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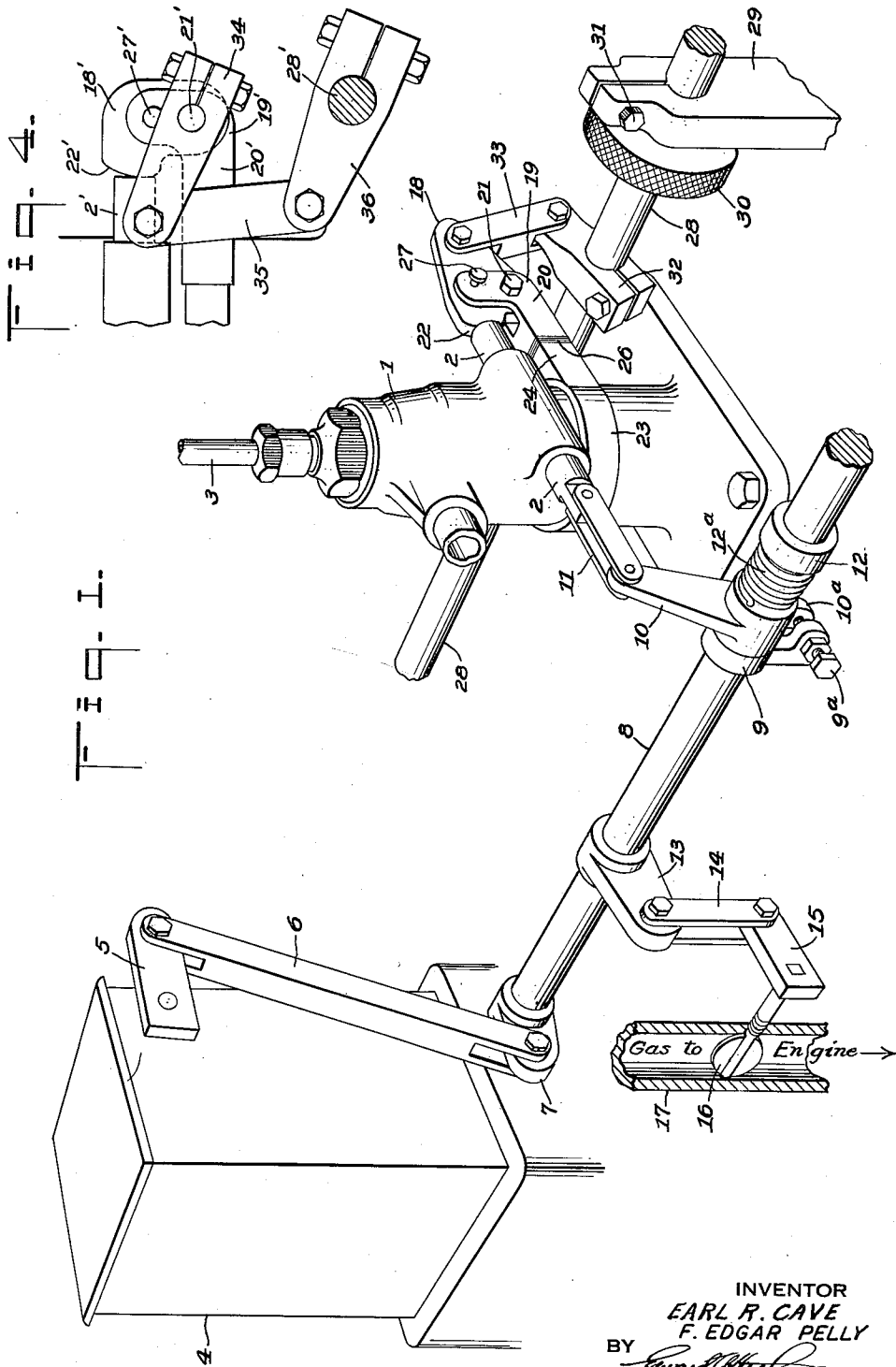
F. E. PELLY ET AL

2,587,376

DUAL FUEL INJECTION PUMP CONTROL

Filed April 27, 1948

2 SHEETS—SHEET 1



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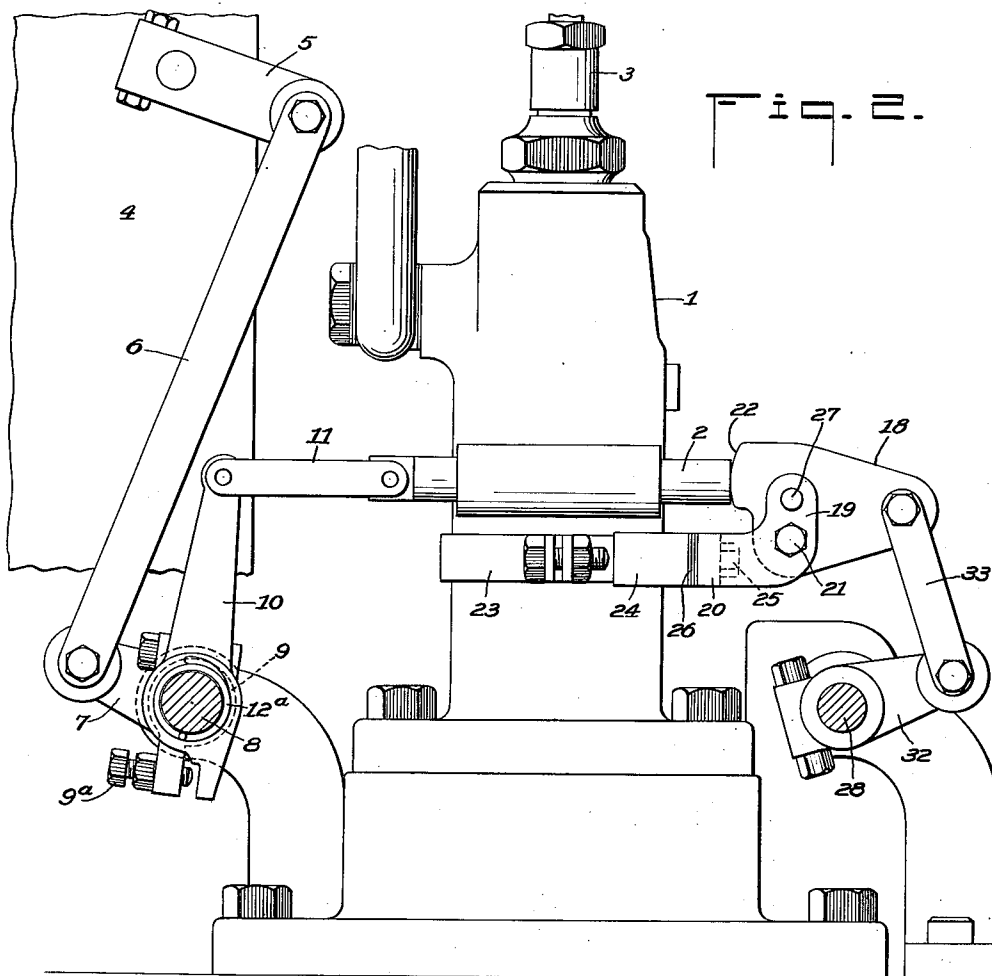
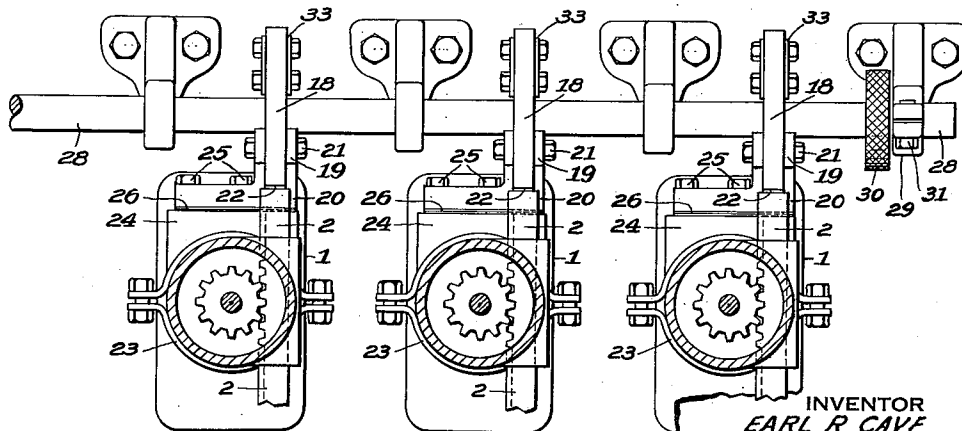
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2 SHEETS—SHEET 2



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DUAL FUEL INJECTION PUMP CONTROL

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This invention relates generally to fuel injection systems for diesel engines and particularly for dual fuel engines. As is well known in the art, dual-fuel engines use, instead of fuel oil, a gas of some kind, such as, for instance, natural gas, which is admitted to the combustion chambers through the air intake manifold or in some other manner. Due to the nature of this gas, compression thereof in the combustion chambers does not cause its spontaneous ignition, as in the case of fuel oil, and accordingly auxiliary means are required to ignite it. While ignition means, such as an electric spark, have been used to accomplish this purpose, a more commonly employed means is the use of pilot charges of fuel oil injected into the combustion chambers by the usual injection pumps. This pilot charge of oil, being ignited by the temperature induced by the compression thereof in the usual manner, then ignites the gas. The purpose of burning gas instead of fuel oil is to make use of gas that may be readily and cheaply available in the vicinity of the location of the engine, such as, for instance, in oil fields where natural gas is to be found in large volume, and thus avoid burning the more expensive fuel oil. To accomplish this economy as fully as possible, the pilot charge of oil should be held to a minimum quantity consistent with being sufficient to assure the ignition thereof and of the gas in the combustion chambers. As some gases are more difficult to ignite than others, the amount of this pilot charge of oil varies and may range, for example, from five to twenty percent of the entire charge. Individual setting of the fuel pump control racks, according to the manufacturer's calibrations thereon, to meter and deliver such a small quantity of oil through the pumps has proved to be inaccurate and unsatisfactory in the case of dual-fuel engines. This is due to inexactness in the machining of pump parts and to inaccuracies in calibrating the fuel control racks, particularly in the range of calibrations indicating these smaller deliveries of oil where the curve of the helix of the pump plunger approaches the longitudinal. Setting the control racks of pumps of a dual-fuel engine according to these rack calibrations has resulted in the delivery of unequal quantities of oil, in the delivery of quantities of oil which are insufficient to cause ignition thereof when subjected to the temperatures and pressure of the combustion chambers, and in the total failure of the pumps to deliver any oil. In addition, when a gas having a different B. t. u. content is to be used it is again necessary to adjust individually all the fuel control rack settings according to the rack calibrations, which is both time-consuming and wasteful of oil. While the device disclosed herein may be used in any type of en-

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gine employing individual fuel injection pumps, it has particular application to dual-fuel engines.

It is an object of our invention to provide improved means for insuring substantially equal predetermined minimum deliveries of fuel oil through the fuel injection pumps for dual fuel operation.

Another object is to provide improved fuel control means that may be effectively adjusted to increase or decrease simultaneously and equally such predetermined minimum quantities of oil and, if desired, to make such adjustment during operation of the engine.

A further object is to provide improved means for not only establishing predetermined minimum quantities of fuel injection for dual operation but also for allowing complete flexibility of fuel control whereby the engine may be easily transferred to straight diesel operation.

Other objects and advantages will be more apparent to those skilled in the art from the following description of the accompanying drawings in which:

Fig. 1 is a perspective view showing the cooperative relation between a conventional fuel injection pump of a dual fuel engine, a governor operatively connected thereto and means acting in conjunction with the control rack of such pump to effect the desired pump operation;

Fig. 2 is a diagrammatic side elevation of most of the elements shown in Fig. 1;

Fig. 3 is a diagrammatic plan view of a number of conventional fuel injection pumps, showing our improved combination therewith including means for simultaneously and equally varying the degree of minimum fuel injection; and

Fig. 4 is a modification of the means for varying the degree of minimum fuel injection.

In the particular embodiment of the invention which is disclosed herein for the purpose of illustrating one specific form among possible others that the invention might take in practice, we have shown in Figs. 1 and 2 one of a number of conventional fuel injection pumps 1 of a dual-fuel diesel engine which per se need not be described as it is well known in the art. Each pump has a usual fuel control rack 2 slidable along its axis through the pump body and whose teeth, Fig. 3, mesh with a geared metering valve within the pump body. The details of such a metering valve are, of course, well known in the art and hence need not be disclosed except in their broader aspects as illustrated herein. To vary the amount of oil delivered by the pump through an outlet pipe 3 to a spray nozzle and combustion chamber (not shown), the control rack 2 is linearly advanced or retracted by a usual speed governor 4 which has an oscillatable arm 5 connected through a link 6 to a collared arm 7 secured to a regulating shaft 8 for oscillating the

same. The oscillating motion is transmitted to fuel control rack 2 first through a collared lever 9 affixed to said shaft and provided with an adjusting screw 9a; then through a free-turning collared lever 10 provided with a lug 10a, Figs. 1 and 2, engageable with adjusting screw 9a; and finally a link 11 connecting collared lever 10 with fuel control rack 2. Such motion of the regulating shaft either advances the rack to the left, as viewed in Figs. 1 and 2, to increase the fuel delivery, or retracts the rack to the right to diminish such delivery. Disposed about regulating shaft 8 and positioned between free-turning collared lever 10 and a spring collar 12 affixed to said shaft is a torsion spring 12a adapted and arranged to bias the outer end of collared lever 10 to the right to exert a continuous yielding pressure in a fuel reducing direction against control rack 2 through link 11. As shown in Fig. 1, governor 4, through regulating shaft 8, a collared lever 13 affixed to said shaft, a link 14, and a lever 15, also performs the function of operating a spring-loaded butterfly valve 16 in a gas supply line 17 to regulate the flow of gas therethrough to the combustion chambers in accordance with the demands of the engine. As the construction and operation of this type of fuel injection pump and of the governor to control the oil through the pumps and the gas to the combustion chambers are well-known and understood in the art, it is deemed unnecessary to describe either further.

To overcome the difficulties incident to the necessity of having extreme nicety of pump control for dual fuel operation we provide means consisting of a stop lever 18 of any suitable contour but preferably that shown in Figs. 1 and 2, which is pivotally mounted on a pin 21 in a bifurcated arm 19 of a bracket 20. A curved edge 22 of stop lever 18 not only provides a line contact with the end of the rack so that stop lever 18 may be rotated with a minimum of friction while in contact with the rack, but is also so offset with respect to fulcrum pin 21 that a portion of such curved edge is advanced or retracted by said rotation. Bracket 20 is preferably clamped to the fuel injection pump body at a convenient point beneath the fuel control rack by a separable clamping ring 23 carrying a mounting member 24 to which the bracket is secured by bolts 25. Shims 26 may be interposed between the bracket and mounting member to insure exact initial positioning of surface 22 relative to control rack 2 in order to obtain the precise minimum amount of fuel for dual fuel operation. After this minimum amount is determined for one particular pump, the stop lever 18 is locked in that position by a removable lock pin 27, of any suitable design, extending through the stop lever and bracket 20. While we have described apparatus of our device as applying to a single fuel injection pump, it is of course understood that identical apparatus is similarly applied to each of the other pumps of an engine and that the stop lever 18 of each pump will be individually adjusted and locked by a pin for dual fuel operation.

The stop means for the several pumps are then connected together to function equally, simultaneously and by means of a single control. To do this, there extends beneath brackets 20 and stop levers 18 of all the pumps a common control shaft 28 mounted in bearings 29, one of which is split. This control shaft is manually rotatable by any convenient means, such as, for instance, a knurled wheel 30 attached to the shaft, and can be locked in any position against movement by

any suitable means, such as, a screw 31 threaded through the farther of the two extended ends of split bearing 29. This control shaft carries a plurality of adjustable collared levers 32, the free ends of which are connected to the outer ends of all stop levers 18 by links 33. When the foregoing connections are fully made, the lock pins 27 are then removed, whereupon rotation of control shaft 28 by wheel 30 in one or the other direction causes curved edges 22 of all stop levers 18, through this linkage means, to be simultaneously advanced or retracted equal distances.

Operation.—The method of assembly and operation of our device are as follows: With the fuel injection pumps removed from the engine, clamping rings 23 carrying mounting members 24 are fastened to the pump body. Disregarding the manufacturer's calibrations on the fuel control racks, each pump is then tested, by a process of trial and error, to meter and deliver a certain estimated quantity of fuel oil per minute, which estimated amount is believed to be the least amount that will ignite under pressure in the combustion chambers. Holding the fuel control rack in this adjusted position and with removable lock pin 27 in position to hold stop lever 18 and bracket 20 relatively immovable, bracket 20 is then secured to mounting member 24 by bolts 25 so that curved edge 22 is in contact with the free end of fuel control rack 2. To obtain a precise fit of curved edge 22 with fuel control rack 2, it may be necessary to interpose shims 26 between the bracket and the mounting member to be held in place by the pressure of bolts 25, Fig. 3. With bracket 20 secured to mounting member 24, the rack is yieldingly held against stop lever 18 by the force of torsion spring 12a acting through free-turning lever 10 and link 11. When all the pumps of the engine have been individually tested and adjusted in the manner described above so that all pumps meter and deliver precisely the same amount, the pumps are then mounted on the engine and secured thereto in their usual positions. Control shaft 28 on which have been previously mounted enough levers 32 to provide one for each stop lever 18 is next locked against turning by tightening screw 31. Links 33 are then connected to stop levers 18 and to levers 32 and levers 32 secured to the control shaft. With the completion of these linkage assemblies, lock pins 27 are removed. Owing to the fact that control shaft 28 is locked against movement and that no play is provided in the linkage means between the control shaft and the stop levers, the removal of lock pins 27 does not alter the adjusted positions of the stop levers and the stop levers, thus rigidly held by said linkage means, act as stops to prevent the racks from moving beyond the point determined by said tests to be the position in which the rack will meter and deliver said estimated quantity of oil through each pump. The advancing of the racks in this manner has had the effect of increasing the gaps between adjusting screws 9a and lugs 10a so that it now becomes necessary to decrease this distance, which is done merely by means of said adjusting screws. If the estimated quantity of oil to be delivered through each pump proves sufficient to operate the engine efficiently and economically, no adjustment of our device is necessary. The pumps operate in the usual manner with the exception that the fuel control racks are now prevented by said stop levers from being retracted beyond the point at which they were set by said test to deliver not less than said estimated quantity of oil. The racks may also be moved in the other direction

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by action of the governor in the usual manner, as when an additional load is placed on the engine or when the gas supply is reduced or cut off entirely. In these instances, as the engine slows down, the governor rotates regulating shaft 8 in a counterclockwise direction, as viewed in Figs. 1 and 2, the first part of said movement actuating butterfly valve 13 in gas supply line 17, the latter part of said movement actuating all fuel control racks through adjusting screws 9a, lugs 10a, free-turning levers 10, and links 11. The movements of all racks are simultaneous and equal, resulting in the maintenance of relatively equal deliveries of oil through the pumps. Should this estimated quantity of oil prove insufficient to cause ignition, or should a gas of poorer quality be used, requiring a greater percentage of fuel oil to cause ignition, control shaft 28 would be unlocked by loosening screw 31, then rotated by wheel 30 in a counterclockwise direction until curved edges 22 were advanced to force spring-loaded fuel control racks 2 to a point where the pumps would meter and deliver larger but still relatively equal amounts of oil. The control shaft would then be relocked in this new position. Conversely, in the event a better quality gas were used, the control shaft, after being unlocked, would be rotated in a clockwise direction, retracting stop levers 18 and allowing fuel control racks 2 to move back under action of torsion spring 12a so that all pumps would then deliver smaller but still relatively equal quantities of oil, the control shaft then being relocked. These adjustments of the stop levers to these new minimum delivery settings can be made while the engine is running.

The modification of our invention, shown in Fig. 4, may be employed in instances where the space between the fuel injection pumps and the engine wall is insufficient to accommodate the outwardly extending levers of the preferred form. In this modification, stop levers 18', now shortened longitudinally, are fixedly mounted on rotatable fulcrum pins 21' between arms 19' of brackets 20' which are adjustably secured to the pump body, as in the preferred form. Secured to an axial extension of each fulcrum pin 21' is a lever 34 which is connected to a common control shaft 28' by a link 35 and an adjustable lever 36. Rotation of common control shaft 28' in a counterclockwise direction advances a curved edge 22' of stop lever 18', forcing spring-loaded fuel control rack 2' forward to meter and deliver a greater minimum quantity of oil, while rotation of the shaft in the other direction retracts curved edge 22' allowing the spring-loaded rack to move backwardly to meter and deliver a lesser minimum quantity of oil. For mounting purposes, bracket 20' is provided with a lock pin 27'. As in the preferred form, each pump of an engine is equipped with a stop lever and means connecting the stop lever with the control shaft so that all stop levers may be advanced or retracted simultaneously and equally by means of the control shaft. Also, as in the preferred form, all pumps are first tested and adjusted to meter and deliver identical quantities before the stop levers are mounted thereon. It should be understood that the control shaft in both modified and preferred forms may be disposed either as shown in the drawings, or positioned in front of the fuel injection pump, or in any other convenient position, depending on the space available in the vicinity of the pumps, the linkage means in both cases being readily adaptable to almost any position of the control shaft.

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While our invention has particular application to dual-fuel engines where only relatively small quantities of oil are metered and delivered through the pumps, as has been described above, it is readily seen that our adjustable stop means may also be used, without modification, with the fuel injection pumps of engines burning fuel oil exclusively to advance or retard the idling speed of the engine.

From the disclosure herein, it is seen that we have provided a simple, efficient and economical adjustable fuel control means for fuel injection pumps of both dual-fuel and single-fuel diesel engines, whereby all pumps after being tested and adjusted to meter and deliver equal quantities of fuel oil, will be held to meter and deliver not less than such quantities, and whereby such minimum quantities may be simultaneously and equally increased or decreased during the operation of the engine.

It will, of course, be understood by those skilled in the art that various changes may be made in the construction and arrangement of parts without departing from the spirit of the invention as set forth in the appended claims.

We claim:

1. The combination in a fuel injection control apparatus for internal combustion engines having injection pumps and a normally movable pump control element for varying the pump discharge comprising, stationary means for limiting movement of said pump control element so that a predetermined minimum pump discharge may be effected, means for varying the limiting position of said limit means so as to vary said predetermined minimum discharge, and means movable relative to said limiting means for operating said normally movable pump element while the limiting means remains stationary, thereby to increase the pump discharge whenever desired, said means for limiting movement of the pump control element including oscillatable members, one for each pump, and the means for varying the limiting position of the limit means including an element commonly connecting said oscillatable members together so that the same may be simultaneously and uniformly actuated.

2. The combination in a fuel injection control apparatus for internal combustion engines having injection pumps and a normally movable pump control element for varying the pump discharge comprising, stationary means for limiting movement of said pump control element so that a predetermined minimum pump discharge may be effected, means for varying the limiting position of said limit means so as to vary said predetermined minimum discharge, and means movable relative to said limiting means for operating said normally movable pump element while the limiting means remains stationary, thereby to increase the pump discharge whenever desired, said movable pump control elements being spring biased in a direction to reduce the pump discharge, and the means for limiting movement of such pump control elements including members, one for each pump, providing abutment surfaces against which said movable elements are yieldably pressed to effect the minimum discharge.

3. The combination set forth in claim 2 further characterized in that the abutment members are pivotally supported and the abutment surfaces are curved so as to be effective in the selection of minimum discharge.

4. The combination in a fuel injection control apparatus for internal combustion engines having injection pumps and a normally movable pump control element for varying the pump discharge comprising, stationary means for limiting movement of said pump control element so that a predetermined minimum pump discharge may be effected, means for varying the limiting position of said limit means so as to vary said predetermined minimum discharge, and means movable relative to said limiting means for operating said normally movable pump element while the limiting means remains stationary, thereby to increase the pump discharge whenever desired, said movable pump control elements being spring biased in a direction to reduce the pump discharge, and the means for limiting movement of such pump control elements including pivoted members adapted to provide abutments against which said movable elements are yieldably pressed to define the minimum discharge, the abutment portion of said pivoted members being offset from the pivotal axes so as to swing in an arc toward or away from the pump control element and thereby control the extent of minimum pump discharge.

5. The combination in a fuel injection control apparatus for internal combustion engines having injection pumps and a normally movable pump control element for varying the pump discharge comprising, stationary means for limiting movement of said pump control element so that a predetermined minimum pump discharge may be effected, means for varying the limiting position of said limit means so as to vary said predetermined minimum discharge, and means movable relative to said limiting means for operating said normally movable pump element while the limiting means remains stationary, thereby to increase the pump discharge whenever desired, said movable elements of the injection pumps being spring biased in a direction to reduce the pump discharge, and the means for limiting movement of such pump control elements including pivoted members adapted to provide abutments against which said movable elements are yieldably pressed to define the minimum discharge, the abutment portion of said pivoted members being offset from the pivotal axes, and the means for varying the limiting position of said abutting portions including an oscillatable shaft commonly connected by levers and links to the respective pivotal members.

6. The combination in a fuel injection control apparatus for internal combustion engines having injection pumps and a normally movable pump control element for varying the pump discharge comprising, stationary means for limiting movement of said pump control element so that a predetermined minimum pump discharge may be effected, means for varying the limiting position of said limit means so as to vary said predetermined minimum discharge, and means movable relative to said limiting means for operating said normally movable pump element while the limiting means remains stationary, thereby to increase the pump discharge whenever desired, said movable elements of the injection pumps being spring biased in a direction to reduce the pump discharge, and the means for limiting movement of such pump control elements including pivoted members adapted to provide abutments against which said movable elements are

yieldably pressed to define the minimum discharge, the abutment portion of said pivoted members being offset from the pivotal axes, and the means for varying the limiting position of said abutting portions including an oscillatable shaft commonly connected by levers and links to the respective pivotal members and the levers having releasable connections with said shaft whereby the abutment members may be separately adjusted in accordance with the individual pump characteristics.

7. The combination in a fuel injection control apparatus for internal combustion engines having injection pumps and a normally movable element for varying the pump discharge comprising, a plurality of members, one for each pump, adapted to provide abutment surfaces for individually engaging said pump control elements to determine a desired minimum discharge for each pump, means for movably supporting said abutment members so that said surfaces are movable to provide a variable distance through which said pump control elements must move before engaging said surfaces and thereby adjust the amount of minimum discharge of each pump individually, and means for commonly actuating said members so that their abutment surfaces simultaneously effect the same degree of minimum discharge position for all pumps.

8. The combination in a fuel injection control apparatus for internal combustion engines having injection pumps and a normally movable element for varying the pump discharge comprising, a plurality of members, one for each pump, adapted to provide abutment surfaces for individually engaging said pump control elements to determine a desired minimum discharge for each pump, means for movably supporting said abutment members so that said surfaces are movable transversely of the direction of movement of the pump control elements to provide a variable distance through which said pump control elements must move before engaging said surfaces and thereby adjust the amount of minimum discharge of each pump individually, and means for commonly actuating said members so that their abutment surfaces simultaneously effect the same degree of minimum discharge position for all pumps.

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