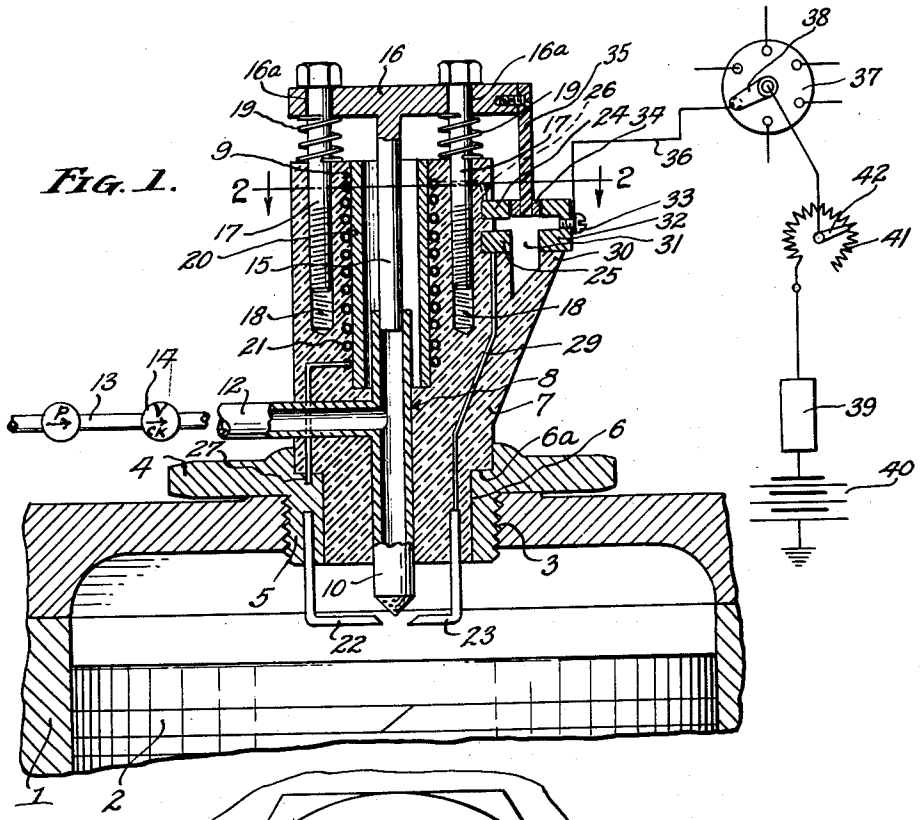
June 11, 1957 T. W. SHOOK II 2,795,214

COMBINED FUEL INJECTION AND IGNITION SYSTEM
FOR INTERNAL COMBUSTION ENGINES
Filed May 20, 1955

FIG. 1.



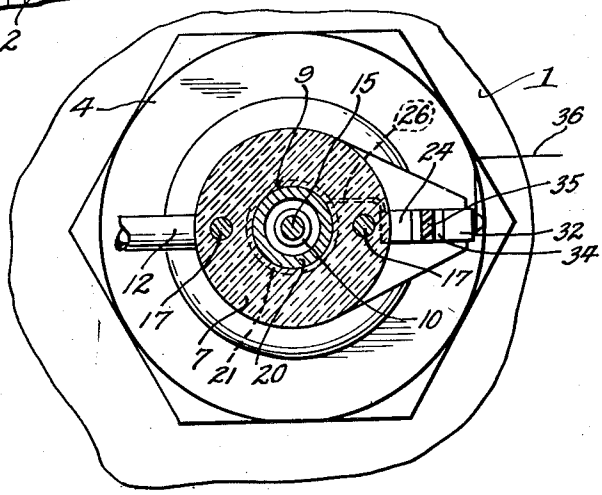


FIG. 2.

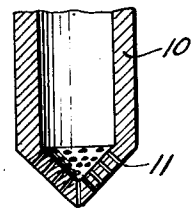


FIG. 3.

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United States Patent Office 2,795,214 Patented June 11, 1957

2,795,214

COMBINED FUEL INJECTION AND IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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Application May 20, 1955, Serial No. 509,938

5 Claims. (Cl. 123—32)

The present invention relates to fuel injection and ignition systems for internal combustion engines and more particularly to a combination fuel injector and ignition device for internal combustion engines intended to replace the usual carburetor and spark plug devices commonly employed in internal combustion engines.

The usual internal combustion engine employed with present day automotive vehicles includes a carburetor for mixing liquid fuel, such as gasoline, with air in desired proportions whereby to provide an efficient combustible mixture for timed introduction within the cylinders of the engine and for firing or igniting by a spark developed through a spark plug associated with each cylinder of the engine.

It has been proposed in the past, particularly in connection with diesel type internal combustion engines, to employ fuel injecting systems wherein controlled charges of raw liquid fuel are injected under pressure into the cylinders at timed intervals to be ignited by the heat and pressure developed in such cylinders through compression of air therein by a reciprocating piston. Also it has been proposed to employ fuel injection systems with internal combustion engines of the type incorporating spark plug or electrical ignition devices for igniting a fuel air mixture within the internal combustion engine. However, in these latter systems, the fuel injection nozzles and pump mechanisms are provided as separate units from the spark plug elements, and are generally actuated by pressures derived from engine-driven pumps. Generally, such prior fuel injection systems, while operating with improved efficiency, as compared with the usual carburetion system, are relatively expensive and structurally complex, with the result that the installation of fuel injection systems on ordinary combustion engines of the type employed in connection with automotive vehicles has not reached any great extent.

The primary object of the present invention is to provide a combined fuel injection nozzle or pump and fuel igniting device adapted particularly for use in ordinary types of internal combustion engines, and in replacement of the usual carburetor and spark plug devices normally found in such engines.

It is another object of the invention to provide a combined fuel injecting and ignition device which is adapted to be operatively connected with the cylinder of the engine after the manner of the usual spark plug, and which functions electrically to inject liquid fuel into the cylinder of the engine, and substantially immediately ignite such fuel within the cylinder for power developing purposes.

A further object of the present invention is to provide a combined fuel injecting and igniting device for internal combustion engines wherein the energy or power required for the operation of such devices is obtained through the usual electrical ignition circuit common to the ordinary automotive vehicle.

Yet another object of the invention is to provide a combined fuel injecting and ignition wherein the quantity of fuel injected in to the cylinder of an associated engine may be controlled through the manual adjustment of an electrical resistance type rheostat connected in the ignition circuit for the engine, thereby providing a relatively simple and efficient throttle control for the engine.

A still further object of the present invention is to provide a relatively compact and structurally simple fuel injecting and ignition device constructed and arranged so as to be operatively installed on the ordinary automotive vehicle internal combustion engine in replacement for the usual spark plug device, and which comprises generally a fuel injecting pump having a reciprocating piston or plunger element adapted to move on its fuel-injecting stroke in response to the energization of an associated electromagnetic field coil, and provided with spark-producing electrodes arranged within the cylinder of the engine, and adapted to be energized immediately following the forcible injection of fuel within such cylinder through the operation of a novel switch structure forming a component part of the fuel injecting and ignition device.

For a further more detailed understanding of the present invention and the additional objects and advantages ambient therein, reference is made to the following description and the accompanying drawing, wherein:

Fig. 1 is a medial vertical sectional view taken through a combined fuel injecting and igniting device formed in accordance with the present invention, and showing the associated electrical circuit in diagrammatic form;

Fig. 2 is a horizontal sectional view taken along the line 2—2 of Fig. 1;

Fig. 3 is an enlarged fragmentary vertical sectional view taken through the fuel discharging nozzle of the device.

Referring to the drawing by reference characters, the numeral 1 designates a cylinder of a conventional 4-cycle-type internal combustion engine in which a piston 2 is arrange to reciprocate. The cylinder head includes the usual threaded spark-plug-receiving opening 3 in which the present combined fuel-injecting and igniting device is positioned and supported, and the cylinder is provided with the usual intake and exhaust valves, not shown.

As exemplary of a presently preferred form of my device, the same comprises a metallic base member 4 of hexagonal nut formation having an integral, depending, exteriorly threaded extension 5 adapted for removable reception in the opening 3. The base 4 is formed with an internal bore 6 provided adjacent to its upper end with an enlarged annular seat 6*a*. Occupying the bore 6, and shouldered for engagement with the seat 6*a* thereof, is a molded dielectric body member 7 which is preferably formed from a porcelain ceramic fused and bonded to the metal base member 4.

The body 7 is formed in the lower part thereof with an axially extending passage 8 which terminates in a relatively enlarged cylindrical chamber 9. Extending through the passage 8 is an injection cylinder barrel 10, the latter opening at its upper end within the chamber 9 and being formed at its lower end with a conical fuel atomizing spray nozzle 11 which projects into the outer end portion of the engine cylinder 1. The barrel 10 is formed with a laterally extending fuel inlet port 12, which extends exteriorly of the body for connection with a fuel supply line 13 through which liquid fuel under pressure of a fuel pump P is conducted to the inlet port 12. The supply line 13 is provided with a check valve 14 which functions to permit free flow of fuel to the inlet port 12 while precluding flow in the opposite direction.

Mounted to reciprocate within the upper end portion of the cylinder barrel 10 is a pump piston or plunger

15 preferably formed in whole or in part from soft iron. The upper end of the plunger 15 terminates in a cross head 16 which is formed with spaced guide openings 16a slidably mounting the cross head 16 on the shanks of a pair of stationary, headed, guide posts 17 extending outwardly from the end of the body 7. The posts 17 are threaded at their inner ends and are carried in screw-threaded sockets 18 formed in the body 7. Compression-type coil springs 19 are carried on the shanks of the post members and are disposed between the upper surface of the body member and the under surface of the cross head 16, the springs 19 imparting upwardly directed biasing forces to the cross member and the pump plunger 15.

Positioned in the chamber 9 of the body member is a sleeve 20, and around the outer surfaces of this sleeve there is disposed a magnetic field coil or winding 21. When the coil 21 is energized, the plunger 15 is attracted by the magnetic field thus established so that the plunger 15 is forced downwardly, against the resistance offered to such movement by the springs 19, to forcibly inject a charge of liquid fuel contained in the lower part of the barrel 10 into the associated engine cylinder 1 for admixture with compressed air within said cylinder whereby to provide an explosive fuel-air mixture without the use of a conventional carburetor. The initial position of the plunger 15 in the barrel 10 and the tension of the springs 19 may be adjusted by threaded post member 17 to determine the maximum pumping stroke of the plunger 15. It will be understood that upon the down stroke of the plunger 15 in producing fuel injection, the check valve 14 is seated and closed against fuel transmission.

Projecting outwardly from the lower end of the base member 4 is a grounded electrode 22 which is bent at its outer end to terminate substantially in closely adjacent relationship to the spray nozzle 11. Disposed in opposed, relatively closely spaced relation to the electrode 22 is a second electrode 23, the latter being anchored within the dielectric body 7. The two electrodes 22 and 23 are arranged to provide a spark producing means for igniting fuel within the cylinder 1, as will be hereinafter more fully described.

Carried on one side of the dielectric body 7 are a pair of relatively spaced stationary electrical contacts 24 and 25. The upper contact 24 is electrically connected by a lead 26 with one end of the field coil or winding 21. The opposite end of the winding 21 is grounded, as at 27, to the metallic base 4 by means of a conductor 28 which is preferably embedded in the dielectric body 7. The opposite contact member 25 is electrically connected with a lead 29 which extends through the body 7 and is connected at its opposite end with the electrode 23. The two contacts 24 and 25 are preferably embedded within the dielectric material of the body 7 and are spaced apart from one another a distance sufficient to prevent arcing upon imposition of electrical current upon either of the contacts. The body 7, adjacent the contacts 24 and 25, is provided with a laterally offset shoulder portion 30 which is spaced from the remainder of the body 7 to provide a chamber or recess 31 adjacent the contacts 24 and 25. Mounted upon the laterally offset extension 30 of the dielectric body 7 is a U-shaped stationary contact 32 provided with a screw connector 33.

Arranged for movement between the stationary contact 32 and the contacts 24 and 25 is a movable metallic bridge element 34 carried upon a dielectric post support 35 carried in depending relation to one side of the plunger cross head 16. The movable bridge element 34 is sized so as to closely fill the gap or space between the U-shaped contact 32 and the opposed contacts 24 and 25, and when positioned in horizontal registry between the respective limbs of the contact 32 and the opposed contacts 24 and 25, serves to electrically connect either of the contacts 24 or 25 with the contact 32.

The connector screw 33, associated with the stationary contact 32, is provided with a lead wire 36 which extends to and is electrically connected with one of the stationary contacts of the usual motor-driven ignition distributor 37. The distributor 37 is, in the usual manner, provided with a number of stationary contacts or posts corresponding in number to the number of cylinders of the associated engine, and embodies the usual rotor 38 which functions to selectively distribute ignition current in timed operation to the respective stationary contacts of the distributor. The ignition circuit further includes the usual induction coil 39 which is connected to receive operating current from the storage battery 40, or generator of the vehicle, not shown.

Electrically connected between the coil 39 and the rotor 38 of the distributor 37 is a variable resistance 41 having a manually adjustable rheostat arm 42. By adjusting the arm 42 of the resistance 41, the magnitude of current flowing between the coil 39 and the rotor 38 of the distributor may be varied within limits, and as will be hereinafter explained, this variable resistance provides a convenient and simplified throttle control for the present fuel injecting and ignition device.

In operation, as the rotor 38 of the distributor 37 moves into contact with the stationary contact point of the distributor connected with the lead 36, current passes from the coil 39 through the resistance 41, the stationary contact 32, bridge element 34, contact 24, and energizes the coil or field winding 21. Energization of the coil 21 results in forcible downward movement of the core-plunger 15 to cause fuel contained within the cylinder barrel 10 to be forcibly injected into the cylinder 1. Simultaneously with the movement of the plunger 15, the bridge element 34 moves downwardly out of registration with the contact 24 and into bridging relation between the contacts 32 and 25, thus causing current to pass through the lead 29 to the electrode 23 where a spark gap is produced between the electrodes 23 and 22 to ignite the fuel just previously injected into the cylinder 1.

It will here be understood that the capacity of the coil or field winding 21 must be such as to cause substantially instantaneous movement of the plunger 15 and bridge element 34, but the extent of movement or travel of the plunger 15 and bridge element 34 may be varied within limits by adjustment of the variable resistance 41. For example, when it is desired to inject a maximum quantity of fuel within the cylinder 1, the adjustable arm 42 of the rheostat or resistance is positioned so as to bypass or provide a minimum amount of resistance in the circuit, thus increasing the amount of current imposed on the coil or winding 21. Since the strength of the magnetic field produced by the coil 21 is directly proportional to the amount of current imposed thereon, the plunger 15 may be caused to move on a maximum stroke determined by the spacing between the cross head 16 and the upper end of the body 7 against the resistance afforded such movement by the springs 19. Conversely, by increasing the resistance within the circuit by adjusting the arm 42 for maximum resistance, the current imposed on the winding 21 will be decreased with a resultant decrease in the stroke of the plunger 15, and a consequent decrease in the amount of fuel injected into the cylinder 1.

It will here be understood, that in order to provide firing or ignition, regardless of the length of stroke of the plunger 15, the spacing between the contacts 24 and 25 must be sufficiently close to insure firing on each injection stroke, and toward this end, the spacing between the contacts 24 and 25 is proportioned in accordance with a minimum stroke of the plunger 15. For this reason, the width of the lower contact 25 and the lower limb of the stationary contact 32 is substantially greater than the width of the upper contact 24 and upper limb of the stationary contact 32 in order to insure the establishment of a spark between the electrodes 22 and 23 regardless of variation in the stroke of the plunger 15.

Advantageously, the adjusting arm 42 of the rheostat or resistance 41 may be employed as a throttle for the associated engine, and toward this end may be mechanically linked with the usual accelerator pedal of the associated vehicle, not shown.

It will be understood that a multiple cylinder engine will, of course, employ one of the present combined fuel injecting and igniting devices for each cylinder, and that the various stationary contacts of the distributor 37 will be appropriately connected with the stationary contact 32 of each of the devices employed with the several cylinders. Similarly, while the pump P has been illustrated diagrammatically in association with a single fuel injecting and igniting device, it will be understood that such pump may through proper manifold arrangement, not shown, be utilized to supply fuel under pressure to a plurality of the present fuel injecting and igniting devices.

In view of the foregoing, it will be seen that the present invention provides a structurally simple yet highly efficient combination fuel injecting and igniting device for internal combustion engines which is capable of injecting variable charges of fuel within the cylinders of such engine through the relatively simple adjustment of an electrical rheostat control.

The combined fuel injecting and igniting devices of the present invention eliminate the necessity for the usual carburetor and spark plug elements of an internal combustion engine, and at the same time greatly increase the efficiency of the associated engine due to the substantially simultaneous injection and firing of fuel within the cylinders of the engine as the piston elements closely approach or reach a top center position, enabling the associated engine to operate on so-called lower grade fuels, such as kerosene. The close arrangement of the injection nozzle and spark-producing electrodes results in substantially instantaneous ignition of the fuel immediately following injection thereof within the cylinder, and when such devices are placed substantially along the center line of the associated engine cylinders, the fuel air mixture tends to burn radially outwardly with respect to the cylinder, thus resulting in increased power-producing efficiency of the engine.

While I have disclosed and described in detail a single preferred embodiment of the invention, it will be understood that various modification as to details of construction and design may be resorted to without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. A combined, unitary, fuel-injecting and igniting device for an internal combustion engine comprising a body member arranged to communicate at one end with a cylinder of an internal combustion engine; electro-responsive fuel-injecting pump means carried by said body member and having a fuel-discharging outlet at one end of said body member, said pump means being operable upon energization to forcibly discharge fuel under pressure from said outlet; electrode means carried by said body adjacent said fuel-discharging outlet and operable upon energization to produce a spark for igniting fuel discharged from said outlet; and switch means carried by said body member and including a switch element movable in association with said pump means for establishing first an energizing circuit for said pump means and secondly an energizing circuit for said electrode means.

2. A combined fuel-injecting and igniting device for an internal combustion engine comprising a supporting body; a fuel injection pump mounted in said body and including a pump cylinder having a fuel inlet disposed intermediate the ends thereof and a fuel-discharging outlet projecting outwardly from one end of said body and a reciprocating pump plunger carried within said pump cylinder and movable to forcibly displace fuel between the inlet and outlet of said pump cylinder; electro-responsive means carried by said body and energizable to move the plunger of said pump on an injection stroke; spark-producing electrode means carried at said one end of said body and energizable to produce a fuel-igniting spark adjacent the outlet of said pump cylinder; and a switch carried by said body having connection respectively with said electro-responsive means, said electrode means and a source of electrical energy, said switch including an element movable in association with the plunger of said pump and arranged for movement to successively establish energizing circuits first for said electro-responsive means and then for said electrode means.

3. A combined fuel-injecting and igniting device as defined in claim 2, wherein the plunger of said pump is formed at least in part of soft iron, and said electro-responsive means comprises a magnetic field winding arranged on said body so as to attract said plunger upon energization and to move said plunger within the cylinder of said pump in a direction to forcibly eject fuel from the fuel-discharging outlet of said pump.

4. A combined fuel-injecting and igniting device as defined in claim 2, including means electrically connected with said switch for varying the electrical input thereto from a source of electrical current, and thereby to vary the amount of energizing current introduced into the energizing circuit for said electro-responsive means.

5. A fuel-injecting and igniting device for internal combustion engines, said device comprising a unitary body structure removably receivable in the normal spark plug-receiving opening provided in the cylinder head of an internal combustion engine, said structure including an internal fuel-injecting cylinder formed intermediately of its length with a fuel inlet and at one end of said structure with a fuel-discharging outlet; a plunger slidably mounted in said cylinder and movable to forcibly eject fuel from the outlet of said fuel-injecting cylinder; spring means cooperative with said plunger to maintain the latter normally in a retracted fuel-admitting position in said cylinder; electrically energized means cooperative with said plunger element to move the same in a fuel-ejecting direction in said cylinder against opposition of said spring means; spaced spark-producing electrodes carried by said body structure and disposed contiguous to the fuel-discharging outlet of said cylinder; and switch means carried by said body structure and having separate connection with said electrically energized means and said electrodes, and having a movable switch element arranged to move in association with said plunger for establishing successive operating circuits for said electrically energized means and said electrodes.

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