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DEVICES FOR VARYING THE BEGINNING OF
DELIVERY IN FUEL INJECTION PUMPS
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Fig. 1.

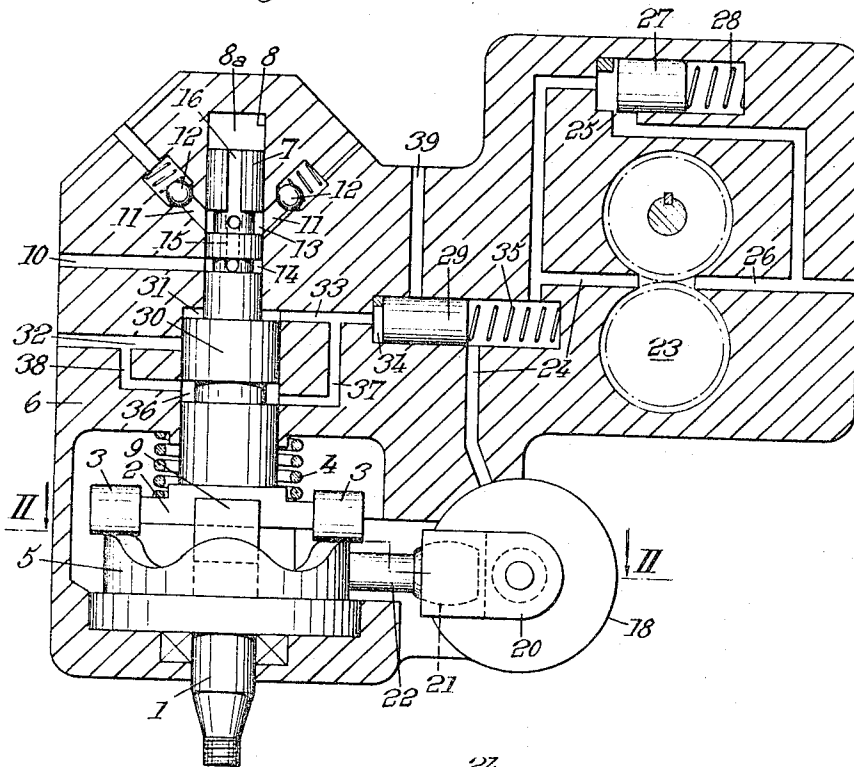
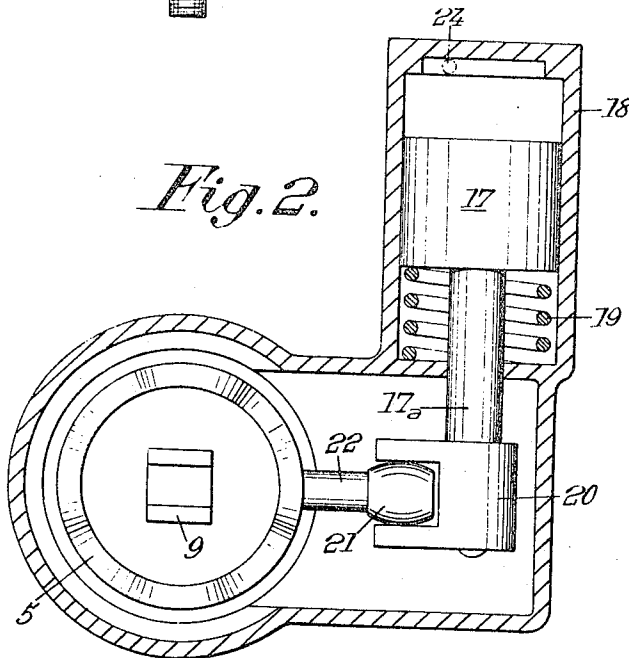


Fig. 2.



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DEVICES FOR VARYING THE BEGINNING OF DELIVERY IN FUEL INJECTION PUMPS

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6 Claims. (Cl. 123—139)

The present invention relates to devices for varying the beginning of delivery in a pump for the injection of fuel (fuel oil, gasoline, kerosene, etc.) into an internal combustion engine whereby the time at which fuel is injected into the cylinder or cylinders of said internal combustion engine is varied.

The invention is more particularly concerned with pumps including a single cylinder cooperating with either a single piston having a reciprocating movement or two pistons having opposed reciprocating movements, said pumps serving to feed fuel successively to the cylinders of a multicylinder internal combustion engine. In this case the distributing means may be constituted either by the pump piston itself which has, in addition to its reciprocating axial movement, a movement of rotation about its axis, or by a distinct rotating element.

It is already known to ensure the reciprocating movement of the piston or pistons of a fuel injection pump by a relative rotation movement between a cam and the piston or pistons of the pump, rollers connected to the piston then having a rolling displacement on the active surface of the cam. Many types of devices for producing this axial reciprocating drive of the piston or pistons exist. For instance there are known pumps in which the cam is in the form of a hollow ring inside of which is located the cylinder, with its piston or pistons. In this case the cam may be fixed and the cylinder is given a movement of rotation or, inversely, the cylinder is fixed and the cam is rotated.

In another type of pump, use is made of a cam driven in rotation and the edge of which cooperates with rollers which are not rotating, or alternately, the cam is fixed and the roller-carrier connected to the piston is given a movement of rotation with respect to this cam.

In all these types of pumps, the beginning of every delivery stroke of the pump is angularly varied (thus producing a variation of the beginning of injection) by an angular displacement of that of the cooperating elements (cam and roller-carrier) which is not driven by the shaft of the pump.

It is also known to obtain this angular displacement by means of a hydraulic jack operated by a liquid the pressure of which varies with the speed of the engine, so that said angular displacement also varies in accordance with said speed.

In this case, care must be taken that the reaction acting upon the piston or pistons during their delivery stroke cannot modify the angular position that has been given, in accordance with the speed, to the angularly movable element in order to adjust the beginning of injection. In other words, it is necessary to lock in the desired position the angularly movable element or the jack which serves to control said position.

The means known up to this time to ensure said locking during the delivery stroke of the piston or pistons either do not ensure a sufficiently accurate position to the angularly movable element or are bulky and occupy a lot of space.

The object of the present invention is to provide simple locking means while ensuring a very accurate positioning of the angularly movable element, such positioning being

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not modified by the reaction acting on the piston during its delivery stroke.

According to the present invention, in order to obtain this result, there is interposed, in the conduit through which a variable pressure liquid is fed to the jack, and preferably close to the place where this conduit opens into the jack, a closing member which is controlled positively in accordance with the reciprocating movements of the piston or pistons of the injection pump, and this in such manner that it closes said conduit during every delivery stroke of said piston or pistons and that it opens this conduit at least during a portion of time elapsing between two consecutive delivery strokes.

According to a preferred embodiment of the present invention, this closing member is a slide valve itself controlled hydraulically by a liquid delivered by the piston of the fuel injection pump or by the piston of an auxiliary pump working in synchronism with said injection pump.

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

FIG. 1 diagrammatically shows, in longitudinal section, a fuel injection pump according to the present invention, and

FIG. 2 is a cross sectional view on the line II—II of FIG. 1.

The pump illustrated by the drawing serves to feed fuel to several delivery conduits leading respectively to several injectors, mounted on the respective cylinders of an internal combustion engine. The shaft 1 of the pump is driven by this engine with a speed proportional to the engine speed. This shaft 1 drives a transverse bar 2 provided, at the respective ends thereof, with rollers 3 applied by a spring 4 against a cam 5 housed in the frame 6 of the pump in such manner that said cam 5 is normally stationary with respect to said frame 6 but can however have angular displacements about the axis of shaft 1 under the action of a device which will be hereinafter described. Cam 5 has four bosses corresponding to four successive fuel injections to be performed during a complete rotation of transverse bar 2 with respect to cam 5. Transverse bar 2 is rigid with the pump piston 7, which cooperates with a cylinder 8 provided in frame 6 and in which said piston is movable. Piston 7 therefore rotates together with transverse bar 2 and has, also together with said transverse bar 2, axial reciprocating movements, under the action of cam 5.

Shaft 1 is coupled with transverse bar 2 through a fork 9 provided at the end of shaft 1, this fork controlling the rotation of bar 2 but permitting axial displacements with respect thereto of bar 2 and piston 7.

A feed conduit 10 on the one hand, and four delivery conduits 11 on the other hand, open into cylinder 8. Delivery conduits 11 are distributed about the axis of cylinder 2 and each of them is provided with a check valve 12. The two annular grooves 13 and 14 are provided in piston 7 and connected together by an axial passage 15 formed inside piston 7. Finally the working chamber 8_a of the pump cylinder 8 is constantly in communication with annular groove 13 through a longitudinal groove 16 provided in the side wall of piston 7. This longitudinal groove 16 places working chamber 8_a, during the successive delivery strokes of piston 7 into communication with the respective delivery conduits 11, whereby piston 7 acts as a distributing valve.

FIG. 1 shows piston 7 at the end of its upward stroke that is to say in its upper dead center position, where it connects working chamber 8_a, through longitudinal groove 16, annular groove 13, passage 15 and annular groove 14, with feed conduit 10. Consequently, the delivery of fuel through one of the conduits 11 ceases when the com-

munication between working chamber 8_a and feed conduit 10 is established. Furthermore, when piston 7 is in its upper dead center position, groove 13 connects together conduits 11 and feed conduit 10, so that the pressures existing in the portions of conduits 11 upstream of check valves 12 are all equal to one another from the beginning of every suction stroke until the beginning of the next delivery stroke.

When piston 7 is in its lower dead center position, groove 13 is located opposite feed conduit 10, so that the working chamber 8_a of the cylinder can be again filled with fuel.

In order to vary the beginning of injection, cam 8 is displaced angularly, and the amplitude of this angular displacement must be a function of the speed (number of revolutions per unit of time) of the engine fed from the injection pump. For this purpose, there is provided a hydraulic jack the piston 17 of which, movable in a cylinder 18, is actuated, against a return force (spring 19), by a liquid the pressure of which varies with the speed of the engine. The amplitude of the displacements of piston 17 in its cylinder 18 therefore depends also upon the speed of the engine. The rod 17_a of piston 17 carries a fork 20 which acts upon the rounded end 21 of an arm 22 rigid with cam 5, whereby the axial movements of piston 17 in its cylinder 18 produce rotations of cam 5 about the axis of shaft 1.

Concerning the means for feeding cylinder 18 with a liquid at a pressure depending upon the speed of the engine, use is made of a pump 23 (a gear pump in the embodiment illustrated) in the delivery conduit 24 of which there is provided a leak passage 25 through which the liquid discharged by pump 23 can escape to return into the feed conduit 26 of gear pump 23. It is known that, with such a system, the pressure of the liquid in delivery conduit 24 is a function of the speed of rotation of pump 23, which speed is itself proportional to the number of revolutions per minute of the engine which drives this pump.

In order to avoid too quick a variation of the pressure in conduit 24, it is advantageous to have leak passage 25 controlled by a slide valve 27 which is placed, on the one hand under the action of the pressure of the liquid delivered by pump 23 (which pressure tends to increase the cross section of the leak passage) and on the other hand under the action of a return spring 28 tending to reduce the cross section of the leak passage.

The chief object of the present invention is to prevent the pressure of the fuel discharged by piston 7 during every delivery stroke thereof from producing, by reaction, transmitted through rollers 3, upon cam 5, a modification of the angular position of cam 5 determined by the jack. For this purpose, valve means are inserted in the conduit 24 which transmits the pressure produced by pump 23 to the cylinder 18 of the jack, said valve means consisting of a sliding member 29 controlled, in accordance with the reciprocating movements of piston 7, in such manner as to close said conduit during the delivery strokes of said piston 7 and to open this conduit at least for a portion of time elapsing between two successive delivery strokes of said piston 7. In the example illustrated by the drawing, control of slide valve 29 takes place through an auxiliary pump, the piston 30 of which moves in synchronism with the piston 7 of the main pump. In the particular embodiment illustrated by FIG. 1, this piston 30 is integral with piston 7 and cooperates with a cylinder 31, also provided in the pump frame 6, coaxial with cylinder 8. Cylinder 31 is of a diameter greater than that of cylinder 8. The working chamber of cylinder 51 and the active surface of piston 30 are of annular shape.

Cylinder 31 is fed with liquid from a feed conduit 32 and liquid is discharged from said cylinder 31 through a conduit 33 interposed between cylinder 31 and a cylinder 34 extending across the delivery conduit 24 of pump

23, preferably close to jack 17-18. Slide valve 29 is slidable in cylinder 34 against the action of a return spring 35.

Furthermore, there is provided in piston 30 an annular groove 36 which, when pistons 7 and 30 are in upper dead center position, connects a conduit 37 communicating with the delivery conduit 33 of auxiliary pump 30-31 with a conduit 38 itself in communication with the feed conduit 32 of said auxiliary pump 30-31.

Finally, cylinder 34, the cross section of which is small as compared with the annular cross section of cylinder 31, is further provided with a discharge conduit 39 which determines the end of the displacement of slide valve 29 toward the right when said slide valve is displaced by the liquid delivered by auxiliary pump 30-31. Of course the position of conduit 39 on cylinder 34 is determined in said manner that when slide valve 29 stops, due to the fact that said conduit 39 is cleared, slide valve 29 is in a position such that it closes conduit 24.

Furthermore, advantageously, the position of feed conduit 32 with respect to cylinder 31 is chosen in such manner that piston 30, at the beginning of its delivery strokes (upward strokes) closes conduit 32 shortly before the time where piston 7, also at the beginning of its delivery stroke, closes feed conduit 10. Consequently the operation of the means for controlling slide valve 29 is as follows:

From the beginning of every upward stroke of pistons 7 and 30 and before fuel is delivered by piston 7 into one of the delivery conduits 11, slide valve 29 is brought from the position shown by FIG. 1, where it clears conduit 24, to the position where it closes said conduit 24. This movement of slide valve 29 is practically instantaneous due to the fact that the active cross section of the working chamber of cylinder 31 is much greater than the cross section of cylinder 34.

The closing of conduit 24 by slide valve 29 has for its effect to entrap the liquid filling the space between the end of the jack cylinder 18 and the jack piston 17 and does not permit piston 17 to move back and cam 5 to be displaced under the effect of the reaction exerted by piston 7-13 upon cam 5 during the delivery stroke of piston 7. The angular position of cam 5 therefore remains unchanged during this delivery stroke. When pistons 7 and 13 reach their upper dead center position, on the one hand the working chamber 8_a of cylinder 8 is discharged as above explained, thus stopping the force which acted upon piston 7 during its delivery stroke, and, on the other hand cylinder 34 is placed in communication, through conduits 37 and 38 and annular groove 36, with feed conduit 32. Piston 29 can therefore return to the position shown by FIG. 1 where it clears conduit 24. If there is a modification of the number of revolutions per minute of the engine, and if, consequently, the pressure in conduit 24 varies, this variation may exert its effect by producing a variation of the angular position of cam 5 during the periods elapsing between the times where pistons 7 and 30 are in their upper dead center positions and the times where, due to the beginning of a new delivery stroke of auxiliary pump 30-31, slide valve 29 is again brought into the position for which it closes conduit 24. Of course, it may happen that a variation of the angular position of cam 5 due to a given variation of the discharge pressure of pump 23 does not take place completely during only one of these periods but takes place gradually during a time corresponding to several consecutive periods.

The locking of jack 17-18, obtained according to the present invention during every delivery stroke of piston 7, has the advantage of keeping cam 5 exactly in the position where it has been brought in accordance with the speed of the engine, and this in a simple manner and without bringing into play voluminous means.

Of course, details of construction may be varied with-

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in the scope of the invention. For instance jack 17-18 is not necessarily tangential with respect to cam 5. This jack may act upon said cam through any intermediate means. Furthermore when it is the cam that is driven in rotation by the shaft of the pump and the axis of the roller-carrier is practically stationary (with the exception of course of the angular movements for varying the relative time of beginning of injection) the hydraulic jack acts of course upon the roller-carrier. Finally the cam and the roller-carrier may be made of a shape different from that above described.

In a general manner, while the above description discloses what is deemed to be a practical and efficient embodiment of the present invention, said invention is not limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the invention as comprehended within the scope of the appended claims.

What I claim is:

1. A fuel injection pump system for feeding fuel to an internal combustion engine, which comprises, in combination,

a main cylinder having an axis of symmetry,
a main piston slidable in said cylinder in the direction of said axis,

a main fuel feed conduit opening into said cylinder,
at least one delivery conduit leading out from said cylinder,

two elements operatively connected with said piston and said cylinder, respectively, adapted to cooperate together for producing reciprocating axial displacements of said piston in said cylinder,

said elements being angularly movable with respect to each other about said axis to adjust the beginning of fuel injection on every piston stroke,

a hydraulic jack, including a jack cylinder and a jack piston movable in said jack cylinder to form therewith a variable volume chamber, for controlling the angular position of said two elements with respect to each other,

means, responsive to a pressure variable in response to variations of the speed of said internal combustion engine, for feeding liquid to said jack cylinder, said liquid feeding means including a pipe opening into said jack cylinder and forming the only communication between said variable volume chamber and the outside,

an auxiliary pump operatively connected with said main piston and said main cylinder for working in synchronism with the relative axial displacements of said main piston and said main cylinder,

means operative by said auxiliary pump for closing said pipe during the delivery strokes of said piston, a discharge conduit,
and means operative by said auxiliary pump for opening said discharge conduit at the end of every delivery stroke of said auxiliary pump.

2. A fuel injection pump system according to claim 1 wherein said main piston is adapted to connect said main cylinder with a discharge space at the same time as said discharge conduit is opened.

3. A fuel injection pump system for feeding fuel to an internal combustion engine which comprises, in combination,

a frame,
a main cylinder rigid with said frame having an axis of symmetry,

a fuel feed conduit opening into said cylinder,
a main piston fitting slidably in said pump cylinder,

a cam symmetrically surrounding said axis adjustable in said frame angularly about said axis,
follower means carried by said piston adapted to cooperate with said cam,

a hydraulic jack operatively connected with said cam

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for controlling the angular position thereof about said axis,

pump means for feeding liquid to said jack at a pressure variable in accordance with the speed of the internal combustion engine,

a pipe extending from said liquid feeding pump means to said jack whereby said last mentioned liquid is fed to said jack,

a slide valve cylinder extending across said pipe,

a slide valve movable in said slide valve cylinder,

an auxiliary pump including a cylinder rigid with said main cylinder, and a piston rigid with said main piston,

and conduit means connecting the delivery of said auxiliary pump with said slide valve cylinder so as to push said slide valve across said pipe and to close it in response to every delivery stroke of said auxiliary pump.

4. A fuel injection pump system for feeding fuel to an internal combustion engine which comprises, in combination,

a frame,

a main cylinder rigid with said frame having an axis of symmetry,

a fuel feed conduit opening into said cylinder,

a main piston fitting slidably in said pump cylinder,

a cam symmetrically surrounding said axis adjustable in said frame angularly about said axis,

rolling means carried by said piston and journaled with respect thereto about an axis perpendicular to said axis of symmetry and fixed with respect to said piston, said rolling means being adapted to cooperate with said cam,

a hydraulic jack operatively connected with said cam for controlling the angular position thereof about said axis,

pump means for feeding liquid to said jack at a pressure variable in accordance with the speed of the internal combustion engine,

a pipe extending from said liquid feeding means to said jack whereby said last mentioned liquid is fed to said jack,

a slide valve cylinder extending across said pipe,

a slide valve movable in said slide valve cylinder,

an auxiliary pump including a cylinder rigid with said main cylinder and a piston rigid with said main piston,

and conduit means connecting the delivery of said auxiliary pump with said slide valve cylinder so as to push said slide valve across said pipe and to close it in response to every delivery stroke of said auxiliary pump.

5. A fuel injection pump system for feeding fuel to an internal combustion engine, which comprises, in combination,

a main cylinder having an axis of symmetry,

a main piston slidable in said cylinder in the direction of said axis,

a main fuel feed conduit opening into said cylinder,

at least one delivery conduit leading out from said cylinder,

two elements operatively connected with said piston and said cylinder, respectively, adapted to cooperate together for producing reciprocating axial displacements of said piston in said cylinder,

said elements being angularly movable with respect to each other about said axis to adjust the beginning of fuel injection on every piston stroke,

a hydraulic jack, including a jack cylinder and a jack piston movable in said jack cylinder to form therewith a variable volume chamber, for controlling the angular position of said two elements with respect to each other,

means, responsive to a pressure variable in response

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to variations of the speed of said internal combustion engine, for feeding liquid to said jack cylinder, said liquid feeding means including a pipe opening into said jack cylinder and forming the only communication between said variable volume chamber and the outside,

5 an auxiliary pump including an auxiliary cylinder and an auxiliary piston adapted to cooperate with said auxiliary cylinder and working in synchronism with the relative axial displacements of said main piston and said main cylinder,

10 means forming a cylindrical housing extending across said pipe,

15 a slide valve movable in said housing in response to the reciprocating relative axial displacements of said main piston and said main cylinder, for closing

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said pipe during the delivery strokes of said main piston, and

a discharge conduit starting from said cylindrical housing and adapted to be opened when said slide valve is moved by said auxiliary pump into the position where it closes said pipe.

6. A fuel injection pump system according to claim 5 wherein the cross section of said cylindrical housing is smaller than the cross section of said auxiliary pump piston.

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