This invention relates to fuel injection devices for internal combustion engines of the kind provided with an accumulator for the fuel charge and with a needle or like valve which is held in its closed position by the pressure of the fuel until injection takes place when it is opened by the fuel itself.

The object of the invention is to provide an improved fuel injection device of the above general type.

According to this invention the pressure of the fuel not only normally holds the fuel injection valve in its closed position but before injection takes place so loads or compresses a spring by means of an intermediate or control piston that the fuel injection valve is automatically closed directly injection is completed. Preferably the needle or like fuel injection valve is raised by the pressure of fuel when the injection period starts until it is in contact with the control piston whereupon as soon as the pressure below the needle valve falls below a predetermined minimum the injection valve is closed by means of the spring. The control piston may be coaxial with the needle or like injection valve or may be disposed laterally of the fuel injection valve connected by a lever or like mechanism therewith. The upper end of the fuel injection valve which is exposed to the pressure of the fuel presents a larger area than the lower conical end thereof and where the control and fuel injection valves are coaxial their adjacent ends may be housed in a single control chamber.

Three constructions according to this invention are diagrammatically illustrated by way of example in the accompanying drawings, in which:

Figure 1 is a sectional elevation of a fuel injection device according to this invention.

Figure 2 is a modified construction with the control member arranged laterally of the fuel injection valve, and

Figure 3 is a further modification.

In the construction illustrated in Figure 1 the injection device comprises a body or casing 1 provided with a fuel injection valve 2 acted upon by means of a spring 4 through a control piston 3. The spring surrounds the stem 6 of a flanged member 5 separated from a lower flanged washer 7 leaving a gap or clearance 8 which determines the lift of the needle valve 2. The initial strength of the spring 4 can be adjusted.

In the lower end of the valve casing is provided a fuel delivery chamber 8 which terminates in a seating 28 for the conical end 9 of the fuel valve and communicates by a passage 10 with orifices 11 through which the fuel is injected into the cylinder of the internal combustion engine. The upper end of the fuel valve 2 extends into and closes the base of a control chamber 12 into the upper end of which extends the lower end of the control piston 3. The fuel delivery chamber 8 is connected by a pipe 13 to a pressure accumulator 14 which communicates by means of a non-return valve 15 with the fuel pipe 16 leading to the control chamber 12. Fuel is drawn by a pump 17 from the suction pipe 18 and delivered to the points of consumption by a piston 19 which is driven by an eccentric 20 through a roller 21. The amount of fuel delivered by the pump is determined by an adjustable suction valve 22 the opening or closing of which is varied in accordance with the cut-off or charge required under the action of an engine governor (not shown) operating on a push rod 23. Fuel injection takes place directly a relief valve 29 is raised thus opening the pipe 32 and permitting the fuel from the control chamber 12 to escape through the pipe 16 into the delivery pipe 32. The fulcrum 33 of the lever 31 is adjustable so as to enable the moment at which injection starts to be altered.

The operation of the fuel injection device is as follows:

The eccentric 20 constantly rotates in the direction of the arrow 26 and through the roller 21 reciprocates the piston 19 of the fuel pump 17. At the start of each delivery stroke of the piston 19 first a proportion of the fuel (according to the charge or cut-off) drawn into the delivery chamber 27 during the preceding suction stroke through the pipe 18 will be returned to the suction pipe through the valve 22 controlled by the governor. During
this operation the relief valve 29 is closed but as soon as the suction valves 22 closes fuel is delivered through the pipe 16 to the control chamber 12 and pressure accumulator 14. In the control chamber 12, owing to the high pressure of the fuel therein, the fuel injection valve 2 will be firmly held against its seat and the control piston 3 will be raised against the pressure of the spring 4, in this way the fuel valve being locked against its seat solely by the fuel pressure.

Any fuel which passes the non-return valve 15 and so enters the accumulator 14 will be stored in the latter and as the pressure fuel in the control chamber 12 acts on a greater area than the pressure of the fuel in the charge chamber 8, the fuel needle valve will be firmly pressed against its seat even after the control piston has been raised and thus ceases directly to hold the needle valve in its closed position.

The fuel delivered by the pump 17 during the first part of its delivery stroke thus ensures the locking of the fuel needle valve against its seat, the charging of the fuel accumulator and the raising of the control piston 3. During the working stroke of the pump piston 19 the push rod 30 will be simultaneously raised by the roller 21 thus lifting the relief valve on making contact therewith. Directly the relief valve opens delivery of fuel by the pump will suddenly stop and the pressure will instantly fall in the pump delivery chamber 27 and in the control chamber 12 which communicates with the pump through the pipe 16. As a result the fuel needle valve 2 will be shot upwards by the action of the fuel pressure in the accumulator 14 and in the delivery chamber 8 so that the fuel stored under pressure in the accumulator will be injected through the orifices 11 into the working chamber of the internal combustion engine.

To regulate the movement of the fuel valve 2 and control member 3 a throttle 34 is provided in the pipe 16 which establishes communication between the pump and the control chamber. Fuel stored under pressure in the accumulator cannot return to the pump delivery chamber 27 owing to the valve 15 and owing to the fall of pressure in the chamber 12, the control piston 13 will be returned to its lower position by the action of the spring 4 thus closing the fuel needle valve before the pressure in the charge chamber 8 drops below a predetermined minimum. The suction stroke of the fuel pump takes place in the well known manner, the quantity of fuel injected thus being determined by the moment at which the suction valve 22 opens or closes. By moving the fulcrum 35 of the lever 31 the opening of the relief valve can be advanced or retarded so as to regulate the moment at which injection begins.

The injection device illustrated in Figure 2 differs from that last described in that the control piston instead of being arranged coaxially with the fuel injection valve is disposed laterally thereof. In this case the control piston 3 acts on a lever 40 which under the action of a spring 4 compresses the fuel valve against its seat at the end of the injection period. As before the control member 3 is provided with an additional controlling chamber 36 into which one end of the control piston extends. As before a spring 4 is provided which only exerts pressure on the fuel valve 2 when pressure on the pipe 13 falls and the control piston 3 therefore is in its lowest position. When the pipe 16 contains fuel under pressure the needle valve is locked by the pressure of the fuel against its seat.

The injection device illustrated in Figure 2 has two separate fuel injection valves and is particularly suited for the lower end of the cylinders of double-acting internal combustion engines. The two separate valves have a common pressure accumulator 14, a single check or non-return valve 15 and two relief valves 29 which by the provision of check valves 33 can effect the opening of the respective fuel injection valves independently of one another, i.e. in succession. In this case a suction valve is connected to the pump chamber 27 and regulated in the same way as in the previous constructions, the suction valves, which are controlled by a governor as in Figure 1, being omitted for the sake of clearness.

I claim:

1. A fuel injection device comprising a valve, a primary piston operating said valve, a resiliently pressed control piston operable to move the primary piston to close the valve, means for supplying a charge of fuel under pressure against the primary piston to cause it to release the primary piston, against the primary piston to cause it to retain the valve in a closed position and against a smaller area of the primary piston and the valve to urge the primary piston to open the valve; means for releasing the pressure against the control piston and against the larger area of the primary piston so that the primary piston may move under the influence of pressure against the smaller area to open the valve despite the action of the control piston and inject the charge of fuel under pressure.

2. A fuel injection device according to claim 1 in which the control piston is resiliently pressed by a spring and is limited in its movement by an adjustable stop.

3. A fuel injection device as described in claim 1 in which the control piston moves the primary piston by direct contact.

4. A fuel injection device as described in claim 1 in which the control piston moves the primary piston through a lever arm.
5. A fuel injection device as described in claim 1 in which a compartment or reservoir is provided for storing the charge of fuel which presses against the smaller area of the piston and the valve.

6. A fuel injection device as described in claim 1 in which the fuel under pressure is supplied by a pump having a reciprocating piston, an inlet valve controlling the amount of fuel supplied at each injection and an exhaust valve controlling the time of release of the pressure upon the control piston and the larger area of the primary piston.

7. A fuel injection device as described in claim 1 in which the fuel under pressure is supplied by a pump having a reciprocating piston, an inlet valve controlling the amount of fuel supplied at each injection and an exhaust valve controlling the time of release of the pressure upon the control piston and the larger area of the primary piston and in which a check valve is provided to prevent the release of the pressure on the smaller area of the primary piston and the valve when the pressure is released on the control piston and the larger area of the primary piston.

In testimony whereof I have affixed my signature.

HANS STEINER.