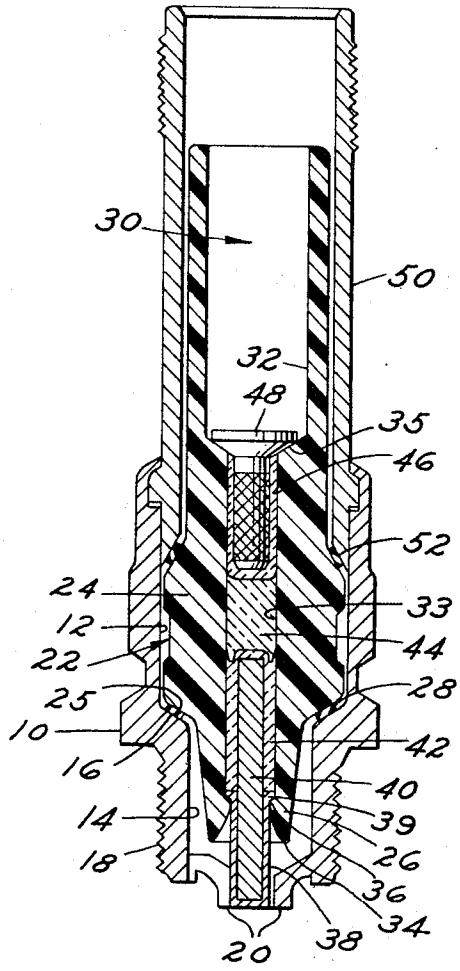
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SPARK PLUG HAVING A SHORT TIP CENTER ELECTRODE

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SPARK PLUG HAVING A SHORT TIP CENTER ELECTRODE

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ABSTRACT OF THE DISCLOSURE

A short cup of corrosion resistant material seats in the tip portion of a spark plug insulator and surrounds the lower portion of an inexpensive metallic wire that extends into the massive portion of the insulator. A heat conducting composite of metal powder and glass surrounds the wire above the cup and provides a heat conducting path from the electrode tip to the massive portion of the insulator.

This invention provides a spark plug that uses a wire seated in a short center electrode cup and surrounded by a heat conducting medium to provide a heat conductivity path from the sparkplug tip. The spark plug requires reduced amounts of the expensive metals needed for center electrodes and also is easier and more economical to manufacture.

Prior art spark plugs comprise center electrodes either of one-piece construction or of a center wire surrounded by a cup-shaped member seating in the insulator at or above the plane in which the insulator seats in the shell. An electrode of this length was necessary to provide a heat conductivity path from the tip of the spark plug to the massive portion of the insulator and, subsequently, to the shell and surrounding mediums.

Large amounts of expensive metals and alloys are required in those long electrodes. In addition, production tolerances are difficult to maintain along the length of the electrode and, in many plugs, a vacuum cementing operation between the electrode and the insulator is required to insure good heat conductivity. In some prior art spark plugs, the long center electrode is cast in place, but differences in thermal expansion coefficients of electrode and insulator necessitate careful control over materials and casting temperatures and thereby deprive such constructions of intended manufacturing and operating advantages.

In the spark plug of this invention, the insulator has a tip portion, a massive portion above the tip portion, and a passage extending through both portions. The electrode comprises an exterior member for resisting electrical discharge erosion that seats in the insulator tip portion. An interior member in intimate heat conducting contact with the exterior member and smaller than the passage extends above the exterior member and into the massive portion of the insulator. A heat conducting composite of metal powder and glass fills the passage between the interior member and the insulator, so that an excellent heat conducting path from the exterior member through the interior member and the composite is provided.

With the exterior member in the shape of a cup, the interior member can be in the form of a wire fitting into the opening of the cup. This construction does not require a seal between the exterior and interior members and increases the heat conducting contact area of the members. A heat conducting medium then fills the space between the wire and the insulator.

Thermal expansion coefficients of metal-glass composites used as the heat conducting medium can be controlled easily to provide a transition zone maintaining

excellent thermal contact with the insulator and the wire. The composite also can serve as a seal for the center electrode structure or as a nonsealing termination for an integral resistor seal.

A cross section of an aircraft spark plug having the short cup center electrode structure of this invention is shown in the drawing and is described below in detail.

Referring to the drawing, the spark plug comprises a conventional shell **10** having a large bore **12** in its upper portion and a smaller bore **14** in its lower portion. A smoothly contoured shoulder **16** is formed between bores **12** and **14**. The outer surface of shell **10** surrounding the lower portion is threaded as at **18** for installation in an engine. Conventional ground electrodes **20** are formed in the lower end of smaller bore **14**.

An insulator **22** made from conventional materials and having a massive body portion **24** smoothly tapering through an external shoulder **25** into a smaller tip portion **26** is mounted in shell **10** with body portion **24** positioned in larger bore **12** and tip portion **26** positioned in smaller bore **14**. Shoulder **25** seats on shoulder **16** where it is sealed by a gasket **28**.

An electrode passage **30** is formed longitudinally in the center of insulator **22**. Passage **30** has a large diameter as at **32** at the top of insulator **22**, a medium diameter **33** extending through body portion **24** and into tip portion **26**, and a reduced diameter **34** in the end of tip **26**. Shoulders **35** and **36** are formed in passage **30** between large diameter **32** and medium diameter **33** and between medium diameter **33** and reduced diameter **34**, respectively.

A metallic cup **38**, the exterior member, has an enlarged lip **39** at its open end seating on shoulder **36**. The closed end of cup **38** extends out of tip **26** to terminate adjacent electrodes **20**. A metallic wire **40**, the interior member, is seated in cup **38** and extends upward into passage **33** above shoulder **16**. Cup **38** can be made of nickel, nickel alloys, platinum, or other materials capable of resisting electrical discharge erosion and combustion gas corrosion. Nickel is preferred in the spark plug of this invention because it is easily formed and relatively inexpensive. Wire **40** can be made of copper, silver, or other materials having high electrical and thermal conductivity. In the spark plugs of this invention, copper is preferred because it has a good combination of these properties.

A heat conducting medium such as a composite **42** of metal powder and glass surrounds wire **40** to fill passage **30** between wire **40** and insulator **22**. The metal powder can be copper, nickel, or other materials having good thermal conductivity. Good electrical conductivity also is desirable in spark plugs of this invention using the composite as a termination for the resistor in the manner described subsequently. The glass is an electrical grade borosilicate glass such as Corning No. 7070 glass made by the Corning Glass Company. Copper and nickel metal powders are preferred because they produce a composite having a good balance of electrical and thermal conductivity.

The composite preferably is about 30 to 100 percent glass when copper or nickel is used as the metal powder because these compositions also provide some sealing of passage **30**. This range can be adjusted somewhat depending on the desired electrical and thermal conductivity and sealing. Copper or nickel composites of about 50 to 70 percent by weight glass have an excellent balance of these properties. A copper powder having a particle size such that a maximum of 5 percent is held on a 200 mesh screen, 15–25 percent is held on a 325 mesh screen, and 70–90 percent passes the 325 mesh screen produces a useful composite when mixed with borosilicate glass to produce compositions in this range.

Mounted in passage **30** above composite **42** is an integral resistor seal **44**. Resistor seal **44** can be made from mixtures of borosilicate glass, titanium oxide, and boron carbide as disclosed in Heischman, U.S. Patent 3,088,921, the disclosure of which is incorporated hereby into this specification. Resistor seal **44** can contact wire **40** directly as disclosed by Heischman or composite **42** can provide a lower termination between resistor seal **44** and wire **40** as shown in the drawing. If desired, ordinary nonsealing resistors made of glass and carbon black mixtures can be used in place of the integral resistor seal but, of course, such constructions require composite **42** to seal the center wire structure.

An upper termination **46** is located in passage **30** above resistor seal **44**. Upper termination **46** is a composite of metal powder and glass similar in composition to composite **42** except that a much broader range of materials and proportions can be used since it is not necessary for termination **46** to have the thermal conductivity or the sealing ability of composite **42**. Mixtures of 30 percent by weight copper powder and 70 percent by weight borosilicate glass are used regularly for upper termination **46**.

A stud **48** is mounted in electrically conducting contact with termination **46** at shoulder **35**. The lower portion of stud **48** can be threaded, knurled, or serrated to provide the desired electrical and mechanical contact with termination **46**.

A sleeve **50** is held in place at the top of shell **10** by rolling the top edge of shell **10** over projections of sleeve **50**. At its lower end, sleeve **50** contacts a gasket **52** that in turn seats on insulator **22** to position the latter in shell **10**.

To assemble the spark plug of this invention, the center wire **40** is forced into cup **38** and the assembly is annealed at a temperature just below the melting point of the wire to insure intimate heat conducting contact between cup **38** and wire **40**. A mixture for forming composite **42** is prepared by mixing the ingredients with a small amount of a suitable binder.

Cup **38** is dropped into passage **30** until lip **39** seats on shoulder **36**. The mixture for composite **42** is placed in passage **30** on top of lip **39** and around wire **40**. If composite **42** is to act as a termination for resistor seal **44**, additional mixture sufficient to cover the top of wire **40** is added. A mixture forming the integral resistor seal **44** is placed on top of the mixture for composite **42**, and a mixture forming upper termination **46** then is placed on top of the mixture for resistor seal **44**.

The assembly then is heated in a furnace to 1600–1800° F. to melt the various mixtures in passage **30**. Stud **48** is pressed into passage **30** by a ram, and the insulator assembly is cooled to room temperature while maintaining pressure on stud **48**.

The entire insulator assembly then is positioned along with gasket **28** in preformed shell **10**. Sleeve **50** is mounted in the top of shell **10** along with gasket **52**, and the upper lip of shell **10** is rolled to attach sleeve **50** to shell **10**.

Manufacturing the spark plug of this invention is simplified because an excellent heat conductivity path through wire **40** and composite **42** is provided without maintaining close tolerances on cup **38** and wire **40** for extensive distances. Composite **42** effectively compensates for variations in both the diameter and length of wire **40**. Cement is not required between cup **38** and insulator **22** as the main heat path from the tip of cup **38** is through wire **40** and composite **42** to insulator **22**.

Thus, this invention provides a spark plug having a short exterior member seating in the tip of the insulator with an interior member in heat conducting contact therewith extending into the massive portion of the insulator. The plug has a performance rating equivalent to plugs requiring far more complicated manufacturing techniques and much greater amounts of expensive metals.

What is claimed is:

1. A spark plug comprising

a shell,

an insulator mounted in said shell, said insulator having a massive portion and a considerably smaller tip portion, an external shoulder separating said massive portion and said tip portion and seating on said shell, and a longitudinal passage extending through said massive portion and said tip portion,

an electrode mounted in said passage, said electrode including a metallic cup seated in said passage in said tip portion and a metallic wire seated in said cup and extending above said shoulder, said wire being in intimate heat conducting contact with said cup, and

a heat conducting medium filling the space between said wire and said insulator, said wire and said heat conducting medium serving as the main heat conducting path for transferring heat from the electrode tip to the insulator massive portion.

2. The spark plug of claim **1** in which the heat conducting medium is a composite of powdered metal and glass.

3. The spark plug of claim **2** in which the powdered metal is nickel or copper.

4. The spark plug of claim **3** comprising an integral resistor seal located in said passage.

5. The spark plug of claim **4** in which the composite of powdered metal and glass forms a lower termination for the resistor seal.

6. The spark plug of claim **5** in which the percent by weight of glass in the composite is about 50 to 70 percent.

7. The spark plug of claim **2** in which the percent by weight of metal in the composite is about 50 to 70 percent.

8. The spark plug of claim **1** comprising an integral resistor seal located in said passage.

References Cited

UNITED STATES PATENTS

2,248,415	7/1941	Schwartzwalder et al.	313—145 X
2,321,840	6/1943	McDougal	313—145 X
2,391,456	12/1945	Hensel	313—141.1 X
2,542,903	2/1951	Cipriani	313—142 X
2,864,884	12/1958	Counts et al.	315—58 X

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