United States Patent

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[54] FUEL INJECTOR PUMP AND LIMITING SPEED GOVERNOR FOR INTERNAL COMBUSTION ENGINE
6 Claims, 3 Drawing Figs.

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[51] Int. Cl. F02m 45/00
[50] Field of Search .... 123/139, 139.3, 139.11, 139.10, 140, 140 (A), 140 (B), 140.1, 140.2; 239/88; 103/41

[56] References Cited
UNITED STATES PATENTS

2,696,807	12/1954	Junge et al.	123/139.3
2,739,802	3/1956	Pope Jr.	123/140
2,810,375	10/1957	Froehlich et al.	123/139.3

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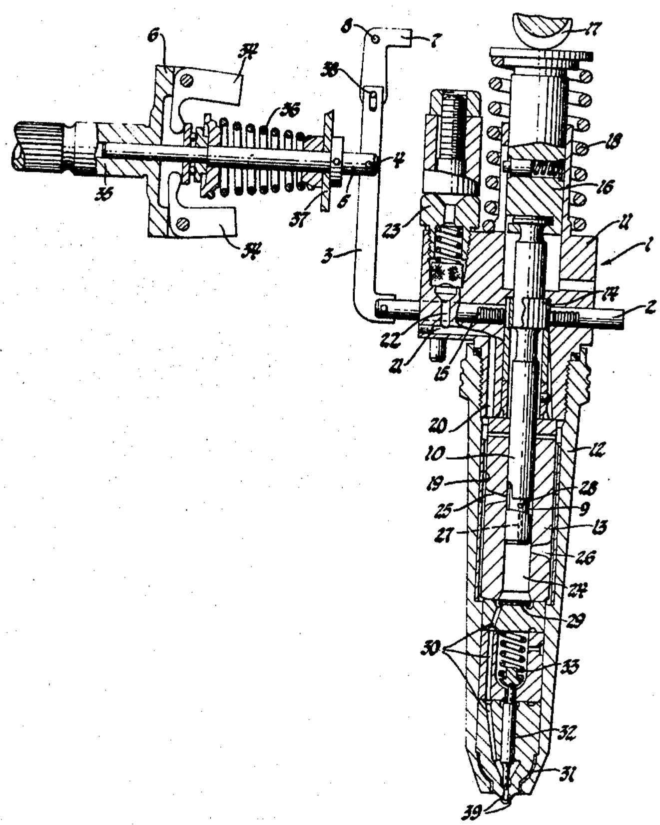
ABSTRACT: A jerk-type fuel injector pump having a rotatively adjustable plunger with differently inclined helix portions controlling the delivery rate in the low and high ranges of adjustment, and an engine speed-limiting governor having flyweights operative under the control of a relatively high rate spring to limit the pump delivery rate over approximately the upper half of the engine speed range.



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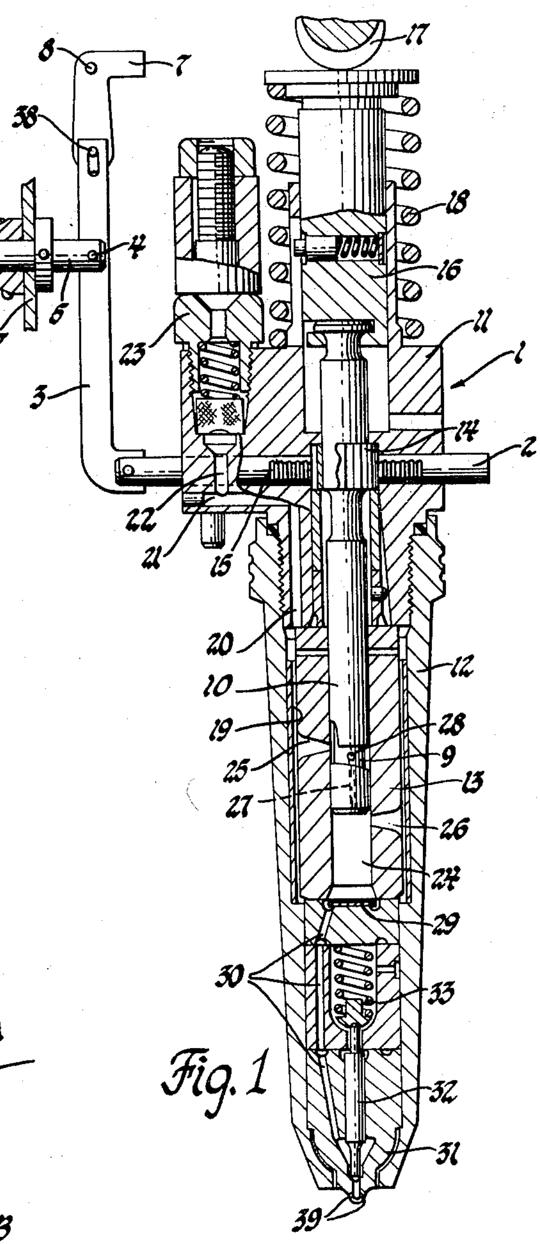

Fig. 1

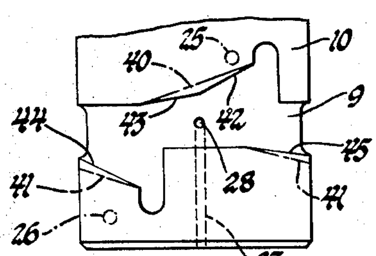

Fig. 2

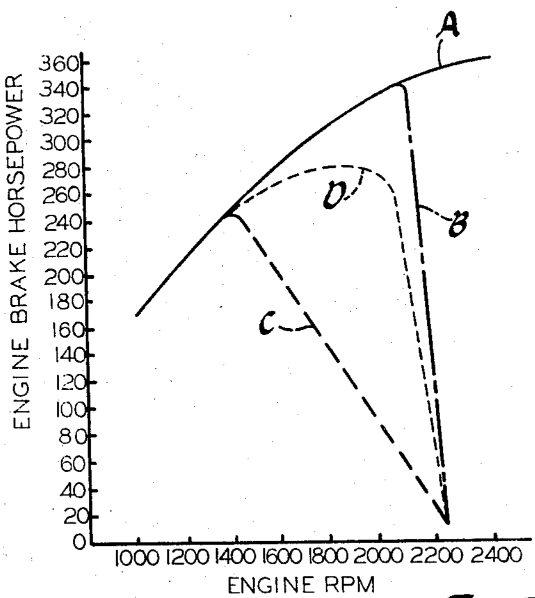

Fig. 3

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FUEL INJECTOR PUMP AND LIMITING SPEED GOVERNOR FOR INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to compression-ignition-type internal combustion engines, and particularly to improvements in jerk-type fuel injector pumps and engine speed-limiting governors therefore, to provide relatively constant full-throttle power over the governed portion of the engine speed range.

It has long been an objective in this art to automatically limit the speed of such an engine to a desired maximum, without either unduly sacrificing its brake horsepower output over the governed portion of the speed range, or allowing the engine to develop excessive horsepower at the upper end of its speed range. Such engines incorporating previously known jerk-type injector pumps will not so operate without being provided with special governing mechanisms which involve additional moving parts, thus adding to the cost, possibility of malfunction, and opportunities for unauthorized tampering of the governor setting.

2. Description of the Prior Art

The prior U.S. Pat. No. 3,006,556 to Shade et al. shows a jerk-type fuel injector pump which is widely used in engines of the type here concerned, including such engines as are equipped with limiting speed governors. The injector pump of this patent operates similarly to that of my present invention, however, it lacks the novel plunger helix construction to obtain the improved results. The earlier U.S. Pat. No. 2,225,019 to Retel shows a governor controlled jerk-type injector pump having a plunger with a double angle of inclination, but its effect is only to improve the sensitiveness of injection timing at low engine speeds. The nearest known approach previously made to obtaining the results of my present invention is a "-Power Control" device (shown on Page 3, Section 2.7.5 of the 1966 "V-71 Engines Detroit Diesel Maintenance" manual) which employs a spring stop to resiliently limit fuel increasing movement of the injector control racks.

SUMMARY OF THE INVENTION

My present invention accomplishes the desired automatic control of engine fuel supply for a generally "flat" power curve over the governed speed range by means which is simple, inexpensive and foolproof, and which requires no additional parts and does not enhance the possibility of unauthorized adjustment of the engine governor setting. The arrangement broadly embodies provision of differently inclined helix portions on the injector pump plunger groove and the substitution of a relatively high rate governor control spring having a preload such that injection delivery is subject to governor control over approximately the upper half of the engine speed range. For a full understanding of the invention, reference is made to the following description and the attached drawing, wherein:

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a view partly in longitudinal section and partly in elevation of the improved injector pump and, shown generally schematically therewith, a high rate spring engine driven governor and manual throttle control for the injector rack.

FIG. 2 is a 360° diagrammatic development of the lower end of the injector pump plunger, illustrating the preferred use of two different helix angle inclinations of each of the upper and lower edges of the metering groove in solid lines, and indicating the conventional single helix configurations thereof in broken outline. The relative locations of the upper and lower fuel supply and bypass ports in the pumping cylinder are also shown in broken outline.

FIG. 3 is a graph of engine full-throttle brake horsepower versus r.p.m. with comparative curves illustrating the advantage obtained by my invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the drawing, and first to FIG. 1, a jerk-type unit injector pump is designated generally by the numeral 1 and has its fuel rate-adjusting rack 2 connected to one end of a lever 3. This lever is shown pivoted at 4 to a shaft 5 of an engine speed-limiting governor 6. The opposite end of the lever is manually movable by a bell crank 7 which may be suitably connected to the engine throttle system (not shown), the bellcrank being pivotable about a fixed pin 8.

Except for the metering control groove 9 in the plunger 10, the injector pump is of conventional construction and comprises an upper housing 11 and lower extension or nut 12. The plunger is reciprocable in a bushing 13 clamped endwise against the housing by the nut, and has a pinion 14 secured thereto and in mesh with teeth 15 on the rack 2. The upper end of the plunger is connected to a follower 16 which is slidable in the housing 11 and is actuatable in a downward direction by an engine driven cam 17 against the biasing force of a plunger return spring 18. An annular fuel-receiving chamber 19 surrounds the bushing within the nut 12 and is supplied with fuel via passages 20, 21 and 22 from an external connection 23. The interior of the bushing 13 forms a pumping cylinder 24 which is connected to the chamber 19 by upper and lower fill and bypass ports 25 and 26, and to the plunger groove 9 by axial and transverse ports 27 and 28. During each downward stroke of the plunger from its position shown, fuel is initially bypassed to the chamber 19 from the pumping cylinder, but after the groove 9 moves out of registry with the upper port 25 and the lower port 26 is closed by the plunger, fuel is displaced under high pressure through the lower open end of the bushing 13 until the groove 9 moves into registry with the lower port 26 to again bypass fuel and terminate injection. The displaced fuel is delivered past an antiblow back valve 29, thence through tip passages 30 into the lower end of the spray tip 31 wherein the fuel pressure causes the injection needle valve 32 to lift against the its spring 33, allowing the fuel to be injected into the engine through a plurality of spray orifices 39. Other details of the injector pump, apart from the configuration of the plunger metering groove 9 are not important to the present invention, but are fully described in the aforementioned U.S. Pat. No. 3,006,556 to Shade et al.

With the governor control shaft 5 in its normally retracted position (shown), rotation of the throttle-controlled bellcrank 7 in a counterclockwise direction about its pivot 8 causes the lever 3 to swing in a clockwise direction about its pivot 4 on the governor shaft and move the injector rack 2 to the left from its position shown. Such movement of the rack, in turn, causes the injector plunger 10 to rotate in a fuel increasing direction such that the plunger-metering groove 9 closes the upper port 25 earlier and uncovers the lower port 26 later during each downward or pumping stroke of the plunger. A detailed description of the plunger groove and the effect of such rotation of the plunger will be taken up in connection with the description of FIG. 2.

The governor 6 is shown as comprising engine speed sensing means in the form of flyweights 34 carried by an engine driven shaft 35, and as engine speed increases the weights tend to swing outwardly and move the shaft 5 toward the right against the biasing force of the governor spring 36 which reacts against a fixed portion 37 of the engine. Such rightward movement of the control shaft 5 thus shifts the pivot 4 of the lever 3 causing the lever to pivot about its connection 38 to the bellcrank and move the injector rack 2 to the right, i.e. in a fuel decreasing direction.

FIG. 2 shows a diagrammatic representation of a 360° development of the plunger 10 and its metering groove 9. The upper and lower extremities of the groove 9 are shown in solid lines, and indicated in broken outline are the relative locations of the upper and lower ports 25 and 26 through which fuel enters and is bypassed from the pumping cylinder 24 (FIG. 1) during portions of each pumping stroke. In accordance with the invention, at least one, and preferably both (as shown), controlling edges of the groove 9, i.e. the edges thereof which initiate the covering and uncovering of the bushing ports, are helically inclined. Also, rather than each such helix having a single continuous inclination (as shown in broken outlines 40 and 41), the upper helix has a first portion 42 inclined at a relatively steep angle and a second portion 43 inclined at a relatively shallow angle. Likewise, the lower helix has a first portion 44 inclined at a relatively steep angle and a second portion 45 inclined at a relatively shallow angle. With the plunger in its rotatively adjusted position corresponding to the relatively fixed locations of the upper and lower ports 25 and 26 shown in FIG. 2, the injection rate of the injector pump is near the lower end of its adjustment range. Thus, as the result of downward movement of the plunger the upper port 25 has only recently moved out of registry with the groove 9 to begin injection, and ending of injection will relatively shortly occur with further downward movement of the plunger to where the control edge portion 44 uncovers the lower port 26. At a higher delivery rate setting of the plunger, as may be envisioned by moving the plunger to the right, relative to the ports 25 and 26 in FIG. 2, such closing and opening of upper and lower ports will occur earlier and later in the pumping stroke, respectively. Likewise if the plunger was rotated in the opposite direction (viewed as moving it to the left from its positive relative to the ports 25 and 26 as seen in FIG. 2) a lower delivery rate would be effected. The minimum pump delivery rate position would be that at which the upper end of the inclined portion 42 of the upper helix controls the closing of the upper port and the lower end of the lower helix portion 44 controls the opening of the lower port 26 during the pumping stroke. Similarly, the maximum pump delivery rate position would be that at which the lower end of the upper helix portion 43 controls the closing of the upper port, and the upper end of the lower helix portion 45 controls the opening of the lower port.

The relatively steeply inclined upper and lower helix portions 42 and 44 are symmetrical to each other in their respective relation to the upper and lower ports 25, 26, and they determine the injection rate throughout approximately the lower half of the adjustment range; and the relatively less steeply inclined upper and lower helix portions 43 and 45 are likewise symmetrical to each other in their relation to the upper and lower ports, respectively, and effect the injection rate control during approximately the upper half of the adjustment range. It will be appreciated that at all times when either the upper port 25 or the lower port 26 is in communication with the plunger groove 9, no injection will occur since the fuel below the plunger is bypassed to the groove 9 via the axial and connecting transverse passages 27 and 28 in the plunger. Various degrees of differences in the extent of inclination of upper helix portions 42 and 43 and lower helix portions 44 and 45 may be used, as well as the circumferential extent of each thereof about the plunger, in order to match the delivery characteristics of the injector pump with the preload and load-deflection rate of the governor spring 26 36.

The governor spring 36 is selected to exert a sufficient preload force to prevent the governor weights 34 from swinging outward with increasing engine speed up to a predetermined speed, corresponding to that point on the engine full throttle power curve A shown in FIG. 3 at which it is desired to initiate control of the injector pump delivery rate. Also, in order for the governor to limit the engine speed to a particular desired maximum (say 2,250 r.p.m., as shown in FIG. 3), the load-deflection rate of the governor spring must be such that its force opposing the outward swinging movement of the governor weights will just balance the thrust force which the weights impose on the governor control shaft 5 at that speed in moving the injector rack to its minimum pump delivery rate position. In other words, the load-deflection rate of the governor spring must be sufficiently high to prevent movement of the injector rack to its minimum pump delivery rate position at engine speeds below such desired maximum speed, and conversely must not be so high as to prevent the control shaft 5 from moving the rack to such minimum fuel rate position when the engine reaches such maximum desired speed. With the prior art injector pump such as shown in the aforementioned Shade et al. U.S. Pat. No. 3,006,556 and a governor having relatively low load-deflection rate and relatively high preload, a governor "droop" curve such as shown at B in FIG. 3 will be obtained wherein the governor control does not take effect until just shortly before the maximum desired operating speed of the engine is reached. As a result, the engine will develop an excessive amount of power at the upper end of its speed range, along with the tendency to have a "smokey" exhaust and a danger of overstressing the mechanical parts of the engine. On the other hand, such a prior art injector pump in combination with a governor spring of substantially higher load-deflection rate, and having a preload sufficiently low to allow the flyweights to swing outward and apply a decreasing fuel movement to the injector rack at a lower speed, a "droop" curve such as shown at C will result, which has the disadvantage of drastically reducing the engine power output below that desired in the upper portion of the speed range. Curve D represents the improved performance obtainable in accordance with the invention wherein the same governor spring as for curve C is used but wherein the double inclination of both the upper and lower plunger helixes 42, 43 and 44, 45 enables obtaining a substantially flatter full throttle power curve over the upper half of the engine speed range.

For certain engine applications it may suffice to provide such a double inclination on either the upper helix only of the groove 9, or on the lower helix only thereof, but a less satisfactory result would be obtained, i.e. in the form of a "droop" curve lying intermediate the curves D and C of FIG. 3. It will also be appreciated that various other changes in the design and arrangement of the parts may be made without departing from the spirit and scope of the invention.

I claim:

1. In the combination of a variable delivery rate fuel injector pump and a speed-limiting governor for an engine having desired maximum no-load and full-load operating speeds, with said maximum full-load speed being approximately midrange between the engine's idling speed and said maximum no-load speed; said pump having a rotatively adjustable plunger with a helix determinative of the pump delivery rate in accordance with the adjusted rotative position of the plunger; said helix having a first angle of inclination effecting the determination of pump delivery rate over the relatively lower portion of the range of delivery rate of the pump, and having a second angle of inclination effecting said determination over the relatively higher portion of the range of pump delivery rate; and a plunger-rotating rack movable through the range from minimum to full pump delivery rate; said governor comprising engine speed-sensing means, a member movable by said sensing means in response to change in engine speed, and resilient means yieldingly opposing increasing engine speed movements of said member above said maximum full-load speed; said rack being connected to said member for actuation in response to movement of said member by said sensing means; said resilient means having sufficient stiffness to prevent movement of said member by said sensing means in response to increasing engine speed up to said maximum full-load speed, and a load-deflection rate accommodating sufficient movement of said member by said sensing means to actuate the rack to the end of its range for minimum pump delivery rate at said maximum no-load speed.

2. The invention of claim 1, wherein said first angle of inclination of said helix is substantially steeper than said second angle of inclination thereof.

3. In the combination of a plunger-type fuel injector pump and a speed-limiting governor for a compression ignition engine having an idling speed and a maximum desired speed; the pump having a fuel supply chamber, a plunger having a circumferentially extending metering groove spaced from one

end thereof and a passage connecting said end to the groove, a cylinder surrounding the plunger with upper and lower side ports connected to the fuel supply chamber, and a plunger-rotating rack having a range of movement transversely of the plunger between a minimum pump delivery rate position and a maximum rate position; said ports being located such that during the plunger-pumping stroke the groove sequentially moves out of registry with the upper port to initiate fuel injection and into registry with the lower port to end injection; said groove having its upper port-controlling edge inclined whereby movement of the rack in one direction results in relatively earlier closing of the upper port for increased fuel delivery during the plunger-pumping stroke, and movement of the rack in the opposite direction results in relatively later closing of the upper port for decreased fuel delivery; the inclination of said upper port-controlling edge being relatively greater for the circumferentially extending portion thereof traversed by said upper port when the rack is within the relatively lower fuel delivery portion of its range of movement, than the inclination of that portion of said upper port-controlling edge traversed by said upper port when the rack is within the relatively higher fuel delivery portion of its range of movement; said governor comprising engine speed-sensing means, a member movable by said means in response to increasing engine speed, and a spring yieldingly opposing increasing engine speed movements of said member above a predetermined speed approximately midrange between the engine-idling speed and said maximum desired speed; said rack being actuatable by said member in the fuel-decreasing direction in response to movement of said member by said engine speed-sensing means; said spring having sufficient stiffness to prevent movement of said member by said sensing means in response to increasing engine speed up to said predetermined speed, and a load-deflection rate accommodating sufficient movement of said member by said sensing means to actuate the rack to its minimum pump delivery rate position at said maximum desired speed.

4. In the combination of a plunger-type fuel injector pump and a speed-limiting governor for a compression ignition engine having an idling speed and a maximum desired speed; the pump having a fuel supply chamber, a plunger having a circumferentially extending metering groove spaced from one end thereof and a passage connecting said end to the groove; a cylinder surrounding the plunger with upper and lower side ports connected to the fuel supply chamber, and a plunger-rotating rack having a range of movement transversely of the plunger between a minimum pump delivery position and a maximum rate position; said ports being located such that during the plunger pumping stroke the groove sequentially moves out of registry with the upper port to initiate fuel injection and into registry with the lower port to end injection; said groove having its lower port-controlling edge inclined whereby movement of the rack in one direction results in relatively later opening of the lower port for increased fuel delivery during the plunger-pumping stroke, and movement of the rack in the opposite direction results in relatively earlier opening of the lower port for decreased fuel delivery; the inclination of said lower port-controlling edge being relatively greater for the circumferentially extending portion thereof traversed by said lower port when the rack is within the relatively lower fuel delivery portion of its range of movement, than the inclination of that portion of said lower port-controlling edge traversed by said lower port when the rack is within the relatively higher fuel delivery portion of its range of movement; said governor comprising engine speed-sensing means, a member movable by said means in response to increasing engine speed, and a spring yieldingly opposing increasing engine speed movements of said member above a predetermined speed approximately midrange between the engine-idling speed and said maximum desired speed; said rack being actuatable by said member in the fuel-decreasing direction in response to movement of said member by said engine speed-sensing means; said spring having sufficient stiffness to prevent movement of said member by said sensing means in response to increasing engine speed up to said predetermined speed, and a load-deflection rate accommodating sufficient movement of said member by said sensing means to actuate the rack to its minimum pump delivery rate position at said maximum desired speed.

5. In the combination of a plunger-type fuel injector pump and a speed-limiting governor for a compression ignition engine having an idling speed and a maximum desired speed; the pump having a fuel supply chamber, a plunger having a circumferentially extending metering groove spaced from one end thereof and a passage connecting said end to the groove, a cylinder surrounding the plunger with upper and lower side ports connected to the fuel supply chamber, and a plunger-rotating rack having a range of movement transversely of the plunger between a minimum pump delivery rate position and a maximum rate position; said ports being located such that during the plunger pumping stroke the groove sequentially moves out of registry with the upper port to initiate fuel injection and into registry with the lower port to end injection; said groove having its upper and lower port-controlling edges oppositely inclined whereby movement of the rack in one direction results in both relatively earlier closing of the upper port and relatively later opening of the lower port for increased fuel delivery during the plunger-pumping stroke, and movement of the rack in the opposite direction results in relatively later closing of the upper port and relatively earlier opening of the lower port for decreased fuel delivery; the inclinations of said control edges being relatively greater for those circumferentially extending portions of each thereof traversed by said ports when the rack is within the relatively lower fuel delivery portion of its range of movement, than the inclinations of those portions of said control edges traversed by the ports when the rack is within the relatively higher fuel delivery portion of its range of movement; said governor comprising engine speed-sensing means, a member movable by said means in response to increasing engine speed, and a spring yieldingly opposing increasing engine speed movements of said member above a predetermined speed approximately midrange between the engine-idling speed and said maximum desired speed; said rack being actuatable by said member in the fuel-decreasing direction in response to movement of said member by said engine speed-sensing means; said spring having sufficient stiffness to prevent movement of said member by said sensing means in response to increasing engine speed up to said predetermined speed and a load-deflection rate accommodating sufficient movement of said member by said sensing means to actuate the rack to its minimum pump delivery rate position at said maximum desired speed.

6. The invention of claim 5, wherein said oppositely inclined portions of said upper and lower port control edges traversed by said ports when the rack is within said relatively lower fuel portion of its range of movement are symmetrical with each other in their relation to said ports, and said oppositely inclined portions thereof traversed by said ports when the rack is within said relatively higher fuel delivery portion of its range of movement are likewise symmetrical with each other in their relation to said ports.