

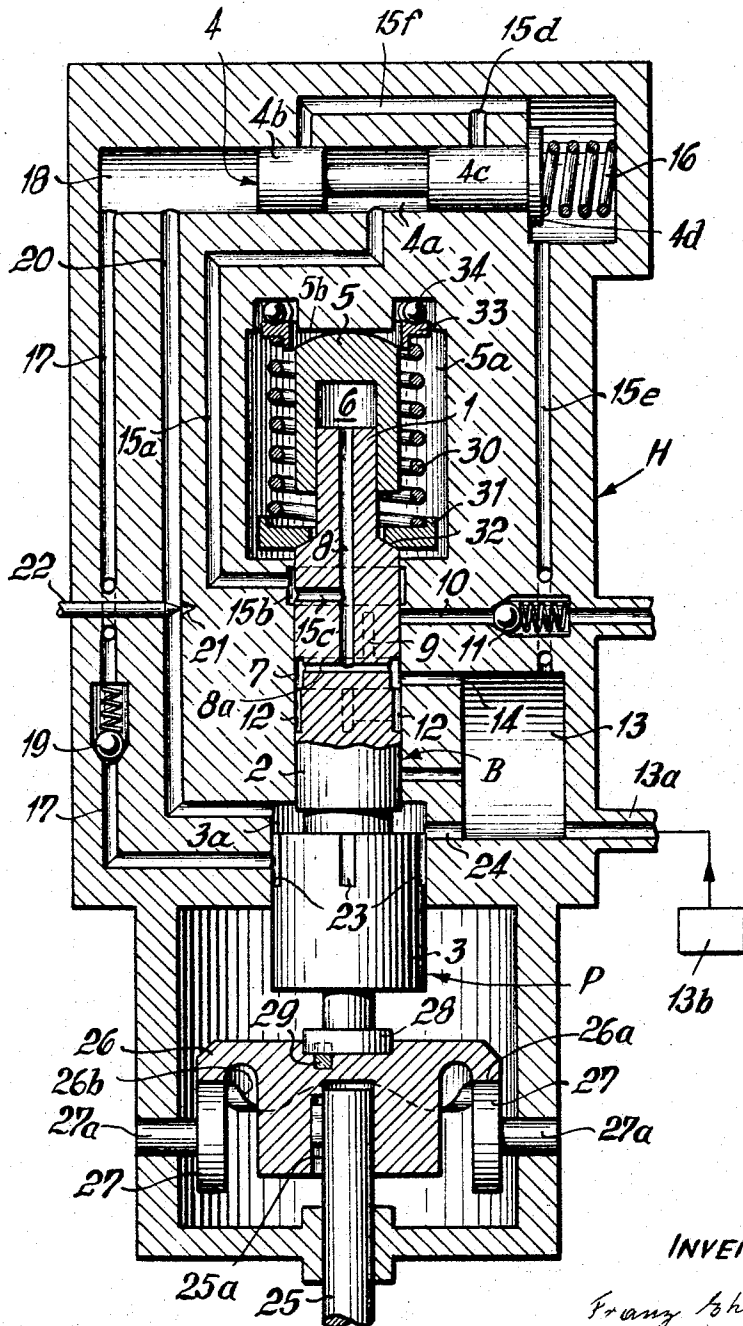
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FUEL INJECTION PUMP

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FUEL INJECTION PUMP

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The present invention relates to fuel injection pumps in general, and more particularly to improvements in fuel injection pumps of the type wherein a multi-stage piston reciprocates in a pump housing.

It is an important object of the present invention to provide a compact fuel injection pump.

Another object of the invention is to provide a fuel injection pump of the type wherein a fuel metering and distributing piston is rotated and reciprocated by means of a cam-and-follower assembly which is biased by one or more resilient elements, and wherein such resilient element or elements are configured and installed in such a way that they do not contribute to bulkiness of the pump housing.

A further object of the invention is to provide a novel housing for a pump of the above outlined characteristics.

An additional object of the invention is to provide a novel multi-stage piston for use in a fuel injection pump of the above outlined characteristics.

Another object of the invention is to provide a novel fuel quantity regulating slide valve which may be utilized in the improved pump.

Briefly stated, one feature of my present invention resides in the provision of a fuel injection pump which comprises a relatively short housing having a blind bore, a multi-stage piston rotatably and reciprocally received in the bore in such a way that its inner end is nearer to the blind end of the bore, a smaller-diameter stage provided on the piston adjacent to its inner end and a larger-diameter second stage adjacent to the first stage and defining therewith an annular shoulder, and drive means including a rotary shaft adjacent to the outer end of the piston, a cam and follower assembly drivingly connecting the outer end of the piston with the shaft so that the piston rotates and reciprocates in response to rotation of the shaft, and resilient means operating between the housing and the shoulder between the first and second stages for biasing the piston outwardly in a direction toward the shaft. Such mounting of the resilient means does not necessitate any increase in the dimensions of the housing. The resilient means may comprise a strong helical expansion spring one end of which bears against an antifriction bearing placed against an internal shoulder of the housing at the blind end of the bore and the other end of which bears against an annular spring retainer which is in direct abutment with the aforementioned shoulder of the piston, i.e., the spring need not abut directly against the piston. The smaller-diameter first stage of the piston is reciprocable in a cylinder which is rotatably received in an enlarged portion of the bore and is surrounded by the spring.

In accordance with another advantageous feature of my invention, the piston may comprise a maximum-diameter third stage which is adjacent to its outer end and is reciprocable in a cylinder chamber defined by the adjoining portion of the bore. This chamber can communicate with a suction space of the housing through a suction port and also through a system of channels containing a fuel quantity regulating slide valve which opens to permit return flow of fuel from the chambers for the first and third stages to the suction space when the rotational speed of the piston P rises to a predetermined value. The suction space is connected with a suitable source of fuel.

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The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved fuel injection pump itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof will be best understood upon perusal of the following detailed description of a specific embodiment with reference to the accompanying drawing, the single illustration of which is an axial section through a fuel injection pump embodying my invention.

Referring to the drawing in detail, there is shown a fuel injection pump which comprises a pump housing or casing H defining a composite blind bore B which receives a three-stage piston P. The blind end of the bore B is enlarged, as at 5a, and accommodates the smaller-diameter first stage 1 of the piston P, this stage extending all the way to the inner end of the piston and being formed with an axially extending fuel-conveying bore 8. The stage 1 is received in a cup-shaped cylinder 5 which is rotatably received in the enlarged portion 5a and defines a working chamber 6 which receives and discharges fuel via bore 8 in response to rotary and reciprocatory movement of the piston P. The larger-diameter second stage 2 of the piston P is adjacent to the stage 1 and serves to distribute metered quantities of fuel to several radially extending fuel lines 10 provided in the housing H and leading to the intake valves (not shown) for the individual cylinders of an internal combustion engine. The maximum-diameter third stage 3 of the piston P forms part of an auxiliary pump and controls the operation of a fuel quantity regulating slide valve 4 which is reciprocable in an auxiliary chamber 18 of the housing H.

The cylinder 5 is received in the enlarged portion 5a of the bore B with such clearance that the portion 5a can accommodate a resilient element in the form of a strong helical expansion spring 30, this spring forming part of the drive means for the piston P and cooperating with a cam-and-follower assembly 26, 27 in a manner to be described hereinafter. The convex upper end face of the cylinder 5 abuts against a short cylindrical boss 5b of the housing H which extends centrally into the enlarged portion 5a.

As stated hereinabove, the second stage 2 serves to distribute fuel to several fuel lines 10 of which only one is actually shown in the drawing. The lower end of the axial bore 8 has two radially extending branches 8a which together form a diametrically extending bore and whose outer ends are in permanent communication with an annular groove 7 machined into the periphery of the second stage 2. Thus, the groove 7 is in permanent communication with the working chamber 6. An axially parallel distributor groove 9 is also machined into the periphery of the second stage 2 and communicates with one side of the annular groove 7. When the piston P performs a working (upward) stroke, the axial groove 9 connects the annular groove 7 with one of the fuel lines 10. For example, if the engine comprises four cylinders, the housing H will be provided with four equidistant fuel lines 10 which extend radially of the bore B. Each fuel line 10 contains a ball check valve 11 which prevents return flow of fuel toward the axial groove 9.

The other side of the annular groove 7 communicates with four equidistant axial grooves 12 (only three shown) which connect the annular groove 7 with a suction port 14 when the piston P performs a suction (downward) stroke. The port 14 connects the grooves 12 serially with a suction space 13 which is machined into the housing H and is connected with a supply conduit 13a leading to a suitable source 13b of fuel. When the suction port 14 admits fuel to the annular groove 7, the working chamber 6 receives fuel from the suction space 13.

The housing H is further provided with a relief bore 15a which connects an annular recess 15b in the internal surface of the housing H with an annular space 4a between the two plungers 4b, 4c of the fuel quantity regulating slide valve 4. The recess 15b is machined into the surface surrounding the second stage 2 and is in permanent communication with a radially inwardly extending branch bore 15c of the stage 2. The branch bore 15c communicates with the axial bore 8. The valve 4 normally seals the relief bore 15a from the duct 15d which communicates with a bore 15e forming part of a composite channel and leading to the suction space 13. When the fuel delivered from the chamber for the third stage shifts the slide valve 4 against the force of the return spring 16 to the right, the annular space 4a between the plungers 4b, 4c connects the relief bore 15a with the duct 15d so that the working chamber 6 can discharge some of its contents via bore 15e and back into the suction space 13. The annular space 4a is in permanent communication with the relief bore 15a. The remainder of the aforementioned composite channel includes a bore 17 which is machined into the housing H and connects the auxiliary chamber 18 with a cylinder chamber 3a forming part of the bore B and receiving the maximum-diameter stage 3 of the piston P. The bore 17 contains a ball check valve 19 which prevents return flow of fuel from the chamber 18 to the chamber 3a. The chamber 18 also forms part of the aforementioned channel.

The connection between the chambers 3a and 18 further comprises a bore 20 wherein the flow of fuel is controlled by an adjustable throttle 21, 22. The needle 22 of the throttle extends outwardly and may be regulated by hand.

The third stage 3 is formed with axially extending peripheral grooves 23 which communicate with the cylinder chamber 3a and communicate seriatim with a suction port 24 which connects the chamber 3a with the suction space 13. Thus, when the piston P performs a suction (downward) stroke, the stage 3 draws from the space 13 fuel via port 24 and, during the next working stroke, urges the drawn-in fuel to flow into the bores 17 and 20 and into the auxiliary chamber 18 to bear against the left-hand plunger 4b of the valve 4.

The aforementioned drive for the piston P comprises a drive shaft 25 which is rotatably mounted in the housing H and is driven by the engine in a manner not forming part of the present invention. The cam 26 is coupled with the shaft 25 by a key 25a so that it can move axially. Its annular cam face 26a is formed with four lobes 26b, one for each cylinder of the engine, and is tracked by roller followers 27 whose shafts 27a are mounted in the housing H. The spring 30 biases the piston P downwardly, as viewed in the drawing, so that the cam face 26a is urged against the followers 27. It is clear that the illustrated drive may be modified without departing from the spirit of my invention. For example, the cam 26 can be fixedly secured to the housing so that its face 26a is turned upwardly. The piston P is then coupled with the shaft 25 in such a way that it shares all rotary movements of the shaft 25 but is free to move axially with respect thereto. The follower rollers 27 are then mounted on the piston P and are biased by the spring 30 to track the face 26a. In the illustrated embodiment, the cam 26 is connected to the outer end 28 of the piston P by a coupling pin 29. The connection between the outer end 28 and the cam 26 need not be of the positive type because the spring 30 insures that the parts P and 26 rotate as a unit. The upper end convolution of the spring 30 bears against the race 33 of an antifriction ball bearing 34 which is adjacent to an internal shoulder of the housing H at the blind end of the bore B. The lower end convolution of the spring 30 bears against an annular retainer 31 which is carried by a shoulder 32 between the stages 1 and 2. Thus, the spring 30 need not bear directly against the shoulder 32; it suffices if the bias is transmitted indirectly in such

a way that the shoulder 32 is urged in a direction toward the shaft 25.

The chamber 18 can communicate with a bore 15f connecting to the duct 15d and bore 15e when the plunger 4b is moved against the bias of the return spring 16 and assumes a predetermined axial position.

The operation of my improved fuel injection pump is as follows:

When the piston P performs a working (upward) stroke, fuel filling the working chamber 6 is expelled through the axial bore 8 and flows via bores 8a, groove 7 and groove 9 into one of the fuel lines 10 and on to the intake valve of the respective cylinder. At the same time, the stage 3 expels fuel from the cylinder chamber 3a and such fuel flows via bores 17 and 20 into the auxiliary chamber 18 to bear against the exposed face of the plunger 4b whereby the valve 4 moves in a direction to the right and compresses the return spring 16. At the very moment when the annular space 4a connects the relief bore 15a with the duct 15d, the injection of fuel into one of the lines 10 is terminated in a fully automatic way because the remaining fuel which is expelled from the working chamber 6 can flow back to the suction space 13 via bore 15e. If the rotational speed of the piston P rises to a predetermined value, the amounts of injected fuel are reduced in a fully automatic way due to a so-called liquid stop. Thus, if the head 4d of the valve 4 cannot return to sealing position before the piston P completes a suction stroke, the next working stroke will result in more rapid connection between the relief bore 15a and the duct 15d so that the corresponding fuel line 10 will receive less fuel. The throttle 21 brakes the return flow of fuel from the chamber 18 to the chamber 3a when the spring 16 expands.

Due to the fact that the spring 30 is located in the enlarged portion 5a of the bore B and operates between the housing H and the shoulder 32 defined by the stages 1 and 2, the dimensions of the improved pump are considerably smaller than the dimensions of an equivalent fuel injection pump of known design.

The manner in which a liquid stop develops at a certain r.p.m. of the piston in a fuel injection pump is disclosed, for example, in U.S. Patent No. 3,122,100.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is:

1. In a fuel injection pump, a housing having a bore; a multi-stage piston rotatably and reciprocally received in said bore, said piston having an inner end and an outer end and comprising a first stage of smaller diameter adjacent to said inner end and a second stage of large diameter adjacent to said first stage, said first and second stages defining between themselves a shoulder; a source of fuel; a cylinder provided in said housing and reciprocally receiving said first stage, said piston having bore means providing paths for flow of fuel from said source into said cylinder and from said cylinder into at least one fuel line provided in said housing in response to movement of said piston with reference to said housing, said second stage being arranged to distribute fuel to said fuel line; and drive means including a rotary shaft adjacent to said outer end, a cam connected for rotation with the outer end of said piston and reciprocally coupled with said shaft for rotation therewith, said cam having an annular face provided with at least one lobe, roller follower means fixed to said housing and tracking the face of said cam, and resilient means operating between said hous-

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ing and said shoulder for biasing said face of said cam against said follower means, said resilient means comprising a helical expansion spring surrounding said cylinder.

2. In a fuel injection pump, a housing having a bore; a multi-stage piston rotatably and reciprocally received in said bore, said piston having an inner end and an outer end and comprising a first stage of smaller diameter adjacent to said inner end, a second stage of larger diameter adjacent to and defining with said first stage a shoulder, and a third stage of maximum diameter adjacent to said outer end, a portion of said bore forming a cylinder chamber for said third stage and said housing further having a suction space communicating with said cylinder chamber and channel means connecting said chamber with said space; a source of fuel connected with said space; drive means including a rotary shaft adjacent to said outer end, a cam and follower assembly drivingly connecting said shaft with the outer end of said piston, and resilient means operating between said housing and said shoulder for biasing said piston in a direction toward said shaft; and fuel quantity regulating valve means provided in said channel means for permitting return flow of fuel from said cylinder chamber into said space when the rotational speed of the piston rises to a predetermined value.

3. A structure as set forth in claim 2, further comprising a cylinder reciprocally receiving said first stage, said piston having bore means providing paths for intermittent flow of fuel from said suction space into said cylinder and from said cylinder into fuel lines provided in said housing in response to rotation and reciprocation of said piston.

4. In a fuel injection pump, a housing having a bore; a multi-stage piston rotatably and reciprocally received in said bore, said piston having an inner end and an outer end and comprising a first stage of smaller diameter adjacent to said inner end and a second stage of larger diameter adjacent to and defining with said first stage a shoulder; drive means including a rotary shaft adjacent to said outer end, a cam and follower assembly drivingly connecting said shaft with the outer end of said piston, and resilient means operating between said housing and said shoulder for biasing said piston in a direction toward said shaft, said housing further having a suction space; a source of fuel connected with said suction space, said bore comprising an enlarged portion receiving said first stage together with said resilient means and a cylinder chamber disposed between said second stage and the outer

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end of said piston, said housing further having channel means connecting said cylinder chamber with said space and a relief bore connecting said channel means with that portion of said bore which surrounds said second stage; a cylinder received in said enlarged portion and defining a working chamber for said first stage, said working chamber receiving fuel from said suction space through bore means provided in said piston when the latter performs a suction stroke and discharging fuel through said bore means into one of several fuel lines provided in said housing when the piston performs a working stroke, said bore means further communicating with said relief bore; a third stage provided on said piston and reciprocable in said cylinder chamber to force fuel into said channel means; and fuel quantity regulating valve means provided in said channel means to normally seal said relief bore from said suction space and to permit escape of fuel from said relief bore when the rotational speed of the piston rises to a predetermined value.

5. A structure as set forth in claim 2, wherein said bore comprises an enlarged portion surrounding said first stage and further comprising a cylinder received in said enlarged portion and reciprocally receiving said first stage, said piston having bore means providing paths for intermittent flow of fuel from said suction space into said cylinder and from said cylinder into fuel lines provided in said housing in response to rotation and reciprocation of said piston.

6. A structure as set forth in claim 5, wherein said second stage is arranged to distribute the fuel flowing from said cylinder to said fuel lines.

7. A structure as set forth in claim 4, wherein said channel means includes an auxiliary chamber and said valve means comprises a slide valve which is reciprocable in said auxiliary chamber.

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