May 28, 1968 K. ECKERT 3,385,219

FUEL INJECTION PUMP

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FIG.1

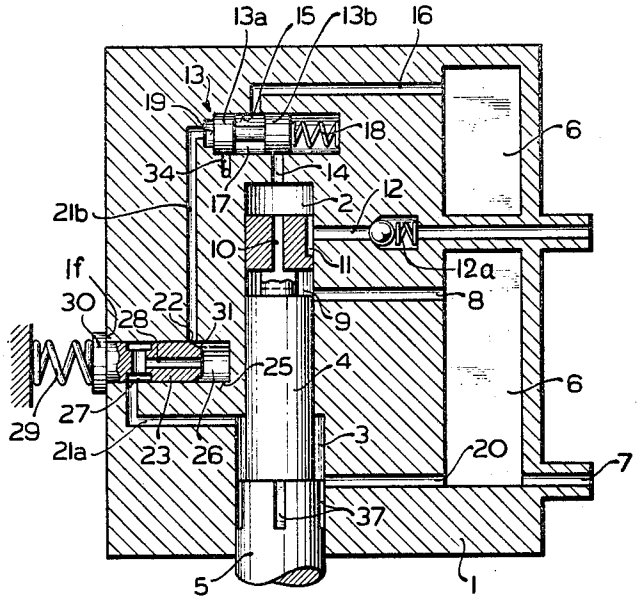
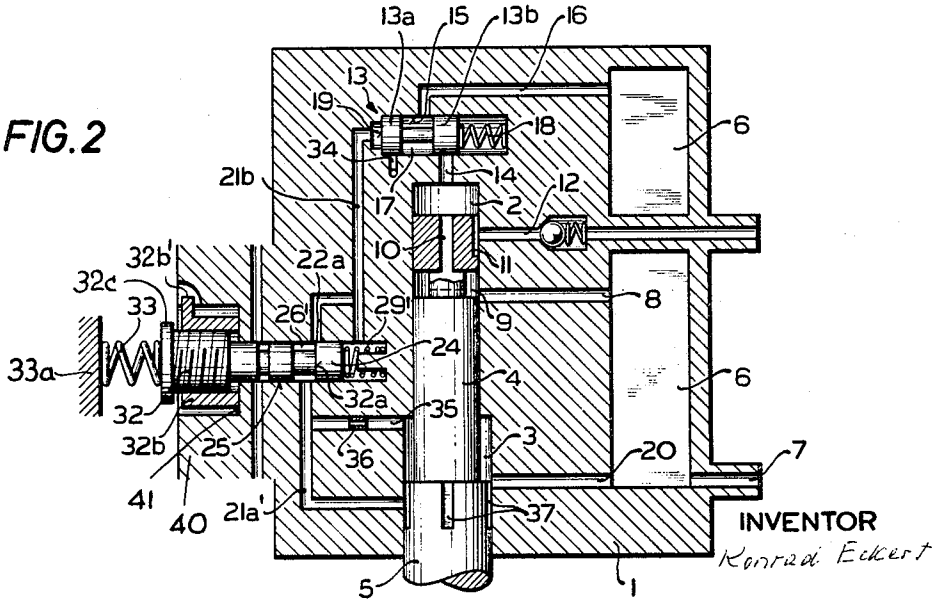


FIG.2



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FUEL INJECTION PUMP

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14 Claims. (Cl. 103—41)

ABSTRACT OF THE DISCLOSURE

A fuel injection pump wherein a reciprocable valve controls the flow of fuel from a working chamber by way of a spill passage and wherein an auxiliary pump delivers fuel to a regulating cylinder which accommodates the valve. A single conduit which connects the auxiliary pump with the regulating cylinder contains an adjustable throttle which offers less resistance to flow of fuel into the regulating cylinder than to flow of fuel from the cylinder back to the auxiliary pump.

The present invention relates to improvements in fuel injection pumps for internal combustion engines. More particularly, the invention relates to improvements in fuel injection pumps of the type which can regulate the amounts of fuel in dependency on the rotational speed of an internal combustion engine and which can also terminate the admission of fuel to the cylinders of an engine when the latter operates at a predetermined maximum permissible speed. Still more particularly, the invention relates to improvements in fuel injection pumps of the type disclosed in U.S. Patents Nos. 3,044,404 and 3,122,100 to Bessiere.

The patents to Bessiere disclose a fuel injection pump wherein a working piston reciprocates in a working cylinder to expel fuel into one or more cylinders of an internal combustion engine and wherein such piston reciprocates and rotates at a speed which is a function of the engine speed. At a predetermined speed, an auxiliary pump which operates in synchronism with the working piston causes a regulating valve to open a spill passage and to permit escape of fuel from the working cylinder so that the amounts of fuel to the cylinders of the engine are either reduced or the cylinders of the engine receive no fuel at all.

The regulating valve is reciprocable in a regulating cylinder and is biased by a spring which tends to move it in a direction to expel fuel that was admitted by the auxiliary pump, such evacuation of fuel taking place between successive working strokes of the working piston. When the piston operates at a very high speed, the intervals between successive working strokes become so short that the spring has no time to return the regulating valve to its end position whereby the valve opens the aforementioned spill passage and permits escape of fuel from the working chamber along a path which does not lead into the cylinders of the internal combustion engine.

Evacuation of fuel from the regulating cylinder is throttled by suitable throttle means installed in a conduit connecting the auxiliary pump with the regulating cylinder. A drawback of presently known fuel injection pumps of the above outlined character is that the throttle means is not adjustable while the pump is in actual use, that such throttle means comprises more than a single throttle, that the flow of fuel between the auxiliary pump and the regulating cylinder takes place through a plurality of separate passages, and that such passages are likely to be clogged with solid impurities which might be present in the fuel. Another serious drawback of presently known

throttle means is that, when rendered ineffective, such throttle means cannot prevent excessive acceleration of the engine.

Accordingly, it is an important object of my invention to provide a fuel injection pump of the above outlined character with very simple, reliable, accurate and readily adjustable throttle means which can regulate the flow of fuel between the regulating cylinder and the auxiliary pump.

Another object of the invention is to provide the pump with a safety device which prevents excessive acceleration of the engine even if the throttle means happens to be ineffective.

A further object of the invention is to provide very simple and reliable adjusting means for such throttle means.

An additional object of the instant invention is to provide a fuel injection pump wherein the rate of fuel flow from the regulating cylinder can be adjusted independently of the working piston and wherein a single conduit or passage suffices to establish a connection between the regulating cylinder and the auxiliary pump.

Briefly stated, my invention is embodied in a fuel injection pump for internal combustion engines, for example, for the engines of automotive vehicles. The pump comprises a working cylinder and a regulating cylinder each of which may form part of a housing accommodating all components of the pump, and a working piston arranged to perform in the working cylinder alternating working and return strokes at a speed which is a function of the engine speed and to respectively draw fuel from a source into and to expel fuel from the working cylinder. The pump further comprises a spill passage which may be constituted by a suitable bore provided in the aforementioned housing and includes a first section connecting the working cylinder with the regulating cylinder and a second section which can receive fuel from the first section through the regulating cylinder to return such fuel to the source. A regulating valve is reciprocably received in the regulating cylinder and is biased by a suitable helical spring or by analogous biasing means tending to move the valve to an end position in which the valve seals the two sections of the spill passage from each other. A conduit which is connected with the regulating cylinder receives fuel from an auxiliary pump which operates in synchronism with the working piston and delivers fuel during each working stroke of the piston whereby such fuel moves the valve in a direction away from the aforementioned end position and, at least upon reaching the maximum engine speed, the valve permits fuel to flow between the two sections of the spill passage to thereby at least reduce the amounts of fuel which are injected into the cylinders of the internal combustion engine.

In accordance with an important feature of my invention, the fuel injection pump further comprises adjustable throttle means yieldably mounted in the aforementioned conduit to offer lesser or no resistance to the flow of fuel into the regulating cylinder in response to admission of fuel into conduit by the auxiliary pump and to offer greater resistance to the flow of fuel from the regulating cylinder via such conduit in response to movement of the regulating valve toward its end position under the action of biasing means. The action of such throttle means can be adjusted independently of the working piston.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved fuel injection pump itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the fol-

lowing detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a somewhat schematic axial sectional view of a fuel injection pump which embodies one form of my invention; and

FIG. 2 is a similar axial sectional view of a modified fuel injection pump.

Referring first to FIG. 1, there is shown a fuel injection pump which comprises a housing **1** including a first or working cylinder **2** whose chamber accommodates a working piston **4**. The housing **1** further includes an auxiliary cylinder **3** whose chamber accommodates an auxiliary piston **5**. The cylinder **3** is coaxial with the cylinder **2** and the pistons **4**, **5** together form a two-stage piston wherein the diameter of the auxiliary piston exceeds the diameter of the working piston. The arrows below the auxiliary piston **5** indicate the directions in which the pistons **4** and **5** are moved by means of a cam or by an analogous drive at a speed which is a function of the engine speed. The pistons **4** and **5** perform alternating working and return strokes and simultaneously rotate about their common axis. This enables the working piston **4** to perform the function of a fuel distributor.

The housing **1** has a suction chamber **6** which is connected with a suitable fuel supply pump (not shown) by means of an inlet pipe **7**.

A supply bore **8** connects the suction chamber **6** with an annular groove **9** in the periphery of the working piston **4**. This groove **9** can admit fuel into the working cylinder **2** through an axial bore **10** in the piston **4**. The position of the discharge end of the supply bore **8** is selected in such a way that the bore **8** is sealed from the groove **9** when the piston **4** performs a working stroke and expels fuel from the cylinder **2**. The periphery of the piston **4** is further provided with an axially parallel distributing groove **11** which can communicate seriatim with a plurality of delivery channels **12**, one for each cylinder of the internal combustion engine. The intake ends of the channels **12** are disributed uniformly about the axis of the working piston **4** but only one such channel is actually shown in FIG. 1. Each channel **12** accommodates a non-return valve **12***a* and the discharge end of each of these channels is connected with a suitable fuel injection nozzle (not shown). The groove **11** communicates with one channel **12** at a time, always when the piston **4** performs a working stroke to this expel fuel from the cylinder **2**, through the groove **11**, and into that channel **12** which happens to register with the groove **11**.

A regulating valve **13**, hereinafter called spool for short, is reciprocable in the chamber of a regulating cylinder **15** forming part of the housing **1**, and this spool controls the flow of fuel from the working cylinder **2** along an alternate path other than that defined in part by the groove **11**. This alternate path is defined by two sections **14**, **16** of a spill passage which returns fuel to the suction chamber **6**. The section **14** connects the working cylinder **2** with the regulating cylinder **15**, and the section **16** serves to return fuel from the regulating cylinder **15** to the suction chamber **6**.

The spool **13** is formed with a circumferential groove **17** and comprises two axially spaced portions or plungers **13***a*, **13***b* which are sealingly received in the regulating cylinder **15**. A biasing means, here shown as a helical spring **18**, bears against the right-hand plunger **13***b* and tends to maintain the spool **13** in a left-hand end position in which the plunger **13***a* abuts against a shoulder **19**. When the plunger **13***a* abuts against a shoulder **19**, the plunger **13***b* seals the section **14** from the interior of the cylinder **15** but the section **16** communicates with the groove **17**.

The purpose of the auxiliary pump which includes the cylinder **3** and piston **5** is to hydraulically displace the spool **13** against the bias of the spring **18**. In a predetermined axial position of the spool **13**, the plunger **13***b* exposes a portion of the outlet of the section **14** whereby the cylinders **2** and **15** communicate wtih each other. In other words, when the plunger **13***b* moves in a driection to the right, as viewed in FIG. 1, and to such an extent that it exposes at least a portion of the outlet of the section **14**, the working cylinder **2** communicates with the suction chamber **6** via sections **14**, **16** and regulating cylinder **15**. This interrupts the delivery of fuel into the channels **12** and hence into the cylinders of the internal combustion engine because, when the piston **4** performs a working stroke and forces fuel out of the cylinder **2**, such fuel finds the path of least resistance and, instead of opening one of the non-return valves **12***a*, escapes through the spill passage **14**, **16** to reenter the suction chamber **6**.

The cylinder **3** of the auxiliary pump can receive fuel through a bore **20** which connects it with the suction chamber **6**. The bore **20** will admit fuel into the auxiliary chamber **3** when the auxiliary piston **5** reaches the end of its return stroke, i.e., when the auxiliary piston assumes its lower end position. The upper end face of the auxiliary piston **5** then moves to a level below the bore **20**. When the auxiliary piston **5** performs a working (upward) stroke, it expels fuel from the cylinder **3** whereby such fuel flows through a conduit including a first portion **21***a* and a second portion **21***b* which latter is connected with the left-hand end of the regulating cylinder **15**. This causes the spool **13** to move in a direction away from its left-hand end position, i.e., the plunger **13***a* then moves away from the shoulder **19** and the spring **18** is caused to store energy.

During the intervals between successive working strokes of the auxiliary piston **5**, the spring **18** tends to return the plunger **13***a* into abutment with the shoulder **19**. The plunger **13***a* then expels fuel from the cylinder **15** through the portion **21***b* of the aforementioned conduit. The orifice **22** at the lower end of the portion **21***b* is spaced from the portion **21***a* and the flow of fuel through this orifice can be regulated by a rotary throttle **23** which is accommodated in a cylinder **25** of the housing **1**. The throttle **23** is also slidable in the cylinder **25** and the chamber of this cylinder connects the orifice **22** with the portion **21***a*. If the throttle **23** obstructs the flow of fuel from the orifice **22** into the portion **21***a*, return movement of the spool **13** toward its left-hand end position will take place at a reduced speed. Thus, in response to a predetermined setting of the throttle **23** and in response to a predetermined rotational speed of the engine (which is tantamount to a predetermined reciprocatory and axial speed of the pistons **4** and **5**), the spool **13** will bring about a so-called "liquid abutment" or "liquid stop" which can be defined as constituting such regulation of fuel flow by the spool **13** that fuel evacuated from the working cylinder **2** flows through the spill passage **14**, **16**, i.e., not into one of the channels **12**. When such liquid stop develops, the intervals between successive working strokes of the piston **3** are too short to allow for movement of the plunger **13***a* into actual abutment with the shoulder **19**. Therefore, the spring **18** cannot expand fully before the auxiliary piston **5** delivers a fresh stream of fuel into the regulating cylinder **15**. Of course, and if the plunger **13***a* does not reach the leftmost end position before the auxiliary piston **5** moves upwardly, as viewed in FIG. 1, the spool **13** must cover a shorter distance in order to assume a position in which its plunger **13***b* permits fuel to flow from the working cylinder **2** into the section **16** of the spill passage. This reduces the amounts of fuel which are delivered into the channels **12**.

The throttle **23** is sealingly fitted into the cylinder **25** and its right-hand end face defines with the bottom surface of the cylinder **25** a compartment or space **26** which communicates with the portion **21***b* and with an axially extending bore **28** of the throttle. The unobstructed portion of the orifice **22** allows fuel to flow from the space **26** into the portion **21***b* or vice versa.

The throttle **23** is further provided with a circumferential groove **27** which communicates with the portion

21*a* and with the bore 28. A resilient element 29, here shown as a helical spring, urges the throttle 23 deeper into the cylinder 25 and thus tends to move the throttle to a position in which the latter reduces the free cross-sectional area of the orifice 22 and allows lesser quantities of fuel to flow between the space 26 and the portion 21*b*. The spring 29 bears against an adjusting collar 30 which is rigidly secured to or integral with the throttle 23 and normally abuts against a stop face 1*f* of the housing 1. The effective (unobstructed) cross-sectional area of the orifice 22 can be regulated by rotating the throttle 23 through the intermediary of the adjusting collar 30. The right-hand end portion of the throttle 23 is formed with a helical cam face 31. As clearly shown in FIG. 1, the rate of fuel flow through the orifice 22 will be reduced if the throttle 23 is rotated by the adjusting collar 30. This throttle can be moved to a plurality of different angular positions each of which corresponds to a different rate of fuel flow through the orifice 22.

The portion 21*a* of the aforementioned conduit is connected with that part of the auxiliary cylinder 3 which is outside of the range of the auxiliary piston 5 so that the cylinder 3 remains in communication with the portion 21*a* in all axial positions of the piston 5.

When the auxiliary piston 5 moves upwardly, fuel admitted into the portion 21*a* of the conduit flows through the groove 27 and bore 28 to enter the space 26 and to bear against the right-hand end face of the throttle 23. The throttle yields by compressing the spring 29 and thus offers a lesser resistance to the flow of fuel via orifice 22, portion 21*b* and into the regulating cylinder 15 wherein such fuel moves the spool 13 against the opposition of the spring 18. When the auxiliary piston 5 performs a return stroke, the spring 18 expands but the spring 29 is stronger and also expands so that the throttle 23 then offers a greater resistance to the flow of fuel into the space 26. The resistance of the throttle 23 to the flow of fuel through the orifice 22 is determined by the setting of the adjusting collar 30, i.e., by the angular position of the throttle.

FIG. 2 illustrates a second fuel injection pump which comprises a modified throttle 24. This throttle resembles a short cylindrical member which is biased by a resilient element, here shown as a helical spring 29′ corresponding to the spring 29 of FIG. 1. In other words, the spring 29′ tends to move the throttle 24 in a direction to reduce the rate of fuel flow through an orifice 22*a* at the adjacent end of the second portion 21*b*′ of the conduit including the portions 21*a*′, 21*b*′. The spring 29′ urges the throttle 24 against the end face 32*a* of an externally threaded adjusting plug 32 which meshes with an adjusting nut 32*b*. The latter is reciprocable in a fixed support 40 provided with a stop face 41 against which the nut 32*b* is urged by a further resilient element 33 operating between the exposed head 32*c* of the plug 32 and a retainer 33*a*. The nut 32*b* has a tooth 32*b*′ which is slidable in a recess of the support 40 and prevents rotation of the nut with reference to the support. However, the nut 32*b* is free to move axially with the plug 32.

When the auxiliary piston 5 of the fuel injection pump shown in FIG. 2 performs a working stroke, fuel flows from the auxiliary cylinder 3 via portion 21*a*′ and exerts pressure against the left-hand end face of the throttle 24 which is displaced against the opposition of the spring 29′ so that the orifice 22*a* of the portion 21*b*′ is fully exposed. In other words, the throttle 24 offers no resistance to the flow of fuel from the portion 21*a*′ into the portion 21*b*′ and thence into the regulating cylinder 15. When the spool 13 thereupon moves toward its left-hand end position (shoulder 19), pressure in the compartment or space 26′ and in the portions 21*a*′, 21*b*′ decreases to such an extent that the spring 29′ can move the throttle 24 against the end face 32*a* of the adjusting plug 32. The throttle 24 then offers greater resistance to the flow of fuel from the portion 21*b*′ into the portion 21*a*′ because it reduces the rate of fuel flow through the orifice 22*a* to the extent determined by the setting of the adjusting plug 32. The liquid stop will develop in response to a predetermined rotational speed of the engine whose cylinders receive fuel from the channels 12, i.e., in response to a predetermined shortening of intervals between successive working strokes of the pistons 4 and 5. The effective cross-sectional area of the orifice 22*a* during return strokes of the pistons 4 and 5 depends on the setting of the adjusting plug 32.

The aforementioned conduit including the portions 21*a*′, 21*b*′ further includes a third or secondary portion 35 which connects the auxiliary cylinder 3 with the portion 21*a*′. This secondary portion 35 accommodates a safety device in the form of a fuel flow restricting element 36. The right-hand end of the secondary portion 35 is connected with the auxiliary chamber 3 at a point which is outside of the range of the auxiliary piston 5. The latter is formed with axially parallel grooves 37 which allow fuel to flow from the cylinder 3 into the portion 21*a*′ only when the auxiliary piston 5 performs a working stroke. This insures that, when the spool 13 moves toward the shoulder 19, all of the fuel which is being expelled from the cylinder 15 must flow through the secondary portion 35 and hence through the flow restricting element 36. If the throttle 24 happens to be ineffective, the flow restricting element 36 will determine the maximum rotational speed of the engine. Such speed exceeds the speed corresponding to the maximum effective cross-sectional area of the orifice 22*a*. The flow restricting element 36 may be made of the type wherein the effective cross-sectional area of the throttling passage may be varied to bring about a desired flow restricting action.

In each of the two illustrated embodiments, impurities which might be present in the fuel are flushed away from the orifice 22 or 22*a*. Clogging of the orifice 22 or 22*a* could affect the operation of the engine during idling. Any such impurities which enter the cylinder 15 are evacuated through a drain bore 34 which also determines the maximum rightward stroke of the spool 13 by connecting the portion 21*b* or 21*b*′ with the fuel tank when the plunger 13*a* exposes the intake end of this bore.

A very important advantage of the yieldable throttle 23 or 24 is that it damps vibrations which develop whenever the spool 13 is set in motion. Such vibrations are due to the inertia of the spool 13 and also to the inertia of fuel which fills the cylinder 15 and the portions 21*a*, 21*b* or 21*a*′, 21*b*′. The damping action of such yieldable throttles 23, 24 enhances the stability of regulation.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is:

1. A fuel injection pump for internal combustion engines, comprising a working cylinder; a working piston arranged to perform in said cylinder alternating working and return strokes at a speed which is a function of the engine speed and to respectively draw fuel into and to expel fuel from said cylinder; a regulating cylinder; a spill passage having a first section connecting said cylinders and a second section for receiving fuel from said regulating cylinder; a regulating valve reciprocably received in said regulating cylinder; biasing means for urging said valve to an end position in which said sections of the spill passage are sealed from each other; a single conduit connecting said regulating cylinder with an auxiliary pump means operating in synchronism with said piston for delivering fuel into said conduit during each working stroke of said piston whereby such fuel moves the valve

in a direction away from said end position and, at least upon reaching the maximum engine speed, the valve permits fuel to flow between said sections of the spill passage; and adjustable throttle means yieldably mounted in said conduit to offer lesser resistance to the flow of fuel into said regulating cylinder in response to admission of fuel into said conduit by said auxiliary pump means and to offer greater resistance to the flow of fuel from the regulating cylinder via said conduit in response to movement of said valve under the action of said biasing means.

2. A fuel injection pump as set forth in claim 1, wherein said conduit comprises two portions one of which has an orifice spaced from the other portion, said throttle means being disposed between said portions and being movable between a plurality of positions to thereby regulate the flow of fuel through said orifice, and further comprising adjusting means for selecting the position of said throttle means.

3. A fuel injection pump as set forth in claim 2, further comprising resilient means for biasing said throttle means in a direction to reduce the rate of fuel flow through said orifice.

4. A fuel injection pump as set forth in claim 1, wherein said conduit comprises a secondary portion and further comprising flow restricting means provided in said secondary portion to oppose the flow of fuel from said regulating cylinder, at least when said throttle means is ineffective, and to thus prevent acceleration of the engine beyond a predetermined maximum speed.

5. A fuel injection pump as set forth in claim 4, wherein said auxiliary pump means comprises an auxiliary cylinder and an auxiliary piston coaxially secured to said working piston and reciprocable in said auxiliary cylinder, said secondary portion of the conduit being in permanent communication with said auxiliary cylinder in each position of said auxiliary piston.

6. A fuel injection pump as set forth in claim 5, wherein said conduit further comprises an additional portion connected with said auxiliary cylinder and wherein said pistons are rotatable in the respective cylinders at a speed which is also a function of the engine speed, said auxiliary piston having groove means establishing a path for the flow of fuel from said auxiliary cylinder into said additional portion only when said pistons perform working strokes.

7. A fuel injection pump as set forth in claim 1, wherein said conduit includes a pair of portions separated from each other by a space, one of said portions having an orifice communicating with said space and said throttle means comprising a member received in said space and movable to a plurality of positions to thereby regulate the flow of fuel through said orifice, and adjusting means for selecting the position of said member, the other portion of said conduit being free to communicate with said space.

8. A fuel injection pump as set forth in claim 7, wherein said adjusting means is rigid with said throttle means.

9. A fuel injection pump as set forth in claim 8, wherein said throttle means is rotatable by said adjusting means to thereby assume said plurality of positions.

10. A fuel injection pump as set forth in claim 9, wherein said member has a substantially helical cam face which regulates the flow of fuel through said orifice in response to rotation of said member by said adjusting means.

11. A fuel injection pump as set forth in claim 10, further comprising stop means for said adjusting means and resilient means for biasing said adjusting means against said stop means.

12. A fuel injection pump as set forth in claim 7, wherein said adjusting means comprises a threaded element and further comprising resilient means for biasing said member against said threaded element.

13. A fuel injection pump as set forth in claim 12, wherein said member is moved to different positions in response to rotation of said threaded element.

14. A fuel injection pump as set forth in claim 13, wherein said adjusting means further comprises a nut meshing with said threaded element, support means for holding said nut against rotation and including stop means for said nut, and further resilient means for urging said nut against said stop means.

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