June 3, 1958 K. SCHWARTZWALDER ET AL 2,837,679

GLASS SEALED CENTERWIRE STRUCTURE

Filed Aug. 22, 1952

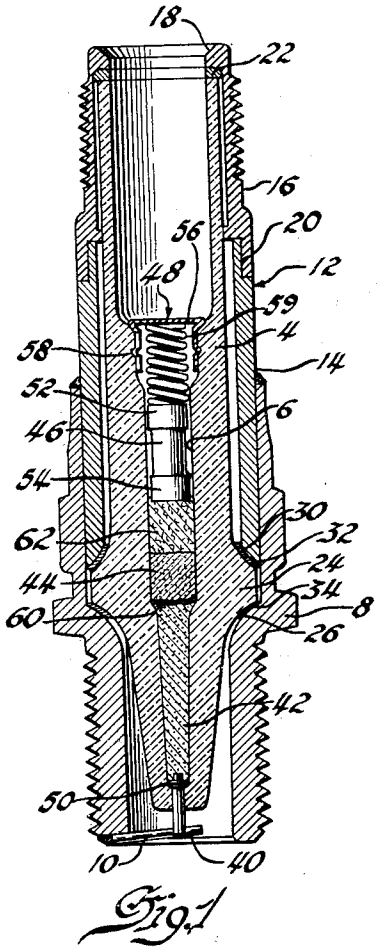


Fig. 1

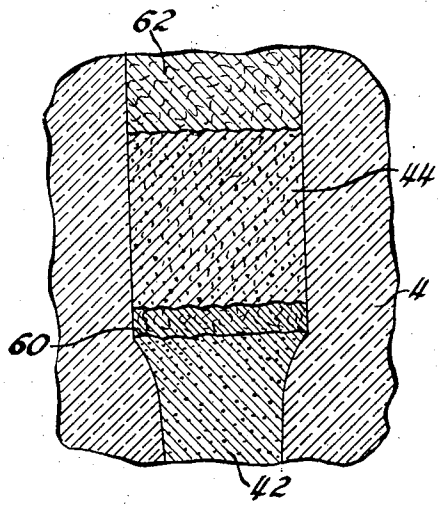


Fig. 2

Inventors,
KARL SCHWARTZWALDER,
ROBERT W. SMITH
By
Willitz, Helwig & Baillio
Attorneys

United States Patent Office

2,837,679

Patented June 3, 1958

2,837,679

GLASS SEALED CENTERWIRE STRUCTURE

Karl Schwartzwalder, Holly, and Robert W. Smith, Flint, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application August 22, 1952, Serial No. 305,876

9 Claims. (Cl. 313—145)

This invention relates to internal combustion engine spark plugs of the type comprising a centerbored insulator surrounded and supported by a metal shell carrying a ground electrode, and a centerwire structure including a resistor element and a conductive seal positioned within the insulator centerbore and having an electrode firing tip extending to the exterior of the base of the insulator into spaced relationship with the ground electrode to form a spark gap. More particularly, this invention relates to a resistor and seal structure for the spark plug centerwire.

One of the essential requirements of a spark plug is that is be gas-tight in order to prevent gas leakage from the combustion chamber of the engine in which it operates. Since gas leakage can occur through the spark plug insulator centerbore, it has always been necessary to provide some adequate sealing means between the central electrode or centerwire structure and the walls of the insulator centerbore. Because of the relatively high temperature and pressures encountered, the sealing means must have optimum properties of heat- and shock-resistance. In older type spark plugs wherein a solid one-piece metal centerwire structure was used, the seal could be formulated to give these optimum properties of heat- and shock-resistance without regard to electrical conductive properties since the seal in such a structure did not serve as a part of the conductive path for the current furnished to the spark gap. However, in recent years it has become conventional practice to provide spark plugs, particularly of the type used in aircraft, with resistor elements to suppress the high frequency oscillations associated with spark discharge in an ignition system. The resistor elements most commonly used are positioned within the insulator centerbore so as to form a part of the centerwire structure and may be one or the other of two general types. One type consists of a monolithic resistor composition which is tamped into an axial portion of the insulator centerbore and then heated so as to hot press the composition and fuse it to the walls of the centerbore. The other type consists of a resistor cartridge which is inserted as a unit into the centerbore to form a part of the centerwire structure.

With the advent of the use of such resistors, it also became the practice to gas-proof the centerbore by means of a conductive seal consisting of a mixture of glass or ceramic material and a conductive powder such as nickel, copper, silver or other metals, or carbon. Such conductive seals may be formed by tamping the glass-conductive powder materials into the centerbore between other elements of the centerwire structure and then hot pressing the powder by heating to soften the glass portion and applying pressure to the fluid or semi-fluid seal composition to cause it to bond to the walls of the centerbore to form a gas-tight seal and also to bond to the abutting portions of the centerwire above and below the seal to form a low resistance conductive path.

Thus, for example, the centerwire structure may consist of a nickel, silver, or other metal electrode spindle

portion positioned in the bottom of the centerbore and having an end portion extending to the exterior of the insulator to form a firing tip, a conductive seal hot pressed in an axial portion of the centerbore immediately above and abutting the top of the metal spindle, a resistor either of the tamped and sintered monolithic type or of the cartridge type immediately above and abutting the seal, and some suitable electrical contact element above the resistor in electrical contact therewith and adapted to make contact with the ignition harness terminal.

With such structure, essential requirements of the seal are that it form a heat-and shock-resistant bond with the centerbore walls, and that it form a good conductive bond with the abutting portions of the centerwire structure. The conductive seal must have negligible electrical resistance and must have sufficient elasticity and ductility to withstand the cyclic thermal stresses resulting from engine operation.

It will therefore be apparent that the conductive seal composition must be such that it will firmly bond to two materials of greatly differing characteristics, namely, the ceramic insulator centerbore walls and the metal abutting portions of the centerwire structure.

The spark plug sealing problem is different from conventional metal-to-glass sealing in three respects. First, the choice of electrode and insulator materials is dictated by operational considerations. Thus, the insulator and electrode compositions cannot be selected solely on the basis of their expansion or bonding characteristics. In other words, the composition of the glass seal must be dictated by the requirements of the insulator ceramic and of the electrode material. Secondly, aside from the requirement that the seal have satisfactory bonding characteristics, it must also be a good electrical conductor. Thirdly, the sealing operation, which includes hot pressing the seal material, must be non-critical as to temperature, atmosphere or hydrostatic pressure, since these variables cannot conveniently and economically be closely controlled during spark plug manufacture.

When a base metal electrode, such as one made of a nickel-chromium alloy, is used, it is possible to formulate the seal to assure a satisfactory bond both to the ceramic and to the electrode and at the same time obtain suitable qualities of elasticity, ductility and conductivity. This is true because of the surface oxide forming property of the nickel-chromium alloys which has good bonding characteristics with conductive seal compositions. Also, this is true because such electrodes are formed prior to insertion into the insulator centerbore and thus can be slotted or roughened at the top or seal abutting portion so as to further assure a good bond. However, when a centrifugally cast silver or silver alloy center electrode spindle is used, as is common in various types of spark plugs, it has been found that when the conductive seal composition is formulated so as to give the most firm and durable bond with the ceramic insulator centerbore wall, the bond between the seal and the silver electrode spindle is unsatisfactory and results in high contact resistance at the junction. On the other hand, if the seal composition is formulated to give an optimum bond with the silver electrode spindle to eliminate high contact resistance, the bond between the seal and the ceramic insulation wall is unsatisfactory and fails to adequately seal against gas leakage. Generally, the inclusion of a greater proportion of metal powder in the bonding material results in a better bond with metal, whereas the inclusion of a greater proportion of glass results in a better bond with ceramic. For example, a composition containing 70% silver powder and the remainder glass bonds well to a silver surface while a composition containing 55% silver and the remainder glass bonds well to an alumina insulator.

Since the silver or silver alloy electrode is cast within the centerbore, there is no opportunity to aid bonding by slotting or roughening the seal abutting surface of the electrode. Also, the difficulty is caused by the more troublesome bonding characteristics of the silver or silver alloy metal. When the seal is formulated to bond well to the insulator, failures manifest themselves by greatly increased electrical contact resistance between the seal and the silver electrode or actual mechanical separation along the boundary.

The problem of adequately sealing the centerbore of a spark plug employing a cast silver center electrode is more pronounced when a cartridge-type resistor is used, since such a resistor is not bonded to the centerbore walls to form a seal as is the case with a monolithic type resistor. Thus, when a cartridge resistor is used, the entire load of sealing the centerbore against gas leakage is carried by the conductive seal.

It is an object of this invention to provide a spark plug centerbore seal structure such as will have optimum bonding characteristics with the insulator material to give a good seal against gas leakage and at the same time optimum bonding characteristics with abutting metal parts to give high conductivity. Another object of the invention is the provision of a centerwire structure for a spark plug which is heat- and shock-resistant, which adequately seals against gas leakage through the insulator centerbore and which is durable and dependable. Still another object is the provision of a process for sealing a spark plug centerbore whereby high conductivity and assurance against gas leakage are attained. These objects are carried out in accordance with the invention by formulating the conductive seal to bond well to the ceramic insulator and by the provision of a layer of conducting powder between the glass seal and the abutting portions of the centerwire structure whereby a good bond is attained therebetween with resulting high conductivity.

Other objects and advantages of the invention will appear more clearly from the following description of preferred embodiments and from the drawings in which:

Figure 1 is a side view in section of a spark plug embodying the invention;

Figure 2 is an enlarged side view in section of the centerwire conductive seal and metal powder layer components as shown in smaller scale in Figure 1.

Referring now to the drawings, Figure 1 shows a spark plug having an insulator 4 provided with a centerbore 6, a metal shell 8 surrounding and supporting the insulator and carrying a ground electrode 10, and a shield 12 secured to the metal shell and surrounding the upper portion of the insulator 4. In the particular embodiment shown, the shield 12 consists of two separate tubular sections 14 and 16, the lower section 14 being secured to the shell 8 by brazing or by other suitable means and the upper section 16, which is provided with an inwardly turned annular flange 18 and which is secured as shown at 20 to the lower section 14 by a weld or braze. A copper or other soft metal gasket 22 is positioned between the top of the insulator 4 and the inwardly turned flange 18 of the upper shield section 16.

The insulator 4 is secured within the metal shell by means of the shoulder 24 which cooperates with an internal annular shoulder 26 on the shell 8 and with the lower edge 30 of the shield 12. Metal gaskets 32 and 34, which are positioned between the insulator shoulder and the shell and shield assembly, assure a tight and secure fit of the parts.

The insulator centerbore 6 is of varying diameter for reception of the various component parts of the centerwise structure as hereinafter described.

In the embodiment shown, the spark plug centerwise structure includes a platinum or other heat-resistant metal or metal alloy firing tip 40, the lower end of which extends to the exterior of the insulator and is positioned in spaced relationship with the ground electrode 10 to

form a spark gap, a centrifugally cast silver electrode spindle 42, a conductive seal 44, a cartridge resistor 46 and a spring-contact cap assembly 48.

The firing tip 40 has an enlarged portion 50 to retain it within the insulator centerbore as shown and to assure better contact with the cast silver spindle 42. The silver or silver alloy electrode spindle 42 is formed by inserting a silver metal plug into the bore 6 after the firing tip 40 has been positioned after which the insulator and slug assembly is heated to the melting temperature of the silver and centrifuged so as to cast the silver spindle in situ. A cast silver or silver alloy center electrode has the advantages of high conductivity as well as high electrical conductivity.

Cartridge resistor 46 is of the conventional type and consists of a suitable resistance material having metal contacts 52 and 54 at either end. The contact cap-spring assembly 48 consists of a split metal cap 56 provided with an annular shoulder 58 which removably engages a mating annular groove in the wall of the centerbore with a spring action to hold the cap in place and a spiral spring 59 which is held pressed by the cap against the contact 52 of the resistor to establish an electrical path.

The conductive seal 44 is formulated so as to have optimum bonding characteristics with the ceramic wall of the centerbore by using a relatively low proportion of metal or other conductive powder and a relatively high proportion of glass. A seal composition which bonds excellently to an alumina type insulator such as is used in the spark plug shown consists of about 45% by weight Pyrex or borosilicate glass and 55% by weight silver or copper powder. Seal compositions of this general type are disclosed in U. S. Patents 2,248,415 Schartzwalder et al., 2,459,282 McDougal et al. and 2,106,578 Kirk. Generally, to attain good binding with the insulator, we have found it preferable to use a conductive seal having a composition of from 30 to 50% by weight alkali alumina boro silicate glass and the remainder metal powder. It is to be understood that various other conductive seal compositions may be used within the spirit and scope of the invention, the only requirements being that it have good conductive properties and good bonding properties with the insulator used.

Interposed between the conductive seal 44 and the cast silver or silver alloy electrode spindle 42 is a compact layer of conductive powder 60. This layer of conductive powder which is bonded firmly to the top surface of the silver electrode spindle 42 and to the conductive seal 44 is preferably a metal such as nickel, silver, iron, cobalt, chromium or silicon, or alloys thereof such as stainless steel. However, non-metals such as oxides, carbides, nitrides, carbon and the like may be used in place of metal powder either in whole or in part. The result of such an intermediate conductive layer 60 is that a firm bond with extremely low contact resistance is attained between the seal 44 and the spindle 42. We have found that nickel and silver are preferable as the conductive powder material for the bonding layer 60. Nickel has been found to be especially suitable.

If metal is used as the material for the layer 60, it is necessary that it be such as to bond to but not form a fusible alloy with silver in the temperature range of from about 1400° F. to 1750° F. which temperatures are usually employed for the hot pressing or sealing operation. We thus have a layer of compact sintered metal firmly adhering to the silver and also, due to its particulate nature, mechanically inter-locked with the adjacent glass seal.

In the embodiment shown, another layer 62 of compact sintered metal powder is used above the seal 44, the top surface of which serves as a contact for the resistor element 46 which is pressed downwardly by the spring 59. Of course, other contact structures such for example as a centerwire screw having one end embedded in the seal 44 can be used in place of the top layer 62

of sintered metal powder. Generally, the metal powder layer 62 is used on a contact when the amount of space available is limited. In other instances a screw type contact may be preferable because of economies thereby attained.

The following description of a preferred process for manufacturing the centerwire structure will serve to more fully describe the exact structure of and relationship between the various layers.

After the platinum or other heat-resistant metal firing tip 40 is positioned in the insulator centerbore, as shown, the cast silver or silver alloy electrode spindle 42 is centrifugally cast in situ as previously described. A load of spherical nickel powder or granulated nickel powder is inserted into the centerbore to form a uniformly thick layer adjacent the top of the electrode spindle 42 and then a load of conductive glass seal composition formulated to assure a good bond with the centerbore wall is inserted over the top of the nickel powder layer. Then another load of nickel powder is inserted to form an even layer on top of the conductive seal. The layers are then tamped or rammed to compact and interlock their surfaces. Thereafter, the insulator is placed in a furnace and heated to from 1400° F. to 1750° F. and preferably to about 1600° F. for about thirty minutes while a pressing force of from 10 lbs. to 85 lbs. is applied. During this hot pressing operation the conductive glass seal flows and firmly bonds to the insulator centerbore walls as well as to the metal powder layers 60 and 62. At the same time the metal powder layer 60 sinters and bonds firmly to the top of the electrode spindle 42. After removal from the oven and after cooling, the cartridge-resistor 46 is inserted and held in place by positioning the contact cap spring assembly 48 in the centerbore, as shown. As stated previously, the top metal layer 62 can, if desired, be replaced by a solid metal screw which is embedded into the conductive glass seal layer to form a contact.

By ramming the conductive powder layer and glass seal together, a firmly inter-locked and compact graded seal is formed. Nickel, silver, iron and the other materials heretofore listed all bond satisfactorily to the cast silver surface under normal glass sealing conditions as described above.

The exact amount of metal powder used will, of course, depend on the size of the centerbore. We prefer to use a load sufficient to provide a layer about 1/32" thick between the cast silver surface and the seal. The top metal layer if used may be of any desired thickness as, for example, from 1/16"t o 1/8".

The following list of metal powders serves to exemplify the types which may be used for the layer 60 and also for the layer 62:

Spherical nickel
Tamping grade silver powder
Granulated regular grade nickel powder
Granulated regular grade iron powder

Generally, we have found that spherical nickel powder is preferable for use as the layer 60 between the silver spindle and the conductive glass seal.

The invention has been described with reference to a structure using a cartridge-type resistor element. As stated previously, the invention is particularly useful when such a resistor is used; however, it is to be understood that a monolithic type resistor could of course be used. In this latter case, the resistor material may be loaded into the centerbore after insertion of the conductive seal layer 44 and then tamped or rammed. Thereafter the firing operation can be performed so as to cause the flowing and bonding of the various layers.

In addition to the advantages of this invention as previously described, we have found that the use of a metal powder layer between the silver spindle and the conductive seal allows the use of a glass-copper powder mixture as the conductive seal with as good results as when a glass-silver powder seal is used. Heretofore, it has usually been the practice to employ silver as the conductive powder in the seal. With this invention, copper can be used to attain optimum results thus affecting great savings in the cost of manufacture.

Various changes and modifications of the embodiments of the invention described herein may be made by those skilled in the art without departing from the spirit and principles of the invention.

We claim:

1. A spark plug comprising an insulator having a centerbore, a silver electrode spindle positioned at one end of said centerbore, a resistor element in said centerbore, a layer of a mixture of glass and conductive powder electrically connected to said resistor element and bonded to the walls of said centerbore between said resistor element and said silver electrode spindle to form a gas-tight seal in said centerbore, and a compact sintered layer of metal powder in contact with and bonded to said first mentioned layer and said silver spindle to form a path of low electrical resistivity.

2. A spark plug comprising an insulator having a centerbore, a silver electrode spindle positioned at one end of said centerbore, a resistor element in said centerbore, a layer of a mixture of glass and conductive powder electrically connected to said resistor element and bonded to the walls of said centerbore between said resistor element and said silver electrode spindle to form a gas-tight seal in said centerbore, and a compact sintered layer of nickel powder in contact with and bonded to said first mentioned layer and said silver spindle to form a path of low electrical resistivity.

3. A spark plug comprising an insulator having a enterbore, a silver electrode spindle positioned at one end of said centerbore, a resistor element in said centerbore, a layer of a mixture of glass and conductive powder electrically connected to said resistor element and bonded to the walls of said centerbore between said resistor element and said silver electrode spindle to form a gas-tight seal in said centerbore, and a compact sintered layer of silver powder in contact with and bonded to said first mentioned layer and said silver spindle to form a path of low electrical resistivity.

4. A spark plug comprising an insulator having a centerbore, a silver electrode spindle positioned at one end of said centerbore, a resistor element in said centerbore, a layer of a mixture consisting of from 30% to 50% glass and the remainder conductive powder electrically connected to said resistor element and bonded to the walls of said centerbore between said resistor element and said silver electrode spindle to form a gas-tight seal in said centerbore, and a compact sintered layer of nickel powder in contact with and bonded to said first mentioned layer and said silver spindle to form a path of low electrical resistivity.

5. A spark plug comprising a tubular metal shell, an alumina insulator secured within said shell and having a bore extending therethrough, a silver electrode spindle positioned in said bore at one end thereof, a resistor element in said bore, a layer of a mixture of glass and metal powder electrically connected to said resistor element and bonded to the walls of said bore between said resistor element and said silver electrode spindle to form a gas-tight seal in said centerbore, and a compact sintered layer of conductive material in contact with and bonded to said first mentioned layer and said silver electrode spindle to form a path of low electrical resistance, said conductive material being selected from the group consisting of nickel, silver, iron, cobalt, chromium, silicon and alloys thereof.

6. A spark plug comprising a tubular metal shell, an alumina insulator secured within said shell and having a bore extending therethrough, a silver electrode spindle positioned in said bore at one end thereof, a resistor ele-

ment in said bore, a layer of a mixture consisting of about 45% glass and about 55% metal powder electrically connected to said resistor element and bonded to the walls of said bore between said resistor element and said silver electrode spindle to form a gas-tight seal in said centerbore, and a compact sintered layer of nickel powder in contact with and bonded to said first mentioned layer and said silver electrode spindle to form a path of low electrical resistance.

7. A spark plug comprising a tubular metal shell, an alumina insulator secured within said shell and having a bore extending therethrough, a silver electrode spindle positioned in said bore, a resistor element in said bore, a layer of a mixture containing from about 30 to 50% glass and the balance substantially all a metal powder electrically connected to said resistor element and bonded to the walls of said bore between said resistor element and said silver electrode spindle to form a gas-tight seal in said bore, and a compact sintered layer of conductive material in contact with and bonded to said first mentioned layer and said silver electrode spindle to form a path of low electrical resistance, said conductive material being selected from the group consisting of nickel, silver, iron, cobalt, chromium, silica and alloys thereof.

8. A spark plug comprising a tubular metal shell, a ceramic insulator secured within said shell and having a bore extending therethrough, a silver electrode spindle positioned at one end of said bore, a resistor element in said bore, a layer of a mixture of glass and conductive powder electrically connected to said resistor element and bonded to the walls of said bore between said resistor

element and said silver electrode spindle to form a gas-tight seal in said bore, and a compact layer of powdered conductive material pressed between and in bonded contact with said first-mentioned layer and said silver electrode spindle to form a path of low electrical resistance therebetween.

9. A spark plug comprising a tubular metal shell, an alumina insulator secured within said shell and having a bore extending therethrough, a silver electrode spindle positioned at one end of said bore, a resistor element in said bore, a layer of a mixture consisting of from about 30% to 50% glass and the remainder metal powder electrically connected to said resistor element and bonded to the walls of said bore between said resistor element and said silver electrode spindle to form a gas-tight seal in said bore, and a compact layer of powdered conductive material pressed between and in bonded contact with said first-mentioned layer and said silver electrode spindle to form a path of low electrical resistance therebetween.

References Cited in the file of this patent

UNITED STATES PATENTS

2,371,211	Barrington	Mar. 13, 1945
2,400,917	Corbin	May 28, 1946
2,436,644	Halstead	Feb. 24, 1948
2,449,403	McDougal	Sept. 14, 1948
2,453,048	Tognola et al.	Nov. 2, 1948
2,459,282	McDougal et al.	Jan. 18, 1949
2,497,158	Dutterer	Feb. 14, 1950