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SELF REGULATING RECIPROCATING PUMPS AND
IN PARTICULAR FUEL INJECTION PUMPS
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Fig. 3.

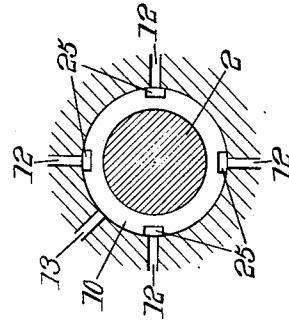
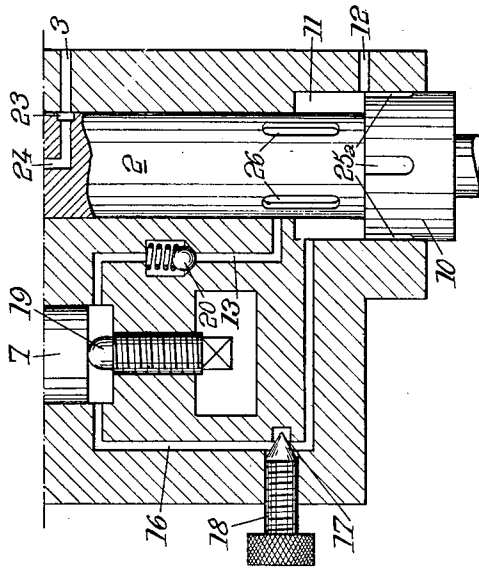


Fig. 2.

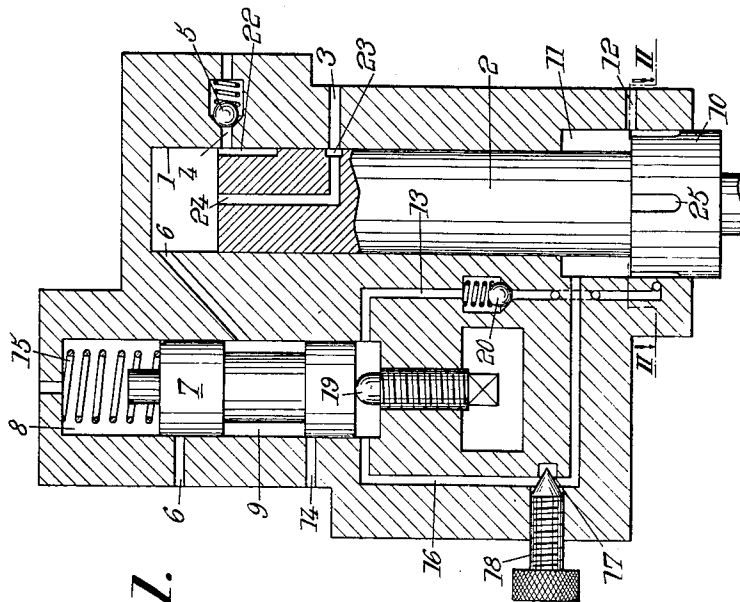


Fig. 1.

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**SELF REGULATING RECIPROCATING PUMPS
AND IN PARTICULAR FUEL INJECTION
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8 Claims. (Cl. 103—41)

The present invention relates to self-regulating reciprocating pumps, that is to say to pumps such that their delivery flow rate per cycle, at least for speeds above a given speed, decreases as this speed increases. The invention is more especially concerned with fuel injection pump for internal combustion engines.

In my U.S. patent applications Ser. No. 90,984 of February 23, 1961, now Patent No. 3,003,421 (this application being a continuation-in-part of my prior patent application Ser. No. 673,343 of July 22, 1957 now abandoned) and Ser. No. 811,176 of May 5, 1959, now abandoned, I describe pumps of the above mentioned kind having a mechanically driven reciprocating piston arranged to produce through hydraulic means, during every outward, or delivery, stroke thereof, a corresponding outward stroke of a regulating member, called shuttle, preferably in the form of an auxiliary piston, whereas, during at least a portion of the period elapsing between the beginning of every return stroke of said piston and the beginning of its next outward stroke thereof, this shuttle member, moving on its own return stroke under the action of a return force, supplied for instance by a spring, expels liquid through a throttled passage, which exerts a braking effect on said shuttle member. Thus when the speed at which the pump is driven exceeds a given value, the shuttle member, which preferably controls a discharge, or by-pass, conduit for the outflow of the liquid present in the working space of the pump, no longer returns to its position of rest from which it starts normally to make its outward strokes, but is stopped before reaching this position by what is called a "liquid abutment" whereby its outward strokes are more and more shortened, thus reducing more and more the delivery flow rate of the pump as the speed at which the pump is driven exceeds more and more said given value.

If, as it is normally the case, the liquid which has produced the outward strokes of the shuttle is fed to the space under this member through a conduit which does not comprise a throttled passage, this conduit must be closed during the return strokes of said shuttle to enable the throttled passage to slow down these return strokes in the desired manner.

It has already been proposed to insert in this conduit a check valve. It may however happen that this check valve is accidentally prevented from closing just as it should. In particular, it may lose some of its liquid-tightness due to the presence of an impurity in the liquid. The regulation of the pump, which is based upon the slowing down effect of the throttled passage, is then disturbed and the engine fed by the pump may unduly accelerate as a consequence of this.

The object of the present invention is to eliminate this drawback.

For this purpose, I make use, to control the conduit through which flows the liquid which produces the outward strokes of the shuttle, in addition to the above mentioned check valve, a mechanically driven valve mounted in series with said check valve and operated to be opened just before said check valve is normally to open and to be closed just after said check valve is normally to be closed.

With this arrangement, the normal operation of the

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check valve is not modified by the presence of the mechanically driven valve, but if the check valve remains jammed in open position, the opening and closing of the conduit are achieved, by the mechanically driven valve, for a time which is slightly longer than that for which the check valve opens this conduit when it works normally. However, the difference is practically without importance in view of the fact that any failure of the check valve to operate normally is generally of very short duration.

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 vertical section a fuel injection pump made according to the invention.

FIG. 2 is a sectional view on the line II—II of FIG. 1.

FIG. 3 is a view similar to FIG. 1 and showing a modification.

The fuel injection pump comprises a main cylinder 1, in which is slidably mounted a main piston 2 which is given a reciprocating axial movement by a cam (not shown) or any suitable driving means operated by the engine to be fed with fuel by the pump. This piston 2 closes, at the beginning of every outward, or delivery, stroke (upward stroke in the example shown) a port 3 through which a fuel feed conduit opens into cylinder 1, this feed conduit being supplied with fuel by a pump not shown and usually called "transfer pump."

From cylinder 1 starts at least one delivery conduit 4 provided with a check valve 5 and leading to an injector (not shown).

A discharge or by-pass conduit 6 starts from cylinder 1, so that when this discharge conduit is opened the pump ceases to deliver fuel through conduit 4 toward the injector. The opening and closing of this conduit 6 are controlled by a regulating member, called "shuttle," in the form of an auxiliary piston 7 movable in a cylinder 8 and provided with an annular groove 9. When shuttle 7 is in the position where this groove 9 connects together the two portions of discharge conduit 6 (which opens at different respective levels into cylinder 8) the discharge conduit is open and the fuel delivered by piston 2, instead of passing into delivery conduit 4, passes through conduit 6 to be returned for instance to a fuel tank. Shuttle 7 is arranged and controlled in such manner that when the speed at which the piston 2 of the pump is driven exceeds a given value, it opens discharge conduit 6, during every upward stroke of piston 2, earlier and earlier (thus reducing the flow rate of the pump for every delivery stroke), as the speed at which piston 2 is driven increases above said given value.

For this purpose, shuttle 7 is hydraulically driven in the direction of its upward strokes, which correspond to the delivery stroke of piston 2, by liquid delivered by an auxiliary piston 10 moving in synchronism with piston 2. Preferably, this auxiliary piston 10 consists of a portion of enlarged diameter of piston 2, this auxiliary piston 10 being slidable in an auxiliary cylinder 11. Liquid, which may for instance consist of fuel, is admitted into cylinder 11 through a feed conduit 12 closed as piston 10 is starting on its upward stroke, and this liquid is fed to the bottom end of cylinder 8 through a conduit 13 which permits the passage of the liquid only from cylinder 11 toward cylinder 8 but not in the opposed direction. The outward (upward) stroke of shuttle clears a discharge conduit 14 opening into cylinder 8.

As for the return strokes of shuttle 7 (downward strokes) they are produced by a return spring 15 which is compressed during every outward stroke of the shuttle. This downward stroke of the shuttle begins when the main piston 2 starts on its own return stroke. In view of

the means, inserted in conduit 13, which prevent back flow of the liquid through this conduit from the bottom end of cylinder 8 toward cylinder 11, the shuttle is compelled to force, during its return stroke, liquid through a conduit 16 comprising a throttled passage 17 (preferably adjustable by means of a screw 18) this conduit 16 opening either to the outside or into auxiliary cylinder 11 as shown. The return strokes of the shuttle are therefore braked by the fact that the liquid is compelled to flow through throttled passage 17.

As long as piston 2 (and therefore piston 10) is driven at a speed lower than a given value, shuttle 7, pushed back by spring 15, reaches its position of rest determined by an abutment 19 (preferably adjustable), despite the braking effect of throttled passage 17, before pistons 2 and 10 start back on the next upward stroke. Consequently, for speeds below this value the amplitude of the shuttle stroke is maximum and the amount of fuel delivered by piston 2 through delivery conduit 4 is also maximum. However, when the speed of the pump exceeds this given value, shuttle 7 is no longer capable of returning into its position of rest, i.e. against abutment 19, but it is stopped by the jet of liquid which, at the beginning of the next upward stroke of piston 10 is delivered into cylinder 8, this jet of liquid constituting what is called a "liquid abutment." Consequently, the upward displacement of the shuttle before it opens discharge conduit 6 becomes shorter and shorter as the speed of pistons 2 and 10 exceeds more and more the above mentioned value, which produces a corresponding reduction of the amount of fuel delivered by piston 2 on every stroke thereof.

It will be understood that the regulation action of shuttle 7 depends upon the liquid tightness of the means that prevent back flow of liquid through conduit 13. Check valve 20, which constitutes said means, may in some cases be insufficiently liquid tight. This is why, according to the present invention, I provide in series with check valve 20, a mechanically driven valve working in synchronism with pistons 2 and 10 so as to open conduit 13 shortly before the time when check valve 20 normally opens this channel, and to close said channel 13 shortly after the time when check valve 20 is normally to close it. The normal operation of check valve 20 is not modified by the presence of the mechanically driven valve which is substituted for this check valve only in case of failure of the check valve to operate normally, this failure being generally of short duration (some seconds) so that the slight increase of the time of opening of conduit 13 which results from the action of the mechanically driven valve cannot produce any serious perturbation in the operation of the engine.

The mechanically driven valve may be a slide valve having a reciprocating longitudinal movement to control conduit 13. However, this valve is preferably a rotating valve.

It is particularly advantageous to make use of piston 2 or of auxiliary piston 10, rigid therewith, to constitute the mechanically driven valve which controls conduit 13. In order to obtain this result, piston 2 or piston 10 should be given a movement of rotation about the axis thereof and this is especially advantageous when piston 2 has a rotating movement to act as a distributing valve sending fuel toward different injectors during successive delivery strokes.

For instance, in the pump illustrated by FIG. 1, auxiliary piston 10 acts as a rotating valve to control the opening and closing of conduit 13 whereas piston 2 acts as a distributing valve to send the fuel delivered by the pump to the different injectors successively. Both of the pistons form a single piece having both a reciprocating longitudinal movement and a movement of rotation about its axis. This movement of rotation is produced by means well known in the art of fuel injection pumps and not shown by the drawings. Furthermore, in the

side wall of cylinder 1, there is provided, at a level higher than that of feed conduit 3, a plurality of (for instance four) delivery conduits 4, each provided with a check valve 5 and leading to a corresponding injector. The side wall of piston 2 is provided, in the upper portion thereof, with a longitudinal groove 22 which, during the successive delivery strokes of piston 2 cyclically connects the working chamber of the pump with the respective delivery conduits 4. The working chamber of the pump is filled with fuel from feed conduit 3 through an annular groove 23 provided in the side wall of piston 2 and which communicates with the working chamber of the pump through an axial conduit 24.

Auxiliary piston 10, in order to be able to act as a mechanically driven valve controlling the opening and closing of conduit 13, is provided with four longitudinal grooves formed in the side wall of said piston 10. The disposition of said grooves 25 with respect to feed conduit 12 or rather (see FIG. 2) with respect to four feed conduits 12 on the one hand and with respect to conduit 13 on the other hand is such that it permits the filling of cylinder 11 from conduit or conduits 12 during the whole of every return stroke of piston 10 while keeping conduit 13 closed, whereas there is always one of these grooves 25 to place conduit 13 in communication with cylinder 11 during every time period starting from just before the time when check valve 20 is to be opened by the flow of liquid delivered by piston 10 during every upward stroke thereof and ending just after the time when check valve 20 is to be closed as a consequence of the next downward stroke of piston 10.

It should be noted that this arrangement of grooves 25 has the further advantage of permitting the inflow of liquid into auxiliary cylinder 11 during the whole return stroke of pistons 2 and 10. Furthermore, it tends to apply pistons 10 and 2 against the cam by which they are driven since feed pressure in cylinder 11 urges piston 10 in the downward direction.

FIG. 3 shows the lower portion of a pump made according to a modification of that shown by FIGS. 1 and 2. In the construction of FIGS. 1 and 2 grooves 25 formed in auxiliary piston 10 serve to control both feed conduit 12 and conduit 13. In the construction of FIG. 3 the grooves 25a provided in the side wall of piston 10 serve only to control feed conduit 12, whereas the opening and closing of conduit 13 is controlled by grooves 26 provided in the side wall of piston 2.

The action on these two sets of grooves is of course the same as above described, concerning the action of the single set of grooves 25.

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 accompanying claims.

What I claim is:

1. For use with an internal combustion engine, a reciprocating action fuel pump which comprises, in combination, a pump cylinder, a piston adapted to cooperate with said cylinder mounted for reciprocating movement therein, so as to limit therewith a variable volume working space, the movements of said piston in said cylinder in the direction for which the volume of said working space is reduced being called delivery strokes, and those in the opposed direction return strokes, a casing rigid with said cylinder provided with a discharge port opening to the outside, a shuttle member adapted to control said discharge port, said shuttle member fitting movably in said casing so as to limit with the inner wall thereof a variable volume chamber, the movements of said shuttle member in said casing in the direction for which the volume of said chamber is increased being called outward strokes

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and the movements of said shuttle member in the opposed direction being called return strokes, a fuel delivery means, conduit means in said casing including a connection from said working space to said fuel delivery means and a connection to said variable volume chamber and conduit means providing an outflow for liquid from the variable volume chamber, means operative by said piston for forcing liquid through said connection to said variable volume chamber during the delivery strokes of said piston to produce outward strokes of said shuttle member, valve means in said connection to the variable volume chamber responsive to movements of said piston to close said connection during the return strokes of said piston, and said outflow having its smallest cross-section very substantially less than the cross-section of the shuttle member so as to slow down said liquid outflow and thus to exert on said shuttle member, during its return strokes, a braking action such that, for speeds of operation of the pump above a given value, said shuttle member return strokes are shorter as the speed of operation of the pump is higher, means, operative at least during the return strokes of said piston, for exerting a limited thrust on said shuttle member to urge it in the direction to produce the return strokes thereof, fuel being fed to said delivery means during the delivery strokes of said piston, the feed of fuel to said delivery means being stopped during every delivery stroke of said piston at least after the shuttle member has cleared said discharge port, said valve means in said connection to the variable volume chamber comprising a check valve and a mechanically driven valve mounted in series in said last mentioned connection, said mechanically driven valve being operatively connected with said piston to be opened just before said check valve opens normally and to be closed just after said check valve closes normally.

2. A self-regulating liquid pump which comprises, in combination, a main cylinder, a main piston fitting slidably in said cylinder, so as to limit therewith a variable volume working space, means for reciprocating said piston in said cylinder, a delivery conduit in communication with said cylinder working space, means forming a housing having at least one cylindrical portion, a discharge conduit leading from said cylinder working space to the outside and including a portion of said housing, a reciprocating shuttle piston having a cylindrical portion thereof fitting slidably in said cylindrical portion of said housing so as to form therein a slide valve controlling the opening and closing of said discharge conduit, said shuttle piston limiting, together with said housing, a variable volume chamber so that variation of the volume of said chamber corresponds to a movement of said shuttle piston in said housing, an auxiliary reciprocating pump operatively connected with said main piston so as to work in synchronism therewith, conduit means for connecting the delivery of said auxiliary pump with said variable volume chamber so as to move said shuttle piston in said housing in one direction in response to every delivery stroke of said auxiliary pump, said discharge conduit being arranged to be opened during every displacement of said shuttle piston in said direction, on every reciprocation thereof, valve means in said last mentioned conduit means for preventing the flow of liquid therethrough from said variable volume chamber toward said auxiliary pump delivery, resilient means for urging said shuttle piston in the opposed direction, an outflow conduit starting from said variable volume chamber, and throttling means in said outflow conduit to brake the displacements of said shuttle piston in said second mentioned direction, said valve means comprising a check valve and a mechanically driven valve mounted in series in said last mentioned conduit

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means, said mechanically driven valve being operatively connected with said main piston to be open just before said check valve opens normally and to be closed just after said check valve closes normally.

3. A pump according to claim 2 in which said mechanically driven valve is a rotating valve.

4. A self-regulating liquid pump which comprises, in combination, a main cylinder, a main piston fitting slidably in said cylinder, so as to limit therewith a variable volume working space, means for reciprocating said piston in said cylinder and rotating it about its axis, a delivery conduit in communication with said cylinder working space, means forming a housing having at least one cylindrical portion, a discharge conduit leading from said cylinder working space to the outside and including a portion of said housing, a reciprocating shuttle piston having a cylindrical portion thereof fitting slidably in said cylindrical portion of said housing so as to form therein a slide valve controlling the opening and closing of said discharge conduit, said shuttle piston limiting, together with said housing, a variable volume chamber so that variation of the volume of said chamber corresponds to a movement of said shuttle piston in said housing, an auxiliary reciprocating pump comprising a portion of enlarged diameter of said main piston and an auxiliary cylinder arranged to cooperate with said enlarged piston portion, conduit means for connecting the said auxiliary cylinder with said variable volume chamber so as to move said shuttle piston in said housing in one direction in response to every delivery stroke of said piston, said discharge conduit being arranged to be opened during every displacement of said shuttle piston in said direction on every reciprocation thereof, valve means in said last mentioned conduit means for preventing the flow of liquid therethrough from said variable volume chamber toward said auxiliary cylinder, resilient means for urging said shuttle piston in the opposed direction, an outflow conduit starting from said variable volume chamber, and throttling means in said outflow conduit to brake the displacements of said shuttle piston in said second mentioned direction, said valve means comprising a check valve in said last mentioned conduit means and a mechanically driven valve constituted by said piston and arranged to connect said last mentioned conduit means with said auxiliary cylinder just before said check valve opens normally and to close said last mentioned conduit means just after said check valve closes normally.

5. A pump according to claim 4 in which the portion of said piston forming said mechanically driven valve is that which is of the same diameter as said main cylinder.

6. A pump according to claim 4 in which the portion of said piston forming said mechanically driven valve is the portion of enlarged diameter of said piston.

7. A pump according to claim 4, including a plurality of delivery conduits starting from different points of said main cylinder located in different radial planes thereof, respectively, the portion of said piston located in said main cylinder acting as distributing means for feeding fuel to said respective delivery conduits respectively on successive strokes of said piston, said portion of enlarged diameter of said piston being provided with several longitudinal grooves to cooperate with said conduit means to form said mechanically driven valve, and at least one feed conduit opening into said auxiliary diameter to cooperate with said groove to control the inflow of liquid into said auxiliary cylinder during the return strokes of said piston.

8. A pump according to claim 7, comprising a number of feed conduits equal to the number of said longitudinal grooves.

No references cited.