

**March 18, 1952**

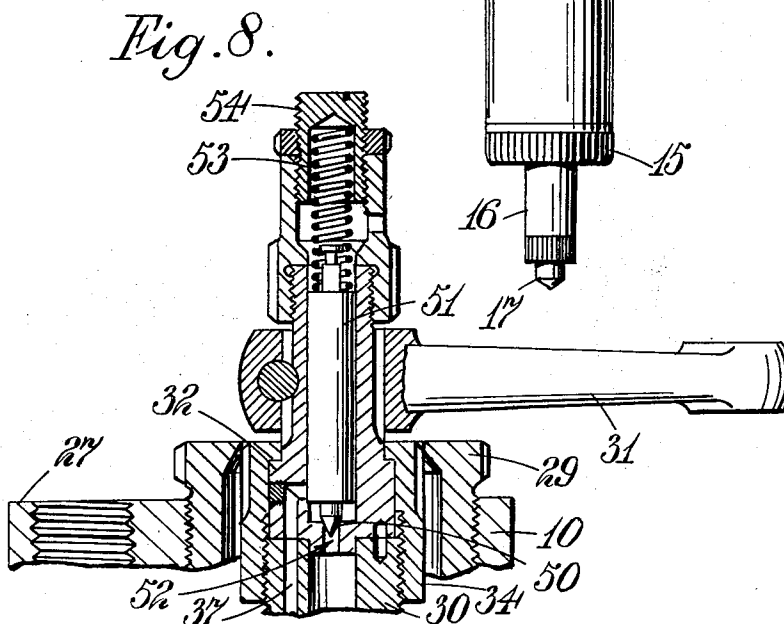
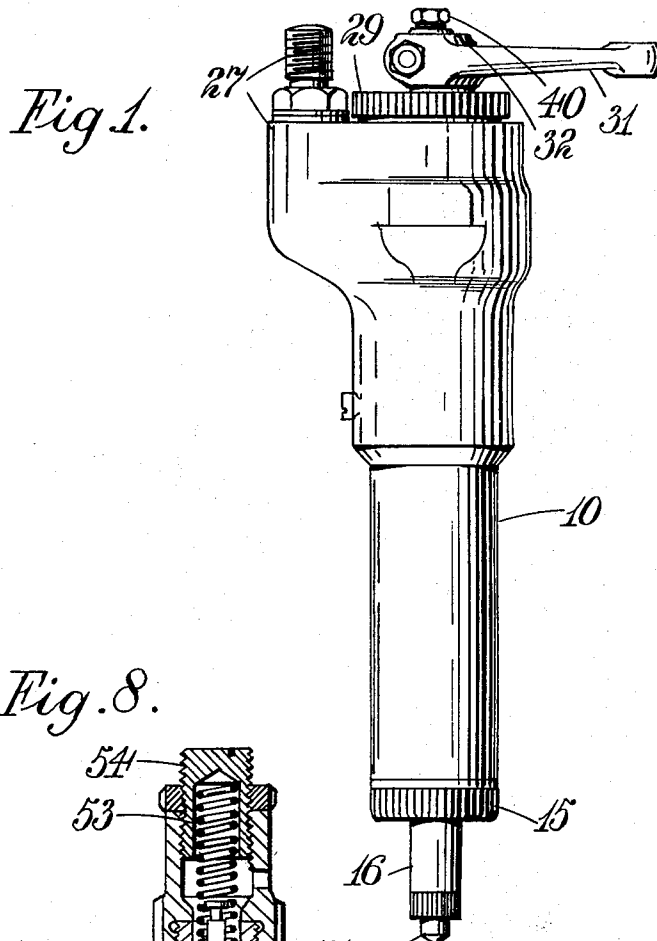
A. J. MORRIS

**2,589,505**

# PUMP INJECTOR FOR OIL ENGINES

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3 Sheets-Sheet 1



INVENTOR.  
ALBERTO JORGE MORRIS  
*By his attorneys*  
*Stebbins, Blank & Webb*

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A. J. MORRIS

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3 Sheets-Sheet 2

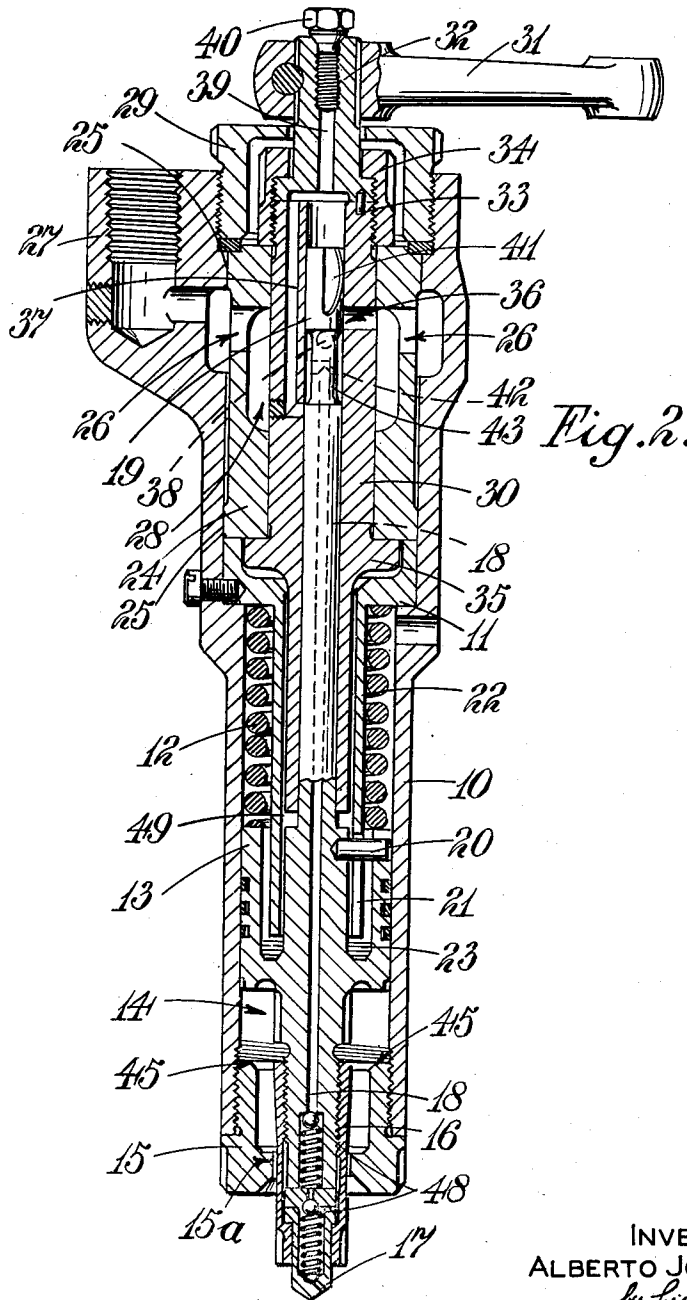


Fig. 2.

INVENTOR.  
ALBERTO JORGE MORRIS  
*by his attorney*  
Stebbins, Blunk & Wolf

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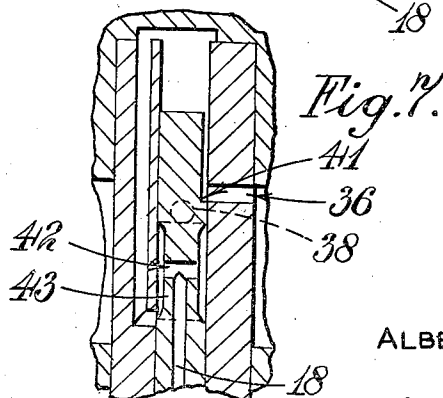
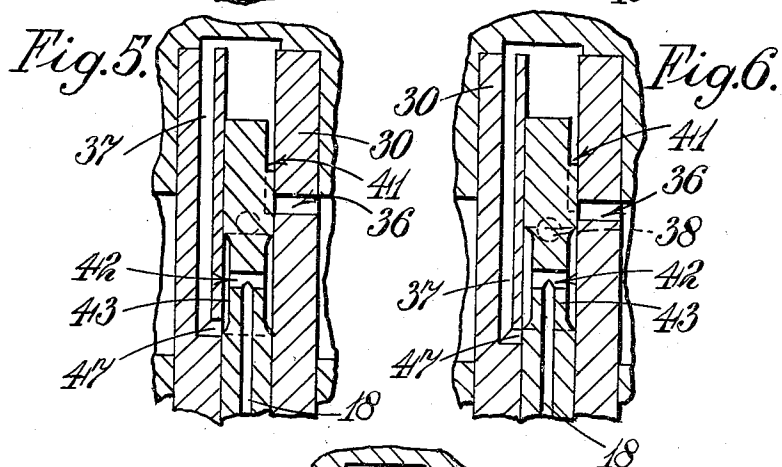
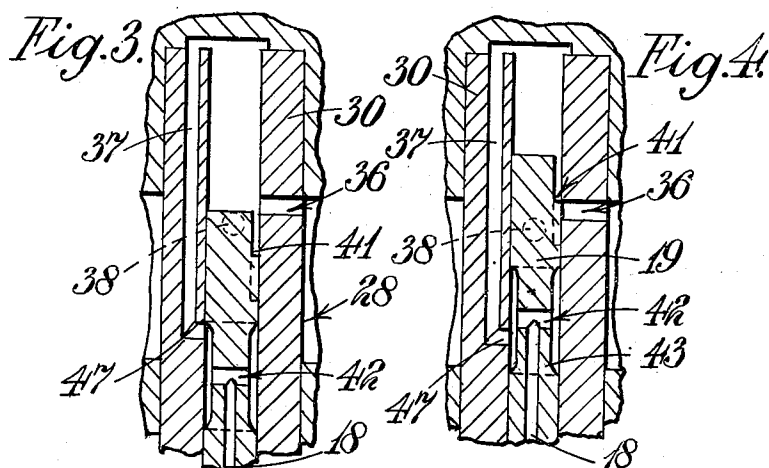
A. J. MORRIS

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PUMP INJECTOR FOR OIL ENGINES

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3 Sheets-Sheet 3



INVENTOR.  
ALBERTO JORGE MORRIS

*By his attorney*  
*Steffens, Bleeker & Hall*

## UNITED STATES PATENT OFFICE

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## PUMP INJECTOR FOR OIL ENGINES

Alberto Jorge Morris, Dursley, England, assignor  
to R. A. Lister & Company Limited, Dursley,  
England, a British company

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11 Claims. (Cl. 299—107.2)

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This invention relates to pump-injectors for oil-engines comprising a plunger which reciprocates to deliver fuel from a cylinder to a nozzle by which the fuel is injected into the engine combustion space. The plunger makes a fuel delivery stroke during which fuel injection occurs and a return stroke during which the cylinder is recharged with fuel.

This invention has for an object to provide an improved construction of such pump-injector which is compact and is less liable to damage of the moving parts at the end of a stroke.

According to this invention, a pump-injector comprises an injector body, a reciprocating plunger working in a cylinder in the body to deliver fuel intermittently to a nozzle provided at one end of the pump injector, a spring-loaded gas-piston arranged to work in a chamber in the body under control of a pressure medium supplied to the chamber, said gas-piston and plunger being operatively connected to move as one piece, and means to provide a cushioning buffer to arrest the plunger and gas-piston at the end of a stroke.

According to one feature of this invention, means constituting a cushioning buffer at the end of the return stroke comprises a tapered extension of the gas-piston arranged progressively to decrease the effective area of a metering orifice through which the pressure medium flows and thereby to control the flow of the pressure medium from the chamber. It will be seen that in use the tapered extension throttles the flow of pressure medium from the chamber on the return stroke thus slowing down the moving parts and preventing damage there to. The extension is preferably given a taper of between 1 in 16 and 1 in 4. Such an arrangement has the further advantage that as the pressure in the chamber increases during the fuel injection stroke the degree of throttling decreases so that a quicker injection is obtained than if the metering orifice were of uniform effective area throughout the stroke.

It is preferred moreover that the metering orifice has an effective area when the piston is at the end of the return stroke equal to between about 0.5% and 2% of the cross-sectional area of the gas-piston in order that satisfactory cushioning and communication with pressure medium supply is obtained and in order to avoid the necessity of providing an auxiliary control to reduce the spring loading on the gas-piston for starting purposes.

It has also been found that the volume of the gas-piston chamber with the piston at the end of the return stroke has a controlling effect on

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the temperature of the gases within the chamber, on the rate of lift of the gas-piston and therefore of the injection plunger and on the cushioning effect secured at the end of the return stroke.

5 According to a further feature of the invention therefore, the volume of the gas-piston chamber when the gas piston is at the end of the return stroke is selected to be within the range of from 5% to 60% of a volume equivalent to the cross-sectional area of the gas-chamber multiplied by the stroke of the gas-piston.

Conveniently, the metering orifice opens to that end of the pump-injector at which the nozzle is located and the nozzle is carried by the tapered extension so that the pressure medium for controlling the gas-piston is constituted by the gases in the combustion space to which fuel is supplied. In such a construction it is preferred that the volume of the gas-chamber when the piston is at the end of the return stroke be selected to be not more than 5% of the volume of the engine combustion space, which volume is calculated with the engine piston at top dead centre, to which fuel is being supplied. If the chamber volume is too large the operation of the engine is adversely affected.

According to another feature of this invention, cushioning of the moving parts at the end fuel injection stroke is effected hydraulically by arranging that the plunger entraps a quantity of fuel in the cylinder towards the end of the fuel-delivery stroke.

In a preferred construction of pump-injector, the plunger has a shaped head co-operating with the fuel inlet port to the cylinder which is rotatable within the body, so that the point in the fuel-injection stroke at which the port is covered may be varied. In this manner the quantity of fuel injected and the point in the engine cycle at which injection commences may be varied. The plunger preferably has a shaped stem which provides during fuel injection communication between portions of a duct leading from the cylinder to the nozzle and which is adapted to open the duct to a spill port to terminate fuel injection prior to the end of the fuel injection stroke and thereafter to cut off that portion of the duct opening to the cylinder from the spill port and that portion of the duct leading to the nozzle thereby to entrap fuel in the cylinder.

According to yet another feature of this invention, a spring-loaded valve is provided controlling the flow of fuel in the duct and means is provided for varying the loading of the valve thereby to vary the point at which fuel injection commences.

In order to facilitate manufacture, it is preferred that the gas-piston and plunger be made as one.

A pump-injector embodying the features of this invention will now be described by way of example, reference being had to the accompanying drawings in which:

Figure 1 is an elevation of the pump-injector,

Figure 2 is a longitudinal section on a larger scale.

Figures 3 to 7 are diagrammatic figures illustrating the operation of the plunger and,

Figure 8 illustrates a modification.

Referring to Figures 1 and 2, the pump-injector comprises a body 10 accommodating in its upper portion (as viewed in the drawings) a fuel-pump and in its lower portion the means for actuating the pump. In this manner, the upper portion is cooled by the incoming fuel. Within the body 10, there is secured a distance piece 11 providing an abutment for a spring 12 which bears on a gas-piston 13 working in a chamber 14 constituted by the wall of the body 10 and a nut 15 screwed into the end of the body. The nut is formed with a central orifice 15a through which projects a tapered extension 16 of the piston 13 carrying at its outer end an injection nozzle 17. A duct 18 runs through the extension 16 so that fuel may be supplied to the nozzle from the pump, the plunger 19 of which is formed as an axial extension of the gas-piston 13. A guide pin 20 is provided between the skirt of gas-piston 13 and the stem of the piston to engage in a slot 21 in an extension 22 of the distance piece to prevent rotation of the gas-piston and plunger in use.

A resilient pad 23 is located in the space between the gas-piston skirt and stem as emergency means for stopping the moving parts and preventing damage thereto.

The pump injector illustrated is of a construction adapted for operation by the pressure within the combustion space to which fuel is being supplied.

Referring to the gas-piston 13 and chamber 14, it has been found that for the most efficient operation the dimensions of the parts must be carefully selected.

Thus, for example, to secure efficient cushioning of the moving parts at the end of the return stroke and at the same time to ensure effective communication between the chamber 14 and the compression space under all running conditions, it has been found that when the gas-piston 13 is at the end of the return stroke (i. e. in a position with its under surface bearing against the shoulder 45 provided by nut 15) its effective area should be selected to be from about 0.5% to about 2% of the cross-sectional area of the piston. By so selecting the area of the orifice, it becomes unnecessary to provide an auxiliary control to relieve the loading of spring 12 for starting purposes.

Moreover, it is preferable to arrange that the area of the orifice 15a increases during the fuel-injection stroke. In this manner the pressure within chamber 14 rises sharply at the injection period giving improved injection. For this purpose it has been found that best results are secured if the tapered extension has a taper of between 1 in 16 and 1 in 4. If the orifice has a uniform cross-section throughout the injection stroke, the characteristic pressure curve for chamber 14 is a replica of the engine compression curve, the slope of which normally decreases as

the engine reaches top-dead centre. Such a characteristic pressure curve would prevent quick fuel injection.

It has also been found that the volume of the gas-piston chamber with the piston at the end of the return stroke has a controlling effect on the temperature of the gases within the chamber, on the rate of lift of the gas-piston and therefore of the injector-plunger and on the cushioning effect secured at the end of the return stroke. According to a further feature of the invention therefore, the volume of the gas-piston chamber when the gas piston is at the end of the return stroke is selected to be within the range of from 5% to 60% of a volume equivalent to the cross-sectional area of the gas-chamber multiplied by the stroke of the gas-piston.

It has also been found that if the volume of the gas-chamber 14 (with the gas-piston at the end of the return stroke) is too large, the engine operation may be affected and therefore it is preferred that the volume be limited to not more than 5% of the volume of the engine combustion space, which volume is calculated when the engine piston is at top dead centre.

Between the distance piece 11 and a threaded collar 29, there is located a sleeve 24 having lands 25 for positioning the sleeve within the body 10 and ports 26 providing communication between a fuel-delivery connection 27 and a chamber 28 formed in the inner surface of the sleeve.

Within the sleeve 24, there is located a cylinder 30 in which the plunger 19 works, and this cylinder is rotatable by means of a lever 31 secured to a head 32 which is pinned to the cylinder 30 at 33. A nut 34 is threaded on the outside of the cylinder 30 and head 32 and bears on sleeve 24 to hold a flange 35 on the cylinder against the sleeve. A fuel inlet port 36 is provided connecting chamber 28 with the cylinder space and a duct 37 is formed in the wall of the cylinder connecting the cylinder space with the duct 18 through a shaped portion of the plunger. Spill ports 38 are also formed in the cylinder just below the level of the inlet port 36. A pump priming duct 39 is formed in the head 32 and is normally closed by plug 40.

The plunger 19 which is an axial extension of the gas-piston 13, has a head with a helical edge 41. It will thus be seen that by rotating the cylinder 30, the point in the fuel delivery stroke at which the inlet port 36 is covered may be varied. In this way the quantity of fuel delivered to the nozzle and the injection time may be varied. The duct 18 communicates at its upper end with a cross duct 42 opening to a neck 43 formed in the stem of the plunger 19.

The operation of the pump injector is as follows:

With the gas-piston 13 and plunger 19 at the end of the return stroke and therefore at the beginning of the fuel injection stroke, pressure within chamber 14 will slowly rise with the pressure in the combustion space until the loading spring 12 is overcome. The piston 13 and plunger 19 will then commence the injection-stroke, the plunger moving from the position shown in Figure 3 until the helical edge 41 of the plunger head covers the inlet port 36 (Figure 4) at which point fuel injection commences, fuel being forced through duct 37, port 47, around neck 43, and through cross duct 42, duct 18 past ball valves 48 to the nozzle 17.

Fuel injection continues until the neck 43 opens spill port 38 to the space around it, (Figure 5),

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thus relieving the pressure within the ducts 18, 37 and in the cylinder.

On further upward movement of the gas-piston and plunger the lower lip of the neck closes port 47 (Figure 6) so that fuel is trapped within the cylinder and duct 37 and provides a hydraulic cushioning buffer for the end of the fuel-injection stroke. In this way damage to the moving parts by violent contact is avoided.

In the event that the cylinder is empty the moving parts are stopped by contact of the resilient pad 23 with the end of the sleeve-like extension 49 of the distance-piece 11.

The parts are now at the beginning of the return stroke.

As the pressure within the combustion space decreases gases escape from chamber 14 through the metering orifice 15a, the effective area of which is gradually decreased so as to throttle the flow of gases thus allowing the moving parts at the end of the return stroke to be stopped gently against abutment 45.

During the return stroke a vacuum will form in the cylinder, and fuel will be drawn into it through port 36 and also partly through spill port 38 and duct 37 until the former is closed in the head of the plunger.

For starting purposes, the cylinder may be primed by loosening the plug 40 and injecting fuel through inlet port 36 by a gravity or pressure feed allowing air to escape through duct 39.

Figure 7 illustrates the position of the cylinder 30 in which no fuel will be injected since the helical edge does not cover the inlet port 36 until the spill port 38 is uncovered.

It will be appreciated from the foregoing that the invention provides a simple compact construction of pump injector in which the possibility of damage to the moving parts is considerably reduced by providing a hydraulic cushioning buffer at the end of the fuel-injection stroke and a throttled gas flow to control the return stroke. Moreover, by suitably selecting the dimensions of various parts of the pump injector, efficient fuel injection is obtained and adverse effects on the engine operation are avoided.

Referring now to Figure 8, in which reference numerals used in Figure 2 are employed to indicate like parts, there is illustrated auxiliary means for varying the point in the fuel injection stroke at which fuel injection commences. The auxiliary means comprises a needle valve 50 having an enlarged stem 51 and mounted within the head 32. The needle valve 50 is normally urged into contact with a seat providing an outlet port 52 between the cylinder and duct 37 by means of a loading spring 53 the loading afforded by which may be varied by abutment screw 54. With this arrangement fuel cannot be delivered to the nozzle until the pressure in the cylinder is sufficient to overcome the spring 53. When the valve 50 is clear of the port 52, the fuel pressure acts on the end of the enlarged stem 51 ensuring rapid lifting of the valve.

I claim:

1. A pump-injector comprising a body, a bore in the body to form a gas chamber having port means for the supply to the chamber of a pressure fluid; a fuel pump cylinder accompanied in the body coaxially with the gas chamber, there being a fuel inlet port to the fuel pump cylinder; a fuel injection nozzle at one end of the pump injector, there being fuel-delivery duct means interconnecting the fuel pump cylinder and the fuel injection nozzle; a reciprocating member re-

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ciprocable within the body under control of the pressure fluid in the gas chamber and having a gas piston portion working in the gas chamber, a fuel pump plunger portion having a head working in the fuel pump cylinder, a stem connecting the head to the gas piston, and a tapered extension projecting from the gas piston portion and extending through the port means of the gas chamber to throttle the flow of pressure fluid through the port means, the taper of said tapered extension being arranged progressively to increase the effective area of the port means during travel of the reciprocating member to increase the pressure fluid receiving volume of said gas chamber to deliver fuel to the injection nozzle and progressively to decrease said effective area during the return travel of the reciprocating member to decrease said pressure fluid receiving volume, and said stem having a part arranged as a valve to control the fuel flow through the duct means to cut off the fuel flow prior to the end of the fuel injection stroke and to entrap fuel in the fuel pump cylinder; and a return spring acting to urge the reciprocating member in the direction of the return travel.

2. A pump-injector as claimed in claim 1, wherein said tapered extension has a taper of between 1 in 16 to 1 in 4.

3. A pump-injector as claimed in claim 1, wherein said port means of the gas chamber and said tapered extension are arranged, when the reciprocating member is at the end of its return travel, to give a value of said effective area of between 0.5% and about 2% of the cross-sectional area of said gas piston.

4. A pump-injector as claimed in claim 1, wherein said gas chamber and said gas piston are arranged, when the piston is at the end of its return travel, to give a pressure fluid receiving volume of said gas chamber within the range of from 5% to 60% of a volume equivalent to the cross-sectional area of the gas piston multiplied by the stroke of the gas piston.

5. A pump-injector as claimed in claim 1, wherein said fuel injection nozzle is carried at the outer end of the tapered extension, the duct means interconnecting the fuel pump cylinder and the fuel injection nozzle comprises duct portions in the pump cylinder and in the stem of the pump plunger, and said stem of the pump plunger has a waisted portion arranged during fuel injection to connect the duct portion in the fuel pump cylinder with the duct portion in the stem of the fuel pump plunger and arranged before the end of the fuel injection travel of the reciprocating member to be moved to brake said connection between said duct portions and to prevent fuel flow through said duct portion in the pump cylinder thereby to entrap fuel in the fuel pump cylinder.

6. A pump-injector as claimed in claim 5, wherein said fuel pump cylinder also comprises a spill port therein, which spill port is arranged to be uncovered by said waisted portion of the stem to terminate fuel injection just prior to the point in the fuel injection travel at which the connection between the duct portions is broken.

7. A pump-injector comprising a body, a bore in the body to form a gas chamber having port means for the supply to the gas chamber of a pressure fluid; a fuel pump cylinder accommodated in the body coaxially with the gas chamber and arranged for angular adjustment about its axis, there being a fuel inlet port to the fuel pump cylinder and a fuel outlet port

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therefrom and a duct portion in the pump cylinder connected with the outlet port, means to rotate the fuel pump cylinder within the body to adjust its angular position therein; a member reciprocable within the body under control of the pressure fluid in the gas chamber and having a gas piston portion working within said gas chamber, a fuel pump plunger portion having a head working in the fuel pump cylinder and a stem connecting the head to the gas piston, said head having a portion shaped to co-operate with the inlet port to determine, according to the angular position of the pump cylinder within the body, the point at which fuel injection commences, and a tapered extension projecting from the gas piston portion and arranged to extend through the port means of the gas chamber to throttle the flow of pressure fluid through said port means, the taper of said tapered portion being arranged so as progressively to increase the effective area of the port means throughout travel of the reciprocating member to increase the pressure fluid receiving volume of said gas chamber and to deliver fuel from the fuel pump cylinder and progressively to decrease the effective area throughout the return travel of the reciprocating member to decrease said pressure fluid receiving volume of said gas chamber, there being a duct portion running through said stem and said tapered extension, and said stem having a waisted portion to provide communication between the duct portion in the fuel pump cylinder and the duct portion in the stem and tapered extension during fuel injection, said waisted portion being so located along the stem that communication between the duct portions is cut off prior to the end of the travel of the reciprocating member in the fuel injection direction; a fuel injection nozzle carried on the free end of said tapered extension and communicating with the duct portion in the stem and tapered extension; and a return spring to effect travel of the reciprocating member in the return direction.

8. A pump-injector as claimed in claim 7,

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wherein said tapered extension has a taper of between 1 in 16 to 1 in 4.

9. A pump-injector as claimed in claim 7, wherein said port means of the gas chamber and said tapered extension are arranged, when the reciprocating member is at the end of its return travel, to give a value of said effective area of between 0.5% and about 2% of the cross-sectional area of said gas piston.

10. A pump-injector as claimed in claim 7, wherein said gas chamber and said gas piston are arranged, when said gas piston is at the end of its return travel, to give a pressure fluid receiving volume within the range of from 5% to 60% of a volume equivalent to the cross-sectional area of the gas piston multiplied by the stroke of the gas piston.

11. A pump-injector as claimed in claim 7 wherein the fuel pump cylinder is also provided with a spill port in such a position in its length that it is uncovered by the waisted portion of the stem to terminate fuel injection prior to cutting off of communication between the duct portion in the pump cylinder and the duct portion in the stem and tapered extension.

ALBERTO JORGE MORRIS.

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