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FUEL INJECTION APPARATUS

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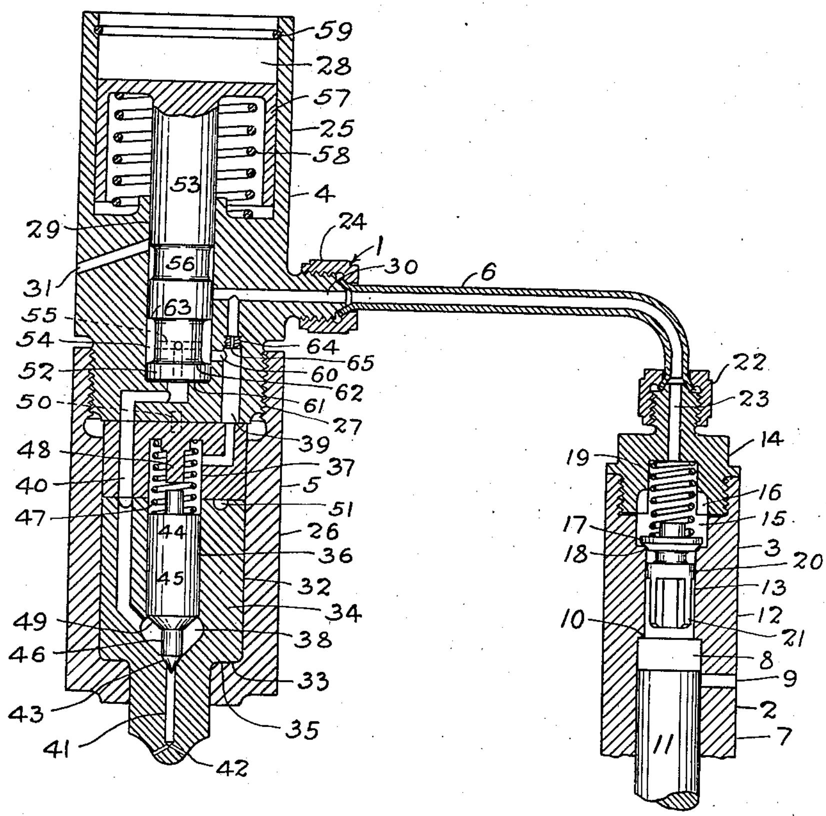

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FUEL INJECTION APPARATUS

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This invention relates to fuel injection apparatus for an internal combustion engine.

An object of the present invention is to provide a fuel injection apparatus for a cylinder of an internal combustion engine, having an injection nozzle and injection pump for attachment to a cylinder head, provided with a spill for effecting a sharp termination of injection by a hydraulic impact closing the nozzle valve.

A further object is to provide a fuel injection apparatus having an injection nozzle and injection pump as aforesaid, for attachment to a cylinder head, and a metering pump remote from the injection pump and connected thereto by piping, thereby preventing overcrowding of the cylinder head, and means between the pumps, preferably a retraction valve, permitting the aforesaid spill.

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

The accompanying drawing forming a part of this application is a longitudinal central sectional view of a fuel injection apparatus, parts being shown in full and parts being broken away.

In its preferred embodiment, the fuel injection apparatus, indicated generally by the reference numeral 1, of the present invention includes four parts, namely a fuel oil metering pump 2, a retraction valve 3, a fuel injection pump 4 and an injection nozzle 5. The metering pump sends a measured quantity of fuel to the fuel pump, which latter pumps it to the injection nozzle for injection into the engine cylinder (not shown). The retraction valve, at the end of the metering pump plunger stroke, causes a displacement in the conduit between the metering pump and injector providing a space for the spill of fuel to quickly terminate injection.

The injection pump and nozzle form a unit, which will be hereinafter referred to as the injector. There is an injector for each engine cylinder, disposed in the cylinder head (not shown). There is a separate metering pump connected to each injector by a delivery pipe 6. The retraction valve is preferably disposed in (integral with) the metering pump as shown, and as thus disposed forms a unit with the metering pump. The retraction valve may be situated at other locations between the metering pump and fuel pump if desired.

The metering pump may be a separate apparatus, i. e., a separate metering pump for each injector, or a multiple metering pump may be employed consisting of a plurality of plungers and cylinders arranged around a single cam shaft for operation by a single adjustable cam. Such a multiple metering pump is shown in patent to Wahlmark, No. 2,031,346, February 18, 1936. The amount of fuel pumped by the metering pump to the injection pump is varied by varying the length of the metering pump plunger stroke. However, metering by pump 2 may be adjusted by other means if desired.

The fuel metering pump 2 includes a casing 7, a cylinder 8 therein, a fuel inlet port 9, a fuel discharge port 10, and a plunger 11 in the cylinder. In the following description and appended claims the various chambers, cylinders, pipes and passages which the fuel must pass through after leaving cylinder 8 and until its admission to the cylinder of the fuel injection pump, will be referred to as the delivery passage of the apparatus.

The retraction valve includes a casing 12 formed integrally with casing 7, a cylinder 13 therein, a head 14 closing the outer end of the casing, a chamber 15 disposed partly in the casing and partly in the head, a fluted valve element stop 16 formed in the head, a valve element 17 normally disposed on a seat 18 formed in the casing around cylinder 13, a spring 19 returning the element to and holding it upon its seat, a piston 20 normally disposed in cylinder 13, and a fluted guide 21 for the piston, the valve element 17, piston 20 and guide 21 being formed as an integral structure. Delivery pipe 6 is secured to a nipple forming part of head 14 by a nut 22, and head 14 is provided with a passage 23 connecting pipe 6 with chamber 15.

The operation of the fuel metering pump and retraction valve is as follows: As shown in the drawing, the downward stroke of the plunger 11 is its suction stroke, and the upward stroke is its pumping stroke. On its suction stroke it draws fuel from a reservoir (not shown) into cylinder 8 through port 9, and on its pumping stroke, after plunger 11 has closed port 9, it pumps fuel to the retraction valve 3.

The fuel being pumped acts against piston 20 of the retraction valve, forcing piston 20 upwards and valve element 17 off its seat 18, thereby compressing spring 19. When piston 20 passes completely out of cylinder 13 (valve element 17 engaging stop 16), fuel will be pumped by plunger 11 past the retraction valve, due to the fluting of guide 21 and stop 16, into the delivery pipe 6 and therefrom to the injection pump 4.

When plunger 11 starts on its downward stroke again, spring 19 forces valve element 17 and piston 20 downward, providing a space for the spill as aforesaid. Valve element 17 acts as a conventional one-way flow delivery valve. Delivery pipe 6 is secured by a nut 24 to a nipple forming part of the injection pump casing 25. Casing 25 is disposed on and secured to injection nozzle casing 26 by a threaded connection 27.

Casing 25 provides a chamber 28, a cylinder 29, a passage 30 leading from pipe 6 to cylinder 29, and a drain passage 31 leading from cylinder 29 to the exterior.

Casing 26 is hollow providing a bore 32 open at both ends and having a shoulder 33 therein. A nozzle housing 34 is disposed in the bore. At one end it is in engagement with casing 25 and at its other end projects beyond casing 26 through the shouldered open end thereof. Nozzle housing 34 has a shoulder 35 engaging shoulder 33 and is securely held in the bore by casing 25.

Nozzle housing 34 is shown made of two pieces in order to simplify its manufacture, but it will be described hereinafter as if it were made in one piece. It includes a central bore providing a cylinder 36, a chamber 37 above the cylinder, and a chamber 38 below the cylinder. A passage 39 connects passage 30 with chamber 37 and a passage 40 connects cylinder 29, at the bottom thereof, with chamber 38. A passage 41 connects chamber 38 with jets 42, and a valve seat 43 is provided at the jointure of chamber 38 and passage 41.

A valve element 44 is disposed in the bore of nozzle housing 34. It includes a piston 45 in cylinder 36 and a valve needle 46 formed integrally with the piston, needle 46 and seat 43 forming a valve. A spring 47 disposed in chamber 37 normally holds the piston 45 downward with needle 46 in engagement with seat 43. A stop 48 limits upward movement of the piston 45 and compression of spring 47. Needle 46 is of smaller diameter than piston 45 providing a shoulder 49 therebetween disposed in chamber 38.

Passages 39 and 40 are formed partly in casing 25 and partly in nozzle housing 34 and therefore nozzle housing 34 is secured to casing 25 against relative rotation by a key 50 to insure alignment of the passages in each. A groove 51 formed in the nozzle housing between the two parts thereof aforementioned insures a free way for passage 40 through the nozzle housing.

The injection pump 4 further includes a plunger formed of a piston 52 and a stem 53 integral therewith, the piston and stem being disposed in cylinder 29. A circumferential groove 54 is provided in the piston and a passage 55 is formed through the piston, connecting groove 54 with cylinder 29 at the bottom of piston 52. An oil collecting circumferential groove 56 is formed in the stem 53 adjacent passage 31. Groove 56 collects lubricating oil passing downward along the stem and fuel oil passing upward along the piston, and passage 31 drains groove 56 to the atmosphere, thereby preventing adulteration of lubricating oil by fuel oil and of fuel oil by lubricating oil. The stem 53 above groove 56 is lubricated by lubricating oil from chamber 28 and the stem below groove 56 and the piston 52 are lubricated by fuel oil.

A tappet 57 is secured to the upper end of stem 53, and works in chamber 28. A spring 58 normally urges tappet 57 upwardly. The uppermost position of tappet 57 is determined by a cam or push rod (not shown) connected to the engine camshaft for operating the injection pump. A split ring 59 disposed in a groove in the upper end of chamber 28 prevents accidental movement of the tappet out of the chamber.

When the piston 52 is at its lowermost position, as shown in the drawing, which is the position at the termination of injection, groove 54 is opposite and in communication with a passage 60 which opens into passage 39. Passage 60 is controlled by the lower edge 61 of piston 52 and the lower edge 62 of the groove 54. The upper edge 63 of the groove 54 controls passage 30, as will presently appear.

An orificed plug 64 is disposed in passage 39 between passages 60 and 30, the orifice 65 of the plug being small in comparison with passages 60 and 30, thereby restricting the flow from and to passage 39 through orifice 65.

The operation of the fuel injector is as follows: When the piston 52 is in its uppermost position, groove 54 is opposite passage 30 and therefore fuel under metering pump pressure is forced into groove 54, through passage 55 into the lower end of cylinder 29, and through passage 40 to chamber 38. The pumping strokes of plunger 11 and piston 52 will be timed to insure the metered charge entering the cylinder 29 before passage 30 is closed by edge 63.

On the downward or pumping stroke of piston 52, edge 63 will close passage 30 substantially simultaneously with the closing of passage 60 by edge 61. Thereafter, until edge 62 again opens passage 60, fuel will be pumped through passage 40. The fuel in chamber 38 builds up a pressure as the piston 52 moves downward until the pressure is sufficient to move element 44 upward against the pressure on the top of piston 45. Although the pressure of the oil on top of element 44 will be relieved by the action of the retraction valve, as aforesaid, nevertheless the passage 39 below the passage 60, and the chamber 37 will remain filled with oil, this being desirable, as will presently appear.

Prior to nozzle valve opening, a sufficient load is exerted on element 44 to insure complete fuel atomization when needle 46 opens passage 41. As the load on the engine varies, the timing of the opening of the valve varies, the valve being opened sooner at high loads than at low loads.

Termination of injection begins when edge 62 uncovers passage 60. As piston 52 is not adjustable, this always happens at the same time for all loads. Thus a uniform termination of injection is obtained. When this happens, pressure in passage 39 and chamber 37, having been relieved, as aforesaid, is lower than injection pressure. At uncovering of passage 60 there is a spill of fuel at injection pressure through passage 60 into passage 39. This spill reduces the pressure in chamber 38 and passage 40. At the same time it increases the fuel pressure in chamber 37 to substantially injection pressure, which augments the spring pressure and effects quick closing of needle 46, sharply terminating injection. The quick closing of the needle is effected by what may be termed a pressure flow to the valve delivering a hydraulic impact on top of piston 45 due to the spill. As needle 46 closes there is an equalization of fuel pressures in passages 39 and 40, the apparatus then being ready for the next injection cycle.

It will be seen from the foregoing description that the quick closing of the valve by the added hydraulic pressure or impact prevents harmful dribbling through the jets 42 at the termination of injection. In accordance with the present invention, the needle is closed by an increase in pressure on top of the needle and not by a degeneration of pressure beneath the needle. Thus at needle-closing injection is at high velocity, causing high atomization and scavenging of passage 41. This augmenting closing pressure enables a lighter spring to be employed, less pressure to open the valve being thereby required as at valve-opening, the augmenting closing pressure is not present.

By using a separate metering pump and a separate injection pump in the apparatus of the present invention, the metering pump, which only measures the quantity of fuel, may be placed at any convenient place where there is sufficient available space although remote from the injection nozzle, as the length of piping between the two pumps would not affect the metering of the fuel. Thus overcrowding of the cylinder head is prevented. The injection pump may be placed in close proximity to the injection nozzle, in fact in the same casing as in the present embodiment, thereby avoiding all objectionable tubing between the injection pump and injection nozzle, which tubing would interfere with accurate delivery of fuel to the injection nozzle.

While there has been hereinbefore described an approved embodiment of this 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 fuel injection apparatus for an internal combustion engine comprising a fuel metering pump having a cylinder; a fuel injector including a fuel injection nozzle and a fuel injection pump having a cylinder; a fuel delivery passage connecting said metering and injection pump cylinders; and a retraction valve disposed in said passage.

2. A fuel injection apparatus for an internal combustion engine comprising a fuel metering pump; a fuel injector; and a fuel delivery pipe connecting said pump and injector, said injector including an injection jet for injection of fuel into a cylinder of said engine, a valve for controlling said injection, a cylinder for said fuel, a piston in said fuel cylinder for pumping the fuel therein, a passage from said fuel cylinder for conducting pumped fuel to said jet, said valve having a valve element provided with opposite faces, a spring opposing opening of said valve, one of said faces being acted upon by said pumped fuel to open said valve, and a spill passage leading from said fuel cylinder to the other of said faces, the spilled fuel causing a pressure flow hydraulically augmenting closing of said valve to sharply terminate injection.

3. A fuel injector comprising a cylinder for fuel; a fuel pumping piston in said cylinder; an injection jet; a valve for controlling said jet, said valve including a seat and a needle therefor; a valve cylinder; a valve piston disposed in said valve cylinder and connected to said needle for opening and closing said valve; a spring normally holding said valve piston in needle valve-closed position, said injector further comprising a passage connecting said fuel cylinder with said valve cylinder at the end of said valve piston adjacent said needle whereby the pressure of said pumped fuel will act on said valve piston to open said valve, and a passage connecting said fuel cylinder with said valve cylinder at the other end of said valve piston; and spill means in said pump piston, effecting spill of fuel into said last mentioned passage to terminate injection, said spill causing a pressure flow to said other end of said valve piston for hydraulically augmenting closing of said valve to sharply terminate injection.

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