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SPARK PLUG

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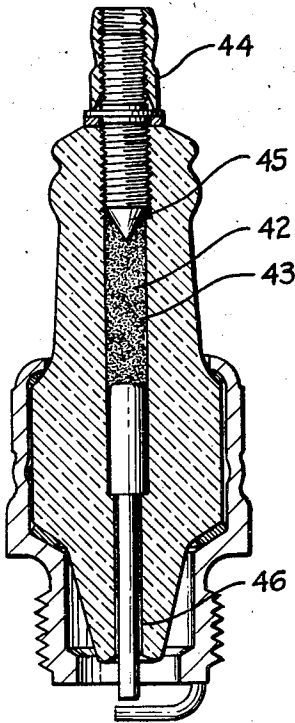


FIG. 4

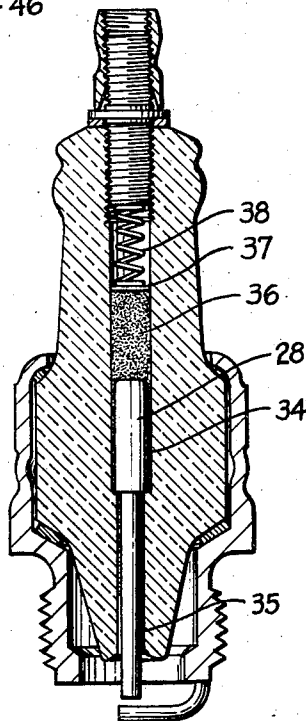


FIG. 3

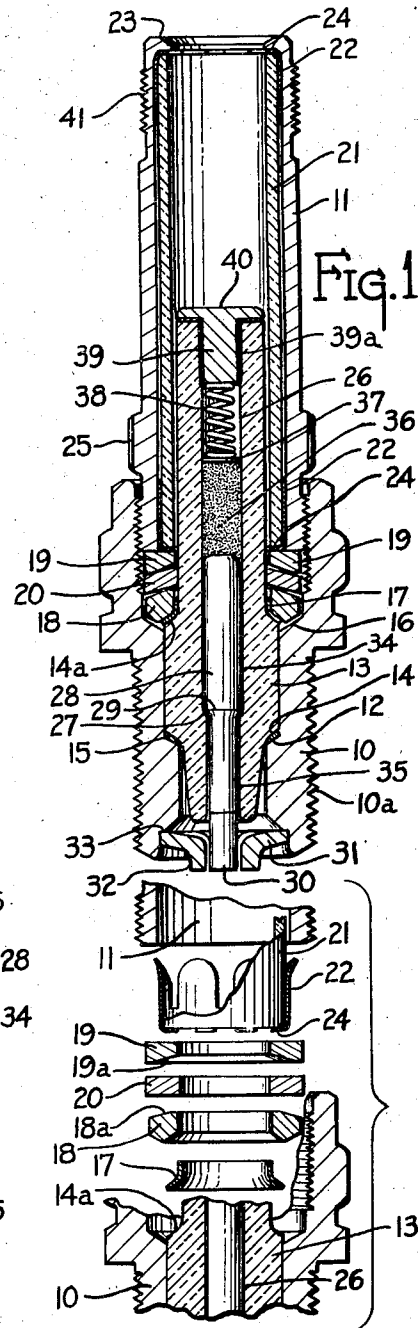


FIG. 1

FIG. 2

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SPARK PLUG

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14 Claims. (Cl. 123—169)

The invention relates to spark plugs, more particularly to the method of sealing center electrodes of spark plugs into a central bore in the spark plug insulator.

The problem of providing a seal between a center electrode having electrically conducting properties, usually being made of metal, and an insulating body with an aperture or bore through which the center electrode extends either only in part or completely through, has given rise to much experimentation and has resulted in a wide variety of sealing methods developed in the art. In some methods, the sealing portion is conductive and becomes a part of the center electrode, while in others a metal center electrode extends completely through an aperture in the insulator core. In the first method a seal to be successful must have relatively low resistance and constituted so that the expansion characteristic under temperature change substantially matches that of the insulator whereby the sealing material remains under substantially constant pressure. In the second method, the metal of the center wire usually has a much greater coefficient of expansion than the insulator in which it is positioned so that a variable space between the two members results, which must be closed to provide a seal. The sealing material must have such characteristics to compensate for the changes in volume of the varying space at the different temperatures within the operating range.

Glass containing a conductor either as graphite or powdered metal has been used for the purpose of sealing according to the first method. Powdered metal alone has also been used for this purpose, a metal being selected which has a temperature coefficient of the proper value to match the coefficient of the insulator. However powdered metal alone is not entirely successful because only metals which are very expensive appear to have the right properties to match the properties of the insulator body. Glass with interspersed metal requires a high temperature to fuse the seal in position.

The present invention provides a novel method of sealing spark plug electrodes in position which allows accurate control of the coefficient of expansion of the sealing material so that practically perfect matching may be obtained. The sealing material comprises a mixture of two entirely dissimilar materials having relatively widely separated coefficients of expansions falling within the range of the spatial expansion at the sealing position. These materials are then comminuted to a desired fineness and mixed together in a proportion

which will give a coefficient of expansion falling between the separate coefficients of expansion of the two materials forming the sealing mixture. Knowing the coefficient of spatial expansion of the insulator, a mixture can be selected which will match this with reasonable accuracy so that a substantially perfect seal will result, even though the temperature may vary within wide limits.

Another aspect of the invention relates to the use of a cement, such as a sodium silicate cement, or a sodium silicate cement containing sodium silica-fluoride in combination with a metal powder or a conducting powder dispersed through the body of the cement. This cement is then used alone or in combination with a powdered conducting mixture as described above to form the seal. It has been discovered that if the powdered mixture is compacted into position above the cement while the cement is still wet that a better seal is obtained which under tests shows itself to be substantially immune to gas leakage to form a substantially perfect seal. When combined with the conducting powder mixture compacted in position either cement alone or cement with interspersed conducting material may be used. It is however preferable to use cement alone when combined with the compacted conducting powder.

It is therefore a principal object of this invention to provide a method of sealing center electrodes in spark plug insulators by the use of a powdered mixture of two or more materials having dissimilar coefficients of expansion.

It is a further object of this invention to provide a method of sealing center electrodes in spark plug insulators which comprises compacting a mixture of two powdered materials having relatively widely separated coefficients of expansion into sealing relation, so that the sealing mixture compacted in position may have a coefficient of expansion varying from the extremes by controlling the percentages of materials mixed together.

It is a further object of this invention to provide a method of sealing center electrodes in spark plug insulators which comprises a mixture of two powdered materials having relatively widely separated coefficients of expansion, one of which is preferably of metal, so that a compacted sealing mixture can be provided to substantially match the coefficient of expansion of the insulator to seal the aperture in the insulator with the compacted sealing mixture, the compacted mixture forming a part of the center electrode

for conducting electric currents through the insulator.

It is therefore a further object of this invention to provide a method of sealing center electrodes in spark plug insulators which uses an air-setting or chemically-setting cement having interspersed through its body a conducting material, preferably either a non-metallic powder such as graphite, or a powdered metal such as copper.

It is a further object of this invention to provide a method of sealing a center electrode into an insulating body of a spark plug which comprises using cement around the body of the electrode between the electrode and the insulating body, and then positioning thereabove a compacted body of powdered material while the cement is still wet, the powdered material consisting of a mixture of two or more comminuted substances having relatively widely separated coefficients of expansion, and substantially matching the coefficient of expansion of the mixture by using various proportions to that of the insulating body in which it is to be compacted.

Other objects and advantages of this invention relating to the arrangement, operation and function of the related elements of the structure, to various details of construction, to combinations of parts and to economies of manufacture, will be apparent to those skilled in the art upon consideration of the following description and appended claims, reference being had to the accompanying drawing forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Fig. 1 is a cross-sectional elevation of an aviation type plug to which the invention has been applied;

Fig. 2 is an exploded view of the central portion of Fig. 1;

Fig. 3 is a cross-sectional elevation of a modification of the invention as applied to an automotive spark plug; and

Fig. 4 is a cross-sectional elevation of another modification of the invention.

Referring to the drawing, particularly to Fig. 1, an aviation type plug is shown which comprises generally an externally-threaded tubular base member 10 and an upwardly-extending sleeve-like gland member 11, which is in threaded cooperation with the base member 10 adjacent the upper portion of the base member 10. The base member 10 is provided with an internally extending annular shoulder 12, within its externally-threaded portion 10a upon which rests an insulating member 13, which is provided with an outwardly extending protuberance resulting in shoulders 14 and 14a. The shoulder 14 cooperates with the shoulder 12 on the base member, and preferably a gasket member 15 is positioned between the shoulders to form a leak-proof seal between the base member 10 and the insulator 13.

The shoulder 14a corresponding to lower shoulder 14 is positioned a short distance above a second inwardly extending shoulder 16 formed on the base member 10. Gasket member 17 is provided for the shoulder 14a of the insulator, which cooperates with a rigid annular member 18, preferably made of hardened steel or the like. To urge the insulator 13 against the shoulder 12 on the base member 10, a resilient means is provided between the upper shoulder 14a of the insulator and the threaded gland member 11, which by means of its threaded relation with the base member 10 is capable of being advanced inwardly

into the bore of the base member 10 to place pressure upon the upper shoulder 14a of the insulator. The annular rigid member 18 provides one element of this resilient means, the other two elements being a second annular member 19 which cooperates with the lower end of the gland member 11, and an intermediate spring member 20 in the nature of a Bellville washer. The upper surface of the rigid annular member 18 is provided with an inclined surface 18a (Fig. 2) having its highest point adjacent to its inner edge. The upper rigid member 19 is similarly provided with an inclined surface 19a on its lower side, the lowest point of this oblique surface being located adjacent to the outer peripheral edge of the member.

In considering this resilient means consisting of the three members, 18, 19, and 20, when they are placed in cooperative relation on the upper shoulder 14a of insulator 13, it will be clear that any downwardly-acting force created by gland member 11 will act upon the upper surface of the member 19 and will be transmitted to the outer edge of the Bellville washer 20, inasmuch as the lowest point of the member 19 is located adjacent the periphery. The downwardly-acting force will be transmitted from the Bellville washer 20 to the lower member 18 adjacent to the inner edge of the member 18 so that a couple is provided which tends to twist Bellville washer 20 through the action of these two forces. The Bellville washer 20 being made of resilient steel, such as tool steel or Inconel, will form a resilient cushion for the gland member 11 which thrusts downwardly on the upper shoulder of 14a of the insulator 13 so as to hold the lower shoulder 14 of the insulator against the shoulder 12 of the base member 10 with a predetermined force. In this way the insulator may be thrust against the gasket 15 on the shoulder 12 to form a seal which prevents leakage of gases between the outer surface of the insulator 13 and the base member 10. This construction has the advantage of holding the parts of the spark plug in closely assembled relation should the Bellville washer 20 fail through breakage or the like. The oblique surfaces 18a and 19a will still hold the insulator against shoulder 12, even though there is a failure of the Bellville washer.

The tubular gland member 11, which threads into the upper portion of the base member 10 is provided with an internal ceramic sleeve 21 held in concentric relation with the inside bore of the gland member by spring members 22 which fit between the sleeve and the gland member. Adjacent the upper end of the gland member an internal flange 23 is provided integral therewith, against which the upper end of the ceramic sleeve 21 rests to prevent longitudinal movement. The lower end of the ceramic sleeve 21 rests on the upper side of the annular rigid member 18, horizontal tangs 24 integral with the spring members 22 being positioned between the two parts as shown. Similarly on the upper end of the horizontal tangs 24 are positioned between the upper end of the sleeve and the internal flange 23. The length of the sleeve 21 is slightly less than the distance between the flange 23 and the bottom end of the gland member 11, so that as the gland member is screwed into the base member 10, the force urging rigid member 18 downwardly against the Bellville washer 20 will not be carried by the ceramic sleeve. The sleeve may be glazed if desired on either its inner or outer sides or both.

The tubular gland member 11, is preferably pro-

vided with a series of vertical serrations 25 to fit a special wrench whereby torque may be applied to the member to screw it into the base member during assembly of the plug.

The invention relating to the methods and means for sealing the insulator in the shell is described and claimed in a copending application Serial No. 482,688, filed April 12, 1943, being assigned to the same assignee.

The insulator 13 is provided with a central bore 26 having an internal shoulder 27 adjacent but preferably slightly above the external shoulder 14 to give greater strength to the insulating body. An electrode member 28 is provided to fit into the bore, having a shoulder 29 to cooperate with the internal shoulder 27 of the insulator to hold the electrode in position. The lower end of the electrode member 28, extends beyond the tapering lower end of the insulator and may be provided with a corrosion resistant tip 30a such as tungsten or the like which may be conveniently welded in position.

The tip 30 cooperates with a fixed electrode which may be in the form of a ring having several inwardly projecting prongs 32 having surfaces parallel to the outer surface of the tip 30a to form spark gaps over which the firing occurs during the use of the plug in an engine. The fixed electrode is preferably brazed or hard soldered in position on a shoulder 33 in the lower inner end of the shell 10 as is well known in the art. Usually a corrosion resistant material is used for this electrode to give long life.

The electrode member 28 is preferably made of material having a coefficient of expansion substantially matching that of the insulator, and is loosely fitted into the bore 26 of the insulator. Before being dropped into position the electrode 28 is preferably covered with a cement 34 which when the electrode is in final position will be positioned between the electrode and the bore as shown in Fig. 1. The cement used for this purpose may have either a sodium silicate base which sets by evaporation of its water content, or a sodium silicate combined with sodium silicofluoride which sets by a chemical reaction. The latter type is preferable as it becomes a denser body after "setting." The tip or tapering portion of the insulator may be cleared of cement for a short distance 35 as shown, this is preferably accomplished by washing the cement out of the insulator bore by means of dipping into water.

Although the cement positioned between the central electrode 28 and the bore 26 gives a partial seal, there is not sufficient cement present to give a seal having permanent holding and sealing qualities. A further agency is provided for the purpose of making a seal which will be certain and which will have durability. The cement body however does provide a heat conductor between the center electrode and the insulator body which allows escape of heat being conducted from the inner end of the center electrode to the body of the plug and so prevent damage to the upper portion of the plug.

To assure absolute certainty in the sealing of the bore of the insulator a second sealing body 36 is positioned in the bore above the upper end of the electrode 28, the sealing body being given conducting properties so that it may become a portion of the central electrode positioned in the bore 26 of the insulator to carry electric currents to the inner sparking end of the plug. Inasmuch as it is preferable to match with reasonable accuracy the coefficient of expansion of the sealing

body 36 with that of the insulator body a novel material was discovered which could be controlled in this respect. To attain this end two materials, although more than two may be used, having relatively widely separated coefficients of expansion were mixed together in various proportions to match the coefficients of expansion of the various types of insulators. To give the resulting mixture conducting properties, one of the two constituent materials must necessarily be a good conductor of electricity, and the resistance of the resulting mixtures must be such as to be within reasonable limits.

Three substances have been found particularly suitable for this purpose, talc being the common constituent, combined with either graphite or powdered copper to give a body with a resistal value suitable for use in spark plugs and having a coefficient of expansion substantially matching that of the insulator to be used in the plug.

A mixture of talc and graphite may have a coefficient of expansion varying from 3×10^{-6} the coefficient of expansion of graphite to 4×10^{-6} , the coefficient of expansion of talc. The resistance value of the mixture must be taken into consideration in selecting the percentages of graphite and talc to be mixed together. The resistance of a mixture of graphite and talc has relatively uniform rising characteristic until the percentage of talc approaches approximately 96% by weight when the resistance value rises quickly to prohibitive values. A mixture, for example of 95% talc and 5% graphite by weight could therefore be used with good results in insulators having a coefficient of expansion of 4×10^{-6} such as for example mullite or zircon insulators.

A mixture of talc and graphite would not be suitable for insulators of alumina or magnesia which have coefficient of expansion of 7.5×10^{-6} and 8.5×10^{-6} respectively. However a mixture of talc and powdered copper has been found successful where the coefficient of expansion of a mixture can be varied from 16.6×10^{-6} which is the coefficient of expansion of powdered copper to 4×10^{-6} the coefficient of expansion of talc. The resistance value of the mixture must again be taken into consideration, the resistance values having a slowly rising characteristic and become prohibitive when the percentage of talc approaches 55% or over by weight. A mixture of 50% each of talc and powdered copper by weight is one suitable for use with either an alumina or magnesia insulator.

The sealing body 36 may comprise the above mentioned mixture, and is then compacted in position in the bore 26 in any convenient manner either while the cement body 34 is wet or dry. It has been discovered that if the sealing body is compacted into the bore 26 while the cement body is still wet, a better seal is obtained which is substantially free of gas leakage. The reason for this is not known but this procedure results in substantially leak-proof seals for the center electrode, and is therefore preferred.

To make electrical contact with the sealing body 36 a small disc of metal foil 37 is firmly pressed upon its upper surface, and a coil spring 38 or its equivalent is positioned above in slightly contracted condition being held by a contact button 39. The contact button 39 may either be threaded into the bore 26 and cemented in position or fused therein by means of a (1100° Fahr.) glass frit 39a having a low melting point. The upper surface 40 is adapted to make contact with a cable insert (not shown) which enters the

gland member 11 and being attached thereto by cooperating with external threads 41. The electric current enters the plug through the agency of the cable in contact with button 39. It then flows through spring 38, the metal foil 37, the sealing body 36, and the metal center electrode portion 28 to the spark gap where the discharge occurs.

In Fig. 3, the invention is shown as applied to a conventional type automobile spark plug where the same reference numerals have been applied to corresponding parts.

In Fig. 4, another modification of the invention is shown wherein the powder pack mixture is replaced by a cement body 42 interspersed with a conducting substance such as graphite or powdered copper. The cement is either a sodium silicate which "sets" by evaporation of water or sodium silicate containing sodium silica-fluoride, which "sets" by a chemical reaction. To these cements are added approximately 10% by weight of either graphite or copper. The electrode is covered with this mixture and dropped into position in the central bore 43 of an insulator 42 of a conventional type automobile spark plug. A binding post 44 is then screwed in position while the cement is still wet. A point 45 may be provided on its lower end so that the post may be screwed into position and a good electrical contact assured. The cement adjacent the lower tip of the insulator 46 may again be removed by dipping it into water to the desired depth. The body of cement containing the conductive material forms the center wire seals and also forms a part of the center electrode which conducts electrical charges from the binding post to the spark gap at the inner end of the plug.

It is to be understood that the above detailed description of the present invention is intended to disclose an embodiment thereof to those skilled in the art, but that the invention is not to be construed as limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawing, since the invention is capable of being practiced and carried out in various ways without departing from the spirit of the invention. The language used in the specification relating to the operation and function of the elements of the invention is employed for purposes of description and not of limitation, and it is not intended to limit the scope of the following claims beyond the requirements of the prior art.

What is claimed:

1. A spark plug comprising a hollow ceramic insulator and a sectional electrode positioned in the insulator, a portion of said sectional electrode comprising a sealing body in said hollow insulator consisting of a compacted body of a mixture of powdered insulating material and a conducting material interspersed therein.

2. A spark plug comprising a ceramic insulator having a central longitudinal bore, a sectional electrode positioned in the bore of the insulator, a central portion of the electrode holding a lower portion in position in the bore of the insulator, sealing the bore, said central portion comprising a compacted mixture of powdered insulating material and powdered conducting material positioned in the bore to form a seal, being adapted to conduct electric discharges to the lower portion of the electrode.

3. In insulators for spark plugs having a sectional central electrode, a section thereof comprising a compacted mixture of comminuted metal and a non-conducting compactible powder,

said section being compacted in a bore of the insulator to form a seal therefor.

4. In a spark plug, the combination of a ceramic insulator having a shouldered central bore, a sectional electrode positioned in the bore comprising at least one metal portion positioned below the shoulder and adapted to project beyond the inner end of the insulator, and a second conducting portion positioned above the metal portion compacted in position in the bore of the insulator against the shoulder consisting of a mixture of comminuted metal and a compactible non-conducting material, said second conducting portion holding the first portion in position and forming a close conducting relation therewith, and sealing the bore of the insulator against gas leakage.

5. In a spark plug, the combination of an insulator having a shouldered bore, a sectional electrode positioned in the bore, comprising a pair of metal portions positioned at the ends of the bore connected by a compacted conducting portion consisting of a mixture of comminuted metal and a compactible non-conducting powder, said compacted portion of the electrode being positioned in the bore above the shoulder to seal the bore against gas leakage and to hold one metal portion in position in the bore against the shoulder.

6. In a spark plug, the combination of a ceramic insulator having a central bore, a sectional electrode positioned in the bore comprising at least one metal portion, a second portion of the electrode adapted to seal the bore consisting of a cement with conducting particles interspersed through the body of the cement in conducting relation with the metal portion whereby an electric current may be conducted through the sectional electrode.

7. In a spark plug, the combination of a ceramic insulator having a shouldered central bore, a metallic electrode portion having a shoulder cooperating with the shoulder in the central bore of the insulator, a cement body having a conducting powder interspersed in its body positioned above the metallic electrode portion and stopping the bore of the insulator to hold the electrode portion in position in the bore and to seal the bore, said cement body forming a part of a sectional electrode positioned in the bore, whereby electric currents may be conducted through the cement body by the conducting powder interspersed therein to the metallic electrode portion.

8. In a spark plug, the combination of a ceramic insulator having a shouldered central bore, a sectional electrode positioned in the bore, comprising at least one metal portion having a shoulder cooperating with the shoulder in the central bore, a body of cement between the metal portion and the bore, and a sealing conducting mixture of at least two powdered materials having relatively widely separated coefficients of expansion compacted in the bore over the terminus of the metal portion of the electrode to hold the metal portion against the shoulder of the insulator and to have electrical contact therewith to form the sectional electrode.

9. In a spark plug, the combination of a ceramic insulator having a shouldered central bore, a sectional electrode positioned in the bore comprising at least one metal portion adjacent the firing end of the insulator having a shoulder cooperating with the shoulder in the central bore, a body of cement adjacent the shoulder posi-

tioned between the metal portion and the bore to form a seal and a highly conductive heat path between the metal portion and the insulator, and a sealing body in the bore comprising a mixture of a compactible non-conducting powder and a conducting powder compacted together to seal the bore in the insulator and in conducting relation with the metal portion to form a part of the sectional electrode.

10. The combination set forth in claim 9 further characterized by an intimate relation between the cement body and the compacted body, wherein the compacted body is placed in position while the cement is still wet.

11. In a spark plug, the combination of a ceramic insulator having properties similar to mullite or zircon, a shouldered central bore in the insulator extending longitudinally thereof, a sectional electrode positioned in the bore comprising, at least one metal portion adjacent the firing end of the insulator having a shoulder cooperating with the shoulder in the bore of the insulator, a compacted body of a mixture of graphite and powdered talc positioned in the bore to form a sealing body and to hold the metal portion of the electrode against the shoulder in the bore, said compacted body comprising from 20 to 96 per cent by weight of powdered talc and the balance graphite.

12. In a spark plug, the combination of an insulator having properties similar to that of corundum or magnesia, a shouldered bore in the insulator extending longitudinally thereof, a sectional electrode positioned in the bore comprising, at least one metal portion adjacent the firing end of the insulator having a shoulder cooperating with the shoulder in the bore of the insulator, an intermediate compacted body of powdered copper and powdered talc to hold the metal portion of the electrode against the shoulder in the bore and to seal the bore against leakage, said compacted mixture comprising from 20 to

55 per cent by weight of powdered talc and the balance powdered copper.

13. In a spark plug, the combination of a ceramic insulator having properties similar to mullite or zircon, a shouldered central bore extending longitudinally of the insulator, a sectional electrode positioned in the bore comprising, at least one metal portion positioned in part below the shoulder and adapted to project beyond the end of the insulator, a second conducting portion of the sectional electrode positioned above the metal portion compacted in position in the bore of the insulator against the shoulder thereof consisting of a mixture of graphite and a compactable non-conducting powdered material, said second conducting portion holding the first metal portion in position in the bore of the insulator and forming a conducting relation therewith and sealing the bore of the insulator against gas leakage and having an expansion coefficient between 3.2×10^{-6} to 4.0×10^{-6} .

14. In a spark plug, the combination of a ceramic insulator having properties similar to corundum and magnesia, a shouldered central bore extending longitudinally of the insulator, a sectional electrode positioned in the bore comprising, at least one metal portion positioned in part below the shoulder and adapted to project beyond the end of the insulator, a second conducting portion of the sectional electrode positioned above the metal portion compacted in position in the bore of the insulator against the shoulder thereof, consisting of a mixture of powdered metal and a compactable non-conducting powdered material, said second conducting portion holding the first metal portion in position in the bore of the insulator and forming a conducting relation therewith and sealing the bore of the insulator against gas leakage and having an expansion coefficient between 9.6×10^{-6} to 14.05×10^{-6} .

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