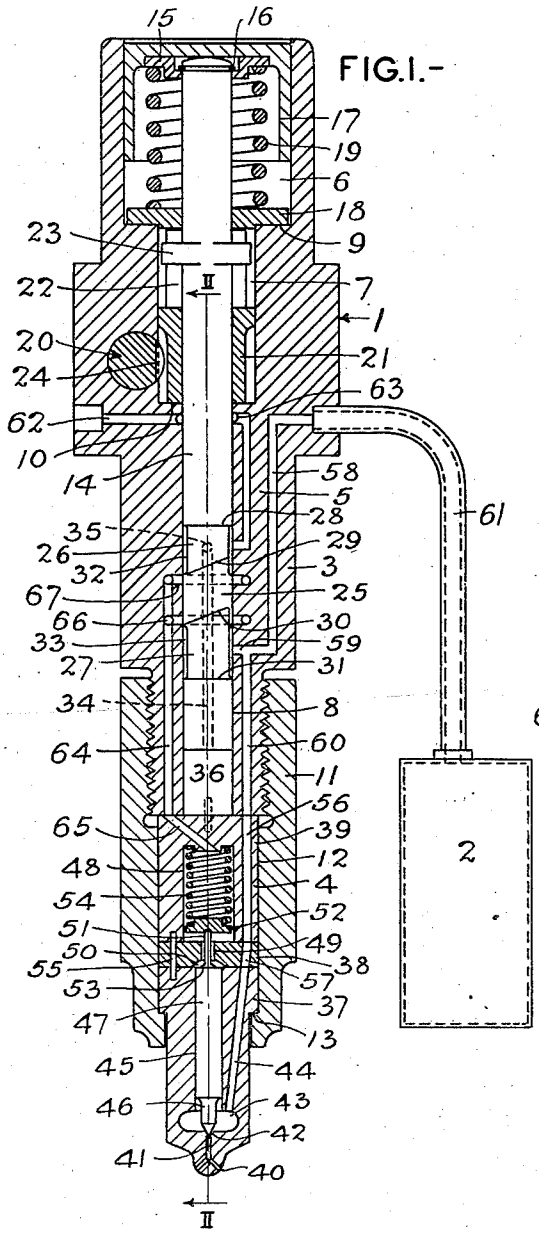
June 4, 1946. R. MILLER 2,401,579

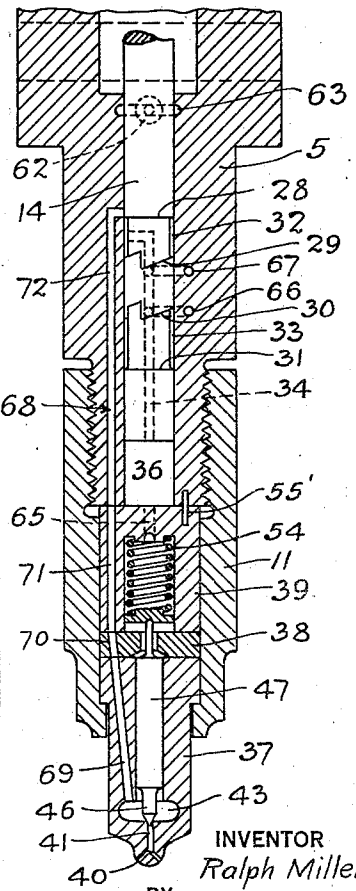
LIQUID FUEL INJECTION APPARATUS

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FIG.1.-



- FIG.2.-



INVENTOR
Ralph Miller
BY
S. C. Yeaton
ATTORNEY

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LIQUID FUEL INJECTION APPARATUS

Ralph Miller, Buffalo, N. Y.

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2 Claims. (Cl. 299—107.6)

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This invention relates to liquid fuel injection apparatus.

An object of the present invention is to provide an improved liquid fuel injection apparatus, for use in high power internal combustion engines, adapted to provide correctly atomized fuel in metered quantity during the short duration of injection existing in engines especially of the high speed, high output type, the apparatus having a nozzle continuously cooled by fuel.

Other and further objects of this invention will appear from the following description, the accompanying drawing and the appended claims.

Referring to the drawing forming a part of this application, Figure 1 is a vertical central sectional view of an injector nozzle and metering valve unitary structure, parts being shown in full, and a source of fuel being shown diagrammatically; and Fig. 2 is a section on the line II—II of Fig. 1, parts being shown in full and parts being broken away.

The fuel injection apparatus shown in Fig. 1, indicated generally by the reference numeral 1, has three parts, the parts being a source of fuel supply 2, a metering valve 3 and an injector nozzle 4, the valve 3 and nozzle 4 being secured together and having common parts, thereby forming a unit injector. Apparatus 1 is for employment in internal combustion engines having an overhead cam shaft mechanism (not shown), as will presently appear.

Metering valve 3 includes a hollow body 5 which has at its top a central chamber 6, therebelow another chamber 7 of lesser diameter than chamber 6 and thereblow an axial bore providing a cylinder 8 of lesser diameter than chamber 7, there being a shoulder 9 between chambers 6 and 7 and a shoulder 10 between chamber 7 and cylinder 8. The bottom portion of body 5 is externally threaded. The metering valve further includes a casing 11 having internal threads screwed on the bottom portion of body 5. Casing 11 has an axial bore 12 below the bottom edge of body 5 and an inwardly extending annular shoulder 13 at the bottom of bore 12.

A valve element 14 is disposed in cylinder 8, chamber 7 and chamber 6. A washer 15 is secured to the upper end of element 14 by a split snap ring 16, and washer 15 supports a crosshead or sleeve 17, which engages the top of element 14 and is adapted to reciprocate in chamber 6 and to be acted upon by a rocker arm of the overhead cam shaft mechanism aforementioned. A washer 18 is supported on shoulder 9, fitting freely around element 14, and a coil spring

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19 is compressed between washers 15 and 18, urging element 14 upward and holding sleeve 17 in engagement with the rocker arm of the cam shaft mechanism in a well-known manner.

Metering valve 3 further includes an adjusting mechanism, indicated generally by the reference numeral 20, which is of well-known construction and therefore it is not fully shown and will be but briefly described. Mechanism 20 includes a gear 21 having upwardly extending spaced lugs 22. Gear 21 is supported on shoulder 10 and fits freely around element 14. Guides 23 formed integrally with the element 14 slide in the guideways formed by the lugs 22. A rack 24 meshes wtih gear 21.

Element 14 has a cylindrical port-controlling part 25 for controlling ports presently to be dedescribed. Part 25 includes reduced portions 26 and 27, shoulders 28 and 29 at opposite ends of portion 26, and shoulders 30 and 31 at opposite ends of portion 27. Portions 26 and 27 are spaced from the wall of cylinder 8 providing chambers 32 and 33 respectively. There is further an axial bore 34 extending from the bottom face of element 14 to the reduced portion 26 and opening into the chamber 32 by means of a radial bore 35. The bottom face of element 14 is spaced from the bottom of the body 5 providing a chamber 36 into which bore 34 opens at its lower end. Shoulders 29 and 30 are inclined and zig-zag as is clearly shown in Fig. 2, this being a well-known pump or metering valve contour for use on adjustable pump or valve elements.

Nozzle 4 is a composite structure and includes a body 37 having a portion disposed in bore 12 and resting on shoulder 13, the remainder of the body 37 extending through the open end of casing 11 surrounded by shoulder 13 and therebeyond. A washer or spacer 38 is disposed in bore 12 on top of the body 37, and a housing 39 is disposed in bore 12 between spacer 38 and the bottom of the body 5. Body 37 has jets 40 in its lower end adapted to open into a cylinder of an internal combustion engine (not shown), a bore 41 communicating with the jets, a port or valve seat 42 at the upper end of the bore 41, an injection fuel chamber 43 above the valve seat, a passage 44 leading from chamber 43 to the upper face of the body 37, and an axial bore providing a cylinder 45 opening at its bottom into chamber 43 and at its top through the top face of the body 37.

A needle valve 46 is disposed in cylinder 45 and chamber 43, and is supported on seat 42 for coaction therewith. A plunger 47 integral with

valve 46 is disposed in cylinder 45 in spaced relation at its upper end with spacer 38. Housing 39 has a chamber 48 for a spring. Spacer 38 has a central bore 49 communicating at its bottom end by means of a conical valve seat 50 with cylinder 45. Seat 50 at its bottom edge is of a larger diameter than cylinder 45. Chamber 48, bores 49 and seat 50 provide a loading fuel chamber for plunger 47, as will presently more fully appear. A stem 51, integral with plunger 47, extends upwardly therefrom through seat 50 and bore 49 into chamber 48, there being clearance around the stem 51 for passage of fuel thereby. A spring seat 52 is supported on top of stem 51. Stem 51 is of smaller diameter than plunger 47, thereby providing a shoulder 53. The top edge of plunger 47 acts as a valve coacting with seat 50, as will presently appear. A coil spring 54 is disposed in chamber 48 and compressed between the seat 52 and the top wall of chamber 48, acting to force plunger 47 downward. A dowel 55 secures body 37, spacer 38 and housing 39 against relative rotation, and another dowel 55' (Fig. 2) secures body 5 and housing 39 against relative rotation.

A passage 56 extends longitudinally through housing 39 and communicates with passage 44 through a passage 57 formed in spacer 38. A passage 58 is formed in the wall of body 5, opening at its upper end through the side wall thereof near the bottom of chamber 7, and extending downwardly through the body to a point adjacent chamber 33, where it is branched, a branch 59 opening into chamber 33, and a branch 60 extending downwardly and communicating with passage 56. Passage 58 is connected at its upper end by a pipe 61 to the source of fuel supply 2 which may be any conventional apparatus adapted to supply fuel under constant pressure to pipe 61. For example, the source 2 may be a pump drawing fuel from a fuel tank (not shown) and pumping it through pipe 61, the pump being provided with means (not shown) for regulating the delivery pressure. It is contemplated that there will be a metering valve injector nozzle unit for each cylinder of the engine and that the source 2 will provide fuel for all the units of the engine. In such case pipe 61 will be a header, with branches for each of the units.

A passage 62 is formed in the wall of body 5, connecting chamber 32 to the exterior below rack 24. An annular groove 63 is formed in the body 5 around cylinder 8, forming part of passage 62, the passage 62 extending from the groove 63 at one side of the element 14 to the exterior and extending from the groove 63 at the other side of the element 14 downwardly to the chamber 32. Passage 62 is connected to a low or atmospheric pressure fuel tank (not shown). The oil in groove 63 lubricates element 14.

The body 5 includes another branched passage 64, communicating at its lower end with chamber 48 through a passage 65 formed in housing 39, and having a branch 66 at its upper portion adapted to open into chamber 33 and a branch 67 thereabove adapted to open into chamber 32. Branches 66 and 67 extend around the element 14, and have diametrically opposite portions opening into the cylinder 8 for balancing transverse oil pressure forces on the element 14.

The apparatus as thus far described is substantially the same as the apparatus of my copending application Serial No. 462,673, filed October 20, 1942.

The operation of the apparatus as thus far described is as follows: Fuel under pressure from the source of fuel supply 2 passes through passage 58, which is the only passage in direct communication with the source. Passage 58 is in continuous communication with the source and with branches 59 and 60, passages 56, 57 and 44, and chamber 43. Thus fuel under constant pressure is continuously present in chamber 43, for injection and for exerting a lifting force on plunger 47. Branch 59 opens continuously into chamber 33 which therefore is in continuous communication with the source of fuel supply 2.

Element 14 is shown in Fig. 1 adjusted for maximum fuel injection. Element 14 is on its down stroke and valve part 25 is just about to close branch 66 from chamber 33. Thus fuel, under the pressure of the source of fuel supply, fills chamber 43 and also acts on top of plunger 47. Branch 67 is also closed by valve part 25 of element 14. Therefore the pressure of the fuel acting on the top and bottom of plunger 47 is the same and plunger 47 is held downward, as the fuel under pressure above the plunger 47 acts on a greater surface of plunger 47 than the fuel under pressure in the chamber 43, and because the spring 54 augments this closing pressure.

Further downward movement of element 14 by the cam shaft rocker arm mechanism (not shown) acting on sleeve 17, effects closing of branch 66 simultaneously with opening of branch 67 to chamber 32. Pressure in chamber 48 is thereby reduced as it is connected to the low pressure tank by means of passages 65 and 64, branch 67, chamber 32, and passage 62. Pressure in chamber 43 then lifts plunger 47 so that its shoulder 53 engages, at its periphery, conical seat 50, and effects injection, which continues until the cam shaft mechanism permits element 14 to rise, due to the action of spring 19, to a position opening branch 66 to chamber 33, whereupon fuel again loads plunger 47, closing valve 46. The conical seat 50 leaves the entire surface of the shoulder 53 available for the action of the loading pressure. During downward movement of element 14, the chamber 36 below element 14 is vented, preventing pressure rise therein, through bores 34 and 35, chamber 32 and passage 62.

The operation of the apparatus as thus far described is substantially the same as the operation of the apparatus of my aforementioned pending application, to which reference may be had for further understanding of the construction and operation of the apparatus of the present invention.

The apparatus of the present invention further includes, as an added feature of the apparatus of my aforesaid pending application, means for cooling the tip of nozzle body 37 so that it is not excessively heated by the heat of combustion in the engine cylinder when the bore 41 is closed. This means is formed by a cooling fuel passage 68 adapted to connect and disconnect chamber 43 respectively with and from passage 62, chamber 43 being connected to passage 62 between injections. The cooling fuel passage is disposed 90 degrees from the injection fuel passage and is shown in Fig. 2 as including a passage 69 in the nozzle body 37, a passage 70 in the spacer 38, a passage 71 in the housing 39 and a passage 72 in the body 5. Passage 72 opens into cylinder 8 just below shoulder 28 when the valve element 14 is at its full uppermost position (above its position shown in Fig. 2). Thus, at this time, the cooling fuel passage 68 opens into

chamber 32 and is connected to passage 62 and therefore to the fuel tank.

The operation of the nozzle cooling feature of this invention is as follows: When the valve element 14 is at its uppermost position, the cooling fuel oil continuously flows from the source of fuel supply 2 through the injection fuel passage to the chamber 43 and therefrom through the cooling fuel passage 68 back to the fuel tank. Thus a continuous flow of cooling oil is flowing through the chamber 43, cooling the tip of the nozzle at this time. When element 14 starts to move downward, passage 68 is closed by the portion of the element 14 above shoulder 28, preventing the flow of fuel at this time through the cooling fuel passage 68. However, substantially simultaneously with the closing of passage 68, valve 46 is lifted to start injection and the cold fuel being injected through the nozzle for injection continues the cooling of the tip of the nozzle. Injection terminates as aforesaid, when element 14 is lifted upward by spring 19 to again open branch 66 to chamber 33. Substantially simultaneously therewith passage 68 is opened to chamber 32 and cooling fuel again flows through passage 68 from chamber 43 to the tank. Thus a substantially continuous flow through the chamber 43 for cooling the nozzle tip is effected, there being a substantially continuous flow of cooling fuel from source 2 either through the nozzle jets when the valve is open or through the cooling fuel passage 68 when the valve is closed.

While the cooling feature has been shown in a unit injector type of apparatus for use in overhead cam shaft engines, it is equally adapted for other types of apparatus for use in other types of internal combustion engines.

While there has been hereinbefore described an approved embodiment of the invention, it will be understood that many and various changes and modifications in form, arrangement of parts and details of construction thereof may be made without departing from the spirit of the invention, and that all such changes and modifications as fall within the scope of the appended claims are contemplated as a part of this invention.

The invention claimed and desired to be secured by Letters Patent is:

1. A liquid fuel injection apparatus comprising a source of pressure fuel supply; and an injector having a casing provided with a nozzle tip, said tip having an injection port and an injection fuel chamber adjacent and communicating with said port, said casing further having a loading fuel chamber, a valve bore connecting said chambers, passageway means connecting said source with said injection chamber for continuous supply of fuel thereto at source pressure, and a valve cylinder, said passageway means further connecting said injection chamber through said cylinder with the exterior of said injector, and further

connecting said loading chamber through said cylinder with said source for supply of fuel to said loading chamber at source pressure and further connecting said loading chamber through said cylinder with said exterior, said injector further having a valve element in said cylinder for controlling said passageway means passing therethrough to effect pressure differentials in said chambers, and a valve element in said bore for controlling said port in response to said pressure differentials in said chambers, said cylinder valve element closing and opening said injection chamber respectively from and to said exterior throughout the entire periods that said port is respectively open and closed whereby said tip is continuously cooled by an uninterrupted flow of pressure fuel through said injection chamber from said source at said source pressure.

2. A liquid fuel injection apparatus comprising a casing having a nozzle tip, said tip being provided with an injection port and an injection fuel chamber adjacent and communicating with said port, said casing further having a loading fuel chamber and a tip-cooling passage open at one end to said injection chamber and open at the other end to the exterior of said casing for flow of fuel therethrough from said injection chamber to said exterior; a source of pressure fuel supply connected to said chambers for supply of fuel from said source to said loading chamber at source pressure and for continuous supply of fuel from said source to said injection chamber at source pressure; an injection valve including a bore in said casing between and opening to said chambers and having a piston-valve element in said bore operably subjectable to fuel pressures in said chambers for controlling said port; a spring loading said element; a valve including a cylinder in said casing and a reciprocable mechanically-actuated member in said cylinder including a valve element for controlling said passage and an adjustable metering-valve element for controlling supply of and release of pressure fuel to and from said loading chamber effective respectively in the closing and opening of said injection valve, said member elements reciprocating in unison with said member; and means for adjusting said metering-valve element, said spring and said chamber pressures operating said piston-valve element to control said port, said passage-control-valve element being closed, closing said passage from said exterior, throughout the injection valve open period and being open, opening said passage to said exterior, substantially throughout the injection valve closed period whereby said tip is continuously cooled by a substantially uninterrupted flow of pressure fuel through said injection chamber from said source at said source pressure.

RALPH MILLER.