

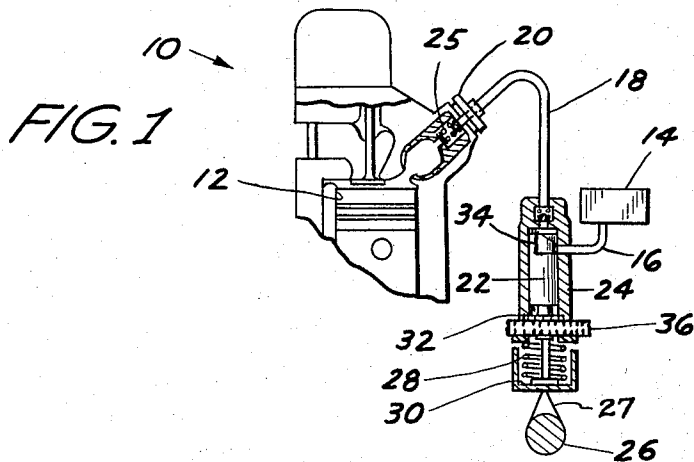
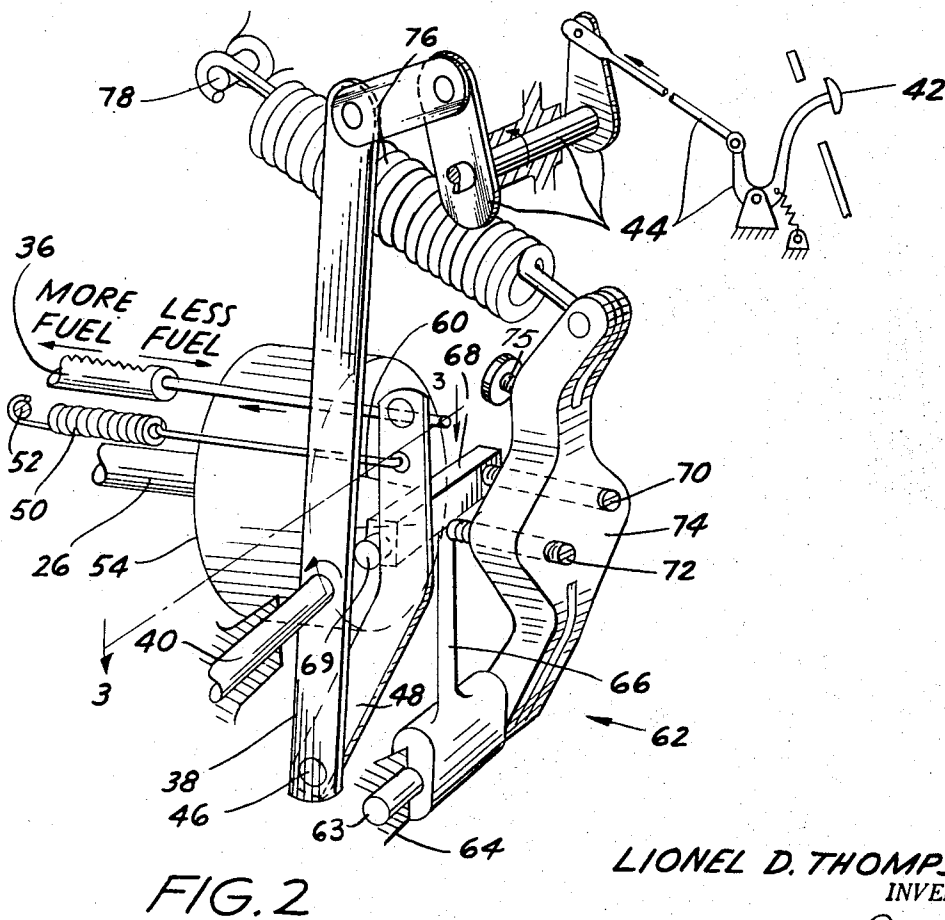
Dec. 19, 1967

L. D. THOMPSON
ENGINE CONTROL DEVICE

3,358,664

Filed June 21, 1965

2 Sheets-Sheet 1



LIONEL D. THOMPSON
INVENTOR.

BY *Walter R. Paton, Jr.*
John P. Moran
ATTORNEYS

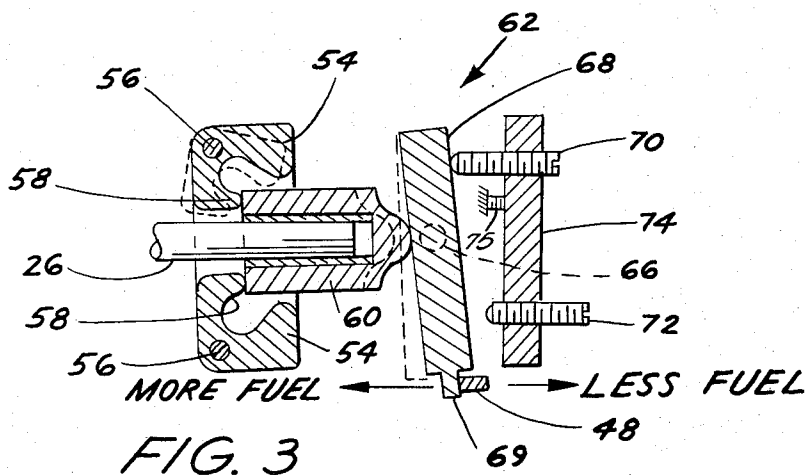
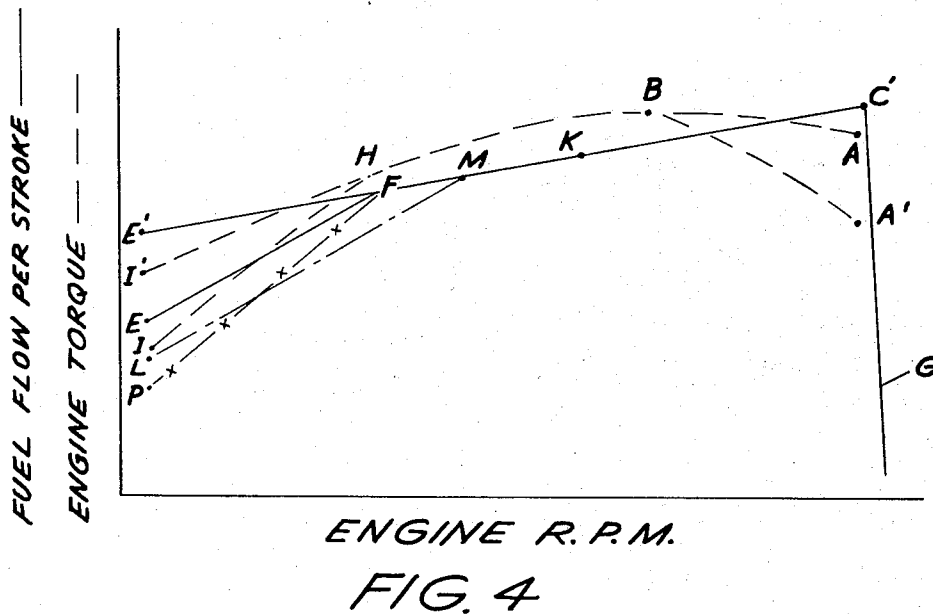
Dec. 19, 1967

L. D. THOMPSON
ENGINE CONTROL DEVICE

3,358,664

Filed June 21, 1965

2 Sheets-Sheet 2



LIONEL D. THOMPSON
INVENTOR.

BY *Walter R. P. Moran*
John P. Moran
ATTORNEYS

1

3,358,664

ENGINE CONTROL DEVICE

Lionel D. Thompson, Bloomfield Hills, Mich., assignor to
Holley Carburetor Company, Warren, Mich., a corporation of Michigan

Filed June 21, 1965, Ser. No. 465,422

10 Claims. (Cl. 123-140)

ABSTRACT OF THE DISCLOSURE

This application discloses an engine fuel system comprising a fuel pump having a fuel control element and an integral maximum-minimum speed governor wherein a force produced by engine driven flyweights opposes an idle spring to govern idle speed and both the idle spring and a preloaded maximum speed governor spring to govern maximum speed, the system including a manually-operated throttle, linkage between the throttle and the fuel control element, a torsion bar member disposed between the flyweights and the portion of the linkage connected to the fuel control element, whereby the torsion spring element modifies the natural fuel flow characteristics of the pump and the engine torque characteristics at engine speeds between idle speed and maximum speed, and means cooperating with the torsion bar member for selecting the nature of the effect of the torsion bar member.

This invention relates generally to engine control devices, and more particularly to a fuel modulating device for internal combustion engines.

A need has developed for a fuel modulating device operable in conjunction with an engine governor, a maximum-minimum governor for example, and the particular engine fuel control linkage for the purpose of tailoring the Fuel Flow Engine Speed relationship to obtain desired torque, lugging, smoke control, or other engine operating characteristics.

For example, some diesel engines, to which fuel is supplied in definitely metered quantities per revolution, have the inherent problem of excessive smoke emission at low speed operation, this being particularly true for engines having a relatively linear Fuel Flow-Engine Speed characteristic. The invention contemplates means to automatically modify the natural engine and fuel system characteristics, for example to cause fuel flow to decrease as engine speed decreases, as due to an increase in load while the accelerator pedal or other manual control lever is in its maximum fuel or some other fixed position at the low speed end of the curve so as to substantially reduce smoke emission.

Accordingly, a general object of the invention is to modulate fuel flow relative to engine speed and in accordance with special operational requirements.

Another object of the invention is to provide means which will reduce low r.p.m. smoking of an engine to a value lower than normally encountered at a fixed accelerator setting.

Still another object of the invention is to provide such a means which may be very simply adjusted to vary the amount that fuel flow can be automatically changed relative to engine speed at a fixed accelerator position.

Still another object of the invention is to provide such means which may be readily adjusted to change the angle of the altered Fuel Flow or Torque vs. Engine r.p.m. curves, either at the low speed end of the curves or the entire curves.

A specific object of the invention is to provide such a means which includes a torsion bar means for automatically modifying the effect of the usual fuel control linkage on fuel flow relative to engine speed.

2

These and other objects of the invention will become more apparent when reference is made to the following specification and the accompanying drawings wherein:

FIGURE 1 is a fragmentary, schematic illustration of a diesel engine with which the invention may be employed;

FIGURE 2 is a perspective illustration of a diesel engine governor embodying the invention;

FIGURE 3 is a cross-sectional view taken along the plane of line 3-3 of FIGURE 2 and looking in the direction of the arrows; and

FIGURE 4 is a graph illustrating the variation of certain engine characteristics made possible by use of the invention.

Referring now to the drawings in greater detail, FIGURE 1 is a very simplified schematic illustration of a diesel engine 10 having a well-known type of fuel pump 24 and the performance of which may be improved by the use of the invention. The engine may have any number of cylinders 12, each of which is supplied with fuel from the reservoir 14 through the inlet conduit 16, the outlet conduit 18 and the nozzle 20, the nozzle having the usual spring loaded check valve 25 which is open to admit fuel each time the pump piston or plunger 22 is moved upwardly in its pumping stroke. The piston 22 is, of course, moved in its pumping stroke against the force of the return spring 28 whenever a cam 27 on the cam shaft 26 engages the retainer 30 secured to an extension of the piston 22.

The piston 22 has formed on the outer periphery thereof gear teeth 32 that remain in mesh with the teeth on the rack 36 at all times regardless of the axial position of the piston, movement of the rack to the right or left in FIGURE 1 causing rotation of the piston. The piston is further formed with a slot 34 having one helical edge cooperating with the inlet 16 in a manner so that a variable quantity of fuel can be injected, depending upon the rotational position of the piston. In other words, when the piston 22 is at the bottom of its downward filling stroke, fuel is supplied to the chamber above the piston through the inlet conduit 16. At the proper time in the cycle, the piston 22 rises to seal the inlet port, thereby forcing the trapped fuel through the outlet conduit and the nozzle. The end of the injection period occurs when the inlet port 16 is uncovered by the helical groove 34 formed in the piston, at which time the high pressure fuel is relieved through the slot 34 to the inlet conduit 16. A more detailed description of FIGURE 1, which represents prior art, can be found on page 6 of Internal Combustion Engines, Second edition, by Edward F. Obert.

Movement of the rack 36 is accomplished in a manner which will be described. It should be understood, however, that in some applications the member 36 may be a shaft, a lever, or some other device; that is, rotation of piston 22 need not always be by a rack and gear mechanism.

Referring now to FIGURE 2, it may be noted (see arrows) that the lever 38 may be pivoted about a fixed pivot pin 40 by manual movement of the usual operator's accelerator pedal 42 and suitable linkage 44. It will be noted that at any particular setting of the accelerator pedal 42, the pivot pin 46 located at the lower end of the lever 38 will serve as a fixed pivot point. A second lever 48 is pivotally secured to the pivot pin 46 at its one end and fixedly attached to an end of the rack 36 at its other end. Initial force on the lever 48, tending to pull the rack 36 to the left in FIGURE 2, is provided by a resilient means such as the idle spring 50, which is fastened at its one end to a midpoint of the lever 48 and at its other end to a manually adjustable mounting pin 52.

A means for producing an axial force proportional to the speed of the engine 10 may consist of flyweights 54, each of which pivots outwardly about a pin 56 (FIGURE

3) in response to increased engine speed. Projections 58 formed on the flyweights 54 abut against a member 60 which is slidably mounted on the end of the cam shaft 26. The structure described thus far in connection with FIGURES 2 and 3 is also known in the art.

A fuel modulating assembly 62 contemplated by the invention is mounted for rotation on a shaft 63 secured in a support member 64, and it includes an upwardly extending torsion bar 66 (FIGURE 2) having a cross-arm 68 provided on the upper end thereof and urged into contact with the member 60 by the lever 48, the latter being held against an extension 69 of the cross bar 68 by the idle spring 50. A pair of adjustable screws 70 and 72 are threaded in a member 74, which is also pivotable on the shaft 64, so as to be engageable with the cross-arm 68. As illustrated in FIGURE 3, it may be noted that the adjustable screws 70 and 72 straddle the torsion bar 66, for a purpose which will be explained later. It will also be noted later that the screws 70 and 72 may at times be fixed pins and may be located either in member 74 or in member 68.

In order to perform a proper maximum speed governing function, the member 74 remains rigid against the usual adjustable stop 75 until such time as the flyweight force on member 60 due to increasing engine speed exceeds the restraining force of governor spring 76, at which time the member 74 moves to the right in FIGURE 2, resulting in the rightward movement of the rack 36. This, of course, reduces the fuel flow and provides overspeed protection, resulting in the usual governor hook (see line G, FIGURE 4). The location of the mounted end of the spring 76 may be changed, if desired, by means of a manually adjustable pivot pin 78, in order to change the spring force and the position of the governor hook.

Operation

It will now be assumed, for purposes of illustration, that the engine 10 is equipped with a pump 24 which delivers fuel to the injection nozzle 20 in accordance with a fuel flow per cam shaft revolution or pump stroke vs. engine speed relationship as illustrated by the straight solid line curve E'C' of FIGURE 4, in which all curves are for the maximum fuel position of throttle or pedal 42, or for any other fixed pedal position. It is also assumed that such a Fuel-Flow—r.p.m. relationship results in a typical Engine Torque vs. Engine Speed curve as illustrated by the dash line curve I'HBA of FIGURE 4. Such normal or natural Fuel Flow and Torque curves would prevail if the fuel modulating assembly 62 embodying the invention were not employed and the speed responsive member 60 acted directly against the member 74, which is urged against stop 75 by spring 76 in a manner similar to prior art maximum-minimum governor systems, such as that shown by Buck et al. 2,507,689 wherein stop 45 eliminates spring 36 until flyweight force due to speed reaches a predetermined value (see columns 2 and 6).

It will be apparent to those skilled in the art, by reference to the foregoing description and FIGURES 2 and 3, that at no-load curb idle operation the engine speed is low and the flyweights are substantially in their retracted position, as shown in dotted lines in FIGURE 3. Since the torsion member 66 is freely pivotable on pivot 63 and since member 74 is pulled against its stop 75 by governor spring 76, lever 48 which is pivotable about the pin 46, is fixed for any given position of the pedal 42. Thus, the spring 76 is out of action, and idle spring 50, which is always applying a force on lever 48, alone urges lever 48 in a counterclockwise direction about the pivot 46 so as to cause the torsion bar 66 to also pivot counterclockwise on pivot 63 so that the cross bar 68 always engages the member 60 movable by the flyweight 54. Counterclockwise movement of the lever 48 also moves the rack 36 in the more fuel direction, and idle speed is determined by a balance of forces between the member 60 and the

idle spring 50, assuming the rack 36 is initially assembled properly.

In the idle condition, the operation is as if the member 74 and spring 76 were not even present, and the torsion bar 66 and its cross member 68 act merely as linkage between the lever 48 and the member 60. The torsion bar 66 does, of course, twist some minute amount because the application of the governor flyweight force through member 60 is displaced from the point of engagement of lever 48 with extension 69 and opposes the force of spring 50, but this twisting or spring action is minute and it is considered in the idle setting. Also, it is noted from FIGURE 3 (dotted lines) that at this time the cross bar 68 is not touching either of the pins 70 or 72. The only time cross bar 68 would be touching pin 70 or 72 during the engine idle condition would be perhaps on a downhill overrun when accelerator pedal 42 is at a minimum fuel position and the special characteristics of the invention are not required.

When the governor member 60 moves out a sufficient distance due to increasing engine speed so that the cross arm 68 first engages or bottoms out on the nearest of the pins 70 or 72, then there is a period of time when the spring rate of the torsion bar is involved to cause a modification of the natural fuel flow, and consequently a modification of engine torque, because twisting of the torsion bar 66 repositions the support or stop 69 for the lever 48 biased by the spring 50. The torsion spring effect continues until the cross arm 68 engages both of the pins or screws 70 or 72. Further increase in speed and associated increased forces of member 60 do not alter the natural Fuel Flow vs. r.p.m. characteristics of the pump until the force is great enough to overcome the preload setting of spring 76, at which time the fuel flow will be as indicated by line G. The force of spring 76 is so much greater than the force of the torsion bar 66, in most applications, that the torsion bar cross member 68 bottoms out on both of the pins or screws 70 and 72 before the force of the spring 76 is overcome.

Referring now to FIGURE 4, it will be remembered that the linear fuel flow curve E'C' and the torque curve I'HBA are typical natural Fuel Flow and Torque vs. Engine Speed curves, respectively, at a fixed accelerator 42 position. If it is desired to modify the low speed end of the above curves to provide curves IH, in the case of torque, or curves PF or LM, in the case of fuel flow, screw 72 is set (opposite to the setting shown in FIGURE 3) so that it is high or closer to the cross arm 68, as compared to screw 70, with the result that cross arm 68 will contact screw 72 before it touches screw 70. Thus, as speed increases so as to increase the force applied by member 60 on the cross bar 68, the torsion bar 66 will twist in a direction to move support or stop 69 to the left in FIGURE 2, allowing spring 50 to cause the lever 48 to increase fuel and torque along curves different from the natural or normal pump curves. Of course, when the cross bar 68 bottoms on both screws 70 and 72, then, from that point on, as the speed is further increased, the engine torque and fuel flow characteristics are normal, or as they would be in the same engine not having the torsion bar modification structure, until the maximum speed governor control spring 76 takes effect, as shown by line G of FIGURE 4.

The cross-sectional area and length and other physical characteristics of the torsion bar 66 which would effect its spring rate determine the slope of the altered torque and fuel flow curves.

The preceding discussion explained how use of the invention alternates the fixed pedal Fuel Flow and Torque vs. Engine Speed relationships on the so-called back side or low speed end of these curves. The alternation described with reference to FIGURE 4 is especially desirable in that it reduces low speed exhaust emission and smoking of the engine.

It can be readily seen that the above described torsion bar device, if dimensioned and adjusted differently, as where the pins 70 and 72 are reversed as to height so that the cross bar 68 rotates in a counterclockwise direction because screw 70 is engaged first (see FIGURE 3), then the modified lower speed end portions (PF or LM and IH) of the Fuel Flow and Torque curves will lie above the original natural curves (E'C' and I'A) because the stop or support 69 for lever 48 is moving in the decreasing fuel direction with increasing speed.

On the other hand, if the spring rate of the torsion bar is sufficiently high so that it does not bottom on both screws, regardless of their relative adjustments, until governed maximum speed is reached, at which time spring 76 is overcome, then the Fuel Flow curve will be modified over the entire speed range, and this can and will normally modify the entire Torque curve. It is possible, for example, to provide a torsion bar spring rate that will result in a more horizontal fuel flow curve, which would have the effect of providing a torque curve having a greater negative slope (BA' in FIGURE 4) at the high speed end thereof, resulting in a greater increase in torque with decreasing engine speed at the high speed end, as compared to the normal curve, thereby providing an engine having much improved lugging characteristics.

The above described structure embodying the invention may be constructed and adjusted so that the modified curves can be varied both in slope and in the point at which they meet the natural curves for an engine not embodying the invention, up to and including modification of the entire curves. It is not possible, however, to modify only the high speed end of the curves without modifying the lower speed end of the curve.

It is thus apparent that the structure described and shown as embodying the invention provides a single, simple, adjustable structure for modifying the Torque and Fuel Flow vs. Engine Speed characteristics of an engine and provides the engine designer with greater design flexibility, particularly when employed along with other modifications of the fuel pump.

It should be apparent that the invention, when employed in conjunction with a conventional governor system, provides more versatile control of an engine, including automatic compensation for various inherent operating characteristics of a particular engine. That is, the invention provides means to automatically modulate fuel flow relative to engine speed and in accordance with special operational requirements.

It should be further apparent that, in a particular application only one of the screws 70 and 72 need be adjustable while the other could be a fixed pin. Furthermore, under production conditions, once a particular ideal setting is determined, both members 70 and 72 may be fixed pins or pivots.

It should also be apparent that the fuel modulating concept of the invention may be incorporated in various applications other than diesel engines. That is, the torsion bar assembly may control any kind of fuel control lever or valve, not in any way limited to the rack and piston assembly illustrated in the drawings.

While but one embodiment of the invention has been shown and described, it is apparent that other modifications of the invention are possible within the scope of the appended claims.

What I claim as my invention is:

1. An engine fuel system, said system comprising a fuel injection pump having a maximum-minimum type governor operative to automatically control engine speed when the engine reaches maximum speed and when the engine is slowed to idle, a manually operated throttle connected by linkage to a fuel control element in said pump, said linkage including a pivotally mounted lever connected to said fuel control element and urged at all times by a first idle spring in the increasing fuel direction against the opposing force of a speed responsive assembly

driven from said engine, a second maximum speed governor spring and a member urged thereby against a stop so that said maximum speed governor spring is preloaded and inoperative until maximum speed corresponding to said spring preload is reached and a torsion bar mounted at one end and having a cross bar at the other end thereof disposed between said assembly and said member, a portion of said cross bar cooperating with said lever so as to be capable of repositioning the same, said cross bar being held in continuous engagement with said assembly by said lever due to the force of said idle spring, a pair of spaced abutments between said member and said cross bar, said abutments having different heights so that engagement of said cross bar and said member first occurs at the higher of said abutments as said cross bar moves toward said member, increasing engine speed at any given fixed position of said manually operated throttle causing said assembly to move said cross bar toward said member and thereby reposition said lever, and said fuel control element in the decreasing fuel direction until said cross bar engages said member through one of said abutments, said cross bar thereafter pivoting about the axis of said torsion bar in a direction dependent upon which one of said pair of abutments is higher and thereby repositioning said lever in the increasing or the decreasing fuel directions until said cross bar engages said member at both of said abutments, any increase in speed thereafter causing the increasing assembly force to also oppose the force of said second maximum speed governor spring.

2. An engine fuel system, said system comprising a fuel injection pump having a centrifugal flyweight maximum-minimum type governor operative to automatically control engine speed when the engine reaches maximum speed and when the engine is slowed to idle, a manually operated throttle connected by linkage to a fuel control element in said pump, said linkage including a pivotally mounted lever connected near one end to said fuel control element and urged at all times by a first spring in the increasing fuel direction against the opposing force of said flyweights, a second maximum speed governor spring and a member urged thereby against a stop so that said maximum speed governor spring is preloaded and inoperative until maximum speed related to said spring preload is reached and a torsion bar mounted at one end and having a cross bar at the other end thereof disposed between said flyweights and said member, a portion of said cross bar engaging said lever so as to be capable of repositioning the same, said cross bar being held in continuous engagement with said flyweights by said lever due to the force of said idle spring, a pair of spaced abutments between said member and said cross bar, said abutments having different heights so that engagement of said cross bar and said member first occurs at the higher of said abutments as said cross bar moves toward said member, increasing engine speed at any given fixed position of said manually operated throttle causing said flyweights to move said cross bar toward said member and thereby reposition said lever, and consequently said fuel control element, in the decreasing fuel direction until said cross bar engages said member through one of said abutments, said cross bar thereafter pivoting about the axis of said torsion bar in a direction dependent upon which one of said pair of abutments is higher and repositioning said lever in the increasing or the decreasing fuel directions until said cross bar engages said member at both of said abutments, any increase in speed thereafter causing the increasing flyweight force to also oppose the force of said second maximum speed governor spring.

3. A system such as that recited in claim 1, wherein at least one of said abutments is adjustable so that the relative heights of said abutments may be varied or reversed, thereby changing the extent of or reversing the pivotal movement of said cross bar about the axis of said torsion bar.

7

4. A system such as that recited in claim 1, wherein at least one of said abutments is formed on said member.

5. A system such as that recited in claim 1, wherein said speed responsive assembly force is applied to said cross bar at a point between said abutments.

6. A system such as that recited in claim 1, wherein said pump includes a fuel plunger for each engine cylinder, each plunger having a gear, and said fuel control element comprises a common rack in mesh with said gear and secured for movement with said lever.

7. A diesel engine fuel system, comprising a fuel pump wherein the fuel supplied is controlled by a common element, said pump including an integral maximum-minimum speed governor wherein engine driven flyweights oppose an idle spring to govern idle speed and said flyweights oppose said idle spring and a preloaded maximum speed spring to govern maximum speed, a manually-operated throttle, linkage between said throttle and said fuel control element, and a torsion bar member disposed between said flyweights and the linkage connected to said fuel control element, whereby said torsion spring element modifies the natural fuel flow characteristics of said pump at engine speeds between idle speed and maximum speed.

8. A fuel system such as that recited in claim 7, where-

8

in means are provided for determining the beginning and the end of the effect of said torsion bar.

9. A fuel system such as that recited in claim 7, wherein means are provided for causing said torsion bar to increase fuel with increasing speed, as compared to the natural fuel flow characteristic of said pump.

10. A fuel system such as that recited in claim 7, wherein means are provided for causing said torsion bar to decrease fuel with increasing speed, as compared to the natural fuel flow characteristic of said pump.

References Cited

UNITED STATES PATENTS

15	2,117,248	5/1938	Hurst et al.	123—140
	2,123,433	7/1938	Mayo et al.	123—139
	2,139,194	12/1938	Lichtenstein	123—240
	2,259,693	10/1941	Hogeman	123—140
20	2,507,689	5/1950	Buck et al.	123—140
	2,539,738	1/1951	Grim et al.	123—139
	2,739,802	3/1956	Pope	123—139
	3,234,927	2/1966	Cramer	123—140

LAURENCE M. GOODRIDGE, *Primary Examiner*,