulking. The ceramic heater glow plug for a diesel engine which is shown in Fig. 1 is assembled in this manner.

[0024] When the ceramic heating element 6 and the metallic outer sleeve 8 are cemented together by a brazing operation as are the ceramic heating element 6 and the electrode fitting 14, if the brazing operation takes place normally, the molten silver brazing filler metal 22 flows, in its entirety, into interstices between the inner peripheral surface of the metallic outer sleeve 8 and the outer peripheral surface of the ceramic heating element 6 and between the inner surface of the attachment opening 6b formed in the end face 6a of the ceramic heating element 6 and the external surface of the electrode fitting 14, and therefore there remains no silver brazing filler metal 22 on the upper end face 6a of the ceramic heating element 6. Accordingly, there cannot occur an electrical short-circuit between the metallic outer sleeve 8 and the electrode fitting 14.

[0025] A mechanism which allows the silver brazing filler metal 22 to flow into the interstices between the ceramic heating element 6 on one hand and the metallic outer sleeve 8 and the electrode fitting 14 on the other hand during the brazing operation will now be briefly considered. The affinity between the liquid and the solid surface is generally referred to as wettability. When the wettability or the affinity is high, the liquid tends to spread extensively along the solid surface while when the wettability or the affinity is low, the liquid tends to agglomerate at a single point on the solid surface to assume a spherical configuration. The molten silver brazing filler metal 22 has a very low wettability with respect to the ceramics and has a high wettability with respect to a surface of Ni (nickel), Ti containing Ni, Cu, Ag alloy or glass.

[0026] Accordingly, when the molten silver brazing filler metal 22 is located on the upper end face 6a of the ceramic heating element 6 in an annular space between the inner periphery of the metallic outer sleeve 8 and the

outer periphery of the electrode fitting 14, the capillary action of the clearance formed between the inner peripheral surface of the metallic outer sleeve 8 and the outer peripheral surface of the ceramic heating element 6 is combined with an absorbing power created by the wettability between the silver brazing filler metal 22 and the Ni which is applied by the surface treatment of the outer peripheral surface of the ceramic heating element 6 and the inner peripheral surface of the metallic outer sleeve 8 to exert an influence upon the silver brazing filler metal 22 to pull it into the clearance. On the other hand, the wettability of the silver brazing filler metal 22 with the entire surface which is contacted by the silver brazing filler metal 22 inclusive of the inner peripheral surface of the metallic outer sleeve 8 located above the upper end face 6a of the ceramic heating element 6 and contacted by the molten silver brazing filler metal 22, the outer peripheral surface of the electrode fitting 14 and the upper end face 6a of the ceramic heating element 6 produces a force which tends to maintain the molten silver brazing filler metal 22 on the ceramic heating element 6. If the sum of the force of the capillary action combined with the absorbing power is greater than the force produced by the wettability which tends to maintain the molten silver brazing filler metal on the ceramic heating element, the silver brazing filler metal 22 can be withdrawn into the clearance.

[0027] It will be seen that the silver brazing filler metal 22 in molten condition which is located on the upper end face 6a of the ceramic heating element 6 includes a fraction which is in contact with the ceramic having a low wettability and another fraction which is in contact with the metallic outer sleeve 8 and the electrode fitting 14 which are Ni plated and have a high wettability. The higher the proportion of an area of contact with the ceramic having a low wettability, the lower the resulting overall wettability. In this instance, the molten silver brazing filler metal 22 is withdrawn into the clearance between the ceramic heating element 6 and the metallic outer sleeve 8, and there remains no silver brazing filler metal 22 on the end face 6a of the ceramic heating element 6. However, as the proportion of the area of contact with the ceramic is reduced, the overall wettability increases, and accordingly, the molten silver brazing filler metal 22 is not withdrawn into the clearance, but remains on the end face 6a of the ceramic heating element.

[0028] As mentioned above, if the brazing operation takes place normally, there remains no silver brazing filler metal 22 on the upper end face 6a of the ceramic heating element 6 between the metallic outer sleeve 8 and the electrode fitting 14, and thus there cannot occur an electrical short-circuit between the metallic outer sleeve 8 and the electrode fitting 14. However, there is an instance that the silver brazing filler metal 22 placed on the upper end face 6a of the ceramic heating element 6 as shown in Figs. 3a-3c cannot flow into the clearance after it melts, as shown in Fig. 3b, thus remaining on the

end face 6a (see Fig. 3c). If the silver brazing filler metal 22 remains on the ceramic heating element 6 located between the electrode fitting 14 and the metallic outer sleeve 8, an electrical short-circuit between the electrode fitting 14 and the metallic outer sleeve 8 is likely to occur.

[0029] In consideration of the mechanism by which the molten silver brazing filler metal 22 on the end face 6a of the ceramic heating element 6 is withdrawn into the clearance between the ceramic heating element 6 and the metallic outer sleeve 8, the present inventors have conducted tests to confirm boundary conditions between a normal brazing operation in which no silver brazing filler metal 22 remains on the end face 6a of the ceramic heating element 6 and an unsuccessful brazing operation.

[0030] To choose parameters used during these tests, both factors relating to the affinity or the wettability and the capillary action and factors relating to the brazing operation have been considered.

[0031] Factors relating to the wettability and the capillary action are listed below.

1. Surface treatment applied to a region which is to be brazed:

The surface of the member in the region where it is silver brazed is treated to increase the wettability or affinity with the silver brazing filler metal 22. For example, it may be formed of Ni or Ni alloy. The surface is Ni plated, the surface is metallized by Ni, Ti containing Ni, Cu or Ag alloy or the surface is formed with a glass film to increase the wettability or affinity with the silver brazing filler metal 22.

2. Clearance between the outer peripheral surface of the ceramic heating element 6 and the inner peripheral surface of the metallic outer sleeve 8:

The force created by the capillary action increases as the clearance is reduced.

3. Area of the end face 6a of the ceramic heating element 6 or the area between the internal diameter of the metallic outer sleeve 8 and the external diameter of the electrode fitting 14:

As the proportion of the area of contact with the ceramic having a reduced wettability with the silver brazing filler metal 22 increases, the overall wettability is reduced. On the contrary when the proportion of the area of contact is reduced, the overall wettability increases.

4. Material of silver brazing filler metal 22:

For the ceramic heater 9 which is used within

the glow plug, the silver brazing filler metal may melt during the time the glow plug produces heat if the brazing temperature is equal to or below 900°C. Accordingly, it is necessary that the brazing temperature be at least equal to 900°C or higher. For this reason, the silver brazing filler metal 22 is limited to one having a silver content which is equal to or greater than 70% such as BAg-8 which has a silver content from 71 to 73%.

[0032] Factors relating to the brazing operation are listed below.

1. Quantity of silver brazing filler metal 22:

A minimum quantity of the silver brazing filler metal 22 is determined from the need to achieve a successful brazing operation in a region which is to be brazed. However, it is necessary to confirm an influence which could result when a quantity in excess of the minimum quantity is used.

2. Runs of brazing operation:

It is necessary to confirm what differences appear between the brazing operation in a single run, namely, in which the brazing between the ceramic heating element 6 and the metallic outer sleeve 8 and the brazing between the ceramic heating element 6 and the electrode fitting 14 take place in one step, and the brazing operation in two runs, namely, in which the electrode fitting 14 is initially brazed to the ceramic heating element 6 and then the ceramic heating element 6 is inserted into the metallic outer sleeve to be brazed therewith.

[0033] A number of confirmation tests have been conducted to consider the various factors mentioned above. In a first confirmation test, the influence of the area of the upper end face 6a of the ceramic heating element 6 is considered.

[0034] Test specimens includes the metallic outer sleeve 8 which is formed of stainless steel SUS430 with its surface Ni plated to a thickness on the order of 10 μ , the electrode fitting 14 which is formed of soft steel wire material with its surface Ni plated to a thickness on the order of 10 μ , and the ceramic heating element 6 which is formed of silicon nitride ceramics with a surface treatment being applied to the inner surface of the electrode fitting attachment opening 6b and a surface portion which is to be brazed to the internal surface of the metallic outer sleeve 8. The surface treatment comprises applying an Ni paste to the surface portion to be brazed, followed by metallizing or baking it at a temperature of 950°C to metallize the metal component (Ni) in the

paste. The silver brazing filler metal 22 comprises BAg-8 in the form of a wire weighing 0.3 gr. The quantity of the silver brazing filler metal 22 is determined in a manner such that when the brazing length between the ceramic heating element 6 and the metallic outer sleeve 8 is 30 mm, the quantity which is required to fill the resulting clearance is incremented by 10%.

[0035] Sizes for the test specimens are such that for the metallic outer sleeve 8, 15 values have been chosen for the internal diameter in a range from $\phi 2.0$ to 4.8 mm in increment of 0.2 mm, and ten values have been chosen for the external diameter of the electrode fitting 14 in a range from $\phi 0.4$ to 2.5 mm, namely, $\phi 0.4$ mm, 0.5 mm, 0.6 mm, 0.8 mm, 1.0 mm, 1.2 mm, 1.5 mm, 1.8 mm, 2.0 mm and 2.5 mm. The clearance between the internal diameter of the metallic outer sleeve 8 and the external diameter of the ceramic heating element 6 measures 75 μ on one side. The brazing length between the metallic outer sleeve 8 and the ceramic heating element 6 is equal to 30 mm.

[0036] Above specimens are sequentially combined to change the area of the upper end face of the ceramic heating element 6 which is contacted by the silver brazing filler metal 22 to perform a brazing operation, and a confirmation is made to see if an electrical short-circuit occurred between the metallic outer sleeve 8 and the electrode fitting 14.

[0037] The test procedure comprises choosing a combination of the specimens, namely, the ceramic heating element 6, the metallic outer sleeve 8 and the electrode fitting 14, disposing them on the brazing jig 20 in the manner illustrated in Fig. 2, placing the silver brazing filler metal 22, heating the assembly to 900°C and leaving it in a hydrogen ambient for 30 minutes to perform a brazing operation. In this manner, the brazing operation takes place in a single step. Subsequently, the occurrence of an electrical short-circuit between the metallic outer sleeve 8 and the electrode fitting 14 is examined.

[0038] Test results are shown in Figs 5 and 6. Fig. 5 is a chart indicating the occurrence of an electrical short-circuit between the metallic outer sleeve 8 and the electrode fitting 14 after the brazing operation and any residue of the silver brazing filler metal 22 on the upper end face 6a of the ceramic heating element after the brazing operation for various combinations of the metallic outer sleeve 8 and the electrode fitting 14. Fig. 6 is a graphical illustration of the test results. In these Figures, a circle indicates the absence of a short-circuit and no residue of the silver brazing filler metal 22 while X indicates the occurrence of a short-circuit and a residue of the silver brazing filler metal 22.

[0039] Results shown in Figs 5 and 6 can be summarized as follows:

[0040] For the internal diameter (X) of the metallic outer sleeve which is in the range from $\phi 2.0$ mm to $\phi 4.8$ mm and the external diameter (Y) of the electrode fitting 14 in the range from $\phi 0.5$ mm to $\phi 2.5$ mm, it is confirmed

that if the difference between the internal diameter of the metallic outer sleeve 8 and the external diameter of the electrode fitting 14 (X-Y) has a value which is equal to or greater than 1.5 mm, there remains no silver brazing filler metal 22 on the upper end face 6a of the ceramic heating element 6 after the brazing operation, and no short-circuit occurs between the electrode fitting 14 and the metallic outer sleeve 8. Conversely, for the difference (X-Y) which is less than 1.5 mm, there is a residue of silver brazing filler metal 22 on the upper end face 6a of the ceramic heating element 6, and the electrode fitting 14 is short-circuited to the metallic outer sleeve 8.

[0041] Analyzing the test results, it is considered that for a difference (X-Y) between the internal diameter of the metallic outer sleeve 8 and the external diameter of the electrode fitting 14 which is less than 1.5 mm, the proportion of the area of contact with the ceramic having a very low affinity or wettability is reduced among the total area of contact of the molten silver brazing filler metal 22 disposed on the upper end face 6a of the ceramic heating element 6 with the ceramic heating element 6, the metallic outer sleeve 8 and the electrode fitting 14, whereby the overall wettability increases. As a consequence, the high wettability produces a force which tends to maintain the silver brazing filler metal 22 in position, overcoming the effect of the capillary action or the absorbing power produced by the wettability which tends to withdraw the silver brazing filler metal into the clearance between the ceramic heating element 6 and the metallic outer sleeve 8, preventing the molten silver brazing filler metal 22 from being withdrawn into the clearance and thus allowing it to remain on the upper end face 6a.

[0042] When the difference (X-Y) between the internal diameter of the metallic outer sleeve 8 and the external diameter of the electrode fitting 14 is equal to or greater than 1.5 mm, the area of contact of the ceramic heating element 6 with the silver brazing filler metal 22 occupies a greater proportion among the total area of contact, thus reducing the overall wettability. As a consequence, the absorbing power which tends to withdraw the silver brazing filler metal into the clearance overcomes the effect of the wettability, withdrawing the molten silver brazing filler metal 22 into the clearance and preventing it from remaining on the upper end face 6a of the ceramic heating element 6.

[0043] A second confirmation test is made to see the influence of the surface treatment applied to the metallic outer sleeve 8 and the ceramic heating element 6.

[0044] Test specimens for the second confirmation test comprises the metallic outer sleeves 8 including samples subject to the same surface treatment by Ni plating as mentioned above in connection with the first confirmation test and samples (of stainless steel SUS430) without the surface treatment, and the ceramic heating elements 6 including samples which are metallized with the same Ni paste as used in the first confir-

mation test and samples formed with glass films. It is to be understood that when a glass film is provided, no surface treatment is applied to an area of the upper end face 6a of the ceramic heating element 6 which is not subject to a brazing operation. No film is formed on the area which passes the current flow.

[0045] Sizes for the test specimens are an internal diameter of ϕ 2.6 mm for the metallic outer sleeve and four external diameters of ϕ 0.8 mm, 1.0 mm, 1.2 mm and 1.5 mm for the electrode fitting 14. These test specimens are tested in the same manner as in the first confirmation test.

[0046] Results of the second confirmation test are shown in Fig. 7. As indicated, no difference over results of the first confirmation test is recognized depending on the presence or absence or the variety of the surface treatment applied to the test specimens. It is seen that a change in the surface treatment according to the second confirmation test does not have any influence upon the results obtained in the first confirmation test, and when the difference (X-Y) between the internal diameter of the metallic outer sleeve 8 and the electrode fitting 14 is equal to or greater than 1.5 mm, there remains no silver brazing filler metal 22 on the upper end face 6a of the ceramic heating element 6 after the brazing operation, and accordingly, without causing any short-circuit between the electrode fitting 14 and the metallic outer sleeve 8.

[0047] When no surface treatment is applied to the metallic outer sleeve 8, its wettability with the silver brazing filler metal 22 is reduced, but a reduction in the wettability caused by the absence of the surface treatment does not have a manifest influence. With respect to the surface treatment of the ceramic heating element 6, providing a glass film thereon results in no difference as compared with the metallization of Ni paste. Obviously when no surface treatment is applied to an area of the ceramic heating element 6 which is to be silver brazed, the wettability is greatly reduced. Accordingly, no test has been conducted inasmuch as there can be no flow of the silver brazing filler metal 22 into the clearance between the metallic outer sleeve 8 and the ceramic heating element 6 under such circumstance.

[0048] A third confirmation test has been conducted to see the influence of the material and the quantity of the silver brazing filler metal 22. The test specimens for the third confirmation test comprises the same as the specimens used in the first confirmation test. To provide different test specimens, BAg-8 and a silver brazing filler metal having a silver content from 95 to 97 % are used for the silver brazing filler metal 22. The quantity of the silver brazing filler metal 22 is in two varieties of 0.5 gr and 0.8 gr, both of which are greater than the quantity used in the first confirmation test.

[0049] The testing procedure remains the same as in the first confirmation test. When the silver brazing filler metal 22 having a silver content from 95 to 97 % is used, the brazing temperature is chosen to be 950°C.

[0050] Test result of the third confirmation test are shown in Fig. 8. As indicated, no difference over the results obtained in the first confirmation test is found depending on the material and the quantity of the silver brazing filler metal 22, and thus, the test results indicate that there is no influence upon the results obtained in the first confirmation test. Considering the results of the third confirmation test, it is considered that if the quantity of the silver brazing filler metal 22 is chosen to be in excess of that which is required to fill the clearance between the ceramic heating element 6 and the metallic outer sleeve 8, as the molten silver brazing filler metal 22 begins to flow into the clearance, an excess amount of the silver brazing filler metal 22 flows out of the lower opening of the clearance. Thus, an increase in the quantity of the silver brazing filler metal 22 used has no influence upon the results. It will be understood that the fraction of the silver brazing filler metal 22 which has flown downward of the clearance rises through the clearance between the outer peripheral surface of the metallic outer sleeve 8 and the brazing jig 20 by capillary action to be attached to the outer peripheral surface of the metallic outer sleeve 8. Because the ceramic heating element 6 and the brazing jig 20 has a low wettability with the silver brazing filler metal 22, the silver brazing filler metal 22 is attached to the outer peripheral surface of the metallic outer sleeve 8.

[0051] A fourth confirmation test is made to see an influence of the size of the clearance between the ceramic heating element 6 and the metallic outer sleeve 8. The test specimens for the fourth confirmation test comprises the same specimens as used in the first confirmation test. To provide different specimens, the internal diameter of the metallic outer sleeve 8 is chosen to be ϕ 2.6 mm, and the clearance (on one side) between the internal surface of the metallic outer sleeve 8 and the external surface of the ceramic heating element 6 is chosen to be 50 μ and 100 μ , which represent a clearance less than and greater than the clearance used in the first confirmation test (75 μ). The testing procedure remains the same as in the first confirmation test.

[0052] Results of the fourth confirmation test are shown in Fig. 9. As indicated, no difference over the results obtained by the first confirmation test is found if the size of the clearance between the metallic outer sleeve 8 and the ceramic heating element 6 is changed, and thus the test results indicate that there is no influence upon the results obtained in the first confirmation test. This is considered to be attributable to the fact that the clearance in a range (50 μ to 100 μ) used in the fourth confirmation test does not cause any significant change in the force produced by the capillary action, and accordingly has no influence upon the results of the first confirmation test.

[0053] Finally, a fifth confirmation test is made to see the influence of performing the brazing operation in one run or two runs. Test specimens for the fifth confirmation test comprises the same specimens as used in the first

confirmation test. The metallic outer sleeve 8 has an internal diameter ϕ 2.6 mm. The testing procedure comprises the same procedure as used during the first confirmation test when the brazing operation takes place in one run, and when the brazing operation takes place in two runs, the distal end of the electrode fitting 14 is initially inserted into the electrode fitting attachment opening 6b formed in the end face of the ceramic heating element 6 to perform a brazing operation, and then the metallic outer sleeve 8 and the ceramic heating element 6 are then loaded on the brazing jig 20 to perform a brazing operation in the similar manner as conducted during the first confirmation test.

[0054] Test results of the fifth confirmation test are shown in Fig. 10. As indicated, no difference is noted between the one run and the two run brazing operation, and thus the test results indicate that there is no influence upon the results obtained during the first confirmation test.

During the two run brazing operation, if the electrode fitting 14 is initially brazed to the ceramic heating element 16, the amount of the silver brazing filler metal 22 required to braze the electrode fitting 14 represents a reduced proportion with respect to the total quantity of the silver brazing filler metal 22 required, and it is considered that this explains why no influence appeared by the two run brazing operation.

[0055] To summarize the results of the five confirmation tests, it is concluded that when the metallic outer sleeve has an internal diameter (X) in a range from ϕ 2.0 mm to ϕ 4.8 mm, the electrode fitting 14 has an external diameter (Y) in a range from ϕ 0.4 mm to ϕ 2.5 mm, and the difference (X-Y) between the internal diameter (X) of the metallic outer sleeve 8 and the external diameter (Y) of the electrode fitting 14 is equal to or greater than 1.5 mm, there remains no silver brazing filler metal on the upper end face 6a of the ceramic heating element 6 and no electrical short-circuit occurs between the electrode fitting 14 and the metallic outer sleeve 8 upon completion of the brazing operation.

[0056] When the metallic outer sleeve 8 comprises stainless steel SUS430 with Ni plating or stainless steel SUS430 without surface treatment and the surface treatment of the ceramic heating element 6 is such that it is applied with an Ni paste which is subsequently metallized or it is provided with a glass film, it is concluded that the presence or absence of the surface treatment or a change in the surface treatment does not influence the test result obtained when the difference (X-Y) between the internal diameter (X) of the metallic outer sleeve and the external diameter (Y) of the electrode fitting 14 is equal to or greater than 1.5 mm. Because there is no influence upon the test results, if the metallic outer sleeve 8 is left without a surface treatment, it is seen that it is sufficient for the purpose of the present invention that a wettability or the affinity comparable to that of the stainless steel can be secured. The same is true when the silver brazing filler metal 22 has a silver

content equal to or greater than 70 % and when the clearance between the outer peripheral surface of the ceramic heating element 6 and the inner peripheral surface of the metallic outer sleeve 8 is chosen in a range from 50 to 100 μ .

[0057] As discussed above, a ceramic heater glow plug according to the present invention comprises a ceramic heater including a ceramic heating element, an end of which is silver brazed to an electrode fitting and which is also silver brazed to a metallic outer sleeve under a condition that the end of the ceramic heating element brazed to the electrode fitting is contained inside the sleeve, with an internal diameter X of the metallic outer sleeve and an external diameter Y of the electrode fitting being chosen to satisfy the relationship $X-Y \geq 1.5$ mm. In this manner, any residue of silver brazing filler metal on the end face of the ceramic heating element between the metallic outer sleeve and the electrode fitting after the silver brazing operation is avoided, and the occurrence of an electrical short-circuit between the metallic outer sleeve and the electrode fitting is also avoided.

[0058] A method of manufacturing a ceramic heater glow plug according to Claim 10 employs a single run of the brazing operation to cement the ceramic heating element and the electrode fitting together and to cement the ceramic heating element and the metallic outer sleeve together, thus allowing a brazing operation of a high quality to be completed in one step to enable a substantial cost reduction.

Claims

1. A ceramic heater glow plug comprising a ceramic heater including a ceramic heating element (6), an electrode fitting (14) connected to the ceramic heating element within an end thereof, and a metallic outer sleeve (8) secured to the ceramic heating element (6) under a condition that the end of the ceramic heating element (6) connected to the electrode fitting (14) is contained inside the metallic outer sleeve (8), the ceramic heating element (6) and the electrode fitting (14) as well as the ceramic heating element (6) and the metallic outer sleeve (8) being cemented together by brazing operations,

characterized by the relationship of $Y \leq X - 1.5$ mm, where X represents an internal diameter of the metallic outer sleeve (8) and Y an external diameter of the electrode fitting (14).

2. A ceramic heater glow plug according to Claim 1, in which the internal diameter X of the metallic outer sleeve (8) and the external diameter Y of the electrode fitting (14) satisfies the relationships of $\varnothing 2.5$ mm $\geq Y \geq \varnothing 0.4$ mm, and $\varnothing 4.8$ mm $\geq X \geq \varnothing 2.0$ mm.

3. A ceramic heater glow plug according to Claim 1 or

2, in which the metallic outer sleeve (8) and the electrode fitting (14) are formed of materials having a high affinity with a silver brazing filler metal (22) or are treated to increase the affinity with the silver brazing filler metal (22) in a region where they are brazed to the ceramic heating element (6).

4. A ceramic heater glow plug according to Claim 3, in which the metallic outer sleeve (8) comprises Ni alloy or is surface treated by an Ni plating.

5. A ceramic heater glow plug according to Claim 3, in which the electrode fitting (14) is formed of an Ni wire or is surface treated by an Ni plating.

6. A ceramic heater glow plug according to one of Claims 1 to 5, in which the ceramic heating element (6) comprises a silicon nitride ceramic and is treated to increase the affinity with the silver brazing filler metal (22) in regions where it is to be brazed to the metallic outer sleeve (8) and the electrode fitting (14).

7. A ceramic heater glow plug according to Claim 6, in which a region of the ceramic heating element (6) which is to be brazed is metallized by Ni.

8. A ceramic heater glow plug according to one of Claims 1 to 7, in which the silver brazing filler metal (22) comprises a wire material having a silver content equal to or greater than 70%.

9. A ceramic heater glow plug according to one of Claims 1 to 8, in which the clearance between the external surface of the ceramic heating element (6) and the internal surface of the metallic outer sleeve (8) is in a range from 50 to 100 μ .

10. A method of manufacturing a ceramic heater glow plug, comprising the step of providing a ceramic heater including a ceramic heating element (6), an electrode fitting (14) connected to the ceramic heating element (6) within an end thereof, and a metallic outer sleeve (8) secured to the ceramic heating element (6) under a condition that the end of the ceramic heating element (6) connected to the electrode fitting (14) is contained inside the metallic outer sleeve (8), the ceramic heating element (6) and the electrode fitting (14) as well as the ceramic heating element (6) and the metallic outer sleeve (8) being cemented together by brazing operations,

characterized by the relationship of $Y \leq X - 1.5$ mm, where X represents an internal diameter of the metallic outer sleeve (8) and Y an external diameter of the electrode fitting (14),

wherein the ceramic heating element (6) and the electrode fitting (14) as well as the ceramic heating element (6) and the metallic outer sleeve (8) are

cemented together in one run brazing operation.

11. A method of manufacturing a ceramic heater glow plug, comprising the step of providing a ceramic heater including a ceramic heating element (6), an electrode fitting (14) connected to the ceramic heating element (6) within an end thereof, and a metallic outer sleeve (8) secured to the ceramic heating element (6) under a condition that the end of the ceramic heating element (6) connected to the electrode fitting (14) is contained inside the metallic outer sleeve (8), the ceramic heating element (6) and the electrode fitting (14) as well as the ceramic heating element (6) and the metallic outer sleeve (8) being cemented together by brazing operations,

characterized by the relationship of $Y \leq X - 1.5$ mm, where X represents an internal diameter of the metallic outer sleeve (8) and Y an external diameter of the electrode fitting (14),

wherein the ceramic heating element (6) and the electrode fitting (14) are cemented together by a silver brazing operation, followed by cementing the ceramic heating element (6) and the metallic outer sleeve (8) by a silver brazing operation.

Patentansprüche

1. Keramikheizer-Glühkerze mit einem Keramikheizer einschließlich eines keramischen Heizelements (6), einem mit dem keramischen Heizelement innerhalb eines Endes dieses keramischen Heizelements verbundenen Elektrodenpassstück (14) sowie einer metallischen äußeren Hülse (8), die an dem keramischen Heizelement (6) unter der Bedingung gesichert ist, dass das Ende des keramischen Heizelements (6), welches mit dem Elektrodenpassstück (14) verbunden ist, sich innerhalb der metallischen äußeren Hülse (8) befindet, wobei das keramische Heizelement (6) und das Elektrodenpassstück (14) sowie das keramische Heizelement (6) und die metallische äußere Hülse (8) durch Lötvorgänge zusammenzementiert sind,

gekennzeichnet durch die Beziehung $Y \leq X - 1,5$ mm, wobei X für einen Innendurchmesser der metallischen äußeren Hülse (8) steht und Y für einen Außendurchmesser des Elektrodenpassstücks (14).

2. Keramikheizer-Glühkerze nach Anspruch 1, bei welcher der Innendurchmesser X der metallischen äußeren Hülse (8) und der Außendurchmesser Y des Elektrodenpassstücks (14) die Beziehungen $\varnothing 2,5 \text{ mm} \geq \varnothing 0,4 \text{ mm}$ sowie $\varnothing 4.8 \text{ mm} \geq \varnothing 2,0 \text{ mm}$ erfüllen.
3. Keramikheizer-Glühkerze nach Anspruch 1 oder 2, bei welcher die metallische äußere Hülse (8) und

das Elektrodenpassstück (14) aus Materialien mit einer hohen Affinität zu einem Silberlötfüllmetall (22) ausgebildet sind oder so behandelt sind, dass ihre Affinität zu diesem Silberlötfüllmetall (22) erhöht ist, und zwar in einem Bereich, wo sie mit dem keramischen Heizelement (6) verlötet sind.

4. Keramikheizer-Glühkerze nach Anspruch 3, bei welcher die metallische äußere Hülse (8) eine Nickellegierung aufweist oder ihre Oberfläche mit einer Nickelbeschichtung behandelt ist.

5. Keramikheizer-Glühkerze nach Anspruch 3, bei welcher das Elektrodenpassstück (14) aus einem Nickeldraht gebildet ist oder seine Oberfläche mit einer Nickelbeschichtung behandelt ist.

6. Keramikheizer-Glühkerze nach einem der Ansprüche 1 bis 5, bei welcher das keramische Heizelement (6) eine Siliziumnitritkeramik aufweist und so behandelt ist, dass seine Affinität zu dem Silberlötfüllmetall (22) in Bereichen erhöht ist, wo es mit der metallischen äußeren Hülse (8) und dem Elektrodenpassstück (14) zu verlöten ist.

7. Keramikheizer-Glühkerze nach Anspruch 6, bei welcher ein Bereich des keramischen Heizelements (6), welcher zu verlöten ist, mit Nickel metallisiert ist.

8. Keramikheizer-Glühkerze nach einem der Ansprüche 1 bis 7, bei welcher das Silberlötfüllmetall (22) ein Drahtmaterial mit einem Silberanteil von zumindest 70% aufweist.

9. Keramikheizer-Glühkerze nach einem der Ansprüche 1 bis 8, bei welcher der Zwischenraum zwischen der Außenfläche des keramischen Heizelements (6) und der Innenfläche der metallischen äußeren Hülse (8) in einem Bereich von 50 bis 100 μ liegt.

10. Verfahren zur Herstellung einer Keramikheizer-Glühkerze, bei welchem ein keramischer Heizer vorgesehen wird einschließlich eines keramischen Heizelements (6), einem mit dem keramischen Heizelement innerhalb eines Endes dieses keramischen Heizelements verbundenen Elektrodenpassstück (14) sowie einer metallischen äußeren Hülse (8), die an dem keramischen Heizelement (6) unter der Bedingung gesichert ist, dass das Ende des keramischen Heizelements (6), welches mit dem Elektrodenpassstück (14) verbunden ist, sich innerhalb der metallischen äußeren Hülse (8) befindet, wobei das keramische Heizelement (6) und das Elektrodenpassstück (14) sowie das keramische Heizelement (6) und die metallische äußere Hülse (8) durch Lötvorgänge zusammenzementiert sind,

gekennzeichnet durch die Beziehung $Y \leq X - 1,5$ mm, wobei X einen Innendurchmesser der metallischen äußeren Hülse (8) darstellt und Y einen Außendurchmesser des Elektrodenpassstücks (14),

wobei das keramische Heizelement (6) und das Elektrodenpassstück (14) sowie das keramische Heizelement (6) und die metallische äußere Hülse (8) in einem einzigen Durchlauf eines Lötvorgangs zusammenzementiert werden.

11. Verfahren zur Herstellung einer Keramikheizer-Glühkerze, bei welchem ein keramischer Heizer vorgesehen wird einschließlich eines keramischen Heizelements (6), einem mit dem keramischen Heizelement innerhalb eines Endes dieses keramischen Heizelements verbundenen Elektrodenpassstück (14) sowie einer metallischen äußeren Hülse (8), die an dem keramischen Heizelement (6) unter der Bedingung gesichert ist, dass das Ende des keramischen Heizelements (6), welches mit dem Elektrodenpassstück (14) verbunden ist, sich innerhalb der metallischen äußeren Hülse (8) befindet, wobei das keramische Heizelement (6) und das Elektrodenpassstück (14) sowie das keramische Heizelement (6) und die metallische äußere Hülse (8) durch Lötvorgänge zusammenzementiert sind,

gekennzeichnet durch die Beziehung $Y \leq X - 1,5$ mm, wobei X einen Innendurchmesser der metallischen äußeren Hülse (8) darstellt und Y einen Außendurchmesser des Elektrodenpassstücks (14),

wobei das keramische Heizelement (6) und das Elektrodenpassstück (14) mittels eines Silberlötvorgangs zusammenzementiert werden, gefolgt von dem Zusammenzementieren des keramischen Heizelements (6) und der metallischen äußeren Hülse (8) mittels eines Silberlötvorgangs.

Revendications

1. Bougie de préchauffage à élément de chauffage en céramique comprenant un élément de chauffage en céramique incluant un élément chauffant en céramique (6), un raccord d'électrode (14) relié à l'élément chauffant en céramique dans une extrémité de celui-ci, et un manchon extérieur métallique (8) fixé à l'élément chauffant en céramique (6) dans un état dans lequel l'extrémité de l'élément chauffant en céramique (6) reliée au raccord d'électrode (14) est contenue à l'intérieur du manchon extérieur métallique (8), l'élément chauffant en céramique (6) et le raccord d'électrode (14) de même que l'élément chauffant en céramique (6) et le manchon extérieur métallique (8) étant scellés par des opérations de brasage,

caractérisée par la relation $Y \leq X - 1,5$ mm,

où X représente un diamètre interne du manchon extérieur métallique (8) et Y représente un diamètre externe du raccord d'électrode (14).

2. Bougie de préchauffage à élément de chauffage en céramique selon la revendication 1, dans laquelle le diamètre interne X du manchon extérieur métallique (8) et le diamètre externe Y du raccord d'électrode (14) satisfont la relation de $\varnothing 2,5 \text{ mm} \geq Y \geq \varnothing 0,4 \text{ mm}$, et $\varnothing 4,8 \text{ mm} \geq X \geq \varnothing 2,0 \text{ mm}$.
3. Bougie de préchauffage à élément de chauffage en céramique selon la revendication 1 ou 2, dans laquelle le manchon extérieur métallique (8) et le raccord d'électrode (14) sont formés à partir de matériaux ayant une haute affinité avec un métal d'apport pour brasage à l'argent (22) ou sont traités pour augmenter l'affinité avec le métal d'apport pour brasage à l'argent (22) dans une région où ils sont brasés à l'élément chauffant en céramique (6).
4. Bougie de préchauffage à élément de chauffage en céramique selon la revendication 3, dans laquelle le manchon extérieur métallique (8) comprend un alliage de Ni ou est traité en surface par un placage au Ni.
5. Bougie de préchauffage à élément de chauffage en céramique selon la revendication 3, dans laquelle le raccord d'électrode (14) est formé d'un fil de Ni ou est traité en surface par un placage au Ni.
6. Bougie de préchauffage à élément de chauffage en céramique selon l'une des revendications 1 à 5, dans laquelle l'élément chauffant en céramique (6) comprend une céramique de nitrure de silicium et est traité pour l'augmentation de l'affinité avec le métal d'apport pour brasage à l'argent (22) dans des régions où il doit être brasé au manchon extérieur métallique (8) et au raccord d'électrode (14).
7. Bougie de préchauffage à élément de chauffage en céramique selon la revendication 6, dans laquelle une région de l'élément chauffant en céramique (6) qui doit être brasée est métallisée par du Ni.
8. Bougie de préchauffage à élément de chauffage en céramique selon l'une des revendications 1 à 7, dans laquelle le métal d'apport pour brasage à l'argent (22) comprend un matériau de fil ayant une teneur en argent supérieure ou égale à 70 %.
9. Bougie de préchauffage à élément de chauffage en céramique selon l'une des revendications 1 à 8, dans laquelle l'espace entre la surface externe de l'élément chauffant en céramique (6) et la surface interne du manchon extérieur métallique (8) se situe dans la plage de 50 à 100 μ .

10. Procédé de fabrication d'une bougie de préchauffage à élément de chauffage en céramique, comprenant l'étape consistant à fournir un élément de chauffage en céramique comprenant un élément chauffant en céramique (6), un raccord d'électrode (14) relié à l'élément chauffant en céramique (6) à l'intérieur d'une extrémité de celui-ci, et un manchon extérieur métallique (8) fixé à l'élément chauffant en céramique (6) dans un état où l'extrémité de l'élément chauffant en céramique (6) reliée au raccord d'électrode (14) est contenue à l'intérieur du manchon extérieur métallique (8), l'élément chauffant en céramique (6) et le raccord d'électrode (14) de même que l'élément chauffant en céramique (6) et le manchon extérieur métallique (8) étant scellés par des opérations de brasage,

caractérisé par la relation $Y \leq X - 1,5 \text{ mm}$, où X représente un diamètre interne du manchon extérieur métallique (8) et Y représente un diamètre externe du raccord d'électrode (14),

où l'élément chauffant en céramique (6) et le raccord d'électrode (14) de même que l'élément chauffant en céramique (6) et le manchon extérieur métallique (8) sont scellés par une opération de brasage en une passe.

11. Procédé de fabrication d'une bougie de préchauffage à élément de chauffage en céramique, comprenant l'étape consistant à fournir un élément de chauffage en céramique comprenant un élément chauffant en céramique (6), un raccord d'électrode (14) relié à l'élément chauffant en céramique (6) à l'intérieur d'une extrémité de celui-ci, et un manchon extérieur métallique (8) fixé à l'élément chauffant en céramique (6) dans un état où l'extrémité de l'élément chauffant en céramique (6) reliée au raccord d'électrode (14) est contenue à l'intérieur du manchon extérieur métallique (8), l'élément chauffant en céramique (6) et le raccord d'électrode (14) de même que l'élément chauffant en céramique (6) et le manchon extérieur métallique (8) étant scellés par des opérations de brasage,

caractérisé par la relation $Y \leq X - 1,5 \text{ mm}$, où X représente un diamètre interne du manchon extérieur métallique (8) et Y représente un diamètre externe du raccord d'électrode (14),

où l'élément chauffant en céramique (6) et le raccord d'électrode (14) sont scellés par une opération de brasage à l'argent, suivie par un scellement de l'élément chauffant en céramique (6) et du manchon extérieur métallique (8) par une opération de brasage à l'argent.

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FIG. 1

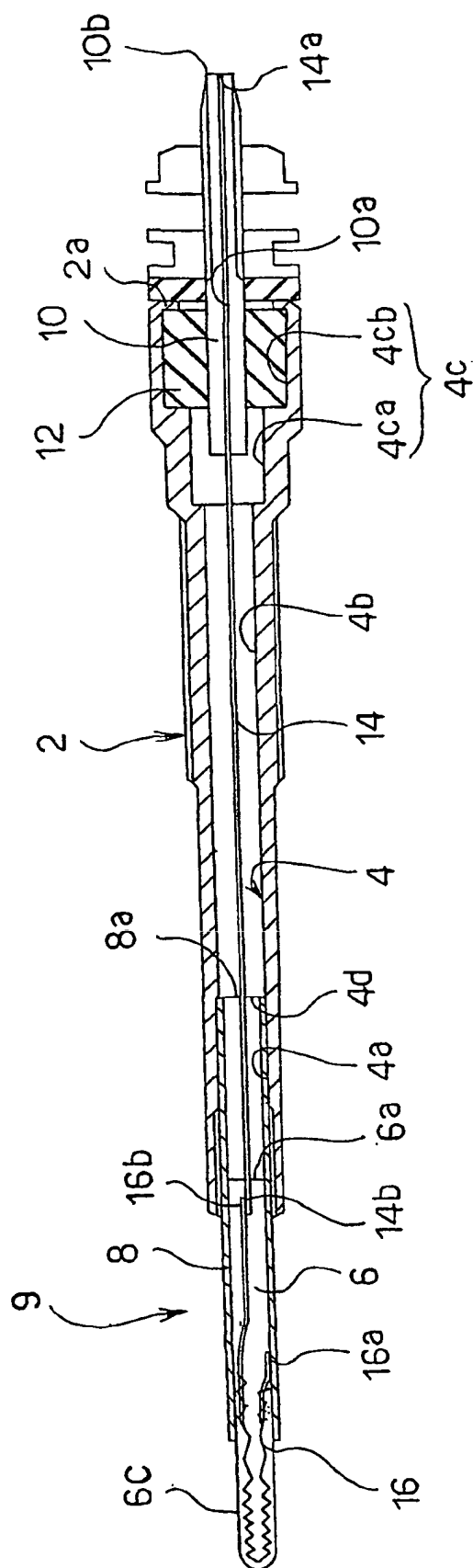


FIG. 2a

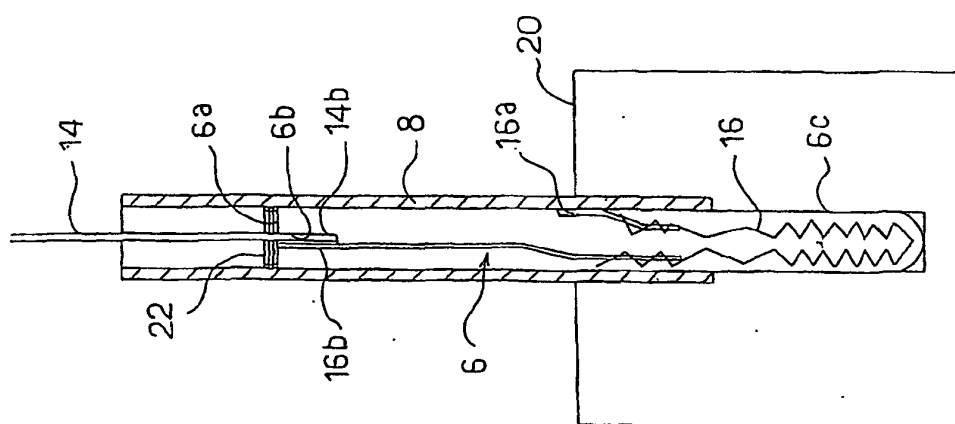


FIG. 2b

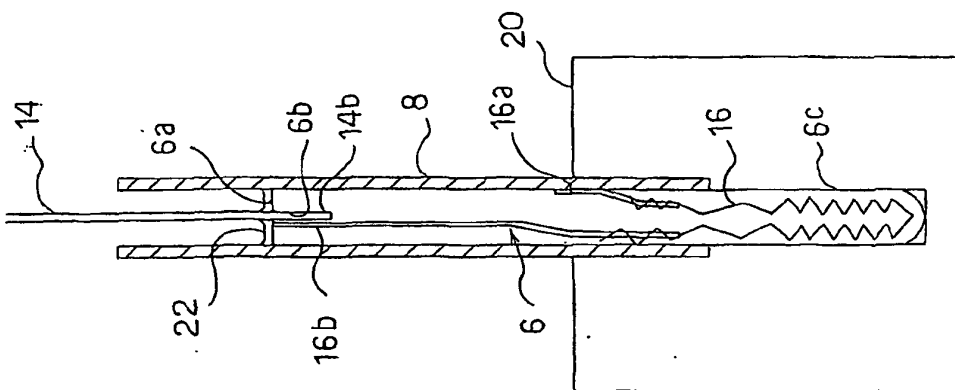


FIG. 2c

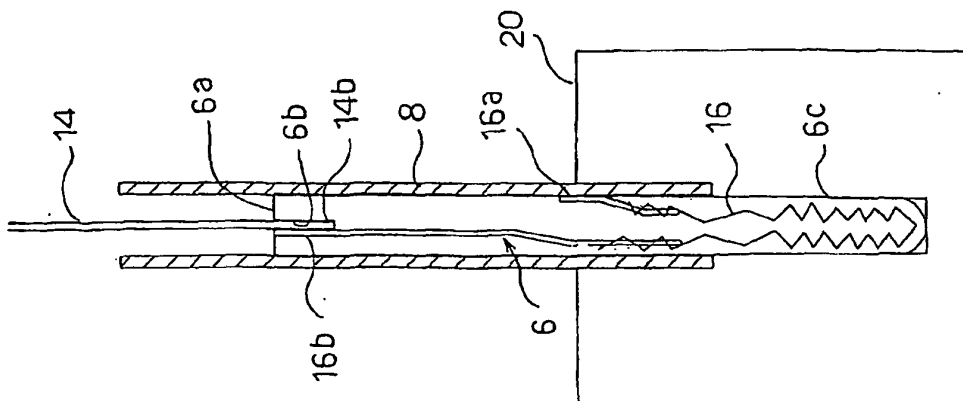


FIG. 3c

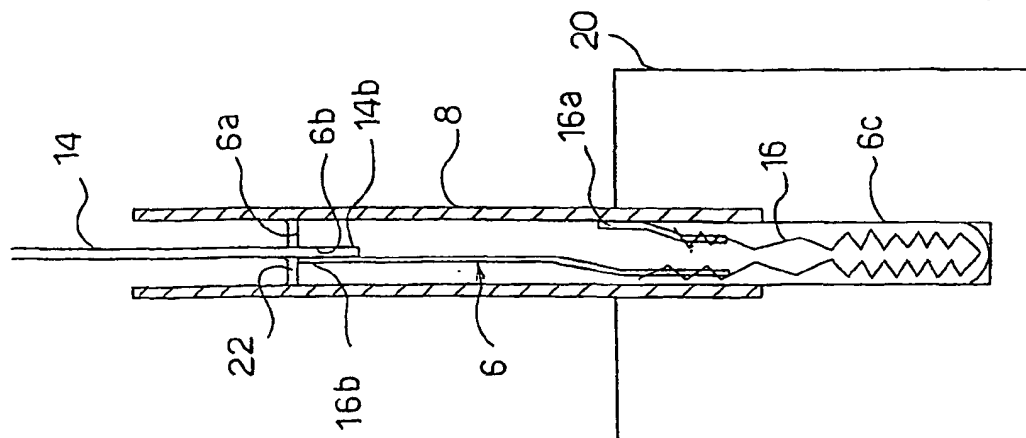


FIG. 3b

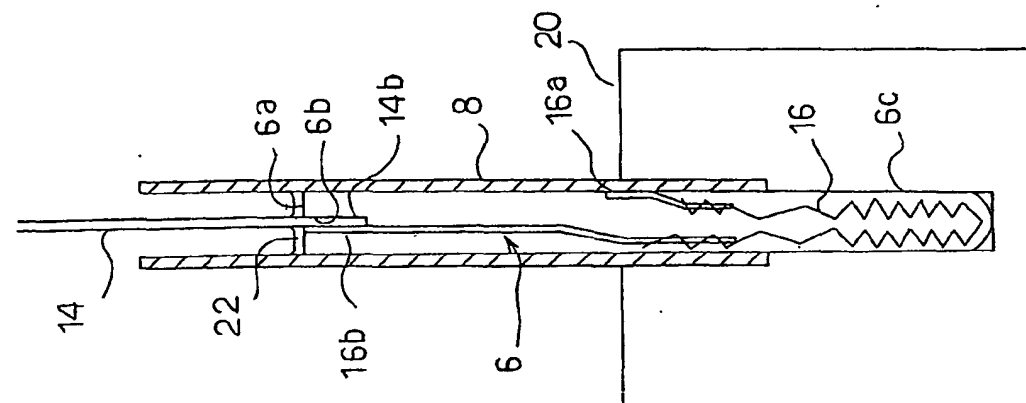


FIG. 3a

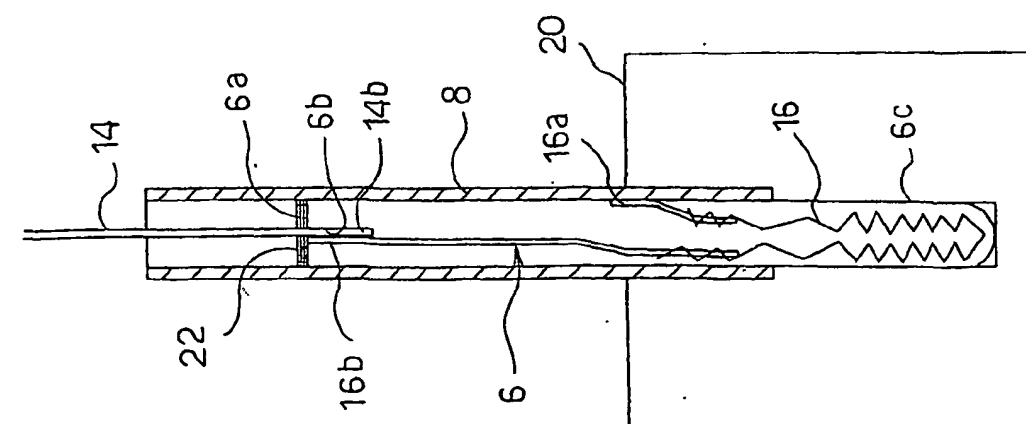


FIG. 4

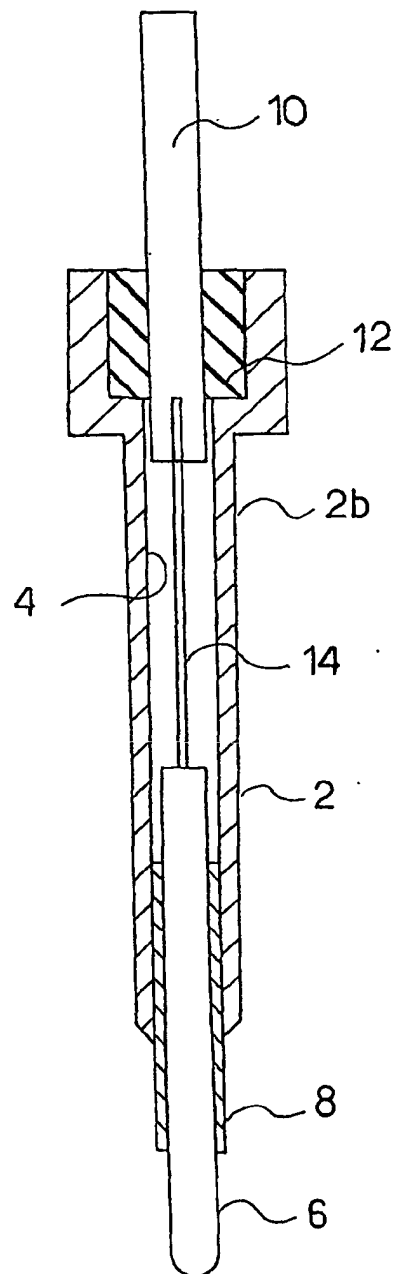


FIG. 5

CONFIRMATION TEST 1: INFLUENCE OF AREA OF END FACE OF CERAMIC HEATER

SPECIMENS			TEST RESULTS		SPECIMENS			TEST RESULTS	
I.D. (X) OF METALLIC OUTER SLEEVE	O.D. (Y) OF ELECTRODE FITTING	X-Y	SHORT-CIRCUIT	SILVER SOLDER ON UPPER END FACE OF CERAMIC HEATER	I.D. (X) OF METALLIC OUTER SLEEVE	O.D. (Y) OF ELECTRODE FITTING	X-Y	SHORT-CIRCUIT	SILVER SOLDER ON UPPER END FACE OF CERAMIC HEATER
φ 2.0	φ 0.4	1.6	○	○	φ 3.2	φ 1.0	2.2	○	○
	φ 0.5	1.5	○	○		φ 1.2	2.0	○	○
	φ 0.6	1.4	x	x		φ 1.5	1.7	○	○
	φ 0.8	1.2	x	x		φ 1.8	1.4	x	x
	φ 1.0	1.0	x	x		φ 2.0	1.2	x	x
φ 2.2	φ 0.4	1.8	○	○	φ 3.4	φ 1.2	2.2	○	○
	φ 0.5	1.7	○	○		φ 1.5	1.9	○	○
	φ 0.6	1.6	○	○		φ 1.8	1.6	○	○
	φ 0.8	1.4	x	x		φ 2.0	1.4	x	x
	φ 1.0	1.2	x	x		φ 2.5	0.9	x	x
φ 2.4	φ 1.2	1.0	x	x	φ 3.6	φ 1.5	2.1	○	○
	φ 0.5	1.9	○	○		φ 1.8	1.8	○	○
	φ 0.6	1.8	○	○		φ 2.0	1.6	○	○
	φ 0.8	1.6	○	○		φ 2.5	1.1	x	x
	φ 1.0	1.4	x	x		φ 1.8	2.3	○	○
φ 2.6	φ 1.2	1.2	x	x	φ 3.8	φ 1.5	2.0	○	○
	φ 1.5	0.9	x	x		φ 2.0	1.8	○	○
	φ 0.5	2.1	○	○		φ 2.5	1.3	x	x
	φ 0.6	2.0	○	○		φ 0.4	3.6	○	○
	φ 0.8	1.8	○	○		φ 1.0	3.0	○	○
φ 2.8	φ 1.0	1.6	○	○	φ 4.0	φ 1.5	2.5	○	○
	φ 1.2	1.4	x	x		φ 1.8	2.2	○	○
	φ 1.5	1.1	x	x		φ 2.0	2.0	○	○
	φ 0.5	2.3	○	○		φ 2.5	1.5	x	x
	φ 0.6	2.2	○	○		φ 2.0	2.2	○	○
φ 3.0	φ 0.8	2.0	○	○	φ 4.2	φ 2.5	1.7	○	○
	φ 1.0	1.8	○	○		φ 2.0	2.4	○	○
	φ 1.2	1.6	○	○		φ 2.5	1.9	○	○
	φ 1.5	1.3	x	x		φ 2.0	2.6	○	○
	φ 1.8	1.0	x	x		φ 2.5	2.1	○	○
φ 3.2	φ 1.0	2.0	○	○	φ 4.4	φ 0.4	4.4	○	○
	φ 1.2	1.8	○	○		φ 1.0	3.8	○	○
	φ 1.5	1.5	○	○		φ 1.5	3.3	○	○
	φ 1.8	1.2	x	x		φ 2.0	2.8	○	○
	φ 2.0	1.0	x	x		φ 2.5	2.3	○	○

FIG. 6

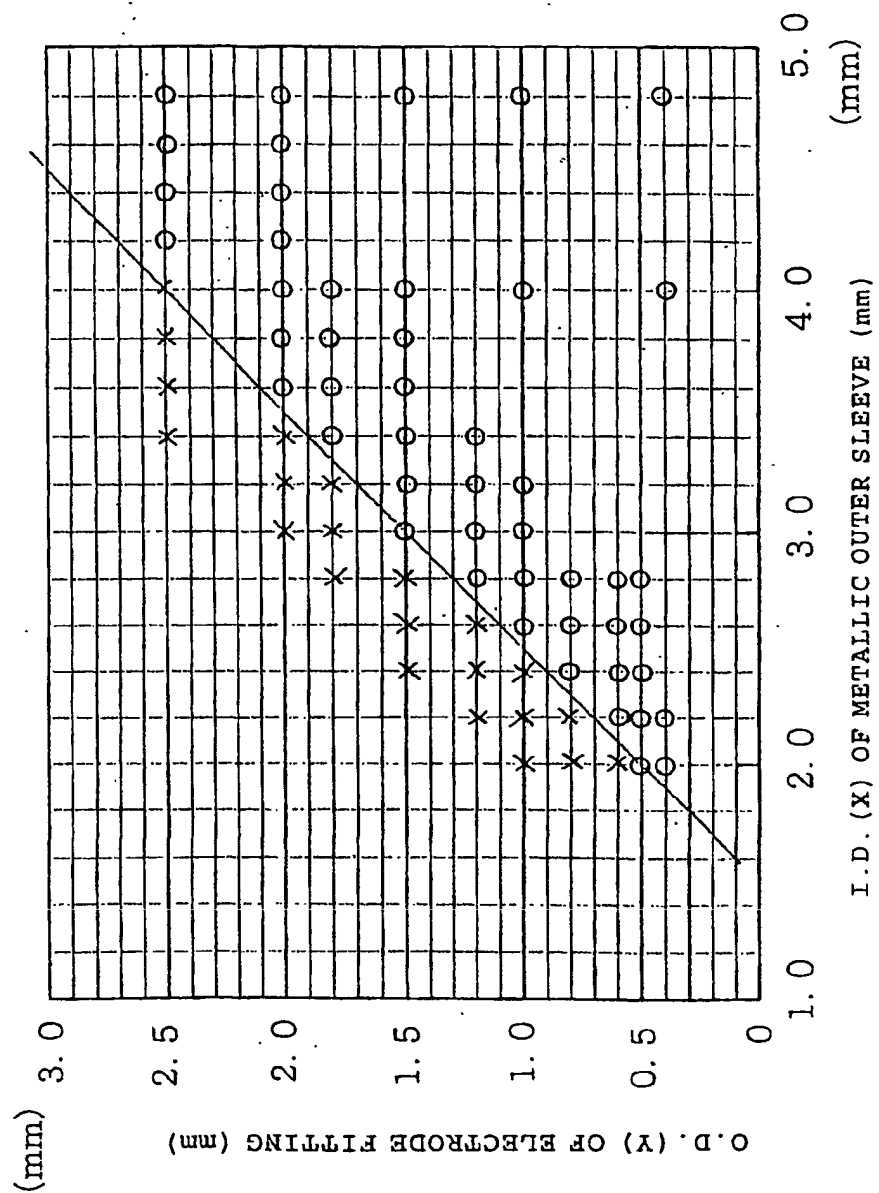


FIG. 7

CONFIRMATION TEST 2: INFLUENCE OF SURFACE TREATMENTS UPON BRAZED RESULT (SHORT-CIRCUIT)

SPECIMENS				TEST RESULTS		
SURFACE TREATMENT OF CERAMIC HEATER	SURFACE TREAT- MENT OF METAL- LIC OUTER SLEEVE	I.D. (X) OF METALLIC OUTER SLEEVE	O.D. (Y) OF ELECTRODE FITTING	X-Y	SHORT- CIRCUIT	RESIDUE OF SILVER SOLDER ON UPPER END OF CERAMIC HEATER
Ni PASTE	Ni PLATING	ϕ 2.6	ϕ 0.8	1.8	○	○
			ϕ 1.0	1.6	○	○
			ϕ 1.2	1.4	x	x
			ϕ 1.5	1.1	x	x
Ni PASTE	NONE	ϕ 2.6	ϕ 0.8	1.8	○	○
			ϕ 1.0	1.6	○	○
			ϕ 1.2	1.4	x	x
			ϕ 1.5	1.1	x	x
GLASS FILM	Ni PLATING	ϕ 2.6	ϕ 0.8	1.8	○	○
			ϕ 1.0	1.6	○	○
			ϕ 1.2	1.4	x	x
			ϕ 1.5	1.1	x	x

FIG. 8

CONFIRMATION TEST 3: INFLUENCE OF MATERIAL AND QUANTITY OF SILVER SOLDER ON BRAZED RESULT (SHORT-CIRCUIT)

SPECIMENS					TEST RESULTS	
MATERIAL OF SILVER SOLDER	QUANTITY OF SILVER SOLDER	I.D. (X) OF METALLIC OUTER SLEEVE	O.D. (Y) OF ELECTRODE FITTING	X-Y	SHORT-CIRCUIT	RESIDUE OF SILVER SOLDER ON UPPER END OF CERAMIC HEATER
BAg-8	0.5gr	φ 2.6	φ 0.8	1.8	○	○
			φ 1.0	1.6	○	○
			φ 1.2	1.4	x	x
			φ 1.5	1.1	x	x
	0.8gr	φ 2.6	φ 0.8	1.8	○	○
			φ 1.0	1.6	○	○
			φ 1.2	1.4	x	x
			φ 1.5	1.1	x	x
SILVER CONTENT: 95-97 %	0.5gr	φ 2.6	φ 0.8	1.8	○	○
			φ 1.0	1.6	○	○
			φ 1.2	1.4	x	x
			φ 1.5	1.1	x	x

FIG. 9

CONFIRMATION TEST 4: INFLUENCE OF CLEARANCE BETWEEN CERAMIC

HEATER AND OUTER SLEEVE ON BRAZED RESULT (SHORT-CIRCUIT)

SPECIMENS				TEST RESULTS	
CLEARANCE BETWEEN CERAMIC HEATER AND METALLIC OUTER SLEEVE	I.D. (X) OF METALLIC OUTER SLEEVE	O.D. (Y) OF ELECTRODE FITTING	X-Y	SHORT-CIRCUIT	RESIDUE OF SILVER SOLDER ON UPPER END OF CERAMIC HEATER
50 μ	ϕ 2. 6	ϕ 0. 8	1. 8	○	○
		ϕ 1. 0	1. 6	○	○
		ϕ 1. 2	1. 4	x	x
		ϕ 1. 5	1. 1	x	x
100 μ	ϕ 2. 6	ϕ 0. 8	1. 8	○	○
		ϕ 1. 0	1. 6	○	○
		ϕ 1. 2	1. 4	x	x
		ϕ 1. 5	1. 1	x	x

FIG. 10

CONFIRMATION TEST 5: INFLUENCE OF BRAZING RUNS ON BRAZED RESULT SHORT-CIRCUIT)

SPECIMENS			TEST RESULTS		
BRAZING RUNS	I.D. (X) OF METALLIC OUTER SLEEVE	O.D. (Y) OF ELECTRODE FITTING	X—Y	SHORT-CIRCUIT	RESIDUE OF SILVER SOLDER ON UPPER END OF CERAMIC HEATER
TWO RUNS BRAZING	ϕ 2. 6	ϕ 0. 8	1. 8	○	○
		ϕ 1. 0	1. 6	○	○
		ϕ 1. 2	1. 4	x	x
		ϕ 1. 5	1. 1	x	x