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SELF-REGULATING PISTON PUMPS, IN PARTICULAR FUEL INJECTION PUMPS FOR INTERNAL COMBUSTION ENGINES

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Fig.1.

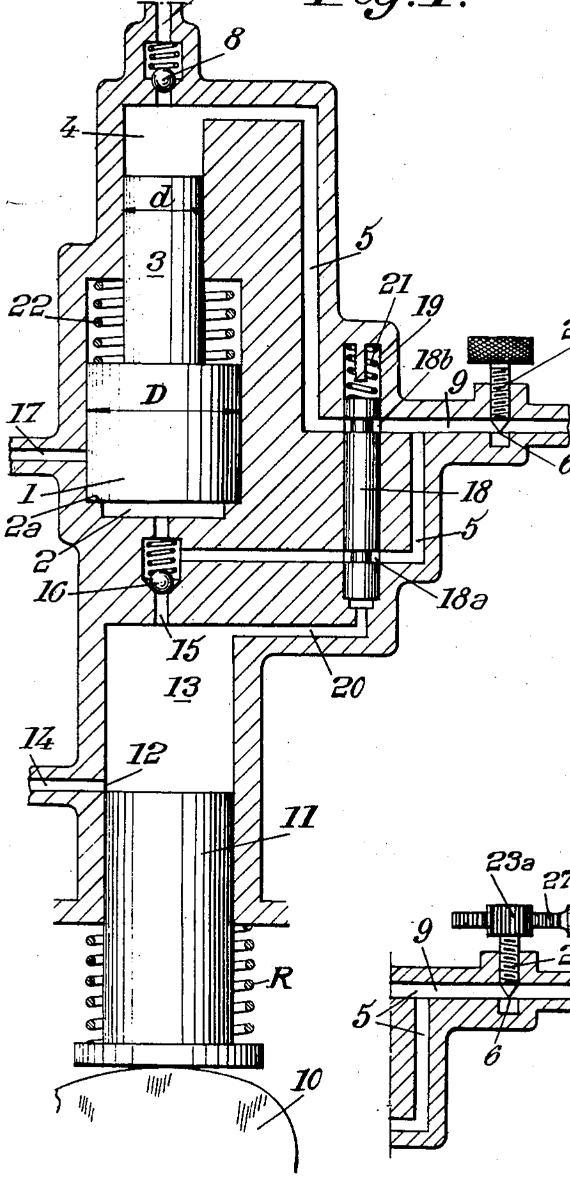
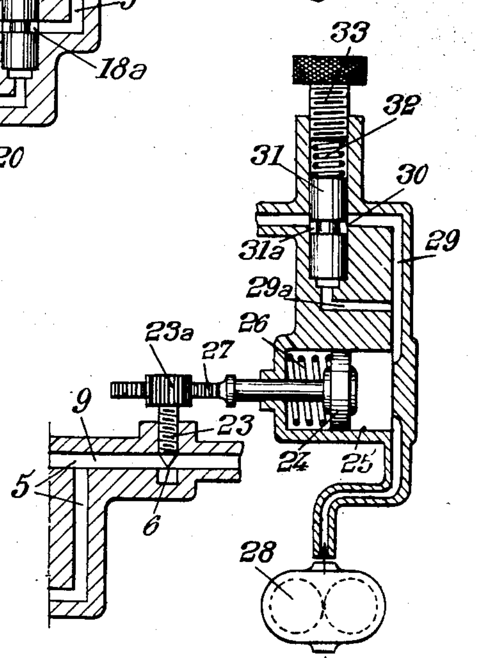


Fig.2.



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SELF-REGULATING PISTON PUMPS, IN PARTICULAR FUEL INJECTION PUMPS FOR INTERNAL COMBUSTION ENGINES

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2 Claims. (Cl. 103—41)

The present invention relates to self-regulating piston pumps, in particular to fuel injection pumps for internal combustion engines, which include a main piston reciprocable in a main cylinder in communication with a source of liquid, this piston being reciprocated at a rate the value of which constitutes the factor of regulation, an auxiliary piston reciprocable in an auxiliary cylinder divided by it into two chambers, the first of said chambers being connected with said main cylinder by a conduit provided with a check-valve opening toward said first chamber, whereby the outward strokes of the auxiliary chamber take place under the driving action of the liquid delivered by the main piston and cause liquid to be delivered from the second of said chambers, resilient means being provided for producing the return strokes of the auxiliary piston, while driving out liquid from said first chamber, at a flow rate limited by throttling means, through a transfer conduit leading to said second chamber, whereby, for speeds of operation exceeding a given value, the length of every return stroke of the auxiliary piston, and therefore of the next outward stroke thereof, is the shorter as the speed of operation is higher.

The object of the present invention is to provide a pump of this kind which is better adapted to meet the requirements of practice than those known up to the present time.

My invention is characterized by the fact that the auxiliary piston and cylinder include a portion of larger diameter on the side of the first chamber and a portion of smaller diameter on the side of the second chamber, whereby the amount of liquid delivered from the first chamber is greater than that capable of being received into the second chamber during every return stroke of the auxiliary piston, the above mentioned throttling means being provided in a discharge conduit branching off from said transfer conduit, for evacuating the excess of liquid.

Preferred embodiments of the present invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example and in which:

Fig. 1 shows, in diagrammatic section, a pump made according to a first embodiment of the invention.

Fig. 2 shows a modification of a portion of the pump of Fig. 1.

The pumps shown by the drawing are fuel injection pumps for use in particular with diesel engines.

The pump includes a main piston 11 reciprocable in a main cylinder 13 under the action of a cam 10 driven at a speed proportional to that of the engine to be fed by

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the pump, piston 11 being applied against cam 10 by a spring R. At the end of every downward stroke, this piston 11 clears the opening 12 of a conduit 14 connected with a source of fuel for the feed of said fuel to cylinder 13.

An auxiliary piston 1, 3 is movable in an auxiliary cylinder which is divided by said piston into two chambers 2 and 4. The first chamber 2 is connected with the main cylinder 13 of the pump through a conduit 15 provided with a check-valve 16 opening toward chamber 2. The other chamber, 4, is provided with a delivery conduit 7, with the interposition of a check-valve 8, said delivery conduit 7 leading to the injector or injectors of the engine fed with fuel by the pump. The auxiliary piston 1, 3 is subjected to the action of return means constituted by a spring 22 which tends to reduce the volume of chamber 2.

The outward (upward) strokes of auxiliary piston 1, 3 are effected under the thrust of the liquid delivered by piston 11 through conduit 15, whereas the return strokes of said auxiliary piston 1, 3 are produced by spring 22.

A transfer conduit 5 extends between the two chambers 2 and 4 of the auxiliary cylinder during the return stroke of the auxiliary piston, valve means being provided to prevent the communication between these two chambers through said conduit during the outward stroke of said auxiliary piston.

In order to limit the displacements of auxiliary piston 1, 3 during its outward stroke, there is provided a discharge conduit 17 which places chamber 2 in communication with the outside after the lower edge of the auxiliary piston has cleared said discharge conduit. On the other hand, the return strokes of the auxiliary piston are limited by an abutment 2*a*.

According to the invention, the auxiliary piston 1, 3 is made in the form of a stepped piston, its portion 1 of larger diameter (D) being on the side of the first chamber 2 and its portion of smaller diameter (*d*) being on the side of the second chamber 4. Of course, the corresponding portions of the auxiliary cylinder are made of corresponding diameters, respectively.

It will be understood that, during every return stroke of the auxiliary piston (downward stroke), the amount of liquid driven out from cylinder 2 is in excess of the amount of liquid that can be received, during the same time, by chamber 4. In order to evacuate this excess of liquid, I provide a discharge conduit 9 which is provided with throttling means 23 capable of braking the return movement of the auxiliary piston.

The discharge conduit 9 might be connected as well to chamber 2 as to chamber 4, but it seems more advantageous to connect it with transfer conduit 5 as shown by Fig. 1.

Advantageously, spring 22 is constituted with a helical spring surrounding the portion 3 of small diameter of the auxiliary piston and bearing upon the end face of the portion 1 of larger diameter.

Advantageously the above mentioned valve means are constituted by a double slide valve 18 moving in a cylindrical housing 19 through which pass the respective portions of conduit 5 located respectively upstream and downstream of conduit 9 and this slide valve is actuated in one direction by the pressure existing in cylinder 13, for instance through the intermediate of a conduit 20, and urged in the other direction by a return spring **21**. The whole is arranged in such manner that the grooves **18***a* and **18***b* of slide valve **18** open conduit **5** when the action of spring **21** is preponderating, but that the body of the slide valve **18** closes the two above mentioned portions of conduit **5** when the action of the pressure in the main cylinder **13** is preponderating. Spring **21** is adjusted in such manner as to yield before the spring of the check-valve **16**.

Of course, it would be possible, in a modification, to divide slide valve **18** into two elementary slide valves each comprising one of the grooves **18***a* and **18***b* and individually controlled in the same manner as the double slide valve **18**. It would also be possible to have one of the grooves **18***a* and **18***b* cooperating with only one of the portions of conduit **5** and the other one with conduit **9**. I might also provide a check-valve at the inlet of chamber **4** and a slide valve between chamber **2** and discharge conduit **9**.

Concerning the throttling means **23** which form a passage of restricted cross-section **6** in conduit **9**, it is advantageous to make them adjustable. For this purpose, such means are preferably constituted by a screw adapted to be adjusted either manually (as shown by Fig. 1), or automatically under the action of a governor, i.e. a centrifugal or another governor, responsive to variations of the speed at which the pump is being driven.

Such an automatic adjustment is shown by Fig. 2. The governor includes a piston **24** reciprocable in a cylinder **25** and subjected in one direction to the action of a pressure which increases when the speed of the engine increases and in the other direction to the action of a return spring **26**. Piston **24** carries a rack **27** in mesh with a pinion **23***a* fixed to the upper end of screw **23**. In the embodiment shown by Fig. 2, where the rack is located behind pinion **23***a* and moves from the right toward the left when the speed increases, screw **23** must have a left handed thread so that said displacement decreases the area of the throttled passage **6**.

The pressure acting upon piston **24** is supplied by a pump **28**, for instance a gear pump, driven at a speed proportional to that of the engine supplied with fuel by the pump and the delivery of which is connected with a conduit **29** provided with a throttled passage **30**. In order to attenuate the effect of the law of increase of the pressure in cylinder **25** as a function of the speed, in particular to obtain an approximately constant fineness of the governor, the throttled passage is advantageously constituted by the groove **31***a* of a slide valve **31** moving transversely to a portion of conduit **29**, said slide valve **31** being subjected to the opposed actions of the pressure transmitted through a conduit **29***a* from the portion of conduit **29** upstream of the throttled passage **30** and of a return spring **32** preferably adjustable by means of a screw **33**, in such manner that the cross-sectional area of throttled passage **30** increases when the delivery pressure of pump **28** increases.

The pump above described works in the following manner:

When piston **11** is in the position shown by the drawing, its cylinder **13** is filled with fuel flowing in through conduit **14**. Then piston **11** moves upwardly and closes the opening **12** of conduit **14**. This causes the fuel present in cylinder **13** to be driven out therefrom. First slide valve **18** is moved upwardly closing both branches of transfer conduit **5**, then piston **1, 3** is driven upwardly against the action of spring **22**, until discharge conduit **17** is opened. During this movement, chamber **2** is filled with liquid. During the same time, the portion **3** of the auxiliary piston causes liquid to be delivered, through conduit **7**, toward the injector or injectors of the engine. As soon as discharge conduit **17** is opened, piston **1, 3** stops whereas piston **11** keeps moving upwardly.

When piston **11** starts moving in the downward direction, check-valve **16** closes and the grooves **18***a* and **18***b* of slide valve **18** open transfer conduit **5** so that the chambers **2** and **4** are in communication with each other and with the discharge conduit **9** provided with the throttled passage **6**.

Piston **1, 3** is urged downwardly by spring **22**. The speed of the downward movement of piston **1, 3** is determined by the condition that passage **6** must permit the flow toward the outside of the difference between the volumes displaced respectively by the portions **1** and **3** of the auxiliary piston, which causes a braking of the downward movement of said piston.

Spring **22** is chosen relatively weak so that, in view of the small cross-sectional area of the throttled passage **6**, the time taken by piston **1, 3** to reach its abutment **2***a* exceeds, for speeds of operation of the pump above a given value, the time elapsing between the end of the upward movement of piston **11** and the beginning of the next upward movement thereof. Consequently, if the speed of the engine increases, there happens a time where the portion **1** of the auxiliary piston is struck by the fresh fuel delivered by piston **11** moving upwardly, before said piston **1, 3** has reached its abutment **2***a*, which reduces the return stroke of the auxiliary piston and therefore the volume delivered by the portion **3** of this piston during the next cycle of the pump. The length of this return stroke is the shorter as the speed of the pump is higher. This constitutes a self-regulation of the pump.

This regulating effect may be combined with that due to the variable throttling means **23** controlled by a governor such as that shown by Fig. 2, which is capable of reducing the speed of the downward movement of the auxiliary piston as the speed of operation of the pump increases.

In the preceding description, it has been supposed implicitly that the portions **1** and **3** of the auxiliary piston were integral with each other, but this is not necessary according to the present invention. As a matter of fact, if parts **1** and **3** were separate, the pressure, which is low during the downward movement of the piston and high during the upward movement thereof, of the liquid contained in chamber **4** would constantly keep part **3** applied against part **1** and the operation would be the same as if these two parts of the auxiliary piston were rigid or integral with each other.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

What I claim is:

1. A self-regulating reciprocating action pump which comprises, in combination, a main cylinder, a main piston reciprocable in said cylinder, an auxiliary cylinder rigid with the first one, one end of said auxiliary cylinder being in communication with the delivery end of said main cylinder, an auxiliary piston reciprocable in said auxiliary cylinder, said auxiliary cylinder being divided by said auxiliary piston into two chambers, to wit a first chamber located at said above mentioned end of said auxiliary cylinder and a second chamber located at the other end of said auxiliary cylinder, a liquid delivery conduit leading out from said second chamber, a check-valve interposed between said main cylinder and said first chamber of said auxiliary cylinder to prevent liquid from flowing back from said first chamber to said main cylinder, resilient means interposed between said auxiliary cylinder and said auxiliary piston for exerting on said auxiliary piston a return force opposed to that exerted thereon by the liquid pressure from said main cylinder during the delivery stroke of said main piston, a transfer conduit leading from said first chamber to said second chamber, valve means in said transfer conduit operative to close

said transfer conduit during the delivery stroke of said main piston, said auxiliary piston and cylinder including a portion of larger diameter forming said first chamber and a portion of smaller diameter forming said second chamber, whereby the amount of liquid delivered from said first chamber during every return stroke of said auxiliary piston is greater than that capable of being received into said second chamber during the same time, a discharge conduit branching off from a point of said transfer conduit upstream of said valve means, and means forming a throttled passage in said discharge conduit.

2. A pump according to claim 1 in which said resilient means consist of a helical spring surrounding said portion of smaller diameter of said auxiliary piston and bearing against the end face of said portion of larger diameter of said auxiliary piston.

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