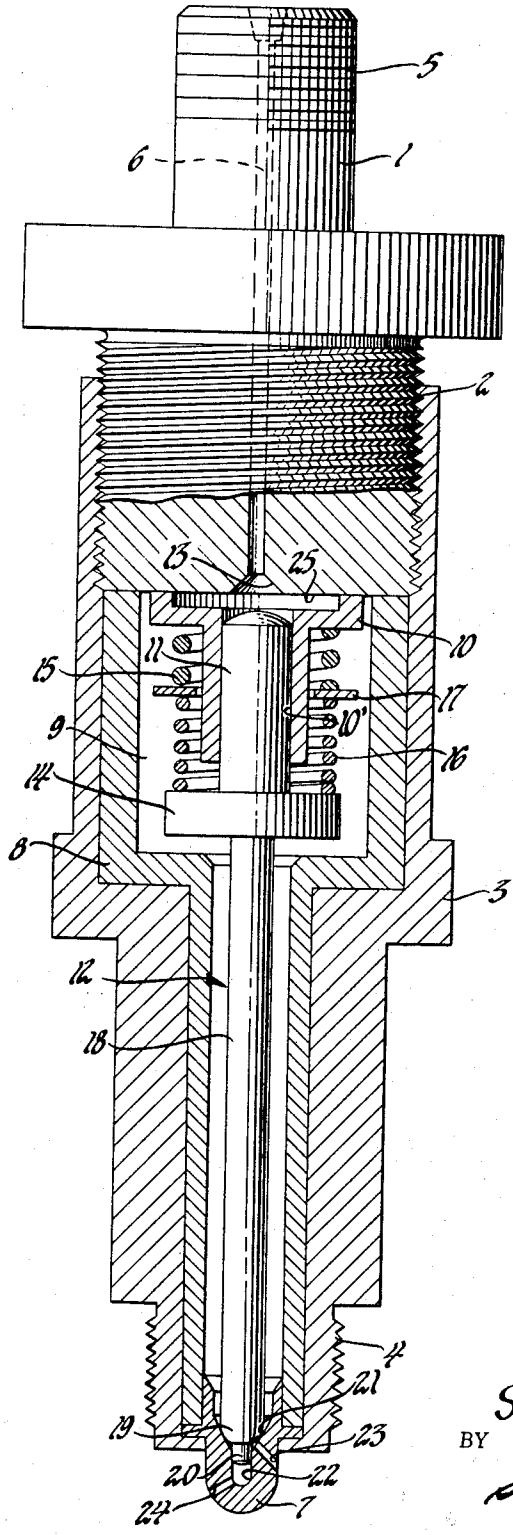
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DUAL STAGE ACCUMULATOR TYPE FUEL INJECTOR

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DUAL STAGE ACCUMULATOR TYPE FUEL INJECTOR

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ABSTRACT OF THE DISCLOSURE

A dual stage accumulator type fuel injector having a needle valve biased closed by two coil springs, one relatively weaker than the other, acting in tandem, the closing end of the valve having stepped-diameters sequentially controlling separate outlets for the fuel.

Background of the invention

This invention relates to apparatus for injecting hydraulic fluid such as liquid fuel into an internal combustion engine cylinder or the like, and particularly to such injectors of the so-called "accumulator type" in which the injection occurs in response to fuel pressure trapped in an accumulator chamber upon cutoff of the pump supply pressure. More specifically, the invention provides an improvement in such accumulator type injectors by employing a dual rate spring biased injection valve therein arranged to sequentially control separate outlets, thereby obtaining different rates of discharge and separate placement of primary or sequential primary and secondary injection fuel sprays dependent upon the quantity of the fuel charge delivered to the accumulator chamber of the injector.

Single stage or non-sequentially opening fuel injectors of the accumulator type are old as shown, for example, in U.S. Patent 2,985,378 to Falberg. Also, so-called "Pintaux type" injectors are known which employ a poppet valve whose opening action is of two-stage nature, i.e. effects first a primary injection upon initial opening movement followed by a secondary injection as the valve continues its opening stroke. British Patent 804,723 shows such an injector of the latter type.

Summary of the invention

Both accumulator and Pintaux type fuel injectors are conventionally supplied with fuel from positive displacement "jerk type" pumps comprising a plunger slidably driven in a close fitting bushing-like cylinder, generally on the order of that shown integrated as a unit with the injector in the aforementioned Falberg patent. While Pintaux injectors can be made to operate with jerk type pumps so as to obtain dual output rates and single injections per cycle or sequential primary and secondary injections per cycle from different holes or groups of holes by regulating the pump output they have the disadvantage, particularly at low engine speeds, that injection begins during the buildup of fuel pump delivery pressure. As a result, under low speed operating conditions the desired quantity of fuel to be injected at the precise time in the engine cycle is not as easily obtained and is not as well atomized as with the accumulator type injector. My invention accomplishes the flexibility in quantitative injection output and control of fuel placement possible with the Pintaux injector, while retaining the more precise injection timing and better atomization obtained with the accumulator type injector.

Brief description of the drawing

The drawing shows a dual stage accumulator type fuel injector, partly in longitudinal section and partly in elevation, employing the features of the invention.

Description of the preferred embodiment

Referring now in detail to the drawing, there is shown an adaptor 1 which is threadedly connected at 2 to a nozzle holder having the form of a hollow nut 3 whose lower end is threaded at 4 for insertion in a suitable opening in an engine cylinder (not shown). In use, the adaptor is connected at its upper end 5 to a suitable fuel injection pump of conventional "jerk" type (not shown) for delivery of fuel through the longitudinal fuel inlet passage 6. Seated against a shoulder in the lower end of the nut 4 and extending through an opening therein is a spray tip 7, and thrustably clamped between this spray tip and the adaptor is a liner-like member which forms an accumulator housing 8 for a fuel chamber 9. Within the enlarged upper portion of this chamber 9 is a check valve 10 in the form of a sleeve whose bore or central opening 10' therethrough slidably engages and supports the upper end 11 of a needle type injection valve designated generally by the numeral 12. The upper end of the check valve sleeve is enlarged and arranged to close against a seat 25 on the lower end of the adaptor surrounding the inlet 13 to the chamber 9. Below its upper end 11, the needle valve is provided with an enlargement or collar 14 which is normally spaced from the lower end of the check valve. Dual rate spring means, comprising a relatively high rate spring portion and a relatively low rate spring portion, is interposed in thrust between the collar 14 and the enlarged upper end of the check valve. As shown, the higher rate spring portion is in the form of an upper coil compression spring 15, and the lower rate spring portion is in the form of a lower coil compression spring 16 of smaller wire size. Separating the adjacent ends of the two coil springs is a washer-like plate 17 of sufficient internal diameter to loosely guide on the outer periphery of the check valve sleeve.

The injection valve 12 is formed below the collar 14 with an elongated stem 18 whose lower end is of stepped diameter to form a first sealing portion 19 and a smaller second sealing portion 20. The first sealing portion 19 normally engages a seat 21 formed in the spray tip 7, and the second sealing portion 20 normally extends into a close fitting recess 22 below the seat 21. Extending through the spray tip from the seat 21, below the sealing portion 19 in closed position, are arranged one or more outlets or spray orifices 23 (only one being shown). Likewise, extending through the spray tip from the recess 22, below the second sealing portion 20 of the injection valve, are one or more additional outlets or spray orifices 24.

During operation, upon introduction of fuel under sufficient pressure through the inlet passage 6 the check valve 10 is forced open against the springs 15 and 16 to charge the fuel chamber 9, while retaining the injection valve 12 in its closed position shown by reason of the fuel delivery pressure being also applied against the enlarged upper end 11 of this valve. Upon cutoff of the pump delivery pressure, as occurs in conventional jerk-type pumps at the end of the effective plunger stroke, the check valve 10 recloses under the action of the springs 15 and 16. The pressure of the fuel thus trapped in the chamber 9 thereupon acts against the differential area that exists between the enlarged upper end 11 and the smaller sealing portion 19 of the invention valve, to raise it away from its seat 21 to initially allow discharge of

or injection of fuel only through the outlet orifices **23** to the engine cylinder. Such lifting action of the injection valve compresses the low rate coil spring **16** and, providing the pressure trapped in the chamber **9** is sufficiently high, this spring **16** will compress to the extent that its convolutions will close up "solid" against each other. Under such conditions, the smaller diameter sealing portion **20** of the injection valve is in the position that any further upward movement thereof will result in its complete withdrawal from the recess **22**. Such further upward movement of the injection valve, resulting from still unbalanced force of fuel pressure in the chamber **9**, is opposed by the higher rate coil spring **15**, and results in opening the recess **22** to the fuel chamber **9** and additional discharge or injection of fuel via the orifices **24** into the engine cylinder. In the closed position of the injection valve, its upper end **11** terminates sufficiently below the adaptor **1** to accommodate the desired full opening travel of the valve necessary to allow withdrawal of the portion **20** from the recess as described. Engagement of the collar **14** with the lower end of the sleeve of the check valve **10** serves to limit further opening of the injection valve. It will be appreciated by those knowledgeable in this art that the nut **3** may be directly threaded to a pump body where it is desired to employ it in a unit injector-pump arrangement of a type shown in the aforementioned Falberg patent, in which case the pump chamber bushing would serve in place of the adaptor **1**. Also it will be appreciated that minor changes in the design and arrangement of the parts of the injector may be made without departing from the spirit and scope of the invention as hereinafter claimed.

I claim:

1. In a fuel injector, means defining a fuel chamber and a recess extending from the chamber, a valve having a first sealing portion exposed to fuel pressure in the chamber and a second sealing portion slidably receivable by the recess, a seat engageable by said first sealing portion in the closed position of the valve, a first fuel outlet within the chamber and closable by engagement of said first sealing portion with the seat, a second fuel outlet within the recess and open to the chamber only upon full withdrawal of said second sealing portion from the recess, said valve being movable from its closed position to a partially open position wherein said first sealing portion is out of engagement with the seat but said second sealing portion is not fully withdrawn from the recess and thence to a fully open position wherein said second sealing portion is fully withdrawn from the recess, and dual-rate spring means biasing the valve to its closed position but yieldable in response to a first predetermined fuel pressure in the chamber to accommodate movement of the valve to said partially open position and to a second predetermined fuel pressure in the chamber to accommodate further movement of the valve to said fully open position.

2. In a fuel injector, means defining a fuel chamber, a fuel inlet to the chamber, a check valve in the chamber accommodating fuel flow thereinto from said inlet but blocking flow outwardly of the chamber via said inlet, said chamber also having a recess, a valve seat defining the entrance to said recess from the chamber, a first outlet adjacent said valve seat, a second outlet within said recess, an injection valve having a first sealing portion engageable with said seat to close said first outlet and a second sealing portion receivable by said recess to block fuel flow into the recess from the chamber, and dual-rate spring means biasing said injection valve closed, said spring means having a first spring portion yieldable in response to a first predetermined fuel pressure in the chamber acting on said first sealing portion to accommodate opening movement of the injection valve sufficient for said first sealing portion to uncover said first outlet and a second spring portion yieldable in response to a greater predetermined fuel pressure in the chamber acting on said first sealing portion to effect further opening movement of the injection valve sufficient to cause withdrawal of said second sealing portion from said recess and thereby allow discharge of fuel from the chamber via both said outlets.

3. The invention of claim **2**, wherein said check valve and injection valve have slidably interengaged surfaces and said spring means reacts against the check valve to bias the check valve closed.

4. The invention of claim **2**, wherein said spring means reacts against the check valve to bias the check valve closed, and said check valve has an opening extending therethrough and in open communication with said inlet, said injection valve having a stem extending oppositely of said sealing portions and slidably fitting said opening, whereby fuel inlet pressure operative to open said check valve also applies thrust against said stem to bias the injection valve closed.

5. The invention of claim **4**, wherein said first spring portion is in the form of a relatively low rate coil compression spring thrustably connected to the injection valve and said second spring portion is in the form of a relatively high rate coil compression spring thrustably connected to the check valve, said springs being in coaxial alignment and having a separator in mutual thrust transmitting relation between their adjacent ends.

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