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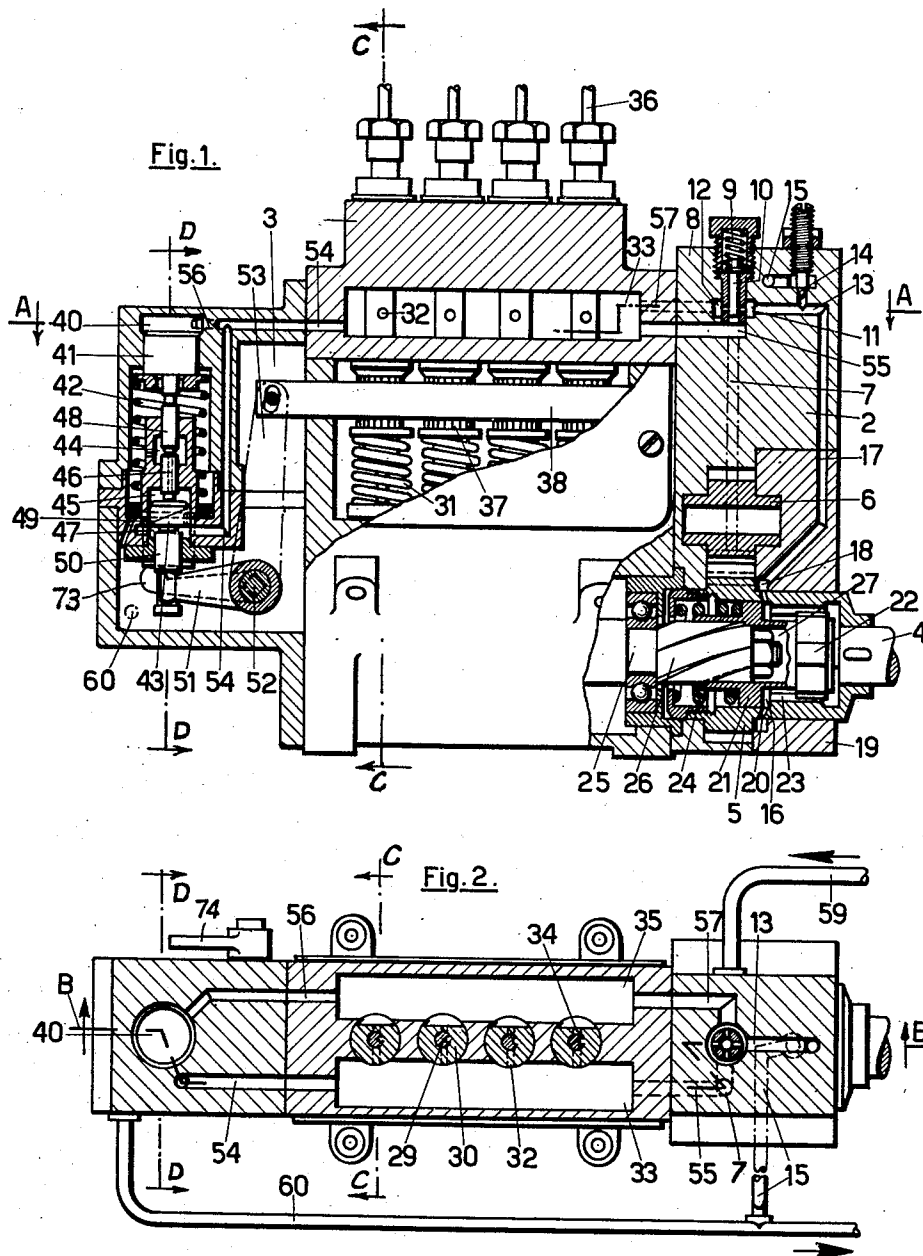
E. SCHAEREN

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FUEL INJECTION APPARATUS

Filed Aug. 31, 1937.

2 Sheets-Sheet 1



Inventor:

Amstschauer

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Fig. 3.

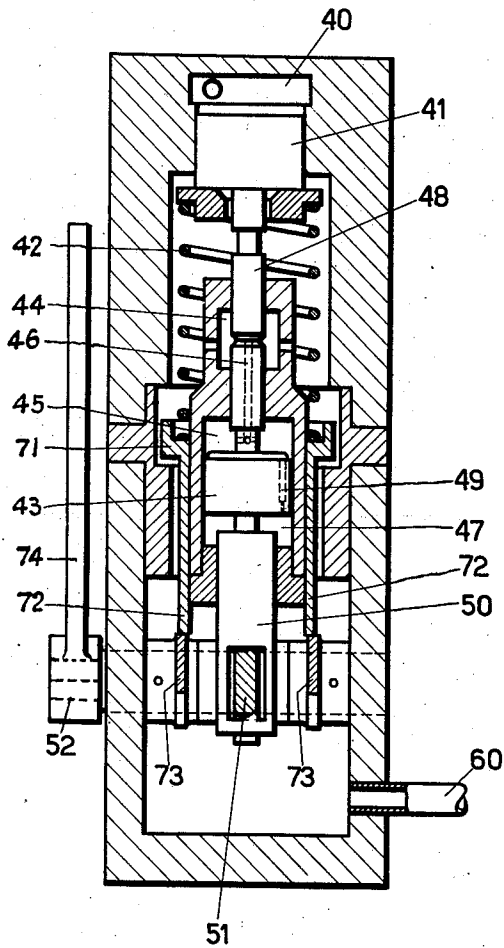
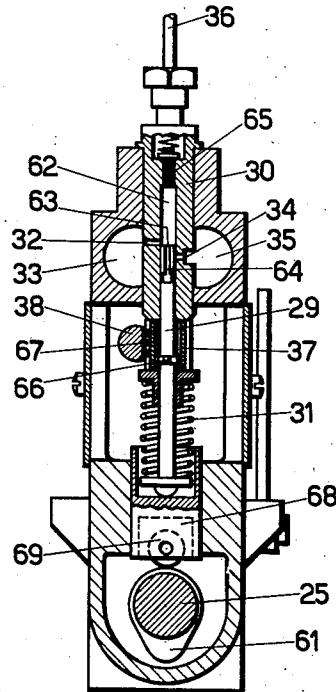


Fig. 4.



Inventor
Ernst Schaearen

3y

Dodge & Sons
Attorneys

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FUEL INJECTION APPARATUS

Ernst Schaeren, Soleure, Switzerland, assignor to
Scintilla, Ltd., Soleure, Switzerland, a corpora-
tion of Switzerland

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10 Claims. (Cl. 123—139)

My invention relates to fuel injection apparatus especially for internal combustion engines and more particularly to such apparatus comprising in combination an injection pump, a feeding pump adapted for supplying fuel to the latter, and governing means influenced by the pressure of fuel supplied by the said feeding pump.

One of the objects of my invention is to provide a neat and compact arrangement of the said elements of the apparatus, so that the latter may be used also under restricted space conditions.

A further object of my invention is to provide an apparatus of the said kind in which at least some of the external piping and linkage necessary for connecting the said elements to each other could be dispensed with, said external piping and linkage being liable to be damaged.

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, and 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 or proportions set forth, or to the particular type of the said elements herein described, as they may be elected and 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 utilized.

In the accompanying drawings,

Fig. 1 shows, partly in longitudinal section on the line B—B of Fig. 2, a fuel injection apparatus comprising an injection pump, a feeding pump, and regulating means.

Fig. 2 is a horizontal section on the line A—A of Fig. 1.

Fig. 3 is a vertical cross section on the lines D—D of Figs. 1 and 2 and shows part of the regulating means at a larger scale.

Fig. 4 is a vertical cross section on the lines C—C of Figs. 1 and 2 to show the working parts of the injection pump.

The injection pump 1 may be of any suitable construction and is represented as a 4-cylinder piston pump of usual design. In each cylinder 30 a piston 29 is moved upwards by a cam 61 on the cam shaft 25 and downwards by the spring 31, a guided pusher 68 provided with a roller 69 being interposed between the cam 61 and the foot of piston 29. The working chamber 62 within the cylinder 30 communicates with the fuel supply chamber 33 through a port 32 controlled by the

top edge 63 of the piston 29, and with a by-pass chamber 35 through another port 34 controlled by the spiral cut-off edge 64 of the said piston. An injection conduit 36 leads from the working chamber 62 through a non-return valve 65 to an injection device not represented in the drawings. The piston 29 has a cross guide 66 engaging longitudinal slots 67 of the gear wheel 37 so as to be angularly coupled with the latter though free to be reciprocated in an axial direction. A longitudinally displaceable rack 38 meshes the gear wheels 37 of all cylinders of the pump. During the upward or displacing stroke of the piston 29, the inlet port 32 is closed by the top edge 63 of the piston; then fuel is delivered from the working chamber 62, through the non-return valve 65 and the injection conduit 36. When the cut-off edge 64 uncovers the by-pass port 34, pressure is released in the working chamber 62 and the fuel delivery through the conduit 36 ceases. The edge 64 being spiral, the time at which the by-pass port 34 is uncovered, and consequently the useful delivery stroke of the piston 29 and the quantity of fuel displaced from the working chamber 62 into the conduit 36 vary according to the angular position of the said piston. The said angular position may be modified by longitudinally displacing the described rack 38, and it will be assumed that a displacement thereof to the left (as shown in Figs. 1 and 2 of the drawings) causes a diminution of the fuel quantity delivered to the conduits 36 for being injected.

The precise formation and porting of the cylinder 30 and piston 29 are not claimed herein and are illustrated merely as one acceptable known arrangement and to facilitate a comprehension of how fuel delivery may be controlled through the shifting of rack 38.

The feeding pump 2 in which also an injection timing device is incorporated is affixed to the drive end of the injection pump 1, whilst the governor 3 provided for adjusting the fuel quantity delivered by the injection pump is affixed to the other end of the latter. The shaft 4 which drives the injection pump 1 and at the same time the feeding pump 2 is positively driven by the internal combustion engine in a way not represented. A gear wheel 5 is keyed to the shaft 4 and meshes with a second gearwheel 6 rotatably supported in the casing 8 and the cover piece 19. Both said gearwheels form a gearwheel pump adapted to displace fuel arriving through a conduit 59 from a tank not shown in the drawings, into the duct 7 provided in the casing 8. The duct 7 is connected to the fuel supply chamber 33 of the pump

by means of the passage 55 and leads to a cylinder in which a piston 10 loaded by a spring 9 by the edge of its face controls the cross-section of outlet ports 11 so as to keep the fuel pressure in the duct 7 substantially constant. The outlet ports 11 issue into an annular chamber 12 which is connected by a passage 57 to the by-pass chamber 35 of the injection pump 1 and by a passage 13 to the adjustable throttling opening 14. From the latter a return conduit 15 joins the collecting line 60 which leads back to the fuel tank in a way not shown in the drawing. Through the duct 17 and the annular groove 18 in the cover piece 19 and through the ports 20 in the hub of the displacement gearwheel 5, the passage 13 also communicates with the cylinder 16 formed in the said hub. The cylinder 16 is fitted by an adjusting piston 21, the dogs 22 of which engage grooves 23 provided in the hub wall and running parallel to the axis of the latter. A spring 24 abutting the adjusting piston 21 counteracts the fuel pressure in the space 16. The drive end of the camshaft 25 of the injection pump 1 carries a bushing 26 provided with a high pitch male thread which engages a corresponding female thread in the bore 27 of the piston 21.

The governor 3 comprises a control cylinder 40 containing a piston 41 acted upon by a spring 42 whose abutment cup 71 has feet 72 supported each by a lever 73 fixed to the shaft 52. By means of the external lever 74, the shaft 52 may be rocked at will to displace the abutment cup 71 for adjusting the force of the spring 42. Through a passage 56, the control cylinder 40 communicates with the by-pass chamber 35 of the injection pump 1. Coaxial to the control cylinder 40 there is a servomotor cylinder containing a piston 43 which separates two spaces 45 and 47 in the said servomotor cylinder. The space 47 communicates with the fuel supply chamber 33 of the injection pump 1 through a conduit 54 and with the space 45 through a restricted passage 49 in the piston 43. The latter carries an extension provided with a longitudinal bore 46 which is connected by lateral ports to the chamber 45 and issues in the space 44.

Through the space surrounding the spring 42 and suitable connecting passages, the space 44 communicates with the collecting sump formed in the bottom of the governor casing and connected to the collecting line 60 which leads back to the fuel tank. The issue of the passage 46 in the space 44 cooperates with the face of an extension 48 of the control piston 41 so as to form a restricted opening the cross-section of which depends on the relative position of the pistons 41 and 43. The rod 50 of the piston 43 engages the arm 51 of a bell-crank lever rotatably supported on the shaft 52; the other arm 53 of this lever is linked to the rack 38.

The fuel quantity displaced in a given time into the passage 7 by the wheels 5, 6 of the feeding pump increases with the speed of the internal combustion engine. One part of this fuel quantity flows into the fuel supply chamber 33 of the injection pump 1 and thence is drawn into the cylinders 30; the remainder leaves through the outlet ports 11 which are uncovered by the edge of the piston 10 so far as it is necessary in order that the fuel pressure in the duct 7 which also acts upon the piston 10 may counterbalance the force of the spring 9. The fuel pressure in the duct 7, which also prevails in the suction chamber 33 of the injection pump and in the chamber 47 of the servomotor cylinder in the governor, there-

fore remains approximately constant. The fuel quantity leaving in the unity of time through the outlet ports 11 and the throttling opening 14, and therefore the fuel pressure in the passage 13, in the cylinder 16 of the injection timing device, in the by-pass chamber 35 of the injection pump and in the control cylinder 40 of the governor 3 increase with the speed of the internal combustion engine. As it increases, the pressure in the cylinder 16 displaces the adjusting piston 21 of the injection timing device against the force of the spring 24, so that by means of the high pitch thread the bushing 26 together with the camshaft 25 carrying it are rotated with reference to the gearwheel 5 and the driving shaft 4, to which the latter is keyed, and the injection is caused to take place earlier in the working cycle of the internal combustion engine.

In the governor 3 a part of the fuel delivered by the feeding pump flows back to the fuel tank from the space 47 through the restricted passage 49, the space 45, the passage 46 and the space 44. If the speed of the internal combustion engine rises so high that the fuel pressure in the control cylinder 40 is able to overcome the force adjusted at the spring 42, the control piston 41 and its extension 48 will move towards the face containing the issue of the bore 46 of the servomotor piston 43. The throttling effect on the fuel between the said face and that of the extension 48 then increases and causes the fuel pressure in the space 45 to rise, so that the piston 43 is displaced by the excess pressure, draws the rack 38 to the left and diminishes the fuel quantity delivered by the fuel pump into the injection conduits 36. Thus, the internal combustion engine can no more increase its speed of rotation.

What I claim is:

1. Fuel injection apparatus comprising in combination an injection pump body having a fuel supply chamber and a second fuel chamber formed therein, injection pump means in said injection pump body adapted for drawing fuel out of said fuel supply chamber, a feeding pump body having a delivery chamber, an auxiliary chamber, ports connecting said delivery chamber to said auxiliary chamber, and a restricted outlet passage issuing from said auxiliary chamber formed therein, said feeding pump body being affixed to one side of said injection pump body, said delivery chamber in said feeding pump body communicating with said fuel supply chamber in said injection pump body and said auxiliary chamber in said feeding pump body communicating with said second fuel chamber in said injection pump body, feeding pump means in said feeding pump body adapted to pump fuel into said delivery chamber, a pressure regulating device adapted to control said ports in accordance with the pressure in said delivery chamber, a governor body having a servomotor cylinder and a control cylinder formed therein, a servomotor piston slidably fitting said servomotor cylinder so as to bound therein a servomotor chamber, a control piston slidably fitting said control cylinder so as to bound therein a control chamber, said governor body being affixed to the opposite side of said injection pump body, said servomotor chamber communicating with said fuel supply chamber and said control chamber communicating with said second fuel chamber in said injection pump body.

2. Fuel injection apparatus comprising in combination an injection pump body having a fuel chamber formed therein, a feeding pump body having a pressure space and a restricted outlet

issuing from said pressure space formed therein, said feeding pump body being affixed to one side of said injection pump body, said pressure space in said feeding pump body communicating with
 5 said fuel chamber in said injection pump body, pumping means provided in said feeding pump body and adapted to pump fuel into said pressure space, a governor body having a pressure chamber formed therein, said governor body being af-
 10 fixed to the opposite side of said injection pump body, said pressure chamber in said governor body communicating with said fuel chamber in said injection pump body.

3. The combination of a fuel pump for deliver-
 15 ing measured charges of liquid fuel to an engine; a member shiftable to vary the quantity delivered per charge; a fluid pressure operated servomotor for shifting said member; a fluid pressure respon-
 20 sive controller for said servomotor; a drive shaft adapted to be driven in timed relation by the engine and arranged to drive said pump; a booster pump driven by said drive shaft; connec-
 25 tions for supplying liquid fuel to said booster pump; two flow restricting means arranged in series to develop two back pressures on liquid fuel discharged by said booster pump, and so arranged
 30 that one back pressure is substantially constant and the other varies with the speed of said booster pump; a connection for causing said variable back pressure to react on said controller; and connections for delivering fuel under said
 35 constant back pressure to said fuel pump and as motive pressure fluid to said servomotor.

4. The combination defined in claim 3 in which
 35 a substantially unitary body is afforded by three closely connected housings, one of which houses the fuel pump, another houses the servomotor with its controller, and the third houses the
 40 booster pump; and all pressure fluid flow passages between the recited elements are formed as ports internal to said unitary body.

5. The combination with the structure of claim 3 of yielding loading means for the servomotor controller; and operator-operated means for
 45 variably stressing said loading means.

6. The combination of a fuel pump for deliver-
 50 ing measured charges of fuel to an engine; a member shiftable to vary the quantity delivered per charge; a fluid pressure operated servomotor for shifting said member; a fluid pressure oper-
 55 ated controller for said servomotor; a driving shaft arranged to be driven by the engine in timed relation thereto; fluid pressure operated timing means forming an adjustable operating connection between said driving shaft and said pump; a booster pump driven by said driving shaft and connected to supply fuel under pressure

to said fuel pump, and to said servomotor; a loaded vent valve for holding a substantially uni-
 5 form back pressure on fuel delivered by said booster pump regardless of changes of speed thereof; flow restricting means beyond said vent valve for retaining a back pressure which in-
 10 creases with speed of said booster pump; and means for subjecting said servomotor controller and said timing means to the last named back pressure.

7. The combination defined in claim 6 in which
 10 the recited instrumentalities are housed in a substantially unitary housing, and all pressure chambers and flow connections for fluid under pressure between said instrumentalities are wholly
 15 within said housing.

8. The combination defined in claim 6 in which
 20 a substantially unitary body is afforded by three closely connected housings, one of which houses the fuel pump, another the servomotor with its controller, and the third the booster pump, and the timing means; and all pressure fluid flow passages between the above recited elements are
 25 formed as ports in said unitary body.

9. The combination of a fuel pump for deliver-
 25 ing measured charges of liquid fuel to an engine; a member shiftable to vary the quantity delivered per charge; a fluid pressure operated servomotor for shifting said member; a fluid pressure re-
 30 sponsive controller for said servomotor; a drive shaft adapted to be driven in timed relation by the engine; a fluid pressure responsive timer forming an adjustable driving connection between said
 35 shaft and pump; a booster pump driven by said drive shaft; connections for supplying liquid fuel to said booster pump; two flow restricting means in series arranged to develop two back pressures on liquid fuel discharged by said pump and so
 40 arranged that one back pressure is substantially constant and the other varies with the speed of the booster pump; connections for causing the variable back pressure to actuate said timer and said controller; and connections for causing the
 45 constant back pressure to cause delivery of fuel to said fuel pump, and to said servomotor.

10. Fuel injection apparatus comprising in com-
 45 bination an injection pump having a fuel supply chamber and a subsidiary fuel chamber; a feed-
 50 ing pump affixed to one face of the said injection pump for supplying liquid fuel under different pressures both to said fuel supply chamber and to said subsidiary fuel chamber; a regulating de-
 55 vice affixed to the opposite face of the injection pump; and displaceable means in said regulating device acted upon by the pressures of the liquid fuel in said supply and subsidiary chambers.

ERNST SCHAEAREN.