

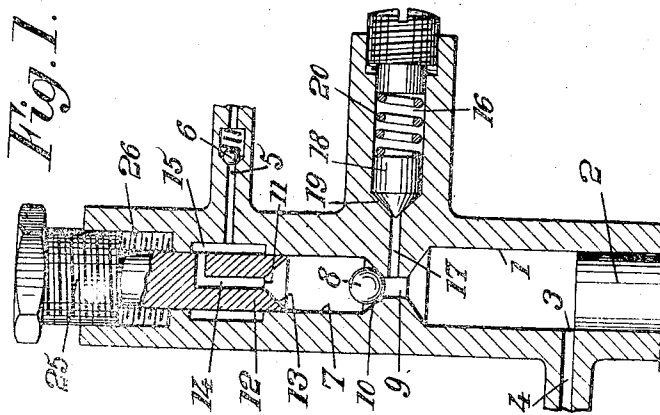
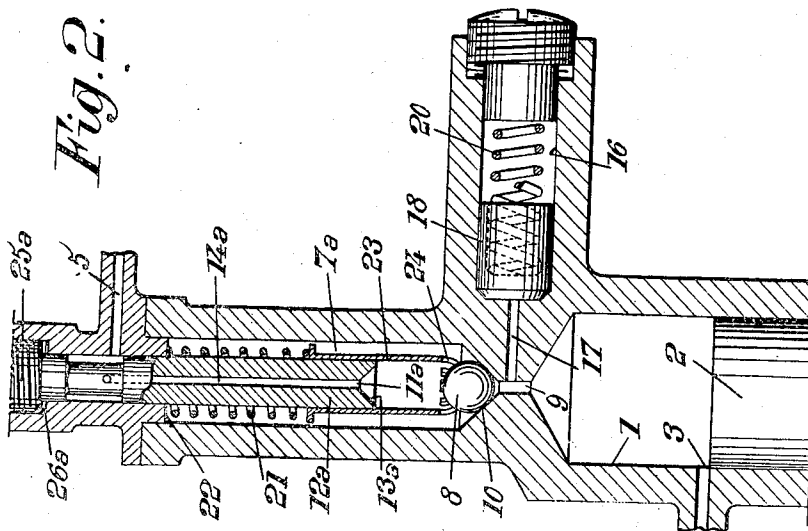
Nov. 1, 1960

P. E. BESSIERE
 RECIPROCATING ACTION PUMPS AND IN PARTICULAR
 FUEL INJECTION PUMPS

2,958,290

Filed Nov. 12, 1957

4 Sheets-Sheet 1



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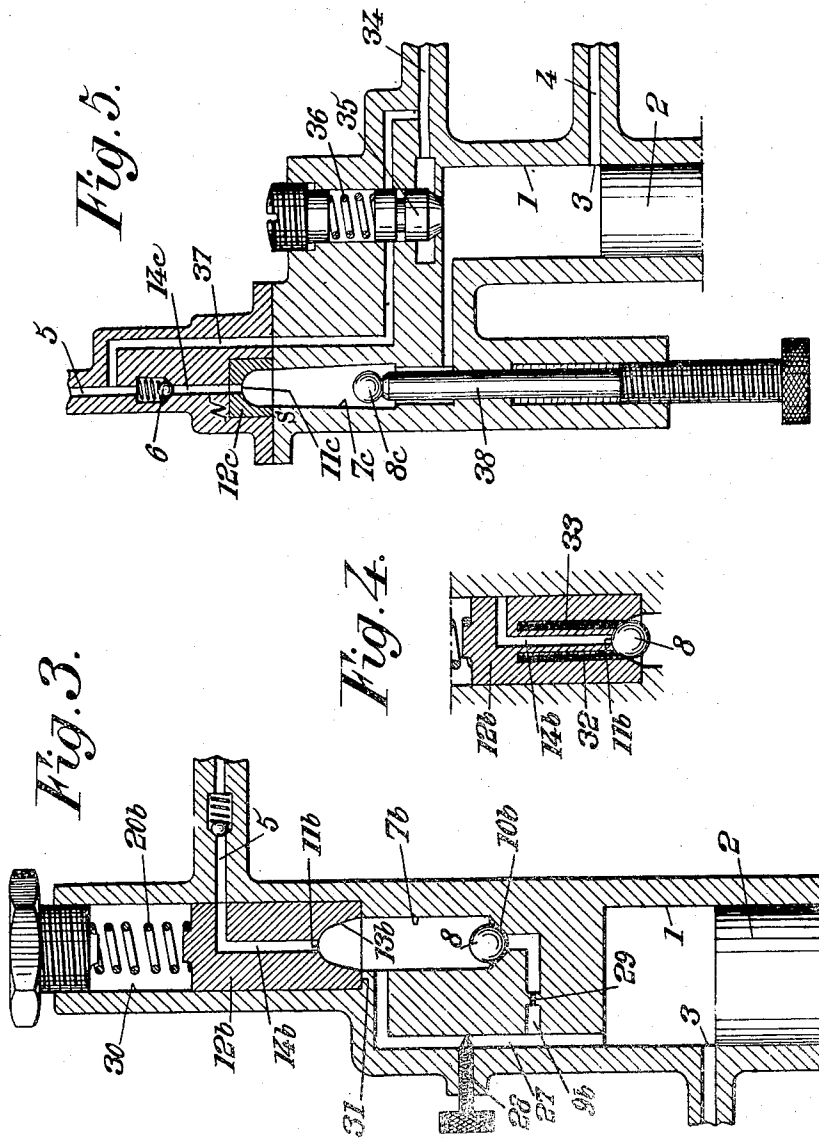
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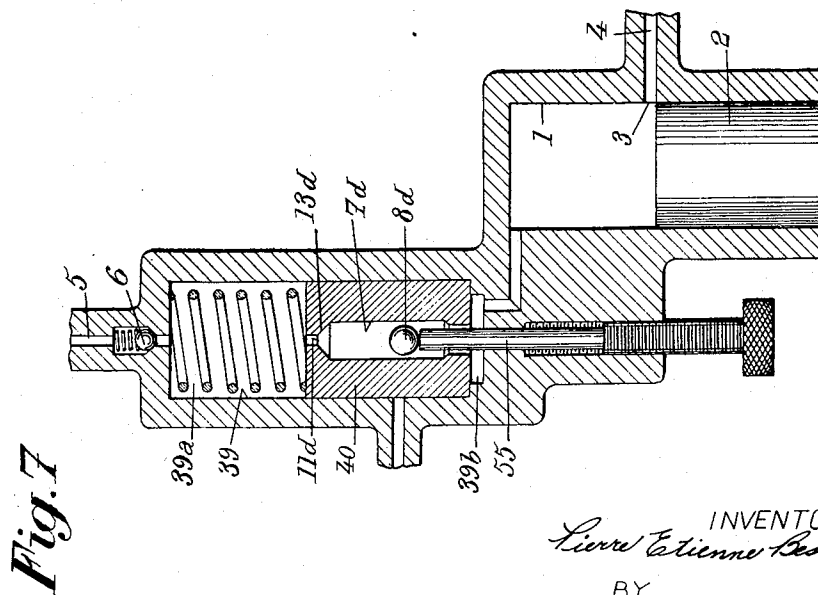
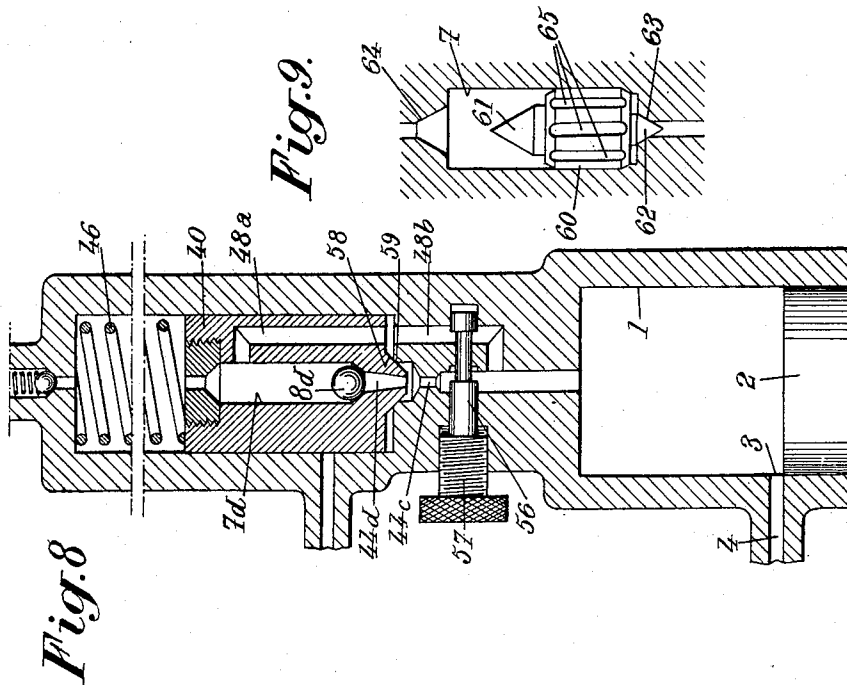
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4 Sheets-Sheet 4



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RECIPROCATING ACTION PUMPS AND IN PARTICULAR FUEL INJECTION PUMPS

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17 Claims. (Cl. 103—41)

The present invention relates to reciprocating action pumps, that is to say pumps in which the driven element (piston, diaphragm or the like) has a reciprocating movement for suction and delivery of the liquid. My invention is more especially but not exclusively concerned with fuel injection pumps for internal combustion engines. Its object is to provide a pump of this type which is better adapted to meet the requirements of practice than those used at the present time and in particular which ensures a self-regulation as a function of the speed at which the pump is driven.

According to my invention, I provide in a chamber through which flows, toward a delivery conduit, at least a portion of the liquid delivered by the piston, or analogous element of the variable volume space of the pump, a movable regulating member constantly urged yieldingly toward one end of the chamber in a direction opposed to that of the flow of the liquid through said chamber, the cross section of said member being substantially smaller than that of the chamber so as to leave an interval between said member and the wall of said chamber, whereby a difference of speed can exist between the liquid flowing through the chamber and the regulating member driven along by said liquid, an abutment being provided at the other end of said chamber to stop the movement of said member when it is driven along by the stream of liquid flowing through said chamber, the flow of the liquid through said chamber being stopped in response to the stopping of said member.

Preferred embodiments of my invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example and in which:

Figs. 1, 2, 3, 5, 6, 7 and 8 show, in axial sectional view, respectively, seven different embodiments of the pump according to my invention.

Fig. 4 diagrammatically shows a modification of an element of the pump of Fig. 3.

Fig. 9 shows another form of the movable regulating member.

In what follows it will be supposed that the invention is applied to the construction of a fuel injection pump for a diesel engine.

Such a pump includes for instance a cylinder 1 co-operating with a piston 2 actuated through any suitable means, for instance a cam not shown on the drawings. A feed conduit 4 opens into cylinder 2 through port 3, this port 3 being cleared by piston 2 when it is located in its lower dead center position, as shown by the drawing. On the cylinder is also mounted a delivery conduit 5 provided with a check-valve 6 and leading to the injector or injectors to be fed by the pump.

In order to obtain a self-regulation of the delivery of the pump as a function of the speed at which the piston is driven, I dispose in a chamber through which flows, toward a delivery conduit, at least a portion of the liquid delivered by the piston, or analogous element, of the variable volume space of the pump, a movable

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regulating member constantly urged yieldingly toward one end of the chamber in a direction opposed to that of the flow of the liquid through said chamber, the cross-section of said member being substantially smaller than that of the chamber so as to leave an interval between said member and the wall of said chamber, whereby a difference of speed can exist between the liquid flowing through the chamber and the regulating member driven along by said liquid, an abutment being provided at the other end of said chamber to stop the movement of said member when it is driven along by the stream of liquid flowing through said chamber, the flow of said liquid through said chamber being stopped in response to the stopping of said member.

This feature may be applied in different ways.

For instance, the chamber above referred to may be arranged so that the liquid that flows therethrough is on its way toward the injectors, that is to say that the flow through said chamber takes place when the check-valve 6 of the pump and the injector or injectors are opened. Injection is directly stopped by the closing of the outlet orifice or passage of said chamber, and this closing is caused by the regulating movable member being applied against the abutment which stops it and which preferably contains said outlet orifice or passage.

Such an arrangement is illustrated by Figs. 1, 2, 3 and 5.

I may also interpose the chamber which contains the movable regulating element in a conduit leading to the space from which fuel is discharged toward the injector or injectors. In this case, the movement of the regulating member and the stopping of the flow of fuel serve to meter the amount of fuel fed to said space. Such an arrangement is disclosed by Figs. 6, 7 and 8.

Referring now more particularly to Fig. 1, chamber 7 which contains the movable regulating member, said member being in this example in the form of a ball 8, is interposed between cylinder 1 and delivery conduit 5, provided with a check-valve 6. Chamber 7, the diameter of which is greater than that of ball 8, communicates with cylinder 1 through channel 9 the outlet of which into chamber 7 forms a seat 10 against which ball 8 is applied in its position of rest under the action of a return force which may be simply constituted by the gravity force. The outlet 11 of chamber 7 is provided in a member 12 which closes chamber 7 at its upper end and which also constitutes an abutment for stopping ball 8 when it is moving upwardly in chamber 7. This abutment 13 forms a seat, for instance of conical shape, for said ball 8, whereby the ball, when it is applied against said abutment, closes the outlet 11 of chamber 7. Outlet 11 leads to a conduit 14 which communicates freely with a groove 15 provided in the pump body and from which the delivery conduit 5 starts.

This pump further includes an auxiliary chamber 16 in communication with the inside of cylinder 3, preferably upstream of seat 10, through a conduit 17 opening for instance into channel 9. This conduit 17 is normally kept closed by a valve 18 applied against its seat 19 by a spring 20, preferably adjustable, with a force such that valve 18 remains closed as long as the pressure in cylinder 1 does not exceed the pressure which ensures injection of fuel.

The device shown by Fig. 1 works as follows.

When piston 2 moves upwardly in cylinder 1, after it has closed feed port 3, it delivers fluid through chamber 7, conduit 14 and conduit 5, toward the injector or injectors, which then open so that injection takes place. Valve 18 then remains closed for the highest pressures which may exist inside cylinder 1 as long as injection is taking place.

The stream of fuel flowing through chamber 7 lifts

ball 8 from its seat 10 and drives it, during the injection period, toward abutment 12. In view of the fact that ball 8 is of a diameter smaller than that of chamber 7, the speed at which the ball is driven along the stream of fuel is lower than the speed of said stream itself. Injection stops as soon as ball 8 reaches the surface 13 of abutment 12 and thus closes the outlet orifice 11. If, at this time, piston 2 has not yet reached its upper dead center position, the increase of pressure in cylinder 1 due to the remainder of the upward movement of piston 2 causes valve 13 to open and the excess of fuel is absorbed by auxiliary chamber 16.

As soon as piston 2 has reached its upper dead center position and during the return movement of this piston, ball 8 moves down in chamber 7, this downward movement being braked by the friction existing between the ball and the fuel present in said chamber. On the other hand, since the beginning of the return (downward) movement of piston 2, the amount of fuel which had been absorbed by auxiliary chamber 16 is discharged by valve 18, acting as a piston, into cylinder 1. After valve 18 has closed and during the remainder of the downward movement of piston 2, a vacuum is produced in cylinder 1, which is filled up only after piston 2 has cleared feed port 3. During all this time, chamber 7 remains filled with liquid so that ball 8 is always in a liquid medium.

The time taken by ball 8 to move up in chamber 7 and to come in contact with surface 13 so as to close orifice 11 depends on the one hand upon the length of the upward stroke of the ball, and on the other hand upon its speed. This speed, in turn, depends upon the following factors:

(a) the clearance existing between ball 8 and the inner wall of chamber 7,

(b) the value of the return force which urges ball 8 toward seat 10,

(c) the speed with which piston 2 delivers fluid toward the injector or injectors.

If it is supposed first that all these factors are constant with the exception of the speed at which the piston 2 is driven, a modification of this speed has a self-regulating effect because, when the speed of the stream that flows through chamber 7 increases, the drag of the ball in said stream increases at a rate higher than the rate of increase of the speed of the stream. Consequently, for high flow rates of the stream, the lag of the ball with respect to the stream is lower than what it is at lower flow rates. In other words, the difference between the upward speed of the ball and the speed of the stream decreases at a higher rate than the speed itself. Consequently, there is already obtained a reduction of the amount of fuel that is injected when the speed at which piston 2 is driven and consequently the speed of the engine increase.

This first effect is further reinforced by a second effect which is produced from the time the speed at which the pump is driven exceeds a given value. This second effect, which will be called "liquid abutment effect" may be explained as follows:

The speed at which ball 8 travels downwardly in chamber 7 is independent of the speed at which piston 2 is driven and depends exclusively upon the return force acting on the ball and upon the friction existing between the ball and the liquid present in chamber 7. When the speed of piston 2 exceeds a given value, the time T taken by the ball to move from the position in which it is applied against seat 13 to the position in which it is applied against seat 10 becomes longer than the time elapsing between the arrival of piston 2 to its upper dead center position and the beginning of the next upward stroke of said piston. For speeds higher than this value, ball 8, moving down in chamber 7, never reaches its lower seat 10 but is struck by a new upward stream of fluid before it has reached said seat. The amplitude of the movement of the ball in chamber 7 is shortened by a

length which is the greater as the speed at which piston 2 is driven is higher. This results in a further reduction of the time taken by ball 8 to stop injection, during the upward stroke of piston 2, due to the closing of orifice 11. The combination of these two effects achieves a very efficient self-regulating action of ball 8.

In order further to improve the self-regulating effect, it is of interest to accelerate the movement of the ball as, in the course of its upward movement, it is nearing abutment 12. This result may be obtained by giving chamber 7 a shape which is not cylindrical but slightly conical so that the small base of the cone is located on the side of abutment 12, as shown by Fig. 5.

The force which urges the ball downwardly may be other than the weight of said ball. Thus, I may use a spring or a magnet or a combination of these elements. For instance, in the embodiment illustrated by Fig. 2, the return force is the sum of the weight of the ball and of the force of a spring 21 which has one of its ends applied against the end 22 of chamber 7a and its other end applied against a sleeve 23 which bears, through projection 24, against ball 8. This ball is therefore pushed by spring 21 toward seat 10. Sleeve 23 is slidably guided on a tube 12a the lower end of which is provided with the outlet orifice 11a of chamber 7a and constitutes the abutment surface 13a forming a seat for ball 8 when said ball is in its upper position. On the inside of tube 12a extends the conduit 14a which connects the inside of cylinder 1 with the delivery conduit 5.

The operation of the device illustrated by Fig. 2 is quite analogous to that already described with reference to Fig. 1.

When it is desired to vary the self-regulating effect, it is possible to act upon at least one of the factors which determine either the amplitude of the displacement of ball 8 or the speed of this ball. In order to vary the amplitude of the displacement of the ball, I may modify the distance between seat 10 or 10a and seat 13 or 13a. Thus, in the constructions of Figs. 1 and 2, abutment 12 or 12a may be displaced axially due to the fact that it is carried by a screw-threaded portion 25 or 25a of abutment 12 or 12a, screwed in a screw-threaded portion 26 or 26a of the pump body.

In order to vary the speed of ball 8, I may vary the strength of spring 21 (Fig. 2) if the return force is supplied by such a spring. However, in order to act upon the speed of the ball during its upward displacement, it seems more advantageous (see Fig. 3) to provide a by-pass conduit 27, parallel to chamber 7b and extending across the ends thereof, the cross-section of said by-pass conduit 27 being adjustable, for instance by means of a screw 28. The greater the cross-section of the by-pass conduit at the point corresponding to the throttling member 28 the longer the time taken by the ball to move upwardly from its seat 10b to its upper seat 13b. In order further to increase the adjustment range, I may dispose, in channel 9b which extends from the inside of cylinder 1 to the inlet of chamber 7b, a throttled portion 29 which may either have a fixed cross-section or be adjustable. If it is adjustable, it is advantageous to link together the means for adjusting the throttling means provided in by-pass 27 and the throttling means at 29.

In the pump such as illustrated by Fig. 3, the auxiliary chamber which receives the excess of fuel after ball 8 has been applied against surface 13b so as to close orifice 11b and to stop injection is controlled by abutment 12b itself. In this embodiment of my invention, said abutment is in the form of a piston slidable inside a cylinder 30 and pushed back by a spring 20b, preferably adjustable, against a shoulder 31 provided at the lower end of cylinder 30. Consequently, as soon as ball 8 closes port 11b, abutment 12b slides upwardly in its cylinder 30, thus affording a supplementary volume for the excess of fuel. At the same time, the movement of abutment 12b cuts off the communication between conduit 14b, extending through abut-

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ment 12b, and delivery conduit 5. Preferably, piston 12b, which forms the abutment, and its cylinder 30 are given a diameter greater than that of chamber 7b, so that said abutment, as soon as it is moved away from shoulder 31, offers a larger area to the action of the liquid pressure, thus reducing the final pressure, not only on abutment 12b acting as a piston, but also on ball 8 which is applied against seat 13b.

It should further be noted that surface 13b is preferably given the shape of a frustum of a cone tangent to a spherical surface having exactly the same radius as ball 8.

Of course, instead of using only the weight of ball 8 to act thereon in the downward direction, I may also add to this force that of a spring by providing in abutment 12b an annular housing 32 sufficiently deep to be able to contain the whole of spring 33 when ball 8 is applied against orifice 11b (Fig. 4).

In the embodiment illustrated by Figs. 1, 2 and 3, the excess of fuel delivered by the piston 2 of the pump is absorbed by an auxiliary chamber controlled by a spring mounted piston, as soon as ball 8 is applied against abutment 12, thus causing injection to be stopped.

In the pump shown by Fig. 5, this auxiliary chamber is replaced by a discharge conduit 34 which is placed in communication with cylinder 1 by the opening of a valve 35 applied against its seat by a spring 36, preferably adjustable. The strength of this spring 36 is such that valve 35 does not open as long as injection is taking place, whatever be the pressure of the fuel during injection. On the contrary, valve 35 opens when ball 8c closes orifice 11c.

According to another feature of my invention, I make use of this valve 35 to control a communication 37 between delivery conduit 5 and a discharge conduit such as 34, or a discharge tank. The opening of conduit 37 causes injection to be stopped very sharply.

In the pump illustrated by Fig. 5, the maximum amplitude of displacement of regulating ball 8c is adjustable by varying the position of rest of this ball which, in this construction, is determined by an abutment 38 of adjustable position on which ball 8c is resting.

Abutment 12c is preferably made of special steel in order to avoid deformation thereof by the ball. It may be advantageous to magnetize said abutment 12c in the north-south direction indicated by letters N—S in Fig. 5 so as thus to increase the time for which the ball remains in the vicinity of the abutment, which facilitates the obtaining of a limit of speed by the production of a liquid abutment. Of course, this magnetization must not be such that it would prevent the ball from moving down toward its position of rest during the downward stroke of the piston 2 of the pump. Otherwise, the operation of the device shown by Fig. 5 results from the preceding description.

In the embodiments illustrated by Figs. 6, 7 and 8, the movable regulating member, which preferably has the shape of a ball, serves to meter the amount of fuel arriving into a space from which the fuel is subsequently delivered toward the injector or injectors. By thus making use of the regulating ball only for the metering before injection proper takes place, I avoid the high pressures under which said ball is applied against abutment 12 in the constructions illustrated by Figs. 1, 2, 3 and 5, when the upward movement of the ball is stopped and when it closes the outlet orifice of the chamber in which it moves.

In the pump illustrated by Fig. 6, the above mentioned space is constituted by the upper chamber 39a of a cylinder 39 in which an auxiliary piston 40 is reciprocable, the lower chamber 39b communicating, through conduits 41 and 42, with the main piston 1 of the pump.

Said upper chamber 39a is in communication with delivery conduit 5 provided with its check-valve 6. Furthermore, a discharge conduit 43 opens from cylinder

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39. As soon as this conduit 43 is cleared by the lower face of auxiliary piston 40, injection stops.

According to my invention, chamber 39b is connected with chamber 39a by means of a conduit 44 in which is inserted a chamber 7d in which the regulating ball 8d is movable. In its position of rest, ball 8d bears upon a seat 10d, whereas in its upper position, the ball is applied against the abutment seat 13d which surrounds the orifice 11d through which the portion 44a of conduit 44 opens into chamber 7d. In the portion of conduit 44 which connects chamber 39b with the inlet of chamber 7d, there is further interposed a check-valve 45 which opens only in the direction from chamber 39b toward chamber 7d. The spring of this check-valve is given a strength such that check-valve 45 is applied upon its seat with a pressure higher than one atmosphere but lower than the pressure with which auxiliary piston 40 is applied, by a spring 46, against a shoulder 47 which determines the lowermost position of said piston 40.

The return force which urges ball 8d toward its seat 10d may be constituted merely by the weight of said ball or it may be supplied through other means including for instance a spring, a magnet, etc.

The operation of the device shown by Fig. 6 is as follows.

As soon as the piston 2 of the pump, at the beginning of its upward stroke, has closed the port 3 of feed conduit 4, it first delivers fuel present in cylinder 1 through conduits 42, 41, past check-valve 45, through conduit 44 and chamber 7d, into chamber 39a, piston 40 remaining applied by spring 46 against shoulder 47. The stream of fuel which thus flows through chamber 7d drives the regulating ball 8d along with it until said ball is applied against abutment 13d and closes orifice 11d. Then the fuel which piston 2 keeps delivering lifts piston 40 which, in turn, drives the fuel previously transferred into chamber 39a, past check-valve 45, into delivery conduit 5 and toward the injector or injectors.

The amount of fuel which, during the first part of the upward stroke of piston 2, has been transferred into chamber 39a, is metered by the action of the regulating ball 8d as a function of the speed at which piston 2 is driven. For reasons which have been explained above, with reference to the operation of the pump of Fig. 1, ball 8d moves upwardly in chamber 7d with a speed which increases at a higher rate than the speed of pump piston 2. On the other hand, for values of the speed of the pump piston higher than a given value, there is formed in chamber 7d a liquid abutment which shortens the downward stroke of ball 8 the more as the speed of pump piston 2 increases. It should be noted here that, in the course of every downward stroke of piston 2, piston 40 is applied against shoulder 47 and the liquid abutment, which produces the self-regulating effect, is formed only under ball 8d and not under piston 40.

Obviously the amount of fuel arriving in chamber 39a is the smaller as ball 8d closes orifice 11d more quickly. The excess of fuel that is further delivered by the pump is absorbed by chamber 39b when piston 40, due to the closing of orifice 11d, moves upwardly to produce injection of the amount of fuel that has been fed into chamber 39a.

The amount thus absorbed by chamber 39b is returned, during the downward stroke of piston 40 and piston 2, into cylinder 1 through conduits 41 and 42. The downwardly moving piston 40 cannot deliver fuel from chamber 39b into chamber 39a in view of the fact that check-valve 45 is applied upon its seat with a pressure higher than one atmosphere and that the pressure produced by spring 46 is lower than the pressure for opening check-valve 45.

The total volume of fuel delivered during every upward stroke of piston 2 may be twice the maximum

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amount to be injected because piston 2, due to its movement, must, for these maximum amounts, be capable of first charging chamber 39a with the maximum amount to be injected and of subsequently pushing piston 40 by a corresponding amount.

The downward movement of ball 8d in chamber 7d is independent of the speed of piston 2. This downward speed is the speed of a body falling freely through a liquid. On the other hand, due to the provision of check-valve 45, chamber 7d is constantly filled with liquid. The sensitivity of regulation is therefore independent of the speed of the engine.

In the case of the device illustrated by Fig. 6, and in all the devices according to my invention, it is advantageous to give chamber 7d a slightly conical shape corresponding to a reduction of its cross-section at the top end thereof, which considerably improves the self-regulating properties of the device.

Up to now I have not yet described, with reference to Fig. 6, means for adjusting the self-regulating effect, such an adjustment making it possible considerably to enlarge the range of loads of the engine for which the self-regulating effect is brought into action. In the device of Fig. 6, these adjustment means include, as in the device shown by Fig. 3, a by-pass conduit 48 and control means for adjustably throttling the flow through the conduit portion 44b which leads toward the inlet of chamber 7d and through by-pass conduit 48, such means being even capable of closing, either said conduit portion 44b or said by-pass conduit 48.

These adjustment means are constituted for instance by a needle valve 49 movable axially by means of a screw 50 operable, either manually (through handle 51) or means of a pedal, or under the action of a governor. This needle valve includes a conical point 49₁ the position of which determines the throttling action exerted in conduit portion 44b and a groove 49₂ which cooperates with conduit 48.

When the cross-section at the place of the throttled portion in conduit 44b is increased and when the cross-section of the throttled portion in conduit 48 is reduced, ball 8d is given a higher speed and the amount of fuel that is fed is reduced. If the variations of cross-section are in the opposed direction, the amount of fuel is increased. When by-pass conduit 48 is wholly closed and conduit portion 44b is wholly opened, the maximum speed of the ball is obtained. This position is that which corresponds to very small loads of the engine controlled by the injection pump. On the contrary, if the conduit portion 44b is closed and by-pass conduit 48 is wholly opened, the ball becomes inoperative. Said ball does not even move away from its seat 10d since both of its faces are subjected to the same pressure and the return means (gravity, spring, etc.) keep it applied against its seat. In this case, I obtain a direct injection of the whole of the volume of fuel delivered by piston 2, this amount corresponding to twice the normal maximum volume. These adjustment conditions are used in particular when the engine is to be started.

According to a particular embodiment of the device shown by Fig. 6, it is also possible to obtain a total stopping of the injection by closing conduits 41 and 42 and by-passing them by means of a conduit 52 in which is mounted a check-valve 53 which opens only in the direction from cylinder 1 toward chamber 39b. If conduits 41 and 42 are closed, auxiliary piston 40 is moved upwardly when piston 2 moves upwardly in its cylinder, and said piston 40 opens discharge conduit 43. In view of the fact that, due to the closing of conduits 41 and 42 and to the provision of check-valve 53 in conduit 52, piston 40 cannot move down and discharges the fuel present in chamber 39b toward cylinder 1, when piston 2 is moving downwardly, said piston 40 remains in the position in which it opens discharge conduit 43, so that the whole of the fuel delivered by piston

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2 passes through this conduit. Advantageously, the means for opening and closing conduits 41 and 42 are combined with the means for controlling the flow through conduit portion 44b and by-pass conduit 48.

Thus I may provide, in needle valve 49, a recess 54 which normally connects conduits 41 and 42 with each other. However, when needle valve 49 is moved beyond the position for which it fully opens conduit portion 44b and closes by-pass conduit 48, conduits 41 and 42 cease to be in communication with each other.

In the pump illustrated by Fig. 7, the fuel is also metered during its transfer to chamber 39a of cylinder 39, after which this amount of fuel is delivered through conduit 5 by auxiliary piston 40. In this case, chamber 7d and conduit 8d are located in the auxiliary piston 40. Furthermore, in this embodiment, the position of rest of regulating ball 8d is determined by an adjustable abutment 55.

The operation of the device of Fig. 7 is quite analogous to that of the device shown by Fig. 6. The main piston pump, after closing port 3, delivers, during its upward stroke, first an amount of fuel into chamber 39a without placing it under pressure. This chamber ceases to receive liquid as soon as ball 8d comes into contact with the abutment surface 13d forming a seat, thus closing orifice 11d. At the same time, the pressure of the liquid delivered by piston 2 rises and this fuel under pressure pushes piston 40 upwardly, so that this piston causes the amount of fuel present into chamber 39a to be delivered past check-valve 6 into delivery conduit 5.

The pump shown by Fig. 8 is a modification of the device shown by Fig. 7. According to this modification, the self-regulating device may be adapted to various loads of the engine with which the pump is cooperating, by means of a by-pass conduit a portion 48a of which is provided in auxiliary piston 40, whereas another portion 48b is provided in the pump body. An adjustment member 56, provided in the pump body and movable by means of a screw 57, adjusts both, and in the opposed manners, the cross-section of throttling provided in the portion 48b of the by-pass conduit and that provided in the conduit portion 44c located in the pump body and extending toward the inlet of chamber 7d. Adjustment by member 56 is such that an increase of the cross-section of the throttled portion in conduit 48b corresponds to a reduction of the cross-section of the throttled portion in conduit 44c and vice versa.

In order to make the portions 44c and 44d of the conduit leading to the inlet of chamber 7d liquid-tight with respect to the by-pass conduit 48a, 48b, I make use of an element 58 in the form of a valve integral with auxiliary piston 40 and cooperating with an element 59 forming a valve seat and which is integral with the pump body. The valve thus constituted is closed when piston 40, under the action of spring 46, is in its lowermost position such as shown by Fig. 8.

Concerning the operation of the adjustment device, it results from the above description, in particular with reference to Fig. 6.

In all the embodiments which have been described, the movable regulating element is in the form of a ball. However this regulating element may have any other suitable shape, for instance that shown by Fig. 9 which shows a chamber 7 in which there is provided a movable member 60 of general cylindrical shape with, at the top and bottom thereof, conical portions 61 and 62 capable of cooperating with seats 63 and 64 provided respectively at the inlet and at the outlet of chamber 7.

In the construction of Fig. 9, cylinder 60 is of an outer diameter equal to the inner diameter of chamber 7, whereby said element 60, during its displacement in chamber 7, is guided by the wall thereof. In order to create intervals between cylinder 60 and the wall of chamber 7, which intervals are necessary in order to permit a difference of speed between the movable regulating mem-

ber and the liquid flowing through chamber 7, I provide longitudinal grooves 65 in the cylindrical surface of member 60.

Of course, the movable element might be given still other suitable shapes.

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. In a system for feeding liquid to a machine, said system including a delivery conduit leading to said machine and a reciprocating pump having a delivery space provided with an outlet orifice for feeding such liquid toward said delivery conduit, a device for regulating the liquid feed from said pump to said machine which comprises in combination means forming an elongated chamber having an inlet end in communication with said pump outlet orifice and an outlet end in communication with said delivery conduit, a movable regulating member in said chamber, said member being constantly urged toward said inlet end of said chamber, said member being of a cross section substantially smaller than that of said chamber, whereby a difference of speed can exist between said liquid flowing through said chamber and said member when driven along by said liquid, an abutment in said chamber to stop the movement of said member when driven along by said liquid after a given displacement of said member, means operative by said member for closing said outlet end of said chamber in response to the stopping of said member by said abutment, and means connected with said pump outlet orifice responsive to the stopping of said member by said abutment for supplying expansion space for the liquid delivered from said outlet orifice during every delivery stroke of said pump after said member has been stopped by said abutment.

2. In a system for feeding liquid to a machine, said system including a delivery conduit leading to said machine and a reciprocating pump having a delivery space provided with an outlet orifice for feeding said liquid toward said delivery conduit, a device for regulating the liquid feed from said pump to said machine which comprises in combination means forming an elongated chamber having an inlet end in communication with said pump outlet orifice and an outlet end in communication with said delivery conduit, a movable regulating member in said chamber, said member being constantly urged toward said inlet end of said chamber, said member being of a cross section substantially smaller than that of said chamber, whereby a difference of speed can exist between said liquid flowing through said chamber and said member when driven along by said liquid, an abutment in said chamber to stop the movement of said member when driven along by said liquid after a given displacement of said member, said member and said abutment constituting a valve and valve seat structure arranged to close said outlet end of said chamber when said member is stopped by said abutment, and means connected with said pump outlet orifice responsive to the stopping of said member by said abutment for supplying expansion space for the liquid delivered from said outlet orifice during every delivery stroke of said pump after said member has been stopped by said abutment.

3. A device according to claim 2 in which said movable member is a ball.

4. A device according to claim 2 in which said last mentioned means comprise a cylindrical housing in communication with said pump outlet orifice and a resiliently yielding piston in said housing adapted to yield in response to the increase of the pressure at said outlet orifice

resulting from the stopping of said member by said abutment.

5. A device according to claim 2 in which said abutment has an at least substantially conical recess adapted to accommodate said member and to form a valve seat for it.

6. A device according to claim 2 in which said inlet end of said chamber forms a valve seat for said member.

7. A device according to claim 2 in which the cross-section of said chamber decreases from the inlet end toward the outlet end thereof.

8. A device according to claim 2 further including means for varying the distance between the inlet end of said chamber and said abutment.

9. A device according to claim 2 including spring means for constantly urging said member toward said inlet end of said chamber.

10. A device according to claim 2 further including a by-pass conduit for the liquid extending across the ends of said chamber and means in said by-pass conduit for throttling the flow of liquid therethrough.

11. A device according to claim 10 further including a throttled passage between the inlet end of said chamber and the corresponding end of said by-pass conduit.

12. A device according to claim 2 in which said abutment is slidable with respect to said chamber, and spring means for preventing said abutment from yielding until said member is applied against said abutment, said sliding abutment being arranged as a slide valve to close communication between said chamber and said delivery conduit when said member is applied against said abutment.

13. A device according to claim 2 in which said abutment is magnetized, to act on said member.

14. In a system for feeding liquid to a machine, said system including a delivery conduit leading to said machine and a reciprocating pump having a delivery space provided with an outlet orifice for feeding said liquid toward said delivery conduit, a device for regulating the liquid feed from said pump to said machine which comprises in combination a cylinder, fixed with respect to the body of said pump, a piston in said cylinder dividing it into two chambers, one of said chambers being in communication with said delivery conduit, conduit means for connecting the other of said chambers with said pump outlet orifice, resilient means between said piston and said cylinder for urging said piston in the direction which corresponds to reducing the volume of said second mentioned chamber, means forming a third chamber, said third chamber being of elongated shape and having an inlet end and an outlet end, conduit means for connecting the outlet end of said third chamber with said first chamber, conduit means for connecting the inlet end of said third chamber with said second chamber, a movable regulating member in said third chamber, said member being constantly urged yieldingly toward said inlet end of said third chamber, said member being of a cross-section substantially smaller than that of said third mentioned chamber, whereby a difference of speed can exist between said liquid flowing through said third chamber and said member when driven along by said liquid, an abutment in said third chamber to stop the movement of said member when driven along by said liquid after a given displacement of said member, said member and said abutment constituting a valve and valve seat structure arranged to close said outlet end of said third chamber when said member is stopped by said abutment.

15. A pump according to claim 14 in which the means forming said third chamber are fixed with respect to said cylinder.

16. A pump according to claim 14 in which said third chamber is provided in said piston.

17. In a system for feeding liquid to a machine, said system including a delivery conduit leading to said machine and a reciprocating pump having a delivery space provided with an outlet orifice for feeding said liquid

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toward said delivery conduit, a device for regulating the liquid feed from said pump to said machine which comprises in combination means forming an elongated chamber having an inlet end in communication with said pump outlet orifice and an outlet end in communication with said delivery conduit, a movable regulating member in said chamber, said member being constantly urged toward said inlet end of said chamber, said member being of a cross section substantially smaller than that of said chamber, whereby a difference of speed can exist between said liquid flowing through said chamber and said member when driven along by said liquid, an abutment in said chamber to stop the movement of said member when driven along by said liquid after a given displacement of said member, means operative by said member for closing said outlet end of said chamber in response to the stopping of said member by said abutment, a check-valve in said delivery conduit arranged to prevent back flow of liquid through said delivery conduit toward said chamber, a discharge conduit, a spring loaded valve between said pump delivery space and said discharge conduit, said last mentioned valve being adapted to connect said space with said discharge conduit in response to the increase of the pressure in said space resulting from the stopping of said member by said abutment, and conduit means be-

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tween the portion of said delivery conduit downstream of said check valve and said discharge conduit, said last mentioned conduit means being arranged to be controlled by said spring loaded valve so as to be opened only when said spring loaded valve is itself opened by said increase of pressure.

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