June 13, 1944. H. D. FEICHTER 2,351,029

SPARK PLUG MANUFACTURE

Filed May 20, 1942

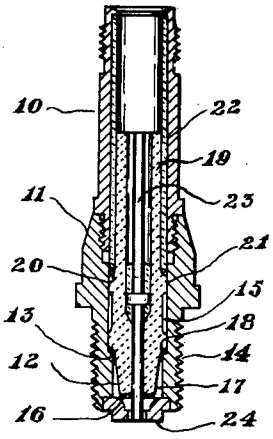


Fig. 1

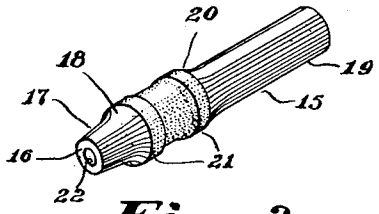


Fig. 2

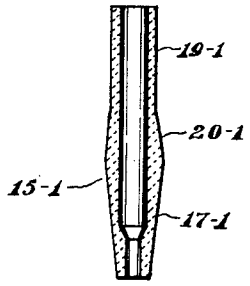


Fig. 4

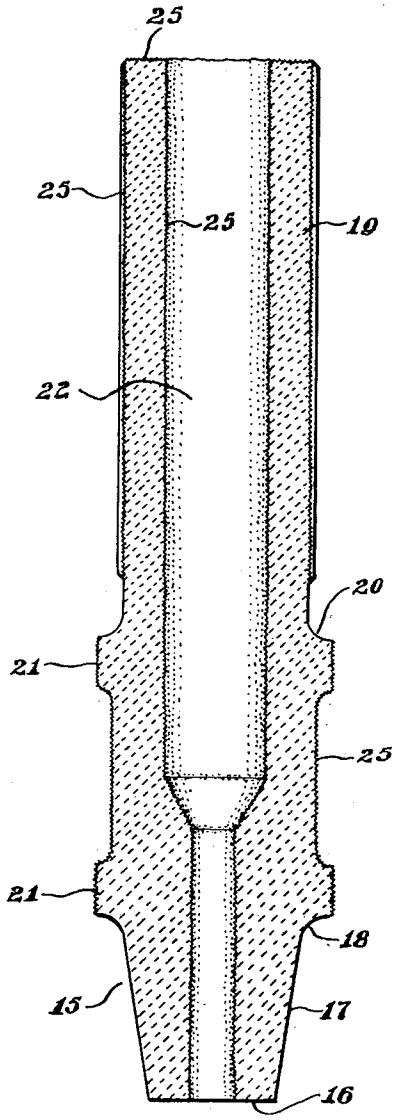


Fig. 3

Inventor

Harold R. Feichter

By Frease and Bishop

Attorneys

Patented June 13, 1944 2,351,029

UNITED STATES PATENT OFFICE

2,351,029

SPARK PLUG MANUFACTURE

Harold R. Feichter, Canton, Ohio, assignor to United States Quarry Tile Company, Canton, Ohio, a corporation of Delaware

Application May 20, 1942, Serial No. 443,733

10 Claims. (Cl. 123—169)

My invention relates to spark plug manufacture, and more particularly to spark plug ceramic insulators for aircraft engine spark plugs.

In a usual ceramic spark plug insulator, pits and projections are produced on the surfaces of the insulator in the firing process. The pits so produced in the surfaces of the shoulders of the usual ceramic spark plug insulator make it difficult to secure a seal between the copper sealing washers pressed between the shoulders and the external metal shell of the spark plug.

The pits so produced in the surfaces of the nose and tip of the usual ceramic spark plug insulator are exposed to the combustion gases of the cylinder served by the spark plug of which the insulator is a part, and carbon lodges in the pits and causes electrical leakage over the surface affected, reducing the spark potential at the points of the electrodes. The carbon also builds up in and beyond the pits, becoming incandescent when the engine is operating and causing preignition.

The carbon so deposited and built up in the pits is difficult if not impossible to remove by the usual sand blast cleaning.

Most aircraft engine spark plugs have had mica insulators, but a mica insulator cannot be cleaned to bring back its electrical properties to be the same as when new due to deterioration of the mica.

The pits and projections on the surfaces of the usual ceramic spark plug insulator result from the fluxing action which takes place during firing.

The fluxing action produces rougher surfaces on the fired piece than existed before firing, because the ceramic body of the insulator is sintered rather than melted in the firing process. The fluxes present in the body mixture have a cementing effect on the particles of the non-fluxing substances of the body, which results in a shrinkage of the fluxing particles leaving the non-fluxing particles standing out in relief.

While improved smoothness of the surfaces of a ceramic spark plug insulator may be obtained by finer grinding of the body constituents, yet the undesirable pits and projections are still produced on the fired insulator.

Melting the body during firing would produce smooth surfaces on the insulator, but it is not practical to melt the body since the high temperature necessary would distort the piece.

Glazing by filling the pits with a ceramic slip before firing, while producing smooth surfaces, changes the characteristics of the insulator.

Glaze is not satisfactory on the surfaces of the nose and tip of a spark plug insulator exposed to the combustion gases of a cylinder equipped with the spark plug of which the insulator is a part, because:

1. Glaze is soft and subject to abrasion and formation in the glaze of rough and pitted surfaces on cleaning by usual sand blast methods;

2. Glaze compositions are subject to attack by lead compounds in high octane gasoline which corrode the surfaces of the glaze to be rough and pitted; and

3. Most glazes become electrical conductors when hot, and therefore form undesirable paths for electrical leakage.

The objects of the present invention include the provision of an improved ceramic spark plug insulator and improved methods of making the same, whereby smooth substantially unpitted surfaces are formed directly on the body of the insulator, and particularly on the shoulders, nose, and tip of a usual form of insulator.

The foregoing and other objects are attained by the ceramic manufacture, ceramic insulators, spark plugs, parts, combinations, sub-combinations, compositions, and methods of making the same, which comprise the present invention, the nature of which is set forth in the following general statement, and preferred embodiments of which together with their mode of use are set forth by way of example in the following description, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the improved ceramic spark plug insulator of the present invention may be stated in general terms as including a fired ceramic body preferably composed of substances not subject to attack by lead compounds or other corrosive agents present in the combustion gases of an internal combustion engine, and which fired ceramic body is at the same time adapted to having its fired surfaces made smooth by polishing to remove the usual projections formed after firing and which projections surround pits. The finished polished surfaces of the improved insulator are made up of particles having surfaces continuous with each other in elemental areas, without voids or pits between the particles of sufficient size to provide lodging places for carbon accumulations of such magnitude as to be detrimental to the continuous satisfactory ignition by the plug, of which the insulator is a part, of the combustible gases in the cylinder equipped with the plug.

The nature of the improved methods of making the improved ceramic spark plug insulators of the present invention may be stated in general terms as including producing a fired ceramic body having surfaces with projections and intervening pits, and reducing the projections by mechanical polishing to form the surfaces on the body smooth and substantially free from the projections and intervening pits.

By way of example, embodiments of the improved spark plug and improved ceramic insulators therefor of the present invention are illustrated in the accompanying drawing forming part hereof, in which

Figure 1 is a longitudinal axial sectional view of one of the improved spark plugs in the form of an aircraft engine spark plug including one form of the improved ceramic insulator;

Fig. 2, a detached isometric view of the improved ceramic insulator of Fig. 1;

Fig. 3, an enlarged longitudinal axial sectional view of the improved ceramic insulators of Figs. 1 and 2; and

Fig. 4, a longitudinal axial sectional view of another form of the improved ceramic insulator.

Similar numerals refer to similar parts throughout the several views.

The improved spark plug indicated generally by 10, includes an outer tubular metal shell 11 having a longitudinally extending central bore 12 with an annular shoulder 13 therein intermediate its ends.

One end of the metal shell 11 is provided with the external threads 14 for screwing into the usual internal threaded spark plug aperture of a cylinder of preferably an aircraft internal combustion engine.

Within the bore 12 of the spark plug shell 14 is located an improved ceramic insulator of the present invention, indicated generally by 15, and which may have a usual external form including at one end a tip 16, a tapered nose 17, and a shoulder 18 at the larger end of the tapered nose 17 intermediate the ends of the insulator 15.

The other end of the insulator 15 is in the form as shown of a neck 19 terminating between the ends of the insulator in a shoulder 20 spaced from the shoulder 18, the shoulders 18 and 20 being located on opposite sides of longitudinally spaced collars 21 which are larger in diameter than the nose 17 or the neck 19.

The insulator 15 with the external surfaces as above described, is generally tubular and includes a central bore 22 which as shown is shouldered for receiving in a usual manner the center electrode 23, which extends beyond the tip of the insulator and cooperates with one or more electrodes 24 on the extremity of the threaded end of the metal shell 11.

For the purposes of the present improvements, the body of the ceramic insulator 15 has such composition as to produce after firing a very high degree of hardness in the order of the hardness of corundum and carborundum, which are usually considered to have a hardness of 9 on Mohs scale of mineral hardness.

Moreover the body of the insulator 15 is preferably composed of substances not subject to attack by lead compounds or other corrosive agents present in the combustion gases of the cylinder of an internal combustion engine served by the improved spark plug 10.

The fired body of the improved ceramic insulator 15 is furthermore highly homogeneous and dense. Substances adapted for composing the body of the improved ceramic insulator 15 to have the desired characteristics indicated herein, are inert oxides of alumina Al_2O_3, magnesia MgO, zirconia ZiO_2, titania TiO_2, and the like.

In compounding the body material, a selected one of such inert oxides to the amount of 85% and up of the body has added to it such other substances as will aid during firing in vitrification and condensation of the mass or mixture, such added substances may be one or more of the above listed inert oxides, or additions of one or more other oxides of elements found in Groups II, III, IV, V, VI, VII, and VIII of the Periodic Table of Elements.

The desired characteristics of the fired body of the improved ceramic insulator 15 are physical rather than chemical, and upon firing the body composed as above indicated becomes a dense vitreous mass which does have however a certain amount of projections and intervening pits which are undesirable.

According to the improved method of the present invention, these undesirable projections indicated by 25 in Fig. 3, are reduced by mechanical polishing so that the finished surfaces of the improved ceramic insulator 15 are smooth and substantially free from projections and intervening pits.

The elemental areas of the finished polished surfaces of the improved ceramic insulator 15 are made up of particles continuous with each other without pits or voids between the particles of sufficient size to provide lodging places for carbon accumulations of sufficient magnitude as to be detrimental to the continuous saitsfactory ignition by the improved spark plug 10 of the combustible gases in the cylinder equipped with the spark plug 10.

Likewise, as above indicated, the body of the improved insulator 15 is not subject to disintegration by the combustible gases of the engine and are adapted for cleaning without destroying the smooth polished surfaces by the usual sand blast cleaning.

It is preferable to polish the shoulders 18 and 20 and the tip 16 and nose 17 of the improved insulator 15 so that in the complete spark plug 10 an effective seal may be obtained between the shoulders 18 and 20 and the usual copper sealing washers interposed between the shoulders 18 and 20 and the shell 11, and also to obtain the desired characteristics above indicated for the nose and tip of the insulator within the cylinder chamber of the engine in which it is used.

Polishing by reducing the surface projections on the fired ceramic body of the insulator 15 provides a means for maintaining the original properties of the material of the insulator 15 and at the same time gaining the advantages of the perfectly smooth surfaces.

Glazing on the other hand, or filling the pits or pores of a fired insulator, to obtain smooth surfaces, changes the characteristics of the insulator as above indicated.

The mechanical polishing of the improved method hereof decreases the surface area of the insulator 15, thereby not only reducing the area upon which carbon may be deposited, but also reducing the rapidity of response of the surface to thermal changes.

All of the outer surfaces of the improved insulator 15 may be mechanically polished, but no particular advantage is gained by polishing the collars 21 and intervening section, and a coat-

ing of glaze may be applied to the neck 19 for strengthening the neck.

A coating or glaze might be applied to the collar 21 and intervening section to increase the mechanical strength of this portion of the insulator 15, but in as much as this portion has the greatest cross section of any portion of the insulator 15, its strength is sufficiently great, and the collars 21 are preferably left unglazed to permit uninterrupted heat conductivity between the insulator collars 21 and the surrounding metal shell 11, with which the collars 21 come in close contact.

A preferred method of polishing the above indicated surfaces of the improved ceramic insulator 15 may be that commonly used in lapidary's art by applying abrasives, of progressively finer grain spread on or impregnated in, a suitable lap, and thereby to the article to be polished, which is in the present instance the fired ceramic insulator 15.

The abrasives may be applied on a revolving or moving lap with the article being polished remaining stationary or revolving.

Furthermore the abrasives may be forced to flow in dry or fluid form around the article or the article revolved or rapidly moved through a mass of the abrasive powder, paste or liquid suspension.

The abrasives used depend upon the hardness of the body being polished. In the case of very hard body of the sintered alumina type where the hardness of the body approached a hardness of 9 on Mohs scale, abrasive powders of equal or superior hardness may be used for the initial stages of the polishing to wear off the largest projections.

Such abrasives as alundum powder, fused aluminum oxide grain, or carborundum powders, silicon carbide grain, may be successfully used. In cases of very great hardness of the body or where considerable roughness must be removed, the use of diamond dust of progressively finer degrees of fineness may be successfully employed.

After the rough surface has been reduced to a smooth surface by the coarser grains of abrasive powder, finer grains are applied to remove the scratches made by the particles of the coarser grain until all but the very finest scratches have been removed. At this point a high polish is obtained on the article by applying finer and softer grain material such as powdered quartz or flint, finely powdered zirconium silicate, chromium oxide, rouge or iron oxide. Best results have been obtained by the use of fine flint powder and zirconium silicate.

A false polish may be obtained where wood laps are used if the resin from the wood is allowed to wax the article due to heat generated by the friction of polishing drawing the resins from the wood. This type of polish is easily detected and can be removed usually by washing in water or alcohol or benzol or some solvent. Also applying a fine polishing powder to such a false polished article will remove a wax polish with very little rubbing.

Another type of false polish is sometimes obtained by the use of materials which will fill the pores and scratches of the article being polished, in which case the filler particles assume a polish. Such materials as clays, some types of paper or very fine powders of alumina will upon the application of great pressures in the polishing process develop a false polish on the article especially when the polishing lap is used dry.

Such false polishes can usually be quickly detected by merely washing the article with water or applying some of the polishing powder wet.

Another type of false polish comes about by application of oils and greases, such effects obtained in this way are not polishes at all but merely brighten the surface giving the appearance of a polish. As soon as the oil or grease evaporates or is removed, the shine or luster is gone.

In Fig. 4 is illustrated another form of improved ceramic insulator indicated generally by 15—1, and including a tapered nose 17—1, a cylindric neck 19—1, and a tapered shoulder 20—1 extending between the larger end of the nose and the smaller neck, the taper of the shoulder being reverse to that of the neck.

The surfaces of the nose, shoulder, and neck of the insulator 15—1 may be mechanically polished so as to be smooth and substantially free from projections and pits, or the nose alone, or the nose and shoulder may be polished, as desired.

The embodiments of the present invention illustrated and described herein are by way of example, and the scope of the present invention is not limited to the same or to the particular details thereof but is commensurate with any and all novel subject matter contained herein which may at any time properly under the United States patent laws be set forth in the claims hereof or originating herein, and the elements of any such claims are intended to include their functional or structural equivalents.

I claim:

1. A spark plug including an outer tubular metal shell, a tubular ceramic insulator within the shell, and a center metal electrode within the insulator, the insulator including at one end a nose and tip having surfaces spaced from inner surfaces of the outer shell, one end of the center electrode extending beyond the insulator nose and tip, a metal electrode on the shell beyond the insulator nose and tip and spaced from the center electrode, and the insulator consisting of a fired ceramic body, surfaces of the body at the nose and tip being smooth and continuous with each other in elemental areas and substantially free from projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfactory ignition by the plug.

2. A spark plug including an outer tubular metal shell having a longitudinally extending bore and a shoulder in the bore intermediate the ends of the shell, a tubular ceramic insulator within the shell, and a center metal electrode within the insulator, the insulator including an external shoulder intermediate its ends and at one end a nose and tip, sealing means between the insulator shoulder and the shell shoulder, the nose and tip having surfaces spaced from surfaces of the shell bore, one end of the center electrode extending beyond the insulator nose and tip, a metal electrode on the shell beyond the insulator nose and tip and spaced from the center electrode, and the insulator consisting of a fired ceramic body, surfaces of the body at the shoulder and at the nose and tip being smooth and continuous with each other in elemental areas and substantially free from projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfactory ignition by the plug.

3. A ceramic spark plug insulator consisting of a fired ceramic body and including at one end a nose and tip having smooth surfaces of the body, the smooth body surfaces including elemental areas continuous with each other and substantially free from projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfactory ignition by the plug in which the insulator is combined.

4. A ceramic spark plug insulator consisting of a fired ceramic body and including an external shoulder intermediate its ends and at one end a nose and tip, the shoulder and the nose and tip having smooth surfaces of the body, the smooth body surfaces including elemental areas continuous with each other and substantially free from projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfacotry ignition by the plug in which the insulator is combined.

5. A ceramic spark plug insulator consisting of a fired ceramic body having smooth surfaces including elemental areas continuous with each other and substantially free from projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfactory ignition by the plug in which the insulator is combined.

6. A ceramic spark plug insulator consisting of a fired ceramic body composed of substances resistant to the corrosive agents present in the combustion gases of an internal combustion engine, and the body having smooth surfaces including elemental areas continuous with each other and substantially free from projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfactory ignition by the plug in which the insulator is combined.

7. The method of making a ceramic spark plug insulator and the like which includes producing a fired ceramic body having characteristics such that the fired surfaces of the body have projections and intervening pits, and reducing the projections by mechanical polishing to form surfaces on the body smooth and substantially free from the projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfactory ignition by the plug in which the insulator is combined.

8. The method of making a ceramic spark plug insulator and the like which includes producing a fired ceramic body having characteristics such that the fired surfaces of the body have projections and intervening pits, and reducing the projections by abrasion to form surfaces on the body smooth and substantially free from the projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satifactory ignition by the plug in which the insulator is combined.

9. The method of making a ceramic spark plug insulator and the like which includes producing a fired ceramic body having characteristics such that the fired surfaces of the body have projections and intervening pits, and reducing the projections by lapping to form surfaces on the body smooth and substantially free from the projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfactory ignition by the plug in which the insulator is combined.

10. In a spark plug including metal members and an insulator, the insulator consisting of a ceramic body, surfaces of the body including elemental areas continuous with each other and substantially free from projections and intervening pits of sufficient size to provide lodging places for carbon accumulations of a magnitude detrimental to continuous satisfactory ignition by the plug.

HAROLD R. FEICHTER.