

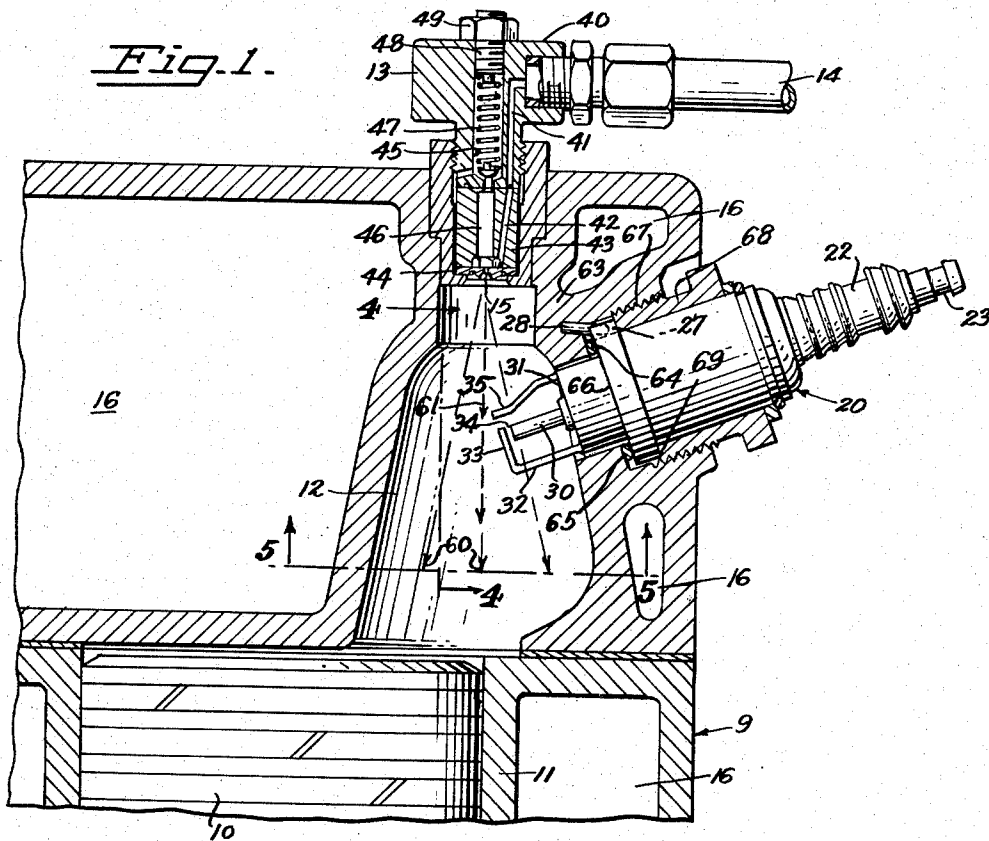
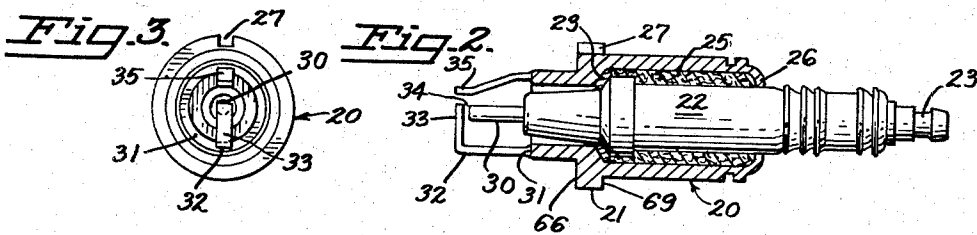
March 17, 1959

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2,878,299

SPARK PLUG

Filed Dec. 23, 1954



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2,878,299

SPARK PLUG

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Application December 23, 1954, Serial No. 477,370

5 Claims. (Cl. 123—169)

This invention relates to an improved spark plug. This application is a continuation-in-part of my application Serial Number 391,204, filed November 10, 1953, now abandoned.

The greatest difficulty in developing efficient internal combustion engines of the fuel-injection spark-ignition type has been in obtaining reliable ignition of the different volumes of fuel injected as required by varying demands on the engine. This difficulty exists because there is no carburetion to maintain a fairly constant air-fuel mixture ratio in a fuel-injection engine and because a spark can ignite only a mixture whose fuel-air ratio lies between certain rich and lean limits. The problem is further complicated by the practical necessity of positioning the spark gap at a fixed location, although the differing amounts of fuel injected at varying loads and engine speeds and the consequent differences in fuel-air ratio, actually result in different optimum locations for ignition.

Thus, when such an engine is operating at light loads, the injected fuel does not penetrate all the air in the combustion chamber; it penetrates only the air near the nozzle along generally fixed and narrow jet paths established by the injection nozzle. As a result, at light loads the optimum location for an ignition device would be directly in the path of a fuel jet and near the nozzle. As the load on the engine is increased, however, more air is penetrated by injected fuel before the ignition spark occurs, and each fuel jet becomes thicker and richer at its center, and ignitable mixtures then occur only in the outer fringe of the fuel jets.

Ignition in the usual spark-ignition type of internal combustion engine is provided by spark plugs which have spark gaps between their electrodes or sparking points. Fuel-injection engines heretofore in use have located the spark plugs near the fuel nozzle adjacent one side wall of the combustion chamber, in a position where the spark gap is away from the direct paths of the fuel jet issuing from the fuel injection device. With the plugs in this position, the engine got proper spark ignition at full loads, but at light loads the gap was too far from the narrow path of the fuel jet for reliable spark ignition. Specifically, when the small amount of gasified fuel surrounding the fuel jets at light load reached the gap, the fuel-air mixture was too lean for ignition.

However, if the spark gaps were positioned sufficiently close to the center of the paths of the fuel jets to obtain reliable ignition at light loads, additional problems were encountered which interfered with proper ignition at full load. For example, positioning the spark gap close to the fuel paths has heretofore caused too much fuel to enter the gap at full loads, subjecting it to mixtures too rich for ignition and resulting in misfiring of the engine. In addition, this excess of fuel tended to wet the electrodes at the gap, cooling the spark points, and after several hours of running, a carbon knob would often build up on the points, resulting in excessive fuel impingement and, eventually, in a shorting of the gap by fuel or carbon. The present invention has solved all these, and other

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problems by providing a fuel-injection engine in which the spark plug can be located directly in the fuel path, near the center of the fuel jet, without any fouling or shorting of the gap. This novel combination insures proper ignition at all loads. The invention accomplishes these important results partly by means of a shielding wire or strip about the same width as the spark plug electrodes, which due to its position, divides the jet of fuel and gently wafts or shunts it around the gap. The fuel jet cannot foul the plug electrodes, and yet comes close enough to the gap to insure ignition at all loads. Moreover, due to its position and structure the shield itself becomes quite hot at its outer end, near the gap, and any wet fuel that may impinge against the shield is therefore vaporized so that it ignites more readily and with less tendency to fouling.

Thus, one object of the present invention is to provide a fuel-injection engine wherein a gap protector or shield is so positioned with respect to the spark gap that the spark gap may be located extremely close to or within the path of a fuel jet from the fuel-injection device and still be protected at full load from excess fuel accumulations in the gap.

Another object of the present invention is to provide a fuel-injection engine in which the spark plug may be positioned approximately centrally of the expanding paths of several fuel jets in a combustion chamber, while its ignition means is protected from the direct liquid spray of the fuel jets, but without blocking the entrance of a combustible gaseous mixture to the spark gap.

Another object is to provide spark plug gap protector means which is extremely simple in construction.

Still another object is to provide a spark plug gap protector that is no more than one to three times as wide as a single spark plug electrode.

Other objects and advantages of the present invention will be apparent from the following description and from the drawings in which:

Fig. 1 is a view in elevation of an engine ignition system embodying the principles of the present invention, showing my novel spark plug in association with my novel fuel injection device and an engine cylinder head, the combustion chamber, cylinder walls, and fuel injection device being shown in section.

Fig. 2 is a view in elevation and in section of the spark plug shown in Fig. 1.

Fig. 3 is an end view of the spark plug of Fig. 2.

Referring to the drawings in detail, Fig. 1 illustrates the ignition portion of a typical cylinder head for an internal combustion engine 9 of the fuel injection type, showing a piston 10, cylinder walls 11, combustion chamber 12, and my novel fuel injection device 13 having a fuel inlet 14 and a nozzle 15. Surrounding the cylinder walls and combustion chamber are the usual water jackets 16 for cooling water.

Mounted in one side of each combustion chamber 12 is my new spark plug 20. The plug 20 (see Fig. 2) includes the usual, generally tubular shell or body 21 of metal and an insulating core 22, provided at its outer end with a binding post 23 for the connection of the wire or electrical conductor. The insulating core 22 may be positioned in the shell 21 by a copper gasket 24 and secured therein by a suitable cement or binder 25. The rear end of the shell 21 may be crimped, as at 26 to insure a snug joinder of parts. A slot 27 is preferably provided in the body 21 for engagement with a dowel 28 in the engine walls, to assure perfect positioning in exactly the right attitude with respect to the nozzle 15.

In carrying out the invention, the inner or power electrode 30 extends longitudinally through the insulating core 22 from a point adjacent the binding post 23 to a point well outside the shell 21. From one side of the

outer peripheral edge 31 of the shell 21, a ground electrode 32 extends out approximately parallel to the power electrode 30 but terminates in a radially bent portion 33 whose end is closely spaced from the power electrode 30. The ends of the electrodes 30, 32 form the points of a spark gap 34 therebetween.

Rigidly secured to the peripheral edge 31 of the shell 21 on the side opposite from the ground electrode 32 is a gap protector or shield 35. The gap protector 35 may take any form suitable for the purpose, but, preferably, is simply formed, for the sake of economy. In the preferred embodiment illustrated the gap protector 35 is formed from a section of the same type of flat rectangular wire as that used in the ground electrode 32. The gap protector 35 should be at least wide enough to prevent the jet of fuel from entering the gap 34. As shown here, it is the same width as the wider electrode 32.

Equally important in carrying out the present invention is the alignment and cooperation of the spark plug 20 with the nozzle 15 of the fuel injection device 13. Since the fuel-injection engine 9 has no carburetor, it is important that the injector 13 and spark plug 20 closely cooperate, the injector 13 sending out a controlled uniform spray of fuel having the required atomization and penetrating force to insure its ignition and combustion at all engine loads.

The injector 13 (Fig. 1) includes a body member 40 having a fuel passage 41 connecting the fuel inlet 14 to a fuel passage 42 in a nozzle valve guide 43, which abuts against an orifice plate 44. The body member 40 and guide 43 have an aligned central bore 45 in which a valve stem 46 is slidably mounted. The stem 46 is urged toward the orifice plate 44 by a spring 47, whose tension may be regulated by the threaded stud 48 retained in position by a lock nut 49.

At light loads, a well-atomized, low-penetrating short blast of fuel from the nozzle 15 is required for each cycle, so that only the air near the spark gap 34 is enriched with fuel. The present invention obtains these desirable characteristics. The fuel passing through the nozzle 15 is whirling in all directions and is highly agitated; so it leaves the nozzle 15 in a diffused low-penetrating spray pattern.

At full load, a more penetrating blast of fuel is required for each injected charge, in order to enrich the entire volume of the combustion chamber with fuel. The present invention obtains these desirable conditions. The fuel then passes through passages more nearly constant in cross-section so it maintains considerable axial velocity. As a result the jets of fuel through the nozzle 15 are diffused about the same amount as the smaller quantity of fuel at light load was diffused, but there is much more fuel in each jet and more momentum; so the jets penetrate further into the chamber.

Similarly, the nozzle is self-adjusting for in-between stages from a very light load to a full load.

As illustrated in Fig. 1, the fuel spray pattern ejected by the nozzle 15 has a plurality of expanding jets generally indicated by the dotted lines 60. According to the invention, the spark gap 34 is located relatively close to the nozzle 15 almost centrally of the expanding paths 60 of the fuel jets. Actually, the end of the shield 35 is preferably retracted about $\frac{1}{16}$ " from the axis of the nozzle 15, which is also the axial center of the fuel jets 60. Likewise, the spark plug 20 is so positioned that the gap protector 35 is between and directly in line with the spark-gap 34 and the nozzle 15.

Thorough, simultaneous ignition of all the main jets 60 from the central source that they surround is insured by the small auxiliary ignition jet 61 from the nozzle 15 aimed axially, so that the protector shield 35 of the spark plug is directly in its path. Preferably, this jet 61 is considerably smaller than any of the main fuel air mixing jets 60. None of the nozzle orifices should be aimed at the spark gap 34. With this arrangement, the frame

spreads uniformly from the central ignition source—the jet 61—outwardly to each of the four main jets 60.

By this unique construction of the spark plug and by the particular positioning of the spark gap and protector in the combustion chamber, the present invention is able to accomplish a result never before possible, namely, efficient and reliable ignition of the air and fuel mixtures at all engine loads and speeds of operation. Even at light loads the spark gap 34 is very close to the diverging paths of the fuel jets so that fuel gasifying in these paths enriches the gap region and gives an ignitable mixture at the point of ignition.

At full loads the gap protector 35 prevents the gap 34 from getting too much fuel, keeping the mixture from getting too rich to be ignited. It does this by wafting the fuel gently away so that it passes adjacent each side of the electrodes 30 and 32, this gentle wafting permitting the fuel at light loads to remain close to the gap 34.

An important point is that the protector keeps fuel from wetting the electrodes and causing carbon deposits to form in the gap 34 to create a short across the gap as might occur under certain operating conditions. It does this partly by the gentle wafting of the fuel jet, as stated above, and partly by actually vaporizing wet fuel, due to the fact that the outer end of the shield 35 is quite hot at all times, being kept hot by the gases of combustion which surround it. This phenomena also helps prevent any accumulation of fuel or carbon on the shield 35. The shield 35 can maintain this high temperature because it projects a substantial distance from the cooler body 21, its length and small cross section permitting its outer end to attain a temperature well above its inner end.

A further advantage of this invention is that the gap protector at all times insures that a gasified mixture within the proper range will have access to the spark gap, since its wafting of the fuel jet is gentle and since it vaporizes liquid fuel that strikes it. This novel operation prevents engine misfiring. It is significant in this respect, that with the gap protector 35 between the gap 34 and the nozzle 15, the gap may be positioned within one inch of the nozzle, and still provide reliable sparking. In practice, a spacing of $\frac{3}{4}$ inch to $1\frac{1}{4}$ inches has produced very efficient results.

To insure proper alignment of the spark plug 20 in a combustion chamber 12, some suitable mounting, such as the one illustrated in Fig. 1, may be provided in a wall 63 of the chamber 12. As shown, a gasket 64 is positioned between the shoulder 65 in the wall 63 and the shoulder 66 of the shell 21. The notch 27 provided in the shell 21 engages the dowel 28 to insure proper positioning and alignment. The casting 63 is threaded at 67 and a sleeve 68 which threads therein encircles the spark plug body 21 and engages the shoulder or rim 69, to hold the plug 20 firmly in place against the gasket 64. Installation of a spark plug 20 with this particular mounting will then insure that the protector 35 is between, and in line with, the gap 34 and the injection nozzle 15.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting. For example, the gap protector could assume many varied forms, such as a double wire or a triangular bar without a substantial variation in the over-all result.

What is claimed is:

1. A spark plug, including in combination a body, a pair of electrodes projecting therefrom and having terminal portions closely spaced from each other to form a spark gap, and a narrow, substantially linear gap-pro-

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lector means projecting from said body, said electrodes and said gap protector being in line and substantially co-planar, said gap-protector means being spaced appreciably further from said electrodes than they are spaced from each other.

2. A spark plug, including in combination a body, a first linear electrode projecting centrally therefrom, a second linear electrode projecting from one side of said body in a direction approximately parallel to said first electrode and having a terminal portion closely spaced from the outboard end of said first electrode to form a spark gap, and a linear shield between approximately the same thickness as the wider said electrode, projecting from said body on the opposite side from said second electrode to a locus beyond said gap, and spaced appreciably farther from said electrodes than they are spaced from each other, said shield being substantially co-planar with said electrodes.

3. A spark plug comprising a hollow body, a power electrode mounted in the hollow body and projecting therefrom, a ground electrode secured to the hollow body adjacent said power electrode and having a terminal portion closely spaced from said power electrode to form a spark gap, and a fuel-deflecting shield substantially the same thickness as said electrodes, and in line therewith but spaced appreciably further from said power electrode than is the terminal portion of said ground electrode, whereby said shield will protect the spark gap from an excess of fuel when said electrodes are positioned directly in the path of a fuel jet, while the fuel still passes close to said gap.

4. A spark plug comprising a shell, an insulating core within the shell, a power electrode extending longitudinally through said core and protruding from said shell, a ground electrode secured to one side of said shell and having a bent portion adjacent said power electrode to form a spark gap, and a gap shield secured to the side

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of said shell opposite from said ground electrode and in line with said electrodes, said shield being substantially the same thickness as said electrodes and spaced from them appreciably farther from said power electrode than said electrodes are spaced from each other.

5. A spark plug adapted to give efficient ignition in a fuel-injection engine at all engine loads and speed of operation, comprising a generally cylindrical shell adapted to be mounted in an engine wall adjacent a combustion chamber, an insulating core within said shell; a power electrode extending longitudinally through said core and protruding from either end of said shell, a ground electrode secured to one side of said shell and extending adjacent said power electrode, said ground electrode having a bent end portion axially adjacent a terminal portion of said power electrode to form a spark gap, a gap protector secured to an opposite side of said shell so as to be in a plane with said electrodes and having a transverse thickness substantially the same as said electrodes, said protector being spaced appreciably farther from said power electrodes than said electrodes are spaced from each other.

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