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FUEL INJECTION DEVICE FOR INTERNAL COMBUSTION ENGINES

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This invention relates to fuel injection devices for internal combustion engines working on airless injection and has for its object to provide an improved form of such device which will be simple in operation and require a minimum number of moving parts.

A fuel injection device according to this invention comprises a chamber in which fuel is accumulated under pressure and to which
10 additional pressure is applied by external means so as to effect the airless injection of the fuel into the combustion chamber.

Preferably the means for applying the additional external pressure to the accumulator can be adjusted before injection takes place so as to determine the quantity of fuel admitted to the accumulator chamber and subsequently injected into the combustion chamber. Additional external pressure may
20 be applied by means of a liquid, such as liquid fuel fed under pressure from a fuel pump and means such as a pressure regulator may be provided for varying this pressure, the arrangement being preferably
25 such that this variation is effected in accordance with the load on the engine.

Conveniently the fuel delivered to the accumulator and to form the additional external pressure is supplied from a common
30 pressure source, for example, a fuel pump, part of the fuel being delivered to the accumulator chamber where it is stored for the next injection stroke, and part to exert additional external pressure on the accumulator
35 to effect the injection of fuel so stored.

In the accompanying drawing,

Figure 1 illustrates diagrammatically one construction of fuel injection device according to this invention, and

40 Figure 2 is a diagrammatic plan of the device illustrated in Figure 1 as applied to a four-cylinder internal combustion engine.

Referring to Figure 1, the apparatus comprises an injection portion 1 and a controlling portion 2. The injection portion 1 includes a fuel needle valve 3 normally maintained on its seating by a spring 5 acting
45 on the top of a plunger 4, and a pressure accumulator 6 within which a piston 7 provided with a stop 9 is movable up and down
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against a spring 8 contained in a chamber 10 provided above the accumulator piston 7. Formed in the injection portion 1 beneath the accumulator 6 is a recess 21 in communication on one side with the fuel
55 needle valve 3 and on the other through a check valve 12 with a fuel supply pipe 13.

The control portion 2 is in the form of a cylinder within which a piston valve 14 is movable against the action of a compression spring 16 by means of a cam 15 through
60 a tappet member 25. The cylinder of the control portion 2 is in communication on one side with the spring chamber 10 through a pipe 11, and on the other side with the
65 fuel supply pipe 13 and also through a pipe 17 with the suction chamber of the fuel pump (not shown) which supplies fuel from a pressure tank and under an approximately
70 constant pressure of, say, 250 atmospheres to the pipe 13. The pipe 17 is provided with a pressure-equalizing tank 18 and a reducing valve 19 which can be set by a
75 hand wheel 20 to permit of any desired pressure between 0 and 100 atmospheres.

If desired, means may be provided whereby the tensions of the springs 5 and 8 can be regulated during working of the engine.

The operation of the device is as follows:

Before injection takes place, the piston
80 valve 14 of the control device is in the position shown in full lines in Figure 1 and the spring chamber 10 is in communication with the suction chamber of the fuel pump
85 through the pipe 17, while the accumulator 6 is being supplied with fuel under a pressure of 250 atmospheres from the fuel pump. The position of the accumulator piston 7 is determined partly by the pressure of the spring 8 and partly by the supplementary pressure upon it of the liquid fuel admitted through the pipe 11. If, therefore, the supplementary pressure is set by the hand
wheel 20 to, say, 100 atmospheres, the accumulator piston 7 will be raised to a smaller extent than when the supplementary pressure is set at zero and it will therefore
be seen that the quantity of fuel admitted to and injected from the accumulator will 100

be determined by the setting of this supplementary pressure.

If, now, the supplementary pressure is set by means of the hand wheel 20 to, say, 50 atmospheres, the pressure on the top of the accumulator piston 7 will consist of this pressure together with a pressure of, say, 200 atmospheres due to the spring, giving a total pressure of 250 atmospheres, and, as the fuel fed into the accumulator will be exerting an upward pressure of 250 atmospheres, the accumulator piston will be held in equilibrium.

When injection is to take place, the piston valve 14 will be brought by the cam 15 into the position shown in chain lines in Figure 1. In this position the communication between the chamber 10 and the pipe 17 is cut off, thus removing the supplementary pressure of 50 atmospheres from the accumulator piston 7. The chamber 10 will, however, be simultaneously put in communication with the fuel feed pipe 13 and a new supplementary pressure of 250 atmospheres applied, thus raising the total pressure on the top of the accumulator piston 7 to 450 atmospheres, 200 atmospheres of which are due to the spring alone. Owing to the check valve 12 this downward pressure of 450 atmospheres, which acts through the accumulator piston 7 upon the fuel within the recess 21 will not be transmitted back to the fuel delivery pipe 13, but the fuel needle valve 3, which is set to open at 350 atmospheres and to close at 300 atmospheres, will be raised thereby from its seating and fuel injected from the accumulator into the combustion chamber by the downward movement of the accumulator piston 7. The provision of the stop 9 ensures a sharp closing of the fuel needle valve 3.

After injection is complete and the cam 15 has rotated far enough to permit the piston valve 14 to be returned by the spring 16 to the position shown in full lines in Figure 1, the pipe 13 is cut off from communication with the spring chamber 10 and communication is re-established between spring chamber and the pipe 17, the supplementary pressure in the spring chamber 10 being thus reduced to the original value of 50 atmospheres and the accumulator piston 7 raised until the spring exerts a pressure of 200 atmospheres, after which the accumulator piston will be held in equilibrium.

If during the idle running of the engine the supplementary pressure is set by the hand wheel 20 to, say, 100 atmospheres, the accumulator spring 8 will be compressed by the upward fuel pressure until the accumulator spring exerts 150 atmospheres so that the upward and downward pressures on the accumulator piston 7 will each be 250 atmospheres and the piston held in

equilibrium to admit a comparatively small quantity of fuel to the accumulator. On the other hand, in the case of a maximum overload on the engine, the supplementary pressure is set at zero so that the spring 8 will be compressed until it provides by itself a downward pressure of 250 atmospheres and thus admits a maximum quantity of fuel to the accumulator.

The fuel needle valve 3 which is dimensioned to open at a pressure of 350 atmospheres is acted on during the charging of the accumulator by a "packing" pressure which is equivalent to a pressure of 100 atmospheres acting on the top of the plunger 4, the fuel needle valve 3 being thus maintained firmly on its seat and any possibility of dribbling of fuel into the combustion chamber avoided. Further, while injection in the case of full load takes place at an initial pressure of 500 atmospheres, the piping of the apparatus has under no circumstances to withstand a pressure greater than 250 atmospheres and may therefore be dimensioned accordingly.

It will be readily appreciated that with an injection device according to this invention the quantity of fuel injected can be regulated by the simple operation of setting the supplementary pressure, i. e. the hand wheel 20 and that the necessity for elaborate regulating means such, for example, as fuel pumps with variable delivery strokes is avoided.

Referring to Figure 2 the fuel pump 23 supplies fuel under pressure through the pressure tank 24 and pressure valve 22 to the delivery pipes 13 each of which is connected to an injection portion 1 and control portion 2 as described above.

As will be readily seen, even for a multi-cylinder engine, a fuel injection device according to this invention requires only one fuel pump and one pressure-regulating device and further, as the control portions 2 have not to take part in any of the working i. e. compressing movements, the cams 15 can be made small and may be arranged to act symmetrically with respect to the dead centre position of the engine piston for either direction of rotation. A fuel injection device according to this invention is therefore particularly suitable for internal combustion engines of the reversible type, as the point of injection remains unaltered whatever the direction of rotation and consequently no form of reversing device need be provided for the fuel injection gear.

I claim:

1. In a fuel injection device for internal combustion engines, the combination with a fuel injection valve and a chamber for accumulating the fuel under pressure, of external means including a source of pressure, for suddenly increasing the pressure on the

fuel in the accumulating chamber by applying additional pressure to the movable wall of the accumulating chamber and lifting the injector valve to effect airless injection of the fuel, and means interposed between the accumulator and the source of pressure for causing the same source of pressure alternately to deliver fuel to the accumulator and to force out and inject the fuel stored therein.

2. In a fuel injection device for internal combustion engines, including a source of fuel and an accumulator, the combination with a fuel-injection valve and a chamber for accumulating fuel under pressure, of external means including a source of pressure for suddenly increasing the pressure on the fuel in the accumulating chamber by applying additional pressure to the movable wall of the accumulating chamber and lifting the injector valve to effect airless injection of the fuel, and means interposed between the accumulator and the source of fuel and including a common fuel pump for delivering some of the fuel to the accumulating chamber in readiness for the next injection and some fuel to apply additional pressure to the accumulator to effect the opening of the fuel-injector valve and the consequent release of the stored fuel, said means cooperating with said pump to cause the pump alternately to deliver fuel to the accumulator and to force out and inject the fuel stored therein.

3. In a fuel injection device, the combination of an injector responsive to a predetermined fluid pressure, an accumulator in communication therewith and comprising a chamber for the storage of a charge of fluid fuel, an element displaceable within the chamber, yielding means for applying pressure to one surface of the element, means for introducing fuel under pressure at the opposite surface of the element to displace the element in a direction in opposition to the yielding means until an equalization of pressures has occurred, means for subsequently applying additional pressure at the first named surface of the element to displace the fuel under sufficient pressure to operate the injector.

4. In a fuel injection device, the combination of an injector responsive to a predetermined fluid pressure, an accumulator communicating therewith and comprising a chamber for the storage of a charge of fluid fuel, a movable partition closing a portion of the chamber, yieldable means for applying pressure to one side of the partition, means for introducing fuel under pressure on the other side of the partition to displace

the partition in a direction in opposition to the yielding means, means for subsequently increasing the pressure on the first named side of the partition to displace the fuel under sufficient pressure to operate the injector.

5. In a fuel injection device, the combination of an injector responsive to a predetermined fluid pressure, an accumulator member in communication therewith and comprising a chamber for the storage of a charge of fluid fuel, a closure separating the accumulator into two compartments, said closure being movable in the accumulator member, means for introducing fuel under pressure into one of the compartments, yieldable means in the other compartment acting against the closure in a counter direction to the fluid in the first compartment, said closure being free to move between the two chambers to permit equalization of pressures against opposite faces of the closure, and means to apply additional pressure to the second-mentioned compartment to cause movement of the closure in the accumulator structure to cause operation of the injector.

6. In a fuel injection device, the combination of an injector responsive to a predetermined fluid pressure, an accumulator in communication therewith and comprising a chamber having a movable wall, a source of fuel supply, means for introducing fuel from said source of supply into the chamber under pressure on one side of the wall, resilient means acting on the other side of the wall and maintaining equalization of pressures on opposite sides of the wall, and means for connecting said source of fuel supply with the last-named side of the wall, whereby the pressure differential on opposite sides of the wall causes movement of the wall with a consequent displacement of the fuel through the injector.

7. In a fuel injection device, the combination of an injector responsive to a predetermined fluid pressure, an accumulator in communication therewith and comprising a chamber having a movable wall, a source of fuel supply, means for introducing a charge of fuel from said source of supply into said chamber under pressure on one side of the wall, resilient means acting on the other side of the wall for maintaining equalization of pressure on opposite sides of the wall, means to regulate the pressure of the introduced fuel, and means for connecting said source of fuel supply with the last named side of the wall whereby the pressure differential on opposite sides of the wall causes movement of the wall with a consequent displacement of fuel through the injector.

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