Oct. 10, 1961 P. E. BESSIERE 3,003,422

RECIPROCATING PUMPS INCLUDING AN AUXILIARY PISTON, IN PARTICULAR FOR THE INJECTION OF FUEL INTO INTERNAL COMBUSTION ENGINES

Filed March 18, 1959 2 Sheets-Sheet 1

Fig. 4

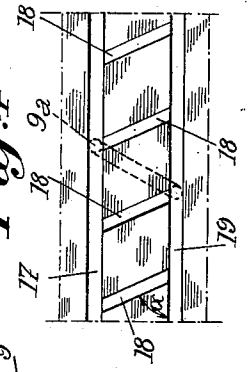


Fig. 2.

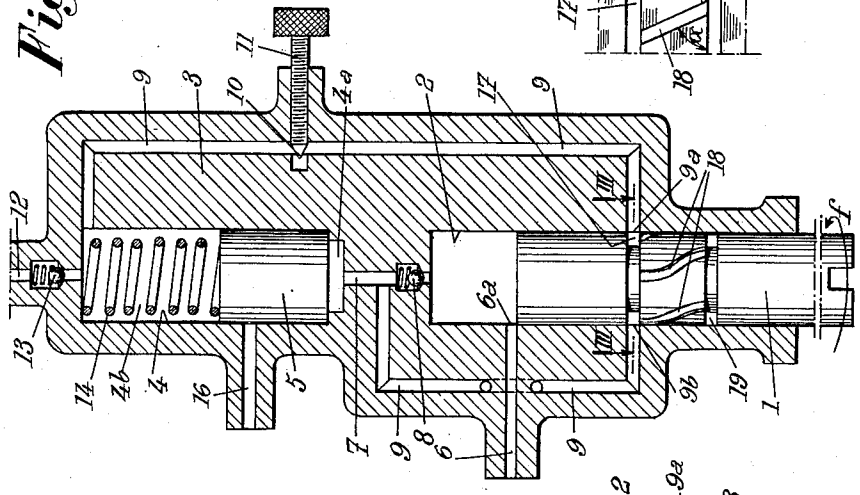


Fig. 3

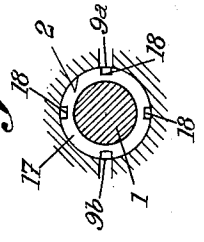
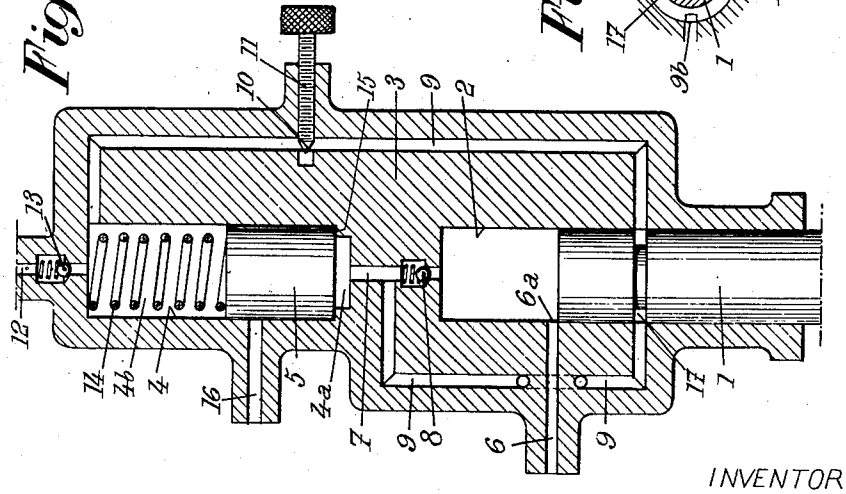


Fig. 1



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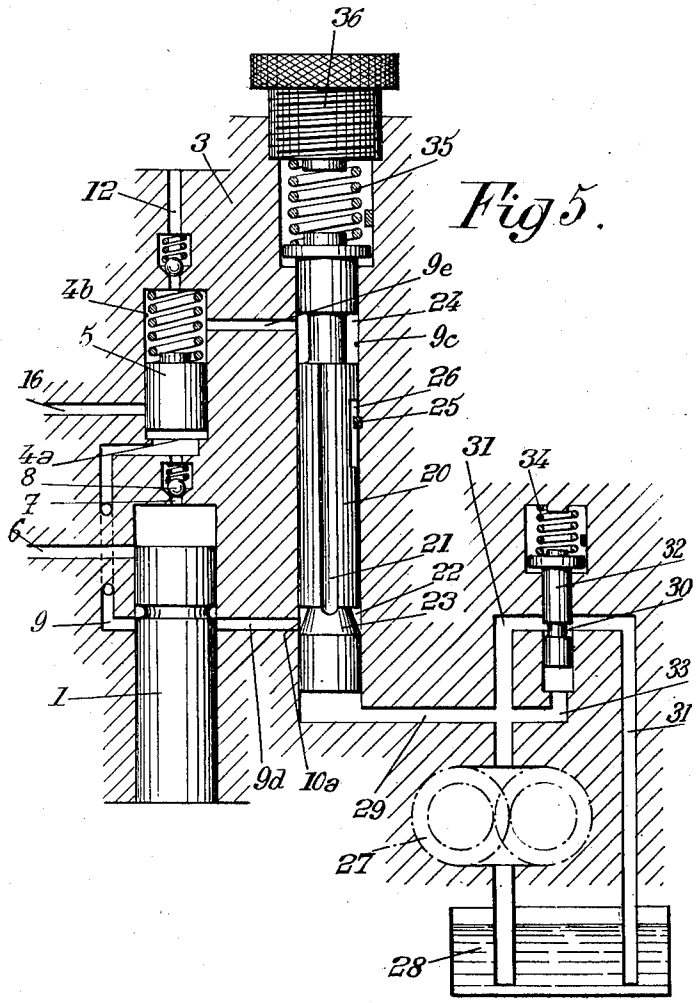


Fig 5.

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RECIPROCATING PUMPS INCLUDING AN AUXILIARY PISTON, IN PARTICULAR FOR THE INJECTION OF FUEL INTO INTERNAL COMBUSTION ENGINES

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4 Claims. (Cl. 103—41)

The present invention is concerned with a reciprocating pump including an auxiliary piston which will be hereinafter called "shuttle" and which is moved, against the action of a return force, during the delivery stroke of the main pump piston, by at least a portion of the liquid delivered by said main piston during said delivery stroke, whereas the auxiliary piston is braked during its return stroke, which takes place independently of the return movement of the main piston under the effect of said return force, this braking being obtained by means of a throttled portion provided in a conduit through which must flow the liquid driven by the auxiliary piston during said return stroke. In this way I obtain that, for speeds of operation of the main piston above a given value, said main piston begins a delivery stroke before the auxiliary piston has finished its return stroke, which shortens said return stroke and serves to reduce the amount of liquid delivered by the pump to the outside.

I have already described, in prior patents, pumps working on these principles. In these pumps there is provided, in the conduit including the throttled portion above referred to, a valve element having in particular the form of a slide valve which closes said conduit during the delivery stroke of the main piston and opens it only during the return stroke thereof and also during the period for which the main piston stops at the end of its suction stroke before starting on a new delivery stroke.

The object of the present invention is to simplify the construction of such pumps.

For this purpose, according to this invention, I make use, as valve elements for controlling said conduit, of the main piston of the pump.

Other features of this invention will become apparent in the course of the following detailed description thereof, with reference to the appended drawings given merely by way of example and in which:

FIGS. 1 and 2 are diagrammatic axial sectional views of two pumps made according to two different embodiments of the invention.

FIG. 3 is a section on the line III—III of FIG. 2.

FIG. 4 is a developed view of a portion of the surface of the main piston of the pump of FIG. 2.

FIG. 5 shows a third embodiment of the pump according to the present invention.

In the following description, it will be supposed that the invention is applied to the construction of a fuel injection pump for an internal combustion engine, and in particular a diesel engine.

The pump includes a main piston 1 having a reciprocating movement in a cylinder 2 provided in the body 3 of the pump. Piston 1 is driven, at a speed proportional to that of the engine on which the pump is fitted, through suitable means constituted for instance by a rotating cam.

In the body 3 of the pump, there is further provided an auxiliary cylinder 4 in which moves an auxiliary piston (or shuttle) 5, this auxiliary piston dividing the auxiliary cylinder 4 into two chambers 4*a* and 4*b*.

A feed conduit 6 opens into the main cylinder 2 at 6*a*, this feed conduit being supplied with fuel from a suitable transfer pump. This port 6*a* is located at a point of the wall of cylinder 2 such that it is cleared by piston 1 when said piston is in its lower dead center position (position shown by FIGS 1 and 2).

The main cylinder 2 communicates with the chamber 4*a* of auxiliary cylinder 4 through a passage 7 provided with a check valve 8 which permits liquid to flow only from cylinder 2 toward cylinder 4. Furthermore, chambers 4*a* and 4*b* are connected together by a conduit 9 including a throttled portion 10, preferably adjustable by means of a screw 11. The delivery conduit 12 of the pump starts from the chamber 4*b* of auxiliary cylinder 4, and a check valve 13 is provided in said delivery conduit 12 in the portion thereof close to chamber 4*b*. Thus, during the delivery stroke of piston 5, fuel is fed from chamber 4*b* to the injector or injectors to be fed by the pump.

There is further provided, in chamber 4*b*, a return spring 14 which urges auxiliary piston 5 toward the position of rest thereof where the under face of said piston rests upon a shoulder 15 provided at the lower end of cylinder 4. A discharge conduit 16 opens into auxiliary cylinder 4 at some distance above shoulder 15, so that when said discharge conduit 16 is cleared by auxiliary piston 5, the delivery stroke of this piston is immediateley stopped.

The liquid delivered by piston 1 through passage 7 into chamber 4*a* must push auxiliary piston 5 upwardly and therefore must not escape during this delivery stroke from chamber 4*a* through conduit 9. This conduit 9 must therefore be closed during the delivery strokes of piston 1. For this purpose, according to my invention, cylinder 2 is interposed across said conduit 9 and the main piston 1 is used as valve means for closing conduit 9 during the whole delivery stroke of piston 1, whereas conduit 9 is opened, in the embodiment of FIG. 1, by means of a groove 17 provided in piston 1 at a place such that this groove connects together the sections of conduit 9 located, respectively, upstream and downstream of cylinder 2 when piston 1 is in its lower dead center position.

In view of the fact that, in the construction illustrated by FIG. 1, conduit 9 is opened only when piston 1 is in its lower dead center position, the means for driving piston 1 must be arranged in such manner that said piston stops for a relatively long time in this position, which can be obtained for instance by giving a suitable profile to the cam which drives piston 1. This profile is such that it ensures a quick return stroke of piston 1 and remains then a relatively long time in its lower dead center position.

The operation of the pump shown by FIG. 1 is as follows:

Piston 1 closes, at the beginning of its upward (delivery) stroke, conduits 6 and 9 and then delivers fuel, present in cylinder 2, into the chamber 4*a* of auxiliary cylinder 4. This causes auxiliary piston 5 to move upwardly in said cylinder 4. The movement of auxiliary piston 5 stops when it clears discharge conduit 16. During its upward movement, piston 5 delivers fuel present in chamber 4*b*, past check valve 13, into delivery conduit 12. The amount of fuel thus delivered into conduit 12 on every delivery stroke of the pump is proportional to the length of the upward stroke of auxiliary piston 5. Piston 1, after it has reached its upper dead center position, starts back on its downward stroke. However, due to the closing of conduit 9, auxiliary piston 5 remains in its upper position until the main piston 1 begins to open conduit 9. Then, piston 5, under the effect of spring 14, moves down and drives the fuel present in chamber 4*a*, through conduit 9 and past throttled portion 10, into chamber 4*b*. When piston 1 is moving at relatively low speeds, it remains a sufficiently long time in its lower dead center position, where

it opens conduit 9, to enable auxiliary piston 5, despite the braking of its movement by throttled passage 10, to reach shoulder 15 before piston 1 starts back upon its next upward stroke. However, when the speed exceeds a given value, piston 5 has not yet reached shoulder 15 when piston 1 starts back upon a new upward stroke. Said auxilitary piston is thus stopped and again pushed back upwardly after a shortened downward stroke. The amount of fuel which, after this shortened stroke, is delivered through conduit 12, is thus correspondingly reduced. The speed from which this reduction of the flow rate is produced may be varied by acting upon screw 11 the position of which determines the cross-sectional area of throttled passage 10. I thus obtain an "all speeds" self-regulation.

In the embodiment which has been described, self-regulation depends upon the ratio of the time for which main piston 1 is stopped in its lower dead center position to the time taken by auxiliary piston 5 to accomplish its maximum downward stroke between its upper position, which is determined by the position of conduit 16 with respect to cylinder 4, and its lower position, which is determined by shoulder 15.

In the embodiment shown by FIG. 2, self-regulation depends upon the ratio of the whole of the time elapsing between the beginning of the downward stroke of main piston 1 and the beginning of its next upward stroke to the time taken by auxiliary piston 5 to accomplish its maximum downward stroke. In this embodiment, there is provided in piston 1, in addition to groove 17, at least one pair of helical grooves 18 diametrally opposed to one another. The upper ends of said grooves open into groove 17 and their length, in the direction parallel to the axis of piston 1, is equal to the length of stroke of this piston. Advantageously, the lower ends of these grooves are connected together by a second groove 19 provided also in the periphery of piston 1. Furthermore, piston 1 is given, in addition to its axial reciprocating movement, a rotation movement in the direction of arrow *f* at a speed, chosen, in relation to its axial speed and in accordance with the inclination α of helical grooves 18, so that, during the upward stroke of piston 1, the communication between the two sections of conduit 9 located on opposite sides of cylinder 2 is cut off by the portions of the surfaces of piston 1 located between said grooves (see the developed view of FIG. 4 where the relative path of the port 9*a* of conduit 9 is shown in dotted lines), whereas, during the downward stroke of piston 1, this communication is restored, first by means of groove 19 and then through the grooves 18 located opposite the ports 9*a*, 9*b* of the respective sections of conduit 9, and also by the grooves which connect together said helical grooves, the axial speed of piston 1 during its downward stroke being chosen so as to maintain this communication during the whole of the downward movement of said piston.

In the embodiment shown by FIG. 4, four helical grooves 18, located at 90° to each other, have been provided. This single piston pump is intended to feed fuel to the respective cylinders of a four-cylinder engine.

The operation of the pump of FIG. 2 is quite analogous to that of the pump of FIG. 1 with the only difference that in this case, for the self-regulation action, the whole of the time elapsing between the beginning of the downward movement and the beginning of the next upward movement of the main piston 1 enters into account.

The pump shown by FIG. 5 corresponds essentially to that shown by FIG. 1 with the difference that, according to FIG. 5, the cross-sectional area of the throttled passage is automatically variable in accordance with the speed of the engine on which the pump is mounted, this cross-sectional area decreasing automatically when this speed increases.

In order to vary the cross-sectional area, I make use of an arrangement which can be used separately and which consists in arranging a portion of conduit 9, for instance portion 9*c*, in the form of a cylindrical housing in which moves a slide valve 20 preferably actuated by a hydraulic speed governor, this slide valve 20 being capable of varying the cross-sectional area of the throttled passage 10*a* provided in conduit 9, this slide valve including a longitudinal groove or channel 21 through which flows the liquid which is to pass through conduit 9, after it has passed through throttled passage 10*a*. Preferably, the lower end of longitudinal groove 21 opens into an annular groove 22 having a conical bottom 23 and also formed in slide valve 20. The throttled passage 10*a* is in the space left between this conical bottom 23 and the port through which the section 9*d* of conduit 9 opens into the slide valve housing 9*c*. The cross-sectional area of this throttled passage thus depends upon the position of slide valve 20 in said housing 9*c*. In order to ensure, for all positions of slide valve 20, the communication between groove 21 and the section 9*e* which connects casing 9*c* with chamber 4*b*, there is further provided, in slide valve 20, a second annular groove 24 into which opens the upper end of groove 21. In order to prevent a rotation movement of slide valve 20, which might bring groove 21 opposite the section 9*d* of conduit 9, there is provided a projection 25 engaged in a longitudinal groove 26 provided in the periphery of slide valve 20.

In order to move slide valve 20 longitudinally in its casing 9*c* and thus to vary the cross-sectional area of throttled passage 10*a*, I make use of a hydraulic governor such as shown by FIG. 5. This governor includes a continuous flow pump 27, such as a gear pump, driven at a speed which constitutes the controlling factor for the displacement of slide valve 20. This speed, in the case of a fuel injection pump, is the speed of the engine on which the pump is mounted. This pump draws liquid from a tank 28, which may be the fuel tank of the engine, and the delivery of pump 27 is connected, through a conduit 29, with the lower end of casing 9*c*. Furthermore, I provide on the delivery of this pump a throttled passage 30 located in a conduit 31 for returning the liquid delivered by pump 27 to tank 28. The cross-sectional area of this throttled passage 30 is adjustable by a slide valve 32 which, on the other hand, is placed under control of the action of the delivery pressure of pump 27 applied to this slide valve through a conduit 33, and furthermore under the action of a return spring 34, the whole being arranged in such manner that the cross-sectional area of throttled passage 30 increases when the delivery pressure of pump 27 increases.

Slide valve 20 is further subjected to the action of an opposing spring 35 the compression of which is adjustable, for instance by means of a screw 36.

When the speed of pump 27 increases, the pressure fed through conduit 29 to the under face of slide valve 20 also increases and this slide valve moves in the direction which causes the cross-sectional area of throttled passage 10*a* to decrease. On the contrary, when the speed of pump 27 decreases, the cross-sectional area of throttled passage 10*a* increases.

The variation of the cross-sectional area of throttled passage 30 in the manner above indicated has for its effect that the increases and reductions, as a function of the speed of pump 27, of the delivery pressure acting upon slide valve 20 take place at a slower rate than if the cross-sectional area of throttled passage 30 were fixed. It is the fineness of the adjustment effect of the governor that remains the same within a wide range of speeds.

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. For use with an internal combustion engine, a reciprocating action fuel pump which comprises, in combination, a pump cylinder, a pump piston adapted to cooperate with said cylinder mounted for reciprocating displacement therein so as to limit therewith a variable 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, fuel inlet means opening into said pump cylinder, a fuel delivery means adapted to be fed during the delivery strokes of said piston with fuel supplied from said pump cylinder, a casing rigid with said cylinder provided with a discharge port opening to the outside, a shuttle member adapted to control said discharge port, the feed of fuel to said delivery means being stopped during every delivery stroke of said piston when said shuttle member has cleared 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, return means interposed between said casing and said shuttle member for urging said member to move in said casing in the opposed direction, the movements of said shuttle member in said last mentioned direction being called return strokes, a passage in said casing extending from said cylinder working space to said casing variable volume chamber, valve means in said passage operative by liquid pressure variations in said cylinder working space for opening said passage during the delivery strokes of said piston and otherwise closing it, a conduit starting from said casing variable volume chamber for the outflow of liquid from said chamber during the return strokes of said shuttle member, said conduit including a throttled portion for braking said shuttle return strokes, and valve means in said conduit constituted by a portion of said pump piston for closing said conduit during the delivery strokes of said pump piston and opening said conduit temporarily during at least portions of the time intervals between said delivery strokes, said throttled portion being arranged to produce a braking action such that, for speeds of operation of the pump above a predetermined value, the return strokes of said shuttle member are the shorter as the speed of operation of the pump is higher.

2. A pump according to claim 1 in which said piston is mounted for reciprocating axial displacement in said cylinder, said conduit including two separate sections opening into said cylinder at two different points of the cylindrical wall thereof, respectively, said piston being provided with a passage therein arranged to connect said two points together when said piston is in the position corresponding to the end of its suction stroke, the portion of said piston which carries said last mentioned passage constituting said valve means in said conduit.

3. A pump according to claim 1 in which said piston is mounted for reciprocating and rotating displacement in said cylinder, said conduit including two separate sections opening into said cylinder at two different points of the cylindrical wall thereof, respectively, said piston being provided at least with one helical groove in its periphery arranged to connect said points together during the suction strokes of said piston while leaving them out of communication during the delivery strokes of said piston, the portion of said piston which carries said helical groove constituting said valve means in said conduit.

4. For use with an internal combustion engine, a reciprocating action fuel pump which comprises, in combination, a pump cylinder, a pump piston adapted to cooperate with said cylinder mounted for reciprocating displacement therein so as to limit therewith a variable 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, fuel inlet means opening into said pump cylinder, a fuel delivery means adapted to be fed during the delivery strokes of said piston with fuel supplied from said pump cylinder, a casing rigid with said cylinder provided with a discharge port opening to the outside, a shuttle member adapted to control said discharge port, the feed of fuel to said delivery means being stopped during every delivery stroke of said piston when said shuttle member has cleared 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, resilient means interposed between said casing and said shuttle member for urging said member to move in said casing in the opposed direction, the movements of said shuttle member in said last mentioned direction being called return strokes, a passage in said casing extending from said cylinder working space to said casing variable volume chamber, valve means in said passage operative by liquid pressure variations in said cylinder working space for opening said passage during the delivery strokes of said piston and otherwise closing it, a conduit starting from said casing variable volume chamber for the outflow of liquid from said chamber during the return strokes of said shuttle member, said conduit including a throttled portion for braking said shuttle return strokes, and valve means in said conduit for closing said conduit during the delivery strokes of said pump piston and opening said conduit temporarily during at least portions of the time intervals between said delivery strokes, said throttled portion being arranged to produce a braking action such that, for speeds of operation of the pump above a predetermined value, the return strokes of said shuttle member are the shorter as the speed of operation of the pump is higher, said throttled portion being in the form of a slide valve comprising means forming a cylindrical slide valve housing inserted between two sections of said conduit, one of said conduit sections opening into said housing transversely thereto, near one end thereof, the other of said conduit sections opening into said housing near the other end thereof, a cylindrical slide valve body fitting slidably in said cylindrical housing, said body being provided with a circumferential groove adapted to cooperate with the opening of said first mentioned conduit section, said slide valve being provided with a longitudinal passage connecting said annular groove with the opening of said second mentioned conduit section, cooperating abutment means carried by said housing and said body for limiting the displacements of said body in said housing in one direction to the position for which said groove wholly clears the opening of said first mentioned conduit section into said housing, and governor means carried by said casing and operatively connected with said slide valve body, said governor means being responsive to variation of a given factor of operation of said engine for moving said body in said casing in the opposed direction from said position when said factor varies.

No references cited.