

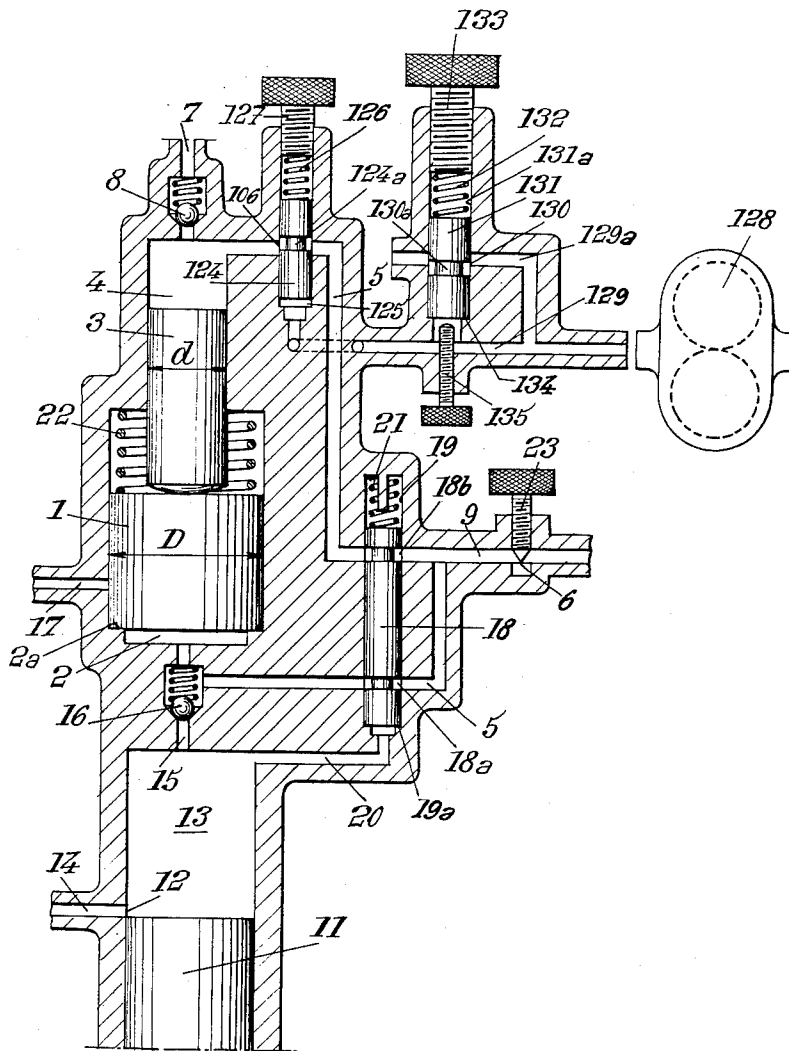
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SELF-REGULATING RECIPROCATING ACTION PUMPS

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SELF-REGULATING RECIPROCATING ACTION PUMPS

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The present invention relates to reciprocating action pumps in which the amount of liquid which is admitted into the cylinder of the pump and therefore the amount of liquid delivered by said pump on every cycle thereof decrease when the speed at which the pump is driven increases above a predetermined value. The invention is more particularly but not exclusively concerned with fuel injection pumps for internal combustion engines, this term including in particular diesel engines.

There are known pumps of this kind in which self-regulation, that is to say automatic regulation of the amount of fuel admitted into the pump cylinder, is controlled by a member which is actuated by a pressure variable with the speed at which the pump is driven and which, under the effect of this pressure, throttles to a variable degree the inlet conduit leading to the pump cylinder. This member is generally constituted by a piston.

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 now.

The invention consists chiefly, in a pump of the above described type where the pressure acting upon the throttling member is supplied by a regulation pump, preferably of the continuous flow type, driven at a speed variable as a function of the speed at which the pump to be regulated is driven, in providing on the delivery conduit of the regulation pump bleeding means permitting the fluid from said pump to leak out from said conduit through a passage of a cross-sectional area variable automatically as a function of the speed which constitutes the factor of regulation, this variation preferably taking place under the effect of the delivery pressure of said regulation pump.

A preferred embodiment of the present invention will be hereinafter described with reference to the accompanying drawing, given merely by way of example and in which the only FIGURE diagrammatically shows a fuel injection pump made according to the present invention.

The pump includes a piston 3 reciprocating in a cylinder 4 into which opens, on the one hand an inlet conduit 5, and on the other hand a delivery conduit 7 provided with a check-valve 8. Piston 3 is driven through means which positively ensure its delivery stroke (upward stroke) with a speed proportional to that of the engine on which the fuel injection pump is mounted but which enable said piston to move during its return stroke (downward stroke) under the effect of the fuel supplied into cylinder 4 through inlet conduit 5, this pressure being then sufficiently strong to overcome the friction of piston 3 on the wall of cylinder 4. The length of the return stroke of piston 3 then depends upon the amount of fuel that has been fed to cylinder 4 through inlet conduit 5. This return stroke stops when this feed of fuel to cylinder 4 is stopped and, on the next upward stroke, piston 3 delivers this fuel into delivery conduit 7.

In order to regulate the amount of fuel that enters cylinder 4, I provide in inlet conduit 5 a control member 124 in the form of a slide valve, which produces a throttled passage 106 the free cross-sectional area of which depends upon the position of slide valve 124 in a cylinder 125.

This slide valve is controlled, on the one hand by a spring 126 the compression of which is adjustable for

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instance by means of a screw 127, and on the other hand by the pressure of a liquid delivered by a regulation pump 128, preferably a continuous flow pump such as a gear pump, a vane pump, etc. Pump 128 is driven at a speed proportional to the speed of the engine on which the fuel injection pump is mounted. In order to cause this pressure to act upon slide valve 124, the delivery end of regulation pump 128 is connected to the lower end of cylinder 125 through a conduit 129.

According to the present invention, I provide, on conduit 129, bleeding means which permit fluid to leak out from said conduit through a passage of a cross-sectional area regulable as a function of the speed of the engine, and preferably as a function of the delivery pressure of the regulation pump 128. For this purpose, I connect with conduit 129 a bleeding conduit 129a including a throttled passage 130 the cross-sectional area of which is controlled by a member advantageously in the form of a slide valve 131, this control member being movable in a cylinder 131a under the action, on the one hand of a spring 132, adjustable for instance by means of a screw 133, and on the other hand of the pressure existing in conduit 129.

Preferably, slide valve 131 cooperates with the conduit 129a in such manner that the cross-sectional area of the throttled passage 130 increases when the speed of the regulation pump 128 and therefore the pressure in conduit 129 increase. Accordingly, the increase of the pressure acting upon slide valve 124, as a function of the speed of the regulation pump 128, is slower than the increase that is obtained by means of a leak passage 130 of constant cross-section. It is thus possible to obtain a fineness of regulation that is constant within a great range of speeds, this range being obtained by a variation of the compression of springs 126 and/or 132.

In the embodiment illustrated by the drawing, the cross-sectional area of the leak produced at 130 increases when the pressure in conduit 129 increases and there is provided a fixed abutment 134 which determines the minimum cross-section of the throttled passage 130. It is possible to modify this minimum cross-section by means of an abutment 135 adjustable by screwing. Of course, I may use means for controlling the cross-sectional area of throttled passage 130 such that said area decreases when the delivery pressure of the regulation pump 128 increases. In this case, the increase of the pressure acting upon slide valve 124 is further accelerated and, within a very narrow range of speeds, a very great fineness of regulation is obtained.

In the embodiment illustrated by the drawing, each of the slide valves 124 and 131 is provided with a groove, respectively 124a and 130a, which determines the cross-sectional area of the throttled passages 106 and 130 respectively. In some cases, it is advantageous to use, in at least one of the slide valves, a hole extending through the slide valve instead of a groove such as shown by the drawing. In this case, the cross-sectional area of the throttled passage is determined by the relative position of cooperating ports, which permits of varying the law according to which said cross-sectional area varies as a function of the longitudinal displacement of the slide valve, this law depending upon the shape of the conjugated ports. I may also provide, instead of the ordinary grooves shown by the drawing, grooves the bottom of which is in the form of a cone having a rectilinear or curvilinear generatrix. Furthermore, I may also compensate for the transverse thrusts exerted on slide valves 124 and 131 by causing the pressure which exists in the conduit portion located upstream of the slide valve to act upon the opposed side thereof.

In order to place under a sufficient pressure the liquid which, after passing through conduit 5 and passage 106,

is delivered into cylinder 4 and pushes piston 3 downwardly, many different means may be used. However, it is particularly advantageous to make use of an auxiliary piston 1 having a diameter D greater than the diameter d of the main piston 3, piston 1 reciprocating in an auxiliary cylinder 2 which is coaxial with the main pump cylinder 4, the same means being used for positively driving, during every delivery stroke of the main piston 3, both of the pistons 1 and 3 which are then merely applied against each other.

It seems particularly advantageous to make use, for this positive drive of the pistons, of hydraulic means which, in this case, may also serve to feed cylinder 2 with fuel when piston 1 is moving on the stroke during which cylinder 2 is to be fed with fresh fuel, which stroke coincides with the delivery stroke of piston 3.

For this purpose, I make use of a third piston 11 reciprocating in a cylinder 13, this piston 11 being driven through any means not shown, for instance by means of a cam, operated either directly or indirectly by a part rotating at the speed which constitutes the factor of regulation of the pump, in particular by the shaft of the engine on which the fuel injection pump is to be mounted.

A feed conduit 14 opens at 12 into a cylinder 13, the opening 12 of said conduit being cleared by piston 11 when it is in its lower dead center position (as shown by the drawing). Cylinder 13 can thus be fed with fuel when piston 11 is in this position.

Furthermore, cylinder 13 communicates, through a conduit 15 provided with a check-valve 16, with the lower end of cylinder 2 and there is mounted, in the upper chamber of said cylinder 2, a spring 22 which tends to keep piston 1 in its lower position, where it rests upon a shoulder 2a provided near the lower end of cylinder 2. Furthermore, cylinder 1 is provided with a discharge conduit 17 which, when cleared by piston 1, stops the upward movement of pistons 1 and 3.

The inlet conduit 5 opening into the main cylinder 4 of the pump starts from a point of conduit 15 located downstream of check-valve 16. There is provided, in conduit 5, a valve member, for instance a slide valve 18, which, during the upward stroke of piston 11, closes conduit 5 upstream of a discharge conduit 9 branching off from conduit 5, this discharge conduit 9, which is provided with a throttle passage 6 preferably adjustable by means of a screw 23, being on the upstream side of throttled passage 106.

Preferably, slide valve 18 is made in the form of a double valve capable of closing conduit 5, not only between the point where it starts from conduit 15 and the point where conduit 9 branches off therefrom, but also between this last mentioned point and the place where conduit 5 opens into cylinder 4. For this purpose, slide valve 18 includes two grooves 18a and 18b which open both of the branches of conduit 5 with which the slide valve cooperates when said slide valve is applied, by a spring 21, against a shoulder 19a. On the other hand, slide valve 18 closes both of the branches of conduit 5 during the whole of the upward stroke of piston 11, under the effect of the pressure of the liquid present in cylinder 13, which pressure is transmitted to the slide valve 18 through a conduit 20 which opens into the lower end of the cylinder 19 in which slide valve 18 is movable.

The pump above described works in the following manner:

During the upward stroke of piston 11 and after the closing of conduit 14, the pressure of the liquid in cylinder 13 first pushes slide valve 18 upwardly so that both of the above mentioned branches of conduit 5 are closed. Then the fuel delivered by piston 11 during its upward stroke enters cylinder 2 and pushes piston 1 upwardly against the action of spring 22. As soon as piston 1 comes into contact with piston 3, it causes it to move upwardly in its cylinder 4 and fuel is delivered, past check-valve 8, into delivery conduit 7. The upward movement of

pistons 1 and 3 stops as soon as piston 1 clears discharge conduit 17.

As soon as piston 11 starts on its downward stroke, slide valve 18 opens the two branches of conduit 5 in which it is interposed and piston 1 starts on its downward stroke under the action of spring 22, so that the fuel which had precedingly been introduced into cylinder 2 is now delivered, by piston 1, through conduit 5, partly into cylinder 4 and partly through discharge conduit 9 past throttled passage 6. In view of the fact that the diameter of piston 1 is greater than that of piston 3, a portion of the fuel delivered by piston 1 must flow out through conduit 9, so that the liquid which is fed to cylinder 4 is placed under a pressure sufficient to push piston 3 in the downward direction. However, the stroke of said last mentioned piston in the downward direction depends on the one hand upon the speed at which piston 11 is driven and, on the other hand, upon the cross-sectional area of throttled passage 106. For speeds of the piston 11 up to a given value, and consequently for speeds of the engine on which the pump is mounted below a given value, piston 3 is applied by the fuel entering cylinder 4 through conduit 5 against piston 1 in its lower position, before piston 11 starts on its next upward stroke, and this despite the braking that may possibly be applied at this time by slide valve 124 on the fuel arriving through conduit 5. The amount of fuel delivered into conduit 7 for every stroke of piston 3 is therefore maximum.

However, when the speed of piston 11 increases beyond said given value, two factors come into play to reduce the amount of fuel delivered by piston 3 to conduit 7 and injected into the cylinder or cylinders of the engine on which the pump is mounted.

The first factor is the reduction of the throttled passage 106 and the second one is the acceleration of piston 11. These two factors act simultaneously to shorten the downward stroke of piston 3 between the time where this downward stroke starts and the time where, due to the next upward stroke of piston 11 which produces an upward stroke of piston 1, piston 3 is again pushed upwardly to perform its next delivery stroke. The shorter the downward stroke of piston 3, the smaller the amount of fuel first admitted into cylinder 4 and subsequently delivered through conduit 7. When the speed of the engine further increases, there comes a value of this speed for which the pressure exerted on slide valve 124 is sufficiently strong to close inlet conduit 5 completely, which prevents any delivery of fuel through conduit 7. This last mentioned speed is therefore a top limit speed which cannot be exceeded in any case.

Of course, instead of using, to drive pistons 1 and 3, hydraulic means as illustrated, I might use mechanical means, for instance a push-piece controlled by a cam and acting directly upon piston 1. I might also make use of a regulation pump having a pulsing flow of liquid.

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 reciprocating action pump which comprises, in combination, a main cylinder, a main piston fitting slidably in said cylinder and defining therewith a variable volume working chamber, a liquid delivery conduit leading out from said working chamber, an intermediate cylinder in line with said main cylinder and fixed in position with respect thereto, an intermediate piston fitting slidably in said intermediate cylinder, said main piston extending into said intermediate cylinder so as to be in contact with said intermediate piston, said intermediate cylinder being of a diameter greater than that of said main cylinder, unidirectional driving means for

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imparting to said intermediate piston successive displacements in the direction for which it pushes said main piston so as to reduce the volume of said working chamber, said displacements being called delivery strokes, return means operatively connected with said intermediate piston for urging it in the opposed direction to produce its return strokes, means for feeding liquid to the space of said intermediate cylinder located on the other side of said intermediate piston from said main piston, said last mentioned means being operative during the delivery strokes of said intermediate piston and being closed during its return strokes, a liquid inlet conduit starting from said space of said intermediate cylinder and opening into said working chamber, a throttled discharge conduit branching off from a point of said inlet conduit, valve means in said inlet conduit operative by said driving means for closing said liquid inlet conduit both upstream and downstream of said point thereof during the delivery strokes of said intermediate piston, a throttling member movably mounted across the portion of said inlet conduit extending between said point thereof and said main cylinder, and means operatively connected with said throttling member for controlling its position to close it more and more as the speed of reciprocation of said intermediate piston increases.

2. A reciprocating action pump which comprises, in combination, a main cylinder, a main piston fitting slidably in said cylinder and defining therewith a variable volume working chamber, a liquid delivery conduit leading out from said working chamber, an intermediate cylinder in line with said main cylinder and fixed in position with respect thereto, an intermediate piston fitting slidably in said intermediate cylinder, said main piston extending into said intermediate cylinder so as to be in contact with said intermediate piston, said intermediate cylinder being of a diameter greater than that of said main cylinder, unidirectional driving means for imparting to said intermediate piston successive displacements in the direction for which it pushes said main piston so as to reduce the volume of said working chamber, said displacements being called delivery strokes, return means operatively connected with said intermediate piston for urging it in the opposed direction to produce its return strokes, means for feeding liquid to the space of said intermediate cylinder located on the other side of said intermediate piston from said main piston, said last mentioned means being operative during the delivery strokes of said intermediate piston and being closed during its return strokes, a liquid inlet conduit starting from said space of said intermediate cylinder and opening into said working chamber, a throttled discharge conduit branching off from a point of said inlet conduit, valve means in said inlet conduit operative by said driving means for closing said liquid inlet conduit both upstream and downstream of said point thereof during the delivery strokes of said intermediate piston, a throttling member movably mounted across the portion of said inlet conduit extending between said point thereof and said main cylinder so as to exert a throttling effect varying in accordance with the position of said throttling member in said conduit, a regulating pump having a delivery circuit supplying fluid under pressure, said pump being driven at a speed proportional to the speed of reciprocation of said intermediate piston, means interposed between said delivery circuit and said throttling member for controlling the position of said throttling member with re-

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spect to said inlet conduit in accordance with the fluid pressure in said delivery circuit and bleeding means mounted on said delivery circuit to permit fluid to leak out therefrom through a passage of cross-sectional area variable automatically as a function of said speed.

3. A pump according to claim 2 in which said bleeding means include a member movable by said fluid pressure in such manner as to increase the cross-sectional area of said passage in response to increases of said fluid pressure.

4. A reciprocating action pump which comprises, in combination, a main cylinder, a main piston fitting slidably in said cylinder and defining therewith a variable volume working chamber, a liquid delivery conduit leading out from said working chamber, an intermediate cylinder in line with said main cylinder and fixed in position with respect thereto, an intermediate piston fitting slidably in said intermediate cylinder, said main piston extending into said intermediate cylinder so as to be in contact with said intermediate piston, said intermediate cylinder being of a diameter greater than that of said main cylinder, an auxiliary cylinder fixed in position with respect to said main cylinder, an auxiliary piston fitting slidably in said auxiliary cylinder and reciprocated therein, a communication passage extending from said auxiliary cylinder to said intermediate cylinder, a check valve in said passage opening toward said intermediate cylinder, whereby said auxiliary piston transmits hydraulically to said intermediate piston its strokes in the direction that tends to reduce the volume of said working chamber, said strokes being called delivery strokes, return means operatively connected with said intermediate piston for urging it in the opposed direction to produce its return strokes, a liquid inlet conduit starting from the portion of said communication passage downstream of said check valve and opening into said working chamber, a throttled discharge conduit branching off from a point of said inlet conduit, valve means in said inlet conduit responsive to the displacements of said auxiliary piston for closing said liquid inlet conduit both upstream and downstream of said point thereof during the delivery strokes of said auxiliary piston, a throttling member movably mounted across the portion of said inlet conduit extending between said point thereof and said main cylinder so as to exert a throttling effect varying in accordance with the position of said throttling member in said conduit, a regulating pump having a delivery circuit supplying fluid under pressure, said pump being driven at a speed proportional to the speed of reciprocation of said auxiliary piston, means interposed between said delivery circuit and said throttling member for controlling the position of said throttling member with respect to said inlet conduit in accordance with the fluid pressure in said delivery circuit and bleeding means mounted on said delivery circuit to permit fluid to leak out therefrom through a passage of cross-sectional area variable automatically as a function of said speed.

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