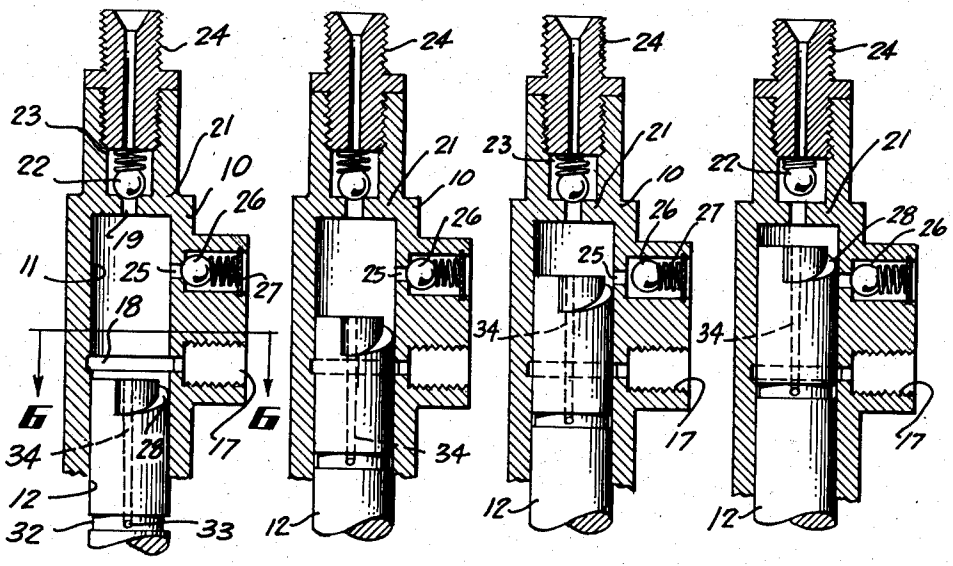
Nov. 20, 1951 J. W. HATCH 2,575,955

FUEL INJECTION PUMP

Filed July 10, 1947

Fig 1 Fig 2 Fig 3 Fig 4



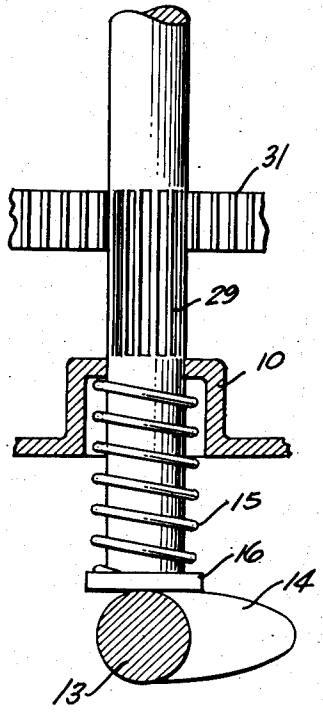


Fig 5

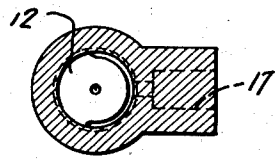
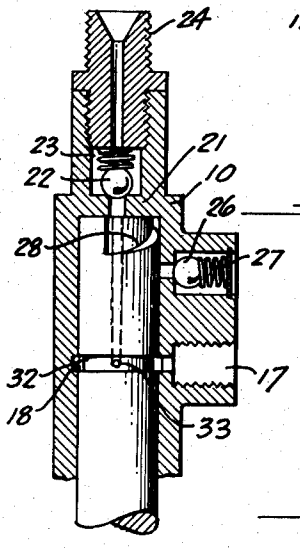


Fig 6



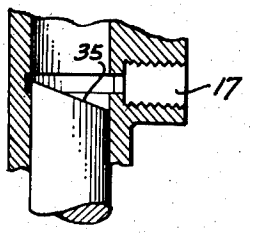


Fig 7

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FUEL INJECTION PUMP

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8 Claims. (Cl. 103—41)

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The invention presented herein is concerned with fuel injection in internal combustion engines and particularly relates to pump-type fuel injectors.

This application is a continuation, in part, of my application entitled "Fuel Injection Pump," Serial No. 513,882, filed December 11, 1943, now abandoned.

Previously, such injectors when utilized with liquid fuels, and particularly with such volatile liquids as gasoline, inescapably operated on their intake stroke to agitate the gasoline while naturally reducing the pressure thereupon. The inevitable result was to transform the intaken fuel into a frothy mixture of fuel vapor, liquid fuel and air. The quantity of fuel drawn into the chamber of previously proposed fuel injection pumps consequently varied depending upon the amount of fuel vapor and air present in the intaken mixture. As the quantity of fuel taken in during the intake stroke of the plunger varied such pumps were not capable of constantly delivering equal fuel charges to the combustion chamber of the internal combustion engine with which they were used.

This successive distribution of unequal charges to a given engine cylinder eventually resulted in overheating of the cylinder, and the simultaneous delivery in one cycle of unequal charges to the various cylinders effectuated uneven power impulses from the various cylinders, with resultant excessive vibration and irregularity of operation. Even more serious is the fact that this overheating, uneven firing, and vibration materially reduced the thermodynamic efficiency and the brake horsepower of the engine.

This problem has been a vexatious one and has been sought to be solved by providing means for metering the fuel supplied to the pump at the intake stroke. The means heretofore proposed for metering the charge supplied the pump have been complicated and difficult to maintain. They have not been entirely successful for they too agitated the fuel while varying the pressure thereon so that the fuel charge supplied the pump was again compressible to varying and undeterminable degrees.

The present invention conceives of a method and a means for enabling fuel injectors to pump an invariably equal amount of highly voltatile fuel at a constant pressure into each of the cylinders of an internal combustion engine on each of the engine cycles. Generically, the invention is predicated upon drawing into the chamber of the pump such a quantum of fuel in mixed-phase

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condition as to insure the presence in the chamber, after reduction of the mixed-phase condition of the fuel to a liquid-phase, of a quantity of liquid fuel in excess of a preselected quantity desired to be injected; reducing the fuel in the mixed-phase condition to a liquid fuel by compression; eliminating from the pump chamber the fuel in excess of the preselected quantity to be injected while retaining the fuel under compression; and thereafter ejecting under a higher compression the remaining fuel from the pump chamber.

The now preferred embodiment of the fuel injection pump of the present invention comprises a compression chamber in which a plunger is reciprocatably mounted. The chamber is formed with an intake port located adjacent the one end of the stroke or path of movement of the plunger and adjacent the opposite end of the stroke of the plunger with an ejection port normally closed by a pressure responsive means. A relief port also normally closed by a pressure responsive means is disposed intermediate the intake and ejection ports.

In carrying out the method of the present invention the quantum of fuel in mixed-phase condition is drawn into the chamber as the plunger reaches the end of its intake stroke and uncovers the intake port. As the plunger begins its compression stroke the intake port is closed and the fuel in mixed-phase condition is subjected to progressively increasing pressure until a pressure is reached at which the fuel in the mixed-phase condition is reduced to a liquid-phase.

The relief port is so spaced from the intake port that the reduction of the fuel in the mixed-phase condition will have been brought about before the plunger reaches the point in its compression stroke at which the same will close the relief port. The pressure responsive means normally closing the relief port is set to open at a pressure slightly in excess of the fuel mixture-liquifying pressure and will open subsequent to the reduction of the fuel in the mixed-phase condition to permit elimination of the quantity of liquid fuel in excess of that quantity remaining in the chamber after the plunger has reached a position in its compression stroke at which the relief port will be closed by the plunger.

The means normally closing the ejection port is operated to open the port by the attainment of a predetermined pressure within the chamber greater than that pressure at which the relief port is opened. There is thus no danger that the

ejection port will open prior to the elimination of the excess fuel by way of the relief port.

The pressure at which the ejection port will open is brought about by movement of the plunger in its compression stroke beyond its position of travel at which the relief port will be closed by the same. When the predetermined pressure is reached by compression of the now liquid fuel the ejection port is opened and the liquid fuel is forced under pressure into the combustion chamber.

The plunger is formed with control means which will upon rotation of the plunger vary the position of the plunger during its compression stroke at which the same will close the relief port. As the position at which the plunger will close the relief port during the compression stroke thereof can be varied the quantity of fuel remaining in the chamber at the time the relief port is closed can consequently also be varied. Thus the injection pump of the present invention provides means for ejecting at each compression stroke a preselected, invariably equal quantity of highly volatile fuel at constant pressure.

Other features and advantages of the present invention will be apparent from the following detailed description thereof taken in connection with the accompanying drawing, in which:

Figure 1 is a fragmentary longitudinal section, partly in elevation, of a fuel injection pump incorporating my invention showing the intake port open and the position of the plunger at the beginning of its compression stroke;

Figure 2 is a view similar to Figure 1 but showing the plunger as having closed the intake port and progressively increasing the pressure on the intaken fuel mixture;

Figure 3 is also a view similar to Figure 1 but showing the relief port open with the plunger approaching the position in its compression stroke at which the relief port will be closed;

Figure 4 is a longitudinal section showing the plunger at a position after the relief port has been closed and the ejection port has been opened;

Figure 5 is a view similar to Figure 4 but showing the position of the plunger at the completion of ejection of the fuel;

Figure 6 is a section taken along lines 6—6 of Figure 1; and

Figure 7 is a fragmentary longitudinal section, partly in elevation, of a modified form of the fuel injection pump of the present invention.

The now preferred embodiment of the fuel injection pump of the present invention, referring now to the accompanying drawing and more particularly to Figure 1 thereof, comprises a housing 10 including a compression chamber 11 in which a plunger 12 is mounted for reciprocatory motion through some conventional driving means. This means may comprise a driven shaft 13 carrying a cam 14 against which the lower end of the plunger is normally urged by a spring 15 surrounding the plunger 12 between the lower surface of the housing 9 and a circular shoulder 16 carried by the lower end of the plunger.

The housing 10 is provided with an intake port 17 adapted to be connected by a suitable conduit, not shown, to a source of fuel such as the conventional fuel tank. A booster pump may be incorporated into the conduit leading to the intake port if found desirable. The inner wall of the housing 10 is formed with an annular groove 18 which intersects the intake port 17 as shown, the purpose of this groove will be hereinafter more fully explained.

An injection port 19 is provided in the transverse wall 21 of the housing 10. This port is normally closed by a ball valve 22 held in port-closing position by a spring 23 seating on the inner end of a fitting 24 serving to connect the ejection port with the combustion chamber of the engine through a conventional nozzle not shown.

A second normally closed port is provided in the housing wall above the intake port 17. This port shown at 25 is normally closed by a ball 26 held across the port by a spring 27 seating on a collar or the like suitably anchored to the wall of the housing. The port 25 is the relief port through which the excess fuel may be eliminated just prior to the ejection cycle of the pump. The intake port 17 and the relief port 25 constitute passage means communicating with the fuel supply.

In the operation of the pump herein disclosed, as the plunger 12 moves downwardly in the housing 10 a partial vacuum is created above the plunger so that when the plunger moves downwardly past the intake port 17 the fuel within the line adjacent the port is suddenly subjected to sub-atmospheric pressure and the quantity of fuel drawn into the housing, because of the partial vacuum therein, takes a mixed vapor and liquid phase condition. The fuel in this mixed-phase condition is highly compressible to varying and incalculable degrees.

The cam 14 is so formed that the plunger remains in an arrested position with the intake port open for a time sufficient to permit the chamber 11 to completely fill with the mixed-phase fuel. The quantity of fuel in the mixed-phase condition drawn into and filling the chamber is sufficient to insure a quantity of liquid fuel, after reduction of the mixed-phase condition of the fuel intaken to a liquid phase, in excess of the preselected quantity to be ejected.

As the cam urges the plunger upwardly the latter first closes the intake port and as it continues to move upwardly, progressively increases the pressure on the fuel mixture held by the chamber. At some pressure, dependent upon the type of fuel, the amount of free air and fuel vapor present in the indrawn mixture, as well as the temperature of the same, the fuel mixture will return to the liquid phase. The spring 27 is of such a rate as to hold the ball 26 in port-closing position until this pressure has been reached. The intake port is so spaced from the relief port that the pressure at which the fuel mixture is reduced to a liquid will be reached under all expected normal operating conditions before the plunger has moved upwardly a distance sufficient to close the relief port.

Continued upward movement of the plunger after the indrawn fuel mixture has been liquefied results in an increased pressure on the liquid fuel now held by the chamber and at some predetermined pressure the ball 26 will be moved back against the action of the spring 27 and thus open the relief port 25. Further upward movement of the plunger now forces liquid fuel from the chamber out through the relief port which is adapted to be connected by some suitable conduit to the fuel tank or other source of fuel. Liquid fuel will be forced out of the chamber until the plunger in its upward movement closes the relief port.

The spring 23 is stronger than spring 27 so that the ball 22 is held against the ejection

port 19 as the liquid fuel is forced outwardly through the relief port. After the relief port is closed by the plunger, however, continued upward movement of the latter increases the pressure on the liquid fuel to overcome the resistance of the spring 23 and the liquid fuel is ejected through the port 19.

As the liquid fuel is substantially incompressible the port 19 is opened almost simultaneously with the closing of the relief port. Thus it can be said that the quantity of fuel ejected by the pump of the present invention is substantially that remaining in the chamber at the time the plunger closes the relief port.

The time the relief port is closed by the plunger in the compression or ejection cycle of the fuel pump herein shown can be varied so that the quantity of fuel remaining in the chamber at the instant of closure of the relief port or the quantity to be ejected can also be varied.

This control may be accomplished by various means but in the now preferred embodiment of the invention this control is brought about by forming the outer cylindrical surface of the head portion of the plunger with a downwardly spiralling shoulder 28. It will be seen that by rotating the plunger various portions of the shoulder 28 will effect closing of the relief port. Thus if the plunger is rotated so that the lowermost portion of the shoulder effects closure of the port the top face of the plunger will have moved a considerable distance beyond the port before the latter is closed. On the other hand, if the plunger is rotated to a position in which the uppermost portion of the shoulder effects the closing, the top face of the plunger will be substantially in alignment with the top of the port when the latter is closed. It is clear that in the first example, a smaller quantity of fuel will remain in the chamber when the relief port is closed than in the example last given.

Although the plunger can be rotated by a number of means it is now preferred to form the lower end of the plunger with peripherally arranged spur-teeth 29 which engage the teeth of a rack 31 mounted for longitudinal movement. Some means not shown, can be provided for selectively moving the rack to bring about the desired rotation of the plunger.

It should now be seen that the fuel injection pump of the present invention is capable of ejecting a predetermined accurately controlled quantity of liquid fuel at each injection stroke thereof. This ejection is accomplished without the employ of complicated and intricate means of metering the fuel to the end that the service life of the pump herein disclosed is extremely long.

In order to quickly terminate the ejection period, the plunger may be provided, at a distance from its upper end face equal to the distance between the intake port 17 and the wall 21 of the casing, with a peripheral groove 32 connected by a diametrical bore 33 and an axial bore 34 to the upper face of the plunger. It will now be seen that when the plunger has moved to a position in which the upper face thereof is substantially contacting the inner face of the wall 21 the groove 32 is substantially registering with the groove 18 and the interior of the chamber is vented to the ambient atmosphere. This obviously results in a sudden decrease of the chamber pressure whereupon the spring 23 quickly moves the ball 22 to its port-closing position. Any fuel remaining in the upper end of the chamber will, of course, be forced out of the chamber through the interconnecting bores 33 and 34 and grooves 32 and 18 back through port 17 into the supply system.

There is shown in Figure 7, a modified form of the means for varying the closure of the relief port. In this form of the invention the plunger is formed with an angularly disposed end surface 35. The surface may be machined, cast or otherwise formed on the plunger, and functions to control the time of closing of the relief port as does the spiral shoulder 28 of the preferred form of the pump of the present invention.

Although the now preferred embodiments of the present invention have been shown and described herein, it is to be understood that the same are not to be limited thereto for the present invention is susceptible to changes in form and detail within the scope of the appended claims.

I claim:

1. In an injection pump for internal combustion engines: a compression chamber having an intake port, a relief port and an ejection port; pressure responsive means engaging both said relief and ejection ports; and a plunger in said chamber having relief passages, and a control member; said control member being constructed and adapted to close said relief port and maintain closure of said relief port throughout the ejection period of said plunger stroke, said relief passages being constructed and adapted to establish communication of said chamber and said intake port at a predetermined point in the compression stroke of said plunger to terminate the ejection period, said pressure responsive means engaging said relief port being adapted to operate at a lower pressure than said pressure responsive means engaging said ejection port.

2. A pump for injecting liquid fuel, from a mixed-phase volatile source, into an internal combustion engine cylinder, including: a compression chamber containing a single piston-like plunger reciprocative therein; an intake port in the lower portion of the chamber for inducting mixed-phase volatile fuel; an ejection port in the upper portion of said chamber; a relief port located along the path of travel of said plunger above said intake port a distance proportional to the conventional amount of vapor-phase in the mixed-phase fuel; pressure-responsive means engaging said relief port and engaging said ejection port, the former being adapted to operate at a lower biasing pressure than the latter, and said plunger including port-obturating means adapted to close said relief port and maintain it closed during the whole of the injection part of the plunger stroke; said plunger including relief-means adapted to establish communication of the upper part of said compression chamber with said intake port at a predetermined part of the injection stroke so as to abruptly terminate the injection of fuel.

3. A pump for injecting fuel into a combustion cylinder of an internal combustion engine, comprising: a compression chamber having a volatile fuel intake port; a plunger reciprocative in said chamber; an ejection port spaced from said intake port; pressure-responsive means normally closing said ejection port, said means opening said port upon the attainment within said chamber of a predetermined pressure; a relief port in a wall of said chamber intermediate said intake port and said ejection port; pressure-responsive means normally closing said relief port, said last

named pressure-responsive means opening said relief port at a pre-selected pressure which is less than said predetermined pressure; and means for reciprocating said plunger whereby a fuel and air mixture is drawn into said chamber during the intake stroke of said plunger and reduced to a liquid during the compression stroke of said plunger, the portion of said liquid in excess of the quantity which will remain in said chamber at the time said relief port is closed by said plunger being ejected through said relief port when the pressure on said liquid equals said pre-selected pressure, the remainder of said liquid being ejected through said ejection port during the compression stroke of said plunger when the predetermined pressure is attained within said chamber.

4. A pump for injecting volatile fuel into a combustion cylinder of an internal combustion engine, comprising: a compression chamber having a fuel intake port; a plunger reciprocating in said chamber; an ejection port spaced from said intake port; pressure-responsive means normally closing said ejection port, said means opening said port upon the attainment within said chamber of a predetermined pressure; a single relief port in a wall of said chamber intermediate said intake port and said ejection port; pressure-responsive means normally closing said relief port, said last named pressure-responsive means opening said relief port upon the attainment within said chamber of a pre-selected pressure which is less than said predetermined pressure; and means for reciprocating said plunger whereby a fuel and air mixture is drawn into said chamber during the intake stroke of said plunger and reduced to a liquid on travel of the plunger between said intake port and said relief port before the attainment of said pre-selected pressure during the compression stroke of said plunger, a portion of said liquid fuel being ejected through said relief port prior to the closure of said relief port by said plunger when the pressure on said liquid equals said pre-selected pressure, the remainder of said liquid being ejected through said ejection port during the remainder of the compression stroke of said plunger when the predetermined pressure is attained within said chamber.

5. A pump for injecting volatile fuel into a combustion cylinder of an internal combustion engine, comprising: a compression chamber having a fuel intake port; a plunger reciprocating in said chamber; an ejection port spaced from said intake port; pressure-responsive means normally closing said ejection port; said means opening said port upon the attainment within said chamber of a predetermined pressure; a single relief port in a wall of said chamber intermediate said intake port and said ejection port; pressure-responsive means normally closing said relief port, said last named pressure-responsive means opening said relief port upon the attainment within said chamber of a pre-selected pressure which is less than said predetermined pressure; and means for reciprocating said plunger whereby a fuel and air mixture containing a quantum of fuel in excess of that quantity to be injected into said combustion cylinder is drawn into said chamber during the intake stroke of said plunger and reduced to a liquid between said intake port and said relief port during the compression stroke of said plunger, the portion of said liquid in excess of that portion which will remain after said relief port is closed being ejected through said relief port prior to the closure of said relief port by said plunger when the pressure on said liquid equal said pre-selected pressure, the remainder of said liquid being ejected through said ejection port during the remainder of the compression stroke of said plunger when the predetermined pressure is attained within said chamber.

6. A pump for injecting liquid fuel into an internal combustion engine comprising: a compression chamber having a fuel intake port at the lower end thereof adapted to be connected to a source of liquid fuel; a plunger reciprocative in said chamber between a position adjacent the upper end thereof to one spaced below said intake port; movement of said plunger downwardly in said chamber creating a partial vacuum therein whereby fuel is drawn into said chamber through said intake port in a mixed vapor and liquid-phase condition; a relief port spaced above said intake port; pressure responsive means normally closing said relief port and operative under a predetermined pressure to open said relief port; an ejection port at the upper end of said chamber; and pressure responsive means normally closing said ejection port and operative under a predetermined pressure higher than said first named predetermined pressure for opening said ejection port; movement of said plunger upwardly in said chamber from its position below said intake port closing the same and thereafter progressively increasing the pressure on said fuel confined within said chamber to reduce the fuel to a liquid, that portion of said liquid fuel in excess of the quantity confined within said chamber between the ejection port and said relief port being ejected through the latter as the pressure of said fuel exceeds said first named predetermined pressure, the remainder of said liquid fuel being ejected through said ejection port during the remainder of the compression stroke of said plunger when the second predetermined pressure is attained within said chamber.

7. A pump for injecting a preselected quantity of liquid fuel into a combustion cylinder of an internal combustion engine, comprising: a compression chamber having a fuel intake port to be connected to a source of volatile fuel; a plunger reciprocative in said chamber between alternate positions adjacent opposite ends of said compression chamber, said intake port in one of said alternate positions of the plunger communicating said chamber with said source, movement of said plunger toward said last mentioned position creating a partial vacuum in said chamber so that as said plunger moves in said position a fuel mixture in a vapor and liquid phase and containing a quantum of fuel in excess of said preselected quantity is drawn into said chamber through said intake port; means, including a relief port, for communicating said chamber with said source; pressure responsive means normally closing said communicating means and operative upon a predetermined pressure within said chamber to open the same to communicate said chamber with said source, said chamber having an ejection port adjacent the other of said alternate positions of said plunger therein; and pressure responsive means normally closing said ejection port and operative upon a predetermined pressure within said chamber higher than said first named predetermined pressure for opening said ejection port, movement of said plunger toward the other of said alternate positions closing said intake port and progressively

increasing the pressure on said fuel mixture to reduce the same to the liquid phase condition, the pressure responsive means closing said communicating means opening upon the attainment within said chamber of a pressure equal to said first predetermined pressure whereby said liquid fuel in excess of the preselected quantity is returned to said source, continued movement of said plunger closing said relief port whereby the preselected quantity of fuel is ejected through said ejection port when the second predetermined pressure is attained within said chamber.

8. A pump for injecting a completely liquid charge of fuel of a predetermined quantity into an internal combustion engine comprising: a pump chamber having a movable wall for expansion and contraction of the chamber, said chamber having an ejection port; passage means for communication between said chamber and a fuel supply; means to move said wall for expansion and contraction of said chamber by a volume difference in excess of the volume of said pre-determined quantity of fuel, expansion of said chamber creating a partial vacuum therein whereby fuel in excess of said quantity is drawn into said chamber from said passage means in a mixed vapor and liquid phase condition; means to close said passage means for an initial portion of the compression movement of said wall and then to open the passage means, whereby said fuel drawn into the chamber is raised to an intermediate pressure to reduce the fuel to liquid and then the excess portion of the liquid is returned to the passage means; means responsive directly to movement of said wall to close said passage means at a later point in the compression movement of the wall to cut off the return flow of the liquid fuel; and pressure-responsive means normally closing said ejection port and operative to open under higher pressure than said intermediate pressure.

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