May 15, 1956 H. T. BOOTH 2,745,625

REPEATED ACTION INJECTOR DEVICE

Filed March 27, 1952

Fig. 1.

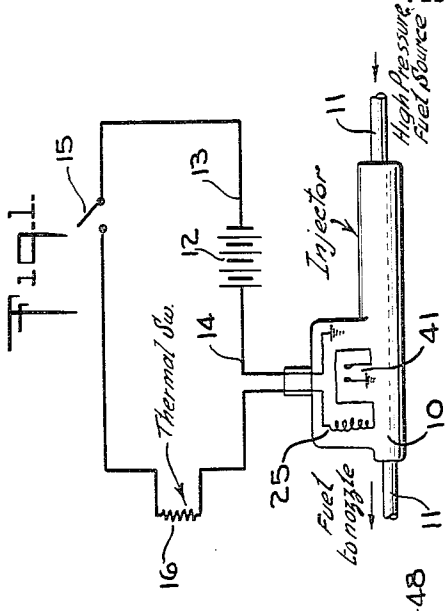


Fig. 3.

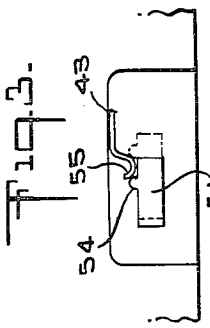


Fig. 2.

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2,745,625

Patented May 15, 1956

2,745,625

REPEATED ACTION INJECTOR DEVICE

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Application March 27, 1952, Serial No. 278,979

7 Claims. (Cl. 251—13)

This invention relates to repeated action injection devices, especially as used in fuel systems to inject repeated quantities of fuel into a burner until ignition occurs.

An object of the invention is to produce a device as described operable to deliver constant, predetermined quantities of fuel during each cycle of operation.

Another object of the invention is to interpose an injector device in a high pressure fuel system in such manner as to effect the supply of fuel in intermittent, repeated injections.

A further object of the invention is to produce a device as described of rugged and reliable construction, particularly suited for use with jet engines for aircraft.

Other objects and structural details of the invention will appear from the following description when read in connection with the accompanying drawings, wherein:

Fig. 1 is a diagram of the electrical circuit comprised in the injection system;

Fig. 2 is a view of the injector device in longitudinal section; and

Fig. 3 is a detail view of a detent mechanism comprised in the device.

Referring to the drawings, an injector device in accordance with the instant invention is shown in Fig. 1 installed in the ignition system of an afterburner in a jet engine. In this system, it is desired to inject a predetermined quantity of fuel into the afterburner chamber at regular intervals until ignition occurs, and then to discontinue the injection action, all to be done automatically after initiation of the action by the operator.

As shown, the injector device 10 is interposed in a line 11 communicating at its one end with a source of fuel under pressure and at its other end with a nozzle discharging into the afterburner. An electro-mechanical valve mechanism 25 in the device 10 is in an electrical circuit including a battery or like source 12, leads 13 and 14 extending therefrom, and switches 15 and 16 as well as a switch assembly 41 in the injector assembly. The device accepts fuel from the high pressure source permitting flow therethrough to the nozzle until a predetermined quantity, for example, 300 cc.'s (18.3 cu. in.), has passed subsequent to the closing of switch 15. This switch may be a push button in the pilot's compartment, or could be made automatically responsive to some control other than the hand of the pilot. The switch 15 is, however, normally open, and when closed, completes a circuit through the valve mechanism in the device 10 to open the line 11 for fuel flow therethrough.

The injector device, after passing 18.3 cu. in. of fuel, automatically opens the electrical circuit, resulting in the valve mechanism closing or shutting off flow through the line 11, following which the device resets itself to its original condition and immediately repeats the injection of 18.3 cu. in. to the nozzle. This cycle repeats itself every three to five seconds, continuing until either switch 15 or switch 16 is opened, the latter being a normally closed switch and temperature responsive in action in

such wise as to open at a selected high temperature indicating ignition has taken place in the afterburner.

Considering now the construction and mode of operation of the device 10, it includes a body or housing 17 having axially aligned longitudinal bores 18 and 19 separated by a wall 21. On opposite sides of the wall 21, the bores 18 and 19 open into a tapped recess 22, by way of respective ports 23 and 24, where they communicate with one another under control of the electromagnetic valve assembly 25. Such assembly comprises generally a case 26, a coil 27 wound on a spool 28 and a body 29 in which a plunger 31 is reciprocably mounted. The plunger 31 has a head portion 32 received in a counterbore 33 in the body 29, which counterbore is in embracing or surrounding relation to the ports 23 and 24. The body 29 is screwed into the recess 22 and seats on a ring seal in the bottom thereof. By means of a transverse pin 34 the plunger 31 carries a valve 35 in its head 32 aligned with and adapted to seat in the port 24. A spring 36 is based in the bottom of counterbore 33 and engages head 32 to urge the plunger 31 outward or in a direction to seat the valve 35 in the port 24. With the parts so positioned, fluid flow between the bores 18 and 19, or, more particularly, flow from bore 18 to bore 19 is not possible and so may be considered to be shut off. Retraction of the plunger 31 is accomplished by energizing the coil 27, and results in an unseating of the valve 35 and a consequent opening of communication between the ports 23 and 24. Deenergizing of the coil 27 restores the plunger 31 to control of the spring 36 which returns the plunger outward, seating valve 35 in the port 24 and discontinuing communication between the ports 23 and 24. The energizing and deenergizing of the coil 27 accordingly effects and results in opening and closing movements of the valve 35, whereby respectively to permit and to deny fluid flow from bore 18 to bore 19. Since these bores are, as will be seen, interposed in the line 11, the further effect of the movements of the valve 35 is to permit and deny the flow of fuel through line 11 to the nozzle.

The end of bore 19 opposite wall 21 is formed for connection with that portion of the line 11 leading to the nozzle. It may, therefore, be termed the outlet or outlet end of the injector device. The end of bore 18 opposite wall 21 opens into a counterbore 37 in the body 17. Such counterbore is further bored out and threaded to receive a tubular supplemental housing 38, internally threaded at its outer end for connection with that portion of the line 11 leading from the fuel source. This then is the inlet or inlet end of the injector device. Installed in the inlet end of the device is a flow restrictor bushing 39. The fuel source may develop pressures on the order of 1000 to 1500 p. s. i., productive of flow rates unnecessarily high for the igniter injector device.

For controlling the energizing and deenergizing of the electromagnetic assembly 25, there is provided the switch assembly 41 housed in a chamber 42 in the body 17. The assembly 41 is a commercially available unit which includes a mounting plate 43 made of spring steel, three upstanding contact bearing switch arms 44, 45 and 46, and a shift arm 47 which has a portion in overlying relation to the center switch arm 45 and connected thereto through a flexible C-shaped member 48. The plate 43 is fastened, as by screws 49, to a wall of the chamber 42. According to the known mode of operation of switch devices of this kind, the rocking of the shift arm 47 to the right exerts through the eccentrically acting member 48 a reverse motion of the switch arm 45, and, similarly, a rocking of the arm 47 to the left effects movement of the switch arm 45 to the right. The parts may be arranged, as indicated, so that in its alternate positions of adjustment the switch arm 45 makes contact respectively with the switch arms 44 and 46. The arm 45 is biased

to assume normally the position illustrated wherein the arm 45 is in contact with the arm 46. Rightward motion of the arm 47, to its alternate position of adjustment, and return therefrom to the illustrated position is effected and controlled by an actuating lever 51 fixed to a sleeve 52 which is rotatably mounted on a stub shaft 53 set in the body 17. One arm of the lever 51 extends upward from the pivot point 53 and is bent over into engagement with the arm 47. As shown in Fig. 3, a detent nose 54 on such bent over end is in cooperative relation with a similar portion 55 on the spring plate 43. Thus, a clockwise motion of the lever 51 will shift the arm 47 in a direction to disengage switch arm 45 from switch arm 46, and, through the cooperation of detent portions 54 and 55, the parts will remain so positioned until the lever 51 is positively returned in the opposite direction, allowing the shift arm 47 to follow such motion.

In the present use of the switch device 41, the switch arm 44 is unconnected in the electrical circuit so that the only action of concern is the engagement and disengagement of the switch arm 45 with respect to the arm 46. Thus as is diagrammatically indicated in Fig. 1, and partly shown in Fig. 2, the electrical lead 13 may extend to the coil 27 and to switch arm 45 while lead 14 extends to switch arm 46. Engagement of the contact points on arms 45 and 46 closes the circuit through the solenoid coil 27, assuming the switches 15 and 16 to be closed, and disengagement of these contact points opens such circuit. As seen, the leads 13 and 14 may be introduced into the chamber 42 by way of insulator-seal assemblies 56. A connector unit 57 receives the leads 13 and 14 and is installed in a hood 58 mounted in overlying, partly enclosing relation to the body 17.

Beyond the inner end of the tubular housing 38, the enlarged, threaded portion of counterbore 37 communicates through a radial opening 59 with the chamber 42. A downwardly extending arm of the lever 51 extends through the opening 59, and further through a radial opening 61 in a cylinder 62 axially disposed in the housing member 38. The cylinder 62 has its inner end received in the counterbore 37. A flange 63 thereon is seated in the enlarged portion of such counterbore and a nut 64 is screwed down in confining relation to the flange, holding the cylinder longitudinally centered in the housing 38. A locating pin 65 holds the cylinder against rotary movement.

The cylinder 62 is spaced from the internal wall of housing 38 in a manner defining an annular passage 66, which at its one end communicates around the outer end of the cylinder with the inlet end of the device. The radial opening 61 in the cylinder 62 communicates the other end of passage 66 with the interior of the cylinder and thereby with the bore 18.

The outer end of the cylinder 62 is closed by a restrictor plate 67 formed with an orifice 68 having a predetermined area relation to the opening 61. Such outer end of the cylinder further is counterbored to define a seat for a ring 69 which provides a base for one end of a compression spring 71. The other end of the spring 71 bears on a piston 72 slidably mounted in the cylinder 62 and urged by the spring to a right hand or outward extreme of motion where it limits against the plate 67. A rod 73 is connected to the piston 72 and extends axially inward through and beyond the ring 69. Over a part of its length, the rod 73 is cut away to define opposed shoulders 74 and 75. That end of the lever 51 which projects into the cylinder 62 is forked and embraces the cut away portion of rod 73 in such manner as to be alternately engaged and moved by the shoulders 74 and 75 in response to a reciprocating motion of the piston 72. Under the influence of the piston 72, therefore, the lever 51 may be rocked to and fro to set the shift lever 47 to alternate positions of adjustment, as before described. The piston 72 is hollow to define a chamber 76 into which fluid may be discharged by way of orifice 68.

Assuming the fuel pumps or other pressure generating means to be operating, and further assuming the valve 35 to be closed, all portions of the device directly communicating with the inlet end thereof are filled with fuel under equal pressure. The piston 72 is accordingly under control of the spring 71 and occupies a retracted position in the cylinder 62. The lever 51 and shift arm 47 are accordingly in a counterclockwise position of adjustment resulting in the switch contact arms 45 and 46 being closed. This is the position of the parts illustrated in Fig. 2, it being still further assumed, in this view, that the main control switch 15 is open. Now if this switch is closed, and since the switch 41 already is closed, the solenoid 27 is energized, drawing plunger 31 upward and unseating or opening valve 35. Flow immediately begins from bore 18 to bore 19 and out of the device to the nozzle. The area of annular passage 66 is greater than the area of opening 61 so that a pressure difference is established on opposite sides of the opening 61, upon opening of valve 35. The greater pressure is applied through the orifice 68 upon the outer end of the piston 72. The inner or opposite end of the piston is exposed to the lesser pressure. The pressure difference so derived and so applied is utilized as a force to effect motion of the piston 72 inward in the cylinder 62, against the resistance of spring 71. The pressure difference obtained is related to the rate of flow through the passage 66 and will be of sufficient magnitude to overcome the spring 71.

The piston 72 will move inward in the cylinder at a rate determined by the rate of flow through the orifice 68, and this may be considered roughly to be a function of the area of the orifice multiplied by the amount of the pressure difference set up by the opening 61. The arrangement is such as to produce a constant ratio between the movement of the piston 72 and the rate of flow through passage 66 whereby for any given travel of the piston a constant predetermined volume of fuel will have passed through the passage 66 and out of the device.

The piston 72 begins to move immediately that valve 35 is opened, and continues until the shoulder 75 engages and shifts lever 51 in a clockwise direction to separate the contact arms 45 and 46. When this occurs, the circuit is opened and coil 27 is deenergized. Plunger 31 drops downward, closing valve 35 and shutting off flow through the device. The liquid pressures upstream and downstream of the opening 61 quickly equalize, in response to the closing of valve 35. The piston 72 accordingly is restored to control of the spring 71 which returns the piston from extended toward retracted position in the cylinder. As the piston reaches fully retracted position, the shoulder 74 engages and rocks the lever 51 to its counterclockwise position of adjustment, reengaging the contact arms 45 and 46. Another cycle of operation of the injector device is so initiated, and, so long as the switches 15 and 16 remain closed, the device will automatically go through repeated cycles, in effect ejecting at each cycle a constant predetermined quantity of fuel.

It may be considered that the fuel entering the inlet end of the device is divided into a primary stream which goes by way of passage 66 and bores 18, 19 to the outlet, and a secondary stream which goes through orifice 68 for the operation of piston 72. As noted there is a predetermined, constant ratio of flow between these streams which is of course variable by substituting other plates 67 having a larger or smaller orifice 68 therein.

What is claimed is:

1. An injector of the class described, comprising a housing to be interposed in a liquid flowing conduit and presenting an inlet and an outlet, means for alternatively opening and closing said housing to the flow of liquid therethrough, means defining a primary flow stream through said housing and a secondary flow stream in said housing, means for producing a pressure drop in the liquid flowing through said primary stream, means in said secondary stream movable in response to creation of said

pressure drop from a retracted to an extended position, a spring for returning said movable means to retracted position, and means operable by said movable means only as it reaches its extended and retracted positions for controlling said alternatively opening and closing means.

2. An injector device of the class described, comprising a housing to be interposed in a line flowing liquid under pressure and presenting an inlet and an outlet, a passage in said housing extending between said inlet and said outlet, a restriction in said passage imposing a pressure drop upon the liquid in said housing, a piston chamber in said housing communicating at its one or upper end with said passage upstream of said restriction and at the other or lower end with said passage downstream of said restriction, a piston movable in said piston chamber, a supplemental restriction in the path of flow into the upper end of said chamber, there being a predetermined ratio of flow through the first said and said supplemental restrictions, a spring urging said piston to a retracted position in the upper end of said chamber, said piston being movable by flow into said upper end toward an extended position in the lower end of said chamber, valve means for alternatively opening and closing said passage to fluid flow therethrough, and a control device for said valve means settable to one positon by said piston only as it reaches extended position to close said valve means and settable to another position by said piston only as it reaches retracted position to open said valve means, the closing of said valve means serving to equalize the pressures in said piston chambers and allow return of said piston from extended to retracted position by said spring, and the opening of said valve means serving to restore the aforementioned pressure drop and initiate motion of said piston from retracted toward extended position.

3. An injector device of the class described, comprising a housing to be interposed in a line flowing liquid under pressure and presenting an inlet and an outlet, a passage in said housing extending between said inlet and said outlet, a valve movable to open and to close said passage for flow therethrough, a control device for said valve having alternative positions of adjustment, piston means for actuating said control device spring urged to a retracted position, said piston means setting said control device to one position of adjustment only as it reaches its retracted position and to the other position of adjustment only as it reaches an extended position, and means for diverting a portion of the liquid from said passage to said piston means creating a pressure drop in said passage to extend said piston means from retracted position.

4. An injector device of the class described, comprising a housing to be interposed in a line flowing liquid under pressure, a valve in said housing adjustable to open and closed positions, in the latter of which flow through said housing is shut off, a control device for said valve having alternative positions of adjustment in a first one of which said valve is open and in a second one of which said valve is closed, a reciprocable piston operable only as it reaches a retracted position to set said control device to said first position and only as it reaches an extended position to set said control device to said second position, a spring urging said piston means from extended to retracted position, and means creating a pressure drop in said housing for diverting a portion of the liquid flowing through said passage in the open position of said valve to said piston means to move said piston means from retracted to extended position.

5. An injector device of the character described, comprising a housing to be interposed in a line flowing liquid under pressure, a valve in said housing adjustable to open and closed positions, in the latter of which flow through said housing is shut off, a control device for said valve having alternative positions of adjustment in a first one of which said valve is open and in a second one of which said valve is closed, a piston in said housing displaceable under the influence of the liquid flow from a retracted position to an extended position, a spring for returning said piston from extended to retracted position in the absence of liquid flow, and a connection between said piston and said control device effective only as said piston reaches said extended and retracted positions respectively for setting said control device to said alternative positions of adjustment.

6. An injector device according to claim 5, characterized in that said control device is set to said first position in the retracted position of said piston and to said second position in the extended position of said piston, said piston having a pulsating motion as said valve is intermittently closed in response to the movements thereof.

7. An injector device of the class described, comprising a housing to be interposed in a line flowing liquid under pressure, a shut off valve in said housing for closing said line to liquid flow, electro-mechanical means for effecting opening and closing movements of said valve, including a switch, a piston chamber in said housing upstream of said valve, a piston therein reciprocable between retracted and extended positions, a connection between said piston and said switch setting said switch to alternate positions of adjustment in response to reciprocatory movements of said piston, means dividing the flow in said housing into a primary stream under control of said shut off valve and a secondary stream acting on said piston to move it from retracted to extended position, a spring for returning said piston from extended to retracted position, restrictions in said primary stream and in said secondary stream so related as to area that a predetermined volume of liquid will flow through said primary passage before said piston reaches extended position, downstream of the restriction therein said primary stream communicating with said piston chamber on one side of said piston and upstream of said restriction communicating with said piston chamber on the opposite side of said piston through the restriction in said secondary stream, the construction and arrangement of parts being such that a pressure difference is provided for operation of said piston by said secondary stream in the open position of the valve while in the closed position of the valve the pressures are equalized allowing operation of said piston by said spring.

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