March 10, 1953 W. H. MASHINTER 2,630,761

FUEL INJECTOR

Original Filed May 29, 1944

Fig. 2.

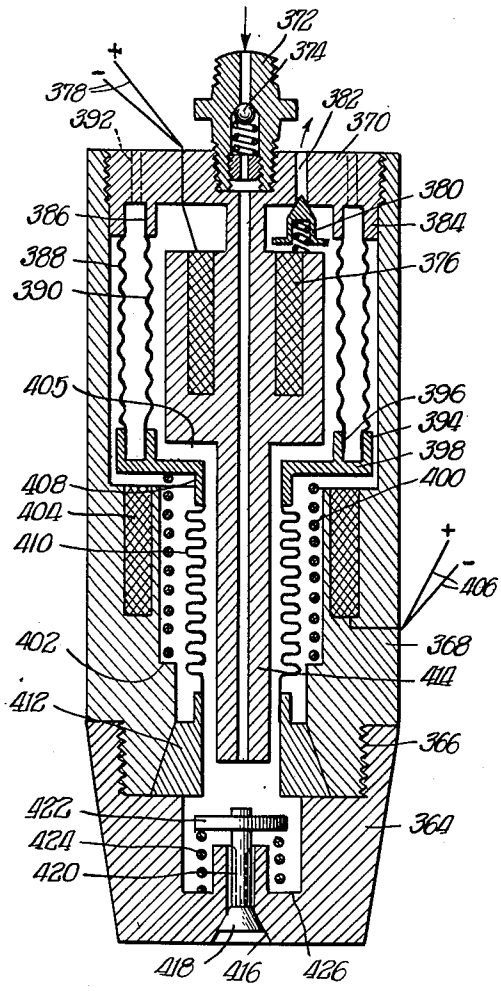
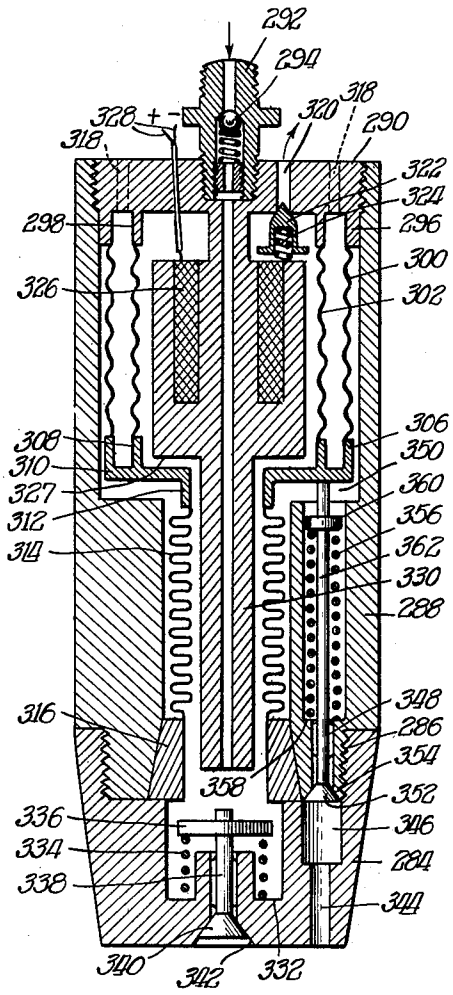


Fig. 1.



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UNITED STATES PATENT OFFICE

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FUEL INJECTOR

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Original application May 29, 1944, Serial No. 537,793. Divided and this application November 2, 1945, Serial No. 626,220

8 Claims. (Cl. 103—152)

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This invention pertains to pump mechanism, injector mechanism or atomizing mechanism adapted to either supply solid liquid or spray comminuted fluid, or mixtures of fluid and solid.

Fuel injection pumps as heretofore designed commonly include a plunger working in a cylinder and intermittently actuated to deliver measured quantities of fuel to the engine. Because of the high fuel pressures ordinarily involved, a very close fit between plunger and cylinder is required for successful operation and a leak-proof fit is extremely difficult to obtain and impossible to maintain, particularly when using light fuels, such as gasoline, having little or no lubricating properties.

One object of the present invention is to provide a substantially leak-proof fuel injection pump.

Another object is to provide a fuel injection pump that is substantially immune to leakage producing wear.

Another object is to provide an improved bellows type of pump capable of withstanding high pressures over long periods of use.

Another object is to combine a bellows type of pump and a fuel injection nozzle into a unitary structure.

Another object is to provide a fuel injection nozzle having a self-contained bellows type of pump and a loaded discharge valve responsive to the pressure in the pump.

Another object is to provide a pump fed fuel injection nozzle having a self-cleaning discharge valve.

Another object is to provide a combined fuel pump and injection nozzle of improved, simple and inexpensive design.

Another object of the invention is to provide pump mechanism so constructed and arranged that it may be used to pump solid liquid.

Another object of the invention is to provide a pump for supplying fluid under pressure and in measured quantities to means for utilizing the supplied fluid, as where fuel is sprayed into the cylinder of an engine or where other liquid, such as water, is sprayed into such cylinder for power or antidetonating reasons.

Another object is to provide injecting means for supplying fuel to an internal combustion engine which may be used with manifold or separate cylinder injection and wherein the fuel is introduced in properly atomized condition over the entire range of operation of the engine, i. e., regardless of the operating speed of the engine.

Another object of the invention is to provide injecting means wherein the amount of fluid supplied therefrom is controlled by the pressure of the fluid delivered to the injecting means.

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With these and various other objects in view, the invention may consist of certain novel features of construction and operation as will be more fully described and particularly pointed out in the specification, drawings and claims appended hereto.

In the drawings, which illustrate embodiments of the device and wherein like reference characters are used to designate like parts—

Figure 1 is a sectional view of a modified form of pump and nozzle adapted to be actuated by engine cylinder pressure of the cylinder to be supplied by the nozzle and wherein electrically controlled throttle venting and circulating means is provided; and

Figure 2 is a sectional view of a modified form of pump and nozzle adapted to be actuated by electrically controlled means and wherein electrically controlled throttle venting and circulating means is provided.

This application is a division of application Serial No. 537,793, filed May 29, 1944, for Fuel Injector, now Patent No. 2,530,128, November 14, 1950.

Referring first of all to the injector illustrated in Figure 1, the injector is adapted to utilize the compression pressure of the cylinder to which fuel is to be supplied by the injector for the operation of the injector. The injector comprises a nozzle **284** secured as by threads **286** to the housing or casing **288**, the upper end of the casing being closed by means of the end head **290**. The head **290** is provided with inlet fitting **292** adapted to be connected to a suitable source of fuel supply, not shown, said fitting being provided with the spring pressed valve **294** seating toward the source of supply.

The end head is provided with the concentric flanges **296** and **298** to which the upper ends of the outer and inner bellows **300** and **302** are secured in a leakproof manner, the lower ends of said bellows being similarly secured to the outer and inner concentric flanges **306** and **308** of the intermediate movable seal **310**. The seal **310** is provided with the oppositely extending flange **312** to which the upper end of the bellows **314** is secured in a leakproof manner, the lower end of said bellows being similarly connected to the lower stationary seal **316** secured between the casing **288** and nozzle **284**.

The head **290** is provided with the vents **318** for the space between the bellows **300** and **302** and is also provided with the exhaust valve opening **320** which in turn is connected to the source

of supply through a fitting, not shown. The opening 320 is adapted to be closed by means of the valve 322 urged toward closed position by means of the spring 324, said valve being controlled by means of the electro-magnet 326 operated through suitable conductors 328 by suitable throttle control means, not shown, such as by a rotary controlled switch similar to a distributor, the switch being rotated by or in accordance with the operation of the engine, but the length of contact being controlled manually.

The head 290 is also provided with the downwardly extending tube 330 extending to a point adjacent the hottest part of the injector, the tube being in communication with the inlet fitting 292. The nozzle is provided with a spring seat 332 for one end of the spring 334, the other end of the spring being seated on the spring seat 336 provided on the valve stem 338 and provided with the valve 340 adapted to seat on the nozzle seat 342.

The nozzle is also provided with the bore 344 communicating with the valve bore 346 which in turn communicates with valve stem bore 348, communicating with the chamber 350 formed between the casing 288 and the bellows 300. The valve 352 is adapted to close the seat 354 of bore 348, the valve being urged toward closed position by means of the spring 356 disposed between the seat 358, provided in the casing 288, and the seat 360 provided on the flattened valve stem 362. The valve stem 362 extends upwardly and is adapted to be contacted by the movable seal 310, downward movement of the seal 310 causing valve 352 to be opened.

On the compression stroke, valve 340 is closed and valve 352 is open and compression pressure will then be introduced to the chamber 350, causing upward movement of the seal 310 to elongate the bellows 314 and compress the bellows 302, causing a predetermined amount of fuel to be supplied under pressure to the valve 340 causing the valve to open and inject a predetermined amount of fuel into the cylinder. This predetermined amount of fuel is determined by operation of the electromagnet 326 to open the valve 322, reducing the pressure at the valve 340 to permit the spring 334 (and cylinder pressure) to close said valve. Predetermined upward movement of the seal 310 as limited by the shoulder 327, will permit the spring 356 to close the valve 352 for the power stroke and a predetermined portion of the exhaust stroke of the engine. The compression pressure in the cylinder is reduced on the exhaust stroke to a predetermined amount, at which time valve 352 will be permitted to open, equalizing the pressures in the chamber 350 and the cylinder, causing downward movement of the seal 310 by the return of the bellows to normal position, urging the valve 352 to fully open position, at which time the injector is in position for repeating the cycle.

In the construction shown in Figure 2, an injector is illustrated which is not dependent upon compression pressure for its operation so that it may be timed to inject fuel on the intake stroke of an engine or on the compression stroke thereof. This injector consists essentially of the nozzle 364 secured as by means of the threads 366 to the housing or casing 368, the upper portion of the casing being closed by means of the end head 370. The end head is provided with the inlet fitting 372 adapted to be connected to a suitable source of supply and being provided with a spring pressed valve 374 closing toward the source of supply.

The head 370 is provided with the electro-magnet 376 connected through suitable conductors 378 to a throttle control, such as described with respect to Figure 1, said electro-magnet being adapted to open the spring pressed outlet valve 380 controlling the outlet opening 382 which is connected back to the source of supply. The spring of said valve urges the valve to closed position.

The head 370 is provided with the depending spaced concentric flanges 384 and 386 to which are secured in a leakproof manner the upper ends of the outer and inner bellows 388 and 390. The space between the bellows is vented as through openings 392. The lower ends of the bellows are similarly connected to the outer and inner concentric flanges 394 and 396, respectively, of the movable seal 398, said seal being urged upwardly by means of the spring 400, one end of the spring seating on the seal 398 and the other end of the spring seating on seat 402 of the casing.

The casing is provided with the electro-magnet 404 connected through suitable conductors 406 to operating means, as for example, a rotary switch operated by the engine and so constructed and arranged that the electro-magnet is energized any time after injection has ceased, for example, on the suction stroke up until the time that injection is initiated, at which time the electro-magnet 404 is de-energized.

The seal 398 is provided with the flange 408 to which the upper end of the bellows 410 is secured in a leakproof manner, the lower end of the bellows being similarly secured to the fixed seal 412 secured between the casing 368 and the nozzle 364. The head 370 is alos provided with the downwardly extending tubular member 414 in communication with the fitting 372 and extending to a point adjacent the nozzle whereby cool fuel is supplied to the hottest part of the injector.

The nozzle is provided with the valve seat 416 adapted to be closed by the valve 418, the valve being provided with the stem 420, said stem being provided with the spring seat 422, for one end of the spring 424, the lower end of the spring being seated on the seat 426 of the nozzle.

In operation of this form of the device the electro-magnet 404 is energized at some time after injection has ceased, for example, on the compression stroke, causing downward movement of the seal 398, elongating bellows 390 and compressing bellows 410 and fuel is supplied through the fitting 372 to the inside of bellows 410, 390, and spring 400 is compressed. At a suitable time prior to the time the piston of the cylinder has completed its compression stroke, the electro-magnet 404 is de-energized, permitting spring 400 to move the seal 408 upwardly, causing fuel under pressure to be supplied to the valve 418 and injected into the cylinder. The amount of fuel is regulated by energizing electro-magnet 376 which will open valve 380 to terminate injection. The pumping stroke of the bellows, as determined by the movement of the seal 398 is always the same, regardless of the speed of the motor as it moves from the lowermost position when the electro-magnet 404 is energized to its uppermost position when magnet 404 is de-energized, against the stop 405 formed in the body of the upper electro-magnet but the amount of fuel that is injected is controlled by the valve 380. The pumping stroke, then, of this device is governed not by the speed of the engine, but by the capacity of the spring 400.

Comparison of load-speed control of injectors of known type and those illustrated herein

In order to obtain the degree of control over the ratio of air and fuel (needed for optimum economy and satisfactory performance) that is introduced into an engine cylinder, it is essential that the quantity of fuel per injection be maintained at a fixed ratio with respect to the quantity of air inducted per suction stroke of the engine cylinder.

In a naturally aspirated (not supercharged) internal combustion engine the quantity of air inducted per suction stroke of the engine decreases with increases in engine speed for each and every air throttle position according to the volumetric-efficiency curve (breathing rate) of the engine.

Thus it is evident that if a constant ratio of air and fuel is to be maintained at all times and under all conditions of speeds and loads (load-speed control), the "speed-delivery" characteristic of the injection system should conform to the same general form as the volumetric-efficiency curve of the engine.

In an engine operating on the Otto cycle (such as a gasoline spark-ignition engine) it is necessary to control the air-charge inducted by a throttle control over the air as well as the fuel introduced to the engine. Thus there is a family of volumetric-efficiency curves (one curve for each throttle position). In the diesel engine, as no air throttle is provided, there is only one volumetric-efficiency curve for the air charge inducted (full throttle).

All commercial forms of fuel injection pumps now in use utilize a plunger-barrel combination, as a pumping means. The type of injection pump in most extensive use at the present time, employs a port controlled by-pass, with an undercut section of the plunger as the slide valve means for controlling the porting of this by-pass port in order to control the quantity of fuel delivered by the pump.

The following formula expresses the leakage rate of the above type of plunger-barrel pumps.

$$\text{Leakage rate } \alpha \frac{cl^3 dsP}{\mu L}$$

1. c is a constant.
2. l is the mean clearance between the barrel or casing and the plunger.
3. d is the pump plunger diameter.
4. s is the plunger velocity.
5. P is the pressure differential between the lapped portion between the plunger and the barrel.
6. μ is the viscosity of the liquid being pumped.
7. L is the length of the lapped fit.

Due to the leakage condition it is necessary in this piston type of pump to provide a cam profile with a rate of lift sufficient to overcome this leakage at slow speeds, especially cranking speeds as are encountered when cold-starting the engine. As a result, the speed-delivery characteristics of this type of pump tend to fall off at slow speeds (when the time for leakage is the greatest) and also at high speeds (when the pressure causing leakage is the greatest).

As a result of the above conditions the tendency at the higher throttle rack settings is to result in speed-delivery characteristics, which fall off much more rapidly with increasing engine speed than the volumetric efficiency of the engine does, and results in the failure to maintain the air to fuel ratio.

As the throttle rack position is decreased, (smaller amounts per injection), the "speed-delivery" characteristics continue to be altered until at the lower range of the throttle settings the curve has an exactly opposite slope. This condition is equally as undesirable as the former.

Thus it may be seen that as the quantity per injection at the higher throttle conditions falls off too rapidly due to leakage, there will be a speed at which delivery will fall below the quantities necessary, and result in a definite limit to engine speeds that can be obtained. This condition is especially bad when the high pressure pump and nozzle are separated by a delivery tube (due to adverse pressure wave characteristics).

In the modifications shown herein the effect of leakage is eliminated by the use of a hermetically sealed pumping element, and a unitary construction is employed in order to overcome the disadvantage of a pump-delivery-tube-nozzle combination. The absence of leakage makes possible the use without adverse effects of whatever cam shape is necessary in order that the "speed-delivery" characteristics of the injector will conform exactly to the volumetric-efficiency curve of the engine. Thus in the modifications herein, it is possible to obtain complete and automatic load-speed control.

The injectors shown herein may readily be operated as pusher or sump pumps located at the source of supply and supplying fuel to injectors or a carburetor, also they may be used to inject liquid, as water, into the cylinders (or manifold) for anti-detonating purposes.

It is to be understood that I do not wish to be limited by the exact embodiments of the device shown, which are merely by way of illustration and not limitation as various and other forms of the device will, of course, be apparent to those skilled in the art without departing from the spirit of the invention or the scope of the claims.

I claim:

1. In an injector, the combination of a housing having a top end closure at one end and a discharge opening at the other, large and small diameter communicating chambers in said housing, an outwardly opening discharge valve in said opening, resilient means urging said valve to closed position, a fixed seal in said small diameter chamber adjacent said valve, an intermediate seal in said large diameter chamber, a bellows in said small diameter chamber having the ends thereof connected to said seals, an inner bellows connected to said intermediate seal and to said top enclosure, an outer bellows connected to said intermediate seal and top end closure, vents in said closure between last named bellows, means extending through said closure and into said first bellows for supplying fuel thereto adjacent said valve, an exhaust valve in said second bellows for returning fuel and vapor to the source of supply, electro-magnetic means for controlling said last valve, a valve in said housing controlled by said intermediate seal for permitting exterior pressure to be introduced to said housing to pulsate the third bellows to cause pulsations of one of the other bellows to supply fuel through said discharge opening.

2. In an injector, the combination of a housing, a valve opening outwardly of said housing, resilient means urging said valve toward closed position, a bellows secured at one end to said housing adjacent said valve, an intermediate seal secured to the other end of said bellows, a second bel-

lows secured at one end to said seal and at the other end to said housing, an outlet from within said second bellows, a normally closed valve for said outlet, electro-magnetic means for selectively opening said valve, means for supplying fluid to be ejected to said first named bellows, and means for moving said seal to thereby pulsate said bellows.

3. In an injector, the combination of a housing having a top end closure at one end and a discharge opening at the other, large and small diameter communicating chambers in said housing, a fixed seal in said small diameter chamber adjacent said opening, an intermediate seal in said large diameter chamber, a bellows in said small diameter chamber having the ends thereof connected to said seals, an inner bellows connected to said intermediate seal and to said top end closure, an outer bellows connected to said intermediate seal and top end closure, vents in said closure between last named bellows, means extending through said closure and into said first bellows for supplying fluid thereto adjacent said opening, an exhaust valve in said second bellows for returning fluid and vapor to the source of supply, electro-magnetic means for controlling said last valve, a valve in said housing controlled by said intermediate seal for permitting pressure to be supplied in a pulsating manner to said housing to pulsate the third bellows to cause pulsations of one of the other bellows to supply fluid through said opening.

4. In an injector, the combination of a housing having a discharge opening at one end, a bellows secured at one end to said housing adjacent said opening, an intermediate seal secured to the other end of said bellows, a second bellows secured at one end to said seal and at the other end to said housing, an outlet from within said second bellows, a normally closed valve for said outlet, means for opening said valve, means for supplying fluid to be ejected to said first named bellows, and means including an electromagnet adapted to be selectively energized and de-energized for moving said seal to thereby pulsate said bellows.

5. In an injector, the combination of a housing having a discharge opening at one end, a bellows secured at one end to said housing, an intermediate seal secured to the other end of said bellows, a second bellows secured at one end to said seal and at the other end to said housing, an outlet from within said second bellows, a normally closed valve for said outlet, electro-magnetic means for selectively opening said valve, means for supplying fluid to be ejected to said first named bellows, and means for moving said seal to thereby pulsate said bellows.

6. In an injector, the combination of a housing having a discharge opening at one end, a bellows secured at one end to said housing adjacent said opening, an intermediate seal secured to the other end of said bellows, a second bellows secured at one end to said seal and at the other

end to said housing, an outlet from within said second bellows, a normally closed valve for said outlet, electromagnetic means for selectively opening said valve, means for supplying fluid to be ejected to said first named bellows, and means including an electromagnet adapted to be selectively energized and de-energized for moving said seal to thereby pulsate said bellows.

7. In an injector, the combination of a housing having a discharge opening at one end, a bellows secured at one end to said housing adjacent said opening, an intermediate seal secured to the other end of said bellows, a second bellows secured at one end to said seal and at the other end to said housing, an outlet from within said second bellows, a normally closed valve for said outlet, electro-magnetic means for selectively opening said valve, means for supplying fluid to be ejected to said first named bellows, and means for moving said seal to thereby pulsate said bellows, said means including a passage for communicating fluid pulsations to said seal, and a valve for controlling said last named means, said valve being controlled by said seal.

8. In an injector, the combination of a housing having a top end closure at one end and a discharge opening at the other, large and small diameter communicating chambers in said housing, a discharge valve for said opening, resilient means urging said valve to closed position, a seal in said large diameter chamber, a bellows in said small diameter chamber having one end connected to said housing and the other end connected to said seal, an inner bellows connected to said seal and to said top end closure, an outer bellows connected to said seal and top end closure, vents in said closure between said last named bellows, means extending through said closure and into said first bellows for supplying fuel thereto adjacent said valve, an exhaust valve in said second bellows for returning fuel and vapor to the source of supply, means for controlling said last valve, and means for moving said seal to thereby pulsate said bellows.

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