

March 10, 1964

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3,124,116

FUEL-INJECTION PUMPS FOR INTERNAL COMBUSTION ENGINES

Filed Feb. 9, 1962

3 Sheets-Sheet 1

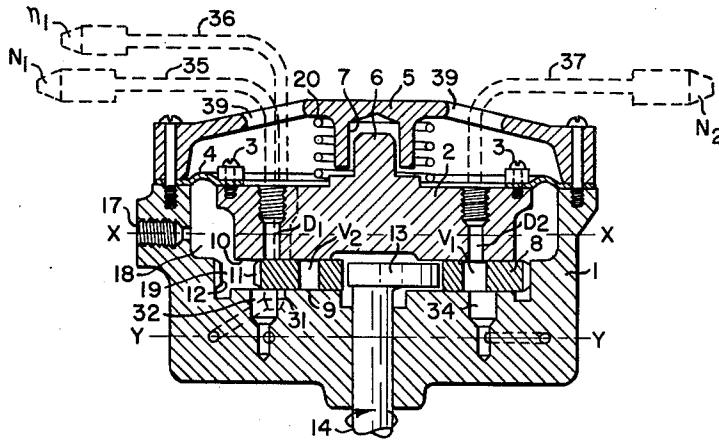


FIG. 1.

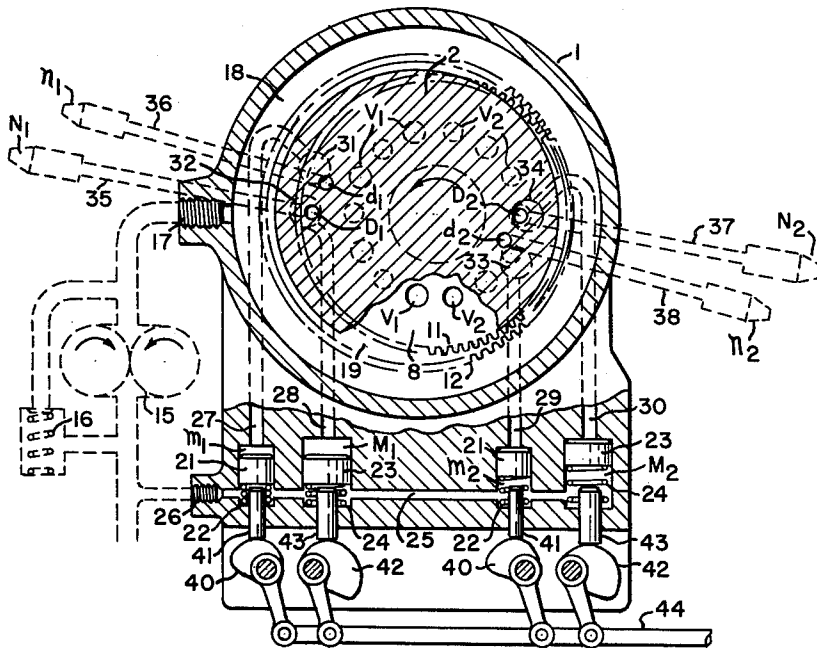


FIG. 2.

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3 Sheets-Sheet 2

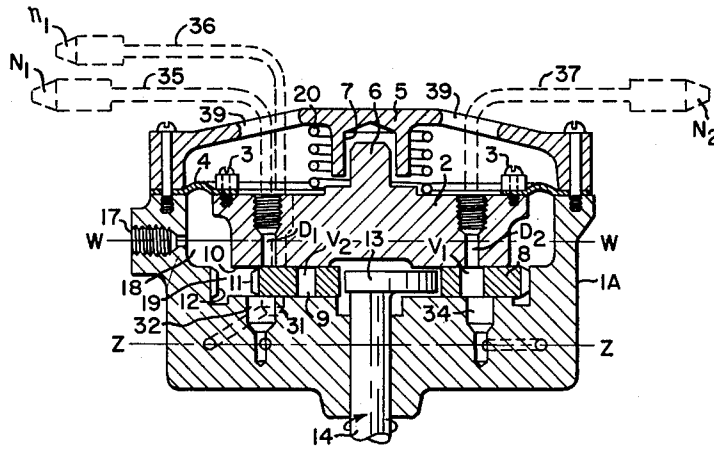


FIG. 3.

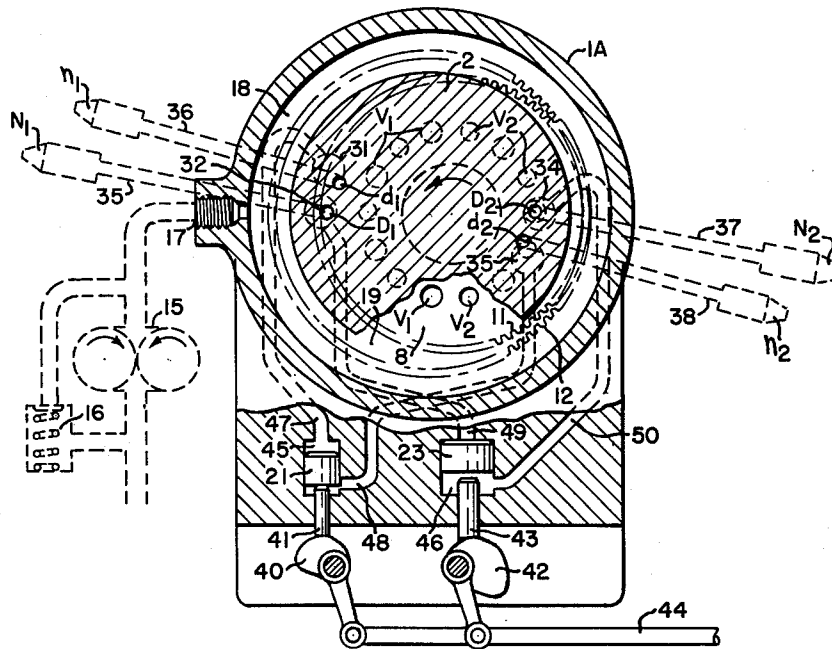


FIG. 4.

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3 Sheets-Sheet 3

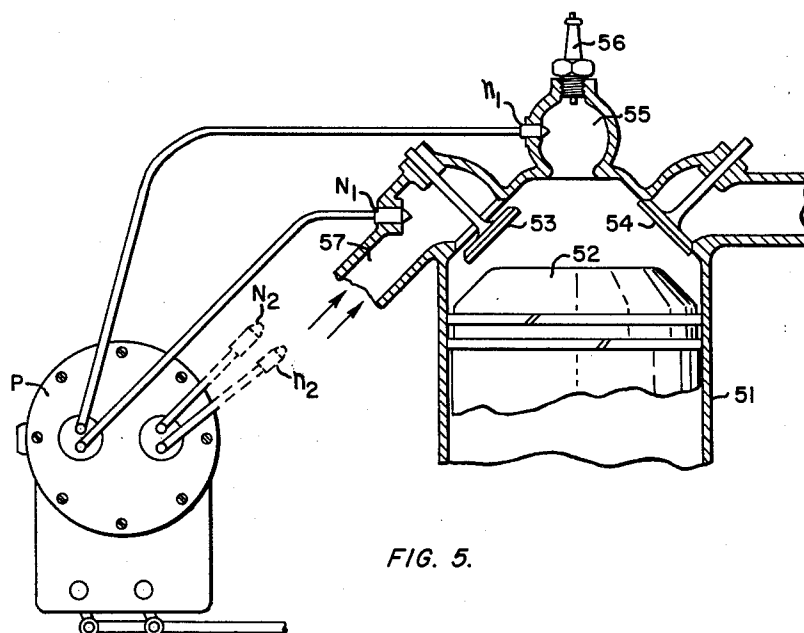


FIG. 5.

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3,124,116

FUEL-INJECTION PUMPS FOR INTERNAL COMBUSTION ENGINES

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Claims priority, application Great Britain Aug. 12, 1961
5 Claims. (Cl. 123—139)

This invention relates to liquid-fuel metering pumps for supplying the fuel-injection nozzles of fuel-injection internal combustion engines of the charge-stratifying type, and, more particularly, that type in which the portion of the total charge entering a cylinder, which, at the moment of ignition, is confined to the area adjacent to the spark plug (or equivalent means of initiating combustion), and is thus maintained at all times in a normally carburetted, i.e. readily combustible, condition relative to its fuel/air content ratio, whereas the remainder of the charge may be of substantially lower fuel/air ratio.

It is well known that in an engine of the type in question the initial combustion of a small pocket of normally carburetted charge is capable of propagating combustion throughout the remainder of the charge, notwithstanding that this remainder may have an extremely meagre fuel content. As a consequence, such an engine can be operated over its entire load-factor range by admitting at all times a full and unrestricted charge of air per cycle, by ensuring a constant and normal fuel/air ratio to that portion of the charge destined for segregation in the vicinity of the spark plug or its equivalent, and by varying only the quantity of fuel per cycle admixed with the main portion of the charge. This method of load-factor control, in which no restriction is at any time imposed upon the ingoing air charge, enables the engine to operate with significantly higher efficiency under part-load conditions, principally because the negative work otherwise entailed during the induction phase, by pressure-drop across a partially closed throttle, is obviated.

In the case of many stratified-charge engines of the fuel-injection type, it is desirable to supply the fuel to a given cylinder via two separate injector nozzles, the combined fuel input per cycle of which can be varied in accordance with the load-factor desired, as also can the ratio in which this combined fuel input is apportioned between the two nozzles.

The principal object of the present invention is to provide a fuel-injection pump in the form of a single unit capable of performing two injections per cycle via two separate injection nozzles situated in each engine cylinder or induction port, or in both of these locations. To this end, according to the invention a fuel-injection pump (in the form of a single unit, and designed to supply the fuel-injection nozzles of a fuel-injection internal combustion engine of the type specified) is characterized in that under the control of a distributing valve, at least two distensible metering chambers of individually adjustable volumetric capacity, serving pilot injection and main injection nozzles, respectively, are charged periodically with pressurized liquid-fuel from a source of supply and, at recurrent intervals, by spring-loading or fluid-pressure, each metering chamber is caused abruptly to contract and thereby rapidly eject its fuel content to the corresponding one of two delivery outlets which respectively serve separate pilot injection and main injection nozzles supplying one and the same cylinder of the engine. Provision is made whereby the two injection nozzles serving the same cylinder either discharge simultaneously, or, in general, in such manner that the discharge from both nozzles occur at times appropriate to their effective utilization

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during the same cycle of operation of that particular cylinder.

The present invention comprises an improvement over the patent to Isreeli et al. No. 2,720,344, issued October 11, 1955, since it incorporates modifications by which the basic designs of fuel-injection devices illustrated in FIGURES 3, 4, 5 and 6 thereof can be rendered capable of serving a stratified-charge engine. The vital distinction between this application and that of the prior device provides is that the patented device for only a single injection nozzle to be associated with each cylinder of the engine, whereas with the organization of the present invention provision is made for two injection nozzles to be associated with each engine cylinder, as already indicated.

Although the distributing valve of the pump of the present invention may be of a different type (e.g. a simple rotating valve), it is preferred to employ a ported valve of the rotary disc type to which an epicyclic motion is imparted continuously during operation; this valve being constructed and arranged to operate as disclosed in the above-mentioned prior specification.

Various other objects, advantages and features of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a sectional side view of one design of fuel-injection pump in accordance with the invention, for serving two cylinders of a charge-stratifying internal combustion engine;

FIGURE 2 is a sectional plan view of the same design, part of this view being a section on the line X—X and the remainder a section on the line Y—Y in FIGURE 1;

FIGURE 3 is a sectional side view of a modification of the design illustrated in FIGURES 1 and 2;

FIGURE 4 is a sectional plan view of the design of pump shown in FIGURE 3, part of this view being a section on the line W—W and the remainder a section on the line Z—Z in FIGURE 3; and

FIGURE 5 illustrates a fragmentary section of an engine cylinder arranged to be served by a fuel-injection pump (shown in plan view) which can be either as in FIGURES 1 and 2 or as in FIGURES 3 and 4.

The design of the fuel-injection pump shown in FIGURES 1 and 2 (which represents the application of the invention to the devices illustrated in FIGURES 3, 4 and 5 of the drawings of the above-mentioned prior patent) comprises a casing 1 which, in any convenient manner, should be restrained from rotating during operation of the pump. A floating metering block 2 is associated with a resilient annular diaphragm 4 by means of screws 3, which restrain the metering block 2 from rotating; the outer margin of the diaphragm being clamped between the top of the metering block 1 and a detachable cover plate 5. The metering block 2 has an axial offstanding extension 6 which is received in a socket 7 in the cover plate 5. In lieu of having the diaphragm 4, the distributing head 2 may be mounted on a resilient sealing means such as an O-ring seal which may be disposed between the periphery of the distributing head 2 and the wall of the surrounding casing, and seated in a retaining groove.

A disc-like ported epicyclic distributing valve 8, having accurately machined flat faces, is located between complementary accurately milled faces 9 and 10 on the metering block 1 and the metering block 2, respectively. The valve 8, the periphery of which is formed with gear teeth 11 which mesh with a stationary ring gear 12 on the casing 1, has an epicyclic motion imparted to it by an eccentric 13 fixed to a drive shaft 14.

A pump 15 (FIG. 2) of any convenient type, having a by-pass relief valve 16, is employed to deliver a pres-

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surized supply of liquid fuel to an inlet 17 in the casing 1 and thence to an annular space 18 which opens into the crescent-shaped space 19 around the valve 8. The fluid pressure exerted upwardly upon the diaphragm 4 and upon that portion of the area of the floating metering block 2 which is exposed to this pressure is at all times overcome by the thrust of a helical compression spring 20 (FIG. 1) on the metering block 2. In other words, this spring is sufficiently strong to ensure that the valve 8 is always maintained in intimate contact with the adjacent faces 9 and 10.

As each engine cylinder has to receive two separate charges of fuel per cycle, namely, a pilot charge (i.e. one segregated in the vicinity of the spark plug) followed by the main charge, the casing 1 contains twice as many metering chambers as there are cylinders in the engine to be served. Thus, one engine cylinder receives fuel both from a pilot injection nozzle n_1 supplied by an auxiliary metering chamber m_1 (FIG. 2), and from a main injection nozzle N_1 supplied by a main metering chamber M_1 . Similarly, another engine cylinder is served by a pilot injection nozzle n_2 supplied by an auxiliary metering chamber m_2 , and also by a main injection nozzle N_2 supplied by a main metering chamber M_2 ; and so on, for the remaining engine cylinders.

Each of the metering chambers is elastically distensible and of adjustable volumetric capacity. The auxiliary ones m_1 and m_2 each have a free piston or plunger 21 loaded by a helical compression spring 22, and the main ones M_1 and M_2 each have a free piston or a plunger 23 loaded by a helical compression spring 24. By means of a duct 25 (FIG. 2) in the metering block, and a connection 26, the rear portion of each metering chamber is (as a convenient means of venting) placed in permanent communication with the suction side of the pump 15.

In accordance with the more usual stratifying engine requirement, the chambers m_1 and m_2 and reciprocable plungers 21 metering the pilot charges are of substantially smaller maximum capacity than those metering the main charges.

The forward ends of the metering chambers m_1 , m_2 , M_1 and M_2 are connected by ducts 27, 28, 29 and 30 respectively to ports 31, 32, 33 and 34 respectively in the face 9 of the metering block. These ports lie on the circumference of a circle concentric with the drive shaft 14, and are arranged so that the ports 31 and 33, and the ports 32 and 34 are diametrically opposed. Spaced equidistantly around the circumference of a circle concentric with its axis, the distributing valve 8 has through-ports arranged in two alternating sets V_1 and V_2 . During the epicyclic rotation of the valve 8, the ports V_1 co-operate with the ports 32 and 34, and the ports V_2 co-operate with the ports 31 and 33.

The distributing head 2 has, leading from its face 10, a pair of diametrically opposed outlet ports D_1 and D_2 , which serve the main injection nozzles N_1 and N_2 respectively; and a pair of diametrically opposed outlet ports d_1 and d_2 , which serve the pilot injection nozzles n_1 and n_2 respectively. Pipe connections 35, 36, 37 and 38 to the various injection nozzles pass through apertures 39 in the cover plate 5.

As depicted in FIGURES 1 and 2, due to the rotation of the valve 8 in the direction of the arrow, the two associated ports 31 and 32 in the metering block 1 have become approximately simultaneously exposed by the outer rim of the moving valve to the region 19 of pressurized fuel. As a result the metering chambers m_1 and M_1 each receive a charge of fuel, the pressure of which overcomes the spring-loading of the respective plungers 21 and 23. Further motion of the valve 8 results in the ports 31 and 32 becoming covered by the body of this valve, whereupon their exposure to the region 19 is terminated. Subsequently, via the through-ports V_1 and V_2 , the valve 8 places each of the metering chambers m_1 and M_1 into communication with the outlet ports d_1 and

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D_1 respectively. Thereupon the metering chambers m_1 and M_1 , under the influence of their respective spring-loaded plungers 21 and 23, contract to expel the fuel through the injection nozzles n_1 and N_1 . It can be seen that, with the valve 8 in the position shown, the metering chambers m_2 and M_2 have delivered their charges of fuel to the injection nozzles n_2 and N_2 respectively.

The stroke of the plunger 21 of each of the pilot metering chambers m_1 and m_2 , and hence the quantity of pilot injection per cycle, is controlled by a cam 40 bearing upon a stop 41 that protrudes slidably into the corresponding metering chamber. Similarly, the quantity of main injection per cycle is controlled by a cam 42 and associated slidable stop 43 pertaining individually to the main metering chambers M_1 and M_2 . The two cams 40 are identical, as also are the cams 42, and all the stroke-controlling cams are interconnected by a single control linkage 44. In this manner, for any selected total quantity of fuel to be injected per cycle; that is, for any load-factor thus imposed on the engine, the ratio in which the total fuel charge per cycle is apportioned between the pilot and main injection nozzles can be predetermined.

The modified design illustrated in FIGURES 3 and 4 has a metering block 1A which is generally similar to the metering block 1 of FIGURES 1 and 2, and the common parts are identified by the same reference numerals and letters. The difference between the two designs resides in the fact that the metering block 1A has double-acting metering chambers 45 and 46, containing the free pistons or plungers 21 and 23 respectively.

The forward end of the pilot injection chamber 45 is connected by a duct 47 to the port 31, serving the pilot injection nozzle n_1 of one engine cylinder; and the rear end of this chamber is connected by a duct 48 to the port 33, serving the pilot injection nozzle n_2 of another engine cylinder. A duct 49 connects the forward end of the main injection chamber 46 to the port 32, serving the main injection nozzle N_1 of the first engine cylinder; and a duct 50 connects the rear end of this chamber to a port 34, serving the main injection nozzle N_2 of the second engine cylinder.

As depicted in FIGURES 3 and 4, the port 31 has become exposed by the outer rim of the moving valve 8 to the region 19 of pressurized fuel. Consequently, the plunger 21 has been impelled rearwardly to the extent allowed by its adjustable stop 41, and the fuel that was in the rear portion of the chamber 45 has been expelled through the duct 48, the port 33, one of the valve ports V_2 , the outlet port d_2 and the connection 38 to the pilot injection nozzle n_2 . The plunger 23 is now about to be impelled rearwardly, to the extent permitted by its adjustable stop 43, as the port 32 is on the point of becoming exposed (by the outer rim of the moving valve 8) to the region 19 of pressurized fuel. Therefore, a charge of fuel is about to be delivered via the duct 50, the port 34, one of the valve ports V_1 , the outlet port D_2 and the connection 37 to the main injection nozzle N_2 . It will be appreciated that, when the ports 33 and 34 in turn become exposed, by the outer rim of the moving valve 8, the other engine cylinder receives, at the proper time-interval, a pilot charge from the nozzle n_1 , and, almost simultaneously, a main charge from the nozzle N_1 .

FIGURE 5 exemplifies the manner in which a fuel-injection pump P (which may be constructed and arranged to operate either in accordance with FIGURES 1 and 2 or FIGURES 3 and 4) is employed to serve a fuel-injection internal combustion engine of the charge-stratifying type. An engine cylinder 51, containing a piston 52 and fitted with an inlet valve 53 and an exhaust valve 54, has a pre-combustion chamber 55 which is fitted with a spark plug 56. As can be seen, the pilot injection nozzle n_1 is arranged to discharge in the vicinity of the spark plug, and the main injection nozzle is arranged to discharge into the inlet port 57. The other injection

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nozzles n_2 and N_2 are associated in the same manner with the next engine cylinder (not shown) and so on, depending upon the number of cylinders to be served.

It will be appreciated that, according to the method of carrying the invention into effect described with reference to FIGURES 1 and 2, an engine having any number of cylinders can be served by the provision of a corresponding number of pilot injection actuating ports, each with its associated main injection actuating port; the desired motion of the epicyclic distributing valve, taken in conjunction with the number of through-ports in this component, having been achieved by choice of an appropriate relative number of the teeth 11 upon its periphery with respect to those within the associated stationary ring gear 12.

Similarly, it will be understood that, in accordance with the method of carrying the invention into effect described with reference to FIGURES 3 and 4, an engine having any number of cylinders divisible by two can be served by the provision of a corresponding number of pairs of oppositely disposed pilot and main injection actuating ports.

It is desirable to make provision whereby the maximum fuel delivery to the engine per cycle is regulated automatically in dependence upon the ambient air temperature and barometric pressure existing at any time.

While the invention has been described in connection with the preferred embodiment thereof, it is to be understood that this description is illustrative only and is not intended to limit the invention.

I claim:

1. In a fuel injection pump for an internal combustion engine in the form of a single unit capable of performing two injections per cycle via two separate injection nozzles situated in each engine cylinder the combination comprising a casing having a liquid-fuel inlet port and two outlet ports for each cylinder, a ported valve mounted within the casing for rotary motion and formed with seating faces on opposite sides thereof, a metering block including a plurality of discharge ports mounted for

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movement within the casing and having one surface adjacent to one seating face of said valve and shaped complementary thereto, said valve being disposed between said block and one end of the casing with its other seating face in contact with said end of the casing, resilient means disposed within said casing for urging said metering block toward said one end of the casing to maintain intimate contact between the casing, the valve, and said metering block, plural metering chambers in said casing having one end opening adjacent to the seating face of said valve, reciprocable free pistons in the chambers, means for imparting motion to said valve, the valve being adapted to connect two of the metering chambers alternately to said liquid fuel inlet port and two outlet ports associated with a respective engine cylinder, and means for causing the free pistons to reciprocate whereby a metered quantity of liquid is alternately received in said metering chambers and expelled through the discharge ports into said engine cylinders.

2. A liquid fuel metering and distributing device according to claim 1, wherein the metering block is spacedly arranged relative to the casing by means of a diaphragm.

3. In a fuel injection pump as claimed in claim 1, wherein the metering block is arranged to float axially within said casing.

4. In a fuel injection pump as claimed in claim 1, wherein the means for causing the free pistons to reciprocate include adjustable stop means actuated by cam means.

5. In a fuel injection pump as claimed in claim 4, wherein the cam means are interconnected and operable by a single control linkage.

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