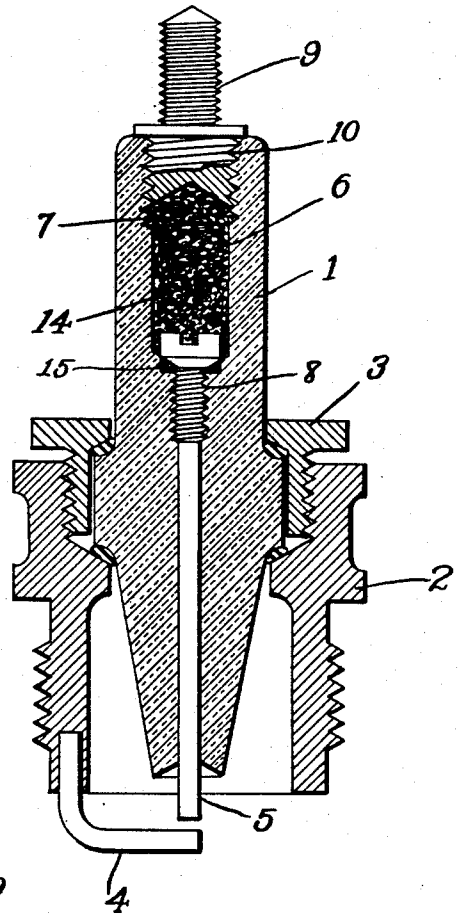
106-97 CROSS REFERENCE EXAMINI

Feb. 4, 1936. A. A. KASARJIAN 2,029,570

SPARK PLUG

Original Filed Dec. 30, 1932

Fig. 1



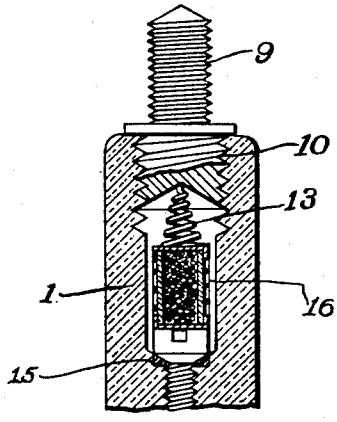


Fig. 2

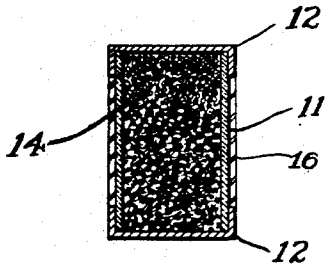


Fig. 3

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Patented Feb. 4, 1936 2,029,570

UNITED STATES PATENT OFFICE

2,029,570

SPARK PLUG

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Application December 30, 1932, Serial No. 649,455
Renewed May 31, 1935

10 Claims. (Cl. 123—169) 31J-J8

This invention relates to spark plugs and is directed more particularly to the provisions of positive means for the elimination of detrimental inductance and the transformation of the energy thus usually wasted into a shower of capacity discharges.

In a conventional type of spark plug, after the initial capacity discharge, the spark gap becomes ionized and loses a greater portion of its resistance and in consequence a low voltage arc is established across the gap. This arc continues until all the energy of the spark is spent.

The ignition of a charge in the automotive engine depends almost entirely upon the capacity component of the discharge across the gap and if this component fails to ignite the charge the inductance component is much too low a voltage to cause such ignition. As a matter of fact, the inductance component is not only of negligible consequence so far as ignition is concerned, but is detrimental in that it produces a considerable amount of heat. It lowers the resistance to erosion of the material used as distributor points and electrodes, and under severe conditions may cause the electrodes to become so highly heated that they remain incandescent and cause pre-ignition.

The object of the present invention is primarily the conversion of the inductance component of the spark into a series of high voltage capacity discharges. This is accomplished by the introduction of a series of minute air gaps in the spark circuit, herein termed the transformer. The resistance of the transformer requires higher voltage than the ionized spark gap would require. Therefore, as soon as the induction arc is established, the circuit is cut off by the transformer. During this no-spark (infinitesimal time) period, the ionization of the spark plug gap is lost, and the voltage in the spark circuit has to rise again to a value necessary to re-ionize the gap. This cycle of operation is continued until all the energy of the spark generator for that period is spent. The result is a shower of high voltage capacity discharges instead of a small capacity discharge and a large inductance arc.

It has been heretofore suggested to incorporate in an ignition circuit a so-called transformer or transformer element for the purpose of utilizing the desirable and essential characteristics of the capacity component, and to eliminate the undesirable qualities of the inductive or heat component. These prior suggestions, however, have invariably depended upon the employment of a laminated structure composed of alternate plies or laminations of conductive and di-electric material arranged in the form of superimposed washers after the manner of a condenser. These prior devices have depended for their operation upon the ionization of air in the gaps between the successive spaced apart conductive washers, and experience with these types of devices has conclusively shown that they are inefficient, unreliable and susceptible to wide variations in operation. In other words, these devices operate in an atmosphere of air and air must be present in order to provide for the ionization which is essential to their operation. Continued oxidation of the parts accordingly takes place and pitting or erosion prevails to a marked degree.

It is the purpose of this invention, among other objects, to provide means which will be uniform and unchanging in its operation for long periods, means which will not require the presence of air for its efficient operation, and means which is, as a matter of fact, hermetically sealed in an air-tight compartment to insure its uniform, constant and unfailing operation.

In one of its preferred practical forms, the invention consists in incorporating in the ignition circuit a body of pulverulent or granular material which material consists of a combination of conductive and non-conductive substances admixed with one another, so that the granules or particles of the one substance are separated or spaced by the granules or particles of the other substance. This body of pulverulent or granular material, packed under pressure in a hermetically sealed chamber, is incorporated or included in the ignition circuit and may conveniently be incorporated within a chamber formed in the plug by packing the material under pressure within such chamber or by enclosing it within a cartridge contained within the chamber. The particular materials which I prefer to use in the manner of their employment will be hereinafter more fully explained.

A further object of the invention is to increase the power factor, and therefore the power available in the ignition circuit through the introduction of an ohmic resistance. When the pulverulent material is packed in the chamber, as stated, there is bound to be a certain amount of entrained air. This air constitutes, initially, a variable resistance. After the initial operation of the circuit, this air becomes ionized and becomes negligible and as the chamber is sealed, it is thereafter constant in character. The metallic particle of the mixture are slightly oxidized during this ionization of the air and thereby attain a

constant and unchanging state having a slightly higher resistance than the metal itself. The resultant material does not change. Through the use of the material in its constant operating form, the power factor is increased according to the formula expressed as follows:—

$$P=EI\cos\theta$$

where
P=power
E=voltage
I=current
θ=the angle of phase difference
$\cos\theta$=power factor

$$\theta=\tan^{-1}[(2\pi fL-1/2\pi fC)/R]$$

where
f=frequency
L=inductance
C=capacity
R=ohmic resistance
When R is increased
θ is decreased
$\cos\theta$ and consequently the P is increased

Exhaustive experiments have shown that certain requisites are essential to highest efficiency. E. g., the condenser chamber should be absolutely air-tight. This essential for the reason that the process of oxidation should be limited to a value desired. Otherwise, the voltage of the spark generator may rise to a higher value than that for which it is designed. For this reason, double sealing is resorted to. The powder mixture is preferably first sealed in a cartridge before placing it in the transformer chamber and the chamber is thereafter sealed. The cross sectional area of the condenser should be of a magnitude so that the current density will not raise the temperature of the metallic parts to a value close to its fusion temperature. The percentage of conducting material to the insulating material and the pressure put on the mixture should be limited to a value so that the aggregate sum of the air gaps will not be any more than .010 inch. The best results are obtained within the range of .006 to .009 inch. The specific gravity of the insulating material and the conducting material should be as close to each other as possible, so that (under the engine vibration) the possibility of separation of conducting particles from insulating particles be eliminated. A variation of 5% in the specific gravity of the two materials has proven to be permissible, by actual test, but a greater difference cannot be depended upon.

Features of the invention, other than those specified, will be apparent from the hereinafter detailed description and claims when read in conjunction with the accompanying drawing.

The accompanying drawing illustrates different practical embodiments of the invention, but the constructions therein shown are to be understood as illustrative, only, and not as defining the limits of the invention.

Figure 1 shows the preferred form of spark plug embodying this invention, the plug being shown in central vertical section.

Figure 2 is a fragmental section of a plug showing a modified doubled seal form of the invention.

Figure 3 is a central section through a cartridge embodying the construction of Figure 2.

The plug shown in Figures 1 and 2 embodies an insulating element 1 which may be conveniently of porcelain. This insulating element is mounted within a metallic shell 2 in which it is clamped by a conventional jamb nut 3. 4 is the usual grounded electrode of the ignition circuit and 5 the central or insulated electrode. In the showing of Fig. 1, the porcelain is made of substantially the same size and shape as is conventionally the case, but the upper portion is hollowed out to form therein a chamber 6, the upper portion of which is interiorly threaded as indicated at 7. The insulated electrode 5 is positioned axially of the porcelain 1 and is secured at its upper end to a screw 8 which threads into the base of the chamber 6. The binding post 9 has an enlarged threaded shank 10 which screws into the top of the chamber 6 and serves to seal the same.

In practice, the screw 8, with copper gasket 15, is dipped into a suitable ceramic cement, i. e., an anhydrous cement, prior to being screwed into place during the assembly of the plug parts and the shank 10 of the binding post is similarly dipped into ceramic cement prior to introduction during assembly and the ceramic cement thus employed is preferably baked in so as to produce tight joints and cause the chamber 6 to be hermetically sealed as shown in Figure 1.

In the form of the invention shown in Fig. 1, the pulverulent or granular material to which I have referred, is merely packed into this chamber, so as to entirely fill the chamber between the screw 8 and the shank 10. When the shank 10 is screwed into the plug, it applies pressure to and packs this material tightly and precludes the material from jarring about, so that in effect the material constitutes a tightly packed mass.

In the structure of Figure 3, the material is contained within a cartridge comprising a cylindrical body 11 of insulating material such for example as mica. The ends of the body are closed by metal caps 12 and the said material is contained within the resulting enclosure. The cartridge is either hermetically sealed in any suitable way as by a peripheral coating of ceramic material 16, as shown in Figure 3, or left unsealed and placed in a sealed plug chamber 6 as shown in Figure 2, so that the bottom cap 12 of the cartridge seats on the head of the screw 8, while electrical current is adapted to be carried from the shank 10 to the upper cap 12 of the cartridge through a small compression spring 13. The chamber may be hermetically sealed through the use of ceramic cement or in any other suitable way as hereinbefore stated.

Two examples of the manner in which the material may be incorporated in the ignition circuit have been given, but I wish it understood that the invention is not limited to these specific features and that said material may be incorporated in the ignition circuit in other ways without departing from the invention.

The material to which I have referred is designated generally in the drawing by the reference character 14. As hereinbefore stated, this material may be either granular or pulverulent or a combination thereof and I am aware that a wide variety of substances may be employed in this connection. For the purpose of illustration, however, and by way of example, I have found that the conductive material employed may be granulated or powdered duraluminum. This material has a high melting point and is not readily oxidized. The conductive material employed should have a relatively high melting point, should be a material which does not readily oxidize and one whose oxide does not have a resist-

CROSS REFERENCE EXAMINER

ance which materially varies from the resistance of the metal itself.

The non-conductive material should be a material which will not readily oxidize, a material which is a good non-conductor, one which has substantially constant characteristics and which will not deteriorate over long periods. It is possible and in some cases may be desirable to employ a mixture of different metals or conductive materials and a mixture of a plurality of non-conductive materials. However, by way of example and for the purpose of illustration, I may state that I have found a mixture of powdered duraluminum and powdered mica to give very excellent results, when these powdered substances in powdered or granulated form are mixed together in substantially equal proportions. It is essential to have the substances which enter into this mixture of substantially the same or relatively close specific gravity, so that they will not tend to separate or stratify under vibration. If these specific gravities are widely divergent, say more than 5%, the heavier will tend to settle to the bottom, while the lighter will be displaced and rise to the top of the mass, whereas according to the present invention, it is necessary for maximum efficiency that the admixture of the particles or granules be such that said mixture is substantially uniform throughout and that the particles of the conductive material be substantially uniformly spaced in relatively close spaced relation with interposed particles of non-conductive material serving the spacing function. While I have referred to mica and duraluminum as productive of satisfactory practical resluts, I am aware that other substances may be used without departing from this invention. Chromium, for example, has given a very satisfactory performance when admixed with mica. For these reasons, and without attempting here to specify all the different conductive materials and all the different granular materials that may be employed, I wish it understood that the examples given are illustrative of equivalent materials that may be used in the carrying out of this invention.

In the foregoing detailed description. I have referred to a mixture of powdered duraluminum and powdered mica as giving very good results and have stated that where they are to be associated as specified, the conductive and di-electric pulverulent materials should be of substantially the same or very close to the same specific gravity so as to preclude separation or stratification under vibration. I have further found, that the present invention also consists in adding to these materials, if desired, a suitable binder which will form these materials into a composite homogenous mass. This binder must be of a material which will not break down or disintegrate under the electrical discharge which must necessarily pass therethrough. For example, I have found that the granulated or pulverulent material specified may be embedded in a body of gypsum, cement, plaster of paris or the like with an anhydrous liquid which acts as a binder and forms the element into a substantially monolithic form. This binder holds the particles together, precludes relative movement of the particles and provides a constant or uniform path for the current which path is unchangeable in its character. When an appropriate binder is employed as stated, it is not essential that the di-electric and conductive materials be of substantially the same specific gravity because when embedded, in a binder as stated, they cannot move or stratify. Consequently, heavier metals or even carbon may be used with any suitable di-electric such as mica or asbestos.

Experience with structures embodying the present invention, as hereinbefore described, has conclusively demonstrated the high efficiency for the purposes stated. The harmful effects of the inductance component in the ignition circuit is eliminated or at least reduced to such small proportions that it is a negligible quantity, while the capacity component is enhanced to an astonishing degree.

An important practical advantage of the present invention resides in its manufacturing economies, as the present invention may be incorporated in plug structure without appreciable additional cost.

Furthermore, the plug when completely fabricated has been found to function efficiently over protracted periods without any apparent loss or drop in efficiency and a noticeable lengthening of the life of the electrodes has been noted as evidenced by the relatively slow erosive effects which generally result from overheating.

The foregoing detailed description sets forth the invention in its preferred practical form, but the invention is to be understood as fully commensurate with the appended claims.

I am aware that aside from the means which I have described the present invention includes a novel method which also forms part of this invention.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In an assembly of the character described, an ignition circuit including a body of matter comprising a mixture of finely divided conductive and non-conductive materials interspersed with respect to one another in the body, said conductive and non-conductive materials being of substantially the same specific gravity.

2. In an assembly of the character described, an ignition circuit including a body of matter comprising a mixture of finely divided conductive and non-conductive materials interspersed with respect to one another in the body, a hermetically sealed walled chamber enclosing said body of matter, said body being firmly packed within said chamber, and the conductive and non-conductive materials being of substantially the same specific gravity.

3. A spark plug provided therein with a hermetically sealed chamber, a conductive member extending from said chamber to the ignition gap of the plug, a second conductive member also leading from said chamber and adapted for electrical connection with an ignition lead, the adjacent ends of said members being spaced apart at the chamber, and a body of matter enclosed within the chamber and embodying a mixture of conductive and non-conductive materials of substantially the same specific gravity in pulverulent or granular form with the particles of said materials interspersed with respect to one another, said body being packed within the chamber to have electrical contact with said conductive members.

4. In an assembly of the character described, a spark plug provided therein with a walled chamber, a conducting member leading from the chamber to the ignition gap of the plug, a second conducting member leading from the chamber and adapted for connection with an ignition lead, said conducting members being spaced apart at

the chamber, a hermetically sealed cartridge within said chamber, said cartridge having conducting terminals and a non-conductive intermediate wall, the terminals of the cartridge being electrically connected with the said respective conducting members, and a body of matter hermetically sealed within said cartridge and in contact with the terminals thereof, said body of matter comprising a mixture of pulverulent or granulated conductive and non-conductive materials, the particles of which are interspersed with respect to one another.

5. In an assembly of the character described, a spark plug provided therein with a walled chamber, a conducting member leading from the chamber to the ignition gap of the plug, a second conducting member leading from the chamber and adapted for connection with an ignition lead, said conducting members being spaced apart at the chamber, a cartridge within said chamber, said cartridge having conducting terminals and a non-conductive intermediate wall, the terminals of the cartridge being electrically connected with the said respective conducting members, and a body of matter enclosed within said cartridge and in contact with the terminals thereof, said body of matter comprising a mixture of pulverulent or granulated conductive and non-conductive materials of substantially the same specific gravity, the particles of which are interspersed with respect to one another.

6. In an assembly of the character described, a spark plug provided therein with a walled chamber, a conducting member leading from the chamber to the ignition gap of the plug, a second conducting member leading from the chamber and adapted for connection with an ignition lead, said conducting members being spaced apart at the chamber, a hermetically sealed cartridge within said chamber, said cartridge having conducting terminals and a non-conductive intermediate wall, the terminals of the cartridge being electrically connected with the said respective conducting members, and a body of matter enclosed within said cartridge and in contact with the terminals thereof, said body of matter comprising a mixture of pulverulent or granulated conductive and non-conductive materials of substantially the same specific gravity, the particles of which are interspersed with respect to one another.

7. A spark plug embodying an insulating element provided therein with a chamber having a threaded open end and from the base of which a passage extends to the inner end of the insulating element, said passage being threaded adjacent the chamber, a central electrode member having a threaded portion, said member extending through said passage and having threaded engagement with the threads thereof, a gasket cooperating with said central electrode member to form a tight joint between said member and the passage to preclude leakage, a metallic plug screwed into the chamber of the insulating element and serving to hermetically seal the open end thereof and to simultaneously provide for an electrical connection with an ignition lead, and a body of matter comprising a mixture of finely divided conductive and non-conductive materials interspersed with respect to one another in the body, said body being positioned within the chamber in electrically conductive relation with the central electrode and the metallic plug, said body of material being thereby hermetically sealed within the chamber of the insulating element.

8. In an assembly of the character described, a spark plug provided therein with a walled chamber, a conducting member leading from the chamber to the ignition gap of the plug, a second conducting member leading from the chamber and adapted for connection with an ignition lead, said conducting members being spaced apart at the chamber, a walled cartridge within said chamber, said cartridge having conducting terminals and a non-conductive intermediate wall, the terminals of the cartridge being electrically connected with the said respective conducting members, and a body of matter enclosed within said cartridge and in contact with the terminals thereof, said body of matter comprising a mixture of pulverulent or granulated conductive and non-conductive materials, embedded in a non-conductive refractory binding material in which the particles are interspaced with respect to one another.

9. A transformer for ignition circuits embodying a cartridge comprising conductive end walls forming terminals, and a non-conductive intermediate wall bridging the space between said end walls and spacing them apart to form between the end walls and within the intermediate wall a closed chamber, a body of matter enclosed within said cartridge and in electrical contact with the conductive end walls thereof, said body of matter comprising a mixture of pulverulent or granulated conductive and non-conductive materials.

10. A transformer for ignition circuits embodying a cartridge comprising conductive end walls forming terminals, and a non-conductive intermediate wall bridging the space between said end walls and spacing them apart to form between the end walls and within the intermediate wall a closed chamber, a body of matter enclosed within said cartridge and in electrical contact with the conductive end walls thereof, said body of matter comprising a mixture of pulverulent or granulated conductive and non-conductive materials, and an impervious sealing material sealing the joints between the end walls and the intermediate wall to hermetically seal the interior of the cartridge.

ARMEN A. KASARJIAN.