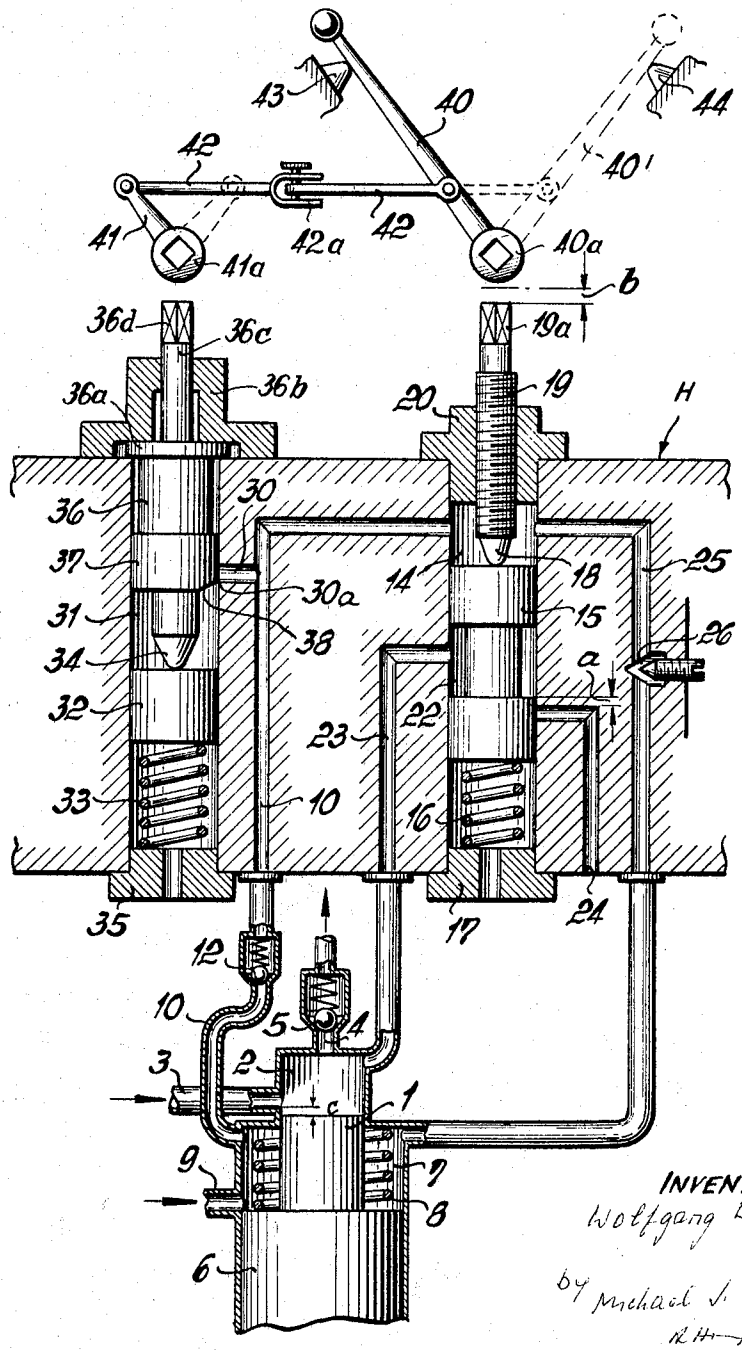
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FUEL INJECTION PUMP

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FUEL INJECTION PUMP

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The present invention relates to fuel injection pumps for internal combustion engines. More particularly, the invention relates to improvements in fuel injection pumps of the type wherein the main fuel injecting piston cooperates with an auxiliary piston and wherein the length of the effective stroke of the main piston, which latter injects fuel into one or more cylinders of an internal combustion engine, is determined by a reciprocable valve member arranged to move to and from an operative position in which surplus fuel conveyed by the main piston is allowed to escape back to the tank. In such manner, the valve member determines the actual r.p.m. of the engine.

In heretofore known fuel injection pumps of the above outlined character, the length of the effective stroke of the main piston is determined by an adjustable throttle valve which regulates the return flow of fuel to the cylinder for the auxiliary piston whereby such fuel controls movements of the valve member. A serious drawback of such conventional pumps is that the rate of fuel flow into the engine increases or decreases suddenly so that the acceleration or deceleration of the vehicle is smooth.

Accordingly, it is an important object of the present invention to provide a novel and improved fuel injection pump which is constructed and assembled in such a way that it can accurately determine the amount of injected fuel when the engine is idling as well as when the engine is driven at a maximum speed.

Another object of the invention is to provide a fuel injection pump which is provided with means for regulating the speed of the engine only when the engine is idling or when the engine operates at a maximum speed.

A further object of the invention is to provide a fuel injection pump wherein the aforementioned valve member regulates the r.p.m. only in the two end ranges and wherein the regulating action of the valve member may be selected with utmost precision.

An additional object of the invention is to provide a fuel injection pump of the above outlined characteristics wherein the auxiliary piston can perform all such functions as the auxiliary piston of a conventional fuel injection pump and also an additional function which enables the pump to regulate the r.p.m. during idling as well as when the engine is driven at a maximum rotational speed.

A concomitant object of the invention is to provide a novel actuating assembly for the improved fuel injection pump.

Briefly stated, one feature of my invention resides in the provision of a fuel injection pump for internal combustion engines. The pump comprises a first and a second cylinder each having a fuel-admitting inlet and an outlet whereby the outlet of the first cylinder can discharge fuel through a one-way outlet valve and into one or more cylinders of the internal combustion engine, a first and a second piston each reciprocably received in the respective

cylinder, means for reciprocating the pistons so that they perform alternating working and return strokes, a housing defining a chamber communicating with the outlet of the second cylinder through a one-way outlet valve which prevents return flow of fuel through such outlet, a valve member reciprocable in the chamber to and from an operative position, relief conduit means connected with the first cylinder and controlled by the valve member to permit outflow of fuel from the first cylinder and to thereby terminate the outflow of fuel through the outlet of the first cylinder when the pistons perform a working stroke and the second piston expels fuel into the chamber to move the valve member to operative position, a return conduit connecting the chamber with the second cylinder, first adjustable throttle valve means in the return conduit, a storage compartment communicating with the outlet of the second cylinder upstream of the chamber, second adjustable throttle valve means for regulating the flow of fuel between the compartment and the outlet of the second cylinder, and plunger means provided in the compartment and arranged to expel fuel from this compartment when the second throttle valve means is open and while the pistons perform a return stroke.

The valve member is reciprocable in its chamber between the aforementioned operative position and a variable end position, and the pump further comprises adjustable stop means for arresting the valve member in such end position. The stop means and the second throttle valve means may be adjusted by a common actuating device which may include a system of levers and links or another suitable motion transmitting unit, preferably in such a way that the flow of fuel into and from the compartment is regulated simultaneously with regulation of the end position of the valve member.

It is preferred to arranged the inlets to the two cylinders in such a way that the effective working stroke of the second piston begins ahead of the effective working stroke of the first piston.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved fuel injection pump itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of a specific embodiment with reference to the accompanying drawing. The single figure illustrates a somewhat diagrammatic section through a fuel injection pump which embodies my invention.

Referring to the drawing in detail, there is shown a fuel injection pump which comprises a first or main piston **1** reciprocable in a main cylinder **2** having an outlet **4** which is provided with a one-way outlet valve **5**. The outlet **4** discharges into a cylinder of an internal combustion engine, not shown, or into a manifold which in turn supplies fuel to two or more cylinders. The inlet **3** of the cylinder is connected with a suitable source of liquid fuel which is not illustrated in the drawing. The main piston **1** forms part of a differential piston which further includes a larger diameter auxiliary piston or second piston **6** reciprocable in an auxiliary cylinder **7**, the latter having an inlet **9** which is connected to the same source as the inlet **3** and an outlet **10** provided with a one-way outlet valve **12**. The chamber of the cylinder **7** accom-

modates a return spring 8 which biases the pistons 1 and 6 downwardly, as viewed in the drawing, and against a suitable cam (not shown) which is driven to move the pistons forwardly and toward the outlets 4 and 10. In other words, the spring 8 and the non-illustrated cam constitute a drive for reciprocating the pistons 1 and 6 as a unit whereby the pistons expel fuel from the cylinders 2 and 7 when they perform a working stroke.

The outlet 10 discharges into a chamber 14 which is defined by a valve housing H and accommodates a reciprocable valve member 15. The latter is biased by a helical expansion spring 16 which bears against a vented plug 17, the function of the spring 16 being to urge the valve member 15 into abutment with an adjustable stop 18. The stop 18 constitutes the tip of a screw or bolt 19 which meshes with a threaded nut 20 serving to close the corresponding end of the chamber 14.

The valve member 15 is formed with a circumferential groove 22 which is in permanent communication with a relief conduit 23 leading to the chamber of the main cylinder 2. An overflow conduit 24 is machined into the valve housing H and can communicate with the relief conduit 23 (via groove 22) when the valve member 15 is shifted to an operative position by a distance *a* in a direction away from the stop 18, i.e., against the bias of the spring 16.

A return conduit 25 connects the chamber of the auxiliary cylinder 7 with the chamber 14 and accommodates an adjustable throttle valve 26. The outlet 10 of the auxiliary cylinder 7 is provided with a branch conduit 30 which is located upstream of the chamber 14 and discharges into a storage compartment or chamber 31 machined into the housing H. The compartment 31 accommodates a reciprocable plunger 32 which is biased by a spring 33 so that it normally bears against a stop 34 provided on a rotary throttling or flow restricting cam 37. The latter has an inclined throttling surface 38 which can define with the housing H a channel or passage 30*a* for entry of fuel from the branch conduit 30 into the compartment 31. The spring 33 bears against a vented plug 35 and the cam 37 is rigid with a rotary carrier or boss 36 having an annular flange 36*a* rotatable in a bearing member 36*b* affixed to the housing H. The carrier 36 has a stem 36*c* provided with a non-circular head 36*d*. The screw 19 is formed with a similar non-circular head 19*a*. It will be noted that the housing H and the bearing member 36*b* cooperate to hold the carrier 36 and the cam 37 against axial movement. The parts 36, 37 together constitue a second adjustable throttle or flow restricting valve which regulates the entry of fuel into and outflow of fuel from the compartment 31. The arrangement is such that the cam 37 can completely seal the compartment 31 from the branch conduit 30. The axial bores provided in the plugs 17 and 35 and the overflow conduit 24 communicate with a space which also communicates with the inlets 3 and 9, for example, with the interior of a fuel tank.

The actuating means for adjusting the axial position of the stop 18 and the angular position of the cam 37 comprises a system of levers 40, 41 which are indicated diagrammatically in the upper part of the drawing. The two levers are coupled to each other by an adjustable connecting link 42 which is provided with a turnbuckle 42*a* or a similar adjuster enabling an operator to change the overall length of the link. The levers 40, 41 respectively carry sockets 40*a*, 41*a* which are fitted over the heads 19*a* and 36*d*. The lever 40 may be rocked between two fixed abutments 43 and 44.

In the illustrated position, the lever 40 rests against the abutment 43 which latter serves as a means for maintaining the levers 40, 41 in a first end position corresponding to the idling speed of the internal combustion engine. By adjusting the turnbuckle 42*a*, the operator can change the angular position of the lever 41 with reference to the lever 40 to thereby regulate the cross-sectional area of the passage 30*a* in dependency on the requirements of the engine. The abutment 44 determines the position of the levers 40, 41 for the maximum r.p.m. of the engine.

When the main piston 1 performs a working stroke, it begins to expel fuel from the main cylinder 2 as soon as it seals the inlet 3. Such fuel flows through the outlet 4 and opens the one-way valve 5 to enter the cylinder or cylinders of the internal combustion engine. The injection of fuel into the engine proper is terminated when the valve member 15 is shifted by the distance *a* to assume its operative position and to provide a passage between the conduits 23 and 24. In such operative position of the valve member 15, the groove 22 allows fuel to flow from the conduit 23 into the conduit 24.

The auxiliary piston 6 expels fuel from the cylinder 7 as soon as it seals the inlet 9, and such fuel flows through the outlet 10 and opens the one-way valve 12. At the same time, fuel also flows from the cylinder 7, through the conduit 25 and into the chamber 14 so that this chamber receives fuel from the outlet 10 and also from the conduit 25. The rate of fuel flow through the conduit 25 is determined by the position of the throttle valve 26. Still further, some fuel also flows into the branch conduit 30, through the passage 30*a*, and into the compartment 31.

The drawing shows the parts in positions they assume when they regulate the r.p.m. during idling of the engine, whereby the levers 40, 41 are in the idling position. The compartment 31 then serves as a reservoir for surplus fuel by accommodating a certain percentage of fuel which is expelled from the auxiliary cylinder 7, namely, an amount which insures that the main piston injects into the cylinder or cylinders of the engine only such quantities of fuel as are required for optimum idling speed of the engine. This means that the compartment 31 receives all such fuel which is expelled from the auxiliary cylinder 7 but does not enter the chamber 14. Fuel which enters the chamber 14 (via outlet 10 and return conduit 25) shifts the valve member 15 against the bias of the spring 16 and enables the groove 22 to establish a path between the conduits 23, 24 whereby the injection of fuel into the engine cylinder or cylinders comes to a halt.

If the actual idling speed drops below the optimum idling speed, the throttling action of the cam 37 is reduced so that more fuel can flow into the compartment 31 and less fuel enters the chamber 14, i.e., it takes longer before the valve member 15 covers the distance *a* whereby the engine receives more fuel. The r.p.m. of the engine then rises accordingly because the engine receives fuel during a longer part of the working stroke of the pistons 1 and 6. Inversely, when the idling speed of the engine is too high, the compartment 31 receives a smaller percentage of such fuel which is expelled from the auxiliary cylinder 6 and the bulk of fuel rapidly shifts the valve member 15 through the distance *a* to thereby reduce the quantity of fuel which enters the engine.

When the pistons 1 and 6 perform a return stroke in response to the bias of the spring 8, the springs 16 and 33 expand and move the valve member 15 and plunger 32 back into abutment with the stops 18 and 34. The fuel then flows from the compartment 31 and from the chamber 14 into the return conduit 25 at the rate determined by the setting of the throttle valve 26. Fuel which is expelled from the compartment 31 flows through the branch conduit 30, into the chamber 14, and thence into the return conduit 25. The position of the throttle valve 26 is selected in such a way that the pairs 15, 32 can return into actual abutment with the stops 18 and 34 before the pistons 1 and 6 begin to perform the next working stroke. The regulation of idling speed can be influenced by proper selection of the springs 16, 33 and of the cross-sectional area of the passage 30*a*.

At very low engine speed, for example, during starting, the throttling action of the cam 37 is so small that the passage 30*a* allows all of the fuel which is expelled from

the auxiliary cylinder **7** to enter the compartment **31**. In other words, the valve member **15** then remains in abutment with the stop **18** and the main piston **1** injects a maximum amount of fuel into the cylinder or cylinders of the internal combustion engine. This will be readily understood since, if the valve member **15** does not allow the conduits **23** and **24** to communicate with each other, all of the fuel which is expelled from the main cylinder **2** must escape via outlet **4**.

If the engine speed rises substantially above the idling speed, the throttling action of the cam **37** increases to such an extent that the valve member **15** covers the distance *a* even before the main piston **1** seals the inlet **3**, i.e., even before the piston **1** begins to inject fuel into the engine. This means that the quantity of injected fuel is reduced to zero because any fuel which is expelled from the main cylinder **2** will flow through the conduit **23**, groove **22**, conduit **24**, and back to the source of fuel. This is due to the fact that the effective working stroke of the auxiliary piston **6** precedes the effective working stroke of the main piston **1**. It is to be noted that the piston **6** begins to seal the inlet **9** immediately after it starts a working stroke whereas the piston **1** must cover a small distance *c* before it reaches the inlet **3** to the main cylinder **2**.

In the partial load range, namely, when the lever **40** is located somewhere between the abutments **43** and **44**, the cam **37** completely seals the passage **30***a* shortly after the lever **40** moves away from the abutment **43**. This means that the compartment **31** is sealed off and the plunger **32** is ineffective. The stop **18** is lifted in response to rotation of the screw **19** to lengthen the distance *a* which must be covered by the valve member **15** before the conduit **23** can discharge into the conduit **24**. All of the fuel which is expelled by the auxiliary piston **6** flows into the chamber **14** (through the outlet **10** and conduit **25**) to move the valve member **15** against the bias of the spring **16**. The injection of fuel into the engine is again terminated when the valve member **15** covers the lengthened distance *a* and allows fuel to flow from the conduit **23**, through the groove **22**, and into the conduit **24**. When the pistons **1** and **6** perform a return stroke, the valve member **15** expels fuel from the chamber **14**, and such fuel flows only through the conduit **25** because the outlet **10** is provided with the one-way valve **12**. In the just described partial load range (when the lever **40** is located somewhere between the abutments **43** and **44**), the throttle valve **26** still allows all of the fuel to escape through the conduit **25** before the pistons **1** and **6** begin to perform the next working stroke. In other words, the quantity of fuel which is injected into the engine in such partial load range depends solely on the axial position of the screw **19** and hence on the distance between the plug **17** and the stop **18**.

For operation at a maximum rotational speed, the lever **40** is shifted all the way into engagement with the abutment **44**. Such end position of the lever **40** is indicated by a phantom line **40'**. The screw **19** is then shifted by a maximum distance *b* so that the valve member **15** must perform a stroke of maximum length before the conduit **23** is free to communicate with the conduit **24**. Therefore, the piston **1** will inject a maximum amount of fuel into the engine. If the rotational speed continues to increase, the interval between two consecutive working strokes of the pistons **1** and **6** is shorter than the interval required for return flow of all surplus fuel from the chamber **14**, i.e., the valve member **15** has no time to return into actual abutment with the stop **18**. This is determined by the adjustment of the throttle valve **26** which throttles the flow of fuel from the chamber **14** to such an extent that the valve member **15** cannot reach the stop **18**. Consequently, the amount of injected fuel is reduced because the valve member **15** requires a shorter interval of time to cover the maximum distance *a*. The rotational speed of the engine then decreases to a permissible value.

It will be noted that the fuel injection pump of my invention will regulate the idling speed by changing the speed

at which the valve member **15** covers the minimum distance *a*. On the other hand, when the pump is to limit the maximum rotational speed of the engine, the stroke of the valve member **15** is automatically reduced by throttling the outflow of fuel from the chamber **14**, i.e., by such adjustment of the throttle valve **26** that some surplus fuel remains in the chamber **14** at the time the pistons **1** and **6** begin to perform the next working stroke.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is:

1. A fuel injection pump for internal combustion engines, comprising a first and a second cylinder each having a fuel-admitting inlet and an outlet, the outlet of said first cylinder being arranged to discharge fuel into the engine; first and second pistons reciprocably received in the respective cylinders; means for reciprocating said pistons so that said pistons perform alternating working and return strokes; a housing defining a chamber communicating with the outlet of said second cylinder; a valve member reciprocable in said chamber to and from an operative position; relief conduit means connected with said first cylinder and controlled by said valve member to permit outflow of fuel from said first cylinder and to thereby terminate the outflow of fuel through the outlet of said first cylinder when said pistons perform a working stroke and the second piston expels fuel into said chamber to move the valve member to said operative position; a return conduit connecting said chamber with said second cylinder; first adjustable throttle valve means in said return conduit; a storage compartment communicating with the outlet of said second cylinder upstream of said chamber; second adjustable throttle valve means for regulating the flow of fuel between the outlet of said second cylinder and said compartment; and means for expelling fuel from said compartment when said second throttle valve means is open and while said pistons perform a return stroke.

2. A fuel injection pump as set forth in claim **1**, wherein the valve member is reciprocable in said chamber between said operative position and an end position, and further comprising adjustable stop means for arresting the valve member in said end position.

3. A fuel injection pump as set forth in claim **2**, further comprising actuating means for simultaneously adjusting said stop means and said second throttle valve means.

4. A fuel injection pump as set forth in claim **3**, wherein said actuating means comprises means for effecting adjustment of said second throttle valve means independently of said stop means.

5. A fuel injection pump as set forth in claim **1**, wherein the position of said inlets is such that the effective working stroke of said second piston precedes the effective working stroke of said first piston.

6. A fuel injection pump as set forth in claim **1**, wherein the outlet of said second cylinder comprises a branch which communicates with said compartment and wherein said second throttle valve means comprises a rotary cam which regulates the flow of fuel between said compartment and said branch.

7. A fuel injection pump as set forth in claim **1**, further comprising one-way valve means provided in each of said outlets.

8. A fuel injection pump as set forth in claim **1**, wherein said pistons together constitute a differential piston and

wherein the diameter of said second piston exceeds the diameter of said first piston.

9. A fuel injection pump as set forth in claim 1, wherein said second throttle valve means comprises a stop for said expelling means and wherein said second throttle valve means is adjustable to and from a position in which said compartment is fully sealed from the outlet of said second cylinder.

10. A fuel injection pump as set forth in claim 1, wherein said housing is provided with overflow conduit means in communication with said relief conduit means

through a groove provided on said valve member when the valve member assumes said operative position.

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