Oct. 1, 1957 R. GROVER 2,808,245

FUEL FEED DEVICES FOR INTERNAL COMBUSTION ENGINES

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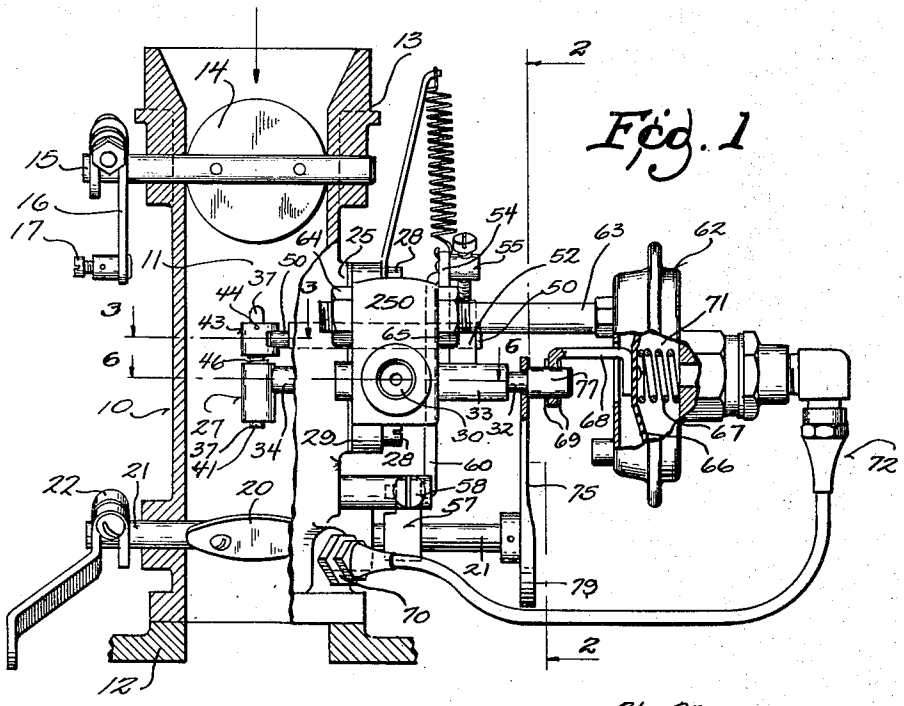


Fig. 1

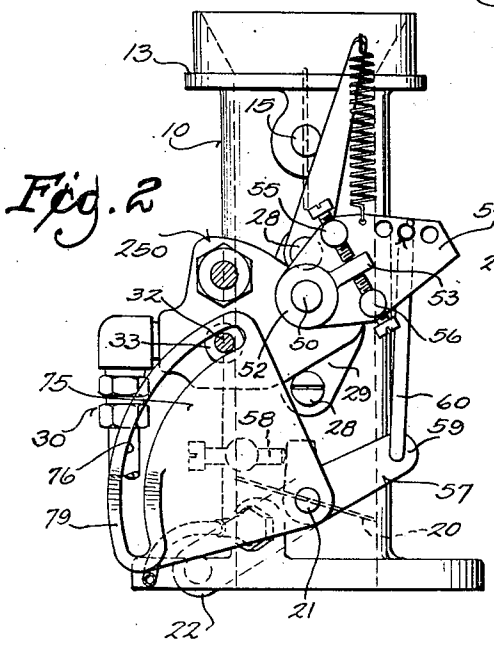


Fig. 2

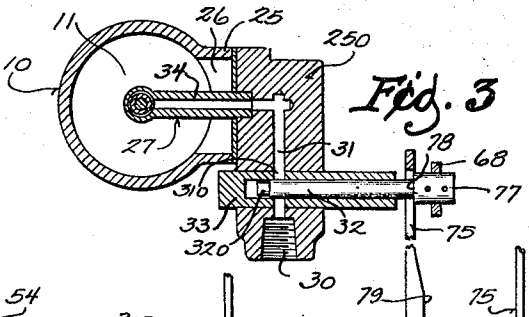


Fig. 3

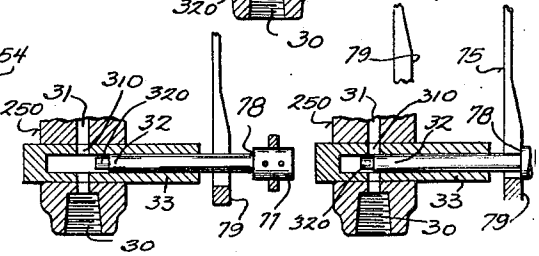


Fig. 4

Fig. 5

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FUEL FEED DEVICES FOR INTERNAL COMBUSTION ENGINES

Filed Nov. 20, 1950 2 Sheets-Sheet 2

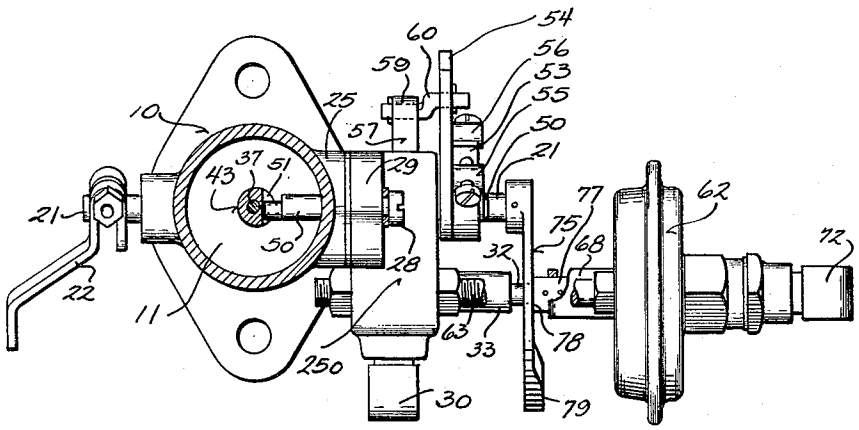


Fig. 6

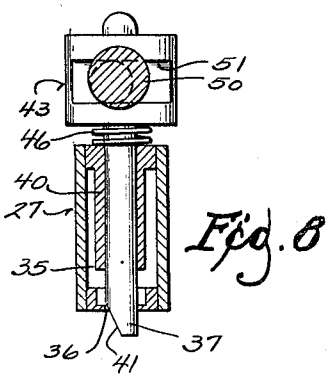


Fig. 8

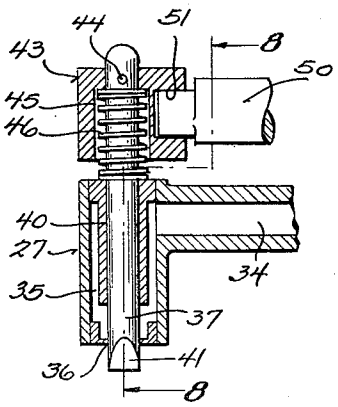


Fig. 7

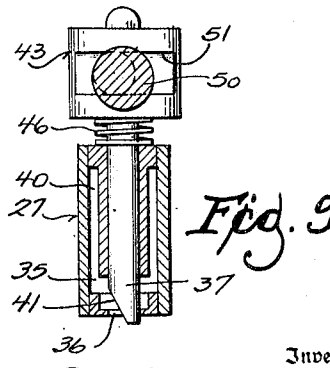


Fig. 9

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FUEL FEED DEVICES FOR INTERNAL COMBUSTION ENGINES

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Application November 20, 1950, Serial No. 196,598

1 Claim. (Cl. 261—51)

This invention relates to improvements in fuel feeding devices for internal combustion engines.

More particularly stated, this invention relates to improvements in devices for the control of injection of fluid fuel into the intake throat of an internal combustion engine; to automatically and positively shut off fluid fuel supply to such devices when the engine is stopped; to automatically shut off fuel injection into the intake throat of an internal combustion engine according to pneumatic pressure in the throat but to prevent such automatic shut off under certain operating conditions; to provide special metering means for fluid fuel injectors for internal combustion engines under operating conditions which result in increased pressure in the intake throat of the engine; and to provide an improved injection valve for passing fluid fuel to the intake throat of an internal combustion engine.

It will be noted in the following description of the invention that the various mechanical, hydraulic and pneumatic elements are incorporated in a unitary assembly comparable in length to the usual carbureter assembly of a modern type automotive engine and comprising a relatively simple mechanical assembly readily interconnectable with the usual and conventional control devices of an automotive vehicle, and the invention requires no special attention or control.

In the drawings:

Fig. 1 is a front elevation of the unitary assembly comprising the invention, portions of the generally tubular intake throat being shown in vertical section to exhibit the elements mounted interiorly of the throat.

Fig. 2 is a section on line 2—2 of Fig. 1.

Fig. 3 is a section on line 3—3 of Fig. 1 whereby to show the two stage metering and shut-off valve to control fuel supply to the injector valve.

Fig. 4 is a fragmentary detail of the metering and shut-off valve of Fig. 3 but showing the valve in wide open position.

Fig. 5 is a view similar to Fig. 4 but showing the valve in its metering position.

Fig. 6 is a section on line 6—6 of Fig. 1.

Fig. 7 is a vertical section through the fuel injector valve and its immediate operating connections; the valve being shown in idling position.

Fig. 8 is a section on line 8—8 of Fig. 7.

Fig. 9 is a view similar to Fig. 8 but showing the valve in open position.

Like parts are designated by the same reference characters throughout the several views.

The principal structural member upon which the other devices pertinent to the invention are mounted is a tube 10 shown clearly in Figs. 1 and 2 to provide a throat 11 through which air may pass in the direction indicated by the arrrows so as to enter the intake manifold 12 of an internal combustion engine. The upper end of the tube 10 is shaped and flanged at 13 to receive any form of conventional air cleaner (not shown). The dimensions

of the tube 10 are of course suited to the particular internal combustion engine to which the fuel injector is attached, but in general it may be said that the tube shown in the drawings is 5½ inches long and has an interior diameter of 1⅜ inches and is suited to the control and supply of air and fuel to a conventional 100 horsepower automotive type internal combustion engine having six cylinders and piston displacement of 97 cubic inches.

Reference has already been made to the fact that the manual control connections for this injector type fuel feed mechanism compare with the conventional control connections with which automotive vehicles are now equipped. By this it is meant that a somewhat conventional choke valve 14 mounted upon shaft 15 and provided with a conventional choke arm 16 secured to the shaft is provided with a Bowden wire clamp 17 so that the choke valve 14 is operable by the conventional Bowden wire choke control with which most automotive vehicles are provided.

At 20 adjacent the outlet end of tube 10 is a butterfly valve mounted on throttle shaft 21 and controlled by throttle arm 22. This throttle arm 22 may be connected to any form of throttle or accelerator connections such as are conventionally provided in automotive practice so that the butterfly or throttle valve 20 may be moved from idling position in which it is shown in Figs. 1 and 2 to a position in which it provides a wide open "throttle" and the butterfly valve is vertically disposed in the tube 10.

Mounted to the side of the tube 10 upon a boss 25 therefor is the injector valve assembly block 250 and the controls therefor as will now be described. This boss is positioned midway between the choke valve 14 and the throttle valve 20 and provides an opening at 26 sufficiently large so that the injector valve housing 27 can be inserted into its position centrally, approximately along the axis of the tube 10. Two machine screws 28 through flange fitting 29 secure the injector assembly to the tube boss 25.

It may be said of this injector for passing fluid fuel, as for instance gasoline, into the tube 10 that any form of fuel feeding device for feeding fluid fuel under pressure may be attached to the injector by means of a conduit connection 30. Actually in the installations thus far made in automotive vehicles the invention has been used in conjunction with a fuel feeding device such as the conventional automobile fuel pump which is a cam operated diaphragm pump adapted to feed gasoline under approximately 4 lbs. fluid pressure through a usual conduit connection such as that shown at 30.

The path of travel of fluid raw fuel entering the assembly mounted at 25 is through the tubular connection 30, thence through conduit 31 controlled by the two-stage valve 32 in its sleeve 33, then through injector valve supporting conduit 34 into the injector valve housing 27. Within this housing is an annular chamber 35 having outlet 36 controlled by reciprocable injector valve member 37.

The moveable injector valve member 37 is in the form of a rod guided in a sleeve 40. It is flatly beveled at 41 at an angle of 24° and it operates in a round opening at 36. Thus when the rod-like valve is in the position shown in Fig. 8 only a small opening for fluid fuel injection remains for passage of a solid, but small sized stream or jet. As the valve is retracted into the valve housing the opening increases, but the stream of fluid continues to be a solid, rod-shaped jet, of increasing diameter. The "solid," round, non-diffused jet of fuel has been found to be more effective and economical than a diffused, or atomized spray. It is to be noted that the rod-like or solid stream jet from the valve 37 through opening 36 is directed at the butterfly throttle valve 20 and the fluid fuel travels over

the surface of this valve toward its edge which is "downstream" of the flow of air in the tube **11**.

The upstream end of the rod-like valve member **37** is provided, exteriorly of and spaced from the housing **27**, with a spool **43** secured to the valve member by a key or pin **44**. The spool has a recess **45** larger in diameter than the valve **37** to provide space for a compression spring **46** of sufficient strength to bias the valve **37** to open position. The spring is abutted against the housing **27** about the valve **37**.

Actuation of valve **37** is accomplished by oscillation of injection control rod **50** mounted in block **250** and extending parallel to conduit **34**. The inner end of rod **50** is eccentrically reduced in size and is received in a slot **51** in the spool **43** so that upon oscillation of rod **50** the valve **37** is caused to reciprocate longitudinally of its axis whereby to open and close the valve and to determine the quantity of fuel to be delivered as a jet into the throat **11**.

Exteriorly of the assembly block **250** the rod **50** is provided with a fixed collar **52** with a projected spud **53**, and it is also provided with a freely swingable arm **54** having its bearing on rod **50**. At either side of the spud **53** the arm **54** has set screws and set screw blocks **55** and **56** as shown in Fig. 2 so that the relative adjustment of spud **53** and the arm about the axis or rod **50** may be determined.

On the end of throttle shaft **21** opposite throttle control arm **22** is a bell crank **57**, one end of which provides an abutment to strike an idling adjustment screw **58** which is the somewhat conventional device to determine the limit of closing movement of throttle valve **20**. The other end **59** of the bell crank **57** is connected to the arm **54** by means of link **60**. Thus as throttle **20** is opened and closed to admit greater or lesser amounts of air to the internal combustion engine for higher or lower speeds of operation the above described connections coordinately open and close the valve **37** to inject greater or lesser amounts of fuel to be mixed with the air in proper proportions. If, for a given throttle opening, there is an incorrect mixture or proportion of air to quantity of fuel being fed through the valve **37** the adjustment of set screws at **55—56** will correct the relative position of throttle and injection valve to correct the proportion.

As thus far described, it will be apparent that any throttle or accelerator connection at **22** may be used to open the throttle valve **20** and, coordinately, to open valve **37**. Since fluid fuel is introduced under the pressure of a fuel pump to the chamber **35** throughout the period of operation of the internal combustion engine the feed of fluid fuel and the induction of air through the tube **10—11** maintains the required feed of fuel and air mixture. When the internal combustion engine served by this improved fuel feeding device is stopped or stalled for any reason, there is nothing in the mechanism thus far described to prevent the continued feeding of fuel through the valve **37** so long as the usual pressure of such fuel from the pump may prevail. The result therefore is an accumulation of fluid fuel in the intake manifold **12** served by this device unless the new control devices now to be described are included in the mechanism. Obviously such an accumulation of fluid fuel, especially in a thoroughly warmed internal combustion engine, will make the restarting of the engine extremely difficult. The following mechanism has therefore been invented and provided.

In connection with the general description of the feed of fluid fuel to the valve **37**, mention has been made of the two-stage valve **32—33**. This valve includes a sleeve **33** in which the valve **32** may reciprocate and there is a cross-bore **310** for the passage of fluid fuel from tubular connection **30** through the conduit **31**. The cross-bore **310** is, however, controlled by valve **32**, the end portion of which is reduced in size at **320** (see Figs. 3, 4 and 5). When the valve **32** is in the position shown in Fig. 3, the valve is in its innermost extreme position of insertion in the sleeve **33** and the full diameter of the valve is in position to completely close conduit **31**. When the valve **32** is in the position shown in Fig. 4, it is in its extreme position of withdrawal from registry with conduit **31** and there is free passage for fuel from tubular connection **30** through conduit **31** and the cross-bore **310**. In an intermediate position as shown in Fig. 5, the larger diameter of the valve **32** partially obstructs cross-bore **310** and the smaller diameter **320** of the valve is partially in registry with cross-bore **310** so as to meter the amount of fuel which may pass the two-stage valve.

The two-stage valve **32** is controlled as to its position by a pneumatically operated diaphragm actuator indicated generally at **62**. This actuator is mechanically supported upon a rod **63** extending through a bore in block **250** and locked in position thereto by clamp nuts **64** and **65**. Within the housing of the actuator **62** is the usual diaphragm **66** which is pressed to the left by a diaphragm spring to which is secured a bracket **68** and this bracket in turn is secured to valve member **32** as shown clearly in Fig. 1. Ordinary cotter keys **69** at either side of the L-shaped end of the bracket insure positive engagement of the bracket **68** with the extended end of valve **32** and the valve therefore moves in its sleeve **33** in accord with movement of the diaphragm **66** in the actuator **62**. Pneumatic connection between the throat **11** "below" the throttle **20** at **70** and the chamber **71** at one side of the diaphragm in the actuator **62** is provided by means of tubular connections indicated generally at **72**.

Normal position of valve **32** is therefore its innermost position as shown in Fig. 3 to which it is biased by the diaphragm spring **67**. Immediately upon the operation of the internal combustion engine however, the reduced pressure in throat **11** acts upon the diaphragm to move it to the right as shown in Fig. 1 and the bracket **68** connected to the diaphragm immediately opens valve **32** for passage of fluid fuel to the valve **37**. There therefore is no delay in the starting of an internal combustion engine equipped with this fuel feeding device, but immediately upon the stalling or stopping of the engine the pressure in the throat **11** below the throttle **20** increases to atmospheric pressure and the spring **67** instantaneously closes valve **32** to prevent passage of fluid fuel to valve **37**. No dribbling of fluid fuel can take place and it has been found that even a thoroughly warmed-up internal combustion engine will start immediately after a shut-down period, however short.

There are circumstances in which a mere shut-off valve would operate with exasperating promptness at **31—32** if it were not for the two-stage feature of the valve as shown in Figs. 3, 4 and 5. If, at times of relatively heavy load and relatively slow speed operation, the operator of an internal combustion engine equipped with this fuel feeding device moves the throttle valve **20** to open position the pressure in the lower end of the throat **11** may be so increased that the diaphragm **66** may move too far to the left as shown in Fig. 1 and close valve **32** completely, were it not for the reduced diameter **320** of that valve. It has been found however, that if there is any rotation whatsoever of the internal combustion engine served by this equipment, there is enough reduction in pressure in the connection **72** so that the valve **32** will take the position shown in Fig. 5 with the valve approaching closed position but not quite reaching it. In this position the cross-bore **310** is partially obstructed and fluid fuel is metered whereby to prevent "flooding" of the heavily overloaded engine. Obviously the small amount of air passing through the tube **11** must not, at such a time, be provided with a heavy proportion of fluid fuel through valve **37**.

It will be obvious from the above description that an automotive vehicle provided with this improved fuel feeding device will receive the proper amount of fuel and there will be no shut-down because of valve closure

at 32 even though the operator of the vehicle presses the accelerator "to the floor" and thus increases the pressure of air in throat 11. Thus in the device indicated generally at 62 and its connection with valve 32, means have been provided to prevent dribbling of fluid fuel when the internal combustion engine is shut-down or stalled and at the same time, by reason of the two-stage valve 32, a metering operation prevents too rich a mixture at slow speeds when the pressure in throat 11 increases during slow speed or overload conditions.

Location of the two-stage valve 32 so as to obtain the metering operation described above is determined by the adjustment of the clamp nuts 64 and 65 and the selection of a spring at 67 to fit the particular characteristics of the internal combustion engine to which the fuel feeding device is attached. With a properly selected spring 67 and with the nuts 64 and 65 adjusted so that the valve 32 is just barely closed with a "dead" engine it may be determined that the metering end 320 of the valve 32 will be in the position shown in Fig. 5 when the throttle 20 is approximately wide open and the engine is operating slowly.

In the event that difficulty is encountered in adjusting the position of the actuator 62 or in the selection of a proper spring 67 to determine the location of valve 32 under low speed overload conditions, a supplemental control device is provided whereby mechanically to control the location of valve 32 at the position shown in Fig. 5. Such a supplementary control device will now be described.

Throttle shaft 21 extends outwardly from the tube 10 beneath valve 32 and its connection with bracket 68. A fan-shaped arm is mounted upon the throttle shaft 21. This fan-shaped arm is arcuately slotted at 76 so that the valve 32 may extend freely through this slot. However, there is an enlarged end 77 on the valve 32 to provide a shoulder at 78 to abut the margins of the slot 76. The arcuate extent of the fan-shaped arm 75 varies in thickness from the relatively thin portion to be contacted by the shoulder 78 when the valve 32 is in completely closed position to the relatively thick portion 79 which is swung into position to abut shoulder 78 when the throttle 20 is in substantially open position. When the shoulder 78 strikes the thicker portion 79 of the fan-shaped arm 75 (see Fig. 5), the valve 32 is in its intermediate position wherein it meters a predetermined amount of fuel, thus there is a positive mechanical stop offered to prevent complete valve closure of valve 32 if the throttle is substantially open; but if the throttle 20 is anywhere near its idling position, the thinner portion of arm 75 is aligned with the shoulder 78 and the valve 32 may then completely close. It will be obvious from the above description that if the pressure in the throat 11 is low, as it will be in ordinary operation of the engine, the valve 32 will be wide open, and the position of the fan-shaped arm 75 will be of no consequence, since the shoulder 78 will be completely withdrawn from contact with any surface of such arm.

From the above description it will be seen that this fuel feeding device comprises an assembly unitarily mounted with the tube 10 which is adapted to be substituted for the conventional carburetor now popularly used with internal combustion engines. It is admirably suited for use as an improvement over such conventional carbureters, for there are important advantages in the use of this improved fuel feeding device and there are no additional manual controls required. Furthermore, the operator of an internal combustion engine equipped with this new fuel feeding device is called upon to perform no control operations different from those heretofore exercised with previously known carbureters.

In the starting, operating, and stopping of an internal combustion engine equipped with this invention, the following conditions and sequence of operations takes place. When the engine is at rest, normal atmospheric pressure

prevails in the throat 11; therefore the diaphragm 66 and the bracket 68 attached thereto are in the extreme position to which they are biased by spring 67 and the valve 32 is completely closed. The tubular connections 30 to the fuel pump are full of fluid fuel in readiness to be fed to the injector valve 37. The operator may then start the engine in the usual way by closing the choke valve 14 and cranking the engine by any suitable means. In the first movement of the pistons in the engine, reduced pressure in the throat 11 is established and the diaphragm 66 will immediately pull valve 32 to its wide open position. At the same time the fuel pump connected to the motor will establish pressure of fluid fuel in the connections 30 and a quantity of injected fuel will pass to the throat through the opening at 36. The quantity of fluid fuel delivered will depend upon the operator's adjustment of the throttle 20 and, coordinately, the adjustment of valve 37 in the opening 36. Of course the reduced pressure in the throat 11 will cause a greater quantity of fuel to flow through the valve at 36 than will flow therethrough when the pressure in throat 11 approaches atmospheric pressure. As soon as the engine commences normal operation or as soon as there is no necessity for fully choking the fuel feeding device, the choke valve 14 may be adjusted in the usual way and when the engine starts, the continued operation of the engine is carried on by the usual manipulation of throttle arm 22 which will determine the speed of operation of the engine and provide the proper fuel mixture because of the coordinated opening and closing of the valve member 37 in opening 36 in accord with the opening and closing of throttle 20.

Assuming however that the engine served by this improved fuel feeding device is so heavily loaded during a portion of its operating time that the throttle 20 is in wide open position and the valve 37 is in wide open position, the slowing down of the motor under such heavy loads may permit the pressure in throat 11 to rise to a point where diaphragm 66 will yield to the pressure of spring 67 and the valve 32 will move toward closed position. So long as there is any rotation of the engine and any motion of the pistons to pull air through the throat 11, the strength of the spring 67 will not be sufficient to completely close valve 32 but will be sufficiently strong to bring the valve 32 to the position shown in Fig. 5 wherein only a portion of the full supply of fuel may be passed to valve 37. This will prevent overfeeding of fluid fuel to the slowly moving engine and there will be no positive shut-down of fuel supply such as would take place if the valve 32 were moved to full closed position as shown in Fig. 3.

If, under special conditions of operation, this fuel device is operated in conjunction with an engine in which it is difficult or impossible to select a spring 67 of proper operating characteristics, the fan-shaped arm 75 may be used on throttle shaft 21 and so set upon this shaft that the thickened portion 79 will move into position for abutment by shoulder 78 when throttle 20 is in wide open position thus, mechanically, preventing the spring biased operation of valve 32 to closed position.

When the engine equipped with this fuel feeding device is shut down or ceases to operate for other reasons, the valve 32 is quickly closed by spring 67 as soon as the pressure in throat 11 rises and the engine comes to rest with the fluid fuel supply held in connections 30 in readiness for the next operating cycle of the engine.

What is claimed is:

For an internal combustion engine having a throttle equipped air intake throat, fuel connections for fluid fuel under pressure and having an injection opening positioned in the throat, said connections having a valve adjustable for graduated feed of fuel and connected to the throttle for coordinate opening and closing thereof, said fuel connections having a second valve biased to closed position and having pressure responsive means for open-

ing said second valve, said means having pressure conduit connection to a point in the throat, the throttle being positioned between the injection opening and said point, said second valve being shaped to move throughout a range of movement from closed to open position, and the throttle is connected to a member movable therewith and positioned to prevent closure of said second valve when the throttle is substantially open.

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