

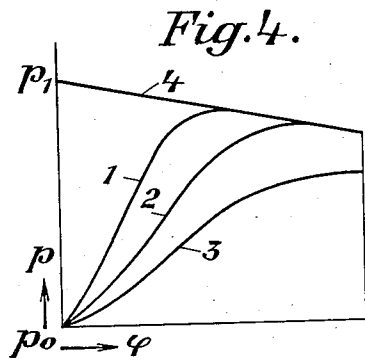
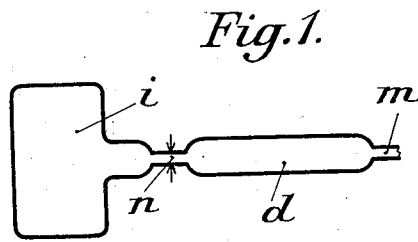
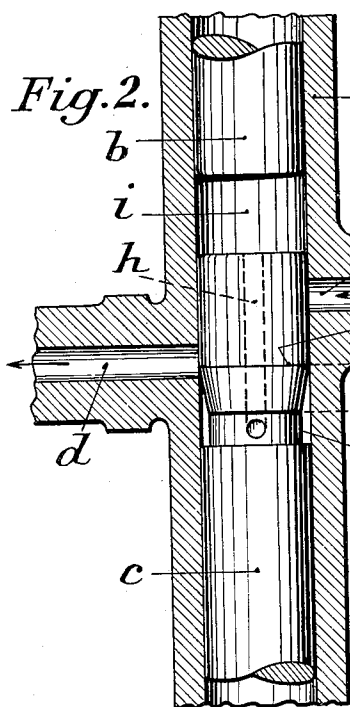
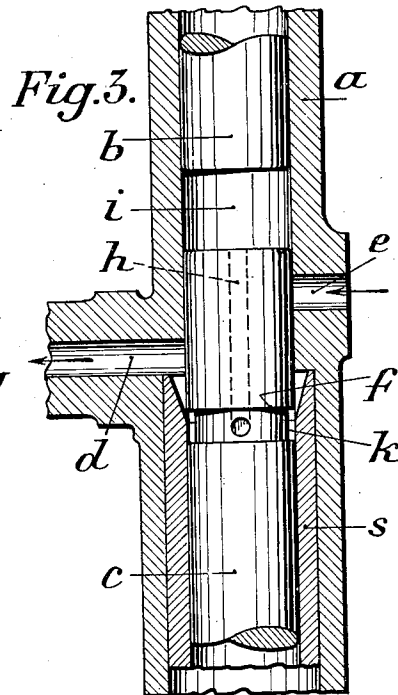
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FUEL INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

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FUEL INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

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3 Claims. (Cl. 103—154)

This invention relates to fuel injection pumps for airless or solid injection of fuel in internal combustion engines and of the kind in which an accumulator or storage piston cooperates with an injection pump plunger having an edge which controls a fuel discharge port.

In fuel injection pumps of this type when injection commences the sudden release of the fuel charge under pressure within the working chamber of the pump results in a drop in pressure in the pump chamber due mainly to the inertia of the accumulator piston and in part to that of the metallic or hydraulic spring whereby the accumulator piston is loaded. As a result the accumulator piston tends to oscillate and cause fluctuations to take place in the injection pressure. Such fluctuations, which may be unappreciable at the commencement of injection, tend to increase in magnitude as injection progresses until the fluctuations reach a maximum value at the end of injection when the mean injection pressure is a minimum. The fluctuations may then be sufficiently effective to cause a momentary vacuum in the fuel delivery system and thereby induce a back flow from the fuel injection device with the result that effective atomization and combustion of the fuel charge are impaired and irregular operation or "knocking" of the engine may occur. The object of the present invention is to overcome this difficulty.

To this end in accordance with the present invention the formation of the control edge of the plunger or the cooperating edge of the delivery port or both is such that the effective cross-section available for the flow of fuel from the working chamber of the pump to the point of injection does not increase abruptly from zero, but gradually as injection proceeds so that a sudden release of the fuel charge from the working chamber of the pump is prevented.

In the accompanying drawing,

Figure 1 indicates diagrammatically the manner in which the invention may be applied,

Figures 2 and 3 illustrate by way of example two constructions of fuel injection pump each embodying the invention, and

Figure 4 indicates by means of curves the variations of the fuel injection pressure which may be obtained in accordance with the invention.

In the diagram shown in Figure 1 the working space of the pump, that is to say the fuel space between the accumulator piston and the pump plunger, is indicated at *i*, the fuel sprayer or injection nozzle being indicated at *m* whilst the fuel delivery pipe through which fuel passes from

the pump to the injection nozzle is indicated at *d*.

In accordance with the present invention the cross-section of the passage *n* available for the flow of fuel from the working space *i* to the delivery pipe *d* does not increase abruptly from zero during the injection period but this increase is effected in such a manner that the value of the cross-section of the passage *n* gradually increases from zero to the maximum value. In this way variation of the injection pressure can be caused to take place in such a manner as to overcome the difficulties which would result from an abrupt release of the fuel from the moment when opening of the delivery port commences.

Figures 2 and 3 illustrate in more detail two constructions of fuel injection pump embodying the arrangement generally indicated in Figure 1. In the construction illustrated in Figure 2 a cylinder *a* contains an accumulator piston *b* and a pump plunger *c* which is reciprocated by means not shown. Formed in the wall of the cylinder *a* is an outlet or delivery port communicating with a delivery passage *d* and an inlet or suction port *e*, both the ports being controlled by the plunger *c* as hereinafter described. The plunger *c* is furnished with an annular recess bounded on one side by an edge *f* which acts as a control edge for opening and closing the delivery port leading to the passage *d*. One side of the recess in the plunger *c* is inclined from the control edge *f* towards the axis of the plunger *c* so as to form a conical or bevelled surface which extends over an axial distance *g* and whose diameter gradually decreases to the full depth of the recess as shown. A bore *h* in the plunger *c* communicates between the working chamber *i* of the pump and a cylindrical portion *k* of the recess in the plunger *c*.

When the plunger *c* moves on its suction stroke fuel is drawn through the inlet port *e* into the working chamber *i* and when the piston returns on its delivery stroke the port *e* is first closed whereupon pressure is applied to the charge in the working chamber *i*, the accumulator piston *b* being moved against its loading spring. As soon as the control edge *f* on the plunger *c* commences to pass over the delivery port communicating with the passage *d* injection of the fuel charge commences, the fuel flowing from the working chamber *i* through the bore *h* and recess in the plunger and thence to the delivery passage *d*. As injection proceeds however the cross-section of the passage available for the flow of fuel from the recess in the plunger *c* to the delivery passage *d* gradually increases in a direction normal to

the axis of the plunger since the diameter of the conical surface of the recess gradually decreases in the direction opposite to that in which the plunger is moving during its delivery stroke. The cross-section available for the flow of the fuel thus gradually increases from a zero value immediately prior to the commencement of opening of the delivery port to a maximum value equal to the depth of the cylindrical portion k of the recess when the delivery port is fully open.

The delivery port is thus not abruptly opened as would be the case if the side of the recess in the plunger c adjacent to the control edge f were normal to the plunger axis, but the fuel charge is gradually throttled in its passage from the recess to the delivery pipe d , this throttling effect gradually decreasing as injection proceeds. A sudden release of the fuel charge with consequent oscillation of the accumulator piston and fluctuation of pressure during delivery are in this way prevented, effective atomization and combustion of the fuel being ensured. By suitably forming the wall of the plunger recess adjacent to the control edge f the pressure variation at the delivery side of the injection nozzle or sprayer may be caused to take place as desired.

In the construction shown in Figure 3 the plunger c is furnished with a rectangular recess k and a liner s is provided in the pump cylinder a . That end of the liner s adjacent to the fuel delivery port communicating with the delivery passage d is cut away as shown so as to form a conical or tapered recess which communicates with the delivery pipe d . As in the construction described with reference to Figure 2, when the plunger c moves on its delivery stroke, the cross-sectional area of the annular passage available for the flow of fuel from the recess k to the delivery passage d gradually increases in the radial direction from zero to maximum opening.

Figure 4 illustrates by means of four curves plotted with injection pressures p as ordinates and angles of rotation ϕ as abscissæ variations of injection pressure which may be obtained in accordance with the invention. When the present invention is not applied so that the fuel de-

livery port is abruptly opened at the beginning of injection the delivery pressure will rise suddenly from the value p_0 to the value p_1 . The curves 1, 2 and 3 indicate the increase of pressure during injection with three different rates of increase of the effective cross-section available for the flow of fuel from the fuel pump to the injection device in accordance with the present invention. The curve 4 indicates the curve of pressure variation applied by the loading spring of the accumulator during the injection period.

It will be understood that the constructions above described are given by way of example only and that details may be modified. For example, the gradual increase of the cross-section available for the flow of fuel from the pump to the point of injection may be effected by inclination not only of the leading wall of the recess or the cooperating edge of the delivery port but by inclining both these parts.

I claim:

1. In a fuel-injection pump having a working chamber, a plunger, an accumulator piston and connection to a fuel-delivery port in the cylinder wall, said pump-plunger having an annular recess therein having means for establishing communication towards the end of the delivery stroke, between the working chamber of the pump and said fuel-delivery port, the control-side of said recess which first uncovers the delivery port during the delivery stroke, being bevelled off to form a conical surface.

2. In a fuel-injection pump having a working chamber, a pump plunger, and a fuel-delivery port in the cylinder wall, and having an accumulator piston in combination with said working chamber, said pump plunger having an annular recess therein for establishing communication between the chamber and the port towards the end of the delivery stroke, and an annular conical recess in the cylinder wall, said delivery port opening at the maximum diameter of the annular conical recess in the cylinder wall.

3. A fuel-injection pump as in claim 1, in which there is a liner in the pump cylinder and said conical recess is formed therein.

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