Aug. 20, 1957 N. C. MOORE 2,803,771

SPARKING PLUG ASSEMBLIES AND OTHER SPARK DISCHARGE DEVICES

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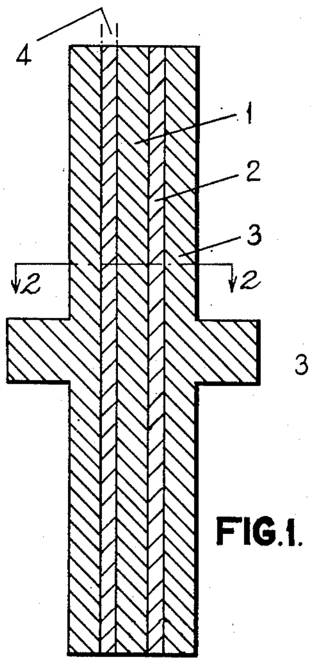

FIG. 1.

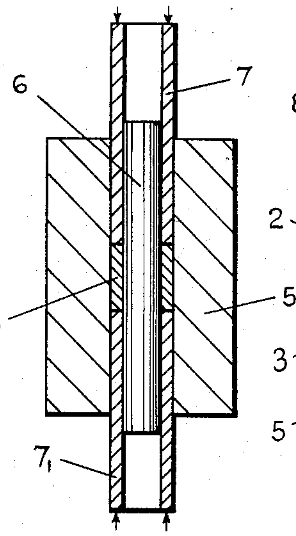

FIG. 4.

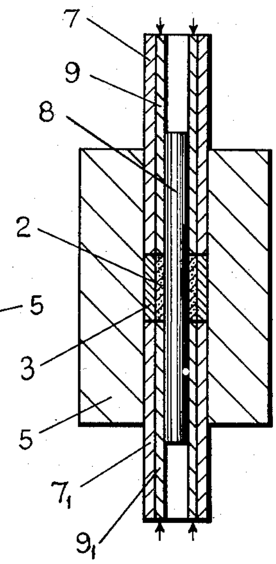

FIG. 5.

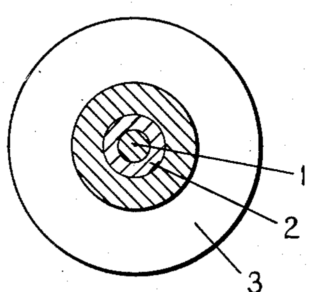

FIG. 2.

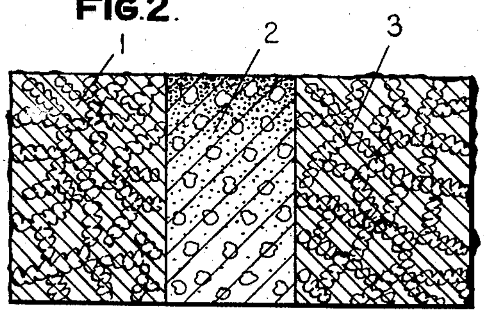

FIG. 3.

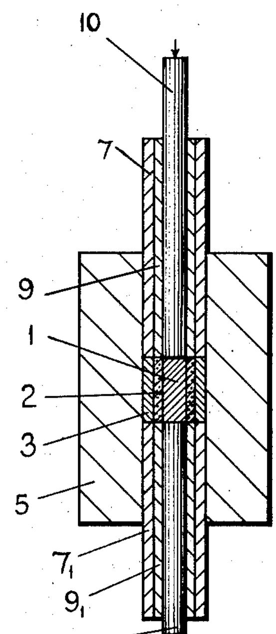

FIG. 6.

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SPARKING PLUG ASSEMBLIES AND OTHER SPARK DISCHARGE DEVICES

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5 Claims. (Cl. 313—130)

This invention relates to spark discharge devices and more particularly to sparking plug assemblies and to methods for their production.

It is known to provide a spark discharge device comprising two electrodes separated by a ceramic material, the latter being of such a character that it permits the passage of a spark discharge across its surface, between the electrodes, at a lower potential than would be required if the gap between the electrodes were replaced by air.

According to the present invention an electrode-ceramic assembly, useful, for example as an element of a sparking plug, comprises two conductor elements each consisting of a mixture of metal and ceramic particles sintered to form a coherent mass with an intervening element consisting of a refractory and insulative material, the elements being compacted to form a coherent structure. The two conductor elements serve as electrodes and by suitably selecting the intervening insulative material it may be arranged that on applying a suitable electric potential to the electrodes a spark discharge occurs across the face of the intervening insulative ceramic.

By means of this invention a very close matching of the thermal expansion characteristics of the electrodes and intervening ceramic may be achieved so that the risk of disconnection of the electrodes is very much reduced and the products may be fabricated as sparking plugs for aero engines or as igniters for turbines which operate on a low tension ignition system, and in that connection possess valuable advantages.

The electrical characteristics of a ceramic containing metal particles vary with the proportion of metal to ceramic base. The inclusion of a high proportion of metal particles leads to a product which is electrically conductive, whereas ceramic containing only a low proportion of metal particles is insulative. It is believed that this difference arises because in the former case the metal particles are sintered together to form a continuum of metal, which is conductive, whereas in the latter case the ceramic forms the continuous phase and the metal exists as agglomerates separated from one another. Thus, for example, a sintered mixture of alumina and particles of chromium metal, where the chromium is less than 20% by weight of the mixture, is usually insulative, whereas a similar mixture containing 40% or more chromium metal is conductive. The insulative materials containing metal particles may be employed if desired as the intervening element between the electrode elements in the assemblies of the present invention.

It is preferable to employ as the metal in the electrode elements one which is known to resist spark erosion and chromium is particularly suitable from this standpoint.

Although the electrode-ceramic assembly of this invention may be of various overall shapes it is convenient to form the elements as concentric tubes, the innermost tube (or rod) consisting of electrode material, the outermost tube consisting of electrode material and the intervening tube consisting of insulative material, the tubes being

formed in situ from the powdered ingredients and compacted and fired in situ.

An embodiment of this invention and of the process employed in accordance with the present invention are illustrated in the accompanying drawings in which:

Fig. 1 is a section of a spark plug body.

Fig. 2 is a cross sectional elevation of Fig. 1.

Fig. 3 is an enlarged detail of a part of the spark plug body shown in Fig. 1 in greater detail.

Figs. 4, 5 and 6 illustrate successive stages in the formation of a plug assembly.

Referring to Fig. 1, the assembly comprises a core rod **1** of conductive material comprising a sintered mixture of alumina and chromium metal in the proportion of 40 parts by weight chromium to 60 parts by weight alumina. Surrounding the rod **1** is a sleeve **2** consisting of the same ingredients in the proportion of 20 parts chromium to 80 parts alumina. Surrounding this in turn is a further sleeve **3** of the same constitution as the rod **1**. Conveniently the thickness of the sleeve **2**, i. e. the spark gap **4**, is about 0.4 inch. By reason of the presence of the metal agglomerates in the sleeve **2** the actual effective gap between the rod **1** and sleeve **3** is shortened so that a greater physical gap between the elements **1** and **3** is made possible while maintaining the ability for a spark discharge to cross the gap.

The end of the sleeve **2** is provided with a surface layer or impregnation of semi-conducting oxide, e. g. nickel zinc oxide.

Fig. 3 diagrammatically illustrates at great enlargement the microscopic structure of the elements **1**, **2** and **3**.

A convenient method of making an assembly of the type illustrated in Figs. 1–3 is shown in Figs. 4–6. Referring to these figures, there is provided a die **5** with a central rod **6**, the external diameter of the rod **6** being less than the internal diameter of the die **5**. Into the annular space between the die **5** and the rod **6** is charged a chromium alumina powder composed of 40% chromium metal powder passing a 200 mesh and 60% alumina of particle size about 5 microns. Co-operating punches **7**, 7_1 are used to compact this powder to form a sleeve **3**.

The rod **6** is then removed and replaced by a rod **8** of smaller diameter. Alumina of particle size about 5 micron is charged into the annulus thus left and compacted by co-operating punches **9**, 9_1 to form a sleeve **2**.

The rod **8** is then removed and the space left is charged with the same chromium alumina powder as used to form sleeve **3** and compacted by cooperating punches, **10**, 10_1 to form a core **1**.

The whole compacted slug is then removed from the die and placed in a graphite mould with two graphite punches co-operating to maintain it under pressure. It is placed inside a high frequency heating coil and heated to a temperature sufficient to enable a slight flow of the materials under the applied pressure. The pressure is conveniently of the order of ½ to 2 tons per square inch and the sintering temperature 1250–1500° C. When the mass is fully sintered the assembly is allowed to cool and is extracted from the mould. It can be shaped to the required form by grinding with diamond-impregnated wheels.

The operative surface of the alumina annulus **2** is provided with a titanium dioxide semi-conducting layer or impregnation by applying butyl titanate to the annulus, e. g. by vacuum impregnation and heating the assembly to 800° C. in an atmosphere of hydrogen, thus converting the butyl titanate to a semi-conducting form of titanium dioxide.

It will be appreciated that the foregoing method of constructing the assembly may be widely varied. For example, the core and two outer sleeves may be preformed, concentrically arranged and the assembly then fired as described above.

The products obtained according to this invention have a good thermal shock resistance and the elements are closely related in their thermal expansion characteristics. The seal between the elements is gas-tight and not easily broken and, as indicated above, wider spark gaps are permissible than were hitherto considered practicable. All these important advantages render the products of especial value in sparking plug and igniter assemblies and they may be used in any system where a spark discharge is required to take place.

I claim:

1. A spark plug comprising a conductive mixture of ceramic particles and metal particles, in the form of a cylindrical core, closely surrounded by a sleeve of a similar but insulative mixture containing a substantially lower amount of metal particles than said conductive mixture, said sleeve being closely surrounded by a shell comprising a conducting mixture the same as that of the core, these three elements constituting a unity ceramic element.

2. A spark plug according to claim 1 wherein the cylindrical core and sleeve consist of ceramic material containing chrome particles dispersed therein in an amount of at least 40% by weight of the mixture and that the sleeve comprises a similar mixture wherein, however, the chrome particles are present in an amount of less than 20% by weight of the mixture.

3. A spark plug according to claim 1 having the operative surface of the sleeve coated with a semi-conducting metal oxide.

4. A spark plug according to claim 1 having the operative surface of the sleeve impregnated with a semi-conducting metal oxide.

5. A spark plug comprising a conductive mixture of ceramic particles and metal particles having in combination a cylindrical core of at least 40% chromium particles and at least 20% of alumina, a sleeve bonded to and enclosing said core and consisting of at least 40% alumina and at least 20% chromium, and an outer sleeve of at least 40% chromium and at least 20% alumina by weight of the mixture, said core and sleeves constituting a unity ceramic element.

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