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FUEL INJECTION SPARK PLUG

Filed Feb. 28, 1940

2 Sheets-Sheet 1

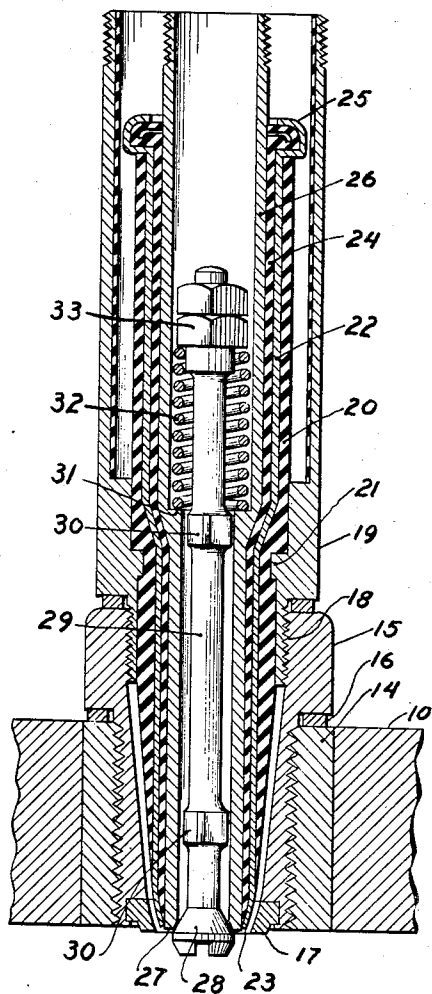


FIG. 1

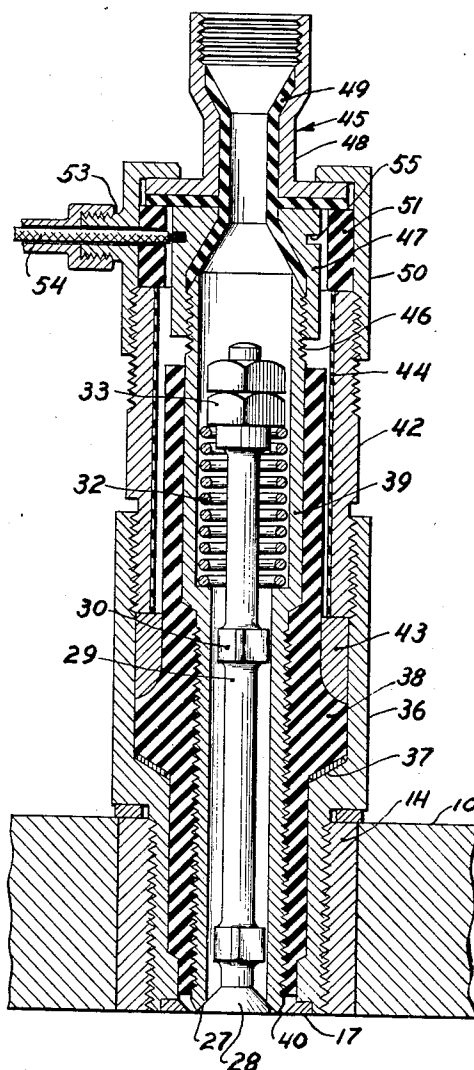


FIG. 2

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2 Sheets-Sheet 2

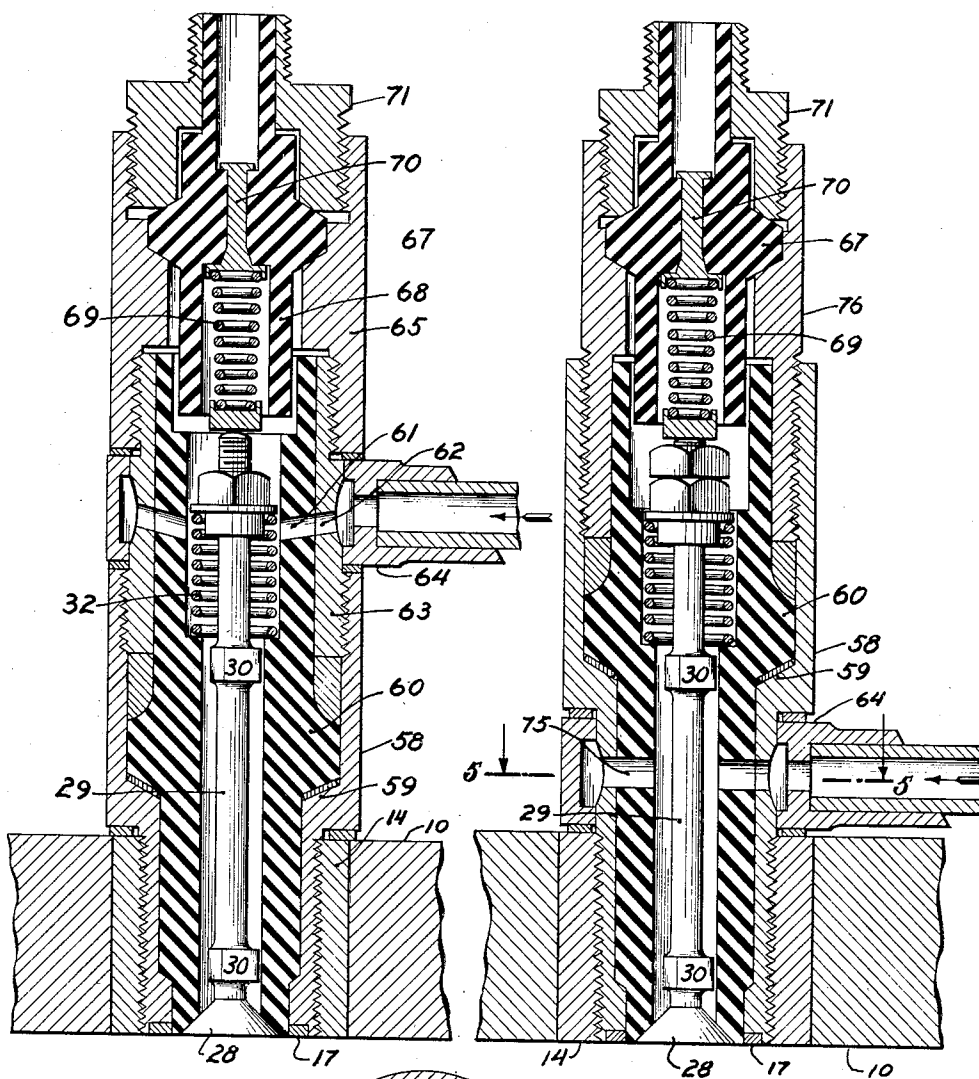


FIG. 3

FIG. 4

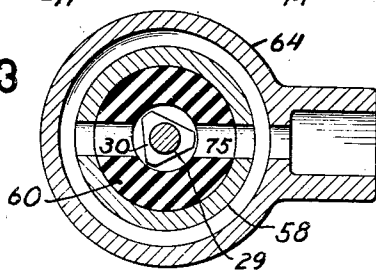


FIG. 5

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FUEL INJECTION SPARK PLUG

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11 Claims. (Cl. 123—169)

This invention relates to internal combustion engines arranged for fuel injection and in particular, comprises improvements whereby the conventional spark plug of the engine incorporates a fuel injection nozzle which heretofore has been a separate device.

By the coordination of the spark plug and fuel injection nozzle in a single unit various advantages accrue, such as:

(a) The cylinder head need have only a single opening for the combined device where before separate openings for the spark plug and the injection nozzle are necessary. Thus, weakening of the cylinder head due to the multiplicity of holes is minimized;

(b) The flow of liquid fuel through the injection nozzle has the effect of cooling the spark plug;

(c) The transfer of heat from the spark plug to the fuel prepares the fuel for quicker vaporization when admitted to the cylinder, particularly when the fuel has low volatility;

(d) The weight of the engine may be reduced, which factor is particularly important in aircraft engines;

(e) Erosion of the sparking points should be reduced due to their lower operating temperatures, and

(f) When two of the combined devices are used in each cylinder, two fuel nozzles as well as two spark plugs would be available and operating characteristics of the engine may be improved by cutting out one of the injection nozzles at idling speeds while using both spark plugs for ignition. When using both nozzles for full power operation improved fuel distribution would obtain.

The objects of the invention will be apparent from the above remarks and from the annexed detailed description of the combined spark plug and fuel nozzle device in connection with the drawings, in which:

Figs. 1 to 4 are sections through alternate forms of the devices, and

Fig. 5 is a section on the line 5—5 of Fig. 4.

In the several figures there are certain common elements which bear the same symbols. Referring first to Fig. 1, which shows an elementary adaptation of the invention, the cylinder head is indicated in part at 10 and is provided with a hard bushing 14 to receive the plug. The plug comprises a lower shell 15 threaded into the bushing 14 against a packing washer 16. The shell 15 has an annular or multi point spark plug electrode 17 set into its lower end and the top end is threaded as at 18 to receive an upper shell 19

in which is formed an insulating sleeve 20 locked against displacement by a shoulder 21. The sleeve 20 and other insulating parts shown in this and other embodiments preferably are formed from a suitable ceramic compound which may be molded into its proper form and which will have adequate mechanical strength and insulating and refractory properties. The compound used should also be capable of formation to close dimensions and have a high finish. Appropriate compounds of this character may comprise oxides or silicates of certain metals such as tin, aluminum or zirconium, but the invention is not to be construed as being restricted to any particular refractory insulating material.

Within the sleeve 20 a metallic electrode sleeve 22 is fitted, such sleeve terminating at its lower end in an annular sparking point 23 in proper clearance relation to the electrode 17. The upper end of the sleeve 22 is spun over an inner insulating sleeve 24, as at 25, to constitute an electric connecting terminal. The sleeve 24 has fitted thereto a valve housing 26 terminating at its lower end in a valve seat 27 engageable by the head 28 of a valve whose stem is indicated at 29. The stem is provided with triangulated bosses 30 whose apices bear on the interior wall of the sleeve 27 for guiding the valve, and whose depressions permit of the passage of fuel from the upper part of the housing 26 to the valve head 28. The housing 26 is provided with a shoulder 31 upon which the spring 32 rests, the upper end of the spring engaging adjustable nuts 33 whereby the valve is normally held in a closed position. A suitable closure structure for the upper end of the plug assembly is provided whereby fuel may be fed to the interior of the housing 26 and whereby electrical impulses may be conducted to the sleeve 22. Such a closure structure would be similar to that shortly to be described in connection with Fig. 2. It will be noted that the shell 19 embraces the whole plug assembly and comprises a grounded electrical shield therefor.

In Fig. 2 a shell 36 is screwed into the spark plug bushing 14 and carries at its lower end the sparking ring 17, the shell having a tapered surface 37 against which an insulating sleeve 38 abuts in sealing relation, said sleeve extending upwardly and downwardly from the surface 37 to embrace a valve housing 39 screwed into the lower end of the sleeve. The valve housing at its lower end comprises an annular sparking electrode 40 and comprises thereat the valve seat 27 against which the valve head 28 may rest. The other elements of the valve assembly are

similar to that above described. An upper shell 42 is screwed into the shell 36 and is tightened against a washer 43 which clamps the sleeve 38 against the surface 37. The shell 42 is preferably lined with an insulating layer 44 to prevent flashover between the housing 39 and the shell 42. Upon the top of the housing a preformed unit 45 is threaded at 46, the unit 45 comprising a screw cap 47 and a fuel inlet 48 separated from one another by an insulating element 49. The part 47 forms a connecting piece for the high voltage furnished by the ignition system, whereas the element 48 is at ground potential. The elements 47 and 48 are secured to one another by the insulating material 49 during the fabrication process. After the assembly 45 is screwed upon the housing 39, a union nut 50 is assembled thereover and is screwed to the shell 42. Prior to attachment of the assembly 45 an insulating annulus 51 is placed thereover to provide further protection against flashover between the valve housing and shell assembly. The nut 50 is provided with a protuberance 53 to which an insulated ignition wire 54 is led, said wire passing through a hole in the insulating ring 51 so that the wire thereof may be engaged in a slot 55 in the element 47. The ignition wire 54 carries conventional shielding which is grounded to the nut 50, which in turn is grounded through the shell 42 and the shell 36. In this embodiment all components of the plug are sealed against fluid leakage and the electrical path is fully insulated from elements at ground potential. The valve housing forms the inner spark plug electrode which is at the same potential as the valve.

In Fig. 3 a shell 58 is threaded into the spark plug bushing 14 and carries at its bottom end an annular spark plug electrode 17, said shell having an inclined annular shoulder 59 against which an insulating sleeve 60 rests, said sleeve extending upwardly and downwardly from the shoulder 59 and comprising a valve housing for the valve 28 and its stem 29, said insulating material itself including a shoulder for the valve spring 32. Toward the upper end of the sleeve 60, cross drillings 61 are formed which mate with cross drillings 62 in an intermediate shell 63 screwed into the shell 58 to hold the sleeve 60 against the shoulder 59. A ring connector 64 embraces the shell 63 for entry of fuel to the cross drillings 61 and 62 and into the housing 60, said ring being clamped in position by an upper shell 65 screwed on to the upper end of the intermediate shell 63. An insulating bushing 67 seats upon a shoulder in the upper shell 65 and has a downwardly extending skirt 68 embracing an electrical connecting spring 69 resting at its lower end upon the top of the valve stem and on its upper end on a metallic connecting pin 70 molded into the bushing 67. Said latter sleeve is secured to the upper shell 65 by a cover plug 71 screwed thereto. The cover plug 71 at its upper end is provided with a normal thread connection for reception of a shielded ignition wire 10. In this arrangement, the electrical connection to the plug is made at the top thereof after the manner of the conventional spark plug, while the fluid feed connection to the ring 64 is spaced therefrom by which manifolding of a plurality of plug units may be more readily accomplished. The arrangement of Fig. 3 lends itself to air-cooled engine cylinders, since the fluid feed ring 64 is elevated from the cylinder head 10 a distance sufficient to clear cooling fins (not shown) which may be formed thereon.

In this embodiment the valve and its stem per se form the center electrode for the spark plug and the periphery of the valve head 28 forms the inner annular sparking point cooperating with the sparking element 17. Preferably, the bottom of the assembly is flush so that sparking of the plug comprises a flashover from the head 28 to the ring 17. The arrangement of Fig. 4 is in general similar to that of Fig. 3, except that the fuel feed ring 64 is clamped between the lower shell 58 and the cylinder surface, the fuel feed cross holes 75 being formed in the shell 58 and in the portion of the insulating sleeve 60 below the shoulder 59. In this arrangement the insulating sleeve 60 is clamped against the shell 58 by an upper shell 76 which carries the bushing 67, the connector 70 and the cover plug 71, electrical connection between the element 70 and the top of the valve stem being accomplished as before by a spring 69. In this arrangement, as in Fig. 3, the valve head 28 and the ring 17 comprise the sparking electrodes, the spark flashing over the end of the insulating sleeve 60 which comprises the valve housing. This arrangement would be well adapted for fluid cooled engines where the fuel feed ring 64 may conveniently lie adjacent the cylinder head surface.

Some of the more modern ceramic materials adapt themselves nicely to constructions of plug units herein shown, for they are possessed of great density, smoothness and strength along with excellent insulating and refractory properties. It is known that highly finished valve seats may be formed thereon which allows of the constructions shown in Figs. 3 and 4. Incidentally, in the arrangement of Figs. 3 and 4, as in the other arrangements, flashover distances within the plug unit are all adequate to avoid electrical breakdown in operation, and secure seals against fluid leakage are incorporated throughout.

In the use of plugs of this character it will be seen that the intermittent flow of fuel through the plug will afford cooling therefor, while the heat interchange from the plug to the fuel will promote vaporization of the latter. The arrangement of the valve 28 and its associated parts is adapted for use with an external fuel feed pump, metering device and distributor, all of which units are known in the art, so that the valve 28 merely functions as an admission nozzle. Ordinarily, the closing force on the valve 28 is quite large, so that fuel pressure within the plug proper and upstream of the valve will always be at a value of several hundred pounds per square inch at which temperature gasification of fuels having high volatility will not be likely to occur at the operating temperatures to which the plug unit is subject.

While I have described my invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding my invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. I aim in the appended claims to cover all such modifications and changes.

I claim as my invention:

1. A combined spark plug and injection valve device for engines comprising an outer shell adapted to be secured to an engine cylinder and constituting a grounded electrode, a refractory insulating sleeve therein, including a valve seat at its inner end, a valve engageable with said seat and constituting an inner electrode, said valve including a spring-loaded stem extending into said

sleeve, means to feed liquid fuel to the sleeve hollow, and electrical conducting means contacting said valve stem.

2. A combined spark plug and injection valve device for engines comprising an outer shell adapted to be secured to an engine cylinder and constituting a grounded electrode, a refractory insulating sleeve therein, including a valve seat at its inner end, a valve engageable with said seat and constituting an inner electrode, said valve including a spring-loaded stem extending into said sleeve, means to feed liquid fuel to the sleeve hollow, electrical conducting means contacting said valve stem, and a grounded electrical shielding casing embracing the entire device.

3. A combined spark plug and injection valve device for engines comprising an outer shell adapted to be secured to an engine cylinder and constituting a grounded electrode, a concentric refractory insulating sleeve therein comprising at one end an integral valve seat, the sleeve fitting closely into said shell, a liquid fuel feed connection secured to the device for feeding fuel to the sleeve hollow, a valve comprising a stem in the sleeve hollow and a head engageable with said valve seat, and an electrical connection to said valve.

4. A combined spark plug and injection valve device for engines comprising an outer shell adapted to be secured to an engine cylinder and constituting a grounded electrode, a concentric refractory insulating sleeve therein comprising at one end an integral valve seat, the sleeve fitting closely into said shell, a liquid fuel feed connection secured to the device for feeding fuel to the sleeve hollow, a valve comprising a stem in the sleeve hollow and a head engageable with said valve seat, an electrical connection to said valve, a central valve and seat assembly in insulated relation to said shell and comprising a center spark plug electrode, the valve including a spring normally holding same closed, and a pressure fuel feed connection to said valve and seat assembly.

5. A combined spark plug and injection valve device for engines comprising an outer shell adapted to be secured to an engine cylinder and constituting a grounded electrode, a concentric sleeve therein comprising a valve seat and a refractory insulator, the sleeve fitting closely into said shell, a liquid fuel feed connection secured to the device for feeding fuel to the sleeve hollow, a valve comprising a stem in the sleeve hollow and a head engageable with said valve seat, an electrical connection to said valve, a central valve and seat assembly having an external flange and in insulated relation to the shell and comprising a center spark plug electrode, a nut embracing the assembly in insulated relation thereto securing the assembly to the shell, a fuel connection passing into the assembly, and a cover element securing the assembly against leakage and comprising an insulated electrical connection to said assembly.

6. A combined spark plug and injection valve device for engines comprising an outer shell adapted to be secured to an engine cylinder and constituting a grounded electrode, a concentric sleeve therein comprising a valve seat and a refractory insulator, the sleeve fitting closely into said shell, a liquid fuel feed connection secured to the device for feeding fuel to the sleeve hollow,

a valve comprising a stem in the sleeve hollow and a head engageable with said valve seat, an electrical connection to said valve, a central valve and seat assembly having an external flange and in insulated relation to the shell and comprising a center spark plug electrode, a nut embracing the assembly in insulated relation thereto securing the assembly to the shell, a fuel connection passing into the assembly, and a cover element securing the assembly against leakage and comprising an insulated electrical connection to said assembly, said shell, nut and cover comprising a shielding completely embracing the device.

7. In a spark plug and valve device, a shell a refractory insulating sleeve therein, the sleeve bottom being substantially flush with the shell bottom and comprising a valve seat, means to secure the sleeve within the shell, a valve comprising a head engageable with the sleeve seat and a stem piloted in the sleeve, a spring between the stem and sleeve urging the valve closed, a fuel feed ring embracing the shell, the latter and the sleeve having registering cross holes admitting fuel to the sleeve interior, a fuel tight insulating closure for the sleeve interior, and an electrical conductor passing therethrough electrically connected to said valve stem; said valve and shell respectively comprising center and edge spark plug electrodes.

8. In a spark plug and valve device, a shell, a refractory insulating sleeve therein, the sleeve bottom being substantially flush with the shell bottom and comprising a valve seat, means to secure the sleeve within the shell, a valve comprising a head engageable with the sleeve seat and a stem piloted in the sleeve, a spring between the stem and sleeve urging the valve closed, a fuel feed ring embracing the shell, the latter and the sleeve having registering cross holes admitting fuel to the sleeve interior, a fuel tight insulating closure for the sleeve interior, an electrical conductor passing therethrough electrically connected to said valve stem; said valve and shell respectively comprising center and edge spark plug electrodes, and a metallic cover embracing said insulating closure, secured to the shell and comprising grounded electrical shielding for the device.

9. A combined spark plug and injection valve device comprising an outer shell for securement to an engine, a homogeneous refractory insulating sleeve fixed therein having its end face formed as a valve seat, an axially movable valve stem passing through the sleeve having a head engaging said seat, and said shell and head comprising spark plug electrodes.

10. A combined spark plug and injection valve device comprising an outer shell for securement to an engine, a homogeneous refractory insulating sleeve fixed therein having its end face formed as a valve seat, an axially movable valve stem passing through the sleeve having a head engaging said seat, said shell and head comprising spark plug electrodes, means for forming an electrical connection to said valve stem, and means to feed fuel to the sleeve hollow.

11. In a combined spark plug and injection valve, a refractory insulating sleeve having one end formed as a valve seat, and a metallic valve engaging said seat said valve comprising a spark plug electrode.

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