Aug. 26, 1941. J. H. DILLON 2,254,169

SPARK PLUG AND METHOD OF MAKING SAME

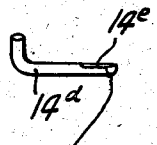
Filed Dec. 29, 1939

FIG.-7




RADIOACTIVE METAL ALLOY ELECTRODES

FIG.-8




RADIOACTIVE METAL ALLOY ELECTRODES

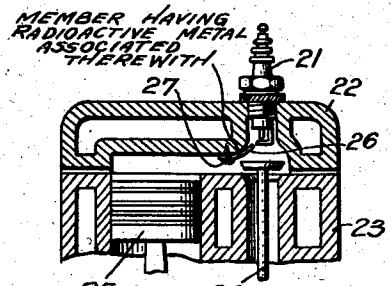



FIG.-9

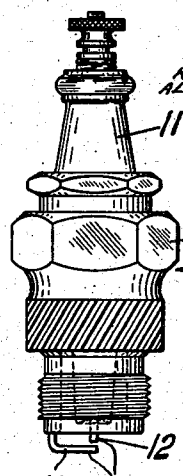
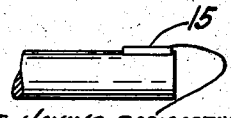



FIG.-1

14 RADIOACTIVE METAL, PLATED ON, ALLOYED OR OTHERWISE ASSOCIATED WITH ELECTRODES

FIG.-2




ELEMENT HAVING RADIOACTIVE METAL ASSOCIATED THEREWITH, WELDED TO ELECTRODE

FIG.-3




ELEMENT HAVING RADIOACTIVE METAL ASSOCIATED THEREWITH, WELDED TO ELECTRODE

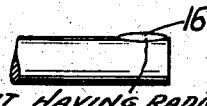



FIG.-4

ELEMENT HAVING RADIOACTIVE METAL ASSOCIATED THEREWITH, FUSED TO ELECTRODE

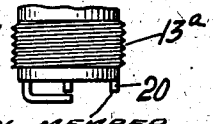
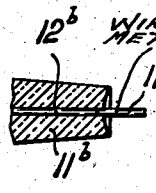



FIG.-5

AUXILIARY MEMBER HAVING RADIOACTIVE METAL ASSOCIATED THEREWITH




WIRE HAVING RADIOACTIVE METAL ASSOCIATED THEREWITH, AFFIXED TO ELECTRODE

FIG.-6

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# UNITED STATES PATENT OFFICE

2,254,169

## SPARK PLUG AND METHOD OF MAKING SAME

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Application December 29, 1939, Serial No. 311,482

24 Claims. (Cl. 123—169)

This invention relates especially to improved radioactive spark plugs for internal combustion engines and to methods of making same, and generally relates to improvements in any electrical discharge device of the ionized gas type.

The use of radioactive material near the spark gap of a spark plug has heretofore been suggested for the purpose of improving the operation of the spark plug, as radioactive material causes ionization of the molecules of gas in the gap by means of the rays or particles emitted, whereby a spark can traverse the gap at a lower electric voltage than with no radioactive substance present. However, previously known types of radioactive spark plugs are not entirely commercially satisfactory for some uses because they are either too expensive and dangerous (when a radium compound is used), or ineffective (when uranium or thorium compounds are used). These and other difficulties have prevented the production of commercially practical radioactive spark plugs. The present invention is, in part, an improvement on the radioactive spark plug disclosed in U. S. Patent Number 1,723,422, to A. M. Hubbard.

The general object of the invention is to provide a commercially satisfactory radioactive electrical discharge device comprising a chemically uncombined strongly radioactive metal, and a method of making the discharge device.

Another object of the present invention is to provide a spark plug for internal combustion engines embodying polonium at or near the spark gap, and a method of making same.

Another object is to provide an electrical discharge device including a strongly radioactive metal at or near the gaseous discharge region whereby an electrical discharge may be made to transverse the region at a lower voltage than that required in previously known constructions.

Another object is to provide a combustion chamber for an internal combustion engine in which a strongly radioactive metal is so situated that ions produced by its rays enter the gap of the spark plug.

A further object is to provide a spark plug comprising polonium, whereby quicker starting, smoother operation, greater power, and increased fuel economy are obtained in an engine employing such spark plugs.

Other objects will be manifest as the specification proceeds.

Referring to the drawing:

Figure 1 is an elevation of a spark plug embodying the invention, for use in an internal combustion engine;

Figure 2 is a fragmentary enlarged elevation of a spark plug ground electrode modified according to one embodiment of the invention;

Figure 3 is a fragmentary enlarged elevation of a spark plug center electrode modified according to another embodiment of the invention;

Figure 4 is a fragmentary enlarged elevation of a ground electrode modified according to another embodiment of the invention;

Figure 5 is a fragmentary elevation of the lower end of a spark plug modified according to another embodiment of the invention;

Figure 6 is a fragmentary sectional elevation of a spark plug insulator and accompanying center electrode modified according to another embodiment of the invention;

Figure 7 is a fragmentary enlarged view of a ground electrode modified according to another embodiment of the invention;

Figure 8 is a fragmentary enlarged view of a ground electrode modified according to a further embodiment of the invention; and

Figure 9 is a diminished sectional view of a combustion chamber of an internal combustion engine, modified in accordance with a further embodiment of the invention.

Broadly speaking, the present invention contemplates providing an electrical discharge device which contains a chemically uncombined strongly radioactive metal, whereby an electrical discharge may be caused to traverse the discharge region of the device at a lower voltage than with standard constructions. Usually, the radioactive metal is so positioned that its ionized field embraces said discharge region. Relays of the ionized gas type represent one form of such electrical discharge device, an example being a cold discharge tube of the Grid-Glow type. Luminous gas tubes, such as neon sign lamps, represent another form of such device. The ordinary spark plug used in gasoline engines constitutes yet another form of such device. It will be understood that the various modifications described below for a spark plug may also be applied to other electrical discharge devices, where suitable.

All radioactive materials give off one or more of three types of ionizing rays called alpha, beta, and gamma rays. The alpha rays, which are rapidly moving, doubly-charged particles, are much more efficient ionizers than either the beta rays (fast electrons) or gamma rays (electromagnetic radiation of extremely high fre-

quency). Furthermore, the alpha rays are not dangerous to human beings, whereas gamma rays may be exceedingly harmful and require extreme safety precautions. The beta rays also are dangerous to some extent. Hence, it is quite apparent that a radioactive material emitting only alpha rays is much to be preferred for spark plug gap ionization.

Table I gives the important relationships existing among members of the uranium-radium series of radioactive elements. (See J. Am. Chem. Soc., 45, 872 (1923).) The half life value for radium D has been corrected to agree with more recent determinations. (See E. Walling, Zeitschrift für Physik, 87, 603 (1934).)

*Table I*

| | Atomic | | Half life | Radiation |
|---|---|---|---|---|
| | Wt. | No. | | |
| Uranium I | 238 | 92 | $4.67\times10^{9}$ yrs. | Alpha. |
| Uranium $X_1$ | 234 | 90 | 24.6 days | Beta. |
| Uranium $X_2$ | 234 | 91 | 1.15 min. | Beta (gamma). |
| Uranium II | 234 | 92 | $2\times10^{6}$ yrs. | Alpha. |
| Ionium | 230 | 90 | $6.9\times10^{4}$ yrs. | Do. |
| Radium | 226 | 88 | 1690 yr. | Alpha (beta and gamma). |
| Radon | 222 | 86 | 3.85 days | Alpha. |
| Radium A | 218 | 84 | 3.0 min. | Do. |
| Radium B | 214 | 82 | 26.8 min. | Beta (gamma). |
| Radium C | 214 | 83 | 19.5 min. | Beta and gamma. |
| Radium C' | 214 | 84 | $10^{-6}$ sec. | Alpha. |
| Radium D | 210 | 82 | 22.3 yrs. | (Beta and gamma). |
| Radium E | 210 | 83 | 5.0 days | Beta. |
| Radium F or Polonium. | 210 | 84 | 136 days | Alpha (gamma). |
| Radium Omega or Lead. | 206 | 82 | | |

( ) means radiation is relatively feeble.

Of the alpha ray emitting elements shown in Table I, only polonium and its transformation product emit substantially no beta or gamma rays. Although radium emits only feeble beta and gamma rays, certain of its products (radium B, C and E) emit strong beta and gamma rays. It is well known that polonium emits only a few quanta of gamma rays for each million alpha rays. (See H. C. Webster, Chemical Abstracts, 32, 1565–6 (1938).) Practically speaking, therefore, polonium emits only alpha rays.

In selecting the proper radioactive material for use, another factor must be considered. All radioactive elements change into other elements according to an exponential law governed by their activity (number of rays per second). The selection of a radioactive material such as uranium, for example, would be unwise, because even though it has a half-life (time required for one mass unit of the substance to be reduced to one-half mass unit) of approximately five (5) billion years and emits only the desirable alpha rays, its activity is so low that several grams would be required to give a definite improvement in a single spark plug, whereas the weight of the ordinary side wire electrode is considerably less than one gram. On the other hand, radium A emits only alpha rays very copiously but has a half-life of only 3 minutes. Polonium emits alpha rays at a rate in excess of 4500 times the alpha emission rate of pure radium and has the reasonable half-life period of 136 days. These properties, in addition to the property of emitting substantially no beta or gamma rays, constitute polonium as an ideal substance for use in a radioactive spark plug, and the invention will be described with reference to polonium as used in a spark plug.

Although polonium is the preferred substance for use in the present invention for the reasons given above, other radioactive substances may sometimes be used in the practice of the invention even though such substances do not have as desirable characteristics as polonium. Certain other strongly radioactive metals emit alpha rays at effective rates and have sufficiently long life periods to render them useful in spark plugs. Such other useful metals are radium, radiothorium, protoactinium, radioactinium and actinium X. It would be necessary to handle devices containing one of these metals with proper precautions in view of the beta and gamma radiation attending the desired alpha ray emission. A metal having an induced radioactivity of a strong character, equivalent to the activity of polonium and the other strongly radioactive metals named above, is also contemplated for use in the present invention.

While polonium usually may be used for the purposes of the invention in any form desired, such as the pure elemental metal, as a plate upon another surface, or as an alloy with one or more other metals, it is alloyed polonium that has been found most convenient for general use in discharge devices. Polonium alloy is preferably prepared by first plating a thin layer of polonium on metallic foil and then adding the required amount of the plated foil to a melt comprising the bulk of the non-radioactive components of the alloy. The mixture of metals is maintained fluid for a sufficient length of time to insure homogeneity and then is cooled. The resulting alloy contains the desired amount of polonium, regulated by the amount present on the foil which was added to the melt. The polonium contents of the foil and of the alloy are determined by a suitable radioactive measuring device, such as the Geiger counter. A nickel alloy containing polonium in the range of one-one hundred thousandth of one per cent to one billionth of one per cent is preferred for the preparation of spark plug electrodes of the kind hereinafter described. Such alloy is readily swaged and drawn into wire form by conventional methods, since it is identical in ordinary physical properties with conventional spark plug alloy, differing from the latter only in radioactivity. The method just described for preparing a polonium alloy may be applied to the production of alloys comprising other strongly radioactive metals, such as those mentioned in the preceding paragraph. If a plated electrode is desired, the base electrode is made and suitably prepared to receive the plated material as by plating a thin film of nickel thereon. Then the polonium can be deposited chemically or electrolytically upon the base metal. Of course, any elemental polonium member used in practice of the invention can be suitably formed from the uncombined material.

In Figure 1 of the drawing, a spark plug 10 of standard construction is shown. This spark plug includes a porcelain insulator 11, mounting a center electrode 12 therein, and a metal shell 13, in which the insulator 11 is received, that carries a cylindrical ground electrode 14. Preferably the ground electrode 14 is made from an alloy comprising polonium and ordinary spark plug wire metal. The center electrode 12 may also be made from the foregoing alloy, if desired, or in some cases only the center electrode may be made from the polonium alloy.

According to another embodiment of the invention, a small piece 15 of polonium, or polonium alloy, may be welded to the ground electrode, as

in Figure 2, or to the center electrode, as at 15' in Figure 3.

According to a further embodiment of the invention, a small piece of polonium or polonium alloy 16 may be used on to the ground electrode, as shown in Figure 4.

Since an important feature of the invention resides in positioning some form of polonium near the electrode gap of a spark plug to aid in ionizing the gap, it is seen that this polonium can be positioned there in numerous ways. Figure 5 shows the lower end of a spark plug shell 13a which has an auxiliary wire 20 carried thereby and extending therefrom, which wire includes polonium. Figure 6 illustrates an embodiment of the invention wherein a short piece of electrode wire 17 having polonium associated therewith is welded, or otherwise secured to a center electrode 12b at the lower end thereof. This wire 17 may extend into the insulator 11b, as shown. In some instances, it may be possible to affix the polonium, or polonium bearing element to the spark plug in a manner different from that shown in Figures 5 and 6 and still have it ionize the electrode gap in the desired manner.

A modified ground electrode 14c is shown in Figure 7. This electrode is of right angular shape and of rectangular, or square cross-section. A circular section electrode 14d, which has a planar face 14e to be positioned opposite the center electrode with which it is associated, is illustrated in Figure 8. These electrodes usually are made from a polonium containing alloy metal.

The effect of polonium in a spark plug may be explained as follows:

When the coil voltage is applied to the plug by means of the distributor, a very short interval of time elapses before the voltage reaches a value at which the spark gap breaks down. If a large number of natural ions, which are always present in varying numbers, happen to be in the gap at the time the voltage is applied, the gap will break down very soon after the beginning of the voltage rise and at a reasonably low voltage. However, if the natural ions are not plentiful, the spark will not occur so promptly after the beginning of the voltage rise and the effective breakdown voltage will be higher. In other words, the plug requires a higher excess voltage under these conditions, which conditions are common with plugs of the conventional type. A partially discharged battery, a defective spark coil or extreme cold often prevents the large voltage rise necessary for satisfactory operation of conventional spark plugs. Frequently, conditions will be so unfavorable that a spark will not occur at all, and it will be necessary to turn the engine over a number of times before a spark occurs. However, if the alpha rays of polonium are passing through the gap, a large number of extra ions are formed by each alpha ray (10,000 ions per alpha ray) and the gap breaks down promptly after the voltage begins to rise and at a lower voltage value than that required by standard spark plugs. Thus, it might be said that polonium creates favorable conditions for gap breakdown under all circumstances.

Many tests have been run which substantiate the above explanations. The most conclusive test of this type consisted in comparing the starting characteristics of many polonium-containing spark plugs with ordinary spark plugs, all plugs having had more than a year of hard service, in several engines at −15° F. It was found that thirty per cent fewer revolutions of an engine were required for starting when the polonium plugs were used.

An interesting discovery has been made which further emphasizes the practical benefits to be derived from the use of spark plugs containing polonium. When a spark plug containing polonium in one or more of the electrode terminals has been used for a time in an internal combustion engine, it is even more efficient in operation than an unused plug of the same type which contains about the same amount of polonium. A possible explanation of this gratifying phenomenon may be that the oxide coating formed on the used terminal provides a higher effective concentration of polonium on the surface of the terminal. Or, the enhanced efficiency may be due to the combination of alpha rays emitted by polonium in the ovide layer and those emitted by the polonium in the underlying metal, the latter rays easily penetrating the porous coating. Moreover, it may be possible that polonium becomes concentrated on the outer surface of the oxide coating.

Polonium has an important secondary effect in the combustion chamber of an internal combustion engine. When an emitted alpha ray strikes a hydrocarbon molecule or an oxygen molecule in the combustion mixture, the molecule becomes ionized or activated so that it will enter into a new chemical combination more readily. By virtue of this activating effect, smoother operation and increased gasoline economy result when polonium-containing spark plugs are used in such an engine.

As a result of many other practical tests made on the polonium-containing spark plugs, it has been proved that such plugs effect better starting of the engine under all conditions, smoother operation of the engine, less choking required with a cool engine (and hence, a considerable saving in fuel) and increased power on hills. Other tests have shown that polonium gives even a greater advantage in plugs that have been run several thousand miles in hard service than in new plugs. Otherwise stated, polonium tends to preserve the good initial properties of the spark plug after thousands of miles of hard service.

The development of a practical radioactive spark plug is important, not only in improving the operation of present internal combustion engines, but also in allowing the development and utilization of engines having higher compression ratios. Development of engines in this direction has been seriously hampered by the inability of conventional spark plugs to operate reliably at high pressures. At high pressures the spark gap breaks down with much greater difficulty than at low pressures because of the greater insulating quality of the increased amount of gas in the gap. However, if alpha rays from a suitable radioactive substance, such as polonium, are passing through the gap, many current-conducting ions are formed and the gap breaks down on the building up of the usual electric voltage on the spark plug to allow a spark to occur, even at very high pressures. Thus, the improved spark plug of the present invention will effect further economies for the motorist by allowing him to take advantage of a more efficient, very high compression engine.

In a further embodiment of the present invention, the polonium may even be associated with the combustion chamber of a gasoline engine. That is, polonium could be alloyed with a portion of the member defining the chamber, or

a piece of polonium could be welded or otherwise secured in the chamber in any desired manner. One embodiment of this feature of the invention is illustrated by Figure 9, wherein a spark plug 21, of conventional design, is shown mounted in an engine cylinder head 22, defining the upper limits of a combustion chamber. The lower limits of the chamber are defined by the engine block 23, valves 24, and a piston 25. Shown mounted on the inner surface of the cylinder head 22 is a member 26 having radioactive metal, such as polonium, associated therewith, and attached to the cylinder head by a suitable means, such as a screw 27. The member 26 is so positioned in the chamber that ions produced by rays from the radioactive metal, associated with the member, are present in the discharge gap of the spark plug 21.

It is to be understood in the appended claims that a radioactive metal is chemically uncombined when it occurs as the pure elemental metal, as a film plated onto another substance, or as a component of an alloy. Although it is thought that the radioactive alloy utilized in the present invention is a substantially uniform dispersion of the chemically uncombined radioactive metal throughout the other components of the alloy, it is possible that some of the radioactive metal is oxidized during the alloying process, so that the alloy may contain a substantially uniform dispersion of the oxidized radioactive metal.

It is obvious that various changes and modifications may be made in the above description without departing from the nature and spirit of the invention.

What is claimed is:

1. An electrical discharge device comprising a pair of opposing electrodes having a gaseous discharge region therebetween, and a member including a chemically uncombined, strongly radioactive metal, said discharge region being embraced by the ionized field of said radioactive metal.

2. An electrical discharge device comprising a pair of opposing electrodes having a gaseous discharge region therebetween, at least one of said electrodes having associated therewith a chemically uncombined strongly radioactive metal.

3. An electrical discharge device comprising a pair of opposing electrodes having a gaseous discharge region therebetween and associated therewith an alloy of a strongly radioactive metal, said discharge region having ions therein produced by rays from said alloy.

4. An electrical discharge device comprising a pair of opposing electrodes having a gaseous discharge region therebetween and a chemically uncombined, strongly radioactive metal associated therewith.

5. An electrical discharge device comprising a pair of opposing electrodes having a gaseous discharge region therebetween, at least one of said electrodes having polonium associated therewith.

6. In an internal combustion engine, a combustion chamber, a pair of opposing spark plug electrodes extending into said chamber, and a member, including a chemically uncombined strongly radioactive metal, associated with said chamber, the gap between said electrodes having ions therein produced by rays from said member.

7. In an internal combustion engine, a combustion chamber having a polonium-containing member associated therewith, and a pair of spaced but opposed spark plug electrodes extending into said chamber, the gap between said electrodes having ions therein produced by rays from said polonium-containing member.

8. A spark plug for an internal combustion engine, said spark plug comprising a pair of opposing electrodes, and a member including a chemically uncombined, strongly radioactive metal, the gap between said electrodes being embraced by the ionized field of said radioactive metal.

9. A spark plug for an internal combustion engine comprising a pair of opposing electrodes, at least one of said electrodes including a chemically uncombined, strongly radioactive metal.

10. A spark plug for an internal combustion engine, said plug comprising a polonium-containing member, and a pair of opposing electrodes, the gap between said electrodes being embraced by the ionized field of said polonium.

11. A spark plug for an internal combustion engine, said plug comprising a pair of opposing electrodes, an outer shell carrying one of said electrodes, and a polonium-containing member positioned on said shell, the spark gap between said electrodes being embraced by the ionized field of said polonium.

12. A spark plug for an internal combustion engine, said spark plug comprising a pair of opposing electrodes, at least one of said electrodes including polonium.

13. A spark plug for an internal combustion engine, said plug comprising a pair of opposing electrodes, at least one of said electrodes being composed of an alloy comprising polonium.

14. A spark plug for an internal combustion engine, said spark plug comprising a pair of opposing metal electrodes, one of said electrodes having a strongly radioactive metal substantially uniformly dispersed therein.

15. In a spark plug, two electrode elements, the end portions of which are positioned in closely spaced right angular relation, one of said elements comprising a polonium alloy and one of said elements having a planar side portion positioned adjacent the end of the second of said elements.

16. A spark plug for an internal combustion engine, said spark plug comprising a pair of opposing electrodes, one of said electrodes being made of a polonium alloy in which between one-one hundred thousandth of one per cent and one-billionth of one per cent polonium is present.

17. In a process of making a radioactive spark plug, the steps of plating a strongly radioactive metal on the surface of a metal, adding the plated metal to molten metal and maintaining the resulting mixture molten until a homogeneous radioactive alloy is produced, cooling the alloy to solidify it, forming same into an electrode, and incorporating the radioactive electrode in a spark plug.

18. In a process of making a radioactive spark plug, the steps of plating a strongly radioactive metal on the surface of a metal, adding the plated metal to molten metal and maintaining the resulting mixture molten until a homogeneous radioactive alloy is produced, cooling the alloy to solidify it, and forming same into an electrode.

19. An electrical discharge device comprising a metallic electrode having associated therewith a chemically uncombined strongly radioactive metal.

20. An electrical discharge device comprising

a metallic electrode having associated therewith an alloy of a strongly radioactive metal.

21. An electrical discharge device comprising a metallic electrode containing a polonium alloy near the discharge portion of said device.

22. An electrode for electrical discharge devices, said electrode having associated therewith an alloy of a strongly radioactive metal.

23. An electrode for electrical discharge through a gaseous medium, said electrode having associated therewith a chemically uncombined strongly radioactive metal, whereby the alpha particle emission from the radioactive metal ionizes the surrounding gaseous medium.

24. An electrode for electrical discharge through a gaseous medium, said electrode having polonium associated therewith, whereby the alpha particle emission from the polonium ionizes the surrounding gaseous medium.

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