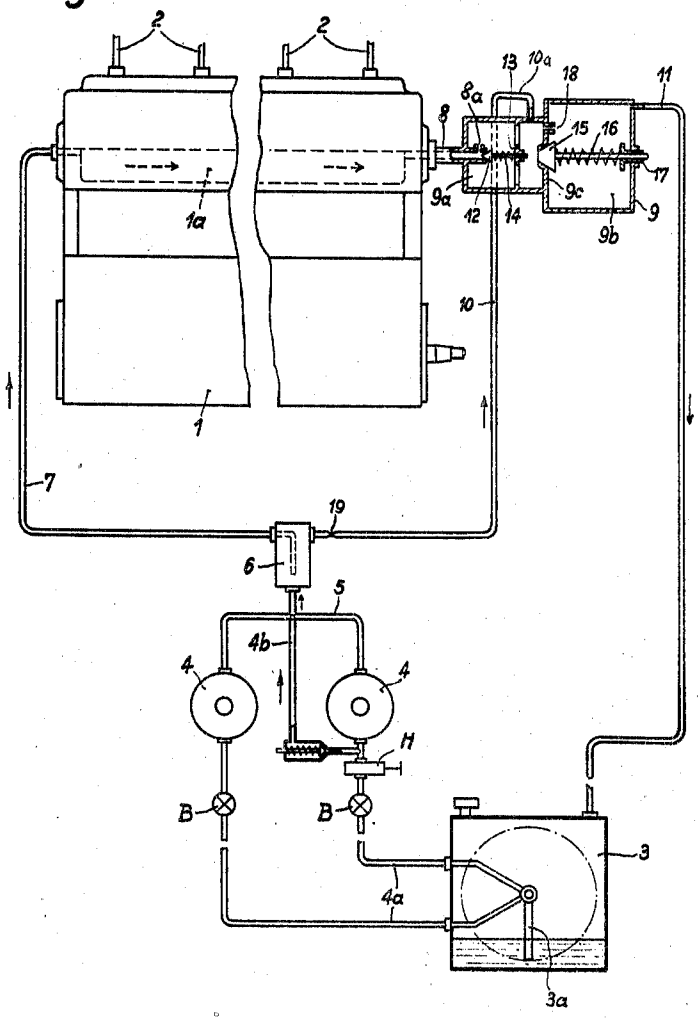
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FUEL DELIVERY APPARATUS FOR INJECTION INTERNAL COMBUSTION ENGINES

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Fig. 1



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Fig. 2

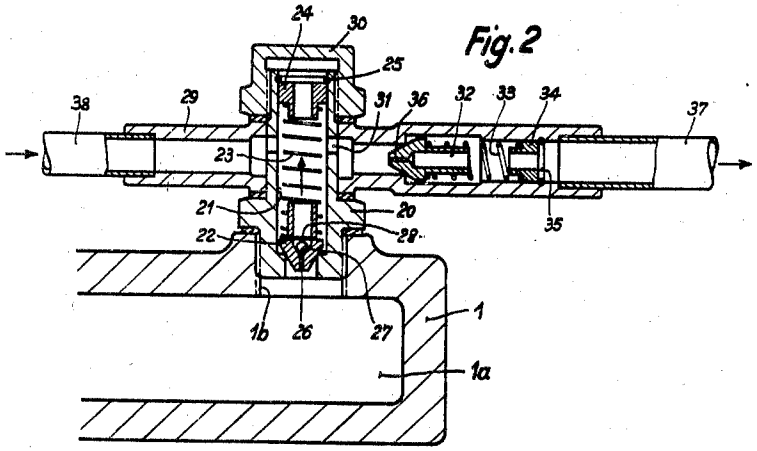
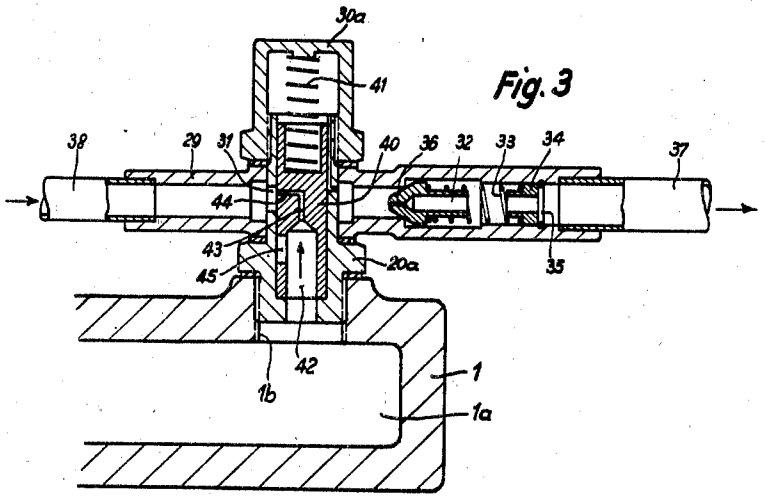


Fig. 3



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FUEL DELIVERY APPARATUS FOR INJECTION INTERNAL COMBUSTION ENGINES

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7 Claims. (Cl. 103—5)

The present invention relates to fuel delivery apparatus for injection internal combustion engines of the type which includes at least one hand pump which is operated before the engine is started to fill up all the chambers and pipes which convey fuel to the engine and wherein air which is displaced on manual pumping to the space between a non-return or back pressure valve and an overflow valve by-passes the overflow valve and is discharged into the overflow pipe.

Since the non-return or back pressure valve provided at the outlet of the suction chamber of the injection pump opens the passage to the space between the two valves when a flow commences from the suction chamber in a direction towards the space between the valves, it is possible, on manual pumping, for fuel to pass into the space between the two valves and fill this space before all the air has been drawn out of the suction chamber of the injection pump.

Now in order to ensure the undisturbed withdrawal of all the air accumulating in the suction chamber during filling up with fuel, the by-pass of the overflow valve according to the present invention, offers no resistance worth mentioning to the air displaced, on hand pumping, from the suction chamber which has not yet been filled with fuel, but, on the other hand, offers such a high resistance to the discharge of fuel, especially to the discharge, towards the space between the two valves, of the fuel delivered in excess during the running of the engine that the pressure in the suction chamber can become large enough to open the overflow valve.

The invention is more particularly described with reference to the accompanying drawings which show three forms of construction by way of example and in which:

Figure 1 is a diagrammatic view of the layout of a fuel delivery plant with an air separator, the casing enclosing non-return or back pressure valve and the overflow valve being shown in longitudinal section.

Figures 2 and 3 show in horizontal sections through the non-return and overflow valves the second and third forms of construction.

In the construction according to Figure 1 a multi-cylinder injection pump 1, is connected by pressure pipes 2 to the injection nozzles (not shown) of an internal combustion engine. A fuel supply container 3 remote from the injection plant is connected through cut-off cocks B with two delivery pumps 4, which take fuel from the container in all operating positions through the pipe 4a by means of a pivoted pipe 3a. Each of the two delivery pumps 4 delivers somewhat more fuel than is taken at full load setting from the suction or inlet chamber 1a, of the multi-cylinder injection pump. In the right hand suction pipe 4a of the delivery pump 4 there is disposed a hand or other manually operated pump H. The suction pipe 4a of the delivery pump 4 is in communication through a pipe 4b with the pressure pipe 5. In the pipe 4b is disposed a reverse pumping valve open towards the pressure pipe 5 and having small preliminary tension. The pressure pipe 5 opens into an air separator 6, the inner chamber of which is connected through the pipe 7 with the suction chamber 1a of the injection pump.

At the highest point in and on that side of the suction chamber 1a which is remote from the mouth of the pipe 7, an overflow pipe 8 branches off into a valve casing 9, the internal space of which is divided by a separating wall 9c into left and right hand chambers 9a, 9b. A pipe 11 branching off from the highest point of the chamber 9b leads back to the supply container 3.

The overflow pipe 8 of the suction chamber 1a of the injection pump projects into the chamber 9a of the casing 9, and at its point of outlet into this chamber there is arranged a non-return or back pressure valve 12, the spindle of which is guided in a ring 13 provided with passage openings. A weak spring 14 tends to keep the non-return valve closed.

In the wall 9c separating the two chambers 9a and 9b there is provided a second opening which an overflow valve 15 tends to keep closed. The pressure at which the valve 15 opens is determined by the tensioning of a spring 16, which abuts on an externally adjustable screw 17.

In the upper part of the separating wall 9c, there is provided a small throttle bore 18, which by-passes the over-flow valve 15. A pipe 10 interconnects the upper part of the air separator 6, and the upper part of the chamber 9a of the valve casing 9. With this arrangement, the highest point 10a of the pipe 10 is situated above the highest point of the suction chamber 1a of the injection pump. In the upper portion of the wall of that end of the pipe 8 projecting into the chamber 9a, there is provided a narrow throttle bore 8a.

In the manual pumping operation the level of fuel in the pipe 7 and in the suction chamber 1a, rises uniformly with that in the pipe 10. Since

the highest point of the suction chamber is situated lower than the highest point of the pipe 10, the suction chamber first fills up completely, before the pipe 10 has been filled with fuel. The air displaced from the suction chamber during this filling can flow away through the throttle bore 8a and 18 without any resistance worth mentioning. As soon as the suction chamber has been filled with fuel however, then, on continuation of hand pumping, the fuel level also rises, in the pipe 10a, until finally fuel flows both through the non-return valve 12 and the pipe 10, 10a into the chamber 9a, and displaces the air enclosed therein towards the pipe 11 through the throttle element 18. Only when the chamber 9a has been completely filled with fuel, does the delivery pressure of the hand pump rise considerably, and enable the complete removal of air from all the spaces in the fuel system to be recognized.

The resistance which that part 10a of the pipe 10, which is situated above the highest point in the suction chamber, during operation opposes the escape of air from the separator is substantially smaller than that resistance which the excess fuel overflowing from the suction chamber of the injection pump towards the chamber 9a encounters by virtue of the throttle 8a and the non-return valve 12.

After the fuel pipe system has been freed from air, the internal combustion engine is started up. When the engine is running, the delivery pumps 4 force fuel in excess of requirements through the pipe 7 towards the suction chamber 1a of the injection pump. From there, the superfluous portion of the fuel flows into the chamber 9a as soon as the pressure reached in the suction chamber is able to open the non-return valve 12. From there, together with the air flowing out of the separator through the pipe 10, it flows back through the overflow valve 15, which is previously tensioned to suit the desired pressure in the suction chamber of the pump, and through the pipe 11 back to the container.

In order to eliminate the possibility on the operation of the internal combustion engine, of the two delivery pumps 4 forcing the main part of the delivery amount into the chamber 9a through the by-pass 10 instead of through the suction chamber 1a and the non-return valve 12, a throttle element 19 may be provided in the pipe 10 as a substitute for or as an addition to the resistance in the pipe, effected by the higher portion 10a thereof.

In the modification according to Figure 2, a hollow hexagonal nipple 20 is screwed in a threaded bore 1b, on the side of the pump casing of the injection pump and opening at the highest point of the suction or inlet chamber 1a, the axial bore 21 of which nipple is somewhat narrowed at the point where it is screwed into the bore 1b. In the axial bore 21 there is accommodated a non-return valve 22, for which the constricted bore of the hexagonal nipple provides a seat. A spring 23 tending to press the non-return valve on to the seating formed by the constricted bore abuts against a ring 24 provided in the other end of the axial bore, which ring is maintained in position by a snap ring 25. The non-return valve itself is longitudinally bored, a section of which longitudinal bore is constructed as a narrow throttle 26. In a tapered and wider section of this longitudinal bore is accommodated a ball valve 27, which is prevented from falling out of the longitudinal bore by a cross pin 28.

Over the free, externally threaded, end, of the hexagonal nipple 20, there is pushed the central part, which is extended to form a boss, of a pipe 29, which is secured by a screw cap 30 to the hexagonal surface of the nipple 20. The interior of the pipe 29 is connected by cross bores 31 with the axial bore of the nipple 20. The axial bore of the right hand branch of the pipe 29 contains the overflow valve 32, which is tensioned by a spring 33, in the same manner as the non-return valve 22. The spring tends to press the valve 32 on to the constricted axial bore of the right hand portion of the pipe 29. In a longitudinal bore in the overflow valve 32, there is provided as in the case of the valve 22, a very narrow throttle 36. To the right hand branch of the pipe, there is attached a flexible pipe 37 leading to the supply container 3. To the left hand branch of the pipe there is attached one end of another flexible pipe 38, of which the other end is attached to the upper part of the air separator 6.

When the pipe system is being filled up by means of the hand pump, the air driven out of the suction chamber of the injection pump opens the small ball valve 27, so that the air is conducted through the throttle bore 26 of the closed non-return valve 22 towards the axial bore 21 in the nipple, and from the latter, together with the air escaping from the separator through the flexible pipe 38, through the throttle bore 36 of the valve 32, which is likewise closed at this stage, and thence towards and through the flexible pipe 37. During running of the engine the non-return valve 22, which has been pre-tensioned to a relatively small pressure, and the overflow valve 32 which is pre-tensioned to a relatively higher pressure, have the same action as the corresponding valves in the construction shown in Figure 1, which together maintain the pressure in the suction chamber at the desired height. As soon as a flow directed towards the suction chamber is likely to commence from the flexible pipe 38 conveying the air from the separator, the ball 27 closes the throttle element 26, so that no accumulation of air in the nipple 20, can reach the suction chamber of the injection pump.

The example shown in Figure 3 differs from that in Figure 2 solely in that in the axial bore of the nipple 20a screwed into the casing of the injection pump, there is provided instead of the valve 22 shown in Figure 2, a piston 40, of which the end facing the suction chamber 1a is seated in the position shown on a projection in the axial bore of the nipple. A spring 41 abuts with one end on the part of the piston remote from the suction or inlet chamber 1a, and with the other end on a cap nut 30a which holds the connecting pipe 29 for the flexible pipes 37, 38 firmly on the nipple and seals it. The part of the piston directed towards the suction chamber is axially bored at 42, from which there leads a throttle 43 which is in communication with a radial bore 44 in the piston which extends to its outer periphery. In the position of the piston as shown the bore 31 provided in the wall of the nipple 20a is situated opposite to the outlet point of the radial bore 44. A wide cross bore 45 branching off from the axial bore 42 in the piston opens below the radial bore 44 of the piston, and in the position shown is covered by the inner wall of the nipple 20a.

When the manually operated pump is being used, the air pushed out of the pipes and out of the suction chamber, in that position of the pis-

ton as shown wherein the spring is substantially relaxed, passes through the bores **42**, **43**, **44** into the pipe **29**, from where it can reach the supply container **3** through the throttle bore **36** of the overflow valve. As soon as all the air has been driven out of the suction chamber by the fuel, and the pressure in the suction chamber is rising, the piston **40** is raised against the action of the spring, and the throttle **43** is covered by the inner wall of the nipple **28**. When the delivery pumps are operated during running of the engine, then should the pressure in the suction chamber rise to the full working pressure the bore **45** will open so that fuel can flow from the suction chamber to the supply container.

In contrast with the example in Figure 1, the pipe **10** may likewise be made to open into the lower part of the chamber **9***a*, and the elevating of the pipe (see **10***a*) above the highest point of the suction chamber **1***a* may thus be discarded, if a non-return valve is arranged in the pipe **10**. If there were no throttle element **19**, the opening pressure of this valve would have to be so proportioned as to be larger than the resistance which the throttle member **8***a* in Figure 1 or **26** in Figure 2, or **43**, **44** in Figure 3, opposes to the efflux of air from the suction chamber on hand pumping. On the other hand, however, the opening pressure of this valve would have to be smaller than the resistance which the throttle member **8***a*, or **26** or **43**, **44**, respectively, together with the non-return valve **12** (Figure 1), or **22** (Figure 2), or **40** (Figure 3), respectively opposes to the discharge of the superfluous fuel from the suction chamber.

We declare, that what we claim is:

1. The combination, in a fuel delivery apparatus for internal combustion engines, comprising a delivery pump, an injection pump, an air separator disposed therebetween, a pipe line through which air-freed fuel is conveyed from said separator to an inlet chamber of the injection pump, a manually operated pump, a supply container, and a pipe connection permitting delivery of fuel by said delivery pump or said manually operated pump from said supply container to said air separator, of a return system including a non-return valve and a return pipe through which superfluous quantities of fuel flow from said inlet chamber back to the supply container, a second pipe by-passing said inlet chamber and said non-return valve for delivery of air and excess fuel from said separator to said return system, an overflow valve and a restricted connection disposed in said return system between the junction of said second pipe therewith and said supply container, said overflow valve being more strongly pretensioned than said non-return valve, said restricted connection by-passing said overflow valve and offering substantially no resistance to the flow of air but offering relatively high resistance to the flow of fuel, and a restricted by-pass for the non-return valve which offers substantially no resistance to the flow of air but which offers a relatively high resistance to the flow of fuel.

2. The combination as set out in claim 1 including an additional non-return valve located in said restricted by-pass for the first non-return valve which opens at the smallest increase of pressure in said inlet chamber in front of the restricted by-pass as compared with the pressure in the space in rear thereof.

3. The combination as set out in claim 1 wherein the restricted by-pass is disposed in a movable part of the non-return valve, said restricted by-pass being controlled by a second non-return valve which opens in a direction towards the space between the first non-return valve and the overflow valve.

4. The combination as set out in claim 1 in which said second pipe has a restriction therein such as to offer little resistance to the free flow of separated air from said separator but offering a substantial resistance to the efflux of fuel from the separator which is greater than the resistance which the fuel encounters on its way through the inlet chamber of the injection pump towards the space situated between the non-return and overflow valves.

5. The combination as set out in claim 1 wherein the separator is located in a position lower than the inlet chamber of the injection pump, and wherein a section of the second pipe connecting the air separator and the space between the non-return and overflow valves is disposed higher than the highest point of the inlet chamber of the injection pump and of the feed pipe thereof.

6. The combination, in a fuel delivery apparatus for internal combustion engines, comprising a fuel delivery pump, an auxiliary manually operated fuel delivery pump, a fuel supply container, an air separator, piping permitting delivery of fuel by said pumps from said supply container to said air separator, an injection pump having a fuel inlet chamber, and a pipe connected to the lower part of said air separator and leading to the inlet chamber of said injection pump, of a return conduit connecting said inlet chamber with said supply container for return flow of superfluous quantities of fuel from said inlet chamber to said supply container, a second pipe beginning in the upper part of said air separator and leading into said return conduit, said second pipe having a higher resistance to flow of fuel than said first pipe and inlet chamber, a non-return valve arranged in said return conduit between the supply container and the junction of said second pipe with said return conduit, said non-return valve opening in the direction of return flow of fuel in said return conduit, a restricted connection in said return conduit which by-passes said non-return valve and which offers a relatively high resistance to the flow of fuel but substantially no resistance to the flow of air, and a passage which connects the upper part of the inlet chamber with said return conduit, said passage having a restricted cross-section which offers a relatively high resistance to the flow of fuel but substantially no resistance to the flow of air.

7. The combination, in a fuel delivery apparatus for internal combustion engines, comprising a fuel delivery pump, an auxiliary manually operated fuel delivery pump, a fuel supply container, an air separator, piping permitting delivery of fuel by said pumps from said supply container to said air separator, an injection pump having a fuel inlet chamber, and a pipe connected to the lower part of said air separator and leading to the inlet chamber of said injection pump, of a return conduit connecting said inlet chamber with said supply container for return flow of superfluous quantities of fuel from said inlet chamber to said supply container, a second pipe beginning in the upper part of said air separator and leading into said return conduit, said second pipe having a higher resistance to flow of fuel than said first pipe and inlet chamber, a non-return valve arranged in said return conduit between the supply

container and the junction of said second pipe with said return conduit, said non-return valve opening in the direction of return flow of fuel in said return conduit, a restricted connection in said return conduit which by-passes said non-return valve and which offers a relatively high resistance to the flow of fuel but substantially no resistance to the flow of air, a passage which connects the upper part of the inlet chamber with said return conduit, and a non-return valve in said passage and which opens in the direction of return flow of fuel in said return conduit, said second non-return valve being very weakly loaded as compared to the loading of the first-mentioned non-return valve.

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