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SELF-REGULATING RECIPROCATING PISTON PUMPS, IN PARTICULAR FOR THE INJECTION OF FUEL INTO INTERNAL COMBUSTION ENGINES

Original Filed May 5, 1959 2 Sheets-Sheet 1

Fig. 1

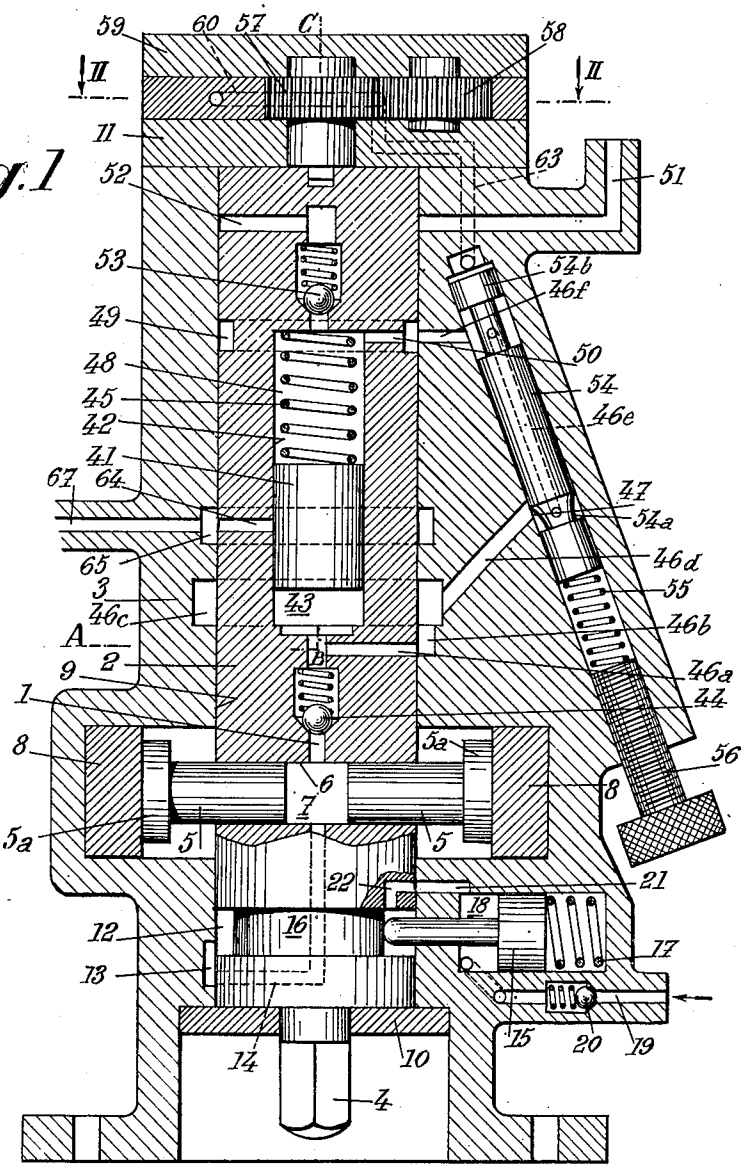

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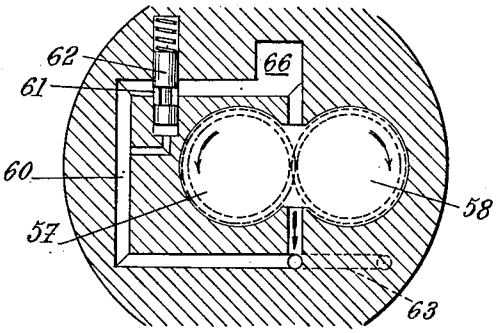
Fig. 2.



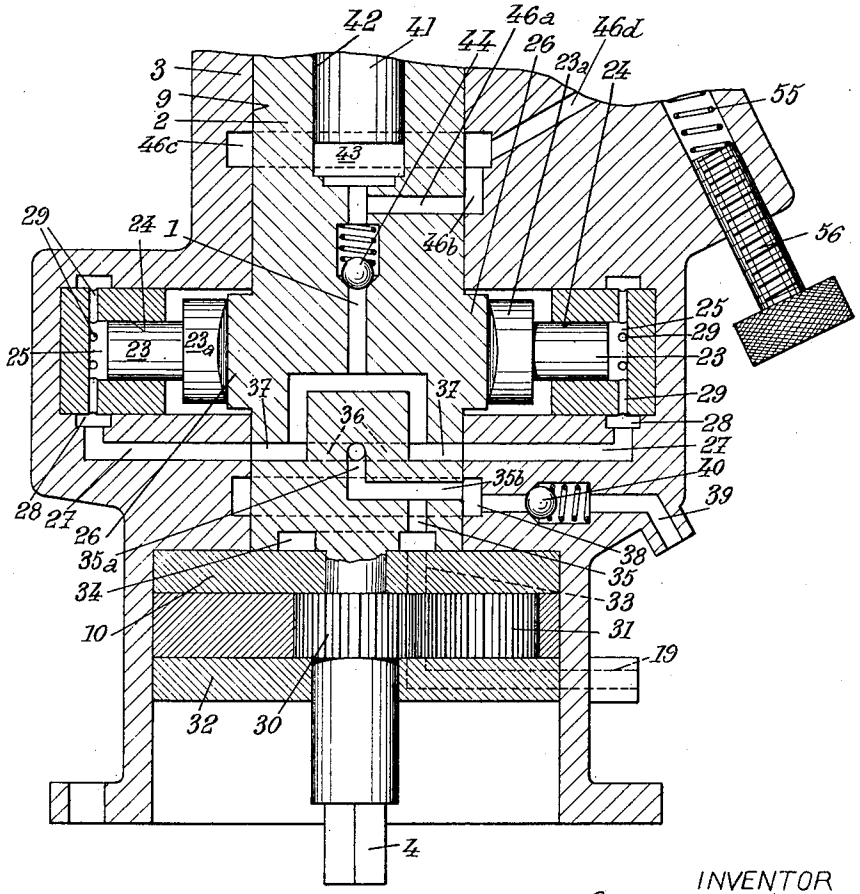


Fig. 3.

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SELF-REGULATING RECIPROCATING PISTON PUMPS, IN PARTICULAR FOR THE INJECTION OF FUEL INTO INTERNAL COMBUSTION ENGINES

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Continuation of application Ser. No. 811,177, May 5, 1959. This application July 11, 1962, Ser. No. 209,132
Claims priority, application France May 19, 1958
11 Claims. (Cl. 103—41)

The present invention relates to reciprocating piston pumps, in particular for the injection of fuel into internal combustion engines.

The pumps with which this invention is concerned are of the type in which liquid is periodically forced through a conduit provided in a distributing member rotating in the pump body (which member will be hereinafter called "shaft"), said conduit having an outlet orifice at the periphery of said shaft, which outlet orifice periodically comes into overlapping relation with at least one distribution channel provided in the pump body. The pistons of these pumps are generally disposed in opposed pairs in suitable radial housings and they are actuated by a cam.

According to a first construction, the housings are formed in the rotating shaft and the cam is carried by the pump body. In another modification, the housings are formed in the pump body and the cam is carried by the rotating shaft.

The object of the present invention is to provide a pump of this kind which is self-regulating, that is to say capable of automatically reducing the effective rate of delivery thereof per cycle as the speed at which the pump is driven increases.

The pump according to my invention comprises a metering piston, called "shuttle piston," housed in the distribution member, where it controls a discharge, or by-pass, orifice the clearing of which by the shuttle piston stops fuel injection, the means for driving the shuttle piston being arranged in such manner that, for driving speeds of the pump above a predetermined value, the shuttle piston clears the discharge, or by-pass, orifice the earlier during the delivery stroke of the pump piston as the driving speed of the pump increases beyond said predetermined value.

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

FIG. 1 shows in diagrammatic axial section a fuel injection pump made according to a first embodiment of the invention, the portion of said pump located on the left and above line ABC being in section by a plane located at 45° to the section plane of the remainder of the figure.

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

FIG. 3 shows a modification of the lower portion of the pump of FIG. 1.

In the pump illustrated by the drawings, fuel is periodically forced through conduit 1 provided in a shaft 2 rotating in pump body 3, said shaft being driven by the engine (for instance at the speed of its cam shaft) to be fed with fuel by the pump, for instance through a portion 4 of square cross section rigid with said shaft 2.

In the construction shown by FIG. 1, pistons 5 are each mounted in a radial cylindrical housing 6 provided in shaft 2 so as to limit a common compression chamber 7. These pistons 5 are actuated by an annular cam 8 carried by the fixed body 3, the outer ends 5*a* of the pistons bearing against said cam 8. Shaft 2 rotates directly, that is to say without any interposition of ball or other bearings on the walls of a cylindrical housing 9 provided in body 3. Shaft 2 is prevented by plates 10 and 11 from

moving axially with respect to fixed body 3. Chamber 7 receives liquid from a feed pump through a circuit including a groove 12 provided at the periphery of shaft 2, a number of longitudinal passages 13 equal to the number of cylinders to be successively fed with fuel and a channel 14 starting from the periphery of shaft 2 and opening into said chamber 7. The feed pump is constituted, in the construction of FIG. 1, by a piston 15 actuated by an eccentric 16 (forming the inner wall of groove 12) toward which it is urged by a spring 17. This piston 15 is slidably mounted in a cylinder 18 in communication with a fuel inlet channel 19 (provided with a check valve 20); this cylinder 18 communicates with groove 12 through a channel 21 provided in body 3 and channels 22 provided in shaft 2 and the number of which is equal to the number of cylinders of the engine. The channels are made to cooperate together in such manner that fuel may be admitted into chamber 7 as soon as the symmetrical projections of cam 8 permit pistons 5 to move away from each other, the centrifugal force under pressure of the fuel fed to said chamber 7 facilitating this movement of pistons 5 from each other.

Instead of eccentric 16, I might use a cam having several sections but this is not necessary due to the fact that piston 15 subjected to the action of spring 17 acts as a pressure accumulator.

In the construction of FIG. 3, pistons 23 are slidable in cylindrical housings 24 fixed with respect to body 3 and in which they limit respective compression chambers 25. Pistons 23 are actuated by a cam 26 carried by shaft 2, the pistons cooperating with this cam through their ends 23*a*.

Every chamber 25 receives fuel from a feed pump through a channel 27 provided in fixed body 3, a groove 28 and a plurality of small channels 29 (giving a large total cross sectional area of flow for small diameters of each of said respective channels 29). The feed pump shown by FIG. 3 is a gear pump; one of the pinions 30 of this pump being fixed on shaft 2 and the other pinion 31 being freely rotatable. The compression chamber of this pump is located between plate 10 and another plate 32. Gear pump 30—31 draws in fuel through inlet channel 19 and delivers it through channel 33, annular groove 34 and channels 35, 35*a*, 36 and 27, to chambers 25, pushing back pistons 23 radially in the centripetal direction against cam 26, which during this portion of its movement permits this centripetal displacement of the pistons. When cam 26 compels pistons 23 to move radially in the centrifugal direction, fuel is delivered from chambers 25 through channels 27 and radial conduits 37 provided in shaft 2, to conduit 1. Channels 37 have been shown in solid lines and channels 36 in dotted lines to show that they are located in different planes, channels 27 and 36 coming into communication with one another just after pistons 23 are at the end of their outer strokes. The number of radial pairs of channels 37 and 36 is equal to the number of cylinders of the engine to be fed with fuel.

Channel 35 also communicates with a channel 35*b* which opens into an annular groove 38 of body 3, this groove 38 being provided with a discharge channel 39 the opening of which is controlled by a loaded valve 40 so as to limit the flow rate and the pressure of the fuel delivered by gear pump 30—31.

Whatever be the particular embodiment that is chosen, a constant amount of fuel is periodically delivered through conduit 1 on every revolution of shaft 2, the cylinders of the pump reciprocating, on every such revolution, a number of times equal to the number of cylinders of the engine.

The pump regulation system essentially includes a metering shuttle piston 41 movable in a cylindrical housing 42 formed in shaft 2, said shuttle piston 41 limiting, on one of its sides, in said housing 42, a chamber 43 of

variable volume. Spring 45 acts upon shuttle piston 41 in such manner as to tend to reduce this volume. Conduit 1, provided with a check-valve 44, opens into said chamber 43.

As shown by FIG. 1, chamber 43 can deliver fuel through a channel 46*a* extending radially in shaft 2, then in body 3 through longitudinal passages 46*b* (the number of which is equal to that of the engine cylinders), an annular groove 46*c*, channels 46*d*, 46*e* and 46*f* (channels 46*b* and 46*f* being provided in body 3 and channels 46*e* in a slide valve 54 which will be hereinafter more fully referred to), a throttled passage 47 being provided between channels 46*d* and 46*e*. Channel 46*f* opens into a chamber 48 (limited in cylindrical housing 42 by shuttle piston 41 on the opposed side thereof from chamber 43) through a groove 49 and a radical channel 50 both provided in shaft 2. From this chamber 48, fuel is delivered by shuttle piston 41 through a channel 52 opening to the periphery of shaft 2 and provided with a check valve 53 into channels 51 leading to the injectors (not shown) of the engine.

Advantageously, as shown by FIG. 1, means are provided for varying the dimension of throttled passage 47 as a function of the speed of the engine.

In the construction that is shown by the drawings, this throttled passage 47 is formed between a groove 54*a* of slide valve 54 in communication with channel 46*e* and the edge of channel 46*b*. Slide valve 54 is urged in the direction which tends to restrict the dimensions of passage 47 by the pressure of a fluid acting upon its end 54*b*. In the opposed direction, slide valve 54 is urged by a spring 55, advantageously adjustable by means of a screw 56. The fluid pressure acting upon slide valve 54 is created by a gear pump one of the pinions 57 of which is driven by shaft 2 and the other pinion 58 of which is freely rotatable. The compression chamber of this pump is located between plate 11 and plate 59. The pump collects fluid from a chamber 66 and feeds it into a channel 60 provided with a throttled passage 61 adjustable by a slide valve 62 subjected to the opposed actions of a spring and of a pressure existing in channel 60 upstream of said throttle passage, this last mentioned pressure being transmitted to the end 54*b* of slide valve 54 through a conduit 63.

In order to limit the upward strokes of shuttle piston 41, a radial discharge conduit 64 opens into cylinder 42 at an intermediate point thereof, this channel 64 communicating with the outside through groove 65 and a conduit 67 provided in body 3.

This pump works as follows:

When fuel is forced through conduit 1, either by pistons 5 (FIG. 1) or by pistons 23 (FIG. 3), the end of channel 46*a* is located opposite a solid portion of the wall 9 of body 3 so that liquid cannot flow through this channel. The liquid that is delivered enters chamber 43 and moves piston 41 upwardly while compressing spring 45. The fuel present in chamber 48 flows past check-valve 53 toward an injector through channels 52 and 51. Then, shuttle piston 41 clears channel 64 and fuel flows out from chamber 43 to the outside through channel 64, groove 65 and channel 67, thus stopping the upward movement of the shuttle piston and fuel injection. When fuel ceases to be delivered through conduit 1, channel 46*a* comes into communication with passage 46*b* and then through circuits 46*d*, 46*e* and 46*f*, groove 49 and channel 50 with chamber 48. Under the action of spring 45, shuttle piston 41 moves in the downward direction and draws out the liquid from chamber 43 into chamber 48, the downward movement of the shuttle piston being braked by throttled passage 47. There comes a time, as the speed of the engine increases, when shuttle piston 41 no longer has time to move down to the end of its downward stroke before the liquid forced through conduit 1 strikes it. The amplitude of the stroke therefore decreases as a function of the speed according to a given law which depends in particular upon the law of variation of throttled passage 47. The amount forced from chamber 43 into chamber 48 therefore decreases and during the next upward stroke of shuttle piston 41, a smaller amount of fuel is delivered from chamber 48 toward the injectors.

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.

This application is a continuation of my prior application Ser. No. 811,177, filed May 5, 1959.

What I claim is:

1. In combination, a fixed body provided with a housing having a cylindrical inner wall, a member having a cylindrical outer wall fitting slidably against said inner wall, means for rotating said member in said housing, a liquid delivery conduit, said member being provided with a cylindrical recess, a shuttle piston fitting slidably in said cylindrical recess, so as to define therewith a variable volume chamber, said shuttle piston being movable longitudinally in said cylindrical recess in one direction in response to rises of the pressure in said chamber, means for urging said shuttle piston in the direction opposed to that above mentioned, the movements of said shuttle piston in the first mentioned direction being called outward strokes thereof and the movements of said shuttle piston in the second mentioned direction being called return strokes thereof, means responsive to longitudinal reciprocating movement of said shuttle piston in said cylindrical recess for forcing into said delivery conduit, on every reciprocation of said shuttle piston, an amount of liquid the smaller as the amplitude of two consecutive strokes is smaller, liquid pumping means for supplying liquid under pressure to said chamber, said pumping means being controlled by the rotation of said member in said body in such manner as to produce pressure rises in said chamber during only first given portions of every rotation of said member in said body, liquid circuit means in communication with said chamber for the inflow of liquid under pressure from said pumping means to said chamber during said first portions of the rotation of said member and for the outflow of liquid under pressure from said chamber during the second portions of the rotation of said member in said body, said second portions extending between said first portions of the rotation of said member, said liquid circuit means including a throttled passage, a first part of said liquid circuit means being formed in said rotating member and opening into the cylindrical outer wall of said member, a second part of said liquid circuit means being formed in said fixed body and opening into the cylindrical inner wall thereof, said respective liquid circuit parts being shaped and located so as to communicate with each other during said second portions of the rotation of said member and to be out of communication with each other during said first portions of the rotation of said member.

2. In combination, a fixed body provided with a housing having a cylindrical inner wall, a member having a cylindrical outer wall fitting against said inner wall, means for rotating said member in said housing, a liquid delivery conduit, said member being provided with a cylindrical recess, a shuttle piston fitting slidably in said cylindrical recess, so as to form therewith a cylindrical chamber, said shuttle piston being movable longitudinally in said cylindrical recess in one direction in response to rises of the pressure in said chamber, resilient means interposed between said member and said shuttle piston for urging said shuttle piston in the opposed direction to that above mentioned, the movements of said shuttle piston in said last mentioned direction being called the re-

turn strokes thereof, means responsive to longitudinal reciprocating movement of said shuttle piston in said cylindrical recess for forcing into said delivery conduit, on every reciprocation of said shuttle piston, an amount of liquid the smaller as the return stroke of said reciprocation is shorter, reciprocating liquid pump means arranged to work in synchronism with the rotation of said member in said fixed body for forcing liquid into said chamber during a given portion of every rotation of said member in said body, means for closing the communication between said pump means and said chamber during the periods for which said pump means are not forcing liquid into said first mentioned chamber, a liquid outflow circuit for the outflow of liquid from said chamber, said liquid outflow circuit including a throttled passage, a first portion of said liquid outflow circuit being formed in said rotating member and opening into the cylindrical wall of said member, a second portion of said liquid outflow circuit being formed in said fixed body and starting from the cylindrical inner wall thereof, said respective outflow circuit portions being shaped and located so as to communicate with each other when said pump means are not forcing liquid into said chamber and to be out of communication with each other when said pump means are forcing liquid into said chamber.

3. In combination, a fixed body provided with a housing having a cylindrical inner wall, a member having a cylindrical outer wall fitting against said inner wall, means for rotating said member in said housing, said member being provided with a cylindrical recess coaxial therewith, a shuttle piston fitting slidably in said cylindrical recess, so as to divide it into a first chamber and a second chamber, located respectively on opposed sides of said shuttle piston, said shuttle piston being movable longitudinally in said cylindrical recess in one direction in response to rises of the pressure in the first chamber, resilient means interposed between said member and said shuttle piston for urging said shuttle piston in the direction opposed to that above mentioned, the movements of said shuttle piston in said opposed direction being called the return strokes thereof, a liquid delivery circuit starting from the second chamber reciprocating liquid pump means arranged to work in synchronism with the rotation of said member in said fixed body for forcing liquid into said first chamber during a portion of every rotation of said member in said body, means for closing the communication between said pump means and said first chamber during the periods for which said pump means are not forcing liquid into said first chamber, and a liquid outflow circuit for the outflow of liquid from said first chamber, said liquid outflow circuit including a throttled passage, a first portion of said liquid outflow circuit being formed in said member and opening into the cylindrical wall of said member, a second portion of said liquid outflow circuit being formed in said fixed body and starting from the cylindrical inner wall thereof, a third portion of said outflow circuit connecting said second portion with said second chamber, said first and second outflow circuit portions being shaped and located so as to communicate with each other when said pump means are not forcing liquid into said chamber and to be out of communication with each other when said pump means are forcing liquid into said chamber.

4. A combination according to claim 2 in which said reciprocating liquid pump means include a cylindrical housing formed in said member at right angles to the axis thereof, a piston fitting slidably in said last mentioned cylindrical housing, and cam means carried by said fixed body for moving said last mentioned piston radially in said last mentioned housing in response to the rotation of said member in said fixed body, said member being provided with a conduit connecting said last mentioned housing with said chamber of said cylindrical recess.

5. A combination according to claim 3 in which said reciprocating liquid pump means include a cylindrical housing formed in said member at right angles to the axis thereof, a piston fitting slidably in said last mentioned cylindrical housing, and cam means carried by said fixed body for moving said last mentioned piston radially in said last mentioned housing in response to the rotation of said member in said fixed body, said member being provided with a conduit connecting said last mentioned housing with said first mentioned chamber of said cylindrical recess.

6. A combination according to claim 2 in which said reciprocating liquid pump means include a cylindrical housing formed in said fixed body at right angles to the axis of rotation of said member, a piston fitting slidably in said last mentioned cylindrical housing and cam means carried by said member for moving said last mentioned piston radially in said last mentioned housing in response to the rotation of said member in said fixed body, said member and said fixed body being provided with cooperating conduits for connecting said last mentioned housing with said chamber of said cylindrical recess.

7. A combination according to claim 3 in which said reciprocating liquid pump means include a cylindrical housing formed in said fixed body at right angles to the axis of rotation of said member, a piston fitting slidably in said last mentioned cylindrical housing and cam means carried by said member for moving said last mentioned piston radially in said last mentioned housing in response to the rotation of said member in said fixed body, said member and said fixed body being provided with cooperating conduits for connecting said last mentioned housing with said first mentioned chamber of said cylindrical recess.

8. A combination according to claim 2 in which said throttled passage is provided in said second portion of said outflow circuit.

9. A combination according to claim 3 in which said throttled passage is provided in said second portion of said outflow circuit.

10. A combination according to claim 2, further comprising an auxiliary pump driven at a speed proportional to the speed of rotation of said member, a delivery circuit for said auxiliary pump, means for producing in said last mentioned delivery circuit a pressure proportional to the speed of operation of said auxiliary pump, said outflow circuit second portion comprising a cylindrical housing provided in said fixed body, a slide valve mounted in said last mentioned cylindrical housing to form therewith said throttled passage, one end of said last mentioned cylindrical housing being connected with said last mentioned delivery circuit to urge said slide valve in one direction to vary the dimension of said throttled passage and resilient means for urging slide valve in the opposed direction.

11. A combination according to claim 3, further comprising an auxiliary pump driven at a speed proportional to the speed of rotation of said member, a delivery circuit for said auxiliary pump, means for producing in said last mentioned delivery circuit a pressure proportional to the speed of operation of said auxiliary pump, said outflow circuit second portion comprising a cylindrical housing provided in said fixed body, a slide valve mounted in said last mentioned cylindrical housing, to form therewith said throttled passage, one end of said last mentioned cylindrical housing being connected with said last mentioned delivery circuit to urge said slide valve in one direction to vary the dimension of said throttled passage and resilient means for urging said slide valve in the opposed direction.

No references cited.