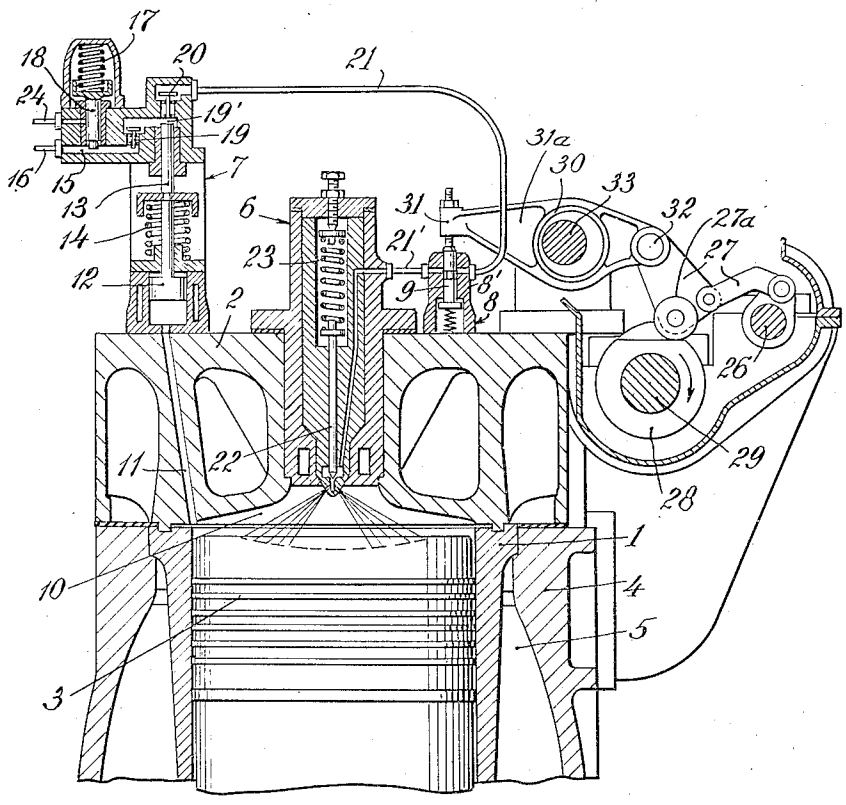
Nov. 9, 1943. H. LIEBERHERR 2,333,944

FUEL INJECTION DEVICE FOR INTERNAL COMBUSTION ENGINES

Filed Aug. 18, 1941 2 Sheets-Sheet 1

Fig. 1,



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Fig. 2,

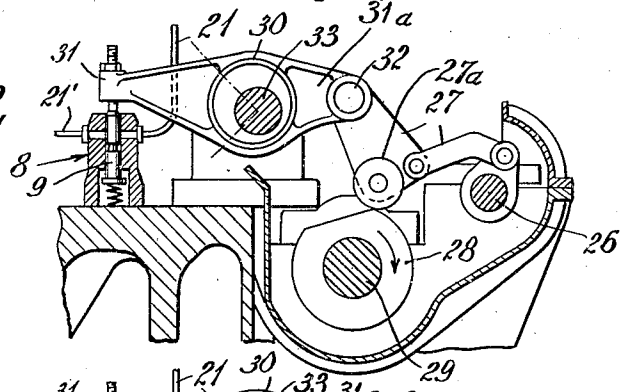


Fig. 3,

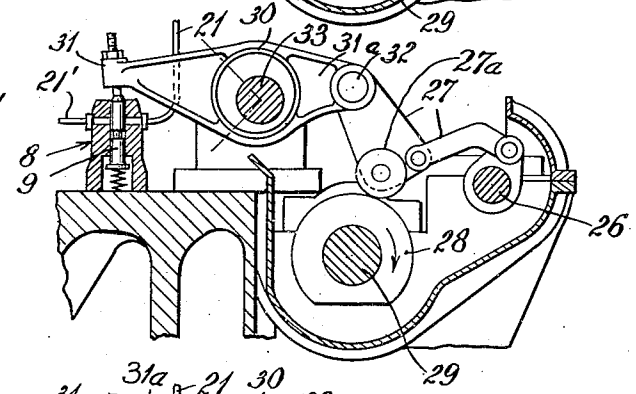


Fig. 4,

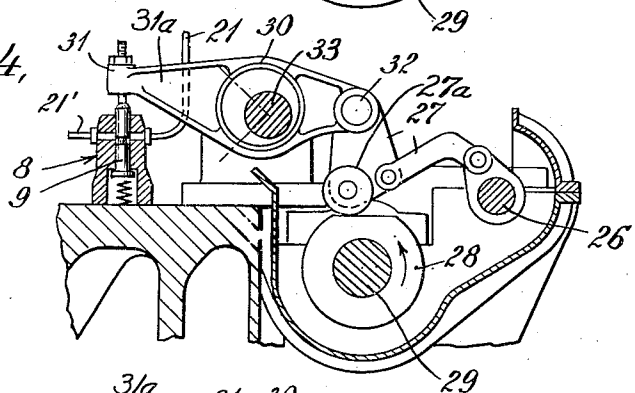
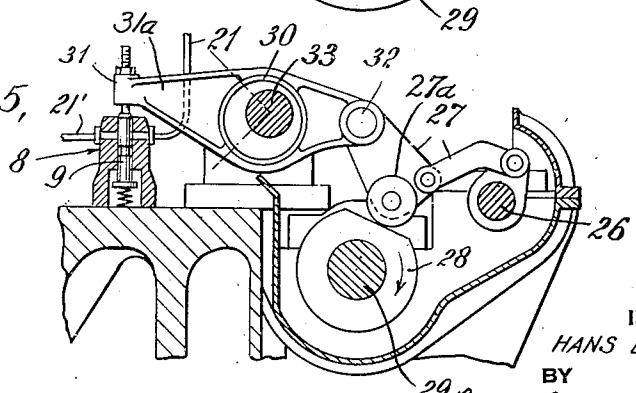


Fig. 5,



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FUEL INJECTION DEVICE FOR INTERNAL COMBUSTION ENGINES

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Application August 18, 1941, Serial No. 407,310
In Switzerland August 17, 1940

2 Claims. (Cl. 123—139)

(Granted under the provisions of sec. 14, act of March 2, 1927; 357 O. G. 5)

This invention relates to a fuel injection device for internal combustion engines having a fuel injection pump operated by the gas pressure in the working cylinder.

It is known how to effect the injection of fuel in internal combustion engines by a stepped piston which on the one hand is subject to the gas pressure in the interior of the cylinder and on the other hand delivers the fuel to a spring-loaded valve. Since the injection with such a device begins at the moment in which the fuel pressure is equal to the opening pressure of the fuel valve, but the fuel pressure increases with increasing load because the gas pressures in the cylinder then increase, injection at high load takes place considerably sooner than at low load, a condition which is not desirable because of the acceleration in the rise of pressure in the cylinder.

This defect has been got over by increasing the spring loading of the valve in accordance with the increasing load on the engine. But this gave rise to the new drawback that the pressure under which the first drops of fuel enter the cylinder changes with the load, and consequently the first initial combustion which is of the greatest importance for the later combustion, is necessarily impaired. In addition to that, regulation of the fuel valve springs in accordance with the load on the engine must be provided.

An endeavour has been made to get over this drawback by mechanical control of the fuel valve needle. In this way it is possible to fix the moment of fuel injection exactly, but not to control the starting of the combustion, since there is no direct relation between the moment of injection and the pressure in the fuel pipe. In addition to that, the moment of termination of the injection is fixed by such an arrangement. It is consequently necessary here also to control the needle in accordance with the load.

The invention comprises a spring-loaded automatic fuel valve, and the fuel pump is connected to the fuel valve by a control member which determines the beginning of the injection. With this arrangement, at any load, and also with the engine running in one direction or the other, the injection is started at the suitable moment and stopped again at the time when the fuel pressure has fallen below the closing pressure of the valve. Consequently there is no annoying late dribbling from the valve. In addition to that, the diameter of the gas piston is such that the pressure caused in the fuel piping is considerably greater than the opening pressure of the fuel valve, even at lowest load. Perfect starting of the combustion is consequently ensured under all conditions of working.

By gradually opening the control member, the rate at which combustion starts can be determined. The drive of the control member can be arranged in such a way that it cannot possibly remain fixed in the open position. By employing a control cam or control eccentric, symmetrically designed and set with the axis of symmetry at the dead center of the working piston, and by changing the point of injection by means of a swinging roller, the engine may be controlled with one and the same control cam or control eccentric when running in either direction.

In the fuel injection device an accumulating piston may also be provided; the fuel supplied by a separate pump is delivered to it at any desired moment during the stroke, and it transfers the fuel into the pneumatic fuel pump when the pressure in the cylinder falls. The accumulating space may be provided with an overflow controlled by the accumulating piston, and this overflow may be of such dimensions that it is not able to take any more fuel than the filling required for one single injection at overload.

In the accompanying drawings:

Fig. 1 is a sectional side view of a fuel injection device embodying the invention, and

Figs. 2 to 5 illustrate various positions of the device of Fig. 1.

In the internal combustion cylinder 1, closed by the cylinder cover 2, a piston 3 is shown in upper dead center. The cylinder 1 is inserted in a jacket 4 and surrounded by a cooling-medium circulating through the space 5. The cylinder cover 2 carries the spring-loaded automatically-acting fuel injection valve 6, the pneumatically working fuel injection pump 7, and the control member 8 having a casing 8' and the piston valve 9.

The gases in the combustion space 10 pass through the passage 11 into the fuel pump 7 and act on the gas piston 12 and pump piston 13. A spring 14 is provided between the gas piston 12 and pump piston 13. Using a spring 14 acting on the piston 13 in the same direction as the gas pressure, has the advantage that the fuel pressure changes much less during the injection than if the fuel pump piston was only under the influence of the gas pressure. In fact, the gas pressure is least when the piston 12 is in its lowest position, and then, on the other hand, the tension of spring 14 is the greatest. The contrary is the case when piston 13 is in its highest position.

An accumulating space 15 is connected with the fuel pump 7 and it receives the fuel through a separate fuel pump not shown in the drawings, the fuel being passed into the accumulating space 15 through the pipe 16 at any desired moment during a revolution of the engine. When the pressure under the gas piston 12 has fallen sufficiently low, a spring 17 forces the accumulating piston 18 downwards. The fuel flows through the valve 19 into the space 19'.

When the pump 7 is making a delivery stroke, the fuel enclosed in the delivery chamber of the pump and in the pipe 21 is at first compressed. When the control member 8 is opened, the delivery valve 20 is now fully opened, and the fuel is injected into the combustion space through the pipes 21, 21' and the injection valve 6. The injection valve 6 has a needle 22 which is loaded by a spring 23.

In the accumulating space 15 an overflow 24 is provided which is of such dimensions that it does not take more than the fuel required for one single injection at overload and it allows the superfluous fuel to escape. In this way dangerous pressures in the fuel pipes are prevented.

The piston valve 9 of the control member 8 is operated from a control shaft 26 through a swinging link 27 which allows the moment of injection to be changed in accordance with the load. The shaft 26 may be set by any suitable control means such as a manually operated lever or a servomotor (not shown). The swinging link 27 has a roller 27*a* engaging cam 28 fitted on the camshaft 29. The eccentric 30 fixed to the shaft 33 turns in the shaft 31*a* which is connected at one end 31 with the piston valve 9 and at the other end 32 with the swinging link 27. The pivot on which lever 31*a* rocks may be adjusted by the eccentric 30. The eccentric shaft 33 for instance may be coupled to the starting device in such a way that the control piston 9 is pressed down so far during the starting period that no fuel can flow to the fuel valve 6.

The apparatus operates as follows: The fuel required for one injection is measured by a separate fuel pump not shown in the drawings and delivered through the pipe 16 into the accumulating space 15 at any desired moment during a revolution of the engine. The accumulating piston 18 is loaded by a spring 17. When the pressure below the gas piston 12 has fallen sufficiently low, the spring 14 causes the fuel to be transferred into the injection pump. The piston 13 is connected to the gas piston 12, which is always subjected to the gas pressure in the combustion space 10 of the engine through the passage 11. The piston 12 is continually pressed upwards by the spring 14 independent of the pressure in the cylinder.

Under the influence of the gas pressure in the cylinder, the fuel contained in the pump 7 and pipe 21 is compressed. At a suitable moment, generally shortly before the piston reaches its upper dead center, the piston valve 9 opens the outlet to the fuel valve. The swinging link 27 and its roller 27*a* are raised by the cam 28, the piston valve 9 moves downwards, and the connection between pipe 21 and piston valve 9 is interrupted.

If for any reason piston valve 9 should stick, the fuel will collect in the accumulating space 15 and keep raising the piston 18 until the overflow 24 opens. Then the accumulating piston 18 at the same time assumes the functions of a safety valve. Under certain circumstances it may be advisable to control the downward movement of the accumulating piston 18 by means of a damper of the spring or liquid type.

The piston valve 9 may be opened gradually in order to control the rate at which combustion starts, the cam 28 for instance being designed as an eccentric, or the profile of the annular groove on the piston valve 9 being designed in such a way that at first only a small cross-sectional area is available for passage of the fuel. Also the control of the piston valve 9 is arranged in such a way that it cannot possibly remain stuck in the open position, since it is forced mechanically into the closed position. By using a control eccentric 28, symmetrically designed and set with the axis of symmetry at the dead center of the working piston, and by changing the point of injection by means of the swinging link 27, the running of the engine in either direction is controlled by means of one and the same control cam.

Fig. 2 shows the position of the piston valve 9 shortly before fuel can pass through at 40 from pipe 21 to fuel valve 6. In Fig. 3 the position of the piston valve 9 is shown when the piston 3 is in the neighborhood of its lower dead center.

Fig. 4 shows the position of the piston valve 9 when the engine is running backwards, the swinging link 27 being brought back into the position symmetrically to the control cam 28 in the ahead position by turning the regulating shaft 26. The piston valve 9 has already half uncovered the opening 40 which connects fuel valve 6 to pipe 21.

During the starting period (Fig. 5) the piston valve 9 can no longer uncover the opening 40 when the starting shaft 33 is rotated. This prevents any highly compressed starting air and fuel from entering the cylinder space 10 simultaneously and causing misfiring. The starting shaft 33 is again turned back as soon as the engine has been set in motion by the starting air.

I claim:

1. In a fuel injection device for internal combustion engines having a fuel injection pump with a gas piston operated by the gas pressure in the engine cylinder, the improvement which comprises a spring in engagement with the fuel pump piston which forces the piston in the same direction as the gas pressure acting on the gas piston, a spring-loaded automatic fuel valve for injecting liquid fuel into the engine, a duct for the passage of fuel from the injection pump to the automatic fuel valve, a control member controlling the passage of fuel in the duct, and means operated in timed relation with the engine pistons for causing the control member to determine the beginning of fuel injection.

2. A fuel injection device for internal combustion engines which comprises a fuel pump having a fuel pump piston connected to and driven in part by a gas piston driven by gas from the engine cylinder and a spring connected to the fuel pump piston which forces the fuel pump piston in the same direction as the gas piston, an injection valve for delivering liquid fuel into the engine cylinder, a duct connecting the fuel pump with the injection valve, a control valve in the duct controlling the admission of fuel to the injection valve, a lever arranged to operate the control valve, a cam driven by the engine, a swinging link interconnecting the lever with the cam, and an adjustment means attached to the swinging link whereby changes in the position of the swinging link may effect the timing of the movement of the control valve with respect to the engine piston.

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