Oct. 12, 1943. T. TOGNOLA 2,331,748

SPARK PLUG

Filed July 9, 1940

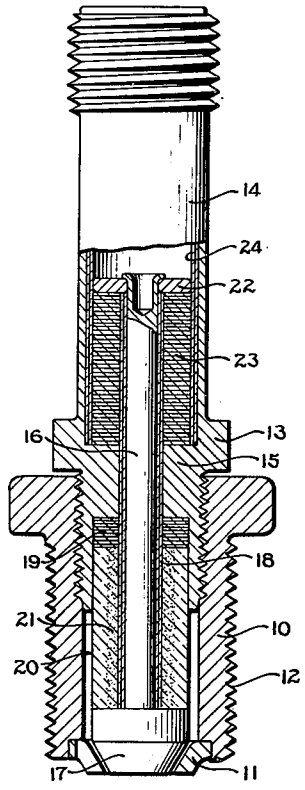


Fig 1

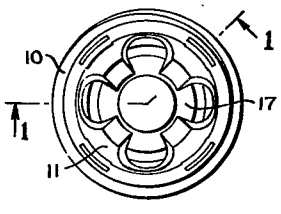


Fig 2

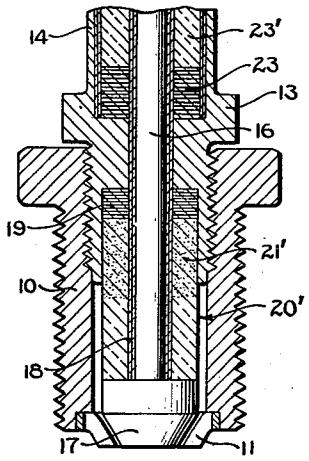


Fig 3

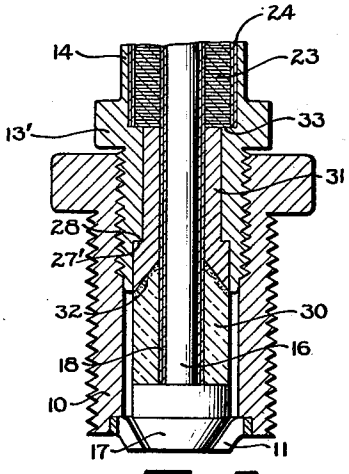


Fig 5

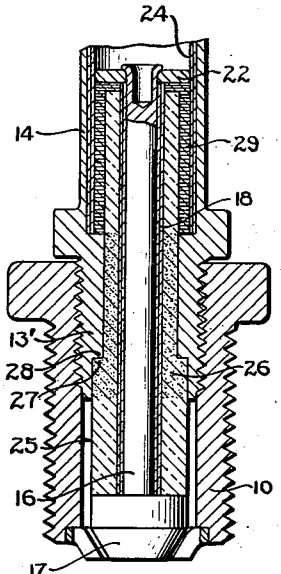


Fig 4

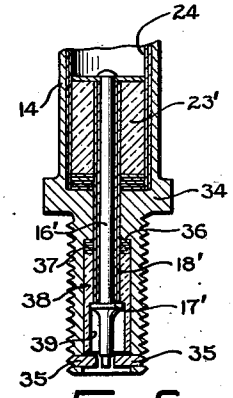


Fig 6

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SPARK PLUG

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13 Claims. (Cl. 123—169)

This invention relates to ignition apparatus, and more particularly to spark plugs for internal combustion engines, insulating means adapted for use therein, and the method of making the same

Spark plugs are quite generally recognized as the weakest links in the ignition systems of modern internal combustion engines, particularly on high compression aircraft engines which must operate continuously for long periods of time at high speed and under heavy loads. One of the chief difficulties has been in providing proper electrical insulation which will withstand the high heat to which the plugs are subjected during use and yet prevent gas leakage and flashovers.

One of the objects of the present invention is to provide a novelly constructed spark plug wherein the foregoing difficulties are substantially obviated.

Another object of the invention is to provide a spark plug wherein novel means are employed for facilitating the conduction of heat from the center electrode to the outer metallic parts thereof.

Still another object is to provide novel electrical insulating means and method of making same, said means being adapted for use in spark plugs and other devices wherein high heat conductivity is desired.

A further object is to provide a novelly constructed spark plug employing ceramic insulating means and cushioning means for the latter to minimize breakage thereof during assembly and use.

A still further object is to provide a novel spark plug and method of making the same whereby the heat conductivity from ceramic parts to metal parts is enhanced.

The above and further objects and novel features of the invention will more fully appear from the following detailed description of the invention when the latter 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 as a definition of the limits of the invention, reference for this latter purpose being had primarily to the appended claims.

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

Fig. 1 is a side elevation view, partly in section and with parts broken away, showing one form of spark plug embodying the invention;

Fig. 2 is a bottom view of the spark plug shown in Fig. 1; and,

Figs. 3, 4, 5 and 6 are views similar to Fig. 1 showing other modifications and embodiments of the invention with the upper portions thereof broken away.

Various embodiments of the invention are illustrated in the drawing, by way of example, in the form of radio-shielded spark plugs which are particularly adapted for use on aircraft engines. It will be understood, however, that the invention is also applicable to unshielded spark plugs and other electrical devices. As shown in Fig. 1, one form of spark plug embodying the invention comprises a metallic shell 10 which carries a ground electrode 11 in the lower end thereof and is externally threaded at 12 for cooperation with a threaded opening in an engine cylinder (not shown) in the usual manner. Threaded into the outer end of shell 10 is a nut or body portion 13 having a tubular radio shielding barrel 14 formed integrally therewith or otherwise suitably secured thereto and an internal flange 15 intermediate the ends thereof for supporting a novel center electrode assembly. Shell 10 and member 13 together form what may be referred to as the body of the spark plug and in some instances, as shown in Fig. 6, may be formed as one piece.

In the form illustrated, said center electrode assembly comprises a metallic cylindrical spindle 16 provided at its lower end with a head portion 17 which is shaped and positioned for cooperation with ground electrode 11 in a manner well understood in the art. Spindle 16 is tightly wrapped in a sleeve 18 of sheet mica or other suitable insulating material which serves to insulate the center electrode from nut 13 and the insulated spindle has a tight sliding fit in the reduced bore surrounded by internal flange 15.

Novel insulating means whereby electrical and gas leaks are minimized and whereby heat conduction between electrode 16, 17 and nut 13, 15 is materially enhanced are provided around insulated spindle 16, 18 between the upper surface of head 17 and the lower surface of flange 15. Said insulating means, in the form shown in Fig. 1, comprises a small stack of mica washers 19 and a novelly fabricated insulating sleeve 20. The inner portion 21 of sleeve 20 is constituted by a mixture comprising a suitable ceramic material and finely divided metallic dust, while the outer portion thereof consists of plain ceramic material. The proportions of metal and ceramic material employed in portion 21 are preferably

such that the mixture, when molded and baked in the manner hereinafter described, is a non-conductor or at most a very poor conductor of electricity, but is a materially better conductor of heat than pure ceramic material.

The metal dust employed in insulating sleeve 20 may consist of nickel, tungsten, or other suitable high heat resisting metallic materials, or a mixture of suitable metals. In one embodiment which has proved successful, one part of metallic powder having a fineness of about 200 mesh was thoroughly mixed with three parts of ceramic material, such as aluminum oxide "Alfrax," also in powder form and having a fineness of about 300 mesh. Finer or somewhat coarser powders may be used but the finer the powders the better the contact between adjacent particles and hence the better the heat conducting ability thereof. The relative percentage of metallic and ceramic powders may be varied, depending upon the portion of the plug in which the mixture is used, the highest proportion of metal being limited chiefly by the ability of the ceramic to function as the binding agent therefor.

In the fabrication of sleeve 20, the dry metallic and ceramic powders for portion 21 are first very thoroughly mixed and just enough water added thereto to dampen it or form a stiff paste. The dampened mixture is then placed in a cylindrical mold around a core corresponding in size to insulated spindle 16, 18 and a plain ceramic paste consisting of dampened ceramic powder is placed in a second and larger cylindrical mold surrounding the first mold which serves as a core therefor. The first or inner mold is then removed and the concentric cylinders of different pastes or materials are pressed together to form the unitary sleeve structure 20 which is then removed from the mold, dried out by heating at a relatively low temperature and then baked or fired at a temperature of approximately 2,200° F. This baking temperature may, of course, vary but temperatures between 2,000° F. and 2,500° F. have been found preferable. After removal of the baked sleeve from the oven, the outer surface thereof may, if desired, be glazed by any suitable method known in the art, and the insulated center electrode 16, 18 then fitted therein.

Surrounding the upper end of insulated spindle 16, 18 and interposed between the upper surface of flange 15 and a washer or plate 22 is a stack 23 of mica washers. The latter and stack 19 are tightly compressed in a suitable press and secured in position by peening the countersunk end of spindle 16 outwardly into contact with the upper surface of washer 22. Shielding barrel 14 may be lined with suitable insulating material, such as mica liner 24, to prevent flash-overs between the upper end of the center electrode and said barrel.

During the installation of the center electrode assembly in nut 13, the axial pressure exerted on ceramic insulating sleeve 20 is cushioned by mica stacks 19 and 23 which yield under pressure, thereby minimizing the possibility of any cracking, chipping or breaking of said sleeve. The mica washers also tend to expand radially against nut 13 and sleeve 18 when compressed and hence contribute to the formation of a tight gas seal to prevent gas leakage along the center electrode or around the insulating parts. Additionally, the mica insulation tends to cushion the ceramic insulator and prevent the breaking or cracking thereof which often results in ceramic plugs heretofore provided by reason of the differential between the coefficients of expansion of the ceramic and metallic parts.

In order to provide further assurance against gas leakage from the engine cylinder through the spark plug, the voids or spaces between the various insulating and metallic parts surrounding the upper end of spindle 16 may be filled with a suitable high heat resistant insulating compound in accordance with a novel method fully described and claimed in my copending application Serial No. 344,507 filed July 9, 1940, for "Spark plug and method of making the same." In general, said method consists in placing the spark plug, completely assembled except for washer 22 and, in some instances, spindle 16, in a vacuum chamber and introducing the insulating compound in liquid form into barrel 14. The liquid is thus caused to flow into and fill the minute spaces around and between the upper end of spindle 16, sleeve 18, mica stack 23 and liner 24. One compound which has been found suitable for this purpose is a cashew nut shell oil product. After the compound has been applied to the plug in this manner, the latter is removed from the vacuum chamber, any excess compound is removed therefrom and washer 22 is installed in the manner heretofore described. The assembled spark plug is then baked for various lengths of time at temperatures increasing from approximately 200° F. to 500° F. until the compound is thoroughly dried and sets, said temperature being kept at all times below the boiling point of the compound, which point varies as the compound dries.

In Fig. 3, there is illustrated a spark plug which is identical with the above-described structure, except for the construction of ceramic insulating sleeve 20' and the provision of a ceramic sleeve 23' which replaces the upper portion of the stack of mica washers 23. Sleeve 20', as shown, comprises a lower portion of plain ceramic material and an upper portion 21' constituted by the novel metal impregnated ceramic heretofore described. Said upper and lower portions are prepared in the same mold while damp and, hence, form an integral unitary sleeve structure. It will be noted that in the embodiment of Fig. 3 the metallic and ceramic mixture is well removed from the otherwise uninsulated portion of center electrode 16, 17 and has direct contact with nut 13, thereby materially facilitating the conduction of heat from the center of the plug to the outer air-cooled surfaces thereof to obviate overheating while minimizing the possibility of flash-overs. In this form, the metallic content in portion 21' may be somewhat greater than in the embodiment of Fig. 1.

In the embodiment of Fig. 4, a molded insulated sleeve 25 extends substantially the full length of spindle 16 and through the reduced bore of a nut 13' which corresponds with nut 13 of Fig. 1. The upper and lower portions of sleeve 25 are composed of plain ceramic material, while the central portion 26 thereof, preferably that portion which contacts nut 13', consists of a mixture of ceramic material and metal of the character above-described. Insulator 25 is preferably molded in a single mold as a unitary sleeve and machined to fit tightly into nut 13', an external shoulder 27 on the insulator being adapted to seat on an internal shoulder 28 on the nut. Surrounding the upper end of insulator 25 in the space formed by the latter, insulating sleeve 24 and washer 22, there is provided suitable insu-

lating means, such as a stack of mica washers 29. In other respects, the spark plug shown in Fig. 4 is the same as that shown in Fig. 1.

In the embodiment of Fig. 5, an insulating sleeve 30 consisting primarily of a suitable ceramic material, such as porcelain or aluminum oxide, surrounds the lower end of spindle 16 between head 17 and a metallic sleeve or liner 31 in body member 13'. Both of the sleeves 30 and 31 have a tight fit around mica cigarette 18 which surrounds spindle 16, and sleeve 31 has a tight sliding fit in the bore of member 13', shoulder 28 on the latter being engaged by an external shoulder 27' on the metal sleeve.

In order to insure good heat conductivity between the engaging ends of sleeves 30 and 31, said ends are shaped and assembled in a novel manner to provide good contact between relatively large engaging surfaces. Preferably, the upper end of sleeve 30 is conical and fits into a similarly shaped recess in the lower end of sleeve 31, thereby providing a relatively large contact area for heat transfer. In assembling sleeves 30 and 31 on insulated electrode 16, 18, the same are placed end to end and pressed together while one is moved angularly with respect to the other until the relatively hard ceramic material grinds for itself a perfect seat in the relatively soft metal of sleeve 31, the latter being made of copper or similarly soft metal having high heat conductivity. Good contact between sleeves 30 and 31 and, hence, a good heat conducting joint therebetween is thus formed, whereby heat from electrode 16 may be readily conducted to body 13'. If desired, the conical end of ceramic sleeve 30 may be provided with a surface consisting of metal impregnated ceramic material, as indicated in the drawing at 32, or the surface may have a coating of suitable metal, such as copper, applied thereto under a flame by a method known commercially as the "Schori process." The upper end of metallic sleeve 31 is preferably flush with an internal shoulder 33 in nut 13' and a cushioning stack of mica washers 23 is seated against the same and said shoulder. That portion of the plug which is broken away may be of the same construction illustrated in Figs. 1 or 3. It will be understood, however, that shielding barrels 14 are not necessary parts of any of the embodiments and may be dispensed with, if desired.

A smaller type of spark plug which is commercially known as a 10 mm. plug is illustrated in Fig. 6. In this type, a one-piece metallic body 34 is employed with ground electrodes 35 installed in the lower end thereof for cooperation with the lower end of a center electrode 16'. The latter has a collar or enlarged portion 17' above which it is surrounded by an insulating sleeve 18'. Surrounding spindle 16' between collar 17' and a shoulder 36 in body 34 is a cushioning stack of mica washers 37 and a ceramic insulating sleeve 38, the latter having a portion 39 with an enlarged bore extending downwardly beyond collar 17' to a point adjacent ground electrodes 35. The upper portion of the spark plug shown in Fig. 6 is illustrated as being similar to the corresponding structure in Fig. 3. It will be understood that portions of ceramic insulators 38 and 23' may, if desired, be impregnated with metallic dust or powder for increasing the heat conducting ability thereof.

There is thus provided a novel spark plug wherein use is made of ceramic materials for insulating means and wherein said means are novelly combined with other insulating materials which serve to cushion the brittle ceramics and thereby obviate breaking and cracking of the latter during assembly of the plugs and during actual use thereof. There is also provided novel metallic impregnated ceramic insulating means and method for making the same, the heat conductivity of which is relatively greater than that of plain ceramic material, while the electrical insulating qualities thereof are not materially less than those of plain ceramic materials. A novel spark plug and method of making the same are also provided whereby good heat conductivity between ceramic and metallic parts is assured. Additionally, the features of the present invention may be incorporated in simply constructed spark plugs at relatively low cost.

Although a limited number of embodiments of the invention are illustrated and above-described, it will be understood that the same is not limited thereto but that various other modifications embodying features of the invention may be made. For example, sleeves 20 and 20', shown in Figs. 1 and 3, are interchangeable in the types of plugs illustrated in said figures, and one or both of the stacks of cushioning washers shown in the several embodiments may be dispensed with, if desired. The shape of the engaging faces of sleeves 30 and 31 in Fig. 5 may also be varied. Various other changes, particularly in the design and arrangement of parts illustrated and in the metallic and ceramic materials above suggested as being suitable, may also be made without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art. For a definition of the limits of the invention, reference is had primarily to the appended claims.

What is claimed is:

1. In a spark plug, a metallic body having a bore therethrough and an annular internal flange intermediate the ends thereof forming a reduced bore, a center electrode in said bore comprising a spindle and an enlarged head portion, an insulating sleeve surrounding said spindle and having a close sliding fit in said reduced bore, insulating means surrounding said sleeve between said head portion and one side of said flange comprising a stack of mica washers and a mold insulating tube having at least a portion thereof impregnated with finely divided metallic particles, insulating means surrounding the upper portion of said spindle and seated against the other side of said flange, and means secured to the upper end of said spindle for holding the foregoing elements in assembled relation.

2. In a spark plug, a metallic body having a bore therein, a center electrode in said bore, a sleeve surrounding a part of said electrode for electrically insulating the same from said body, insulating means surrounding said sleeve and interposed between said body and an enlarged portion of said electrode, said insulating means comprising compressible insulating means and a rigid tube consisting of insulating material with scattered, finely divided metallic particles therein, and means for holding said body, electrode and insulating means in assembled relation.

3. In a spark plug, a metallic body having a differential bore therein, a center electrode in said bore comprising a spindle and an enlarged portion, a sleeve surrounding said spindle for electrically insulating the same from said body, insulating means surrounding said sleeve and

interposed between said body and said enlarged portion of the electrode, said insulating means including a yieldable stack of insulating washers and a substantially rigid tube consisting at least in part of metal impregnated insulating material, and means for holding said body, electrode and insulating means in assembled relation.

4. In a spark plug, a metallic body having a bore therein, an electrode comprising a spindle and an enlarged portion, an insulating sleeve surrounding said spindle and having a close sliding fit in the smallest portion of said bore, insulating means surrounding said sleeve on opposite sides of the smallest portion of said bore, said insulating means including at least one stack of flexible insulating washers and a substantially rigid insulating tube comprising finely divided metallic particles dispersed therein, and means for holding said body, insulation and electrode in assembled relation with said stack of washers under compression.

5. In a spark plug, a body having a bore therethrough, an electrode extending through said bore, an insulating sleeve surrounding a portion of said electrode for insulating the same from said body, insulating means surrounding said sleeve at opposite ends of the smallest portion of said bore, said insulating means comprising compressible insulating means and a substantially rigid insulating tube having finely divided metallic particles dispersed therein, and means for holding said body, electrode and insulation in assembled relation.

6. In a spark plug, a body having a bore therein, an electrode in said bore, and means for electrically insulating said electrode from said body comprising a substantially rigid tube surrounding a portion of said electrode, the outer portion of said tube consisting of plain insulating material and the inner portion consisting of metal impregnated insulating material.

7. In a spark plug, a body having a bore therein, an electrode extending through said bore, and means for electrically insulating said electrode from said body comprising a substantially rigid insulating tube surrounding a portion of said electrode, one end of said tube consisting of plain insulating material and the other end thereof consisting of metal impregnated insulating material.

8. In a spark plug, a body having a bore therethrough, an electrode in said bore, and means for electrically insulating said electrode from said body comprising compressible insulating means and a substantially rigid insulating tube surrounding said electrode and interposed between an enlarged portion of the latter and said body, one end of said tube consisting of plain insulating material and the other end thereof consisting of insulating material having fine metallic particles dispersed therein.

9. In a spark plug, a body having a differential bore therein, an electrode extending through said bore, and a rigid insulating sleeve surrounding said electrode and having a close sliding fit in said bore, at least a portion of said sleeve in contact with said body consisting of a molded mixture of finely divided insulating and metallic materials.

10. In a spark plug, a body having a bore therethrough, an electrode extending through said bore, a substantially rigid insulating sleeve surrounding said electrode and having a close sliding fit in said bore, an enlarged portion of said sleeve being interposed between a shoulder in said body and an enlarged portion of said electrode, at least a portion of said sleeve in contact with said body consisting of a molded mixture of powdered insulating and metallic materials, and means for holding said body, sleeve and electrode in assembled relation.

11. In a spark plug, a metallic body having a bore therein, an electrode extending through said bore, and means for electrically insulating said electrode from said body comprising a substantially rigid insulating tube surrounding a portion of said electrode, said tube consisting of molded insulating material having finely divided metallic particles dispersed therein.

12. In a spark plug, a metallic body having a bore therein, an electrode extending through said bore, and means for electrically insulating said electrode from said body comprising a substantially rigid insulating tube surrounding a portion of said electrode, said tube consisting of molded insulating material having finely divided particles of an electrically conductive material dispersed therein.

13. In a spark plug, a metallic body having a bore therein, an electrode extending through said bore, and means for electrically insulating said electrode from said body comprising a substantially rigid insulating tube surrounding a portion of said electrode, said tube consisting of insulating material, such as of a ceramic having dispersed therein finely divided particles of a material having greater heat conductivity than said insulating material.

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