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SELF-REGULATING RECIPROCATING PUMPS

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Fig. 1.

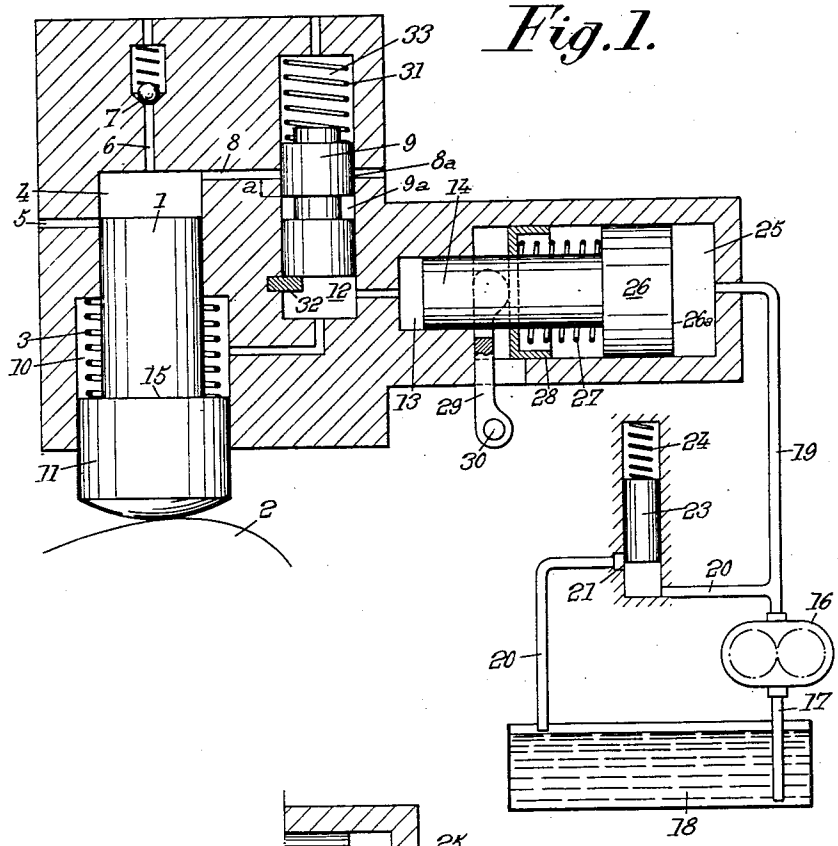
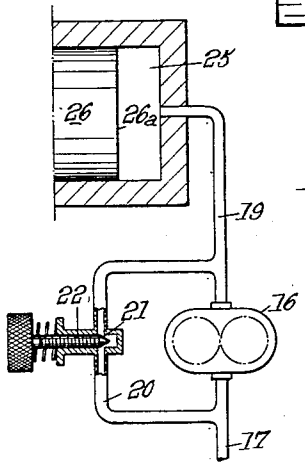



Fig. 2.




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# SELF-REGULATING RECIPROCATING PUMPS

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The present invention relates to self-regulating reciprocating pumps, that is to say in pumps the main active element of which (hereinafter called "piston") has a reciprocating movement and the delivery rate per cycle of which, at least within a given range of operation, varies, and in particular decreases, when the speed of operation of the pump increases. This invention is more especially concerned with fuel injection pumps for internal combustion engines, the term "internal combustion engine" including both explosion engines and combustion engines such as diesel engines and the like.

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

Such pumps comprise a reciprocating member or shuttle which controls a discharge or by-pass conduit provided on the main cylinder of the pump, said shuttle being actuated in one direction hydraulically by a liquid extending between this shuttle and a reciprocating piston moving in synchronism with the main piston of the pump and in the opposed direction by a return force, produced for instance by a spring.

According to my invention, said liquid is enclosed in a space the shape of which for a given position of said driving piston is varied in response to variations of the speed of operation of the pump by means of a regulating piston or analogous element constituting one of the walls of this space and the position of which is adjustable through means responsive to said variations of the speed of operation of the pump, whereby this speed determines the amount of liquid interposed between said driving piston and said shuttle to transmit the movement from one to the other, and consequently the limit position of the shuttle and the period during which, during every cycle, said shuttle opens the discharge or by-pass conduit, that is to say finally the delivery rate of the pump per cycle of operation thereof.

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 is a diagrammatic vertical sectional view of a fuel injection pump made according to the invention.

FIG. 2 shows a modification of a portion of FIG. 1.

The pump illustrated by the drawings is intended for the injection of fuel to a diesel engine.

The pump which, with the exception of its regulating means, may be of any suitable construction, comprises a main piston 1 driven by the engine fed with fuel by the pump (and not shown) through a rotating cam 2 acting against a return spring 3. Piston 1 cooperates with a main cylinder 4 provided with a fuel inlet conduit 5 controlled by piston 1 and with a delivery conduit 6 provided with a check valve 7. Inlet conduit 5 comes from a fuel tank and delivery conduit 6 leads to the injectors of the diesel engine.

Concerning now the regulating means of the pump, they essentially comprise a discharge or by-pass conduit 8 starting from the pump cylinder 4 and controlled by a shuttle 9, slidable in a casing 33 formed integral with the pump cylinder, this shuttle being provided with a groove 9*a* adapted to connect discharge conduit 8 with the outside



for some positions of the shuttle through an outlet port 8*a* formed in said casing.

Shuttle 9 is actuated, for its upward displacements, hydraulically by a liquid extending between said shuttle and a driving piston 11 actuated in synchronism with the main piston 1 of the pump so that to every delivery stroke of said piston there corresponds an upward stroke of shuttle 9. For its downward displacements, shuttle 9 is subjected to the action of a return force, exerted for instance by a spring 31 tending to apply shuttle 9 against an abutment 32.

According to my invention, the liquid serving to transmit the movements of driving piston 11 to shuttle 9 belongs to a mass of liquid enclosed in a space (comprising the variable volume chamber 12 under shuttle 9, the variable volume chamber 10 above piston 11 and an adjustable volume chamber 13 in free and constant communication with said chambers 12 and 10) the shape of which, for a given position of piston 11, can be varied, in response to variations of the speed of operation of the pump, by means of a regulating piston 14, forming one of the walls of this space (as a matter of fact of chamber 13 thereof) and the position of which depends, through suitable means, upon the speed of operation of the pump.

Advantageously, as shown by the drawings, piston 11 consists of an extension of enlarged diameter of piston 1, cam 2 acting directly upon this piston 11. Chamber 10 consists of the annular volume existing between the side wall of piston 1 and the shoulder 15 connecting this piston 1 to piston 11, return spring 3 being preferably housed in this volume and bearing against this shoulder.

Advantageously, the means for actuating regulating piston 14 in accordance with the speed of operation of the pump consist of a pump capable of delivering liquid at a pressure varying with the speed of operation of the pump, this pressure being applied to a surface fixed with respect to piston 14, against the action of resilient means.

This last mentioned pump is for instance gear pump 16 which draws liquid through a conduit 17 from a tank 18 and delivers this liquid into a conduit 19 from which branches off a leak conduit 20 provided with a calibrated orifice 21 and returning to tank 18. Pump 16 is driven by the internal combustion engine which is fed with fuel by pump 1–4.

Calibrated orifice 21 may be adjusted manually by means of a screw 22 (FIG. 2) but preferably it is adjusted automatically in accordance with the pressure existing upstream of orifice 21, by means of a valve 23 urged downwardly by a spring 24, as shown by FIG. 1, so as to moderate the increase of pressure that takes place when the speed increases.

Delivery conduit 19 opens into a cylinder 25 where regulating piston 14 is slidable. The surface of piston 14 to which the pressure of the liquid from pump 16 is applied consists of the end face 26*a* of an extension of enlarged diameter 26 of piston 14. The resilient return means consists of a spring 27 surrounding piston 14 and extending between a bearing member 28 and the shoulder which connects piston 14 with its extension 26. Advantageously, as shown, means are provided for adjusting the position of bearing member 28 and consequently the stressing of spring 27, this device consisting of a lever 24 pivotable about an axis 30.

It should be noted that the liquid contained in the space formed by cylindrical chambers 10, 12 and 13 may or may not be of the same nature as the fuel to be injected into the engine. The same remark applies to the liquid fed by pump 16 to control the position of piston 14 in accordance with the speed of operation.

The pump above described works in the following manner.

During every delivery stroke of main piston 1, piston

11 drives liquid from chamber 10 into chamber 12, thus moving shuttle 9 upwardly. If it is supposed that said shuttle, in its initial position, was applied against its abutment 32, the shuttle opens discharge conduit 8 after a stroke of a maximum amplitude *a*, then cutting off injection. During the next return stroke of main piston 1, shuttle 9 is moved downwardly by its spring 31 until it is stopped by abutment 32. The same operation takes place on every cycle of the engine. In this case, injection is stopped during every cycle always for the same position of main piston 1 and the delivery rate of the pump is maximum.

If the speed of operation increases, the pressure in cylinder 25 rises and piston 14 is moved toward the left by this pressure, so that the volume of chamber 13 limited by regulating piston 14 is reduced. This reduction of volume can be compensated only by an increase of the volume of chamber 12. Therefore, during every return stroke of pump piston 1, shuttle 9 is stopped before it reaches abutment 32, and this the earlier as the speed of operation is higher. During the next upward stroke, the displacement of the shuttle before it opens discharge conduit 8 is smaller than *a*. The delivery rate of the pump therefore decreases as the speed increases. At the limit, shuttle 9 may keep discharge conduit 8 constantly open so that there is no longer any injection of fuel.

The delivery flow rate of the pump may be varied by stressing spring 27 more or less by means of lever 29, by varying the cross section area of orifice 21 or by adjusting the strength of spring 24 (FIG. 1) or the angular position of screw 22 (FIG. 2).

Of course, the means responsive to variations of speed of operation of the pump for controlling regulating piston 14 are of any kind whatever and are not necessarily hydraulic means as shown.

Furthermore, chamber 13 may not have its axis perpendicular to that of chamber 12 as shown.

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 liquid pump which comprises, in combination, a pump cylinder, a piston cooperating 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, means forming a casing in communication with said working space, said casing being provided with a discharge port opening to the outside, a shuttle member controlling said discharge port, said shuttle member fitting movably in said casing so as to limit with the inner wall thereof a first 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 and the movements of said shuttle member in the opposed direction being called return strokes, a liquid delivery conduit starting from said working space whereby liquid is fed through said delivery conduit during the delivery stroke of said piston as long as said discharge port is closed by said shuttle member, means operatively connected with said piston forming a second variable volume chamber in constant free communication with said first variable volume chamber and of a volume varying in synchronism with that of said variable volume working space, means, operative at least during the return strokes of said piston, for exerting at least a limited thrust on said shuttle member to urge it in the direction to produce the return strokes thereof, means forming an adjustable volume third chamber in constant free communication with both of said two first mentioned variable volume chambers, a mass of liquid filling the whole of the space of said three communicating chambers, and means operatively connected with said last mentioned means and responsive to variations of the speed of operation of said pump to vary the volume of said third chamber in accordance with variations of said speed of operation.



2. A pump according to claim 1 wherein the means forming the second variable volume chamber comprise a driving piston consisting of a cylindrical extension of larger diameter of the pump piston, the pump cylinder being provided with a cylindrical recess adapted to accommodate said extension.

3. A pump according to claim 1 wherein the means for varying the volume of the third chamber in accordance with variations of the speed of operation of the pump comprise a pump driven at a speed proportional with that of the main pump and adapted to feed liquid at a pressure varying with said speed, and a piston subjected to the action of said liquid under pressure and limiting the third chamber.

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