

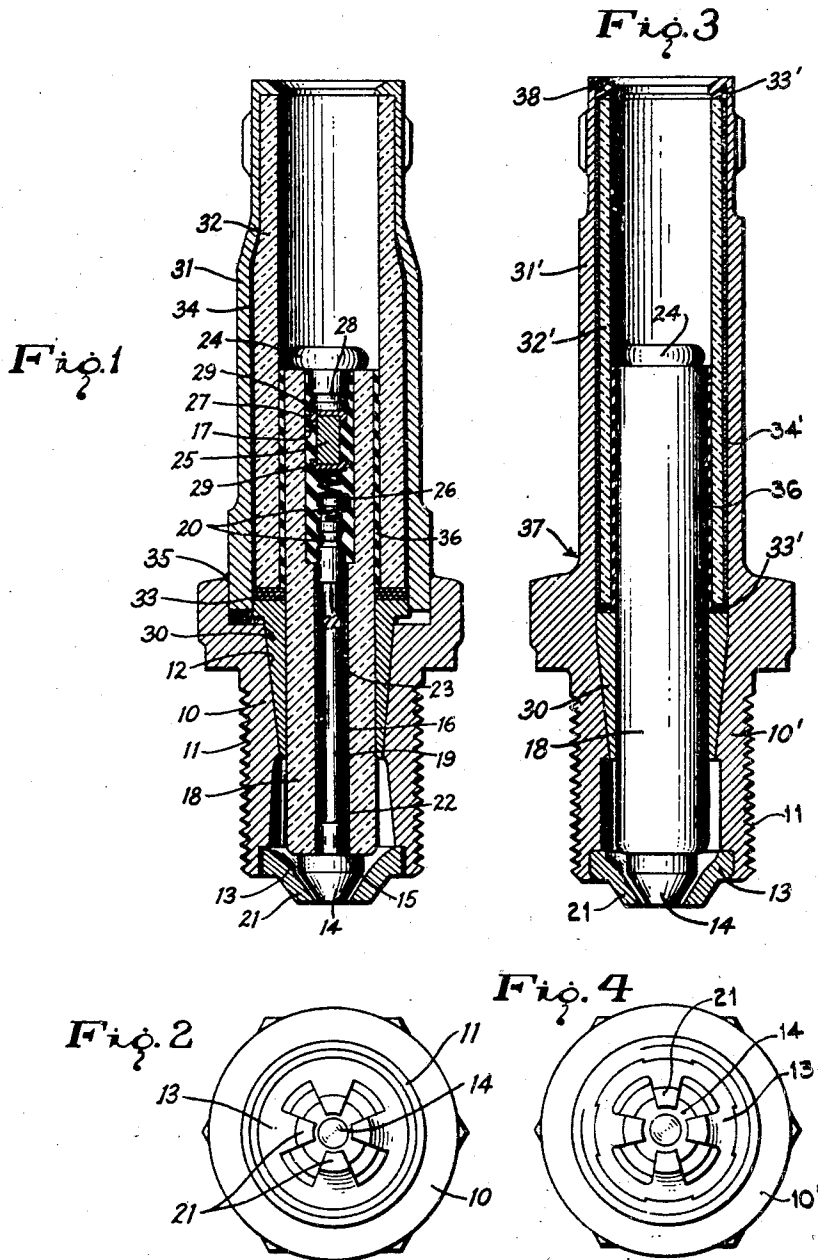
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SPARK PLUG AND METHOD OF MAKING THE SAME

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SPARK PLUG AND METHOD OF MAKING
THE SAME

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This invention relates to ignition apparatus and more particularly to spark plugs adapted for use in igniting the combustible charges in the cylinders of internal combustion engines and the like and to methods of making said spark plugs.

One object of the present invention is to provide a novel spark plug which is so constructed that the leakage of gas therethrough from an engine cylinder is wholly or substantially eliminated.

Another object of the invention is to provide a novel radio-shielded spark plug of simplified construction consisting of a relatively small number of parts.

Still another object is to provide a spark plug structure wherein means for reducing or retarding erosion of the electrodes thereof are incorporated in a novel manner.

A further object is to provide a novel center electrode assembly for a spark plug employing ceramic insulation whereby danger of any cracking of the ceramic during assembly or during operation due to wide temperature and pressure changes is reduced to a minimum.

A still further object is to provide an insulated electrode for a spark plug wherein novel means are utilized for centering the electrode in an insulator and enhancing the conduction of heat from the electrode to the insulator.

Another object is to provide novel means for securing an electrode in the bore of an insulator and sealing said bore against the passage of moisture and gases.

Another object is to provide a novelly constructed ground electrode in a spark plug whereby the efficient life of the plug may be materially enhanced.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended to define the limits of the invention, reference for this latter purpose being primarily had to the appended claims.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a half-sectional elevation view of one form of radio-shielded spark plug embodying the present invention;

Fig. 2 is a bottom end view of said spark plug;

Fig. 3 is a side elevation, partly in section, show-

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ing another form of spark plug embodying the invention; and

Fig. 4 is a bottom view of the spark plug shown in Fig. 3.

The invention is illustrated in the drawings, by way of example, as being embodied in radio-shielded spark plugs of the general type universally used in present day aircraft engines but it will be understood that the features of the invention are equally applicable to spark plugs which are not of the shielded type. In the embodiment shown in Fig. 1, the spark plug comprises a tubular metallic shell 10, which is externally threaded at 11 for cooperation with a threaded opening in an engine cylinder (not shown). The bore through shell 10 is provided with a tapered wall portion 12 for a purpose which will more fully appear hereinafter. A ground electrode 13 of any suitable known construction is secured in the lower end of shell 10 by means of silver solder or other suitable means.

Ground electrode 13 is in cooperative spark gap relation with the enlarged head portion 14 of a center electrode 15 which constitutes a part of novel conducting means mounted in the differential bore 16, 17 of a ceramic or like insulator 18 for conducting high tension electrical current therethrough. In the form shown, the head 14 of the center electrode engages the lower end of insulator 18 and the elongated spindle 19 thereof extends through the small or reduced portion 18 of bore 16, 17 and terminates in the larger portion 17 thereof. The upper end of spindle 19 is provided with one or more annular grooves 20 or other suitable deformations for a purpose to appear hereinafter.

In the molding and firing of insulators made of ceramics, aluminum or other metallic oxides and similar insulating materials from which insulator 18 may be fabricated, no means or method has yet been discovered whereby a finished spark plug insulator having exact predetermined dimensions can be consistently produced with any degree of certainty. In view of this fact, the spindles of center electrodes in prior spark plugs, for practical reasons dictated principally by production methods and operating conditions, have been slightly smaller than the bore of the insulator. This has been necessary, for example, to prevent cracking of the insulators due to the difference between the coefficients of expansion of the metal electrodes and the ceramic insulators but it induces leakage of gases through the plug. This difference in size often results in a slight longitudinal tilting of the electrode which, in turn,

throws the head 14 thereof out of center with respect to ground electrode 13, thereby disturbing the uniformity of the spark gap between the adjacent surfaces of head 14 and prongs 21 of the ground electrode and, hence, reducing the efficiency and operating life of the spark plug. Additionally, any space between the spindle and the walls of the bore in the insulator prevents good heat conduction from the spindle to the outer cooler portions of the plug, which, in turn, results in the heat being conducted from the hot gases and combustion in the engine cylinder to the insulated incoming or supply cable (not shown), the insulation of which generally deteriorates rapidly at high temperatures.

The present invention accordingly comprehends means for mounting center electrode 15 in insulator 18 in a novel manner whereby accurate centering of the electrode and good heat conduction therefrom are assured without subjecting the insulator to the danger of being cracked by expansion of the electrode. In the form illustrated, spindle 19 of the electrode has the diameter thereof slightly reduced for a major portion of the length thereof in bore 16 to form shoulders 22, 22. The diameter of spindle 19 adjacent the ends of said reduced portion, i. e. the diameter of said shoulders, is slightly less than the diameter of bore 16, the clearance of these parts in the bore being determined by the accuracy with which insulator 18 is constructed. The surface of the central reduced portion of spindle 19 is preferably roughened slightly, such as by sand-blasting, and several layers 23 of thin metallic foil or the like are wrapped around the same, the number of layers or turns being just sufficient to provide a tight siding fit in bore 16.

The wrapping of the foil or similar heat resisting sheet material on the body of spindle 19 between shoulders 22, 22 and the insertion of the spindle into the bore of the insulator may be effected by hand while holding the head 15 of the electrode in a tool or chuck, thereby providing sufficient leverage or torque to insure tight wrapping of the foil and a tight fit in the insulator. The foil layers 23 serve to center the electrode in bore 16 and act as a good conductor of heat between the electrode and the insulator. Said layers are sufficiently yieldable, however, in a radial direction to obviate any danger of cracking of the insulator by expansion of spindle 19 when the assembled parts are subjected to high temperatures during assembly of the remainder of the plug and during operation in an engine. Since the heat is conducted away from the nose 14 of the electrode more readily than in prior spark plugs the pre-ignition pressure of the engine is increased and a so-called "colder" spark plug is obtained.

Novel means are installed in bore 17 of insulator 18 in a novel manner for sealing said bore against leakage of gases therethrough, for holding electrode 15 in the insulator, and for conducting high tension electrical current to said electrode. In the form shown, current is conducted to electrode 15 from a suitable source through a metallic terminal 24, an electrical resistor or other suitable conductor 25 and a wire 26 of very small radial cross-section. The space around these conducting elements is completely filled with a suitable electrically non-conductive material 27 having a high melting point. The sealing material is a unitary rigid mass and has interlocking relation with spindle 19 at grooves 20 and with terminal 24 at groove 28, or other similar de-

formations in said spindle and terminal, to thereby hold the parts in assembled relation.

The use of resistor 25 is optional but is preferably provided for the purpose of reducing erosion of the active parts 14 and 21 of the electrodes 13 and 15. Said resistor may have a resistance value of anywhere from approximately 75 ohms to 10,000 ohms, but a value between 500 ohms and 1,000 ohms is most desirable for the purpose mentioned above. One resistor which has been found suitable is made by the Globar division of the Carborundum Company and is commercially known as "Globar type B" resistor. The resistor may be made of the similar material as the heating elements for electric furnaces, for example. The ends of resistor 25 may be protected by metal caps 29 or the like and these, in turn, may be coated with graphite or similar material to insure good electrical contact with terminal 24 and conductor 26. Although several suitable non-conducting sealing materials may be employed at 27, one which has been found to be particularly advantageous comprises a mixture of approximately five parts by weight of aluminum oxide, such as "Aloxite" cement No. 314 made by the Carborundum Company, and two parts by weight of lead oxide. These proportions are not critical, however. One of the considerations is to provide a sealing material which will become plastic-like or pasty only when heated to a temperature above the maximum operating temperature of the spark plug but below any temperature which might be detrimental to the spark plug parts. This result may be obtained by using a mixture consisting primarily of an insulator with a high melting point, such as aluminum oxide, which melts at approximately 2,050° C., and an insulator having a somewhat lower melting point, such as lead oxide, which melts at approximately 838° C. The aluminum oxide might be replaced in the above mixture by talc (magnesium aluminum silicate), magnesium oxide, bentonite, or other clays or, in general, any refractory oxide which is adapted to withstand temperatures comparable to those mentioned above without decomposing. The lead oxide component of the mixture may be replaced by any inorganic, non-conducting material having a melting point between approximately 900°-1800° F. When a mixture of the above character is heated to a temperature at or slightly above the melting point of the lead oxide or its equivalent, the latter becomes liquid and a pasty or plastic-like compound results which will not become glassy and brittle when it solidifies on cooling. The aluminum oxide or equivalent substitute gives strength to the mixture when it cools and solidifies to a unitary mass.

Conductor 26 may consist of a Nichrome or other suitable wire having a small diameter. A wire, commercially known as Driver-Harris Company No. 193 alloy having an outside diameter of .008" has been found suitable. One end of said wire is secured to the upper end of spindle 19 before the latter is inserted in insulator 18 and the free end thereof is coiled by winding the same around a suitable tool having a diameter somewhat smaller than that of bore 16. After electrode 15, with wire 26 attached thereto, is inserted into insulator 18 in the manner heretofore described, said wire is preferably extended until about three turns thereof remain in bore 17 and the same is then cut off substantially flush with the end of said insulator.

When the assembling of the parts has reached

the stage last mentioned above, bore 17 is filled with the sealing material 27 in finely divided powder form, the components thereof being thoroughly and intimately mixed with one another. A powder which will pass a 200 mesh screen has been found suitable. After the powdered material has been settled, such as by vibration of the assembly, tamping or the like, the same is placed in a chuck on a press and resistor 25 is set on the surface of the powder in contact with the coiled end of wire 26. Terminal 24 may be magnetically or otherwise suitably supported by the plunger of the press and lowered into engagement with the resistor. While a longitudinal compression pressure of approximately 50 pounds is being applied to the parts by the press, one or more gas flames are played on the outer surface of insulator 18 or other suitable heating means are employed to raise the temperature of the filling powder to the melting point of the lead oxide or other equivalent component of the powdered mixture having the lowest melting temperature. As the powder is rendered pasty by the melting of one of its components, resistor 25 and terminal 24 will be forced into final position by the applied pressure. When the parts reach the positions illustrated in the drawings, the source of heat is removed and as soon as the parts have cooled somewhat at normal room temperature, the center electrode assembly, completed except for minor machining operations, is removed from the press for mounting in shell 10.

The center electrode assembly, when thus sealed against the leakage of gases, is preferably mounted in shell 10 in such a manner as to prevent any gas leakage between insulator 18 and said shell. This mounting is effected by wedging a sleeve 30 of relatively soft metal, such as copper, between a surface of insulator 18 that is coated with a thin layer of powdered graphite or the like and tapered wall 12 in shell 10, said sleeve being held within the shell by a shielding barrel assembly consisting of a metallic barrel 31 surrounding a rigid insulating sleeve 32. Barrel 31 may be silver-soldered, as at 35, or otherwise suitably secured in shell 10. Annular shims 33 made of mica, asbestos or the like may be interposed between insulating sleeve 32 and metallic sleeve 30 to insure proper longitudinal dimensions of the spark plug. For the purpose of centering sleeve 32 in barrel 31, any space between these parts is preferably taken up by one or more layers 34 of sheet asbestos or the like wrapped around said insulating sleeve.

In assembling the insulated center electrode, shell 10 and shielding barrel assembly 31, 32, the center electrode assembly is loosely inserted into shell or body 10, the latter being threaded into or otherwise suitably held by a fixture adapted to position the center electrode assembly in proper axial relation to said shell. Copper bushing or sleeve 30 is inserted over insulator 18 into shell 10 between tapered surface 12 and the outer graphite coated surface of insulator 18. In order to avoid any possibility of the insulated center electrode being dislodged by pressure within an engine cylinder, the outer surface of insulator 18 engaged by sleeve 30 is preferably provided with a slight taper. A taper of .010" over the whole length of the insulator is sufficient, the smallest diameter being at the upper or outer end adjacent terminal 24. The inner diameter of sleeve 30 is preferably somewhat greater than the outer diameter of insulator 18 to facilitate assembly and, hence, rests initially upon tapered surface 12 of shell 10.

The shielding assembly 31, 32, 33 is inserted

in the upper, enlarged bore of shell 10 after the adjacent surfaces of barrel 31 and shell 10 have been coated with a suitable soldering flux and a ring of silver solder or its equivalent is then placed on the upper end of shell 10 in close proximity to the base of barrel 31. The central portion of the entire assembly comprising sleeve 30 and the lower end of barrel 31 is then heated, such as by means of a "Lepel" coil or gas flames, to or above the melting temperature of the silver solder, i. e., approximately 1,300° F. Electric induction heating as effected by a "Lepel" coil is preferable since it localizes the heat and heats both the internal and external parts quickly with substantial uniformity.

While the parts are thus heated to effect the melting of the solder 35 to thereby join shell 10 and barrel 31, a pressure of approximately 1,500 lbs. is applied to the top of shielding assembly 30, 31, thus forcing the latter against the soft metallic sleeve or bushing 30 and causing the latter to wedge firmly between the tapered wall 12 of shell 10 and the slightly tapered outer surface of insulator 18. This insures substantially perfect sealing against gas leakage around the center electrode assembly and locks the ceramic insulator in position relative to shell 10, said position being determined by the shell holding fixture which fixes the shell and center electrode assembly against relative axial movement during the application of pressure to sleeve 30. The pressure is maintained after termination of the heating until the parts have cooled sufficiently to permit solidification of solder 35 so that it will hold the parts in assembled relation. By reason of the fact that the bodily expansion of sleeve or bushing 30 is relied upon to fill the tapered annular space between surface 12 of shell 10 and insulator 18, it will be seen that exact dimensions for the parts are not essential.

The assembly of the spark plug is completed by installing ground electrode 13 in shell 10 in spark gap relation with the head 14 of center electrode 15. The ground electrode may be secured in the shell by means of silver solder or any other suitable means known in the art.

If desired, the annular space between insulator 18 and insulating sleeve 32 may be filled with a suitable insulating compound 36. Suitable compounds for this purpose may consist of polymerized cashew-nut-shell oil or polymerized linseed oil mixed with a suitable drying agent which will cause the polymerized oil to solidify through chemical reaction. Such mixtures may be inserted under vacuum in liquid form or the same may be poured into the bore of shielding assembly 31, 32 and then subjected to pressure. Solidification may be accelerated by application of heat.

The structure of the spark plug embodying the present invention may be modified in accordance with the illustration of Fig. 3 wherein the shell 10' and shielding barrel 31' are formed integrally as a unitary element 37. In assembling this modified structure, the necessary pressure for wedging sleeve 30 into place may be accomplished by extending a force transmitting sleeve or the like through barrel 31' into engagement with sleeve or bushing 30. Thereafter, insulating sleeve 32', 34' and any necessary shims 33', 33' are inserted in barrel 31' and the outer end of the latter is spun inwardly to form a retaining flange 38. Shims 33' may consist of mica or asbestos washers or other equivalent material.

There is thus provided a novel spark plug wherein the deleterious effects of high tempera-

tures and pressures to which the same is subjected during operation in an engine are materially reduced and wherein the deterioration of the electrode surfaces is reduced to a minimum. Also, this novel spark plug is fabricated from a small number of simple and rugged parts and embodies novel means for mounting and sealing the center electrode assembly in the spark plug shell. There is also provided a novel center electrode assembly for a spark plug wherein the bore of the insulator is sealed against gas leakage therethrough in a novel manner.

Although only two modifications of the invention are illustrated and described, it is to be expressly understood that the same is not limited thereto. For example, it will now be apparent to those skilled in the art that the invention is equally as applicable to unshielded spark plugs and other types of shielded spark plugs as it is to the specific types shown. It will also be apparent that materials other than those specifically mentioned may be used for sealing purposes and for the purpose of centering certain parts with respect to others without departing from the invention. Various changes may also be made in the design and arrangement of parts illustrated without departing from the spirit and scope of the invention. For a definition of the limits of the invention, reference is had primarily to the appended claims.

What is claimed is:

1. A spark plug comprising a cylinder engaging shell, a ground electrode secured in said shell, a center electrode assembly comprising a rigid tubular insulator, a metallic conducting spindle in said insulator, said spindle terminating at one end intermediate the ends of said insulator and having an enlarged head portion at the other end thereof in spark gap relation with said ground electrode and in engagement with a laterally extending surface of said insulator, radially yieldable means, such as a plurality of layers of metallic sheet material, surrounding a portion of said spindle for centering the same in the bore of said insulator, a metallic terminal extending into the bore of said insulator, a rigid mass of non-conducting filling material comprising aluminum oxide and lead oxide in the bore of said insulator between said terminal and spindle, said mass having interlocking relation with said terminal and spindle, conducting means embedded in said mass for electrically connecting said terminal and spindle, said conducting means including an electrical resistor having a resistance in excess of 75 ohms and a wire of small diameter, a tapered sleeve of deformable metal wedged between said insulator and a tapered internal wall of said shell for supporting said electrode assembly in said shell, and means secured in said shell for holding said sleeve against movement out of said shell, said last-named means comprising a metallic shielding barrel and an insulating liner therefor, said liner including a rigid insulating tube placed end to end with at least one slightly yieldable insulating washer and a filling of sheet material for centering said rigid tube in said barrel.

2. A spark plug comprising a cylinder engaging shell, a ground electrode secured in said shell, and a center electrode assembly in said shell comprising a rigid tubular insulator, a metallic conducting spindle in said insulator, said spindle terminating at one end intermediate the ends of said insulator and having an

enlarged head portion at the other end thereof in spark gap relation with said ground electrode and in engagement with a laterally extending surface of said insulator, radially yieldable means, such as a plurality of layers of metallic sheet material, surrounding a portion of said spindle for centering the same in the bore of said insulator, a metallic terminal extending into the bore of said insulator, a rigid mass of non-conducting filling material comprising aluminum and lead oxides in the bore of said insulator between said terminal and spindle, said mass having interlocking relation with said terminal and spindle, and conducting means embedded in said mass for electrically connecting said terminal and spindle, said conducting means including an electrical resistor having a resistance in excess of 75 ohms and a conducting wire of small diameter.

3. A spark plug comprising a tubular shell, a ground electrode secured in said shell, and a center electrode assembly in said shell comprising an insulating tube, an electrically conducting spindle extending into said tube and having one end thereof in spark gap relation with said electrode, said spindle terminating intermediate the ends of said tube, a terminal member extending into said tube in spaced relation with said spindle, means including a fine wire for electrically connecting said spindle and terminal member and a rigid mass of electrically non-conductive material sealing the bore of said tube around said wire and having interlocking relation with said spindle and terminal member for holding the same in assembled relation.

4. In a spark plug, a tubular insulator, a center electrode in said insulator with one end thereof terminating intermediate the ends of said insulator, means surrounding a portion of said electrode for centering the same in the bore of said insulator, a terminal at the end of said insulator in spaced relation with said end of said electrode, means for electrically connecting said terminal and said electrode comprising an electrical conductor of small transverse cross-section, and a rigid mass of electrically non-conductive materials surrounding said conductor and having interlocking relation with said terminal and electrode.

5. In a spark plug, a tubular insulator, a center electrode in said insulator with one end thereof terminating intermediate the ends of said insulator, means surrounding a portion of said electrode for centering the same in the bore of said insulator, a terminal at the end of said insulator in spaced relation with said end of said electrode, means for electrically connecting said terminal and said electrode comprising an electrical conductor of small transverse cross-section, and a rigid mass of electrically non-conductive materials surrounding said conductor and having interlocking relation with said terminal and electrode, said connecting means also including an electrical resistor having a value in excess of 75 ohms embedded in said rigid mass.

6. In a spark plug, a tubular insulator, current conducting means extending through the bore of said insulator including a metallic electrode having an elongated spindle in said bore, and one or more layers of thin flexible, electrically conductive, heat transmitting, compressible sheet material surrounding a portion of said spindle and substantially filling the annular space between said portion and the wall of said bore.

7. In a spark plug, a rigid tubular insulator, a rigid metallic conductor extending through at least a portion of the bore of said insulator, and means for centering said conductor in said bore comprising a plurality of layers of metallic foil surrounding said conductor.

8. In a spark plug, a rigid insulator having a bore therethrough, means for conducting electrical current through said bore, including an electrode having a head portion disposed externally of said insulator and an elongated spindle of a diameter less than the diameter of said bore, said spindle having a reduced portion intermediate the ends thereof forming spaced annular shoulders thereon, and electrically conductive means comprising a plurality of layers of metallic sheet material surrounding the reduced portion of said spindle and disposed between said shoulders for centering said head portion with respect to said bore.

9. In a spark plug, an insulator having a bore therethrough, means for conducting electrical current through said bore, including an electrode having a head portion and an elongated spindle, and means surrounding said spindle for centering said head portion with respect to said bore, said last-named means comprising a plurality of layers of metallic foil surrounding said spindle within said bore.

10. In a spark plug, a tubular insulator, means for conducting electrical current through the bore of said insulator, including a rigid metallic spindle and a plurality of layers of metallic sheet material surrounding said spindle for a substantial portion of its length within said bore for centering said spindle in said bore.

11. In a spark plug, a tubular insulator, current conducting means extending through the bore of said insulator including a rigid metallic spindle, and radially-yieldable electrically-conductive means comprising a plurality of layers of metallic material in the clearance space around a portion of said spindle within said bore for centering said spindle in said bore.

12. In a spark plug, an insulator having a bore therethrough, a conducting spindle secured in said bore with one end thereof terminating intermediate the ends of said insulator, radially yieldable means surrounding said spindle for centering the latter in said bore, a terminal at the end of said insulator in spaced relation with said end of said spindle, means for electrically connecting said terminal and spindle, and a rigid mass of electrically non-conducting material sealing said bore around said connecting means and having interlocking relation with said spindle and terminal for holding the same in assembled relation.

13. A spark plug comprising a tubular shell, a ground electrode secured in said shell, and a center electrode assembly mounted in said shell and comprising an insulating tube, an electrically conductive spindle terminating intermediate the ends of the bore of said tube and having one end thereof in spark gap relation with said ground electrode, a terminal member extending into one end of said tube in spaced relation with the end of said spindle, means including a wire of small radial cross-section for electrically connecting said spindle and terminal member, and a rigid mass of electrically non-conductive material sealing the bore of said tube around said connecting means and having interlocking relation with said spindle and terminal member for hold-

ing the same in assembled relation, said wire and a portion of said non-conductive mass completely filling an appreciable longitudinal portion of the bore in said tube.

14. The method of making a spark plug which includes the steps of making a tubular insulator and a metallic electrode having an elongated spindle, wrapping a plurality of layers of metallic sheet material around at least a portion of said spindle, inserting said wrapped portion of said spindle in the bore of said insulator with said sheet material in close contact with the walls of said bore and securing said spindle in said bore.

15. The method of making a spark plug which includes the steps of molding a tubular insulator, making a metallic electrode having a spindle, wrapping a plurality of layers of metallic sheet material around at least a portion of said spindle, securing a fine, electrically conductive wire to one end of said spindle, inserting said spindle in the bore of said insulator with said sheet material in close contact with the walls of said bore and with said wire extending from one end of said bore, filling the bore of said insulator around said wire and a portion of said spindle with a powdered mixture of insulating materials having different melting temperatures, heating said mixture to a temperature equal to at least the melting temperature of the component of said mixture having the lowest melting temperature, and inserting electrically conductive terminal means into said bore in contact with said wire to embed at least a portion of said terminal means in said insulating mixture, and thereafter permitting said mixture to cool and solidify.

16. A spark plug comprising a shielding tube, asbestos sheeting snugly fitting inside the tube, a rigid insulator snugly fitting within the asbestos sheeting, insulation snugly fitting inside the insulator, another insulator snugly fitting within the insulation, and an electrode within the last named insulator and snugly fitted therein by means comprising a winding of flexible material, the arrangement of the parts presenting a substantially solid section adapted to minimize the effects of vibration and shock.

17. A spark plug comprising a shielding tube, asbestos sheeting snugly fitting inside the tube, a rigid insulator snugly fitting within the asbestos sheeting, insulation snugly fitting inside the insulator, another insulator snugly fitting within the insulation, and an electrode within the last named insulator and snugly fitted therein, the arrangement of the parts presenting a substantially solid section adapted to minimize the effects of vibration and shock.

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