United States Patent

[11] 3,590,794

[72] Inventor Roger O. Durham, 3958 Marathon St., Los Angeles, Calif.

[21] Appl. No. 783,984
[22] Filed Dec. 16, 1968
[45] Patented July 6, 1971

[54] **FUEL INJECTION AND TRANSFER PUMP**
26 Claims, 8 Drawing Figs.

[52] U.S. Cl. ..... 123/140 MP, 123/139 AW
[51] Int. Cl. F02m 51/02
[50] Field of Search ..... 123/139, 139 B, 123.8, 139.15, 139.17, 139.18, 139.2, 140, 140.2, 140.3; 103/5

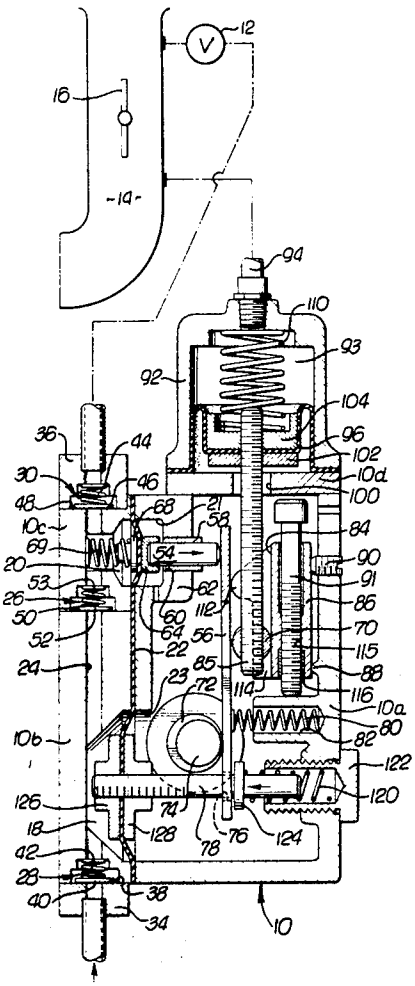
[56] References Cited

UNITED STATES PATENTS

1,466,085	8/1923	Buschke	123/139 X
1,726,303	8/1929	Knudsen	123/139.2
3,046,894	7/1962	Machen	123/140.3
3,354,876	11/1967	Durham	123/140.2

Primary Examiner—Laurence M. Goodridge
Attorney—Flam and Flam

ABSTRACT: A fuel injection pump operates on the fuel density principle. A pump element 54 (FIGS. 1 and 2) is reciprocated in order to deliver a controlled volume of fluid each cycle to the intake manifold 14. A lever 56 operates the pump element 54 and is reciprocated about a fulcrum 70. An eccentric 72 synchronized with the engine shaft operates the lever 56.



PATENTED JUL 6 1971

3,590,794

SHEET 1 OF 3

FIG. 1.

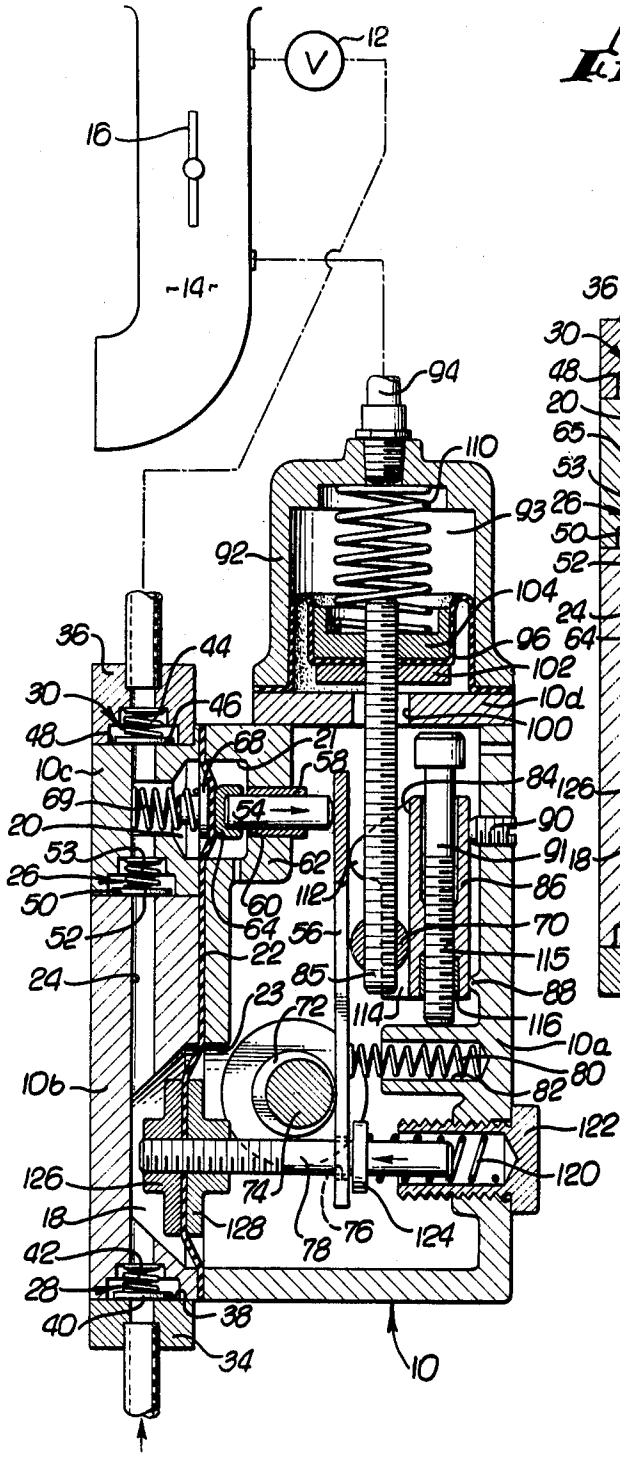
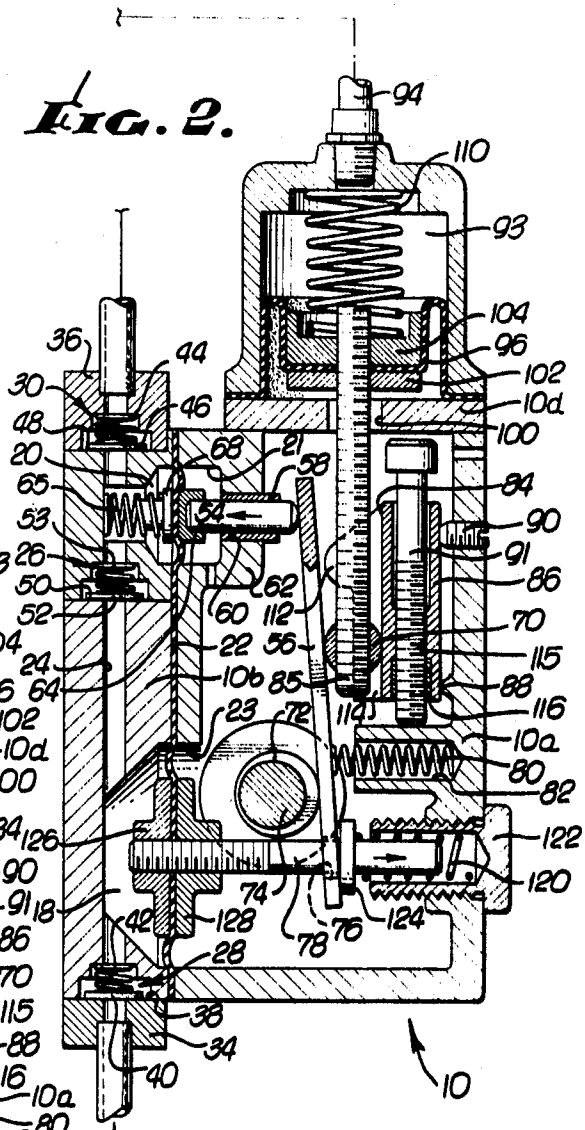


FIG. 2.



INVENTOR.
ROGER O. DURHAM
By Flam and Flam
ATTORNEYS.

FIG. 3.

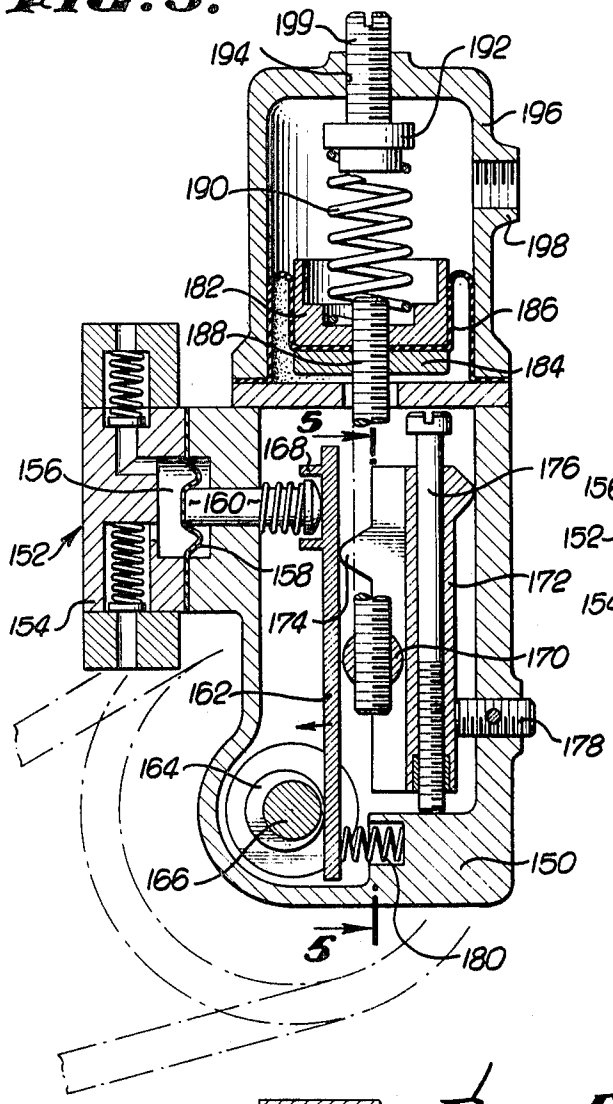


FIG. 4.

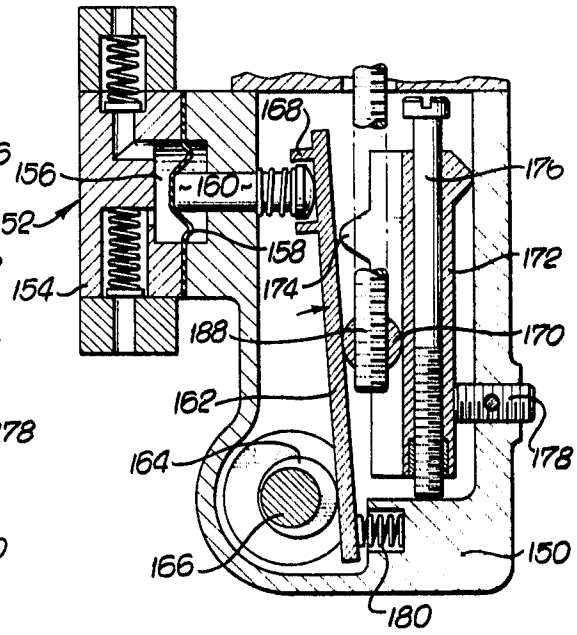
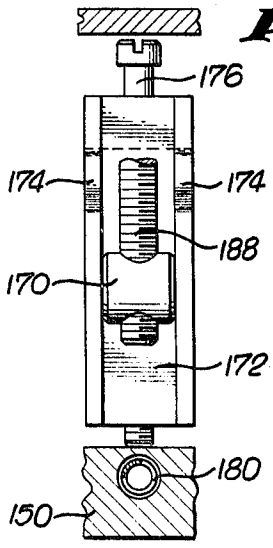


FIG. 5.



INVENTOR.
ROGER O. DURHAM
By Flam and Flam
ATTORNEYS.

FIG. 6.

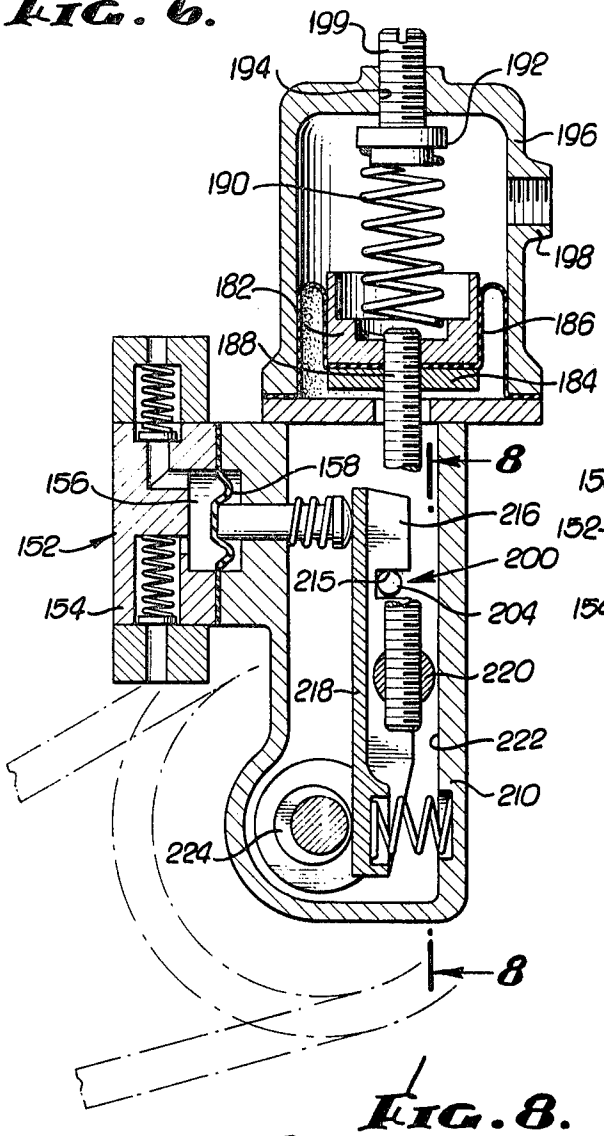


FIG. 7.

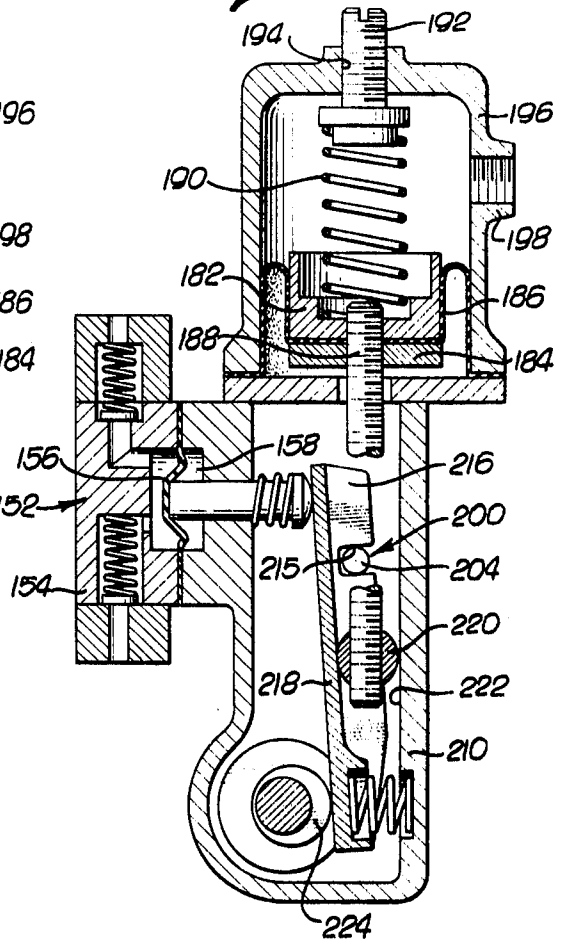
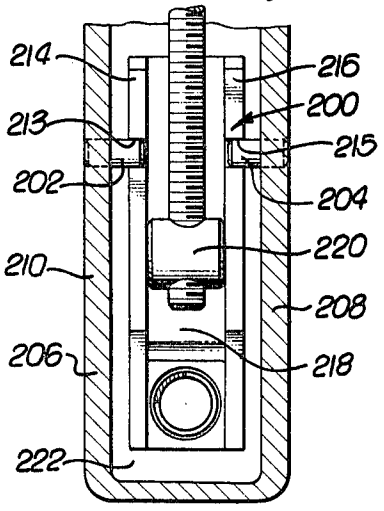


FIG. 8.



INVENTOR.
ROGER O. DURHAM
By Flam and Flam
ATTORNEYS.

FUEL INJECTION AND TRANSFER PUMP

RELATED APPLICATIONS

My copending application Ser. No. 716,780 filed Mar. 28, 1968 and entitled "Speed-Density Fuel Injection Pump" discloses related subject matter, as does my U.S. Pat. No. 3,354,876.

BRIEF SUMMARY OF INVENTION

This invention relates to a fuel injection pump of the type in which fuel is delivered to the combustion chamber at a rate proportional both to speed and to intake manifold pressure. A sensing element responsive to manifold pressure effectively adjusts the per cycle displacement. The theory of operation of such speed-density pumps is well known. Optimum fuel-air ratios are maintained for maximum efficiency and minimum contamination exhaust products.

Friction within pumps of previous configuration restricts the free response of the sensing element, resulting in hunting or insufficient or excessive compensation. In my above-identified copending application there is disclosed a positive displacement pump designed to provide sensitive and rapid response that operates by positioning an abutment in the path of movement of the pump element in accordance with manifold pressure whereby the return stroke is variably reduced. In my above-identified patent, there is disclosed a positive displacement pump that operates by changing the fulcrum position of a multiple lever system.

One object of this invention is to provide a simpler variable displacement pump that operates on the movable fulcrum principle, but which yet retains the desirable design features of sensitive and rapid response. This is made possible by a floating mounting for a single lever. This mounting determines operative lever positioning only at the end of the cycle at which the fulcrum is relieved of pump load.

In the usual fuel injection system, a transfer pump is ordinarily provided to deliver a sufficient supply of fuel to the metering fuel injection pump to satisfy demand. Such a transfer pump provides a nearly constant pressure at the inlet to the metering pump in order to ensure flow free of vapor formation despite volatility, resistance of check valves, fuel lines, etc., despite the speed of operation. An accumulator chamber is sometimes provided between the pumps.

Another object of this invention is to provide a compact structure that performs the functions of the transfer pump. The work strokes of the two pumps are always in a fixed phase relationship relative to a common drive, and efficient operation results without a separate accumulator chamber.

Another object of this invention is to provide a simple mechanism whereby easily made adjustments determine displacement of the metering pump at idle conditions independently of the other operational characteristics of the mechanism.

This invention possesses many other advantages and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification, and which drawings are true scale. These forms will now be described in detail illustrating the general principles of the invention. Structural and operational characteristics attributed to forms of the invention first described shall also be attributed to forms later described, unless such characteristics are obviously inapplicable or unless specific exception is made. It is to be understood that the following detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1, 3 and 6 are similar sectional views of three different embodiments of the invention.

FIGS. 2, 4 and 7 are sectional views corresponding to FIGS. 1, 3 and 6, but illustrating the position of parts at different portions of the cycle.

FIGS. 5 and 8 are sectional views taken along planes corresponding to lines 5–5 and 8–8 of FIGS. 3 and 6 respectively.

DETAILED DESCRIPTION

In FIGS. 1 and 2 there is illustrated a pump casing 10 housing components that coact to withdraw fuel from a tank (not shown) and inject it in controlled or metered amounts past a pressure relief valve 12 and into the intake manifold 14 of the engine. A butterfly or other suitable throttle valve 16 controls the admission of air in a conventional manner.

The casing 10 houses two pump stages. The first stage pumps fuel from the supply tank and holds it at a chamber 18 at a substantially constant pressure for use by the second stage. The second stage of the unit admits fuel into a metering chamber 20 and expels it therefrom at a rate related to the operating conditions of the engine. Thus the flow from the metering chamber 20 is directly proportional to engine speed and inversely proportional to manifold vacuum. The mechanism for adjusting the flow from the metering chamber will be described hereinafter. First the parts forming the chambers 18 and 20 will be described.

The casing 10 is formed by four main parts 10*a*, 10*b*, 10*c* and 10*d*. The part 10*a* may be formed as a hollow casting having provisions (not shown) for mounting adjacent the engine. The casing parts 10*b* and 10*c* are secured together to form a common plate attached at one flat side surface of the casting 10*a*. The parts 10*b* and 10*c* have recesses opposed to the flat casting side, and defining the chambers 18 and 20. The chambers 18 and 20 are closed by a common diaphragm 22 capable of flexing to vary the volume of the pump chambers. To permit such flexing, the casting 102 has a recess 21 opposite the chamber 20 and has an opening 23 opposite the chamber 18.

A bore 24 through the casing parts 10*b* and 10*c* intersects both chambers 18 and 20 and forms inlets and outlets for them. That part of the bore between the chambers forms the outlet from the first and the inlet to the second. A check valve 26 in interposed in the passage 24 at the juncture of the casing parts 10*b* and 10*c*. A check valve 28 at the lower end of the passage 24 allows the buildup of pressure in the holding chamber 18. A check valve 30 at the upper end of the passage 24 allows the pressure to be reduced for drawing fuel into the metering chamber past the check valve 26.

Inlet and outlet fittings 34 and 36 are clamped to the ends of the casing parts 10*b* and 10*c*. The fitting 34 provides a seat 38 for the closure element of the valve 28. The passage 24 is counterbored to accommodate the closure 40 as well as a spring 42 for urging the closure 40 against the seat 38. The fitting 36 is counterbored to provide a space for the spring 44 that urges the closure 46 against a seat 48 provided by the end surface of the casing part 10*c*. A seat 50 is formed on the casing part 10*b* for the closure member 52 of the check valve 26. The casing part 10*c* is counterbored to accommodate the spring 53 that urges the closure member 52 toward the seat 50.

The diaphragm 22 is reciprocated for displacing fuel from the chamber 20. For this purpose an actuator mechanism is provided comprising a push rod or pump element 42 and a lever 56. The push rod or pump element 54 is guided for rectilinear movement in a bushing 58 accommodated in an aperture 60 in an offset wall portion 62 that forms the recess 21. A cap 64 carried at the outer end of the rod 54 engages the diaphragm 22 on one side. A button 68 engages the diaphragm from the inside of the chamber 20 and keeps it in following relationship with the cap 64 and element 54 by the action of a spring 69. Reciprocation of the rod 54 causes fluid displacement in an amount directly proportional to the stroke of the rod 54. The upper end of the lever 56 engages the inner end of the rod and moves it by oscillating about a main fulcrum 70. The lower other end of the lever is engaged by an eccentric 72

attached to a shaft 74. The shaft 74 extends transversely of the casing 10 and is supported by suitable bearing structures. The shaft 74 is coupled to the engine so that the greater the engine speed, the greater the speed of the metering pump.

The lever 56 has an aperture 76 that rides on a second rod 78 to be described more fully hereafter. This locates the lower end of the lever 56. The upper end of the lever is held in position by the restraint of the sidewalls of the casing part. A spring 80 accommodated in a recess 82 keeps the lever in following relationship with the eccentric 72.

In order to make the displacement per cycle inversely proportional to vacuum of the intake manifold 12, the fulcrum 70 is moved closer to or farther from the eccentric. When the manifold pressure is high (throttle open), the fulcrum 70 moves downwardly toward the eccentric 72 and the displacement per cycle increases. When the manifold pressure decreases (throttle closed), the fulcrum 70 moves upwardly away from the eccentric 72 and the displacement per cycle reduces.

The fulcrum 70 is in the form of a cylinder having a transverse threaded opening engaged by a threaded rod 85. The fulcrum 70 tracks along a surface 84 of a guide 86 mounted in the casing behind the lever. The guide is urged laterally against stops projecting inwardly of the casing wall and the fulcrum, in turn, is held against the guide track by virtue of the force of the pump spring 69. The spring 69 acts through the rod 54, lever 56 and the fulcrum 70. One of the stops 90 is in the form of an adjustment screw to determine the tilt of the guide surface 84 relative to the lever for purposes hereinafter to be described. An adjustment screw 91 carries the guide 86 and is trapped by casing parts.

The rod 85 and fulcrum 70 are positioned in accordance with manifold pressure by the aid of a simple transducer mechanism. This mechanism includes a cup 92 forming a chamber 93 that communicates with the manifold 14 via a conduit 94. The open end of the cup 92 is closed by a rolling diaphragm 96 to which the rod 85 is connected. The edges of the diaphragm 96 are clamped between the casing part 10*d* and the rim of the cup by suitable means (not shown). The rod 85 extends through a clearance aperture 100 in the casing part 10*d* and through the center of the diaphragm 96. Nut members 102 and 104 clamp opposite sides of the diaphragm and serve to connect it to the rod 85. A compression spring 110 located in the cup engages the inner nut member 104 to urge the diaphragm outwardly. The spring force is opposed by the net inward force due to manifold vacuum. As the vacuum increases (throttle closed), the rolling diaphragm 96 together with the nut members 102 and 104, the rod 85 and fulcrum 70 move upwardly. A decrease in displacement per cycle results. Similarly, a decrease in intake manifold vacuum (throttle open) allows the compression spring 110 to move the rolling diaphragm 96 downwardly, whereupon the displacement per cycle increases.

In order to allow the fulcrum 70 rapidly and sensitively to positioned in accordance with the pressure in the chamber 93, the spring load on the fulcrum 70 is removed during a short part of the cycle of operation. For this purpose, a supplemental or idle fulcrum is provided. This idle fulcrum 112 is formed as two crests on flanges 114. The flanges 114 extend from sides of the guide surface 84 and form with the surface 84 a channel in which the fulcrum 70 is confined. The idle fulcrum 112 is positioned to engage the lever 56 just prior to the time that the eccentric 72 reaches its nadir and as shown in FIG. 1. At the nadir, a very slight clearance exists between the fulcrum 70 and the lever 56, which is depicted in exaggerated fashion in FIG. 1. The main fulcrum 70 is accordingly unburdened during this portion of the cycle whereby it can freely follow the conditions in the sensing chamber 93. As the eccentric 72 passes its nadir, the lever rotates and is picked up by the main fulcrum 70.

The idle fulcrum 112 is spaced from the guide surface 84 by an amount just slightly greater than the diameter of the main fulcrum 70. The screw 90 is adjusted when the eccentric is at its nadir so that the surface 84 is then parallel to the surface of the lever 56 engaged by the main fulcrum 70.

The strength of the spring 110 determines the excursion of the power fulcrum 70 between full throttle and idle. Full throttle mixture adjustments are made by changing the position of the fulcrum 70 on the rod 85. At idle, the fulcrum 70 retracts to a position between the two crests of the idle fulcrum 112 and is operative. Thus, the delivery at idle conditions is adjusted by moving the fulcrum guide 86 upwardly and downwardly. This is accomplished by the adjusting screw 91. The adjusting screw 91 extends through a bore 115 in the fulcrum guide that parallels the tracking surface 84. The lower end of the bore carries a self-locking insert 116 that keeps the screw 91 from turning of its own accord. The entire sensing mechanism, including the fulcrum 70, rod 85, casing part 10*d* and cup 92, is removed for adjustment of both idle and full throttle mixtures. It will be seen that the engine will continue to idle during adjustment.

The metering pump is supplied with fuel at a constant pressure from the transfer chamber 18. For this purpose, pressure is exerted upon the fluid in the chamber 18 by means of a compression spring 120. This compression spring is accommodated in a recess of a threaded fitting 122 attached to the casing part 10*a*. The spring engages a flange 124 on the push rod 78. The rod 78 in turn is attached to the diaphragm 22 that closes the transfer chamber 18. The rod 78 has a threaded end projecting through the diaphragm 22 and on opposite sides of which nut members 126 and 128 are mounted for clamping the diaphragm therebetween.

Upon withdrawal of fluid from the chamber 18 by the metering pump, the spring 120 moves the flange 124 into the path of retracting movement of the lower end of the fulcrum lever 56. Accordingly, the rod 78 s actuated and fuel is drawn into the transfer chamber 18 during the next half of the cycle which occurs when fuel is being expelled from the metering chamber 20. When fuel is admitted to the metering chamber 20, the spring 120 is operative to pressurize the inlet to the metering pump. These out-of-phase operations are, in this instance, accomplished by using opposite ends of the lever 56 for the respective pumps.

In the form of the invention shown in FIG. 3, no transfer pump is provided. The hollow casing part 150 is thus smaller, since it accommodates only the elements of a metering pump 152. A separate transfer pump is provided. The metering pump structure operates in a manner similar to the form of FIGS. 1 and 2. Casing part 150 cooperates with a small plate 154 to define a metering chamber 156 sealed by a flexible diaphragm 158. A push rod 160 engaging and guided by the casing part 150 follows the movement of an actuating lever 162 that is similar to the lever 56. The lever 162 is oscillated by an eccentric 164 mounted upon a shaft 166. The lever 162 in this instance is held in position by a circular flange 168 encompassing the head of the push rod 160.

A main fulcrum 170 is provided as in the previous form. The main fulcrum 170 tracks along the surface of a fulcrum guide 172. As in the previous form, the guide provides an idle fulcrum 174, the position of which is adjusted by the screw 176. A screw 178 adjusts for parallelism between the fulcrum guide and the lever 162 at the nadir position of the eccentric 164. A compression spring 180 maintains the lever 162 in following arrangement with the eccentric and is similar to the spring 80.

The nut members 182 and 184 attach the rolling diaphragm 186 to a threaded rod 188. In the present instance, a compression spring 190 is held on an adjustable seat 192 at the end of a threaded rod 199. Said adjustable seat 192 is positioned within the cup 196. The threaded rod 199 engages a threaded hole 194 of the cup 196. The fitting to the intake manifold (in the present instance not shown) attaches to a threaded boss 198 at the side of the cup 196. By adjusting the rod 199, the position of the fulcrum 170 is adjusted.

The form illustrated in FIGS. 6, 7 and 8 is similar to the form shown in FIGS. 3, 4 and 5, except that the idle fulcrum 200 is fixed. The idle fulcrum is in the form of a pair of pins

202 and 204 (FIG. 8) that extend inwardly from the sidewalls 206 and 208 of the housing 210. The pins 202 and 204 engage recesses 213 and 215 formed in side flanges 214 and 216 of the lever 218.

In the present instance, the main fulcrum 220 tracks along a guide surface 222 formed on the inside of the case 210 instead of along a separate guide structure. The parts are so proportioned that the guide surface 222 is parallel to the surface of the lever 218 engaged by the main fulcrum 220 when the eccentric 224 is at its nadir.

The side flanges 214 and 216 of the lever 218 serve to locate the lever 218 in proper position. In all other respects the operation is similar to the form of FIGS. 3 to 5.

I claim:

1. In a fuel injection pump cooperable with a rotary drive member coupled to the engine and cooperable with the intake manifold: means forming a pump chamber; a pump element reciprocable in a path for displacing a volume of fuel from the chamber corresponding to the stroke of said element; a single floating lever engageable with the element; a fulcrum engageable with said lever; means operated by the drive member for oscillating the lever about its fulcrum substantially in a plane of oscillation parallel to the path of reciprocation of the pump element, said drive member operated means having a zenith position corresponding to the end of the positive displacement stroke of said pump element and a nadir position corresponding to the end of the negative displacement or return stroke of said pump element; said pump element and said drive member operated means causing said lever to impose a thrust load upon said fulcrum; the stroke of said pump element corresponding to the ratio of the distance of said pump element from said fulcrum to the distance of said drive member operated means from said fulcrum; means responsive to the pressure of said intake manifold for mechanically changing said ratio whereby the displacement per cycle is inversely proportional to the manifold vacuum; and a stop operative when said drive member operated means reaches its nadir relative to the lever for freeing said fulcrum during a short portion of the cycle from the load of said lever whereby said fulcrum is freely positioned in accordance with the manifold vacuum conditions.

2. In a fuel injection pump cooperable with a rotary drive member coupled to the engine and cooperable with the intake manifold: means forming a pump chamber; a pump element reciprocable in a path for displacing a volume of fuel from the chamber corresponding to the stroke of said element; a single lever engageable with the element; a fulcrum engageable with said lever; means operated by the drive member for oscillating the lever about its fulcrum; the stroke of said pump element corresponding to the ratio of the distance of said pump element from said fulcrum to the distance of said shaft operated means from said fulcrum means responsive to the pressure of said intake manifold for mechanically changing said ratio whereby the displacement per cycle is inversely proportional to the manifold vacuum; a demand-type transfer pump for supplying fuel to said injection pump, including a pump element spring biased to pressurize the outlet; and a lost motion connection between the lever and the pump element for said transfer pump and operative to retract it during the delivery stroke of the injection pump.

3. The combination as set forth in claim 2 in which said transfer pump element is spring urged in one direction corresponding to transfer pump displacement, said transfer pump element having an abutment engaged by said lever to move said transfer pump element against the force of said spring during the time that said lever is moving in a direction to cause displacement of said metering pump.

4. In a fuel injection pump cooperable with a drive member coupled to said engine and cooperable with the intake manifold: means forming a pump chamber; a pump element reciprocable in a path for displacing a volume of fuel from the chamber corresponding to the stroke of said element; a single floating lever; means forming a direct connection between one end of said lever and said pump element to cause positive displacement from said pump chamber; a cam carried by said drive member and positioned to engage the other end of said lever; a spring urging said lever to engage said cam; a fulcrum for said lever; the stroke of said pump element corresponding to the ratio of the distance of said pump element from said fulcrum to the distance of said cam from said fulcrum; means responsive to the pressure of said intake manifold for moving said fulcrum whereby the ratio is changed; and stop means operative when said cam means is near a nadir position for freeing said fulcrum during a portion of the cycle from the load of said lever whereby said fulcrum is freely positioned in accordance with the manifold vacuum conditions during said cycle portion.

5. The combination as set forth in claim 4 together with means for adjusting the position of said stop means for varying the displacement per cycle at idle conditions.

6. In a fuel injection pump cooperable with a drive member coupled to said engine and cooperable with the intake manifold: means forming a pump chamber; a pump element reciprocable in a path for displacing a volume of fuel from the chamber corresponding to the stroke of said element; a single floating lever; means forming a direct connection between one end of said lever and said pump element to cause positive displacement from said pump chamber; a cam carried by said drive member and positioned to engage the other end of said lever; a spring urging said lever to engage said cam; a fulcrum for said lever; the stroke of said pump element corresponding to the ratio of the distance of said pump element from said fulcrum to the distance of said cam from said fulcrum; means responsive to the pressure of said intake manifold for moving said fulcrum whereby the ratio is changed; a fulcrum guide providing a surface along which said fulcrum tracks, said surface being substantially parallel to the lever surface engaged by said fulcrum when said cam is at its nadir position; and stop means carried by said fulcrum guide and having a height just exceeding that of said fulcrum whereby clearance between fulcrum and lever is obtained when said cam is near its said nadir position.

7. The combination as set forth in claim 6 together with means for 10*d* said fulcrum guide and the stop means carried thereby correspondingly to adjust the displacement per cycle during idle conditions.

8. The combination as set forth in claim 6 together with means for adjusting said guide to be parallel to said lever when said eccentric is in its nadir position.

9. In a fuel injection pump cooperable with a drive member coupled to the engine and cooperable with the intake manifold: means forming a metering pump chamber; a pump element for said metering pump chamber reciprocable in a path for displacing a volume of fuel from the chamber corresponding to the stroke of the element; a lever having an aperture; a rod extending through said aperture and loosely mounting said lever at one end, the other end of said lever being positioned to engage said pump element; spring means urging said pump element in a direction to engage said lever; an eccentric carried by the drive member and engageable with the lever at a place intermediate the rod and the said pump element; a fulcrum for the lever; means responsive to the pressure of said intake manifold for changing the position of said fulcrum whereby the displacement per cycle from said metering pump chamber is inversely proportional to the manifold vacuum; means forming a transfer chamber; a coupling between said rod and said transfer chamber to cause said rod to act as a pump element for said transfer chamber; spring means urging said rod in a direction to pressurize said transfer chamber; conduit means connecting the outlet of said transfer chamber to the inlet of said metering pump chamber; and a lost motion connection between said lever and said rod for moving said rod against the force of said spring to draw fluid into said transfer chamber during the portion of the cycle in which fluid is displaced from said metering chamber.

10. The combination as set forth in claim 9 together with a guide having a surface along which said fulcrum tracks, said guide surface being substantially parallel to said lever when said eccentric is at a nadir position.

11. The combination as set forth in claim 9 together with a supplemental fulcrum having a fulcrum point spaced from said guide surface by an amount slightly greater than the distance of the fulcrum point of said first named fulcrum whereby said supplemental fulcrum becomes operative at the nadir position of said eccentric and when said first fulcrum approaches the position of said supplemental fulcrum.

12. The combination as set forth in claim 10 together with a supplemental fulcrum carried by said guide having a fulcrum point spaced from said guide surface by an amount slightly greater than the distance of the fulcrum point of said first named fulcrum whereby said supplemental fulcrum becomes operative at the nadir position of said eccentric and when said first fulcrum approaches the position of said supplemental fulcrum.

13. The combination as set forth in claim 11 together with means for selectively shifting the position of said supplemental fulcrum to change the ratio of delivery per cycle at idle relative to delivery per cycle at full throttle.

14. The combination as set forth in claim 12 together with means for selectively shifting the position of said supplemental fulcrum to change the ratio of delivery per cycle at idle relative to delivery per cycle at full throttle.

15. In a fuel injection pump cooperable with the intake manifold of an internal combustion engine and cooperable with the crankshaft of said engine: a casing; a diaphragm means at one side of the casing; closure means clamping the diaphragm means in place, and providing a transfer chamber closed by said diaphragm means and a metering chamber closed by said diaphragm means; a conduit means connecting the outlet of the transfer chamber to the inlet of the metering chamber; a check or nonreturn valve interposed in said conduit means; a pair of pump elements engaging said diaphragm means of said chambers, one forming a transfer pump element and the other forming a metering pump element; spring means urging the transfer pump element inwardly to apply pressure to the fuel in the transfer chamber; a lever; a fulcrum located intermediate said pump elements about which said lever may pivot; a connection between one end of said lever and said metering pump element to cause displacement of said metering pump upon oscillation of said lever; a lost motion connection between said lever and said transfer pump element whereby the stroke of said transfer pump is determined by the volume delivered by said metering pump element on its previous cycle; means for oscillating said lever at a speed proportional to the rotational speed of said crankshaft; and means responsive to intake manifold pressure for shifting the position of said fulcrum.

16. The combination as set forth in claim 15 together with a stop means forming a supplemental fulcrum relieving the first fulcrum when said lever reaches a nadir position.

17. In a fuel injection pump cooperable with a drive member coupled to the engine and cooperable with the intake manifold: means forming a pump chamber; a pump element reciprocable in a path adapted for displacing a volume of fuel from the chamber corresponding to the stroke of the element; a link; an element movable in response to the pressure in said manifold and connected to one end of the link adapted for moving said link in a direction transverse to said path; a fulcrum member carried by the outer end of said link; a single floating lever having a surface engageable with said fulcrum member and engaging said pump element adjacent one end of said lever; a cam carried by said drive member and engaging the other end of said lever adapted for oscillating said lever about said fulcrum member to reciprocate said pump element; means forming a fulcrum guide surface engaging said fulcrum, said fulcrum guide surface arranged to be parallel to said lever when said cam is in its nadir position in relation to said lever; stop means operative when said cam means is near a nadir position relative to said lever, said stop means freeing said fulcrum from the load of said lever during a portion of each cycle.

18. The combination as set forth in claim 17 together with means for adjusting the position of said stop means in such a manner as to alter the ratio of the distance of said pump element from said stop means to the distance of said cam from said stop means.

19. The combination as set forth in claim 17 together with means for adjusting said fulcrum guide surface to be parallel to said lever when said cam means is at its nadir position relative to said lever.

20. In a fuel metering pump with a drive member coupled to said engine crankshaft and cooperable with the intake manifold: means forming a pump chamber; a pump element reciprocable in a path for displacing a volume of fuel from the chamber corresponding to the stroke of said element; a floating lever having one end engaging said pump element; a fulcrum engageable with said lever; an eccentric carried by said drive member and positioned to engage the other end of said lever to cause oscillation of said lever in a plane substantially parallel to the path of reciprocation of the pump element; said eccentric having a zenith and a nadir position respectively corresponding to the ends of the positive and return strokes of said pump element; said pump element and said eccentric causing said lever to impose a load upon said fulcrum; the stroke of said pump element corresponding to the ratio of the distance of said pump element from said fulcrum to the distance of said eccentric from said fulcrum; means responsive to the pressure within said intake manifold for positioning said fulcrum; stop means operative when said eccentric is near a nadir position relative to said lever, said stop means freeing said fulcrum from the load of said lever during a portion of each cycle.

21. The combination as set forth in claim 20 together with means for adjusting the position of said stop means in such a manner as to alter the ratio of the distance of said pump element from said stop means to the distance of said eccentric from said stop means.

22. The combination as set forth in claim 20 together with a fulcrum guide carrying said stop means, said fulcrum guide providing a surface along which said fulcrum tracks, said surface being substantially parallel to the lever when said eccentric is at its nadir position, said stop means being of a height just exceeding that of said fulcrum.

23. The combination as set forth in claim 22 together with means for adjusting the position of said fulcrum guide stop means whereby the ratio of the distance of said stop means from pump operating element to the distance of said stop means from said eccentric may be adjusted.

24. In a fuel injection pump cooperable with a drive member coupled to the engine supplied by said fuel injection pump and cooperable with the intake manifold of the engine:

a. means forming a metering pump chamber having an inlet;
b. a pump element for said metering pump chamber and reciprocable in a path for discharging from the chamber and for drawing into the chamber a volume of fuel corresponding to the stroke of the element;
c. means forming a transfer pump chamber having an outlet;
d. a pump element for said transfer pump chamber and reciprocable in a path for discharging from the chamber and for drawing into the chamber a volume of fuel corresponding to the stroke of the element and in a quantity sufficient to supply the demands of the metering pump chamber;
e. conduit means connecting the outlet of said transfer pump chamber to the inlet of said metering pump chamber;
f. said conduit means including a nonreturn valve;
g. a spring acting directly or indirectly upon said pump element for said transfer pump chamber in order to provide a level of pressure at the nonreturn valve;
h. an actuator reciprocated in a path by said drive member;

i. a direct connection between the actuator and the pump element for said metering chamber whereby a positive displacement is provided from said metering chamber;

j. a lost motion connection between the actuator and the pump element for said transfer pump, said connection being operative to move the pump element for said transfer in opposition to said spring and only during that portion of the cycle of the actuator corresponding to the pressure stroke of the pump element for said metering pump; and

k. means for adjusting the stroke of the actuator in accordance with the pressure of the intake manifold without affecting said direct and lost motion connections whereby said lost motion connection causes said transfer pump chamber to operate in accordance with the demand of said metering pump chamber.

25. In a lever-type fuel injection pump for internal combustion engines, the combination of:

a. a lever-actuated variable-stroke positive displacement injection pump; and

b. a lever-actuated demand-type transfer pump feeding said variable-stroke positive displacement injection pump in out-of-phase relationship.

26. In a lever-type fuel injection pump for internal combustion engines, the combination of:

a. a variable-stroke positive displacement injection pump; and

b. a demand-type transfer pump feeding said positive displacement injection pump in out-of-phase relationship.