Feb. 24, 1959 E. W. PIERCE 2,875,365

SPARK PLUG AND METHOD OF MANUFACTURING SAME

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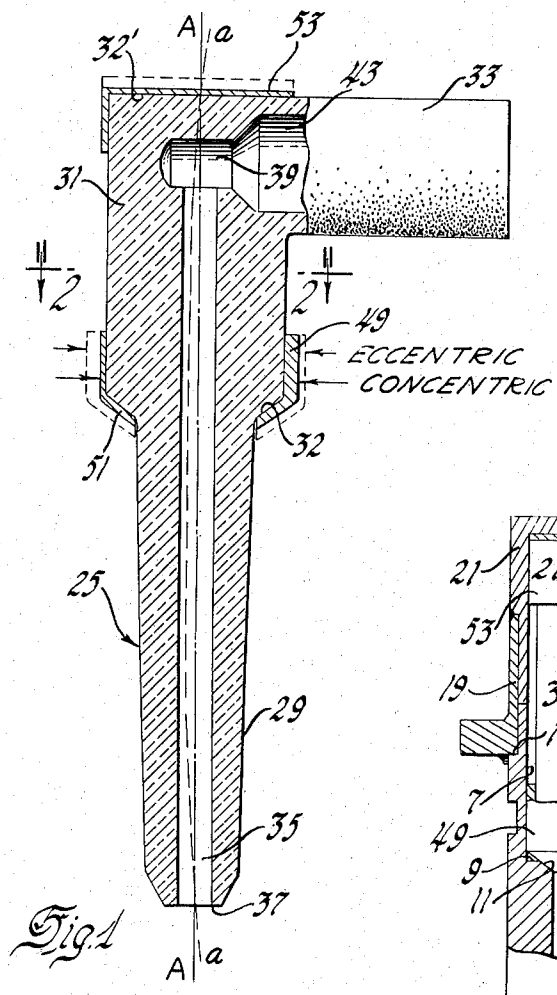


Fig. 1

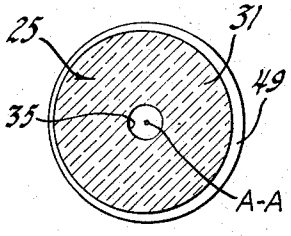


Fig. 2

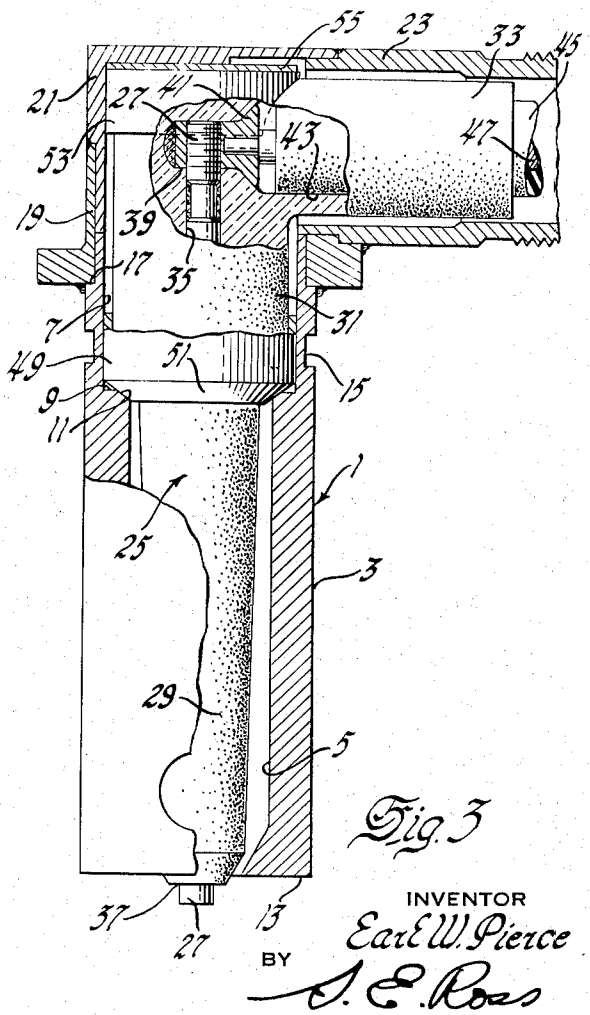


Fig. 3

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SPARK PLUG AND METHOD OF MANUFACTURING SAME

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This invention relates to a spark plug and the method for manufacturing same and more particularly to an angle type shielded spark plug and to the method of centralizing and sealing a warped insulator in the spark plug shell.

In the manufacture of spark plugs a relatively elongated ceramic insulator body is used to insulate the center electrode from the plug shell which acts as the grounding portion of the ignition system. Such insulators are commonly formed by pressure molding the ceramic powder into a blank having the desired configuration followed by a firing operation to sinter the ceramic powder into a fused unitary body. It has been found that the ceramic blanks are generally warped or otherwise distorted during the firing operation with the result that the axis of the center electrode counterbore is no longer a straight line through the center of the two axial extremities of the insulator.

Assembly of a spark plug with such an insulator results in the eccentric location of the center electrode with respect to the shell or ground electrode. This presents a serious problem where it is necessary to accurately control the centrality of the insulator. This problem is especially acute in the manufacture of aviation type spark plugs wherein the outer or ground electrode is generally the annular end of the plug shell. Likewise, the distortion frequently precludes the insulator seating squarely within the plug shell. Under these conditions it is practically impossible to attain the desired pressure seal of the insulator within the plug shell without resort to high sealing pressures which tend to break the body of the insulator, and the use of exceedingly thick and soft gasket materials such as metal foils which increase the cost and probability of seal failure. The unequal application of sealing pressure to the insulator likewise increases the probability of insulator breakage.

Insulator distortion presents a further problem where the insulator is of the angle type, that is, where a cable receiving portion is formed integral with and at an angle to the upper end of the electrode portion and is used with a spark plug body of corresponding angle configuration surrounding the entire insulator as an electrical shield, the shield being in close adjacency with the outer end of the cable portion of the insulator. The distortion of the insulator may be such that, as measured in a plane passing through the center of the outer end of the cable portion of the insulator and parallel with the axis through the center of the two axial extremities of the insulator, the distance between the cable portion center and upper extremity of the insulator is sufficiently different from that provided for in the metal shell as to preclude the assembly of the upper or shield portion of the spark plug body about the insulator without causing the insulator cable portion to break.

It is therefore an object of my invention to provide a method for centralizing a spark plug insulator in a simple and inexpensive manner.

It is another object of my invention to provide a method

for assuring the proper seating of a spark plug insulator within the spark plug shell for attaining the desired pressure seal.

It is another object of my invention to provide a method for simply and inexpensively centralizing a spark plug insulator within a spark plug shell and for properly seating the insulator therein.

It is another object of my invention to provide an angle type insulator adapted for concentric and proper seating within a spark plug shell having a metallic shield portion formed as an integral part of the upper portion of the shell.

It is another object of my invention to provide an angle type shielded spark plug wherein the plug body and insulator are each formed with unitary correspondinlgy shaped angularly arranged portions.

To attain these objects, I provide a metal gasket adapted to be fitted on the locating surfaces of the insulator following which I rotate the insulator on an axis through the center of its two axial extremities to permit machining of the surfaces of the gasket concentric and true with this axis. The compensated insulator is then positioned in the spark plug shell and the remaining portions of the plug body are secured to the shell to form a unitary shielded spark plug.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing, wherein a preferred form of the present invention is clearly shown.

In the drawing:

Figure 1 is a diagrammatic vertical section with parts broken away of the insulator of my invention showing the metal compensating members both before and after machining.

Figure 2 is a sectional view on line 2—2 of Figure 1 showing the degree of distortion in the insulator.

Figure 3 is a sectional view with parts broken away of the spark plug of my invention.

Referring now to the drawing and more particularly to Fig. 3, there is shown an angle type spark plug 1 embodying the several features of my invention. Plug 1 comprises a cylindrical main portion or shell 3 having a longitudinal bore 5 therein, the upper portion 7 thereof being counterbored to form a shoulder 9. The edge of shoulder 9 is beveled to provide a conical seating ledge 11 having an axis coincident with the axis of shell 3. The bottom portion 13 of shell 3 serves as the outer or ground electrode and is annular in configuration. Seating ledge 11 acts both to support the spark plug insulator with its tip end concentric with the outer electrode 13 and as an abutment for establishing a seal between the insulator and the shell 3.

Shell 3 is provided with an annular groove 15 on its outer surface adjacent shoulder 9 to enable a gas-tight seal between the shell and insulator by means of the "Cico" weld process wherein, under the influence of axial pressure and electrical heating, the shell thermoplastically collapses in the annular thin wall section 15 to clamp the insulator on ledge 11.

The upper end of shell 3 adjacent groove 15 is necked down to provide a shoulder 17 on which a metal mounting pad 19 is telescopically positioned. Pad 19 serves to provide the means for mounting the assembled plug in the engine and at the same time provides an extension of the shell 3 for shielding the plug.

The metal plug body and electrical shielding of plug 1 is completed by means of metal shield cap 21 and shield sleeve 23, these elements being shown as telescopically fitted to each other and to pad 19. The several body portions 3, 19, 21 and 23, are securely attached to each

other in any suitable manner, i. e., welding, to form a single unitary structure.

It should be noted that in the particular embodiment shown on the drawing, the cap 21 abuts the top of the insulator and cooperates with ledge 11 in a manner fully disclosed hereinafter to clamp the insulator in the plug body and provide a gas-tight seal therebetween. Cap 21 is of such configuration as to provide, together with mounting pad 19, a side opening in the plug body in which sleeve 23 is adapted to be positioned, its axis extending transversely to the axis of the shell 3.

Having reference now to Figs. 1 and 3, a ceramic insulator 25, having a center electrode 27 positioned therein, is mounted within the metal body in a manner fully disclosed hereinafter as to position the electrode concentric with the outer electrode 13, bottom portion of shell 3. Insulator 25 is generally cylindrical in shape and has a generally tapered lower section 29 and a raised upper section 31. Section 31 provides a lower shoulder 32 and a generally circular top surface 32' serving as an upper shoulder. A tubular section 33 extends laterally from the raised section 31. Insulator 25 is provided with a substantially concentric bore 35 extending from the firing end 37 of section 29 to within the upper portion of raised section 31. A laterally extending bore substantially concentric with section 33 is provided to intersect the upper end of bore 35 and form a recess 39 in which a metal contact cap 41 is adapted to be positioned. A counterbore 43 is provided in section 33 and is adapted to receive an insulated ignition cable 45.

The electrical connection between cable 45 and center electrode 27 is assured by inserting the inner end of the electrode into a corresponding opening in cap 41. The end of the electrode may be either threaded as shown or slotted to form either a threaded or a spring-like friction connection with the cap. The conductor 47 of cable 45 is retained in contact with the outer end of cap 41 in any of a number of ways which are well known in the art and form no part of the present invention. Any spaces in cap recess 39 and around electrode 27 are filled with a sodium silicate-kaolin type cement also well known in the art. The cement seems to both seal and retain the electrode in the insulator.

As shown on the drawing, novel means are provided to compensate for the warpage and deformation of the insulator 25 that occurs in the firing operation and to assure (1) the centrality of the center electrode, (2) the formation of a gas-tight seal between the insulator and the spark plug hollow metal body without the use of excessive pressures and (3) the positioning of the outer end of the laterally extending section of the insulator substantially concentric within the sleeve portion of the plug body.

Having particular reference now to Fig. 1, insulator 25 is shown as having a distorted axis *a—a* as a result of firing. It is to be understood that the bending and distortion of the insulator upon firing is not as extreme as shown on the drawing but that it is nevertheless sufficient to destroy the concentricity and alignment of the surface of section 31 and shoulders 32 and 32' with respect to axis A—A through the center of the two axial extremities 32' and 37 of insulator 25.

In order to compensate for this misalignment, a generally cup-shaped gasket 49 having a conical bottom portion 51 corresponding to conical shoulder 32 is securely attached to the lower portion of section 31. Gasket 49 is made of such relatively soft metal as nickel or copper and may be attached to the insulator in any suitable manner, i. e. press-fitted, shrink-fitted, etc. It is to be understood that the gasket may be secured on the insulator by building it up on the insulator by such methods as electrodeposition or spraying. Insulator 25 is then positioned in a lathe to revolve about axis A—A passing through the true center of axial extremities 32' and 37. The side wall of gasket 49 is then turned down concentric with axis A—A and to a diameter corresponding to that of the counterbored portion 7 of shell 3 in which it is to be mounted. In this manner, the centrality of the center electrode 27 is assured. At the same time, the conical surface of portion 51 is turned down true with axis A—A, that is, the turned conical surface of portion 51 has its generating axis coincident with axis A—A. In this manner, a gas-tight seal is assured between the insulator 25 and shell 3 since the surface of portion 51 is turned down to correspond to conical seating ledge 11. As shown on Fig. 1, the dashed outline of gasket 49 denotes its original dimensions with its surface eccentric and in misalignment with axis A—A. The solid outline of gasket 49 is its final configuration after machining to make its surface concentric with axis A—A.

As described above, a gas-tight seal between insulator 25 and shell 3 is obtained by applying pressure to shield cap 21 which collapses the thinned-out portion of shell wall 3 in annular groove 15, cap 21 then acting to clamp insulator shoulder 32 on ledge 11 with bottom portion 51 of gasket 49 therebetween. In order that the sealing pressure may be applied evenly to the surface of insulator shoulders 32 and 32' and thus preclude insulator breakage otherwise resulting, a cap or gasket member 53 made of nickel or copper is secured to top surface 32' in a manner such as that used with gasket 49. Insulator 25 is then mounted in a lathe to revolve about axis A—A and the surface of member 53 is turned down to square it off or make it true with the axis of revolution. At the same time, the amount of metal machined off gasket 53 is controlled to compensate for the warpage in laterally extending section 33 and asure that its outer end will be positioned substantially concentric within sleeve 23 when cap 21 and sleeve 23 are assembled about the insulator.

In order to facilitate the ready understanding of the principles of my invention, the following is a concise description of the production of a spark plug as shown on the drawing. The several metal parts of spark plug body 3, 19, 21 and 23, are accurately machined so that their several seating and wall surfaces are concentric and true with the longitudinal axis of shell 3 as well as being so dimensioned as to fit together telescopically with sleeve 23 at a predetermined angle to shell 3. The angle type ceramic insulator 25 is then molded of a suitable heat resisting powder following which the molded blank is fired to sinter it into a composite fused body. Centralizing gasket 49 is then pressed on the lower end of raised section 31 and its surfaces are turned down concentric and true with axis A—A through the true center of insulator extremities 32' and 37. Insulator 25 is then gaged for the desired angular positioning of laterally extending section 33 to the axis of rotation A—A. Distortion of such nature acts to change the distance between the center of the outer end of section 33 and the surface of upper extremity 32' with resultant breakage of section 33 upon assembly with sleeve 23. The deviation in this distance from standard is noted. Cap or gasket member 53 is then pressed on the upper end of raised section 31 and its surface 32' is turned down square with axis A—A and an amount sufficient to compensate for the deviation above noted thus assuring concentricity of the outer end of section 33 in sleeve 23. The insulator is then positioned in shell 3 squarely on ledge 11 with the center electrode concentric with the annular ground electrode 13. The remaining body parts are then telescopically assembled on the shell and the assembly is placed in an oven at about 2000° F., the interlocking surfaces of the several parts having been previously coated with a copper brazing paste. On cooling, the assembly is formed into a unitary, completely shielded subassembly. The gas-tight seal of the insulator 25 within shell 3 is accomplished by mounting the plug 1 in a jig for supporting the shell 3 while passing an electric current therethrough at the same time that axial pressure is applied to shield cap 21. A spacer gasket 55 may be used on top of cap 53 when necessary.

Contact cap **41** is then inserted into recess **39** and center electrode **27** is threaded into an opening therein. All spaces in recess **39** and about electrode **27** are then filled with a silicate base cement to seal the electrode in the insulator and fix the elements in position to form the completed and compensated plug **1**.

From the above description, it can be seen that I have provided a simple and integrally formed shielded angle spark plug by a method of fabrication which permits the assembly of spark plugs to dimensional limits heretofore not possible because of excessive warpage which is inherent in most spark plug insulators. At the same time, the even application of sealing pressure to the shell is made possible thus reducing insulator breakage both in assembly and in field use.

I have described my invention as applied to an angle type plug. However, I wish it to be understood that it is equally applicable to straight type spark plugs. In such a plug the upper portion of raised section **31** may have the same configuration as the lower portion and a gasket member similar to contralizing gasket **49** may be used.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted as may come within the scope of the claims which follow.

What is claimed is:

1. In an angle type unitary spark plug, the combination of a metal shell the bottom portion of which constitutes an annular ground electrode and having a seating ledge on its inner surface, a tubular metal member having angularly arranged portions secured to the top of said shell to form an angular tubular unitary metal body, an angle type ceramic insulator having a configuration generally corresponding to that of the inner surface of said body positioned therein, said insulator having a lower section and a raised upper section providing an upper and lower shoulder and a section extending laterally outward from said raised section and integral therewith, an axial bore in said upper and lower sections, a connecting axial bore in said laterally extending section, a center electrode secured in said first-mentioned bore, a metal centralizing member secured on the lower portion of said raised section and having its surface concentric and true with an axis through the center of the two axial extremities of said insulator, and a metal member on the upper end of said raised section having its surface true with said axis, the inner top surface of said tubular metal member being in abutment with said metal member to clamp said insulator on said ledge with substantially evenly distributed pressure in gas-tight relationship with said shell, said center electrode being accurately located concentric with said annular ground electrode, and the outer end of said laterally extending section being substantially concentric with said shield sleeve.

2. In an angle type unitary spark plug, the combination of a cylindrical metal shell the bottom portion of which constitutes an annular ground electrode and having a seating ledge on its inner surface, a mounting pad secured to said shell, a shield cap secured on the top of said shell and having a side opening formed therein, a shield sleeve secured within said opening at an angle to said shell to form an angular tubular unitary metal body, an angle type ceramic insulator positioned within said body and having a configuration generally corresponding to that of the inner surface thereof, said insulator having a lower section and a raised upper section providing an upper and lower shoulder and a section extending laterally outward from said raised section and integral therewith, an axial bore in said upper and lower sections, a connecting axial bore in said laterally extending section, a center electrode in said first-mentioned bore extending into said connecting bore, a metal centralizing gasket secured to the lower portion of said raised section and having its surface concentric and true with an axis through the center of the two axial extremities of the insulator,

and a metal gasket on the upper end of said raised section and having its surface true with said axis, the inner top surface of said shield cap being in abutment with said metal gasket to clamp said insulator on said ledge with substantially evenly distributed pressure and in gas-tight relationship with said shell, said center electrode being accurately located concentric with said annular ground electrode, and the outer end of said laterally extending section being substantially concentric with said shield sleeve.

3. In an angle type unitary spark plug, the combination of a cylindrical metal shell the bottom portion of which constitutes an annular ground electrode and having a conical seating ledge on its inner surface, a mounting pad telescopically secured to the top of said shell, a shield cap telescopically secured to said pad and cooperating therewith to form a side opening, a shield sleeve secured within said opening at an angle to said shell to form an angular tubular unitary metal body, an angle type ceramic insulator positioned within said body and having a configuration generally corresponding to that of the inner surface thereof, said insulator having a generally tapered lower section and a raised upper section providing an upper and lower shoulder, and having a section extending laterally outward from said raised section and integral therewith, an axial bore in said upper and lower sections, a connecting axial bore in said laterally extending section, a metal contact cap in said connecting bore, a center electrode in said first-mentioned bore, said electrode having threaded engagement with said contact cap, a generally cup-shaped metal centralizing gasket pressed on the lower portion of said raised section and having its wall and bottom surface concentric and true, respectively, with an axis through the center of the two axial extremities of the insulator, and a metal gasket on the upper end of said raised section and having its surface square with said axis, the inner top surface of said shield cap being in abutment with said metal gasket to clamp said insulator on said ledge with substantially evenly distributed pressure and in gas-tight relationship with said shell, said center electrode being accurately located concentric with said annular ground electrode, and the outer end of said laterally extending section being substantially concentric with said shield sleeve.

4. In an angle type unitary spark plug, the combination of a metal shell the bottom portion of which constitutes an annular ground electrode and having a seating ledge on its inner surface, a mounting pad secured to said shell, a shield cap secured on top of said shell and having a side opening formed therein, a shield sleeve secured within said opening at an angle to said shell to form an angular tubular unitary metal body, an angle type ceramic insulator having a configuration generally corresponding to that of the inner surface of said body positioned therein, said insulator having a lower section and a raised upper section providing an upper and lower shoulder and a section extending laterally outward from said raised section, said sections being formed as an integral unitary body, an axial bore in said upper and lower section, a connecting axial bore in said laterally extending section, a center electrode in said first-mentioned bore having its upper end positioned in said connecting bore, the inner top surface of said shield cap being in abutment wtih said insulator to clamp said lower shoulder on said ledge in gas tight relationship with said shell, said center electrode being accurately located concentric with said annular ground electrode and said insulator being substantially centralized within said body.

5. In an angle type unitary spark plug, the combination of a cylindrical metal shell the bottom portion of which constitutes an annular ground electrode and having a conical seating ledge on its inner surface, a cylindrical mounting pad telescopically secured to the top of said shell, a shield cap telescopically secured to said pad and cooperating therewith to form a side opening, a shield

sleeve secured within said opening at an angle to said shell to form an angular tubular unitary metal body with said shell, an angle type ceramic insulator positioned within said body and having a configuration generally corresponding to that of the inner surface thereof, said insulator having a generally tapered lower section and a raised upper section providing an upper and lower shoulder and a section extending laterally outward from said raised section, said sections being formed as an integral unitary body, an axial bore in said bore in said upper and lower section, a connecting axial bore in said laterally extending section, a metal contact member in said connecting bore, a center electrode in said first-mentioned bore secured to said contact member the inner top surface of said shield cap being in abutment with said insulator to clamp said lower shoulder on said ledge in gas tight relationship with said shell, and said center electrode being accurately located concentric with said annular ground electrode.

6. In the manufacture of a spark plug having an angle type unitary metal body and a correspondingly shaped insulator, said insulator having a generally tapered lower section, a raised upper section providing an upper and lower shoulder, and a section extending laterally outward from the raised section, intersecting axial bores being provided in the upper and lower sections and in the laterally extending section, the steps of molding the insulator blank of suitable material, firing said blank to sinter said material into a composite structure, pressing a metal centralizing gasket on the lower end of the insulator raised section, positioning said insulator in a lathe to revolve about an axis through the center of its two axial extremities, turning down the surface of said gasket concentric and true with said axis, pressing a metal gasket on the upper end of said insulator raised section and turning down its surface true with said axis an amount necessary to compensate for any warpage present in said laterally extending section, positioning the thus compensated insulator in the spark plug shell, assembling a mounting pad, shield cap and shield sleeve on the shell and about said insulator, applying end pressure to said shell through said shield cap to collapse an annular portion of the shell and clamp said insulator in gas-tight relationship therewith, positioning the center electrode

in the bore of said upper and lower insulator sections with the upper end of said electrode extending into the bore of said laterally extending section.

7. In the manufacture of a spark plug having an angle type unitary metal body and a correspondingly shaped insulator, said insulator having a generally tapered lower section, a raised upper section providing an upper and lower shoulder, and a section extending laterally outward from the raised section, intersecting axial bores being provided in the upper and lower sections and in the laterally extending section, the steps of molding the insulator blank of suitable heat resisting ceramic powder, firing said blank to sinter said powder into a composite structure, pressing a generally cup-shaped metal centralizing gasket on the lower end of the insulator raised section, positioning said insulator in a lathe to revolve about an axis through the center of its two axial extremities, turning down the wall and bottom surface of said gasket concentric and true, respectively, with said axis, pressing a metal gasket on the upper end of said insulator raised section and turning down its surface square with said axis an amount necessary to compensate for any warpage present in said laterally extending section, positioning the thus compensated insulator in the spark plug shell with its lower shoulder on a correspondingly shaped supporting ledge on the shell, telescopically assembling a mounting pad, shield cap and shield sleeve on the shell about said insulator, applying pressure to said upper shoulder through the shield cap to collapse an annular portion of said shell and clamp said insulator in gas-tight relationship with the shell, positioning a contact cap in the bore of said laterally extending insulator section, positioning the center electrode in the bore of said upper and lower insulator sections, and securing said electrode to said contact cap by threaded engagement of said electrode in said cap.

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