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P. E. BESSIERE

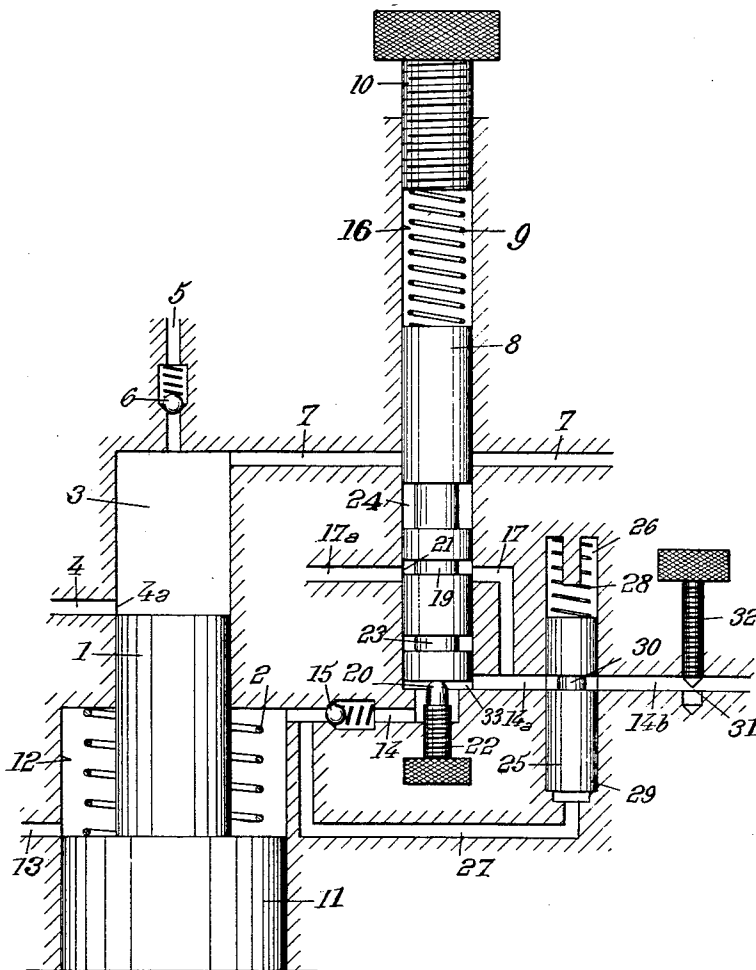
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SELF REGULATING PUMPS IN PARTICULAR FOR THE INJECTION
OF FUEL INTO INTERNAL COMBUSTION ENGINES

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2 Sheets-Sheet 1

Fig. 1



INVENTOR
PIERRE ETIENNE BESSIERE

BY
Bailey, Stephens & Huetting
ATTORNEYS

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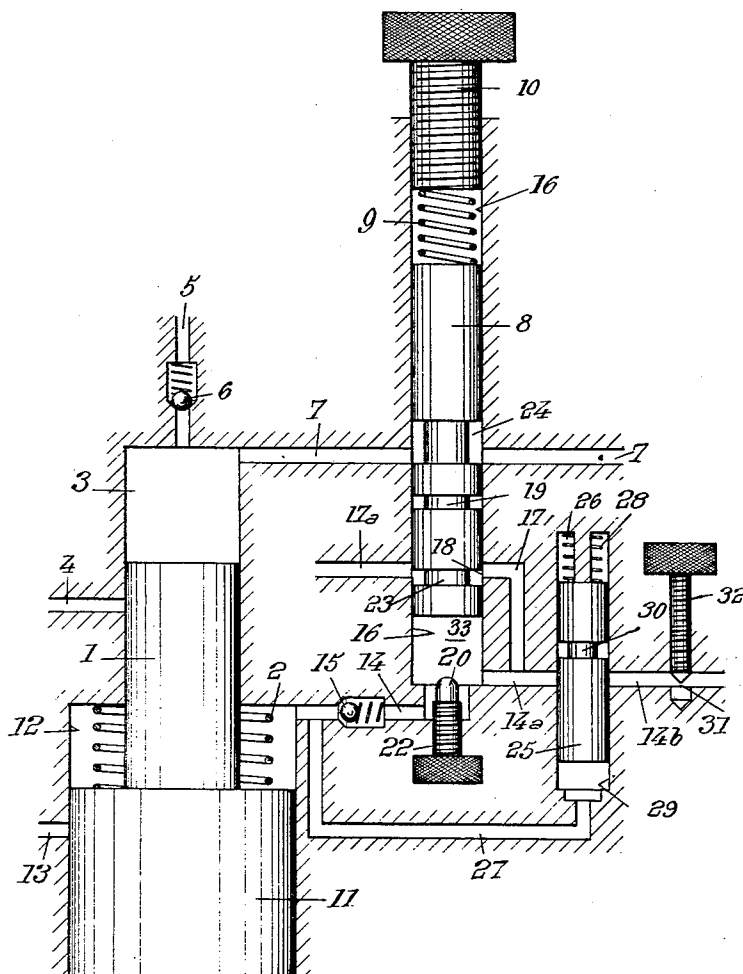
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Fig. 2.



INVENTOR
PIERRE ETIENNE BESSIERE
BY
Bailey, Stephens & Hutton
ATTORNEYS

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SELF REGULATING PUMPS IN PARTICULAR FOR THE INJECTION OF FUEL INTO INTERNAL COMBUSTION ENGINES

Pierre Etienne Bessiere, Neuilly-sur-Seine, France, assignor to Societe Anonyme pour l'Exploitation des Procédes Chimiques et Physiques, Zug, Switzerland, a Swiss company

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9 Claims. (Cl. 103-41)

The present invention relates to self-regulating pumps and in particular to pumps for the injection of fuel into internal combustion engines.

The pumps with which my invention is concerned include a discharge conduit the opening of which prevents the pump from delivering liquid, this discharge conduit being controlled by valve means urged by resilient means toward discharge conduit closing position and actuated to open this discharge conduit by a control fluid receiving, owing to the provision of a throttled passage in the circuit through which said control fluid is flowing, pressure impulses at a frequency equal to that of the reciprocating movement of the pump piston, the maximum pressure reached by this control fluid during every impulse and preferably the rate of increase of the fluid pressure during each of said impulses being the higher as this frequency is higher until said maximum fluid pressure is capable of overcoming the action of said resilient means and of opening said discharge conduit.

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

For this purpose, according to my invention, I provide means for braking the return displacements of said valve means from discharge conduit opening position toward discharge conduit closing position so that return displacements take place at a rate independent of the frequency of reciprocation of said piston per unit of time and such that, for high values of said frequency, said discharge conduit is open during the whole of every compression stroke of said piston.

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

FIGS. 1 and 2 diagrammatically show, in axial section, a fuel injection pump made according to the present invention, the parts being shown in two relative different positions in said figures respectively.

The pump shown by the drawings includes a piston 1 driven in such manner, for instance by means of a cam (not shown), that the movement of the piston is accelerated from the time, at the beginning of its upward stroke, when fuel starts being compressed and delivered. When the upward stroke of piston 1 is obtained by means of a cam, the downward stroke thereof is obtained by means of a return spring 2.

Piston 1 reciprocates in a cylinder 3 into which opens, at 4a, a feed conduit 4 through which fuel arrives in the usual manner from an auxiliary pump (not shown). Furthermore, a delivery conduit 5 provided with a check-valve 6 leads out from said cylinder 3. This delivery conduit 5 conveys the fuel delivered by the pump toward the injector or injectors (not shown) of the engine fed by the pump.

A discharge conduit 7 also leads from the top cylinder 3 to the outside. This discharge conduit 7 is controlled by a moving element 8 consisting for instance of a slide valve.

Piston 1, during its upward stroke and after it has

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closed port 4a, delivers fuel into conduit 5 as long as slide valve 8 keeps discharge conduit 7 closed. But fuel delivery through conduit 5 ceases as soon as slide valve 8 opens discharge conduit 7.

In order to control slide valve 8, I apply thereto, on the one hand a downwardly directed force preferably produced by a return spring 9, for instance adjustable by means of a screw 10, and on the other hand the upwardly directed thrust of a fluid (and in particular a liquid) receiving pressure impulses at a frequency equal to that of the reciprocating movement of piston 1, this pressure reaching, during the upward strokes of piston 1, peak values which increase, as the speed at which the pump is driven (i.e.) (the speed of the engine fed by the pump) increases up to a value for which said pressure overcomes the resistance of spring 9. Then, for speed exceeding this value, the liquid pressure capable of overcoming the resistance of spring 9 is reached for shorter upward displacements of piston 1.

In order to produce said pulsating pressure of the liquid used to actuate slide valve 8, I make use of an auxiliary reciprocating pump including an auxiliary piston 11 fitting slidably in an auxiliary cylinder 12. Cylinder 12 is provided with a feed conduit 13, also preferably connected with the delivery of a primary pump (not shown) which may be the same as that which supplies liquid to conduit 4. A delivery conduit 14, leading from auxiliary cylinder 12 and containing a check-valve 15, is in communication with one of the ends 33 of a cylinder 16 in which slide valve 8 is slidably fitted, the pressure of the liquid in conduit 14 acting against the thrust of return spring 9 on slide valve 8.

According to a particularly simple construction illustrated by the drawing, the main piston 1 and the auxiliary piston 11 form a single unit and cylinders 3 and 12 are in line and coaxial with each other. In this case, return spring 2 may be housed in cylinder 12, this spring being common to both of the pistons 11 and 1, which are driven by the same cam. Feed conduits 4 and 13 are disposed in such manner as to be simultaneously closed by pistons 1 and 11 respectively, so that the compression strokes of said pistons begin simultaneously.

In order to comply with the above stated conditions concerning the pressure of the liquid delivered by piston 11, this liquid is caused to pass through a throttled passage controlled by slide valve 8 itself. An outlet conduit 17 branching out from conduit 14, for instance from the portion 14a thereof located downstream of cylinder 16, opens into the wall of cylinder 16 opposite a discharge conduit 17a in line with conduit 17. Slide valve 8 is provided with a groove 19 located at a level such that, when slide valve 8 is in its position of rest (where the bottom end of said valve is applied against an abutment 20 as shown by FIG. 1), the lower edge of groove 19 and the opening of conduit 17 into cylinder 16 limit between them a throttled passage 21 through which the liquid delivered by piston 11 must flow to pass into discharge conduit 17a.

The initial value of the cross-section of this throttled passage depends upon the position of abutment 20, which position is preferably adjustable by means of a screw 22.

It will be seen that as soon as the pressure of the liquid delivered by piston 11 reaches a value sufficient to overcome the thrust of return spring 9, the area of the cross-section of throttled passage 21 decreases, and quickly becomes equal to zero. If, at this time, piston 11 has not yet reached the end of its upward stroke, slide valve 8 is suddenly pushed upward until a second groove 23, provided in slide valve 8 below groove 19, comes opposite conduits 17 and 17a and thus enables the liquid still delivered by piston 11 to flow to the outside. This movement of slide valve 8 simultaneously brings opposite dis-

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charge conduit 7 a third groove 24 provided in slide valve 8 above groove 19, whereby conduit 7 places cylinder 3 in communication with the outside.

In order to obtain the return of slide valve 8 to its position of rest immediately after the beginning of every downward stroke of pistons 11 and 1, the portion 14a of delivery conduit 14 is placed in communication, during every downward stroke of piston 11, with a discharge conduit 14b by-passing throttled passage 21, this conduit 14b being of course closed during every upward (delivery) stroke of piston 11.

In order to control this discharge conduit 14b, I advantageously make use of a slide valve 25 actuated in synchronism with the reciprocating movement of piston 11 by means of the pressure of the liquid present in cylinder 12. For this purpose, one of the ends of cylinder 26, in which slide valve 25 is movable, is connected through a conduit 27 to cylinder 12, or delivery conduit 14. In this last case, which is that illustrated by the drawings, the point of conduit 14 from which conduit 27 branches out is located upstream of check-valve 15. A return spring 28 interposed between the upper end of cylinder 26 and slide valve 25 urges said slide valve toward its position of rest where it is applied against a shoulder 29 at the lower end of cylinder 26. In this position of rest, slide valve 25 opens, through its groove 30, the communication between conduit 14a and discharge conduit 14b. Thus, slide valve 25 is in its position of rest during every downward stroke of piston 11 and it is moved away from its position, thus closing the communication with discharge conduit 14b, during every upward stroke of piston 11.

In the embodiment of my invention shown by the drawings, conduits 4 and 13 open into the respective cylinders 3 and 12 at points such that, during every upward stroke of pistons 1 and 11, piston 11 closes conduit 13 and starts compressing liquid and delivering it from cylinder 12 at the same time as piston 1 closes conduit 4 and delivers liquid from cylinder 3 toward delivery conduit 5.

Discharge conduit 14b is throttled at 31 and the cross-section of this throttled portion of conduit 14b is advantageously adjustable by means of a screw 32 the end of which projects more or less into conduit 14b to form said throttled portion.

Groove 24 is of a height much greater than that of discharge conduit 7. Furthermore groove 23 is positioned in slide valve 8 so as to open discharge conduit 17—17a and thus to stop the upward movement of slide valve 8 when said slide valve has moved a substantial distance beyond the position for which its groove 24 starts opening discharge conduit 7.

FIG. 1 shows the parts in the position they occupy when pistons 1 and 11 are approximately in their lower dead center position.

This pump works as follows.

Since pistons 11 and 1 are supposed to undergo an acceleration, during every upward stroke thereof, even when the engine on which the pump is mounted runs at a constant speed, the pressure of the liquid which, during every upward stroke of piston 11, flows through the throttled passage 21, rises during said stroke up to a value which, as long as slide valve 8 is not lifted, i.e. for relatively low values of the speed of the engine on which the pump is mounted, increases when said speed increases. For a given value of the engine speed, this liquid pressure, which acts upon the lower end face of slide valve 8, becomes sufficiently high to overcome the resistance of spring 9 and slide valve 8 starts moving upwardly. This movement further reduces the cross-section area of throttled passage 21 which, in turn, increases the liquid pressure acting on the lower end face of valve 8 and further accelerates the reduction of the cross-section area of throttled passage 21. Full closing of throttled passage 21 and upward displacement of slide valve 8 to the position where it opens discharge conduit 7 are therefore

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practically instantaneous. Slide valve 8 then remains in its upper position (FIG. 2) until the end of the upward stroke of piston 11, groove 23 opening the communication between conduits 17, 17a by an amount just sufficient to keep it in this position.

For higher and higher speeds of the engine above the above mentioned value, this opening of discharge conduit 7 takes place for shorter and shorter upward strokes of piston 11. As long as the opening of discharge conduit 7 takes place after inlet conduit 4 has been closed by piston 1, some amount of fuel is delivered by piston 1 through delivery conduit 5 toward the injector or injectors to be fed by the pump but this amount decreases as the speed of the engine (i.e. the frequency of reciprocation of pistons 1 and 11) increases.

Furthermore, during the return (downward) movements of slide valve 8 (which then discharges the liquid present in chamber 16 through conduit 14b, slide valve 25 having been pushed into lower position by spring 28), the flow of liquid is slowed down by the throttling of said conduit 14b at 31, thus braking said downward movements of slide valve 8. For a given throttling at 31 and a given adjustment of spring 9, the time taken by slide valve to move down from its upper position (shown by FIG. 2) to a bottom position in which groove 19 opens passage 21 between 17 and 17a is always the same, irrespective of the speed at which the pump is driven. Therefore, as this speed increases, it reaches a value such that piston 11 begins its compression (upward) stroke before slide valve 8 has had time to reach this bottom position. The liquid pressure then supplied by piston 11 quickly returns slide valve 8 into the position where discharge conduit 7 is fully opened. Injection is then reduced to a minimum. If the engine speed has reached a value such that piston 11 starts on its upward stroke before slide valve 8 has begun to shut off discharge conduit 7, said discharge conduit remains constantly open. There is no longer any injection and a limit speed has been reached.

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 arrangements, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

This application is a continuation of my prior application Ser. No. 780,452, filed December 15, 1958, for "Improvements in Self Regulating Pumps in Particular for the Injection of Fuel Into Internal Combustion Engines," now abandoned.

What I claim is:

1. A pump which comprises, in combination, a pump body forming a cylinder, a piston fitting slidably in said cylinder and having a reciprocating movement therein, a liquid delivery conduit leading from one end of said cylinder, so that liquid can be delivered from said cylinder through said delivery conduit during the compression strokes of said piston, feed conduit means opening into said cylinder for filling said cylinder with liquid during the suction strokes of said piston, a discharge conduit leading from said cylinder and opening to the outside thereof, a valve casing mounted in fixed position on a portion of said discharge conduit, a valve in said casing to control the discharge of liquid from said cylinder to the outside thereof through said discharge conduit, whereby opening of said discharge conduit by said valve during a compression stroke of said piston prevents the delivery of liquid through said delivery conduit, resilient means operatively connected with said valve for constantly urging it toward discharge conduit closing position, said valve casing and said valve limiting between them a variable volume chamber such that expansion of the volume thereof urges said valve toward discharge conduit opening position, a fluid

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control circuit full of fluid and wholly distinct from said delivery conduit and said discharge conduit, said fluid control circuit having an inlet and a throttled passage opening to the outside, said control circuit being in communication with said casing so that it includes said variable volume chamber, means operatively connected with said piston and in communication with said control circuit inlet for periodically applying fluid pressure impulses to the fluid in said control circuit at a frequency equal to the frequency of reciprocation of said piston so that the maximum fluid pressure during every impulse increases as said frequency increases, whereby, for a given value of said frequency, said maximum fluid pressure becomes capable of overcoming the action of said resilient means and of bringing said valve into discharge conduit opening position, said means for applying pressure fluid impulses being operatively connected with said piston in such manner as to start each of said pressure impulses with a given constant phase relation with respect to the beginning of the corresponding compression stroke of said piston, an outflow conduit wholly distinct from said delivery conduit and said discharge conduit and in communication with said chamber to permit escape of fluid therefrom during the displacements of said valve from discharge conduit opening position toward discharge conduit closing position and a throttled passage in said outflow conduit to brake said last mentioned valve displacements so that they take place at a rate independent of said frequency of reciprocation of said piston.

2. A pump which comprises, in combination, a pump body forming a cylinder, a piston fitting slidably in said cylinder and having a reciprocating movement therein, a liquid delivery conduit leading from one end of said cylinder, so that liquid can be delivered from said cylinder through said delivery conduit during the compression strokes of said piston, feed conduit means opening into said cylinder for filling said cylinder with liquid during the suction strokes of said piston, a discharge conduit leading from said cylinder and opening to the outside thereof, a valve casing mounted in fixed position on a portion of said discharge conduit, a valve in said casing to control the discharge of liquid from said cylinder to the outside thereof through said discharge conduit, whereby opening of said discharge conduit by said valve during a compression stroke of said piston prevents the delivery of liquid through said delivery conduit, resilient means operatively connected with said valve for constantly urging it toward discharge conduit closing position, said valve casing and said valve limiting between them a variable volume chamber such that expansion of the volume thereof urges said valve toward discharge conduit opening position, a fluid control circuit full of fluid and wholly distinct from said delivery conduit and said discharge conduit, said fluid control circuit having an inlet and a throttled passage opening to the outside, said control circuit being in communication with said casing so that it includes said variable volume chamber, means operatively connected with said piston and in communication with said control circuit inlet for periodically applying fluid pressure impulses to the fluid in said control circuit at a frequency equal to the frequency of reciprocation of said piston so that the rate of increase of the fluid pressure during every fluid pressure impulse is the higher as said frequency is higher and that the maximum fluid pressure during every impulse increases as said frequency increases, whereby, for a given value of said frequency said maximum fluid pressure becomes capable of overcoming the action of said resilient means and of bringing said valve into discharge conduit opening position, said means for applying pressure fluid impulses being operatively connected with said piston in such manner as to start each of said pressure impulses with a given constant phase relation with respect to the beginning of the corresponding compression stroke of said piston, an outflow conduit wholly distinct from said delivery conduit and said discharge conduit and in

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communication with said chamber to permit escape of fluid therefrom during the displacements of said valve from discharge conduit opening position toward discharge conduit closing position and a throttled passage in said outflow conduit to brake said last mentioned displacements so that they take place at a rate independent of said frequency of reciprocation of said piston.

3. A pump which comprises, in combination, a cylinder, a piston fitting slidably in said cylinder and having a reciprocating movement therein, a liquid delivery conduit leading from one end of said cylinder, so that liquid can be delivered from said cylinder through said delivery conduit during the compression strokes of said piston, feed conduit means opening into said cylinder for filling said cylinder with liquid during the suction strokes of said piston, a discharge conduit leading from said end of said cylinder and opening to the outside thereof, a cylindrical casing transverse to said discharge conduit and intersecting it so that a length of said discharge conduit consists of a portion of said casing, a slide valve fitting slidably in said cylindrical casing and movable therein to control the discharge of liquid from said cylinder to the outside thereof through said discharge conduit, whereby opening of said discharge conduit by said slide valve during a compression stroke of said piston prevents the delivery of liquid through said delivery conduit, resilient means interposed between said slide valve and said casing for constantly urging said slide valve toward discharge conduit closing position, one end of said cylindrical casing forming a chamber such that expansion thereof causes said slide valve to move toward discharge conduit opening position, means operatively connected with said piston for feeding into said chamber, during every compression stroke of said piston, fluid at a flow rate constantly increasing for a time, the rate of increase of said flow rate being the higher as the number of reciprocations of said piston per unit of time is higher, an outlet conduit leading from said chamber and having a length thereof constituted by a portion of said casing, said slide valve being provided with a groove arranged to cooperate with said outlet conduit and to clear it partly, when said slide valve is in the position where the volume of said chamber is minimum, to such a degree that expansion of the volume of said chamber causes a reduction of the cross-section area of said outlet conduit thus cleared by said groove, said slide valve being provided with another groove, arranged to clear said outlet conduit when said slide valve is in discharge conduit opening position, whereby said fluid can then be discharged to the outside through said outlet conduit, said casing being so dimensioned that, for a given value of said frequency of reciprocation of said piston, the fluid fed into said chamber reaches a pressure capable of overcoming the action of that resilient means and of bringing said slide valve into discharge conduit opening position, an outflow conduit in communication with said chamber to permit escape of fluid therefrom during the return displacements of said slide valve from discharge conduit opening position toward discharge conduit closing position and a throttled passage in said outflow conduit to brake said return displacements so that they take place at a rate independent of the number of reciprocations of said piston per unit of time.

4. A pump according to claim 1 further including valve means in said outflow conduit operatively connected with said piston for closing said outflow conduit during the compression strokes of said piston and opening said outflow conduit during the return strokes of said piston.

5. A pump according to claim 1 further including means carried by said casing for adjusting said resilient means.

6. A pump according to claim 1 further including means carried by said casing for adjusting the limit position toward which said slide valve is urged by said resilient means.

7. A pump according to claim 1 in which said means

for feeding fluid into said chamber include a cylinder coaxial with said first mentioned cylinder and in fixed position with respect thereto, a piston rigid with said first mentioned piston and fitting slidably in said second mentioned cylinder and feed conduit means opening into said second mentioned cylinder and positioned so that the compression strokes of both of said pistons occur simultaneously, said pump further including a conduit leading from said second mentioned cylinder to said chamber, and a check valve in said last mentioned conduit mounted to open only toward said chamber.

8. A pump which comprises, in combination, a pump body forming a cylinder, a piston fitting slidably in said cylinder and having a reciprocating movement therein, a liquid delivery conduit leading from one end of said cylinder, so that liquid can be delivered from said cylinder through said delivery conduit during the compression strokes of said piston, feed conduit means opening into said cylinder for filling said cylinder with liquid during the suction strokes of said piston, a discharge conduit leading from said cylinder and opening to the outside thereof, a valve casing mounted in fixed position on a portion of said discharge conduit, a valve in said casing to control the discharge of liquid from said cylinder to the outside thereof through said discharge conduit, whereby opening of said discharge conduit by said valve during a compression stroke of said piston prevents the delivery of liquid through said delivery conduit, said valve being so arranged that, when it is moved from its discharge conduit closing position in the direction to open said discharge conduit, it can move well beyond the position where it first opens said discharge conduit while leaving said discharge conduit open, as far as a position which will be called discharge conduit final opening position, resilient means operatively connected with said valve for constantly urging it toward discharge conduit closing position, said valve casing and said valve limiting between them a variable volume chamber such that expansion of the volume thereof urges said valve toward discharge conduit opening position, a fluid control circuit full of fluid and wholly distinct from said delivery conduit and said discharge conduit, said fluid control circuit having an inlet and a throttled passage opening to the outside, said

control circuit being in communication with said casing so that it includes said variable volume chamber, means operatively connected with said piston and in communication with said control circuit inlet for periodically applying fluid pressure impulses to the fluid in said control circuit at a frequency equal to the frequency of reciprocation of said piston so that the maximum fluid pressure during every impulse increase as said frequency increases, whereby, for a given value of said frequency said maximum fluid pressure becomes capable of overcoming the action of said resilient means and of bringing said valve into discharge conduit final opening position, said means for applying pressure fluid impulses being operatively connected with said piston in such manner as to start each of said pressure impulses with a given constant phase relation with respect to the beginning of the corresponding compression stroke of said piston, an outflow conduit wholly distinct from said delivery conduit and said discharge conduit and in communication with said chamber to permit escape of fluid therefrom during the displacements of said valve from discharge conduit opening position toward discharge conduit closing position and a throttled passage in said outflow conduit to brake said last mentioned valve displacements so that they take place at a rate independent of said frequency of reciprocation of said piston, whereby for high values of said frequency, said discharge conduit is open during the whole of every compression stroke of said piston.

9. A pump according to claim 8 wherein said valve is a slide valve provided with an annular groove in its intermediate portion so that said discharge conduit is opened when a portion of said groove is located opposite said discharge conduit, the height of said groove being at least twice the diameter of said discharge conduit.

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