Sept. 11, 1934. H. C. GILL 1,973,146

FUEL INJECTION APPARATUS FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 1, 1933 2 Sheets-Sheet 1

Fig. 1.

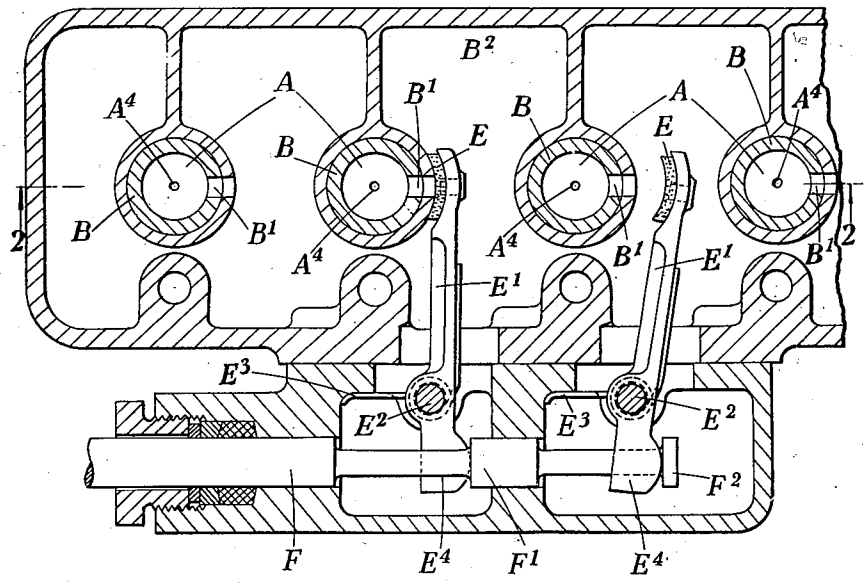

Fig. 2.

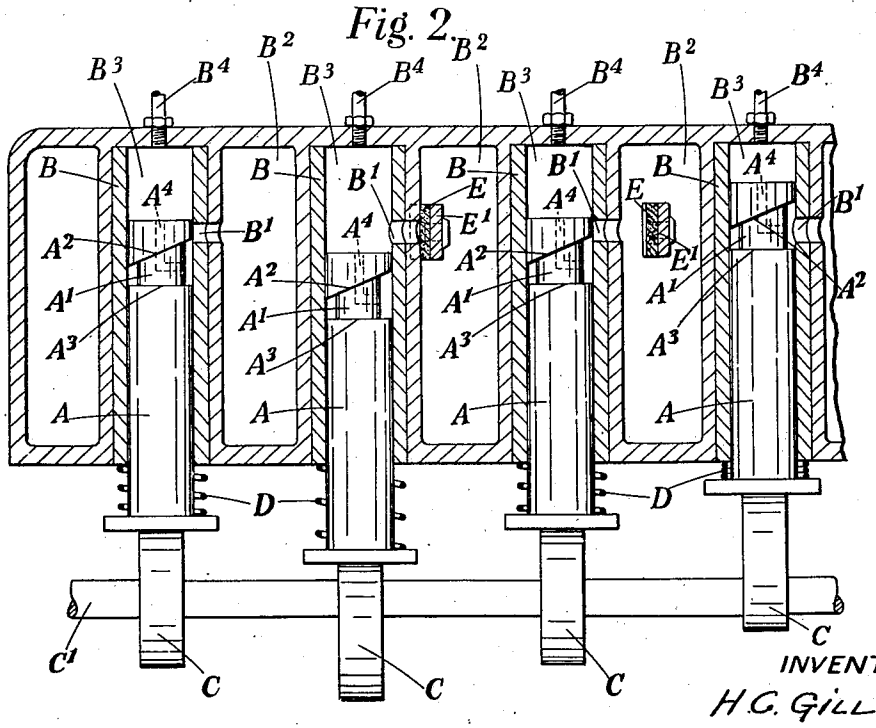

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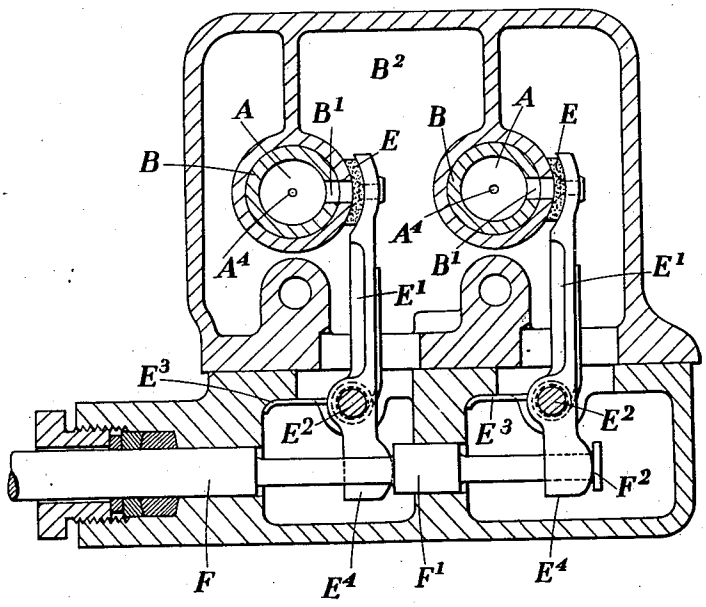
Fig. 3.



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FUEL INJECTION APPARATUS FOR INTERNAL COMBUSTION ENGINES

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In Great Britain December 14, 1932

15 Claims. (Cl. 103—41)

This invention relates to fuel injection apparatus for internal combustion engines of the solid fuel injection type in which fuel in liquid form is delivered to the engine cylinder by a pump to the pressure chamber of which the fuel passes through one or more combined inlet and relief ports, that is to say a port or ports which serve not only to admit fuel to the pressure chamber during suction strokes but are also opened during a part or parts of each delivery stroke to permit discharge from the pressure chamber of any fuel in excess of that required for injection so as to render inoperative such part or parts of this stroke.

In fuel injection apparatus of the above kind according to the present invention a valve device for rendering the pump inoperative is provided which, in its open position, permits free flow of fuel to and from the pressure chamber of the pump through the combined inlet and relief port or ports so that the pump operates normally, and in its operative or closed position prevents flow of fuel through the port or ports into the pressure chamber of the pump but permits excess fuel to flow from the said pressure chamber through the port or ports.

The invention is particularly, though not exclusively, applicable to fuel injection apparatus for engines of the multi-cylinder type having two or more fuel pumps of the kind in question either built as a unit or not. In such engines it is sometimes desirable to render one or more of the cylinders inoperative and to operate on the remaining cylinder or cylinders in the normal manner, and to this end a valve device constructed and arranged in the manner according to the present invention may be associated with one or more of the pumps. Further, where two or more of the pumps have such valve devices associated therewith, means are preferably provided for selectively controlling the several valve devices.

Conveniently the valve device or each valve device is resiliently held in its operative or closed position so that it will yield under pressure from within the pressure chamber of the pump, the valve device being preferably in the form of a sealing member carried towards one end of a pivoted lever which is controlled by a spring tending to turn the lever so as to cause the sealing member to cover the port or ports, means being provided for maintaining the valve in the inoperative position against the action of the control spring.

The invention may be applied to fuel pumps of various kinds, for example of the kind in which a series of pumps are formed as a unit or separately, and wherein each pump comprises a plunger which can be reciprocated within a cylinder so that on the suction stroke of the plunger fuel is drawn into the pump cylinder through a combined inlet and relief port in the wall of the pump cylinder, the plunger itself acting as a valve or a separate valve member being provided, which brings the combined inlet and relief port into communication with the pressure chamber of the pump during a part or parts of each delivery stroke, so as to render such part or parts of the stroke inoperative by permitting fuel in the pump cylinder in excess of that required for injection to be returned through the combined inlet and relief port. When the present invention is applied to such an arrangement the combined inlet and relief port of one or more of the pumps is conveniently controlled by a valve device comprising a sealing member adapted to be moved so as to cover or uncover the open mouth of the port.

Two constructions according to this invention are illustrated by way of example and somewhat diagrammatically in the accompanying drawings, in which

Figure 1 is a sectional plan view,

Figure 2 is a sectional side elevation in the plane 2—2 of Figure 1, and

Figure 3 is a similar view to Figure 1 of an alternative construction according to this invention.

In the construction illustrated in Figs. 1 and 2 the fuel injection apparatus comprises four fuel pumps conveniently formed as a unit, each pump being adapted to deliver fuel, for example, to one cylinder of an engine. Each fuel pump comprises a plunger A adapted to be reciprocated within a cylinder B by a cam C on a camshaft C^1, the return movement of the plunger being effected by a spring D. Each cylinder has formed in its wall a combined inlet and relief port B^1 communicating with a fuel supply chamber B^2 to which liquid fuel is adapted to be delivered from a reservoir. Each pump plunger has formed in its circumferential surface in known manner a relief groove or recess A^1 having an upper edge A^2 inclined to the piston axis and a lower edge A^3 lying in a plane normal to the piston axis, each relief recess communicating through a passage A^4 with the pressure chamber B^3 of the pump from which leads a delivery pipe B^4. The pump operates in known manner so that during the initial part of each delivery stroke fuel is forced out through the combined inlet and relief port B^1 until a

point is reached at which the upper end of the plunger A covers this port B^1, whereupon fuel is delivered through the delivery pipe B^4 until the inclined cut-off edge A^2 passes over the combined inlet and relief port B^1 and thus brings the relief recess A^1, and hence the pressure chamber of the pump, into communication through the combined inlet and relief port B^1 with the supply chamber, the length of the effective part of the delivery stroke of the plunger, and hence the quantity of fuel delivered, being variable by rotating the plunger. Fuel is normally drawn into each cylinder so as to substantially fill the pressure chamber of the pump at the end of the suction stroke through the combined inlet and relief port.

In the construction shown in Figures 1 and 2 there is associated with the combined inlet and relief port of two of the pump cylinders, a valve device comprising a sealing member E in the form of a pad of resilient material, i. e. leather or the like, as shown, mounted on the end of a lever E^1 pivoted at E^2. Each lever E^1 is controlled by a spring E^3 which tends to turn it about the pivot E^2 so as to cause the pad of sealing material E to be pressed over the combined inlet and relief port B^1 and thus prevent flow of fuel from the supply chamber B^2 into the pump cylinder B while permitting fuel to flow out of the pump cylinder through the combined inlet and relief port by reason of the pressure of this fuel. The end of each lever E^1 remote from the pad E is forked or provided with a slot as shown at E^4, and through this slot passes an actuating rod F which is freely movable in a direction substantially at right angles to the axis of the pivot E^2. The actuating rod is common to both levers and is provided with two collars F^1, F^2 one of which lies on one side of the forked end of each lever so that when the rod is moved longitudinally in one direction, first one of the levers is engaged by its associated collar F^2 so as to move the valve E into its inoperative position as shown in Figure 1, while further longitudinal movement of the rod causes the collar F^1 to act on the other lever to move it into a corresponding inoperative position.

Thus, when both valve members E are in their inoperative position, all four pump cylinders operate in the normal manner. If then it is desired to cut one or more of the engine cylinders out of operation, the actuating rod F is moved so as to release one or each of the levers E^1 so as to permit it to move under the action of its spring to close the combined inlet and relief port of the associated pump cylinder. If, at the moment when the combined inlet and relief port of the pump cylinder is closed in this manner, the plunger of that pump is in such a position that the pump cylinder contains fuel in excess of that to be injected on its delivery stroke, that quantity of fuel will be discharged through the combined inlet and relief port of the pump since the corresponding valve E^1 will yield under the pressure of the fuel within the pump cylinder. Thus, though the supply of fuel to the pump cylinder from the supply chamber is interrupted, the last delivery stroke of the pump will not inject fuel in excess of the correct quantity. On the succeeding suction stroke of the plunger no fuel will be drawn into the pump cylinder or delivered and the associated engine cylinder will thus be inoperative until the actuating rod F is again moved to move the valve E into its inoperative position.

It will be understood that the pressure of the spring E^3 tending to maintain the valve device in the operative or closed position is small as compared with the pressure necessary to inject the fuel into the engine cylinders, so that there will be no tendency for excess fuel to be injected during the normally inoperative part or parts of the plunger delivery stroke if one of the valve members happens to be closed at a moment when the pump cylinder contains more fuel than that which it is desired to inject on the following plunger stroke.

The actuating rod F may be operated by mechanical, pneumatic or hydraulic means, or where, for example, remote control of the engine is desired, by electrical means. Further, operation of the actuating rod F may be effected automatically as by a governor or other means employed for controlling the engine.

Figure 3 shows a construction generally similar to that shown in Figures 1 and 2 as applied to a two-cylinder fuel pump. The general construction, arrangement and operation of each plunger A, cylinder B, port B^1, valve member E, E^1, E^4 and rod F are similar to those of the corresponding parts in the construction shown in Figures 1 and 2. In the construction shown in Figure 3, however, the collars F^1, F^2 are so spaced on the rod F as to move the two members E^1 into and out of their operative positions simultaneously so that the two pumps can be simultaneously rendered operative or inoperative. Such an arrangement may be employed, for example, where the operating member F is adapted to be actuated by a safety device such as an emergency governor so as to stop the engine in case of emergency.

It is to be understood that the invention may be applied to a single cylinder fuel pump or to multi-cylinder fuel pumps having various numbers of cylinders, one or more of such pump cylinders having apparatus associated therewith according to the present invention, and that where two or more cylinders of a multi-cylinder fuel injection pump have apparatus according to the present invention associated therewith, the valve devices associated with the various cylinders and adapted to render them inoperative may be arranged so as to be capable of being brought into and out of operation simultaneously or in succession.

It is further to be understood that the invention may be applied to fuel pumps of the kind in which two or more combined inlet and relief ports are employed in each cylinder, that is to say in which a valve device, which may be constituted by the pump plunger itself, is furnished with passages or recesses which bring the working chamber of the pump successively into communication with the several combined inlet and relief ports.

What I claim as my invention and desire to secure by Letters Patent is:—

1. Liquid fuel injection apparatus for internal combustion engines including in combination a fuel pump comprising a cylinder having at least one combined inlet and relief port therein and a piston acting not only as a plunger but also as a valve which maintains the combined inlet and relief port open during at least a part of the delivery stroke of the plunger to render such part of the stroke inoperative, and a valve device which in its inoperative position permits free flow of fuel to and from the pressure chamber of the pump through the combined inlet and relief port and in its operative position prevents

flow of fuel through the combined inlet and relief port into the pump pressure chamber but permits excess fuel to flow from the said pressure chamber through the combined inlet and relief port.

2. Liquid fuel injection apparatus for internal combustion engines including in combination two or more fuel injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger within the cylinder and valve means whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, and a valve device associated with at least one of the pumps which valve device in its inoperative position permits free flow of fuel to and from the pressure chamber of the pump through the combined inlet and relief port and in its operative position prevents flow of fuel through the combined inlet and relief port into the pressure chamber but permits excess fuel to flow from the said pressure chamber through the combined inlet and relief port.

3. Liquid fuel injection apparatus for internal combustion engines including in combination two or more fuel injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger within the cylinder and valve means whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, a valve device associated with each of at least two of the pumps, each valve device in its inoperative position permitting free flow of fuel to and from the pressure chamber of the pump through the combined inlet and relief port and in its operative position preventing flow of fuel through the combined inlet and relief port into the pump pressure chamber but permitting excess fuel to flow from the said pressure chamber through the combined inlet and relief port, and means for selectively causing movement of the valves into and out of their operative positions.

4. Liquid fuel injection apparatus for internal combustion engines including in combination two or more fuel injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger within the cylinder and valve means whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, a valve device associated with each of at least two of the pumps, each valve device in its inoperative position permitting free flow of fuel to and from the pressure chamber of the pump through the combined inlet and relief port and in its operative position preventing flow of fuel through the combined inlet and relief port into the pump pressure chamber but permitting excess fuel to flow from the said pressure chamber through the combined inlet and relief port, and a single operating member for the valve devices whereby these valve devices can be moved into and out of their operative positions in succession.

5. Liquid fuel injection apparatus for internal combustion engines including in combination a fuel pump comprising a cylinder having at least one combined inlet and relief port therein and a piston acting not only as a plunger but also as a valve which maintains the combined inlet and relief port open during at least a part of the delivery stroke of the plunger to render such part of the stroke inoperative, a valve device adapted when in its operative position to close the outer end of the combined inlet and relief port, means for resiliently holding the valve device in its operative position, and means for moving the valve device into its inoperative position.

6. Liquid fuel injection apparatus for internal combustion engines including in combination two or more injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger within the cylinder and valve means whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, a valve device adapted when in its operative position to close the outer end of the combined inlet and relief port, means for resiliently holding the valve device in its operative position, and means for moving the valve device into its inoperative position.

7. Liquid fuel injection apparatus for internal combustion engines including in combination two or more injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger disposed within the cylinder and acting also as a valve whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, a valve device associated with each of two or more pump cylinders and adapted when in its operative position to cover the outer end of its associated combined inlet and relief port, means for resiliently maintaining the valve device in its operative position, and a single operating member whereby the valve devices can be moved in succession out of their operative positions.

8. Liquid fuel injection apparatus for internal combustion engines including in combination two or more fuel injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger within the cylinder and valve means whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, and a valve device associated with at least one of the pumps which valve device in its inoperative position permits free flow of fuel to and from the pressure chamber of the pump through the combined inlet and relief port and in its operative position prevents flow of fuel through the combined inlet and relief port into the pressure chamber but permits excess fuel to flow from the said pressure chamber through the combined inlet and relief port, each valve device comprising a pivoted lever, a sealing device carried towards one end of the lever and adapted to cover the combined inlet and relief port, and a spring tending to turn the lever so as to cause the sealing member to cover such port.

9. Liquid fuel injection apparatus for internal combustion engines including in combination two or more fuel injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger within the cylinder and valve means whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, a valve device associated with each of at least two

of the pumps, each valve device in its inoperative position permitting free flow of fuel to and from the pressure chamber of the pump through the combined inlet and relief port and in its operative position preventing flow of fuel through the combined inlet and relief port into the pump pressure chamber but permitting excess fuel to flow from the said pressure chamber through the combined inlet and relief port, and a single operating member for the valve devices whereby these valve devices can be moved into and out of their operative positions in succession, each valve device comprising a pivoted lever, a sealing device carried towards one end of the lever and adapted to cover the combined inlet and relief port, and a spring tending to turn the lever so as to cause the sealing member to cover such port.

10. Liquid fuel injection apparatus for internal combustion engines including in combination two or more injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger disposed within the cylinder and acting also as a valve whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, a valve device associated with each of two or more pump cylinders and adapted when in its operative position to cover the outer end of its associated combined inlet and relief port, means for resiliently maintaining the valve device in its operative position, and a single operating member whereby the valve devices can be moved in succession out of their operative positions, each valve device comprising a pivoted lever, a sealing device carried towards one end of the lever and adapted to cover the combined inlet and relief port, and a spring tending to turn the lever so as to cause the sealing member to cover such port.

11. Liquid fuel injection apparatus for internal combustion engines, including in combination at least two injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger within the cylinder, and valve means whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, a valve device associated with each pump cylinder and adapted when in its operative position to close the outer end of the combined inlet and relief port therein to prevent flow of fuel through the combined inlet and relief port into the pump pressure chamber but to permit excess fuel to flow from the pump pressure chamber through the combined inlet and relief port, and a single operating member for the valve devices adapted to be operated by a safety device, such as an emergency governor, whereby these valve devices can be moved simultaneously into and out of their operative positions.

12. Liquid fuel injection apparatus for internal combustion engines, including in combination at least two injection pumps each comprising a cylinder having formed therein a combined inlet and relief port, a plunger within the cylinder and valve means whereby during at least a part of the delivery stroke of the plunger the combined inlet and relief port is maintained open to render such part of the stroke inoperative, a valve device associated with each pump cylinder and adapted when in its operative position to close the outer end of the combined inlet and relief port, means for resiliently holding each valve device in its operative position, and means adapted to be operated by a safety device, such as an emergency governor, for moving the valve devices simultaneously into their inoperative positions.

13. In liquid fuel injection apparatus for internal combustion engines, in combination, a fuel pump having a cylinder to the pressure chamber of which fuel passes through at least one combined inlet and relief port, a continuously operated valve device controlling the combined inlet and relief port to maintain it open during a part of the delivery stroke to permit discharge from the pressure chamber and thus render said part of the stroke inoperative and to close it during a further part of the stroke to render such part operative, and a separate valve device which in its inoperative position permits free flow of fuel to and from the pressure chamber of the pump through the combined inlet and relief port and in its operative position prevents the flow of fuel through this port into the pump pressure chamber but permits excess fuel to flow from the said chamber through the said port or ports.

14. In liquid fuel injection apparatus for internal combustion engines, in combination, a fuel pump having a cylinder to the pressure chamber of which fuel passes through at least one combined inlet and relief port, a continuously operated valve device controlling the combined inlet and relief port to maintain it open during a part of the delivery stroke to permit discharge from the pressure chamber and thus render said part of the stroke inoperative, and to close it during a further part of each delivery stroke to render such part operative, a separate valve device adapted when in its operative position to close the outer end of the combined inlet and relief port, means for resiliently holding the valve device in its operative position throughout the pump cycle, and means for moving the valve device into its inoperative position throughout the pump cycle.

15. In liquid fuel injection apparatus for internal combustion engines, in combination, a fuel pump having a cylinder to the pressure chamber of which fuel passes through at least one combined inlet and relief port in the cylinder, a continuously operated valve device controlling the combined inlet and relief port to maintain it open during a part of the delivery stroke to permit discharge from the pressure chamber and thus render such part of the stroke inoperative, and to close it during a further part of the delivery stroke to render such part of the stroke operative, and a separate valve device which in its inoperative position permits free flow of fuel to and from the pressure chamber of the pump throughout the pump cycle through the combined inlet and relief port and in its operative position prevents flow of fuel through the port into the pump pressure chamber but permits excess fuel to flow from the said chamber through the said port, the valve device comprising a pivoted lever, a sealing device carried towards one end of the lever and adapted to cover the combined inlet and relief port, and a spring tending to turn the lever so as to cause the sealing member to cover the said port.

HARVEY COOPER GILL.