FUEL INJECTION AND DISTRIBUTION MEANS

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My invention relates to fuel injection means for internal combustion engines and particularly to a novel distribution and injection means wherefore it is called fuel injection and distribution means.

The principal objects of my invention are to provide a means for the distribution and injection of fuel to internal combustion engine cylinders which means shall be simple in construction, simple in operation, and durable and efficient in operation. An object is to provide such a means which shall be effective as an automatic means at each cylinder so that impairment of the functioning of any cylinder will not affect the others and so that the distribution and injection is dependent on the operation of the individual cylinder but which shall at the same time provide an effective and simple means for such purpose for engines of many cylinders.

The principal devices and combinations of devices comprising my invention are as hereinafter described and as defined in the claims. In the accompanying drawing which illustrates my invention in several different forms like characters refer to like parts throughout the several views.

Referring to the drawing:

Figure 1 is a view in vertical section through the longitudinal axis of a cylinder of an internal combustion engine embodying my invention, there being shown in this view only so much of a cylinder and its reciprocating piston therein as is necessary to show the particular invention, it being contemplated that the cylinder and piston are related to a crank and crank shaft and other cylinders therewith connected.

Referring again to the Figure 1, the numeral 1 indicates a cylinder and the numeral 2 a cooperating piston of an engine embodying my device, the piston being reciprocable in the cylinder and cooperating with a cooperating crank shaft 30 and connecting rod 3. In the device as illustrated in Figure 1 there are shown two cylinders, it being contemplated that any number of cylinders from one to any number may be used.

Each cylinder has attached to its side by bolts or otherwise a so-called valve body 4 which has formed therein a fuel chamber 5 and a valve piston chamber 6. The fuel chamber 5 has connection by means of a small injection port 7 with a passageway 8 formed as a connecting passage between the combustion space 9 of the cylinder and an auxiliary combustion space 10. The combustion spaces 9 and 10 are thus connected with each other but have no other communication, except that as the related piston 2 reciprocates it will at the lowermost period of its reciprocation uncover inlet port 11 and exhaust port 12 in the side walls of the cylinder 1 whereby the cylinder 1 may have exhaust and air charging from low pressure air supply 13 in the manner in which two cycle engines are usually exhausted and charged with air for combustion.

The valve piston chamber 6 of the valve body 4 has reciprocable within it through a limited range which may be not more than one eighth or one quarter of an inch or thereabouts, a small valve piston 14. The valve piston 14 has attached to or formed integrally with it a fuel needle valve 15 which latter extends through wall 16 and its packing member 17 to fuel chamber 5 where its point 18 is normally seated against the seat of the port 7 but from which it may be withdrawn whenever the valve piston 14 is moved downwardly say about one eighth or one quarter of an inch. The valve piston 14 with its needle valve 15 is normally thrust upwardly yieldably by the spring 19 acting between the valve piston 14 and the apered wall 20.

The valve piston 14 has a close fit in the valve piston chamber or cylinder 6 but is easily reciprocable therein. The combustion space 9 and auxiliary combustion space 10 as they are connected by part 8 form virtually one combustion space and when the piston 2 is at the upper extreme of its reciprocation there is no communication with that combustion space except that through aperture 17 liquid fuel is sprayed into the combustion space and that gases or air under pressure in that combustion space may freely either way flow through conduit 25 into or out of the division or part of valve piston chamber 6 which is above valve piston 14, which division is permanently in communication with combustion space 9 by means of the conduit 25. The pressure of air or gas in this division of valve piston chamber 6 on the upper side of valve piston 14 is thus always the same as the pressure in combustion space 9, be it high or low.

In the lower part of the valve body 4 there is a chamber 21 which is in free communication with the division or part of valve piston chamber 6 which is below valve piston 14 by means of aperture 22 and this chamber 21 is by means of a control port or conduit 24 passing from chamber 21 to the interior wall of cylinder 1 adapted to be placed in communication with the interior of cylinder 1 above piston 2 whenever piston 2 in its cycle of operation descends sufficiently to uncover this control port 24. Conversely this communication of the interior of cylinder 1, with
chamber 21 and thus with the lower division of valve piston chamber 8 is closed whenever piston 2 has in its cycle risen sufficiently to close or cover the control port 24. The control port 24 at its opening into the cylinder 1 may be placed at any height or location which is in practice determined to be the most practicable location, and this location should be such that closure of control port 24 by piston 2 and thus opening of fuel aperture 7 is procured during the period which constitutes sixty in some constructions, seventy, ninety or even as much as 120 degrees in other constructions of the cycle of operation during which the related piston 2 is passing through its uppermost reciprocation, that is the period comprising in each cycle of operation the last part of the compression stroke and the earliest part of the working stroke. The length of the period is dependent on the construction adopted, the use of the engine and the nature of the combustion cycle, that is, whether the engine is constructed to operate on a compression ignition or so-called Diesel cycle or upon another cycle and if some other means of or form of ignition. In any event the movement of valve piston 14 downwardly and the opening of aperture 7 occurs when ports 11—12 are closed, and, during the alternate periods, that is during the remainder of the cycle of operation of piston 2, the valve piston 14 is raised by spring 19 and the aperture 7 closed by point 18 of needle valve 15 so that no injection of fuel is in such alternate periods permitted. The downward movement of valve piston 14 to open aperture 7 is at approximately, the moment of closure of control port 24 in the upward stroke of piston 2, caused by the increase of pressure above valve piston 14, as pressure of compression increases in the combustion space 9—10, since the pressure on the lower side of valve piston does not in such instance but remains lower until the control port 24 is again opened by descent of piston 2, the pressures then becoming equalized.

The fuel chamber 5 receives fuel under pressure of say one thousand or more pounds or thereabouts from the common fuel pressure supply conduit 23 which is supplied by fuel pump means 26. It is contemplated that the fuel pump means will be so constructed that a steady supply of fuel at the high pressure under conditions of maximum demand is available at all times of operation, the delivery to the common conduit 39 being controllable by hand valve 27. The construction of fuel pump 26 may be of any form which will deliver fuel up to the maximum quantity required per cycle, but so that under the control of hand valve 27 its delivery may be safely throttled thereby. This fuel pump 26 is shown diagrammatically only as a pump unit operable by eccentric rods 28 and eccentrics 29 on crank shaft 30. It is understood that the pistons 2 will be reciprocatable by the connecting rods and crank shaft in the usual manner or any manner and that the engine is started in its cycle by any means. When so started the cylinders will be severally exhausted and charged with air for combustion and the air charges will be compressed in each cylinder cyclically to say five or six hundred pounds. Electric ignition may be used instead of this high pressure ignition. As each piston rises into the 45 degrees of the upward reciprocation which is the period of fuel injection, the piston 2 will prior thereto have compressed the air in the cylinder 1 to say two, three or four hundred pounds, but this pressure is equally effective on either side of the valve piston 14 related. But as soon as the piston 2 covers the control port 24 the combustion chamber 9 will be cut off from the lower side of the valve piston chamber 8 related and thereupon the further upward movement of the piston 2 will further compress air in the combustion chamber 9 which will be effective in the space 6 above the valve piston 14 but will not be effective on the lower side of the valve piston 14 so that during this period the pressure differential may be as much as two or three hundred pounds, the higher pressure being on the upper side of the valve piston 14 and the lower pressure on the lower side of the valve piston 14 so that therefore the valve piston 14 with the needle valve 15 is moved downwardly and the port 7 opened and the fuel is then permitted to inject from the fuel chamber 5 to the passageway 8. The fuel as injected will ignition with and mix with the air in the passageway 8 and will be carried back and forth from the space 9 to space 10 as the pressure of air and type of fuel are such and in that passageway 8 thereby producing rapid internitewriture. The fuel needle valve 15 is held downwardly through the period when the control port 24 is covered which may be the ninety degrees of the upper part of the cycle or slightly less depending on the construction and the contemplated speed. The port 7 should be of such small size that an injection of fuel at the high pressure may occur through a considerable period at the high pressure without too excessive quantity of injection. The fuel pumps should be so designed as to prevent or limit the supply to the maximum quantity of fuel utilisable in the air charge.

While I have shown particular devices and combinations of devices in the illustration of my invention I contemplate that other detailed devices and combinations of devices may be used in the realization of my invention without departing from the spirit and contemplation thereof.

What I claim is:
1. An engine cylinder and cooperating reciprocable piston, a supplementary pressure chamber and a pressure responsive actuator therein forming two divisions in the supplementary pressure chamber one division of the supplementary pressure chamber having permanent connection with the combustion chamber of the engine cylinder and the other division having connection with the engine cylinder this connection being closable by compression strokes of the piston and uncoverable on working strokes of the piston, a fuel supplying conduit a port therefrom to the combustion chamber and valve means operable by the pressure responsive actuator whereby fuel is admitted to the engine cylinder on movement of the pressure responsive actuator induced by the differential of pressure on its opposite sides on increase of the combustion chamber in the period of closure of the connection.

2. An engine cylinder and cooperating reciprocable piston, a supplementary pressure chamber and a pressure responsive actuator therein forming two divisions in the supplementary pressure chamber, one division of the supplementary pressure chamber having permanent connection with the combustion chamber of the engine cylinder and the other division having a connection with the engine cylinder this connection being closable by compression strokes of the piston and
uncoverable on working strokes of the piston, a conduit supplying fuel under pressure, a port from the conduit to the combustion chamber and a valve controlling said port operable by the pressure responsive actuator to admit fuel to the combustion chamber on movement of the pressure responsive actuator induced on increase of pressure in the combustion chamber in the period of closure of the connection.

3. A multi-cylinder engine having a plurality of engine cylinders and cooperating pistons, a source of fuel supply and a distributing conduit receiving fuel therefrom, each engine cylinder having a related supplementary pressure chamber and pressure responsive actuator therein forming two divisions in the supplementary pressure chamber one division of the supplementary pressure chamber having permanent connection with the combustion chamber of the related engine cylinder and the other division having connection with the related engine cylinder this connection being closable by compression strokes of the related piston and uncoverable on working strokes of the said piston, each pressure responsive actuator having a related fuel valve operable thereby to procure injection of fuel from the distributing conduit to the related engine cylinder of the multi-cylinder engine on increase of pressure in the combustion chamber in the period of closure of the connection.

4. A multi-cylinder engine having a plurality of engine cylinders and cooperating pistons, a source of fuel supply and a distributing conduit receiving fuel therefrom, each engine cylinder having a related supplementary pressure chamber and pressure responsive actuator therein forming two divisions in the supplementary pressure chamber one division of the supplementary pressure chamber having permanent connection with the combustion chamber of the related engine cylinder and the other division having connection with the related engine cylinder this connection being closable by compression strokes of the related piston and uncoverable on working strokes of the said piston, each pressure responsive actuator having a means operable thereby to admit fuel from the distributing conduit to an engine cylinder of the multi-cylinder engine on increase of pressure in the combustion chamber in the period of closure of the connection.

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