

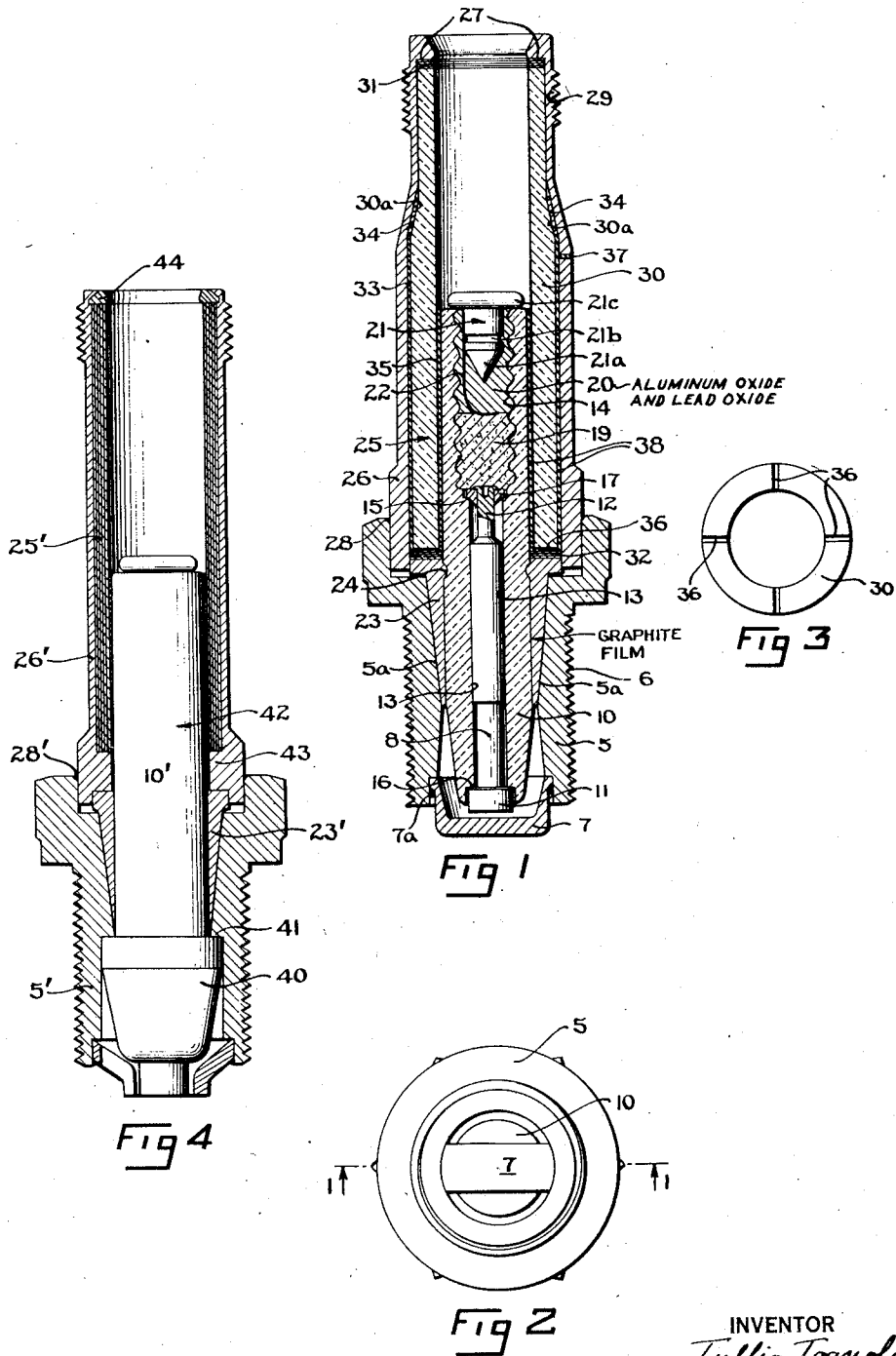
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SPARK PLUG AND METHOD OF MAKING THE SAME

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SPARK PLUG AND METHOD OF MAKING
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This invention relates to ignition apparatus and more particularly to spark plugs for internal combustion engines and the like and to methods of making said plugs.

One of the objects of the present invention is to provide a novel spark plug adapted to withstand high operation temperatures and pressures and one wherein gas leakage is substantially eliminated.

Another object is to provide a novel method of making a spark plug to render the same gas-tight under all operating conditions.

A further object of the invention is to provide a spark plug having a novel central electrode assembly which may be readily and inexpensively assembled.

A still further object is to provide a spark plug with novel means for securing and supporting the central electrode assembly in gas-tight engagement with the shell or outer body of the plug whereby the necessity for accurate machining of the parts is obviated.

A further object is to provide novel means and a novel method for insulating and mounting the central electrode of a spark plug relative to the shell or casing thereof whereby electrical losses and undesirable flash-overs are substantially eliminated.

Another object is to provide novel means in a spark plug for substantially eliminating gas leakage between adjoining metallic and ceramic surfaces.

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 drawing. It is to be expressly understood, however, that the drawing is for the purpose of illustration only and is not intended to define the limits of the invention, reference for this latter purpose being primarily had to the appended claims.

In the drawing, 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 plan view of said spark plug;

Fig. 3 is a bottom view of an insulating sleeve or liner mounted in said plug; and

Fig. 4 is a side view, partly in section, of another form of spark plug embodying the invention,

The invention is illustrated in the drawing, by way of example, in the form of a radio-shielded spark plug of the type used in aircraft engines. As shown in Fig. 1, the spark plug comprises a tubular metallic shell 5, which is externally threaded at 6 for cooperation with a threaded opening in an engine cylinder (not shown). The lower portion of the bore of said shell has walls which taper from the ends to a point intermediate the ends, the upper tapered surface 5a being provided for a novel purpose to appear more fully hereafter. Mounted in the lower end of body 5 is a ground electrode 7 which may be of any suitable type and is secured in place in any well-known manner, such as by silver solder 7a.

The novel and highly advantageous center electrode assembly comprehended by the invention comprises a central electrode 8 mounted in an insulator 10 of suitable ceramic or other heat-resisting insulating material, said electrode having a head 11 of enlarged diameter in spark gap relation with ground electrode 7 and a neck portion 12, preferably of decreased diameter, at the upper end thereof. Insulator 10 has a central bore 13, 14 provided with an intermediate cylindrical portion 13 of decreased diameter for receiving electrode 8, shoulders 15 and 16 being provided at the upper and lower ends, respectively, of said portion. The central longitudinal portion of electrode 8 preferably has a sliding fit in bore 13, whereas a portion thereof adjacent head 11 is slightly undercut and the circumference of said head is also cut so as not to touch the inner wall of insulator 10, thereby preventing any breakage of the latter upon heating to high temperatures during operation. Head 11 of said electrode engages shoulder 16, and neck portion 12 extends through a washer 17 of relatively soft or deformable metal, such as copper, which engages shoulder 15, the electrode being secured between said shoulders by rolling or riveting the upper end of neck 12 outwardly into engagement with the upper face of said washer. The upper end of said electrode is preferably recessed or counterbored to facilitate the rolling or riveting thereof. The pressure applied during the riveting operation is effective to squash washer 17 into close interlocking engagement with the rough surface of shoulder 15 and the rough broken edge of the rolled portion of spindle 8 bites into the upper surface of said washer, thereby preventing any undesirable turning of the center electrode relative to the insulator.

To prevent leakage of gases from the engine

cylinder through bore 13, 14 of insulator 10 and, at the same time, provide an electrical connection from the upper end of said insulator to electrode 8, the enlarged upper portion 14 of said bore is filled in a novel manner with a layer 19 of compressed conducting and sealing material, such as powdered graphite, in contact with washer 17 and electrode 8, and a layer 20 of suitable cement or sealing composition disposed above said graphite layer. The wall of bore portion 14 is preferably corrugated or threaded to facilitate molding of insulator 10 and to provide a good bond and a greater area of engagement between layers 19 and 20 and said bore wall, thereby minimizing the possibility of gas leakage and increasing the mechanical strength of the unit. A metallic terminal 21 preferably has the body thereof embedded in layer 20, said body being provided with a pointed end 21a for facilitating insertion into said layer and a peripheral groove 21b for increasing the effectiveness of the bond between the cement and the terminal. Head 21c of said terminal is adapted to engage the upper end of insulator 10 and covers bore 14. To electrically connect terminal 21 to graphite layer 19, a very small wire 22 of a suitable conducting material, such as Nichrome, is provided and has the outer end thereof compressed between head 21a and the upper end of insulator 10 and the other end in engagement with the upper surface of layer 19. It is preferable to provide a coil comprising a plurality of turns of said wire in engagement with layer 19 in order to insure good electrical contact between said wire and said layer. As will appear more fully hereafter, the compacted graphite or similar material is of such a nature as to intimately fill all crevices and minute pores and to form an excellent barrier to the passage of hot gases. The cement or filler 20 serves to provide the necessary mechanical strength to hold the graphite under pressure and to hold terminal 21 in position.

It is to be noted that ceramic insulator 10 has an outer wall which, except for groove 24 and a slight taper at the lower end thereof to form the nose, is cylindrical over its entire length and the wall thickness is relatively uniform in comparison to insulators heretofore used. This structure makes it possible to produce a more uniform insulator during fabrication thereof than would be possible if the latter were to have flanges or other abutments formed thereon. Particularly, it makes it easier to mold the insulators without violating desired dimension tolerances and, hence, obviates the necessity for any grinding thereof after molding and renders quick and satisfactory assembly of the parts possible.

Novel means are provided for securing insulator 10 in operative position within shell 5 and, as shown, comprise a tapered metallic bushing or sleeve 23 of deformable metal, such as copper, compressed in the space between the wall of insulator 10 and the tapered internal wall 5a of said shell. It is preferable to provide a peripheral groove 24 in the outer wall of said insulator adjacent the upper end of said sleeve, said groove being adapted to be filled with the metal of said sleeve. If desired, groove 24 may be eliminated. In the absence of such a groove or the equivalent, the outer surface of insulator 10 may be given a very slight taper where it is engaged by sleeve or wedge 23.

In order to insure a fluid-tight seal between

sleeve 23 and insulator 10, a film of graphite powder is preferably disposed between the engaging surfaces of said sleeve and insulator, said film filling the pores and irregularities of the ceramic insulator and metal, thereby eliminating possible gas leaks. A colloidal graphite powder or fine flake graphite may be employed in producing this novel structure.

To apply a compressive force to bushing 23 and hold the latter under pressure in operative engagement with insulator 10 and shell 5, novel means engage the upper end of said bushing and are secured to said shell. In the illustrated embodiment, said means also serve as radio-shielding and comprise a novel insulating sleeve 25, preferably surrounding the upper portion of insulator 10 and extending upwardly a substantial distance above the end thereof, and a metallic barrel 26 having an internally extending shoulder 27 at the upper end thereof for engaging the upper end of sleeve 25, thereby holding the lower end of said sleeve in engagement or operative relation with the upper flanged end of bushing 23. The lower end of barrel 26 extends into the bore of body 5 and is secured thereto by suitable means, such as silver solder 28. The upper end of said barrel is provided with threads 29 for cooperation with a shielding conduit for a cable (not shown) from a magneto or other source of electrical current.

Insulating sleeve 25 preferably comprises an elongated tube 30 of ceramic and a plurality of mica washers disposed in two groups 31 and 32 at the upper and lower ends, respectively, of said tube. The ceramic tube improves the heat resistance and electrical insulating properties of sleeve 25 while the mica washers cushion the tube against impacts and shocks and serve as shims or spacers for insuring exact dimensions for the length of shielding barrel 26 above body 5. It is to be understood, however, that sleeve 25 may be entirely ceramic or may be formed from the usual combination of mica washers and a tube of sheet mica.

If desired, the outer diameter of the upper end of the spark plug may be decreased (Fig. 1) by decreasing the thickness of the upper end of sleeve 25 while maintaining the inner diameter thereof constant, the outer wall of said sleeve having a conical section 25a joining the two portions of different diameters. Barrel 26 conforms substantially to the outer configuration of said sleeve and has the inner wall of the upper portion thereof in engagement with the outer wall of sleeve 25. An annular space 33 is preferably provided between the lower portions of said barrel and sleeve, and a gasket or ring 34, for example, of copper, is disposed at the upper end of said annular space, being compressed between the inclined walls of said sleeve and barrel. An annular space 35 is also preferably provided between sleeve 25 and central insulator 10, said space being connected to space 33 by passages adjacent the lower end of said sleeve, said passages being constituted by a plurality of radial slots or grooves 36 in the lower end of ceramic tube 30 (Fig. 3). One or more bleeder holes 37 may be provided in the wall of barrel 26 to connect with the upper end of annular space 33, and spaces 33 and 35 are preferably filled with a suitable insulating compound 38, such as polymerized cashew nut-shell oil.

A novel method of fabricating and assembling the elements of the above-described spark plug is provided whereby the necessity for accurate

machining of parts is eliminated and the speed of production is enhanced. Said method includes the steps of installing central electrode 8 in bore portion 13 of central insulator 10 and securing washer 17 to neck 12 of said electrode by rolling or spinning the recessed end of said electrode over against the face of said washer, the pressure employed for this operation being effective to deform said washer and securely fasten electrode 8 in position. A suitable measured amount of fine graphite powder is then inserted into bore portion 14 of said insulator and compressed to a hard body, said graphite when compressed preferably filling approximately half of the space provided in bore portion 14. Conducting wire 22 is then located in bore 14 so as to project therefrom about half an inch, said wire having a coiled portion thereof in contact with the upper surface of graphite layer 19 to insure good contact with the latter. A Nichrome wire having a diameter of approximately .008", the coiled portion having a diameter of about .016", has been found to be satisfactory for this purpose. After the wire is located in the bore, a suitable amount of sealing compound is introduced into bore portion 14 to form layer 20. One suitable cement or compound which has been found suitable for this purpose consists, by weight, of five parts "Alfrax" cement and two parts lead oxide, said ingredients being intimately mixed in powder form and then compressed into bore portion 18 until the space therein is completely filled. "Alfrax" cement is a substance consisting of approximately 85% aluminum oxide and 15% lead oxide. Accordingly, filler 20 consists of approximately 40% lead oxide which is fusible at 1200° F. or less and 60% aluminum oxide which is non-fusible at this temperature. When the former is fused by application of heat, the latter acts as a body to form a plastic mass. Both the graphite 19 and the material 20 may be inserted in bore 14 in the form of slightly compressed pills which are easily crushed by application of pressure.

Heat is then applied to the upper end of said insulator, for example, by a gas flame, until a temperature of approximately 1200° F. is reached, at which temperature the lead oxide content of filling material 20 fuses and renders the latter plastic in nature. The plastic filler is tamped down and replenished until bore 14 is full. Terminal 21 is then inserted gradually into the plastic and the application of heat is discontinued while the terminal is held in position under pressure until cement 20 cools and becomes solidified. Thereafter, the length of wire 22, which protrudes from beneath terminal head 21c, is removed.

After the electrode assembly has been thus assembled, the same is prepared for assembly with shell 5. To this end the surface of insulator 10 which is to contact bushing 23 is coated with a thin film of graphite powder, suitable precautions being taken to confine the application of said graphite powder to the surface adapted to engage bushing 23. For example, the upper end and the nose portion of said insulator may be provided with a coating of readily removable protective material, such as Scotch tape, or the same may be covered with sleeves during the application of the graphite. Any excess graphite is preferably removed by gently blowing on the coated surface.

The central electrode assembly, when completed in the above-described manner, is loosely

inserted into shell or body 5, the latter being threaded into a suitable fixture adapted to position said assembly in proper relation to said body. Copper bushing 23 is inserted over insulator 10 into shell 5, being located between tapered surface 5a of said shell and the graphite-coated portion of the surface of said insulator. The inner diameter of sleeve 23 is preferably slightly greater than the outer diameter of insulator 10 and, hence, rests upon tapered surface 5a of said shell 5.

To assemble radio-shielding 25, 26, mica washers 31, if the same are used, are first inserted into barrel 26 against shoulder 27, and tapered ring 34 is placed on sleeve 30 in engagement with tapered portion 30a thereof. Thereafter, said sleeve with the ring thereon is inserted into barrel 26 to bear against washers 31, and mica washer stack 32 is located in said barrel to bear against the lower end of tube 30 or around insulator 10 in engagement with bushing 23. Barrel assembly 25, 26 when completed in this manner is placed over the upper end of insulator 10 and inserted into the upper end of shell 5. The lower portion of barrel 26 is preferably coated with a soldering flux and a ring of silver solder is dropped over said barrel to rest on the upper end of body 5. The upper part of the latter is then heated, for example, by a "Lepel" coil or gas flames to the melting temperature of the silver solder, i. e., approximately 1300° F.

While shell 5 is thus heated for the soldering or brazing operation, a pressure of approximately 1500 lbs. is applied to the top of barrel assembly 25, 26, thus forcing the latter against soft metal bushing 23 and causing the latter to wedge firmly between said shell and insulator 10 and to fill annular groove 24. This insures substantially perfect sealing against gas leakage around the electrode assembly and locks the ceramic in the position relative to shell 5 determined by the shell holding fixture. The pressure is maintained after termination of the heating until the shell has cooled sufficiently to permit solidification of silver solder 28 so that it will hold the parts in assembled relation. The groove 24 may be eliminated since the pressure of sleeve 23 against insulator 10 is sufficient to hold the latter in position. By reason of the fact that the bodily expansion of bushing 23 is relied upon to fill the space between insulator 10 and shell 5, it will be seen that exact dimensions for the parts are not essential.

The assembly of the plug is completed by installing ground electrode 7, soldering the latter by means of a silver solder to shell 5, and cleaning the chamfer of the plug with hot water to remove excess silver solder. However, if desired, spaces 33 and 35 or either of them may be filled with a suitable insulating compound 38. The latter may be inserted under vacuum in liquid form or poured into the bore of barrel assembly 25, 26 and then subjected to pressure. As a result, said compound fills space 35 and flows through passages 36 to fill space 33, the air being exhausted from the latter through bleeder hole or holes 37. Each of the latter is preferably approximately .04" in diameter.

A modified form of spark plug embodying the present invention is illustrated in Fig. 4, the center electrode assembly thereof being the same as that illustrated in Fig. 1 except that groove 24 is not provided in insulator 10' and the nose 40 of the latter is enlarged to engage an internal shoulder 41 in shell 5'. During the assembly of

shell 5 and center electrode assembly 42, pressure is applied to metallic bushing or wedge 23' through an internal flange 43 near the lower end of metallic shielding barrel 26' which is secured in shell 5' by brazing or soldering at 28'. Barrel 26' may be lined with an insulating sleeve 25' consisting of coiled sheet mica or other suitable insulating material. Said liner 25' rests against the upper surface of flange 43 and is held in place by a ring 44 secured in any suitable manner in the upper end of barrel 26'. Any space immediately surrounding the upper end of insulator 10' may be filled with a suitable insulating compound, such as 38 in Fig. 1.

It will be noted that by using the lower end of barrel 26' or a similar part in either of the illustrated embodiments of the invention, an unshielded spark plug may be readily provided. The method of assembling the spark plug illustrated in Fig. 4 is substantially the same as that described above in connection with the embodiment of Fig. 1. In the second embodiment, however, the center electrode assembly is positioned relative to shell 5' by the engagement of the former with shoulder 41 of the shell. The insulating sleeve 25' may be inserted either before or after the assembly of the remainder of the plug.

There is thus provided a novel spark plug wherein the deleterious effects of high temperatures and pressures are reduced to a minimum, said spark plug being fabricated from a small number of simple and rugged parts and having novel means for mounting and sealing around the central electrode assembly thereof. There is also provided a novel central electrode assembly having novel means for sealing the bore of the insulator containing the electrode. The invention comprehends the provision of a novel method for producing a gas-tight bond between a ceramic surface and a metallic surface and there is additionally provided a novel method for making spark plugs and the central electrode assemblies therefor and for securing and sealing the parts thereof.

Although only two embodiments 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 plugs as it is to the specific types shown. Various changes may also be made in the design and arrangement of parts illustrated and in some of the particular materials specified 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 unitary 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, a comparatively soft metallic ring surrounding said one end of the spindle and pressed between an internal shoulder in said insulator and an outwardly rolled portion of said spindle, a compacted layer of powdered graphite in said insula-

tor adjacent the end of said spindle, a rigid mass of non-conducting filling material comprising aluminum and lead oxides in said insulator adjacent said layer, a terminal pin projecting into said insulator and partially embedded in said rigid mass and an electrical conductor of small cross-section extending through said rigid mass and contacting said graphite layer and terminal pin, a tapered sleeve of deformable metal wedged between said insulator and a tapered wall of said shell, said sleeve constituting the sole means for supporting said electrode assembly in said shell, a thin layer of powdered graphite interposed between the engaging surfaces of said insulator and sleeve, 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 ceramic tube placed end to end with at least one yieldable stack of insulating washers.

2. A spark plug comprising a tubular shell, a ground electrode secured in said shell, a center electrode assembly comprising an insulating tube, an electrically conducting spindle secured in said tube for cooperation with said electrode, said spindle terminating intermediate the ends of said tube, a compacted mass of finely divided electrically conducting particles completely filling a portion of the bore of said tube adjacent the end of said spindle, a terminal pin extending into said tube in spaced relation with said compacted mass, a fine wire electrically connecting said mass and pin, a rigid mass completely filling the space in said tube around said wire and between said terminal pin and compacted mass, a sleeve of deformable metal having a tapering wall thickness wedged between said tube and a tapered internal wall of said shell, said sleeve constituting means for supporting said electrode assembly in said shell, a thin layer of finely divided particles interposed between the engaging surfaces of said tube and sleeve, and means secured in said shell for holding said sleeve against movement out of said shell.

3. In a spark plug, a tubular insulator, a center electrode secured in said insulator with one end thereof terminating intermediate the ends of said insulator, a terminal at the end of said insulator in spaced relation to said electrode, means for electrically connecting said terminal and electrode comprising a compacted mass of powdered conducting material filling a portion of the bore of said insulator and an electrical conductor of small transverse cross-section, and a rigid mass of non-conducting materials surrounding said conductor and filling the space in said insulator between said terminal and said compacted mass.

4. 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, a compacted mass of conducting material completely filling a portion of said bore adjacent the end of said spindle, a terminal at the end of said insulator, a small conductor connecting said terminal and said mass, and a rigid mass in said bore for holding said compacted mass, said conductor and said terminal in fixed relation to said insulator.

5. In a spark plug, a center electrode assembly comprising a tubular electrical insulator, a conducting spindle fixed in said insulator, one end of said spindle terminating intermediate the ends of said insulator, means for sealing the bore of said insulator against leakage of gases there-

through comprising a mass of finely ground electrical conducting material filling a portion of said bore adjacent the end of said spindle and non-conducting means in said bore for holding said mass in position in said insulator, a terminal, and means including said mass for electrically connecting said terminal and said spindle.

6. In a spark plug, a tubular insulator, a conducting spindle secured in said insulator, a compacted mass of finely divided electrically conducting particles filling a portion of the bore of said insulator adjacent the end of said spindle, rigid means adapted to become plastic only at temperatures higher than the maximum temperature to which the same is subjected during use filling a portion of said bore adjacent said mass, a terminal partially embedded in said rigid means, and a hair-like conductor extending through said rigid means for electrically connecting said terminal and mass.

7. In a spark plug, a tube of electrical insulating material, a conducting spindle extending partially through said tube and secured therein, a compacted mass of high heat-resisting finely divided particles filling a portion of the bore of said tube, and a second mass substantially filling a portion of said tube adjacent said first mass and having interlocking relation with said tube, said second mass being rigid at temperatures below those to which it is subjected during use of the spark plug and plastic in nature at and above some higher temperature.

8. In a spark plug, a center electrode assembly comprising a tubular insulator, and means for sealing the bore of said tube against the leakage of gases therethrough comprising superposed masses of compacted graphite and a hardened rigid substance comprising a mixture of aluminum and lead oxides.

9. In a spark plug, a center electrode assembly comprising a unitary tubular insulator, a conducting spindle fixed in said insulator, and means for sealing the bore of said insulator against leakage of gases therethrough comprising a compacted layer of finely divided electrically conducting particles completely filling an appreciable portion of the bore of said insulator measured longitudinally thereof and an adjacent layer of non-conducting fusible material.

10. In a spark plug, a center electrode assembly comprising a tubular insulator, means for sealing the bore of said insulator against leakage of gases therethrough comprising a rigid mass filling an appreciable portion of said bore measured longitudinally thereof, said mass being constituted by a mixture of lead oxide and finely divided particles of at least one other substance having a melting point higher than the melting point of lead oxide, and a fine wire of electrically conducting material extending through said mass.

11. In a spark plug, a tubular metallic shell having a ground electrode thereon, a center electrode assembly comprising a spindle in spark gap relation with said electrode and an insulator surrounding said spindle, and means for supporting said assembly in said shell constituted substantially by a unitary mass of deformable metal wedged between said insulator and an internal wall of said shell, the sole connection between said insulator and mass being the gripping action created by the wedging of said mass between the insulator and shell.

12. In a spark plug, a tubular metallic shell having a ground electrode thereon, a center electrode assembly comprising a spindle in spark gap

relation with said electrode and a rigid unitary insulator surrounding said spindle, and means for supporting said assembly in said shell constituted by a unitary mass of deformable metal wedged between said insulator and an internal wall of said shell, a portion of said mass extending into a depression in the outer surface of said insulator, the sole connection between said insulator and said mass being that created by the wedging of said mass against said insulator.

13. In a spark plug, a tubular metallic shell having a ground electrode thereon, a center electrode assembly comprising a spindle in spark gap relation with said electrode and a rigid unitary insulator surrounding said spindle, and means for supporting said assembly in said shell constituted substantially by an annular mass of readily deformable metal, such as copper, wedged between said insulator and a tapered internal wall of said shell, the sole connection between said insulator and said mass being that created by the wedging of said mass between said insulator and said shell.

14. In a spark plug, a tubular metallic shell having a ground electrode thereon, an insulated center electrode and means for supporting the latter in spark gap relation with said ground electrode comprising a tubular mass of comparatively soft metal, such as copper, pressed between said shell and the insulator surrounding said center electrode, the sole connection between said insulator and said tubular mass being that created by the pressing of said mass between said shell and said insulator, and means secured in said shell for holding said mass in position independently of said insulated center electrode.

15. In a spark plug, a tubular metallic shell, a center electrode and insulating means interposed between said shell and electrode, metallic means contacting said insulating means, and a thin film of finely divided particles on the surface of said insulator engaging said metallic means.

16. In a spark plug, a tubular shell, a center electrode assembly comprising a center electrode and insulating means interposed between said shell and electrode, a metallic sleeve surrounding said insulating means and having a press fit thereon, and a coating of finely divided graphite between the adjacent surfaces of said sleeve and insulating means.

17. The method of making a spark plug which comprises the steps of making a tubular insulator, securing an electrode in a portion of the bore of said insulator, compressing a layer of finely divided graphite in said bore adjacent the end of said electrode, placing a fine wire in contact with said layer, the ends of said wire projecting from said insulator, filling the remaining portion of said bore with a mixture comprising aluminum and lead oxides, heating said mixture to the fusing temperature of said lead oxide to convert said mixture into a mass which is plastic in nature, inserting a terminal pin into said plastic mass and into contact with said wire, and permitting said plastic mass to solidify.

18. The method of making a spark plug which comprises the steps of making a tubular insulator, securing an electrode in a portion of the bore thereof, inserting a quantity of graphite in said bore adjacent the end of said electrode, subjecting said graphite to pressure to compact the same, placing an electrical conductor of small cross-section in said bore in contact with said graphite, inserting a quantity of material having a fusible

component in said bore, applying heat to said material to fuse said component and render said material plastic in nature, and pressing a terminal into said material and into contact with said conductor before said material solidifies.

19. The method of making a spark plug which comprises the steps of making a hollow electrical insulator, inserting a quantity of graphite in said insulator, subjecting said graphite to pressure to compact the same into a layer completely filling a central portion of said insulator, placing an electrical conductor of small cross-section in said insulator in contact with said graphite, inserting a quantity of material having a fusible component in said insulator, applying heat to fuse said component, and inserting a terminal into said insulator into electrical contact with said conductor before said component solidifies.

20. The method of making a spark plug which comprises the steps of making a tubular insulator, securing an electrode in a portion of the bore thereof, inserting a quantity of electrical conducting material in said bore adjacent the end of said electrode, subjecting said material to pressure to crush and compact the same into a layer completely filling a longitudinal portion of said bore, placing a hair-like electrical conductor of small cross-section in said bore in contact with said layer, inserting a quantity of a substance having a fusible component in said bore, applying heat to said substance to fuse said component and render the substance plastic in nature, and inserting a terminal in said bore into electrical contact with said conductor before said substance solidifies.

21. The method of making a spark plug which comprises the steps of making a tubular metallic shell having a tapered internal wall portion, positioning a cylindrical insulator in said shell, placing a metallic sleeve of deformable material, such as copper, between said insulator and said tapered wall portion, and applying pressure to said sleeve while heating said shell and sleeve to thereby wedge said sleeve between said shell and insulator.

22. The method of making a spark plug which comprises making a tubular metallic shell having a tapered internal wall portion, inserting an electrical insulator and a metallic sleeve in said shell, said sleeve having a loose sliding fit on said insulator and having an external surface engaging said tapering wall portion, heating said shell and sleeve, applying pressure to said sleeve during the application of heat to wedge the sleeve between said wall and insulator while holding the latter in a predetermined position relative to said shell, and continuing the application of pressure until said sleeve and shell have cooled.

23. The method of making a spark plug which includes the steps of making a tubular shell having a tapered internal wall portion, inserting an electrical insulator and a metallic sleeve into said shell, said sleeve having a loose sliding fit on said insulator and a tapered external surface engaging said wall portion, inserting means including an annular metallic portion into the end of said shell into engagement with said sleeve, applying heat to said shell and sleeve, applying pressure to said means during the application of heat to wedge said sleeve between said wall portion and insulator, and brazing said annular metallic portion to said shell before discontinuing the application of pressure.

24. The method of making a spark plug which comprises making a tubular shell having a ta-

pered internal wall portion, inserting an electrical insulator and a metallic sleeve into said shell, said sleeve being positioned between said insulator and said tapered wall portion, inserting a rigid tubular insulating lining into a metallic shielding barrel, inserting the end of said barrel into said shell, heating said shell and sleeve, applying pressure through said insulating liner to said sleeve during the application of heat to wedge said sleeve between said shell and insulator, and brazing said barrel to said shell during said application of pressure.

25. The steps of making a spark plug which include making an insulator, applying a coating of finely divided graphite to an annular portion of the surface of said insulator, placing a metallic sleeve around said surface, and pressing said sleeve into intimate contact with said surface while heating the same.

26. In a spark plug, a center electrode assembly comprising a tubular one-piece insulator having a differential bore therethrough forming an internal shoulder intermediate the ends of the insulator, a conducting spindle in said insulator having an enlarged head portion adjacent one end thereof engaging a laterally extending surface of said insulator, the remainder of said spindle having a central portion with a sliding fit in a portion of said differential bore having a small diameter and a reduced portion of smaller diameter than said bore at the other end thereof, said reduced portion terminating in a portion of said bore having a large diameter, and a comparatively soft metallic element surrounding said reduced portion of the spindle and clamped between said shoulder and an outwardly pressed portion of the reduced end of said spindle, said element having an annular portion between the inner and outer peripheries thereof in biting engagement with the corner of said shoulder.

27. In a spark plug, a center electrode assembly comprising a tubular one-piece insulator having a differential bore therethrough forming an internal shoulder intermediate the ends of the insulator, a conducting spindle extending through the smaller portion of said bore and terminating adjacent said shoulder, the inner end of said spindle being of smaller diameter than the small portion of said bore, and a comparatively soft metallic element surrounding the inner end of said spindle and clamped between a laterally extending surface of said shoulder and an outwardly pressed portion of the end of said spindle, said element having a cone-like portion extending into the smaller bore of said insulator and pressed into biting engagement with the corner of said shoulder.

28. In a spark plug, a center electrode assembly comprising a tubular one-piece insulator, a conducting spindle in said insulator having an enlarged head portion adjacent one end thereof engaging a laterally extending surface of said insulator, the remainder of said spindle including a central portion with a sliding fit in the bore of said insulator and a reduced portion adjacent said enlarged head portion having a smaller diameter than the internal diameter of the insulator bore surrounding the same, and means for securing said spindle in said insulator.

29. In a spark plug, a center electrode assembly comprising tubular electrical insulating means, a conducting spindle in the bore of said insulating means terminating intermediate the ends of the latter, means for sealing said bore against leakage of gases therethrough comprising a mass

of electrically conducting material completely filling a portion of said bore, said mass having sealing engagement with the walls of said bore and electrical contact with said spindle, and rigid non-conducting means holding said mass in position in said insulating means, means constituting a terminal extending into the bore of said insulating means, and means comprising a fine wire-like conductor extending through said non-conducting means for electrically connecting said terminal and said mass.

30. In a spark plug, a center electrode assembly including tubular insulating means, an electrode in the bore of said insulating means comprising conducting members extending into said bore from opposite ends thereof and terminating in spaced relation to each other within the bore and conducting means including an elongated hair-like element connecting said members, and a unitary non-conducting sealing mass completely filling said bore around at least portions of said element and one of said members for securing the latter and said element in said bore.

31. In a spark plug, a center electrode assembly comprising an insulator having a bore therethrough, electrically conducting means extending through said bore, said conducting means including spaced conducting members and means for electrically connecting said members within said bore, said connecting means including an elongated conductor of very small transverse cross-section as compared to the transverse cross-section of said bore, and rigid sealing means molded into said bore around said conductor, said sealing means being adapted to be rendered plastic by heat.

32. A spark plug comprising insulating means having a bore therein, electrode means in said bore comprising a lower section having an end serving as a sparking electrode, an upper section constituting a terminal for connection with a suitable lead, an intermediate electrically conducting seal for said bore in contact with one of said sections and an elongated wire-like element of small transverse cross-section electrically connecting said seal and the other of said sections, and non-conducting sealing means completely filling a longitudinal portion of said bore around said element.

33. A spark plug comprising insulating means having a bore therein, conducting means extending through said bore, a central portion of said conducting means being constituted by a wire-like conductor, and non-conducting fusible sealing means molded into and completely filling an axially extending portion of said bore around said conductor.

34. In a spark plug, insulating means, a thin film of finely divided particles on the surface of said insulating means, and metallic means pressed against said surface for preventing gas leakage between said insulating means and said metallic means.

35. The method of making a spark plug which comprises the steps of making tubular insulating means, compressing a layer of electrically conducting material in said bore to seal the same, placing a wire-like conductor in said bore in contact with said layer, inserting a non-conducting substance having a fusible component in said bore, applying heat to said substance to fuse said component, and permitting said substance to cool and seal said bore around said conductor.

36. The method of making a spark plug which comprises the steps of making a tubular metallic shell having a tapered internal wall portion, positioning a rigid insulator, such as ceramic, in said shell, placing a metallic sleeve of deformable material in contact with said insulator between the latter and said tapered wall portion, and applying pressure to said sleeve in a direction parallel to the axis thereof while holding said insulator against axial movement relative to said shell to thereby wedge said sleeve between said shell and insulator.

37. A method of making a spark plug which comprises the steps of making a tubular metallic shell, inserting an electrical insulator and a metallic sleeve in said shell, said sleeve surrounding said insulator, applying pressure to said sleeve in a direction parallel to the axis thereof while holding said insulator against axial movement relative to said shell to deform said sleeve and thereby simultaneously press the same into intimate contact with said insulator and shell.

38. The method of making a spark plug which includes the steps of making an insulator, applying a coating of finely divided particles to at least a portion of the surface of said insulator, and pressing a metallic element into intimate contact with said coated surface.

39. In a spark plug, an insulated center electrode, a metallic shielding barrel surrounding the upper end of said electrode and extending beyond said upper end to form a terminal well, the upper end of said barrel having a smaller internal diameter than the portion thereof adjacent the upper end of said electrode, and an insulating sleeve lining said barrel, said sleeve having a substantially uniform internal diameter and an external diameter conforming generally to the internal diameter of said barrel.

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