

Nov. 10, 1942.

J. A. DORAN

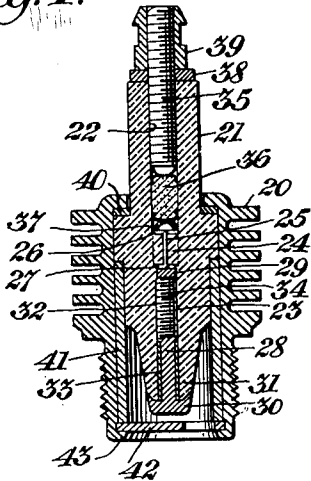
2,301,686

SPARK PLUG

Filed Feb. 8, 1940

2 Sheets-Sheet 1

Fig: 1.



Pig:4.

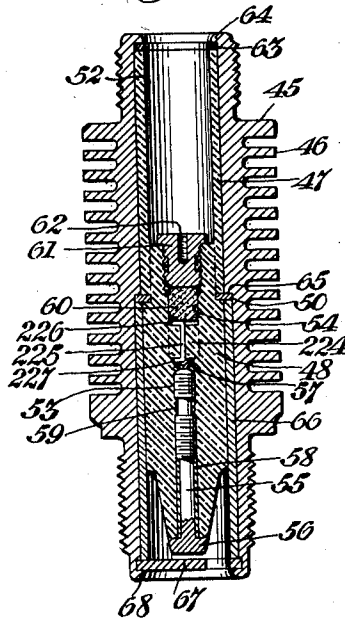


Fig: 2.

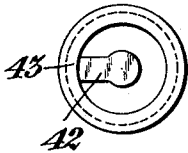


Fig:3.

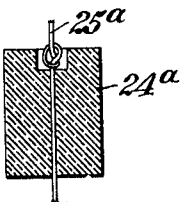


Fig: 7.



Fig: 8.



Fig: 9.



Pig: 5.

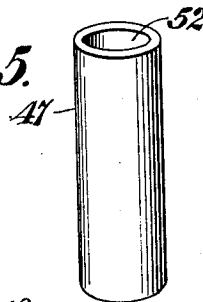
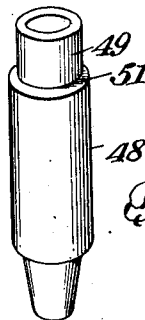


Fig: 6.



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2 Sheets-Sheet 2

Fig. 10.

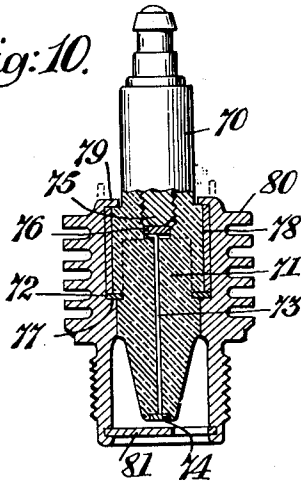


Fig. 18.

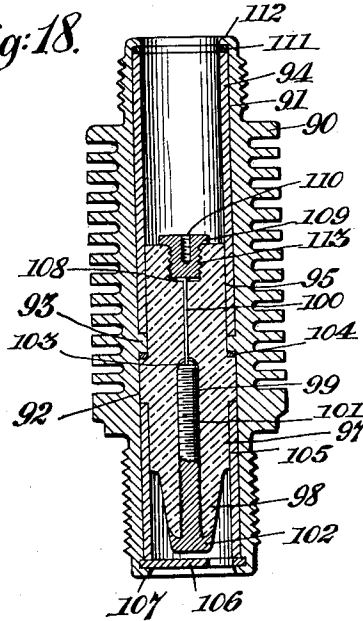


Fig. 11.

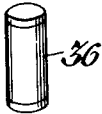


Fig. 12.



Fig. 13.

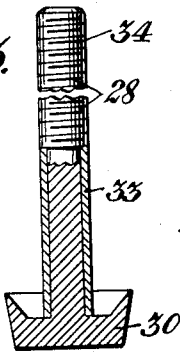


Fig. 14.

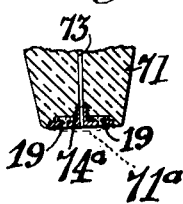


Fig. 16.



Fig. 15.

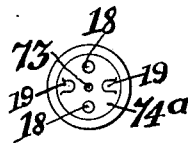


Fig. 17.

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UNITED STATES PATENT OFFICE

2,301,686

SPARK PLUG

James A. Doran, Providence, R. I.

Application February 8, 1940, Serial No. 317,795

10 Claims. (Cl. 123—169)

This invention relates to improvements in spark plugs and has for an object the provision of a spark plug including a ceramic insulator at least a portion of which forms a solid barrier between the interior of the engine cylinder in which it operates and the outside atmosphere, said barrier having baked in, at the time the ceramic was made, a conductor formed of platinum or other metal oxidizable at an extremely low rate at the temperatures encountered in the ceramic ovens, thereby providing zero leakage therethrough.

Another object of the invention is the provision of a spark plug including a ceramic with a terminal well formed therein and a heat barrier between said well and the firing points to permit a lower temperature to be maintained in the terminal well than in the devices of the prior art.

A further object of the invention is the provision in a spark plug, of a ceramic insulator having a metallic annulus the interior of which is fused into the body of the insulator and the exterior of which forms a positive metal to metal seal with the shell.

Other objects and advantages of the invention will be apparent to those skilled in the art as the following specification is read on the accompanying drawings.

All types of spark plugs have heretofore been subject to considerable gas leakage between the members, thus causing many serious results including overheating of the plugs, loss of compression and waste of fuel. Such leakage has been inherently difficult to overcome because the insulators must be sealed with metal electrodes interiorly and with metal shells exteriorly; and joining such totally opposite kinds of materials presents serious difficulties.

Furthermore, wide heat ranges must be endured which injuriously affect the sealing of the parts, due to the fact that the expansion of the metal members is so much greater than the expansion of the insulating member.

There are two sources of gas leakage through spark plugs:

- (1) Between the center electrode and the insulator and
- (2) Between the insulator and the shell.

According to this invention the first source is foiled by eliminating a continuous bore through the insulator. The bore is broken by a solid wall of insulating material having a small platinum conductor extending therethrough and baked in when the insulator is made.

The second source is eliminated by means of

a thin metallic annulus built into the insulator at the time the insulator is made. This annulus projects outwardly from the insulator and permits a new method of sealing to be effected by the use of metal parts only. In other words, by having metal parts of the shell positively engage both sides of the annulus, zero leakage between the shell and insulator is very easily obtained.

Many attempts have heretofore been made to "bake in" electrodes or conductors into the porcelain or other ceramic used as an insulator but such attempts have failed because the electrodes or conductors would oxidize and a sealing bond between the metal and the porcelain could not be obtained. Many patents of the prior art casually state that the electrode is embedded in the porcelain at the time the insulator is made, but obviously the patentees did not actually try to do so, as they would have found out that it was impossible to obtain a gas tight seal due to the fact that the metal of which the electrodes is formed would have wasted away by oxidation at the temperature at which the porcelain is baked. Another effect of the kiln temperatures upon the electrodes is that they would be annealed and would also warp.

Referring to the drawings:

Figure 1 is an elevation in section showing one embodiment of the invention;

Figure 2 is a view of the ground electrode end of the plug in Figure 1;

Figure 3 is an enlarged sectional view of the ceramic pellet positioned in the bore of the insulator of Figure 1;

Figure 4 is a sectional elevation of a shielded type of spark plug embodying my new and improved double seal insulator;

Figure 5 is a perspective view of the upper portion of the insulator of Figure 4;

Figure 6 is the perspective view of the lower portion of the insulator, Figure 4;

Figure 7 is a view of a metallic annulus adapted to be assembled in partly embedded relation with the upper and lower portion of an insulator;

Figure 8 is a view of a portion of a modified form of the annulus;

Figure 9 shows a further modification of the annulus of Figure 7;

Figure 10 is a sectional elevation of an unshielded spark plug embodying further modifications of my sealing method;

Figure 11 is a perspective view of the resistance unit shown in the plug in Figure 1;

Figure 12 is an enlarged sectional view of the compressible contacting disk, and Figure 13 is an

enlarged cross-sectional view of the electrode shown in Figure 1;

Figures 14, 15, and 16 are sectional views of modifications of the electrode tip shown in Figure 10;

Figure 17 is a lower plan view of the modification shown in Figure 14; and

Figure 18 is a cross-sectional elevation of a further modification of the plugs shown in Figures 1, 4, and 10, one of the important features being the use of a two part insulator.

In all of the embodiments herein shown and described, the insulators are preferably made of ceramic materials, however any other suitable materials may be used. In using such other materials, the method of building up the insulators may vary due to the different temperatures encountered. However, the low oxidizing metal which I employ will stand the temperatures encountered and a sealing bond will be formed between the metal and the insulating material.

Platinum is especially satisfactory for this purpose, although any other suitable metal, or platinum alloys may be used, provided they have a sufficiently high melting point to withstand the heat of fusing and molding, and provided they are sufficiently non-oxidizable to withstand the oxidizing effects of the insulating materials employed. It is furthermore highly important that such a metal should have as nearly the same coefficient of expansion as the insulating materials as possible, to insure against leakage at various temperatures.

Referring first to Figure 1, the metal shell 20 has mounted therein an insulator 21, having a bore 22 extending therein from the electrode end, and a barrier or dam 24 is formed therebetween.

Through this barrier or dam 24 is a metallic wire 25 preferably of a low oxidizable material, for example platinum which is bonded to the ceramic or other material of which the insulator is made, so that gases from the cylinder cannot leak through.

One reason why the wire 25 is preferably small in diameter is that, in using precious metals, the cost per unit is very low; and another reason is that the heat conduction of the wire is very low, thereby maintaining the terminal end of the plug at a much lower temperature than in plugs of the prior art. This is particularly valuable in plugs of the "well type" such as illustrated in Figure 4.

In making insulators of ceramic materials it is sometimes convenient to extrude the ceramic from presses in continuous tubular form with a small hole through the center. This hole may be approximately the diameter of the electrode. Lengths of the tubular extruded material are cut off, then placed on the mandrels and the outside is turned to the size and shape required. If the hole through the center needs to be of some special shape or form, for example threaded, etc., this is done after the mandrel is removed. However, the hole extends all the way through; so in order to provide a barrier or dam such as 24, a separate pellet 24a such as is shown in Figure 3 is made with a hole extending longitudinally through the center and a length of small platinum wire 25a is placed in the center hole of the pellet. In order to retain the wire in place, it may have a knot formed therein as shown in Figure 3.

The pellet 24a is then pushed into the central hole of the insulator such as 21 until it rests against the shoulder therein, assuming the posi-

tion shown in dotted lines in Figure 1. A flux or glazing material is placed between the joints and bearing surfaces in order to insure that the fusing operation will bond the insulator, the pellet and the platinum together. After being vitrified, the upper end 26 of the wire 25 is bent down, and the lower end 27 is bent up as shown, and the insulator assembly is complete.

The electrode 28 is then screwed into the threaded hole 23 with a soft metallic disk 29 contacting against the bent end 27 of the wire 25, thereby establishing contact between the electrode 28 and the wire 25. Due to the fact that the disk 29 is soft and compressible it also absorbs mechanical variations and permits the electrode head 30 to firmly enclose the insulator tip 31.

On the electrode 28 are flat spots 32 embedded in cement to prevent it from loosening. On the lower portion of the electrode stem is a metal tube 33 of the same external diameter as the screw thread 34. This tube is preferably made of copper in order to accelerate heat transmission from the firing head 30. The tube is placed on the stem of the electrode before the thread 34 is rolled. Figure 13 illustrates this construction in which the head 30 is upset on the end of the stem, the stem then being of the smaller diameter its entire length. The snugly fitting copper tube is then placed upon the stem abutting upon the upper portion. The stem is then roll-threaded, which operation enlarges the diameter of the stem, and holds the tube in firm engagement between the head 30 and the thread 34.

This electrode construction, wherein a tube is utilized to obtain an increase of diameter equal to the diameter of a rolled screw thread, is highly valuable and novel method applicable to many arts and uses where a rolled thread is desirable, and where at the same time a full diameter stem is necessary.

The terminal screw 35 is set down firmly against a resistance unit 36 contacting a compressible cupped disk 37 which in turn makes a positive contact with the turned over end 26 of the wire 25. A terminal flange 38 is mounted on the screw 35 snugly against the insulator, while 39 is a conventional terminal nut.

After assembling the insulator 21 in the shell 20, a gasket 40 is first placed in position in the shell, followed by the insulator assembly. A metal tube 41 forces the insulator against the gasket 40, and seals the insulator in the shell; such pressure being exerted when the electrode 42 is pressed against the sleeve 41 by the pressure from the curling or spinning over of the lower edge 43 of the shell.

Before assembling the metal parts in the insulator, all surfaces are coated with a suitable sealing cement or compound to insure the thermal conductivity between the members and to prevent the loosening of electrode 28 and terminal screw 35. Likewise, before assembling the insulator in the shell, all bearing surfaces are preferably coated with a compound that will maintain the maximum thermal conductivity between all the interior members and the shell. The tubes 33 and 41 are coated with compound for the purpose of rapidly extracting heat from the ground electrode 42 and from the electrode head 30, and rapidly transmitting such heat to the radiating flanges of the shell.

The shielded type plug shown in Figure 4 shows a modification of the arrangement shown in Figure 1, in which in addition to providing a

solid barrier to gases tending to pass through the insulator, a second solid barrier is provided through which it is impossible for any gases to leak through between the insulator and the shell.

The shell 45 is preferably provided with a maximum number of thin radiating flanges 46, inasmuch as this type of plug is commonly used on aircraft engines operating under very high temperatures. The insulator is composed of an upper tubular portion 47 and a lower portion 48. In the lower portion 48 is a pellet 224, in which is located conducting wire 225 with bent-over ends 226 and 227.

In constructing the insulator a thin platinum disk is provided, such as that shown in Figure 7 and designated by the numeral 50, or it may be of the modified forms 150 shown in Figure 8, or 250 shown in Figure 9. The upper part 47 is made tubular as shown in Figure 5, and the lower part 48 Figure 6 has a reduced portion 49 thereby forming a shoulder 51 upon which the platinum washer 50 may rest. The reduced portion fits the hole in the washer 50 and also fits the interior hole formed in the tubular portion 47.

The portion 48 of the insulator has a bore 53, bounded by the pellet 224, after the latter is placed in the bottom of the bore 54, portions of the bores 53 and 54 are threaded to accommodate matching threads on the electrode stem and the terminal shank respectively. The ceramic parts having been formed up and having been coated with suitable flux or the like are assembled as follows: The pellet 224 having a knotted platinum wire 225 therein is pushed in the shouldered end 49 until it reaches the bottom of the bore 54. The platinum washer 50 is slipped over the boss 49 and caused to rest on shoulder 51, after which the sleeve 47 is slipped on the boss and pushed down until it touches the upper face of the washer 50, leaving the projecting part of the washer to form a projecting flange. The assembly is then placed in a furnace or kiln to vitrify the ceramic and seal in the conducting wire 225 and the projecting flange 50. Due to the fact that the coefficients of expansion of the platinum and the ceramic are nearly equal, and due to the fact that the platinum can stand the heats encountered for the required amount of time the surfaces of the platinum form a bond or permanent seal with the ceramic, which bond is not affected by any conditions, no matter how extreme, under which the insulator, or the plug in which it is embodied, may have to work.

The electrode 55 has a head 56 enclosing and reinforcing the tip of the insulator. The electrode 55 is screw threaded at its upper end, and presses firmly against the compressible disk 57, to insure positive contact against the end 227 of the conducting wire 225. The electrode also has a copper tube 58 to accelerate heat dissipation from the head 56, and flattened portion 59 for cement facilitates the locking in of the electrode. In the upper portion of the insulator is a carbon resistance 60 contacting against the end 226 of the conducting wire 225, under pressure from the terminal screw 61. In the upper end of the screw 61 is a tapped hole 62 into which any suitable connector device may be screwed.

The entire insulator assembly is then placed in the shell 45 with a gasket 63 resting against an upper ledge 64 of the shell. The flange 50 is secured against the shoulder 65 by the metallic sleeve 66, being held under positive pressure by the electrode 67 and the curled over edge

68 of the shell. The gasket 63 acts as a thrust washer to support the insulator against cylinder pressures, and thus relieves the flange 50 from bearing such mechanical stresses. The flange 50 being severely compressed between the shoulder 65 and the sleeve 66 functions as a sealing member to prevent gas leakage between the insulator and the shell.

The carbon resistance member 60 should be of about fifteen hundred ohms resistance in order to serve as a means for overcoming the capacitance existing between the metal conduit and the conducting ignition cable in a shielded ignition system, however other values may be employed in accordance with the conditions under which the plug is to be used. Thus, the resistor 60 also serves to reduce the burning away of the electrodes 39 and 42; it being particularly efficient because of its location so close to the electrodes. In engines where the heat is not excessive, this resistor could be located between the conductor wire 125 and the electrode stem 55.

The metal sleeve 66 may be of any material desired but I prefer to use copper due to its high conductivity for conducting heat from the ground electrode 67 and also from the insulator to the shell. In the plug of Figure 4, cement or compound is applied to the insulator and the sleeve to form bonds therebetween to facilitate the dissipation of heat.

The carbon resistance member 36 in Figures 1 and 2 is used as a radio suppressor and for such purpose should be of about twenty thousand ohms resistance. Suppressors are ordinarily mounted exterior to the plug itself; but the suppressing action is more efficient when the resistor is located as close as possible to the sparking gap.

An unshielded spark plug wherein the insulator is mounted from the top of the shell 80 is a further modification shown in Figure 10. In this figure a modified form of fused-in wire is shown instead of the pellet arrangement above described. This insulator is made of two portions; an upper portion 70 and a lower portion 71 with a metal collar 72 fused between the two portions. The conducting wire 73 is mounted in the lower portion 71, and carries a firing tip 74 which is embedded within and has its face flush with the tip of the insulator. The electrode 74 and the wire 73 must both be of a substantially non-oxidizable metal inasmuch as it is placed in position, together with the wire 73 and the collar 72 before the portions are fused together and vitrified.

After being vitrified, the terminal screw 75 is screwed firmly down against the disk 76 in order to contact with the bent portion of the conducting wire 73. The complete assembly is then placed in the shell 80 with the flange 72 resting on the shoulder 77, while a sleeve 78 is inserted from the top of the shell to contact 72. The curling over of the upper edge 79 creates pressure upon the insulator body and upon the flange 72 to effect a metal to metal gas-tight seal between the insulator and the shell. All bearing surfaces between terminal screw 75 and the insulator, as well as the bearing surfaces between the insulator and the shell are preferably coated with a cement compound before assembly for the purpose of obtaining a bond promoting maximum thermal flow.

In this construction, the firing tip 74 is further protected against overheating by reason of it being embedded in the insulator tip and thus is

protected against cylinder temperatures on all surfaces excepting its face. In this construction, platinum or a platinum alloy can be used as the firing electrode most advantageously, as it does not readily oxidize and burn away; therefore, a comparatively thin disk may be used in order to keep the cost of the material down to a point that is not prohibitive. The ground electrode 81 is similar to the ground electrode 42 except that its central portion is of a diameter to correspond with the electrode face 74.

In Figures 14 and 17, the electrode 74a has tapered holes 18 and lugs 19 formed therein. Before the ceramic is fused, the electrode is coated with flux or glazing material and applied to the ceramic. By fusing, the tapered holes 18 and the space around the lugs 19 are filled with glaze, and a portion 71a which covers the end of the electrode 74a is ground off to expose the face of the electrode.

Figure 15 shows another form of the electrode, wherein the conducting wire 73b passes through the electrode 82a so that the two members may be riveted or welded at 84. Figure 16 shows another form of electrode tip wherein a wire 85 is formed spirally, and fused or glazed to the insulator when the latter is being vitrified.

In the modification shown in Figure 18, the shell 90 has a bore 91 extending in from one end thereof and a bore 92 extending therein from the other end, the portion 93 between said bores being of reduced diameter and forming a ledge. A thin annulus 107 is provided on the firing chamber end, and a second annulus 112 is provided on the terminal well end.

The insulator is comprised of two parts. The upper part 94 is a plain straight sleeve. It may be of ceramic material, glass, or any other suitable material. The lower part consists of: a portion 95 over which a portion of the length of the sleeve 94 extends, a shoulder portion 96, a straight portion 97 and a tapered portion 98 at the bottom as shown in Figure 18. From the bottom a threaded hole extends upwardly along the center line to a point above the middle of the lower part. From the upper end a threaded hole extends downwardly.

Between the threaded hole 113 and the threaded hole 99 extends a platinum wire 100 having its ends extending into said threaded holes.

When the lower part of the insulator is formed up, prior to vitrifying the same, a small hole is formed joining holes 99 and 113, and a knotted or bent platinum wire is inserted. Suitable flux or the like is applied and the insulator member is placed in the kiln or oven to vitrify the same with the result that the platinum wire is fused in and thereby an imperforate barrier is formed in the insulator between the threaded holes 99 and 113. The protruding ends of the platinum wire are bent over. A washer 103 of soft material is forced into intimate contact with one end of the platinum wire when the screw 101 carrying the electrode 102 is screwed in, and since the washer is soft the electrode may be brought right up to the lower end of the insulator. The screw 103 when screwed into the hole 113 forces soft washer 108 into intimate contact with the upper end of the platinum wire 100. It is of course necessary to apply a cementitious compound to the screws before they are applied to the insulator and it is also understood that the bearing surfaces of the upper and lower portions of the insulator are also coated with a sealing and bonding com-

pound before they are assembled into the shell.

The order of the assembly hereinafter described need not be followed literally, as any order capable of giving as a resultant, the arrangement shown in Figure 18 may be followed.

The lower portion of the insulator (having the electrode end screwed in and the terminal screw assembled therein), has a suitable sealing gasket 104 positioned on the upper surface of its shoulder 96 and, sufficient sealing compound having been applied to all of the bearing surfaces, the insulator is then inserted through the bottom of the shell until the gasket 104 encounters the ledge 93, after which a copper sleeve 105 also having had compound applied thereto is inserted into the shell from the bottom. Following this the ground electrode is applied and the annular rim 107 is spun over, thereby forcing the sleeve 105 against the shoulder 96 and the shoulder and the gasket 104 against the annular ledge 93, thereby effecting a seal between the ledge and the shoulder with the gasket therebetween.

The sleeve member 94, having been coated with compound is then inserted into the shell from the upper or outer end, whereby it overlaps the upper portion 95 of the lower insulator member and comes to rest on the upper surface of the ledge 93. The gasket 111 which may be of lead and serves as a cushioning member is then inserted and the thin annular rim 112 is then spun down onto the gasket 111. The distance from the terminal screw 109 along the top of the lower insulator member, and thence downwardly, between the sleeve 94 and the lower insulator member, to the ledge 93 is far greater than the greatest safety distance, therefore this plug with the two piece insulator has an ample factor of safety plus the following advantages:

1. The two part insulator permits the manufacture of 50% more units per day as the sleeve portion may be produced by extrusion and a cutting off operation, and the lower part of the insulator has fewer operations and can therefore be formed up more rapidly than any of the other forms herein described; therefore, the two part insulator shown in Figure 18 costs less to produce.

2. The length of platinum conductor may be applied to and fused into the lower insulator member directly instead of employing the pellet hereinbefore described.

3. The short length of insulator (shoulder) between the copper tube and the gasket tends to fully compensate for the unequal expansions of the steel of the shell, the copper tube and the ceramic of the insulator. In Figure 18 the proportions are for the ceramic 1.0 as against the copper tube 0.6, plus 0.4 for the steel.

4. A sealing and bonding compound is applied to all bearing surfaces to facilitate the dissipation and disposal of heat from the electrodes.

5. The platinum wire is small in diameter and in addition to forming an imperforate barrier against the leakage of gases therethrough, it also permits a heretofore unattained low rate of conduction of heat from the firing chamber, and the electrode, to the terminal well of the insulator.

In this application, I have shown the advantages of a conducting wire being fused into an insulator, and also a flange being fused into the exterior walls of an insulator; both features as adaptable and advantageous for spark plug practice. However, I wish it understood that I do not limit this invention to this particular use since it is adaptable to various electrical devices

where the advantages of an interior conductor and an exterior supporting flange are of value.

Having described my invention, I claim:

1. In a spark plug, an insulator having an electrode circuit therethrough including a length of precious metal fused into said insulator and forming an imperforate barrier between the firing chamber and the exterior of said plug, said metal having a coefficient of expansion similar to that of the insulator and being capable of standing the high temperatures of the kiln in which said insulator is fused, for the required length of time without oxidizing.

2. The method of making a ceramic insulator for spark plugs or the like which includes the step of forming said insulator of unfused material with a passage therethrough, the step of applying a length of non-oxidizing conductive material in at least a portion of the length of said passage, and the step of fusing said insulator and said conductive material together to form a vitrified imperforate body.

3. The method of making insulators for spark plugs or the like which includes the step of forming an insulator body of ceramic material with a longitudinal passage therethrough, the step of forming a pellet of ceramic material having a small passage therethrough, the step of applying a length of nonoxidizing conductive material in said last mentioned passage, the further step of positioning said pellet within said first passage, and the step of fusing the above named parts together to form an insulator having a barrier therein, imperforate to the passage of gases therethrough, yet freely permitting current to pass therethrough.

4. The method of making insulators for spark plugs which consists in forming a body of unfused ceramic material, forming a hole therethrough at least a portion of the length of which is of minute diameter, inserting a conductor formed of nonoxidizing material in the portion of minute diameter, and fusing said body to vitrify the same and to bond said conductor therein.

5. In spark plug, an insulator body having a bore extending therein from the terminal end thereof, a second bore extending therein from the electrode end, a barrier in said body between said bores having a platinum conductor extending therethrough and bonded therewith to form a permanently impervious dam through which gases under pressure cannot pass.

6. A spark plug insulator formed of ceramic

material, said insulator having a terminal bore extending therein from one end, an electrode bore extending therein from the other end thereof, an imperforate body of material between said bores, and a conductor fused into said body and extending from one of said bores to the other.

7. An insulator according to claim 6 in which a terminal member is mounted in said first mentioned bore in contact with said conductor, and in which an electrode member is secured in said second mentioned bore in contact with said conductor, whereby current may readily pass through said insulator, but gas under pressure cannot.

8. The method of making a spark plug insulator which consists of forming a body of unfused ceramic material with a threaded hole extending therein from one end, a larger threaded hole extending therein from the other end, and an unthreaded hole therebetween, forming a pellet of unfused ceramic material, placing a non-oxidizing conductor in said pellet with its ends extending therefrom, mounting said pellet in said unthreaded hole with fluxing material therebetween, and fusing said ceramic materials to form a unitary imperforate insulator.

9. The method of making a ceramic insulator for spark plugs which includes, the step of extruding the ceramic material from an unfused ceramic mixture under pressure to form a continuous tube of said material with a small concentric hole extending longitudinally therethrough, the further step of cutting the extruded material off in lengths, the step of externally shaping said lengths by turning, the step of positioning in the hole in each of said lengths an electrode conductor, and the step of fusing said lengths in a kiln or oven to produce fused insulators having said conductors fused into and bonded therewith to form an imperforate body.

10. The method of making an insulator for spark plugs or the like which consists of, forming a body of an unfused ceramic mixture, a longitudinal hole being formed therein simultaneously with the forming of said body, at least partially embedding an electrode in one end of said insulator, said electrode being formed of non-oxidizing metal and having a conductor connected thereto and extending into said longitudinal hole, and the step of vitrifying said body and bonding said electrode and said conductor together to form an imperforate body.

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