Sept. 19, 1939. B. BISCHOF 2,173,813

FUEL INJECTION APPARATUS

Filed Oct. 20, 1937

Fig.1.

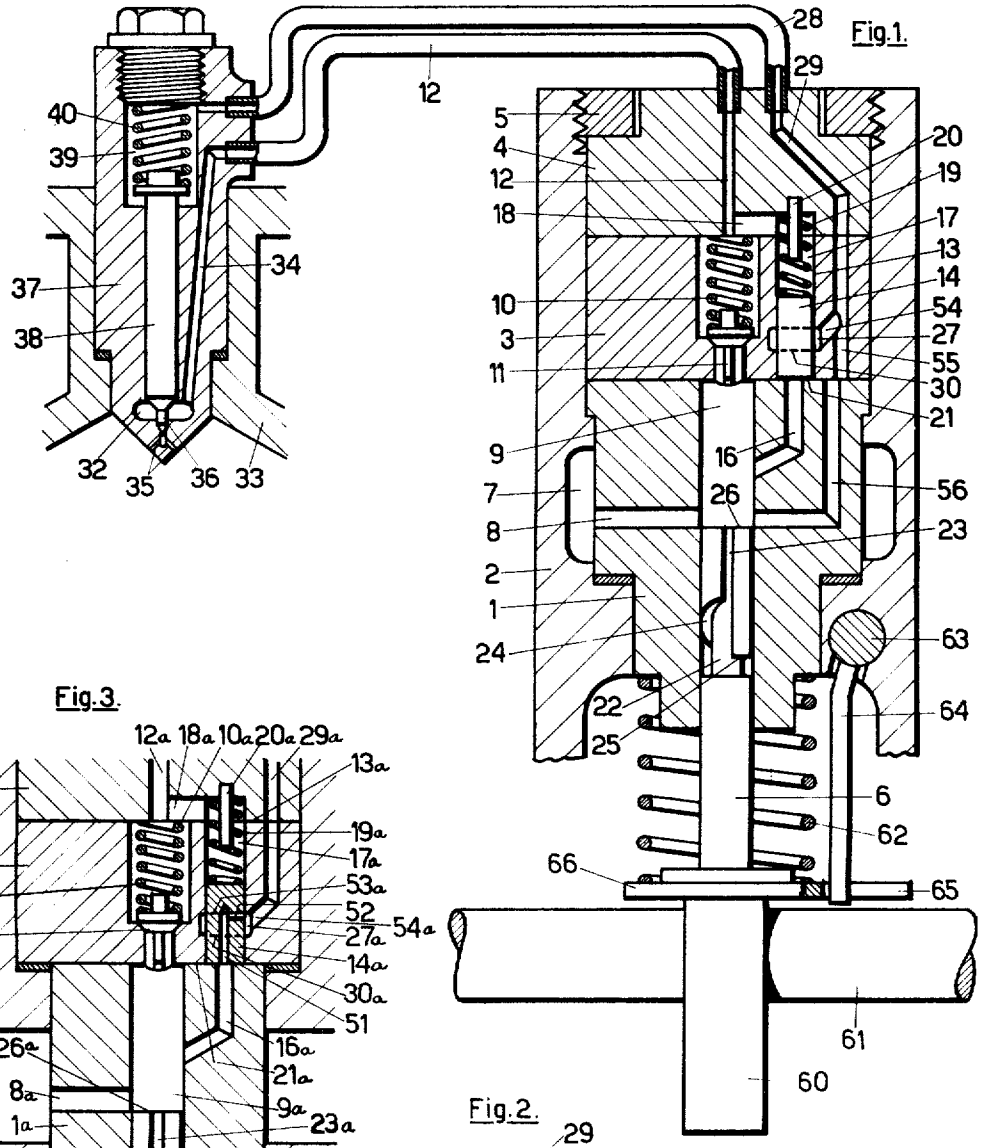
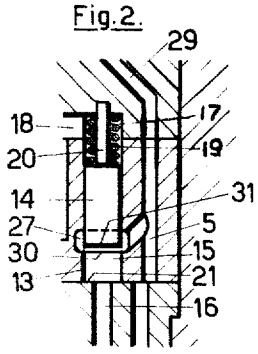


Fig.3.

Fig.2.



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2,173,813

FUEL INJECTION APPARATUS

Bernhard Bischof, Winterthur, Switzerland

Application October 20, 1937, Serial No. 170,114
In Switzerland October 20, 1936

22 Claims. (Cl. 123—139)

The present invention relates to fuel injection apparatus and, in particular, to apparatus of this kind as used in conjunction with internal combustion engines.

It is known that the rate of the initial rise of pressure in the combustion space of the internal combustion engine, in each combustion period, is mainly influenced by the quantity of fuel present in the said combustion space at the moment at which said fuel is ignited. It has therefore been found convenient to have a small quantity of fuel injected to be ignited preparatory to the injection of a main fuel charge, the latter being varied according to the load of the internal combustion engine.

With known devices used for this purpose, difficulties have been met in obtaining an exact measuring of the comparatively small fuel quantity to be injected during the preliminary injection, said small fuel quantity being measured by the same or similar means as the main fuel charge subsequently injected, said means involving the closing of an inlet or a by-pass port, and the reopening of such port during the displacing stroke of a pump piston, or the like.

One of the objects of my invention is to provide means by which a more exact control or measuring of the preinjected fuel quantity may be obtained.

Another object of my invention is to provide means for effecting the preliminary injection under pressure conditions different from those prevailing during the main injection, either at the beginning of the main injection or at the end thereof, or at both beginning and end.

According to the invention, an auxiliary piston hydraulically actuated by fuel displaced by the pump piston is provided for displacing a fuel quantity to be injected preparatory to the injection of the main fuel charge, which is displaced by means of the pump piston.

With these general statements of the objects and purposes of my invention I will now proceed to describe the embodiment thereof and the manner in which my invention is carried out; it will be understood that while I have described what may be considered as a preferable embodiment of my invention, I do not limit myself to the precise conditions and proportions herein set forth, as they may be varied by those skilled in the art in accordance with the particular purposes for which they are intended, and the conditions under which they are to be utilised.

In the accompanying drawing,

Fig. 1 is a sectional view of an injection apparatus embodying the invention;

Fig. 2 shows, in another position of the parts, a portion of the apparatus shown in Fig. 1;

Fig. 3 shows a modified construction of a part of the apparatus.

In the embodiment shown in Fig. 1, the pump cylinder 1 is lodged in the pump housing 2 and retained therein together with the intermediate body 3 and the cover piece 4, by means of the threaded ring 5. The parts 1, 3 and 4 are provided with plane faces along which they are in fluid-tight contact. The pump piston 6 is a tight fit in the cylinder 1 and reciprocable therein under the action of the cam 60 carried by the shaft 61, which is driven by the internal combustion engine in a way not shown in the drawing, and of the spring 62. Said piston 6 may also be rotated about its axis by longitudinally displacing the rod 63 which carries a pin 64 engaging a fork 65 provided on the spring plate 66 of the piston. In the pump housing 2 there is a fuel supply or low pressure chamber 7 to which fuel is fed at low pressure through a supply conduit not shown in the drawing. Through the inlet port 8, the supply space 7 communicates with the pump working space 9.

In the intermediate body 3 there is a delivery port issuing from the working space 9 and controlled by the delivery valve 11, which is of the non-return type and loaded by the valve spring 10, and opens under the fuel pressure in the working space 9. The said delivery port communicates with the injection conduit 12.

The intermediate body 3 is also bored to form an auxiliary cylinder 13 in which the auxiliary piston 14 is a tight fit, said piston being shiftable between two limit positions determined, one by its abutting against the face 21 of the pump cylinder 1, and the other by its abutting against the abutment pin 28 fixed in the cover piece 4. In the auxiliary cylinder 13, the piston 14 separates an actuating space 15 (shown in Fig. 2) which communicates with the pump working space 9 through the auxiliary port 16, and an auxiliary working space 17 joining the injection conduit 12 through the recess 18 of the cover piece 4. A spring 19 is provided for pressing the auxiliary piston 14 into its actuating space 15 and towards the abutment 21, the force of said spring 19 being chosen in such relation to the force of the delivery valve spring 10 that a lower pressure is required in the actuating space 15 for displacing the auxiliary piston against the force of the spring 19 than the pressure neces-

sary in the working space 9 for opening the delivery valve 11 against the force of the spring 10.

The pump piston 6 is arranged to control the fuel inlet port 8 and the auxiliary port 16. To that end, the piston front forms a control edge 26 situated just below the issue of the inlet port 8 when the pump piston is in its outer or bottom dead centre position as shown in Fig. 1, said inlet port being then open to the working space 9. The pump piston 6 has a further control edge 24 bounding a recess 22 of the piston, which recess communicates with the working space 9 through the longitudinal groove 23, said edge 24 being oblique with reference to the piston axis in the portion of the piston circumference where it is to control the inlet port 8. In the remaining portion of said circumference, the recess 22 is bounded by the edge 25 located so as not to control any port.

The auxiliary cylinder 13 has a circumferential groove 27 forming the issue of the outlet or valve-loading port 54. Through the duct 29, the latter communicates with the valve-loading conduit 28. The lower edge 30 of the groove 27 forms a narrow but not intently restricted passage with the bottom edge 31 of the auxiliary piston 14 when the latter abuts the pin 20. By said passage, the port 54 is then open to the actuating space 15, as shown in Fig. 2.

The valve-loading duct 29, through the duct 55, is connected to the release port 56 communicating with the working space 9 and controlled by the pump piston 6 and more particularly by the control edge 26 of the latter. When said piston is in its outer dead centre position, and during a first portion of its displacing stroke, the release port 56 is open to the working space 9, and through the latter and through the inlet port 8, which is also open at that time, to the low pressure or supply space 7. The communication from the duct 29 to the release port 56 includes a restricted passage formed in the junction of the duct 55 in the body 3 with the said release port in the cylinder 1, the issues of said duct and port in the contact plane 21 of said body and cylinder covering each other only on a small area.

The injector device is lodged in the head 33 of a combustion cylinder of the internal combustion engine. The injector body has a one-hole or multi-hole injection passage 35 whose communication with the injection conduit 12, through the space 32 and the duct 34, is controlled by the valve pin 36. The latter is integral with the stem 38 formed as the piston of a double-acting fluid pressure motor and separates the valve-opening working chamber 32, which has just been mentioned and which communicates with the injection conduit 12, on one side, and the valve-loading working chamber 39 communicating with the valve-loading conduit 28, in which valve-loading chamber the fuel pressure is assisted by the pressure of a spring 40, on the other side.

When the pump piston 6 assumes its outer dead centre position shown in Fig. 1, the working space 9 is in open communication with the supply space 7, through the fuel inlet port 8, and has been filled therethrough with fuel under low pressure. The auxiliary piston 14 is in contact with its abutment 21. In the beginning of the displacement stroke of the piston 6 into the working space 9, the inlet and release ports 8 and 56 are closed by the edge 26, and the pump piston then displaces fuel from the working space 9 through the auxiliary port 16 into the actuating space 15. Thus, the auxiliary piston 14 is moved, by fuel pressure, into the auxiliary working space 17, from which it displaces fuel through the recess 18 towards the injection conduit 12, the duct 34 in the injector body, and into the valve-opening working space 32. The fuel pressure increases in the latter and by its action upon the valve stem 38 causes the pin 36 to open the injection passage 35, whereupon the fuel further displaced by the auxiliary piston 14 is injected into the combustion space of the internal combustion engine.

Just before the auxiliary piston 14 meets the abutment pin 20, its edge 31 passes the edge 30 of the groove 27, thus connecting the pump working space 9 to the valve-loading working space 39. The fuel further displaced by the pump piston 6 being now able to escape into the space 39, the movement of the auxiliary piston 14 ceases, the latter being also at any rate stopped by the abutment pin 20 substantially at the same time, and no more fuel is displaced from the auxiliary working space 17 to the injection conduit 12. As the fuel continues to flow out through the passage 35, the pressure soon drops, in the space 32, to a figure at which the spring 40 assisted by the now increasing fuel pressure in the valve-loading space 39 is able to shift the stem 38 for closing the passage 35 by means of the valve pin 36, thus terminating the preliminary injection.

It is apparent that the volume of fuel displaced into the injection conduit 12 by the auxiliary piston 14 in its described movement is wholly independent from any lack of precision due to progressive throttling, leakage or the like in the closing of the inlet port 8, the position in which the auxiliary piston 14 comes to a standstill after having opened the port 54 being the only variable factor capable of influencing said displaced fuel volume. However, this position is only variable between narrow limits on account of the abutment pin 20.

When proceeding in its displacing stroke, the pump piston 6 compresses the fuel in the working space 9, auxiliary port 16, actuating space 15, groove 27, port 54, duct 29, valve-loading conduit 28 and valve-loading space 39. As soon as the pressure therein has reached a sufficient figure, the delivery valve 11 is opened against the pressure of the spring 10 and against the residual pressure left in the injection conduit 12 at the closing of the injection passage 35 after the preliminary injection. Though the delivery valve 11 may thus be opened before the control edge 26 of the pump piston 6 has closed the auxiliary port 16, it seems preferable to give the spaces involved such proportions that the said auxiliary port is closed before the pressure in the working space 9 has become sufficient for opening said delivery valve.

The auxiliary port 16 being closed, the pressure of the fuel trapped in the valve-loading working space 39 and in the spaces communicating therewith up to the said auxiliary port 16 determines, together with the pressure of the spring 40, the pressure necessary in the valve-opening working space 32 for opening the passage 35.

After the opening of the delivery valve 11, the pump piston 6 compresses the fuel in the injection conduit 12, in the duct 34, and in the valve-opening space 32, until its action, in the latter, upon the stem 38 overcomes the loading force of

the valve 36 and causes the latter to open the injection passage 35 for the main injection of fuel therethrough. Said main injection is terminated by the control edge 24 reopening the inlet port 8, whereby the working space 9 comes into communication with the low-pressure or supply space 7, through the groove 23, the recess 22 and the said port 8. The fuel is then bypassed from the working space 9 to the space 7, and the pressure is released in the said working space. As a consequence, the delivery valve 11 is closed again. The fuel continuing to leave the valve-opening space 32 through the injection passage, the pressure falls again in said space, till the passage 35 is closed by the injection valve pin 36, under the action of the fuel and spring pressures in the valve-loading space 39. On account of the shape and disposition of the control edge 24 the time at which the inlet port 8 is reopened for the by-passing of fuel may be varied by rotating the pump piston 6 about its axis, whereby the quantity of fuel displaced for the main injection may be adjusted.

Whilst in the embodiment shown in the drawing the inlet port is reopened by the control edge 24 for the purpose of by-passing fuel from the pump working space, it will be obvious to anybody skilled in the art that a separate by-pass port might be provided for the same purpose, said by-pass port communicating with the supply space 7 or with any other low-pressure space, and I wish it to be understood that wherever the inlet port as used for the said purpose is referred to in the present specification and in the appended claims, this term also shall include such separate by-pass port.

On the outward stroke of the pump piston 6 and after the inlet port 8 has been closed again by the edge 24, the said piston generates a depression in the working space 9. When the auxiliary port 16 is reopened, said depression will also extend to the actuating space 15, whereby the auxiliary piston 14 is enabled to be shifted back to the cylinder face 21, by the pressure of the spring 19 and of the fuel in the auxiliary working space 17. By this operation, the pressure in said space 17, which also prevails in the injection conduit 12 and in the other spaces communicating therewith, is substantially lowered, so that said conduit and spaces are again ready for effecting the subsequent preliminary injection therethrough.

When the edge 26 has reopened the inlet port 8, fuel is drawn into the pump working space 9 from the supply space 7, and the said depression filled up. Thereupon, the edge 26 also reopens the release port 56, whereby the fuel pressure in the valve-loading space 39 is released, said fuel expanding towards the supply space 7 through the conduit 28, the ducts 29 and 55, the release port 56, the working space 9, and the inlet port 8. The restricted passage at the junction of the duct 55 with the port 56 prevents the expansion of the fuel from occurring so rapidly as to introduce disturbing effects, such as the partial emptying of some space as the result of momentum.

The embodiment partly shown in Fig. 3 differs from the one described above in that the release port 56 and duct 55 in restricted communication therewith are omitted. In lieu of these parts the auxiliary piston 14*a* is provided with a longitudinal bore 51 which is in free communication with the actuating space 15*a* and a lateral restricted passage 52 which connects the bore 51 with the groove 27*a* when the auxiliary piston 14*a* is in contact with the shoulder 21*a*. After the reopening of the auxiliary port 16*a* during the outward or suction stroke of the pump piston 6*a* and after the auxiliary piston 14*a* has seated against said shoulder 21*a*, the fuel under pressure in the valve loading working space (corresponding to the space 39 of Fig. 1) is progressively released by flow toward the working space 9*a* which at that time will be at low pressure. Such flow occurs through the conduit 29*a*, port 54*a*, groove 27*a*, restricted passage 52, bore 51, and port 16*a*. Such flow of the valve loading fuel may continue during the period in which the inlet port 8*a* is open until the fuel pressure in the loading space (corresponding to the space 39 in Fig. 1) has become substantially equal to the low pressure prevailing in the supply port 8*a*. When the auxiliary piston 14*a* commences its displacement stroke through the auxiliary working space 17*a*, the restricted passage 52 is closed by the edge 53*a* of the groove 27*a*.

It will be observed that the parts identified with the distinguishing letter "*a*" are essentially identical with corresponding parts in Figs. 1 and 2 and that the operating cycles of the two embodiments are essentially identical.

What I claim is:

1. Fuel injection apparatus comprising in combination an injection passage; a pump cylinder and reciprocable piston enclosing together a pump working space, said pump cylinder having a fuel inlet port communicating with said working space and a delivery port through which said working space communicates with said injection passage; an auxiliary cylinder having an outlet port; an auxiliary piston shiftable in said auxiliary cylinder and separating in said auxiliary cylinder an actuating space communicating with said pump working space and with said outlet port, and an auxiliary working space communicating with said injection passage; an abutment for limiting the travel of said auxiliary piston toward said auxiliary working space; inlet valve means associated with said pump piston for controlling said inlet port; and delivery valve means responsive to pressure in said pump working chamber for controlling said delivery port, outlet controlling means associated with said auxiliary piston for controlling said outlet port so that the latter is open when said auxiliary piston is in its limit position towards said auxiliary working space.

2. Fuel injection apparatus comprising in combination an injection passage; an injection valve shiftable to open and close said injection passage; a doubleacting pressure motor for actuating said injection valve, said motor having a valve-opening working space in communication with said injection passage, and a valve-loading working space; a pump cylinder and reciprocable piston enclosing together a pump working space, said pump cylinder having a fuel inlet port communicating with said pump working space and a delivery port through which said pump working space communicates with said injection passage; an auxiliary cylinder having a valve-loading port communicating with said valve-loading working chamber; an auxiliary piston shiftable in said auxiliary cylinder, and separating in said auxiliary cylinder an actuating space communicating with said pump working space and through said valve-loading port with said valve-loading working space, and an auxiliary working space communicating with said injection passage; an abutment for limiting the travel of said auxiliary piston toward said auxiliary working space; inlet

valve means associated with said pump piston for controlling said inlet port; delivery valve means responsive to pressure in said pump working space for controlling said delivery port; and valve-loading control means associated with said auxiliary piston for controlling said valve-loading port so that the latter is open when said auxiliary piston is in its limit position towards said auxiliary working space.

3. Fuel injection apparatus as claimed in claim 2 in which the parts are so arranged that during the displacing stroke of the pump piston the inlet port is closed and, when the pump piston has displaced thereafter a volume definitely exceeding the volume which can be displaced by the auxiliary piston during its travel, the actuating space of said auxiliary piston is isolated from said pump working space, and thereafter the inlet port is reopened.

4. Fuel injection apparatus comprising in combination an injection passage; a pump cylinder and reciprocable piston enclosing together a pump working space, said pump cylinder having a fuel inlet port and an auxiliary port communicating with said pump working space, and a delivery port through which said pump working space communicates with said injection passage; an auxiliary cylinder; an auxiliary piston shiftable therein and separating in said auxiliary cylinder an actuating space communicating through said auxiliary port with said pump working space, and an auxiliary working space communicating with said injection passage; an abutment for limiting the travel of said auxiliary piston toward said auxiliary working space; inlet valve means associated with said pump piston for controlling said inlet port; delivery valve means responsive to pressure in said pump working space for controlling said delivery port; and valve means associated with said pump piston for controlling said auxiliary port.

5. Fuel injection apparatus as claimed in claim 4 in which the parts are so arranged that during the displacing stroke of the pump piston the inlet port is closed and, when the pump piston has thereafter displaced a volume definitely exceeding the volume which can be displaced by the auxiliary piston during its travel, the auxiliary port is closed.

6. Fuel injection apparatus comprising in combination an injection passage; an injection valve shiftable to open and close said injection passage; a doubleacting pressure motor for actuating said injection valve, said motor having a valve-opening working space in communication with said injection passage, and a valve-loading working space; a pump cylinder and reciprocable piston enclosing together a pump working space, said pump cylinder having an inlet port and an auxiliary port communicating with said pump working space and a delivery port through which the latter communicates with said injection passage; an auxiliary cylinder having a valve-loading port communicating with said valve-loading working space; an auxiliary piston shiftable in said auxiliary cylinder and separating therein an actuating space communicating through said auxiliary port with said pump working space, and an auxiliary working space communicating with said injection passage; an abutment for limiting the travel of said auxiliary piston toward said auxiliary working space; inlet valve means associated with said pump piston for controlling said inlet port; delivery valve means responsive to pressure in said pump working space for controlling said delivery port; valve means associated with said pump piston for controlling said auxiliary port; and loading port valve means associated with said auxiliary piston for controlling said valve-loading port in such a way that the latter is open when said auxiliary piston is in its limit position towards said auxiliary working space, the parts being so arranged that during the displacement stroke of the pump piston said inlet port is closed and when the pump piston has thereafter displaced a volume definitely exceeding the volume which can be displaced by said auxiliary piston during its travel, the said auxiliary port is closed.

7. Fuel injection apparatus as claimed in claim 6 in which the parts are further so arranged that during the displacement stroke of the pump piston the inlet port is reopened after the auxiliary port is closed, and comprising means for varying the interval in said displacement stroke between the closing of said auxiliary port and the reopening of said inlet port.

8. Fuel injection apparatus as claimed in claim 2 and comprising a receiver containing a low-pressure fuel space; fuel-conducting means connecting the valve-loading working space to said low-pressure space; and release valve means associated with the pump piston for controlling said fuel-conducting means.

9. Fuel injection apparatus as claimed in claim 2 and comprising a receiver containing a low-pressure fuel space; fuel-conducting means including a restricted passage connecting the valve-loading working space to said low-pressure space; and release valve means associated with the pump piston for controlling said fuel-conducting means.

10. Fuel injection apparatus as claimed in claim 2 in which the pump cylinder has a release port through which the valve-loading space communicates with the pump working space; and release valve means associated with said pump piston for controlling said release port.

11. Fuel injection apparatus as claimed in claim 2 in which the pump cylinder has a release port through which the valve-loading space communicates with the pump working space; and release valve means associated with said pump piston for controlling said release port; the parts being so arranged that the inlet port is open when said release port is open.

12. Fuel injection apparatus as claimed in claim 2 in which the pump cylinder has a release port including a restricted passage through which the valve-loading space communicates with the pump working space; and release valve means associated with the pump piston for controlling said release port.

13. Fuel injection apparatus as claimed in claim 2 in which the auxiliary piston serves as a valve and connects the valve loading port with the working space of the pump when said auxiliary piston is in its limiting position toward the actuating space.

14. Fuel injection apparatus as claimed in claim 2 in which the valve-loading control means include a restricted passage through which said valve-loading port is open when the auxiliary piston is in its limit position towards the actuating space.

15. Fuel injection apparatus comprising in combination an injection passage; a pump cylinder and reciprocable piston enclosing together a pump working space, said pump cylinder having a fuel inlet port communicating with said working space and a delivery port through which said working space communicates with said injection

passage; an auxiliary cylinder; an auxiliary piston shiftable therein between fixed limit positions and separating in said auxiliary cylinder an actuating space communicating with said pump working space and an auxiliary working space communicating with said injection passage; inlet valve means associated with said pump piston for controlling said inlet port; delivery valve means responsive to pressure in said pump working space for controlling said delivery port; and resilient means arranged to press said auxiliary piston towards said actuating space, and, when retaining said auxiliary piston in its limit position towards said actuating space, to yield under a lower pressure acting in the latter upon said auxiliary piston than the pressure required in said pump working space for causing said delivery valve means to open said delivery port.

16. The combination of a fuel injector valve including means responsive to the pressure of liquid fuel delivered to the valve to urge the valve in an opening direction, means for biasing the valve in a closing direction, and fluid pressure operated means for loading the valve in a closing direction; a liquid fuel delivering pressure pump of the type including means for varying the delivery stroke of the pump; yielding means resisting the delivery of fuel from said pump to said injection valve; and a secondary pump piston operated by delivery pressure developed by the first named pump and serving to deliver a definite measured quantity of fuel to said injection valve; and means controlled by said secondary pump and effective at the end of the delivery stroke thereof to deliver fuel under pressure from the first named pump to said loading means.

17. The combination defined in claim 16 in which the parts are so arranged that the yielding flow resisting means prevents flow to the injection valve from the first named pump until the secondary piston has moved through its range of motion and has functioned to deliver the loading pressure fluid, and in which means are provided thereafter to isolate such secondary piston from the first named pump whereby delivery of fuel to the loading means is terminated and the first named pump overpowers the flow-resisting means and delivers fuel directly to said injection valve.

18. The combination defined in claim 16 in which the yielding flow of resisting means is a loaded check valve opening in the direction of flow from the first named pump to the fuel injection valve and the secondary pump piston is more lightly loaded and also serves as a valve opening at the end of its displacement stroke to deliver liquid fuel from the first named pump to said loading means.

19. Fuel injection apparatus comprising in combination an injection passage; a pump cylinder and reciprocable piston enclosing together a pump working space, said pump cylinder having a fuel inlet port and an auxiliary port communicating with said pump working space and a delivery port through which said pump working space communicates with said injection passage; an auxiliary cylinder having an outlet port and communicating with said auxiliary port and with said injection passage; an auxiliary piston shiftable in said auxiliary cylinder and separating therein an actuating space communicating with said auxiliary port and with said outlet port, and an auxiliary working space communicating with said injection passage; valve means actuated by said pump piston for controlling said inlet port and said auxiliary port; delivery valve means responsive to pressure in said pump working chamber for controlling said delivery port; outlet controlling means actuated by said auxiliary piston for controlling said outlet port so that the latter is open when said auxiliary piston is in its limit position towards said auxiliary working space; and an abutment for limiting the travel of said auxiliary piston towards said auxiliary working space.

20. Fuel injection apparatus comprising in combination an injection passage; an injection valve shiftable to open and close said injection passage; an actuating device for said injection valve, said device having a valve-opening working space in communication with said injection passage, and fluid pressure operated valve-loading means tending to urge said injection valve closed; a pump cylinder and reciprocable piston enclosing together a pump working space, said pump cylinder having a fuel inlet port communicating with said pump working space and a delivery port through which said pump working space communicates with said injection passage; an auxiliary cylinder; an auxiliary piston shiftable in said auxiliary cylinder and separating therein an actuating space communicating with said pump working space and an auxiliary working space communicating with said injection passage; an abutment for limiting the travel of said auxiliary piston towards said auxiliary working space; inlet valve means actuated by said pump piston for controlling said inlet port; delivery valve means responsive to pressure in said pump working space for controlling said delivery port; and means for varying the fluid pressure acting on said valve-loading means substantially in time with the motion of said pump piston, said pressure varying means being so arranged that the fluid pressure tending to close the injection valve has a comparatively low value during a first portion of the displacement stroke of the pump piston, then increases during a further portion of the said stroke, remains at an increased value at least over the subsequent portion of the said displacement stroke, and thereafter drops to its initial value before the pump piston again begins its displacement stroke.

21. A fuel injection apparatus comprising in combination, a fuel injection valve; means subject to pressure of fuel delivered to said valve for urging the valve in an opening direction; yielding means biasing said valve in a closing direction; fluid pressure operated loading means for augmenting the closing bias of said valve; a fuel pump of the reciprocating type for delivering fuel under pressure; a floating piston interposed in a passage between the said pump and said fuel injection valve, and adapted to move in response to the initial portion of the fuel delivery stroke of the pump to displace fuel ahead of it to said injection valve; means for limiting reciprocating movement of said floating piston; means for delivering further fuel from said pump to said injection valve after said floating piston has completed its fuel displacing excursion; and valve means rendered effective upon the displacing movement of said floating piston to deliver fuel under pressure from said pump to said fluid pressure operated loading means.

22. A fuel injection apparatus comprising in combination, a fuel injection valve; means subject to pressure of fuel delivered to said valve for urging the valve in an opening direction; yielding means biasing said valve in a closing direction; fluid pressure operated loading means for aug-

menting the closing bias of said valve; a fuel pump of the reciprocating type for delivering fuel under pressure; a floating piston interposed in a passage between the said pump and said fuel injection valve, and adapted to move in response to the initial portion of the fuel delivery stroke of the pump to displace fuel ahead of it to said injection valve; means for limiting reciprocating movement of said floating piston; means for delivering further fuel from said pump to said injection valve after said floating piston has completed its fuel displacing excursion; valve means rendered effective upon the displacing movement of said floating piston to deliver fuel under pressure from said pump to said fluid pressure operated loading means; and means controlled at least in part by said floating piston for dissipating the pressure acting on said loading means.

BERNHARD BISCHOF.

CERTIFICATE OF CORRECTION.

Patent No. 2,173,813. September 19, 1939.

BERNHARD BISCHOF.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, first column, line 19, claim 16, for the word "injector" read injection; line 50, claim 18, strike out "of"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 10th day of October, A. D. 1939.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

menting the closing bias of said valve; a fuel pump of the reciprocating type for delivering fuel under pressure; a floating piston interposed in a passage between the said pump and said fuel injection valve, and adapted to move in response to the initial portion of the fuel delivery stroke of the pump to displace fuel ahead of it to said injection valve; means for limiting reciprocating movement of said floating piston; means for delivering further fuel from said pump to said injection valve after said floating piston has completed its fuel displacing excursion; valve means rendered effective upon the displacing movement of said floating piston to deliver fuel under pressure from said pump to said fluid pressure operated loading means; and means controlled at least in part by said floating piston for dissipating the pressure acting on said loading means.

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