

Jan. 15, 1952

G. C. DROUOT
FUEL INJECTION PUMP

2,582,535

Filed April 7, 1949

4 Sheets-Sheet 1

Fig. 1.

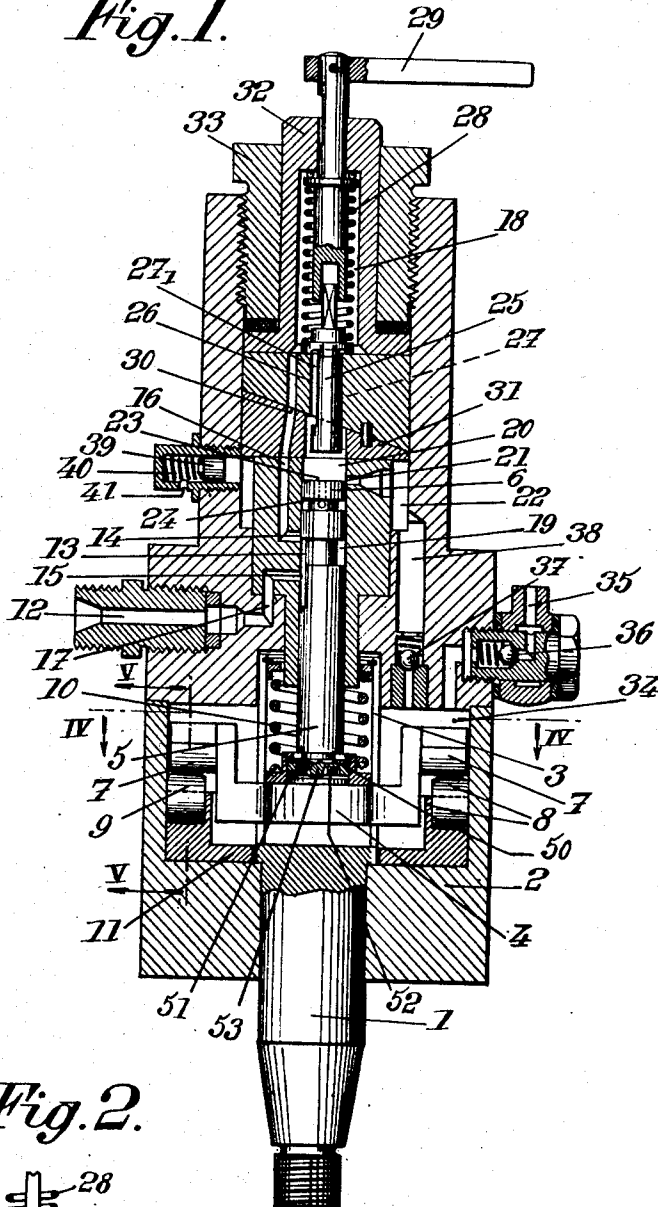
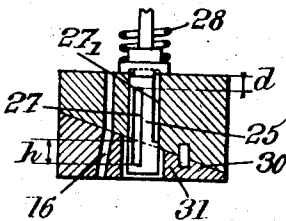


Fig. 2.



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Fig. 3.

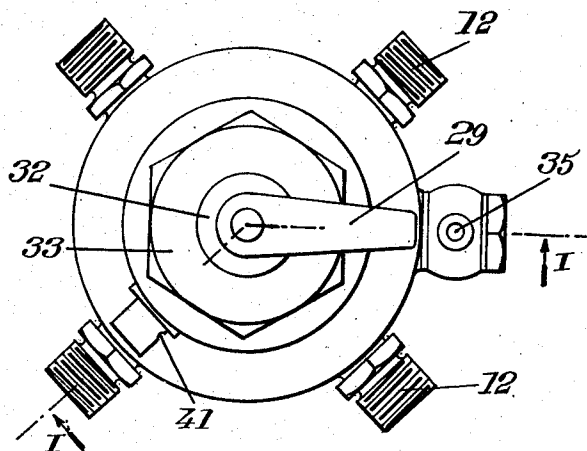


Fig. 4.

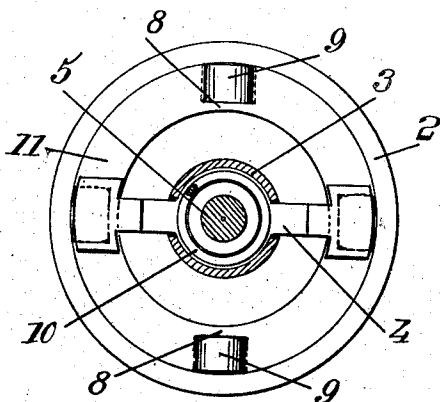


Fig. 5.

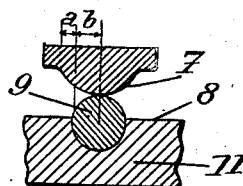


Fig. 7.

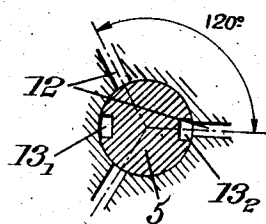
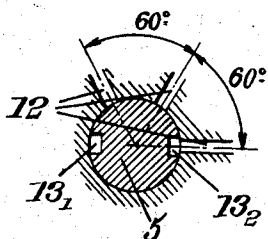


Fig. 6.



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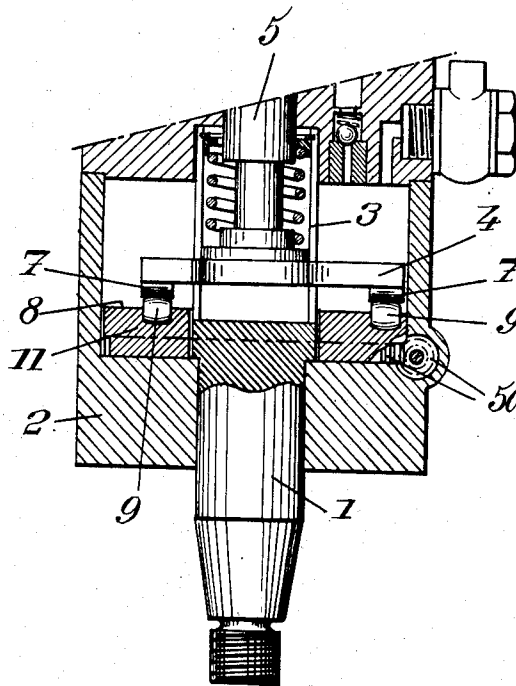
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Fig. 8.



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Fig. 9.

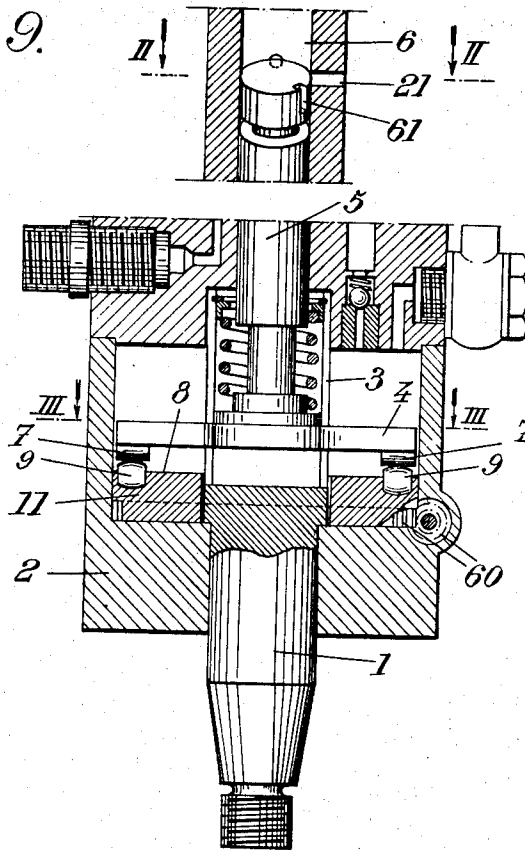
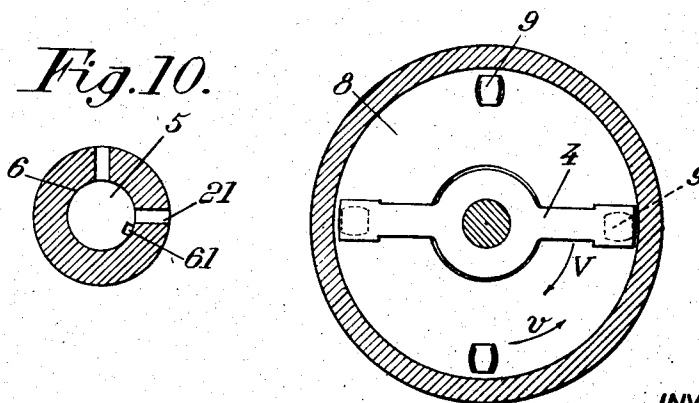


Fig. 11.



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FUEL INJECTION PUMP

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12 Claims. (Cl. 103—2)

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The present invention relates to piston machines, and especially to pumps (as it will be supposed in the following description), and it is more particularly, but not exclusively, concerned with pumps for the injection of fuel into internal combustion engines, in particular multi-cylinder engines.

Its chief object is to provide a pump of this kind which is better adapted to meet the requirements of practice than those used up to the present time, and in particular which is of simpler construction.

According to my invention, in a pump the piston of which is adapted to receive, concurrently with axial translatable displacements, a rotation movement with respect to its cylinder, so as to permit in particular of distributing fuel to a plurality of distinct orifices or conduits, the rotary movement of this piston is imparted thereto from the outside whereas means are provided in the pump, in particular cam means, for obtaining from this rotary movement the above mentioned axial displacements.

Other features of my invention will appear in the course of the following description of some embodiments thereof, given merely by way of example, and in which:

Figs. 1 to 5 show respectively in axial section, in part section analogous to Fig. 1 but showing a regulating member in a position of adjustment different from that of Fig. 1, in top view, and in section on the lines IV—IV and V—V of Fig. 1, a fuel injection pump for a four-cylinder engine made according to my invention;

Figs. 6 and 7 are two diagrammatic sections in planes transverse to the piston axis of such a pump, for distribution to three distinct conduits, and according to two different embodiments;

Fig. 8 is a part axial section of a pump of the same kind made according to another embodiment of my invention;

Figs. 9 to 11 show respectively in diagrammatic and part section, in transverse section on the line X—X of Fig. 9 and in plan view on the line XI—XI of Fig. 1, an injection pump embodying various other features of my invention.

My invention will be described as applied to a pump for delivering liquid into several distinct conduits, in particular for injecting fuel into the respective cylinders of a multi-cylinder internal combustion engine.

First, it should be reminded that the pumps of this kind generally include as many pump bodies (and pistons, valves, cams, push-pieces, etc.) as

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there are cylinders to be supplied. This necessitates a multiplicity of parts which, in addition to the high cost of the whole, are liable to be frequently out of adjustment, due to the lack of total similitude between these various parts. On the other hand, regulation, i. e. measurement of the amounts of fuel injected in accordance with the desired speed and power to be obtained, is generally ensured by a mechanical or pneumatic regulator which acts upon the adjusting means of said pumps; but, due to the multiplicity of these means, the effort that is required is considerable and consequently necessitates big and costly regulators.

It is known that there are also piston pumps in which the piston moves both axially and in rotation, in order to ensure by means of the same piston fuel delivery toward several distinct conduits, but their construction is relatively complicated and requires a lot of room.

According to my invention, the pump includes a piston of this kind, having both an axial and a rotary displacement, cooperating with several delivery conduits, this piston receiving its rotary movement from a driving shaft whereas means are provided, in the pump, for obtaining the desired reciprocating movement of the piston for predetermined angular positions of said shaft.

These last mentioned means advantageously include a kind of crossbar provided at its ends with cams adapted to cooperate with abutment elements, such as rollers, carried by a fixed plate or disc, which may be adjustable.

For instance, my pump includes a shaft 1 running in at least one suitable bearing of the pump frame 2 and which drives, through a fork 3, a crossbar 4 capable itself of driving the rod 5 of the piston 6 of said pump. This crossbar is provided at its ends with cams of suitable profile 7 cooperating with a cam track or race 8 on which are provided parts 9 capable of producing the axial translatable movement, the whole being subjected to the action of return spring 10. These last mentioned parts 9 are advantageously constituted by balls or rollers mounted in suitable housings of plate 11 which carries said cam track.

It will be understood that, according to the number and position of the abutment means 9, it is possible to adjust in a suitable manner the number and angular position of the piston strokes for every revolution of the shaft, in accordance with the number of cylinders to be fed.

Preferably, I provide, between crossbar 4 and the rod 5 of the piston to be driven, a connec-

tion which gives the crossbar (which, besides, is guided by fork 3) some relative freedom, this connection being constituted by any joint of a known type and including for instance a disc 50 carried by rod 5 and provided on its periphery with teeth 51 adapted to engage in the notches of a disc 52 carried by crossbar 4, which a centering at 53, the whole being held in contact by spring 10. In this way, I ensure a perfect contact between the two cams 7 and their rollers.

As for the means for ensuring distribution of the liquid or fuel toward the outgoing conduits such as 12, they may be of the most different kinds, one of the embodiments that may be adopted consisting, as shown, in causing a lateral passage 13 formed in the piston to cooperate with two ports such as 14, 15 leading to conduits 16, 17 intended to connect each conduit 12 with the delivery chamber 18 of the pump body. There may be provided a single conduit 16, and also a single port 14, which cooperates also with a circular groove 19 of the piston.

In the case shown by Figs. 1 to 5, where the pump is intended to supply two or four outgoing conduits 12, the roller carrying disc 11 carries two pairs of rollers diametrically opposed, the piston being supposed to be provided with only one lateral passage 13 and rotating at the rate of one revolution per cycle of the engine. In the case of six outgoing conduits, in particular for a six cylinder engine, six rollers would be provided at 60° from one another.

If it were desired to supply an engine having an odd number of cylinders (1, 3, 5, etc.), I would for instance provide the piston, supposed to rotate at one half of the engine speed, two distributing passages such as 13₁ and 13₂ (Figs. 6 and 7), and provide a number of rollers 9 equal to 2, 6 or 10, disposed by pairs diametrically opposed at 120°, 80° or 36°, the outlets toward the different cylinders being:

Either distributed over one half of a circumference, the same passage 13₁ or 13₂ coming successively opposite the orifices of conduits 12 or 17 during one engine cycle (Fig. 6),

Or uniformly distributed around the whole periphery of the pump body, the diametrically opposed passages 13₁, 13₂ passing alternately before the outflow orifices (Fig. 7).

For an engine having two cylinders at 90°, ring 11 will be provided with two pairs of rollers at 45° from each other, the pump running at one half of the engine speed and the piston being provided with two passages 13₁, 13₂.

It should therefore be noted that, whatever be the number and arrangement of the engine cylinders, it will always be possible to ensure a correct distribution thereof.

I have illustrated, in particular, on Figs. 8 to 11, other arrangements which may be used in some cases, in particular for ensuring correct timing of the various injections with respect to the engine cycle.

It has been seen above that, due to the symmetry of the two cams carried by the crossbar and to the corresponding symmetry of the rollers, every upward movement of the pump piston is necessarily repeated after the piston or the crossbar has rotated through 180°. This will generally make it necessary to have the pump running at a speed different from that of the engine.

In order to remedy this drawback, according to the embodiment of Fig. 8, the rollers, that is to say in the present case, those of each pair, are disposed in a non-symmetrical manner with

respect to the piston axis, so that the cross bar is caused to contact them only once per revolution.

It will be seen on Fig. 8 that the two cams 7 of the crossbar, which are themselves disposed in dissymmetrical fashion with respect to the piston axis, are acted upon by the rollers only once per cycle, that is to say once per revolution of 360°. This is due to the fact that, after a rotation of 180°, cams 7 no longer meet with rollers but remain in contact with track 8, due to the above mentioned dissymmetry.

Such an arrangement is particularly advantageous, not only because it permits of adopting for the speed of the pump the same value as for the engine, but also because it permits of adapting the pump to all kinds of engines whatever be the number of cylinders, since it is possible to dispose the different pairs of rollers 9 along diameters disposed at the desired angles.

According to the arrangement of Figs. 9 to 11, I can maintain the symmetry of the cams and rollers (although this is not necessary), owing to the fact that means are provided for enabling the piston, for some of its upward movements, not to deliver fuel.

I may proceed, for this purpose, in different ways, and in particular provide the piston with suitable channels, as it will be hereinafter explained.

For instance (Figs. 9 to 11), considering the distributing head 6 of piston 5, which is intended to cooperate with one or several intake orifices 21, this head may be provided with at least one lateral channel 61 arranged in such manner that it can come opposite said orifices during the corresponding upward movement.

Supposing for instance that it is desired to inject fuel into a two cylinder engine requiring injections at 90° intervals, the pump such as described with reference to Fig. 1 with two pairs of opposed rollers 9 at 90° will make it possible to solve the problem, provided that the head of piston 6 includes a lateral channel 61 adapted to cooperate with two intake orifices at 90° to each other.

In this way, two of the upward strokes of the piston, corresponding to the passage of channel 61 opposite orifice 21, will be inoperative, whereas the two other strokes, occurring at 90° to each other, will permit of ensuring correct injection.

The same method might be used for injecting fuel into engines having one cylinder, or two cylinders at 90°, or three cylinders at 60° or 120°, or five cylinders, etc.

However, it may be advantageous to make use, in particular when the number of cylinders is still higher, of another feature of the invention, according to which the roller carrier 11 is driven with a continuous movement of rotation in a suitable direction and also at a suitable speed.

In particular, crossbar 4 might be driven in one direction at a speed V and roller carrier 8 in the opposed direction, with a different speed v (Fig. 9). All means may be used for this purpose, such as screw gears 60 or the like.

Besides, it should be well understood that the possibility of moving roller carrier 11 might be provided for other purposes, in particular for adjusting the lead to injection. In this case, the roller carrier will not be driven in a continuous manner, but will be merely adjustable in position.

As a matter of fact, as well known, it is often useful, for the good operation of engines at dif-

ferent speeds, to be able to vary the beginning of injection with respect to the engine cycle.

As a rule, this result is obtained by a controlled or automatic modification between the pump drive and its cam shaft operation, in the case of pumps of current types.

In a pump such as above referred to, the same result is obtained, in a more simple manner, by shifting roller carrier 11 in the suitable direction; in this way, cams 7 will act upon rollers 9 with the same phase difference and the beginning of the injection will thus be changed with respect to the engine cycle.

Concerning now the supply of liquid or fuel to the compression chamber 20 of piston 6, it may be ensured in any suitable manner, preferably so that said piston, according to the commonly used arrangement, controls itself the inflow and discharge of the fuel, in cooperation with at least one orifice 21 in communication with a feed chamber 22. Besides, it should be noted that the surfaces of the piston acting as valve elements, such as shown at 23, 24, on Fig. 1, and which are supposed to be plane and at right angles to the piston might be oblique and carried by a head 6 rotatable with respect to the rod 5 of the piston, so as to be adjustable in angular position for varying the feed rate and/or the lead or end of injection. This adjustment might be controlled through all means of the known type adapted to modify the relative angular positions of two rotating parts.

Preferably, according to an advantageous arrangement, cams 7, the profile of which can be given any suitable shape (possibly adjustable), will be adapted to ensure, during the first portion of the piston stroke (which corresponds to closing of orifices such as 21 and to the building up of pressure) an accelerated movement, while on the contrary the movement will be given a more moderate speed during the subsequent stroke portion corresponding to normal injection. As a matter of fact, during the first stroke portion and since the fuel is not yet under pressure, the energy required from the cam is used only for providing acceleration of the masses in movement. Furthermore, when there is made use of a regulating device including a movable valve member as will be hereinafter described, this acceleration is, at it will be seen, advantageous for increasing the rate of injection at low speeds corresponding to the starting of the engine.

The obtainment of suitable profiles for these conditions of operation is particularly easy in the case of cams moving with a translatory motion by cooperation with abutments or rollers 9, as it is the case. On Fig. 5, I have differentiated the zones *a* and *b* along which this profile produces, respectively, a quick upward movement and then a slower upward movement of piston 5, 6.

According to another feature of my invention, the pump is provided with a single regulating device constituted in the form of a valve member interposed between compression chamber 20 and delivery chamber 18. This valve member 25, movable in a bore 26 interposed between said chambers, is in particular provided over a portion of its length with at least one lateral channel 27 adapted to permit the flow of fuel therethrough for some of the relative positions of member 25 along the axis of bore 26, which positions are determined by the hydrodynamic pressures or by the effects of inertia, to ensure the

desired regulating action as stated in said patents.

In particular, this regulating device may be arranged in such manner as to be adjustable at will, according to arrangements set forth in a copending application, an embodiment of which is illustrated by Figs. 1 and 2.

This adjustment is made possible by the fact that I provide for the possibility of varying at least one of the active heights such as *h* and *d* which represent, in the position of rest of the valve member subjected to the action of its spring 28, respectively the free height of channel 27 extending in chamber 20 and the distance between the upper edge of said channel and the seat of the valve member.

In the embodiment that is shown, where two channels 27 and 27₁ are provided, height *h* is made variable at will by making valve member 25 rotatable about its axis, through a control member 29, and by causing the lower end of channels 27, 27₁ to cooperate with an oblique edge 30 which constitutes the outlet of bore 26 into the compression chamber.

This oblique edge 30 is for instance carried by an intermediate piece 31 held on the pump body through any suitable means, for instance by means of a cap kept in position by a nut 33.

The device works in the following manner. In the relative position illustrated by Fig. 1, which corresponds to the starting of the engine, with the feed of a supplement of fuel, channel 27₁ is cleared at its lower end by oblique edge 30, whereas, on the contrary, channel 27 cannot open simultaneously into chambers 20 and 18 (*h* being then smaller than *d*). If the pump and the engine run very slowly, the whole of the fuel fed by piston 6 is caused to flow through channel 27₁, valve 25 being slightly lifted above its seat. The height over which channel 27₁ opens into compression chamber 20 is calculated in such manner that the speed of the engine is limited to a value lower than the possible utilization speed, for the flow of fuel is stopped as soon as said speed tends to be exceeded since the valve member is then driven into its bore and the flow of fuel is accordingly reduced to zero by the fact that liquid is subsequently sucked back, during the return stroke of the valve member, from delivery chamber 18.

When the engine has started running, control member 29 is rotated, to bring the regulating valve member 25 into a position such as that shown by Fig. 2, where the super-feeding channel 27₁ no longer comes to open into chamber 20 and can no longer serve to the flow of fuel. On the contrary, channel 27, intended for normal operation of the engine, is then sufficiently cleared to permit the flow of fuel therethrough, but the output that is then obtained is always reduced by the amount of sucked back liquid which corresponds to distance *d*, which shows that this distance *d* corresponds to a supplementary feed for starting.

When the control member is more or less rotated, the useful height (*h-d*) of channel 27 can be varied, and also, consequently, the limit speed for which the valve member, in the position of Fig. 2, is caused to move into its bore and thus to stop the flow of fuel through said channel, and therefore to limit the speed.

The choice, for cams such as 7, of a profile of the kind of that above specified, i. e. permitting an acceleration at the beginning of the stroke of piston 5, 6, is particularly advantageous for the

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operation of the regulating device above described.

As a matter of fact, the beginning of the stroke corresponds, during the starting period, to the injection of the supplement of fuel feed through channel 27; the rate of which injection it is of interest to accelerate, in view of the fact that the engine is then running at low speed. On the other hand, during normal operation, this stroke takes place without a delivery pressure of any appreciable value, because it corresponds to the inward movement of valve member 25 which compensates for the volume of re-sucked liquid corresponding to d , so that acceleration has no drawback, despite the higher speed of the engine. Normal injection takes place only after the valve member has been moved in a distance equal to d and the portion a of the cam profile has already been left behind, so that piston 1 is urged to move at a more moderate speed.

According to another feature of my invention, in order to ensure a correct filling of pump body 20 in the lower position of piston 5, through orifice or orifices 21, a suitable pressure is provided in feed chamber 22, this pressure being advantageously obtained by means of piston 5 itself, which acts as a feed pump for a suitable chamber or casing.

Fig. 1 shows a preferred embodiment of the above mentioned feature, according to which the lower portion of the pump body, which contains the piston driving means, is made in the form of a fluidtight chamber 34 communicating on the one hand with the fuel intake 5 through an inlet check valve and on the other hand with chamber 22 through a delivery check-valve 37 and a conduit 38.

The reciprocating movement of piston 5 produces, in chamber 34, a pump-like action, which can thus feed annular chamber 22 with fuel at the desired pressure. However, as the periods of delivery of this pump are not exactly in phase with the periods of filling of the upper pump body, it is advisable to fit chamber 22 with a small elastic accumulator, constituted for instance by a piston 39 subjected to the action of a spring 40, this piston being adapted to open a by-pass 41 in its rear position, in case of excess of fuel feed.

Of course, the valves, the accumulator and the by-pass may be combined together, and include diaphragms of other members capable of ensuring a correct and regular working.

Such a pump has many advantages, in particular:

A greatly reduced number of parts, in particular in the case of an injection pump for a multi-cylinder engine,

Greatly reduced overall dimensions due to the fact that the feed pump is incorporated in the pump body proper, when this arrangement is used,

And the possibility of easily varying the conditions of operation of the regulating device while ensuring a high reliability of operation of this device.

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 com-

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prehended within the scope of the accompanying claims.

What I claim is:

1. A piston pump which comprises, in combination, a frame, a pump body rigid with said frame, a piston both rotatable and slidable axially in said body, a driving shaft, a crossbar extending on either side of the axis of said piston operatively connected with said piston, joint means for coupling said piston with said crossbar with a limited amount of freedom, at least two cams carried by the respective ends of said crossbar, a fixed race carried by said frame adapted to cooperate with said cam, spring means for urging said cam against said race, and at least two rollers journaled in said race with their respective axes located along different diameters of said race and adapted to cooperate with said cams for causing said piston to move axially against the action of said spring means for at least one predetermined angular position of said piston with respect to said body.

2. A piston pump which comprises, in combination, a frame, a pump body rigid with said frame, a piston both rotatable and slidable axially in said body, a single external means for rotating said piston about its axis with respect to said body, two elements, one coupled in rotation with said piston and the other carried by said frame, one face of one of said elements being at right angles to said piston axis and forming at least one circular race the center of which is on said axis, at least two rollers journaled in said race with their respective axes located along different diameters of said race, said rollers projecting from the surface of said race, and cam means rigid with the other of said elements and located in a single axial plane thereof arranged to cooperate with said race and said rollers for causing said piston to move axially every time said cam means run on said rollers.

3. A piston pump according to claim 2 in which said cam bearing element is coupled in rotation to said piston.

4. A pump according to claim 3 and means for rotating said race about said piston axis with a speed of revolution different from that of said piston.

5. A pump according to claim 2 further including means for preventing operation of said pump for at least one of said axial translatable movements of the piston in every cycle.

6. A pump according to claim 2 in which said pump body is provided with at least one liquid intake orifice, valve means carried by said piston for controlling inflow of liquid from said orifice, said piston being provided with at least one lateral longitudinal passage in the peripheral wall thereof to prevent operation of said pump for at least one of said axial translatable movements of the piston in every cycle.

7. A pump according to claim 2 in which said race is adjustable angularly about the piston axis.

8. A pump according to claim 2 in which the profile of said cams is determined to produce first a quick upward movement of the piston and then a slower movement.

9. A piston pump according to claim 2, and spring means urging said two elements together in an axial direction.

10. A piston pump according to claim 2, means forming a compression chamber in said pump body, said piston being slidable and rotatable in said compression chamber, means forming a de-

livery chamber in line with said compression chambers and connected thereto by a cylindrical bore, a regulating valve member having its stem in said bore provided with at least one longitudinal channel in its periphery, said channel having both of its ends at a distance from the corresponding ends of said valve member, and spring means urging said valve member toward said compression chamber.

11. A pump according to claim 10 further including means for adjusting the operation of said regulating valve member.

12. A piston pump which comprises, in combination, a frame, a pump body rigid with said frame, a piston both rotatable and slidable axially in said body, a single external means for rotating said piston about its axis with respect to said body, two elements, one coupled in rotation with said piston and the other carried by said frame, one face of one of said elements being at right angles to said piston axis and forming at least one circular race the center of which is on said axis, at least two rollers journaled in said race with their respective axes located along different

diameters of said race, and cam means constituted by two cams rigid with the other of said elements and located on either side of said piston axis in the same axial plane arranged to cooperate with said race and said rollers for causing said piston to move axially every time said cam means run on said rollers.

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