United States Patent [19]
Regneault et al.

[11] 3,759,239
[45] Sept. 18, 1973

[54] INJECTION DEVICES FOR COMPRESSION-IGNITED INTERNAL COMBUSTION ENGINES

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[22] Filed: May 11, 1971

[21] Appl. No.: 142,169

[30] Foreign Application Priority Data

June 8, 1970 France 7020929

[52] U.S. Cl. .... 123/32 G, 123/139 AF, 123/32 F, 123/139 AS, 123/140 FG

[51] Int. Cl. F02d 1/04, F02d 1/06, F02m 39/00

[58] Field of Search .... 123/32.6, 32.61, 123/140 FG, 139 AF, 139 AS

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[57] ABSTRACT

Injection device for a compression-ignited combustion engine comprising a modifying device between the injector and the fuel supply pump. The modifying device operates by taking off and restoring fuel so as to modify the injection law of the injection device. The injection device comprises an injection pump having a delivery chamber in which are movable pumping and/or distributing means which comprise first means for ensuring the non-simultaneous openings of communications between the delivery chamber and the injector and the delivery chamber and the modifying device. The modifying device comprises means for retarding the restoration of the fuel taken off to the delivery chamber so long as the first means leave the modifying device in communication with the delivery chamber.

10 Claims, 16 Drawing Figures

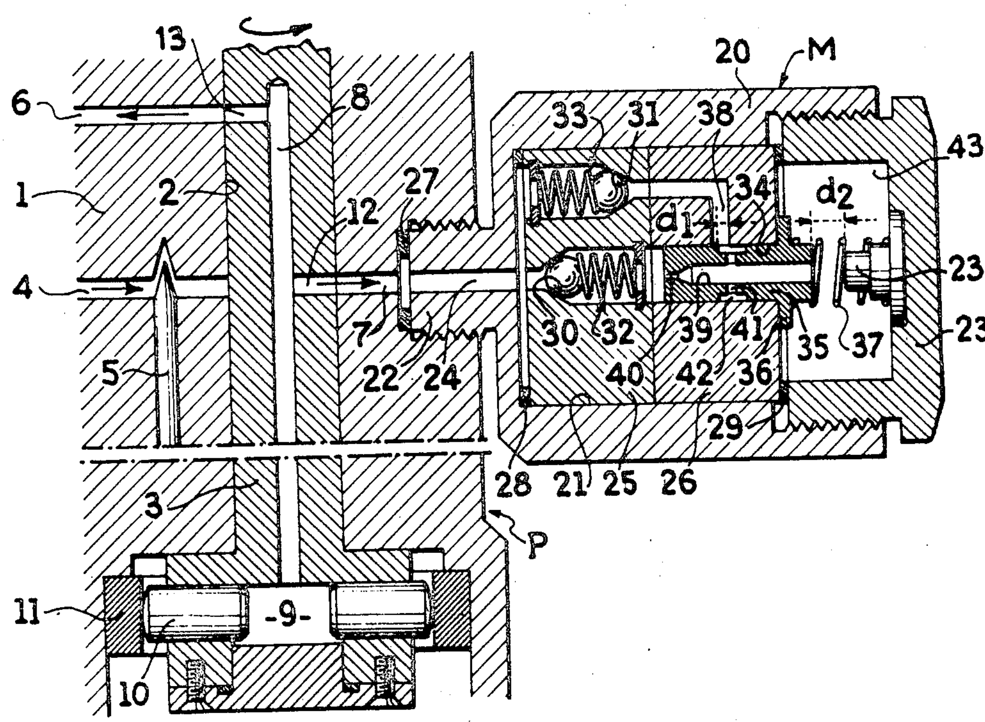


FIG.1

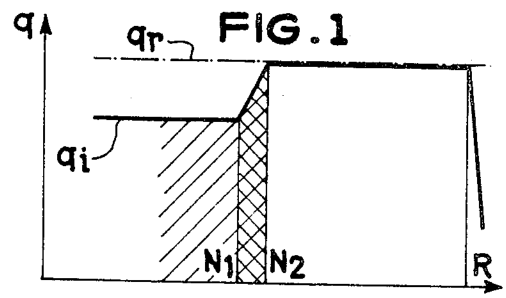


FIG.2

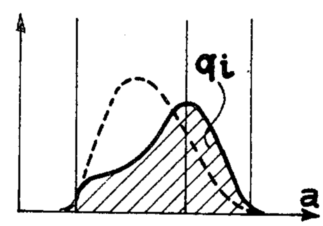


FIG.3

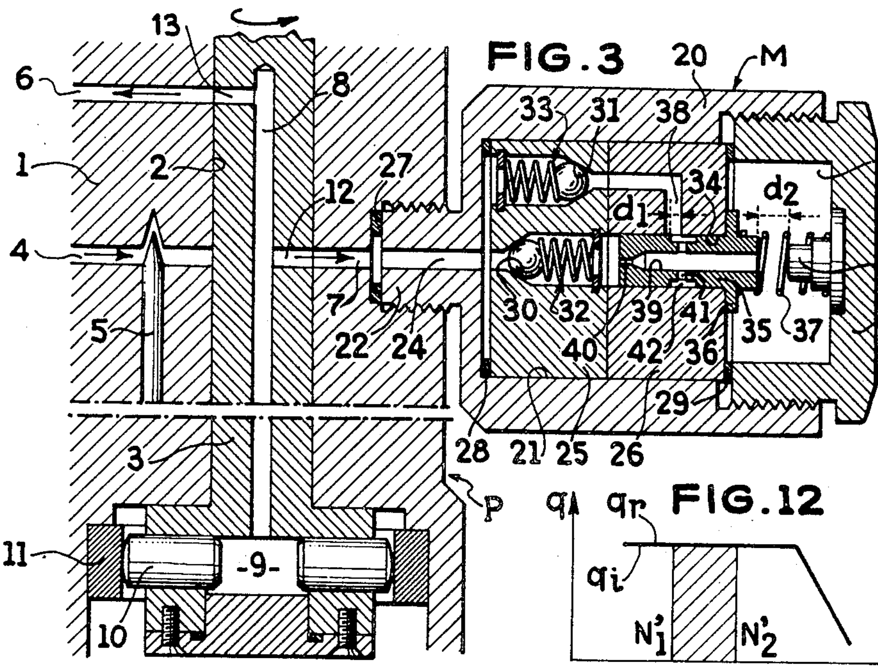


FIG.12

FIG.10

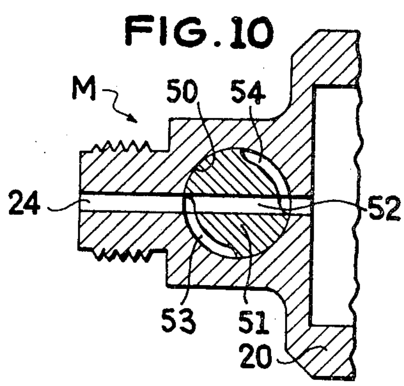


FIG.11

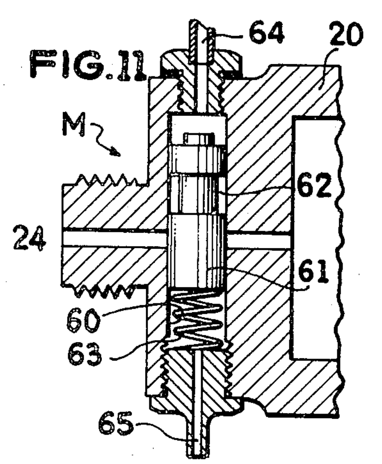


FIG.4

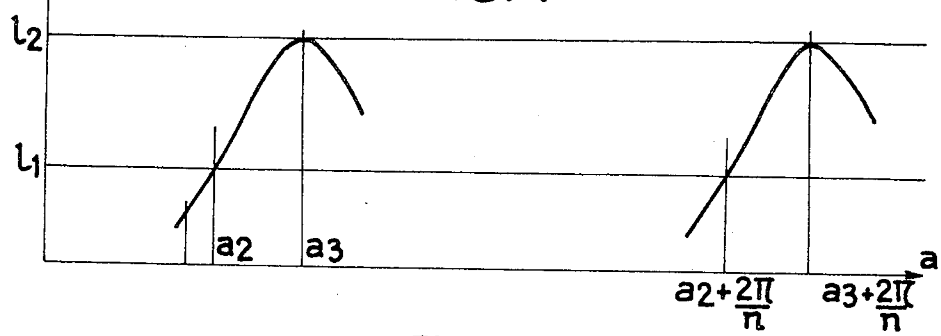


FIG.5

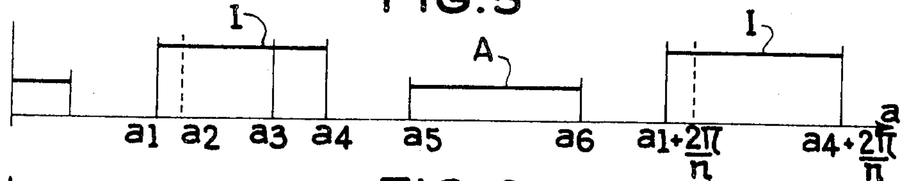


FIG.6

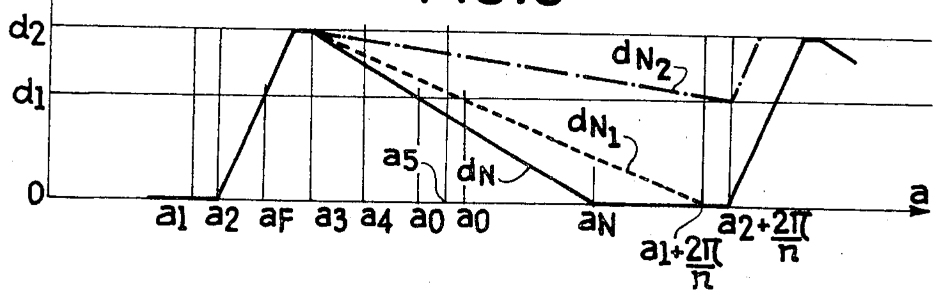


FIG.7

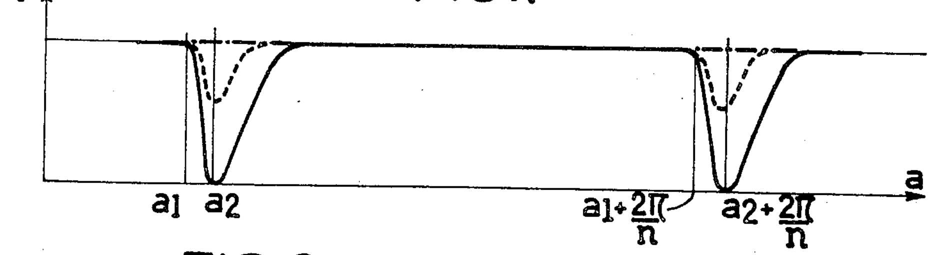


FIG.8

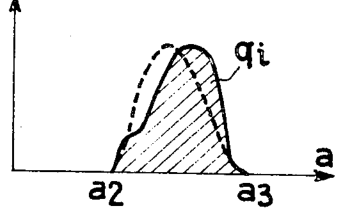


FIG.9

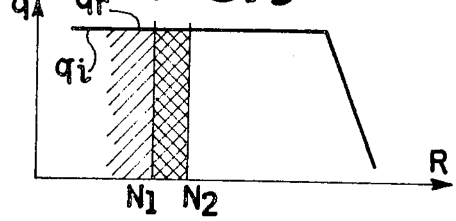


FIG. 14

FIG. 13

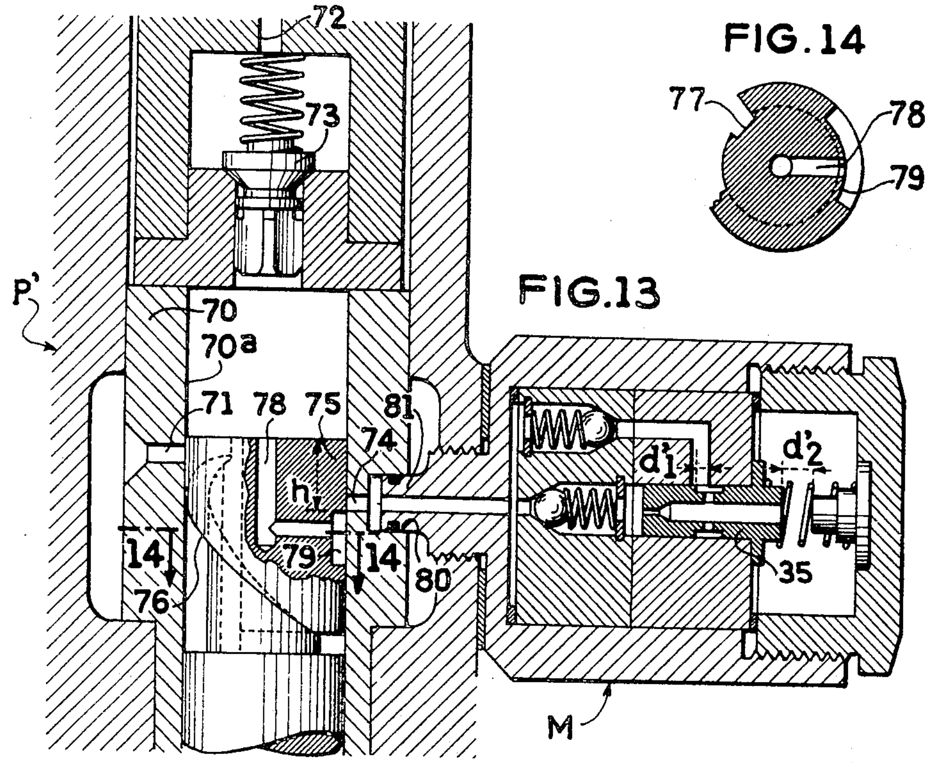


FIG. 15

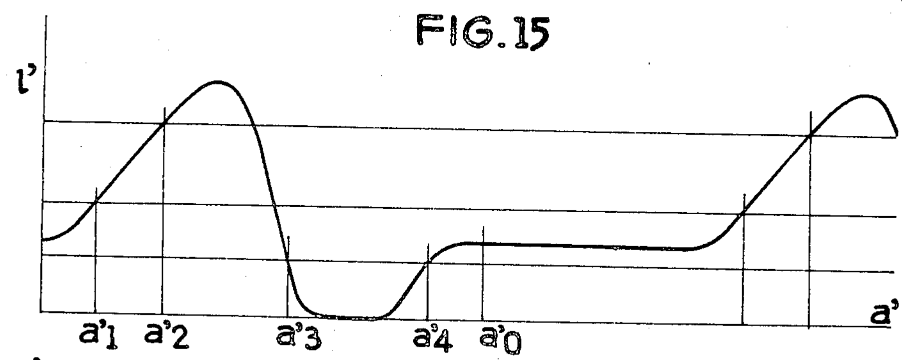
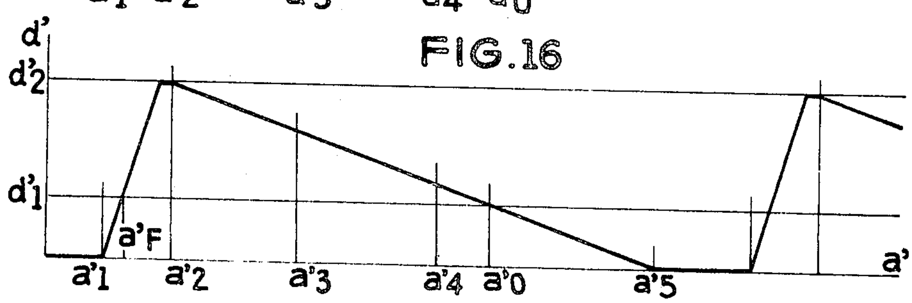


FIG. 16



INJECTION DEVICES FOR COMPRESSION-IGNITED INTERNAL COMBUSTION ENGINES

The present invention relates to injection devices for compression-ignited internal combustion engines.

It is known that these devices comprise an injection pump, the pumping element or each pumping element of which is actuated by a cam rotated by the output shaft of the engine, the speed at which the pump is driven being consequently proportional to the running speed of the engine. There is associated with this pump a regulating device which determines, as a function of the load and the speed of operation of the engine, the amount of fuel injected for each delivery stroke of the pump. Now, the profile of the cam actuating the injection pump is designed to provide an optimum injection law in the most frequent conditions of operational speed and load and, when it is desired to deviate from these conditions, the injection law becomes less suitable and results in noisy operation of the engine, imperfect combustion and emission of harmful exhaust gases. This is why, in order to remedy the aforementioned defect, it has been suggested to incorporate in these injection devices means whereby it is possible to modify the fuel injection law in operational ranges outside the most favourable conditions and in particular at engine speeds in the neighbourhood of the idling speed of the engine.

Such means are described in particular in the U.S. Pat. No. 3,456,629, in U.S. Pat. application Ser. No. 801,961 and in the U.S. Pat. application Ser. No. 67,173. These means modifying the injection law comprise a take-off chamber adapted to remove, during the delivery stroke of the injection pump, a part of the delivered fuel and restore this fuel to the pump after the injection has ended. Means are also provided to prevent any fuel take off outside speed conditions in which the modification of the injection law is desirable. Outside the conditions of full load, the regulator compensates the fuel removed by increasing the amount of fuel admitted into the injection pump so that the motor remains supplied with the correct amount of fuel. On the other hand, for conditions of full load, or in the neighbourhood of full load, that is, when the engine must receive all the fuel delivered by the injection pump, these take-off devices are no longer satisfactory since the amount of fuel taken off during the delivery stroke of the pump can no longer be compensated and the engine fails to receive the required amount of fuel. Now, experience has shown that it is also desirable to modify the injection law at full load for certain ranges of engine speeds outside optimum operational ranges for the reasons already given, that is, to reduce noise, improve the combustion and decrease the amount of harmful fumes in the exhaust gases.

The object of the invention is to provide an injection device for a compression ignited internal combustion engine comprising an injection pump having a delivery chamber with which communicate at least one first inlet conduit, at least one second injection conduit connected to an injector, and a third conduit connected to a device modifying the injection law operating by taking off or deducting and restoring fuel and with which chamber there is associated at least one pumping and/or distributing means whereby it is possible to effect in required operational speed ranges and for all load conditions the desired modification of the injection law

without however modifying the amount of fuel injected.

The invention provides an injection device wherein said pumping and/or distributing means comprise first means for controlling the non-simultaneous opening of the connection of the first conduit and third conduit to the delivery chamber, the modifying device comprising means adapted to retard restoring the fuel taken off to the delivery chamber so long as said first means leave said third conduit connected to the delivery chamber.

In view of the fact that the pump and/or distributing means are arranged in such manner as to put the delivery chamber in communication with the first and third conduits respectively at different moments, the fact of deferring the restoration of the fuel taken off enables this restoration to be effected only after the delivery chamber has been put in communication with, and then once more out off from, the inlet conduit or, in other words, after this chamber has been once more supplied with fuel. In this way and in particular in the course of operation under full load, the fuel under pressure restored to the delivery chamber by the modifying device is not deducted from the amount of fuel injected and the engine can be correctly supplied with fuel. It will be noticed that the restoration of fuel in the delivery chamber, which at full load is on principle completely filled during the fuel supply stage, is possible owing to the appreciable compressibility of the fuel, bearing in mind the prevailing volume and pressure ratios.

To achieve this, according to one embodiment of the invention, in the modifying device, which is of the type comprising a take-off chamber, there is provided between said third conduit and the take-off chamber a take-off path and a return path, the take-off path comprising a first valve or "take-off" valve and a throttled passage formed in a piston movable in a bore which communicates with the take-off chamber, and the return path comprising a passage which communicates laterally with said bore and has an opening controlled by the position of said piston and a second valve or "discharge" valve arranged to operate in opposition to the first valve.

During the delivery stroke of the pumping means, and assuming that the operation occurs in a operational speed range in which the modifying device is operative, a part of the fuel travels along the take-off path and simultaneously urges back the piston which closes the return or discharge passage. At the end of the injection, the restoration of the taken-off fuel to the delivery chamber can only occur when the piston opens the return passage and the movable element in the delivery chamber once more puts the take-off conduit and the delivery chamber in communication.

The invention is applicable to various types of pumps, distributing or in-line pumps, as will be apparent from the ensuing description with reference to the accompanying drawings.

In the drawings:

FIGS. 1 and 2 are diagrams relating to a known injection device;

FIG. 3 is a diagrammatic sectional view of a device according to the invention applied to a distributing pump;

FIGS. 4 – 9 are diagrams showing the operation of the device shown in FIG. 3;

FIGS. 10 and 11 are partial sectional views of two modifications of the invention;

FIG. 12 is a diagram showing the advantage of the two modifications shown in FIGS. 10 and 11;

FIG. 13 is a partial sectional view of an arrangement according to the invention applied to an in-line pump;

FIG. 14 is a partial sectional view taken along line 14—14 of FIG. 13, and

FIGS. 15 and 16 are two diagrams showing how the device shown in FIGS. 13 and 14 operates.

The pump P shown in FIG. 3 comprises a body 1 in which is formed a bore 2 receiving fuel delivery means which here take the form of a distributing valve element 3 which is rotated, via a mechanism (not shown), by the output shaft of the engine. The body 1 is provided with a number of conduits which communicate with the bore 2, namely: a supply conduit 4 whose section of passage is regulated by an element 5 actuated by the regulating device known per se (not shown); at least one injection conduit 6 connected to an injector (not shown); and a conduit 7 connected to a device M which modifies the injection law. In the illustrated embodiment, the conduits 4 and 7 are contained in a common plane perpendicular to the axis of the bore 2. The rotary distributor valve 3 has a blind axial bore 8 communicating with a delivery chamber 9 in which pistons or plungers 10 are caused to reciprocate by the action of an annular cam 11 when the distributor valve rotates. The distributor valve has, furthermore, between the bore 8 and its periphery, radial passages 12 and 13 which are so disposed that the passage 12 can come into alignment with the conduits 4 and 7 and the passage 13 can come into alignment with the conduit 6. FIGS. 4 and 5 show respectively a part of the law of the cam determining the movement 1 of the pump pistons 10 as a function of the angular position *a* of the distributor valve 3, and a time chart in which are shown two series of segments A,I respectively representing the periods during which, on one hand, the inlet conduit 4 and, on the other hand, the injection conduit 6 and take-off conduit 7 communicate with the delivery chamber. These diagrams will be explained in the description of the operation of the device.

The modifying device M associated with the injection pump P has a body 20 defining a cylindrical cavity 21, a screw-threaded end portion 22 screwed in the body 1 of the pump in alignment with the conduit 7 and a hollow screwthreaded plug 23 carrying an axial abutment 23*a*. The end portion 22 has a longitudinal passage 24. The cavity 21 receives a valve-carrier block 25 and a slide-carrier block 26 held in position by the plug 23. Sealing elements 27, 28, 29 are respectively provided between the end portion 22 and the body 1, between the block 25 and the body 20 and between the block 26 and the plug 23. The block 25 has two longitudinal passages 30, 31 containing two check valves 32, 33 mounted in opposed relation. The block 26 has a bore 34 in alignment with the passage 30 and containing a piston 35 constituting a slide valve including a flange 36 biased against the block 26 by a spring 37 having one end which bears against the end wall of the plug 23. The block 26 also has a cranked passage 38 which communicates at one end with the bore 34 and at its other end with the facing passage 31 of the block 25. The piston 35 has an axial passage 39 having a throttling portion or constriction 40, radial passages 41 and an annular recess 42. In the presently described embodiment, a take-off chamber 43 of the modifying device is defined by the hollow plug 23 and the block 26. This chamber therefore has a fixed volume, but it is clear that it can be partially defined by a movable wall and have a variable volume, as disclosed in the aforementioned patents.

The principle of operation of this device will now be explained with reference first to the diagram shown in FIGS. 1 and 2 which will permit explaining the drawbacks of known modifying means and then to the diagrams shown in FIGS. 4 – 7 pertaining to the device itself.

The diagram in FIG. 1 shows two lines representing, as a function of the operational speed R, respectively (in dot-dash line) the amount of fuel *qr* supplied at full load by each delivery stroke of the injection pump, this amount being constant since it is determined by the profile of the cam actuating the pumping means, and (in full line) the amount of fuel *qi* in fact injected into the engine under the same conditions of full load. It can be seen that the device modifying the law of injection, which acts by taking off or withdrawing a part of the fuel at the start of injection, in fact produces throughout the range in which it operates, that is, for the operational speeds lower than speed N_2, a decrease in the amount of fuel injected, which is of course quite disadvantageous. It is only beyond the speed N_2 that the take-off means are neutralized and that the entire amount of fuel required can be supplied to the engine. It is clear from FIG. 2, which shows in full line the injection law for a speed less than N_2 and at full load, that the total amount of fuel injected *qi* , which is proportional to the crosshatched area, is less than that which would be injected by a device which does not have fuel take-off means (dotted curve).

The operation of the device according to the invention will be explained with reference to FIG. 3 and to the diagrams shown in FIGS. 4 – 9. It has already been explained what the diagrams shown in FIGS. 4 and 5 mean. FIGS. 6, 7 and 8 show, as a function of *a*, corresponding to the angle of rotation of the distributor valve, respectively the movements *d* of the piston 35 (FIG. 6), the pressure P prevailing in the delivery chamber (FIG. 7), and the amount *qi* of fuel injected at full load (FIG. 8). FIG. 9 shows the amount *q* of fuel delivered and injected at full load at each delivery stroke of the pump, as a function of the engine speed R.

It will first be assumed that at the start of the considered injection stage, the piston 35 is in the position shown in FIG. 3, that is, that the device has the maximum modifying effect on the injection law.

Under the control of a conventional mechanism (not shown), the distributor valve 3 is driven in rotation about its axis. For an angular position *a*1 of this distributor valve 3, the passage 13 is put in communication with the conduit 6 and the passage 12 is put in communication with the conduit 7. This state of affairs is represented by the segment I in the time diagram shown in FIG. 5. Simultaneously, the plungers 10 reciprocate in the pumping chamber 9 so that fuel under pressure is pumped into the passages 12 and 13, to the modifying device M and an injector (not shown). For an angle of rotation *a*2 of the distributor valve, the pressure in the delivery chamber reaches a value which is sufficient to open the injector and consequently start the injection. Simultaneously, a part of the fuel escapes through the passage 12, the conduit 7, the passage 24, the valve 32, the throttle 40, the bore 39 in the piston

35 and reaches the take-off chamber 43. Owing to the presence of the constriction or throttle 40 in this path, the rapid rise in pressure which occurs upstream of the piston 35 results in a displacement of this piston against the abutment 23*a* and the discharge into the chamber 43 of a certain volume of fuel. In the course of this displacement, the piston 35 closes the passage 38 and consequently closes off the communication between the take-off chamber 43 and the return path to the conduit 7 and passage 12. This stage of the displacement of the piston can be seen in FIG. 6 in which it is represented by the abscissae points *a*2, *a*F, *a*3, the angle *a*3 corresponding to the end of the injection. During the displacement of the piston 35 toward the abutment 23*a*, the supply of fuel to the engine therefore results at each instant from the difference between the amount delivered by the pump and the amount which enters the chamber 43 of the modifying device.

When the piston reaches the abutment 23*a*, which may occur before the end of the injection (FIG. 6), practically no more fuel enters the device M and almost all of the fuel delivered by the pump is then injected into the engine. The corresponding injection law is shown in FIG. 8 by the curve in full line, the curve in dotted line representing an injection law in a device which does not have injection modifying means. It can be seen that, in contradistinction to what occurs in conventional devices (FIG. 2), the amount of fuel injected is not reduced.

When the pump ceases to deliver fuel, a pressure relief occurs which causes the end of the injection and the closure of the valve 32. As the piston 35 has been displaced and the passage 38 is closed, the fuel which had been taken off is trapped in the chamber 43. The presence of the jet or constriction 40 ensures the establishment of a pressure balance between the upstream and downstream sides of the piston. However, under the action of the spring 37 a pressure differential is created and a slight amount of fuel is supplied through the jet 40 and results in a slow displacement of the piston away from the abutment 23*a*. This displacement of the piston is shown in FIG. 6 by a segment *a*3 *a*N. As a result of this slow displacement of the piston, the outlet passage 38 is only opened after a certain period of time corresponding to the segment *a*3, *a*0 in FIG. 6, and it can be seen that at the moment when this passage is once more opened, the communication between the delivery chamber, on one hand, and the conduits 6, 7, on the other, has been closed for the value *a*4 (FIG. 5). Consequently, the fuel taken off can only be restored to the delivery chamber at the moment when the latter is once more put in communication with the conduit 7 and the modifying device, which occurs for a value *a*1 + $(2\pi/n)$ in which *n* represents the number of cylinders of the engine (FIG. 5). Meanwhile, the delivery chamber has been put in communication with a supply conduit 4 (segment A) and has received a predetermined amount of fuel, regulated by the position of the needle valve 5 and exactly corresponding to the needs of the engine.

The curve *d*N shown in full line in FIG. 6 just described corresponds to an engine speed N for which the piston 35 has time to come back to the left abutment opposed to abutment 23*a*, that is, to the position shown in FIG. 3, before the start of the following delivery and injection stage. The dotted line *d* N_1 corresponds to engine speed N_1 for which the piston has just time to move back to the left abutment opposed to abutment 23*a* at the moment when the following delivery stage starts. For speeds higher than this speed N_1, the piston 35 has not returned to this left abutment at the moment when the delivery stage starts and as its travel toward the abutment 23*a* is decreased, the modifying effect on the injection law is less. This procedure corresponds to a stage of progressive elimination of the modifying device, full elimination being achieved at engine speed N_2 for which the piston 35 constantly closes the discharge orifice 38. This is embodied in FIG. 7, which shows as a function of angle *a* the value of the pressure P in the delivery chamber, in a pressure variation which is smaller; the curve in full line corresponding to the maximum modifying effect, the curve in dotted line corresponding to the stage of progressive elimination of the modifying effect and the dot-dash line corresponding to full elimination of the modifying effect.

It can be seen that, owing to this arrangement and assuming that it concerns ranges of engine speed in which maximum or partial modification of the injection law occurs, the fact of deferring until the start of the injection stage the restoration of the fuel taken off to the fuel delivery chamber, permits avoiding a decrease in the amount of fuel delivered by the injection pump and consequently permits supplying the engine with the exact amount of fuel it requires. This takes on its full signification when the engine operates at full load, that is, when it must receive the full amount of fuel delivered by the injection pump. This is in contradistinction to what occurs in conventional modifying devices in which the fuel taken off and restored to the delivery chamber is deducted from the amount of fuel furnished to the delivery pump by the supply pump, which does not allow supplying under full load conditions the required amounts of fuel to the engine.

This is also revealed in the graph shown in FIG. 9 where it can be seen that the total amount *qr* of fuel delivered by the pump and the amount *qi* of fuel injected into the engine (under full load conditions) are equal, even for engine speeds lower than N_1, between N_1 and N_2; this graph should be in this respect compared with that shown in FIG. 1.

FIG. 3 shows a pump in which the distributor valve rotates and causes reciprocation of the pump plungers 10. It must be understood that the invention also applies to any other type of injection pump and in particular to a pump in which the pumping element and distributor element undergo simultaneously a movement of translation and rotation about an axis. Similarly, it is not essential that the injection conduit and the conduit communicating with the modifying device be opened and closed in a strictly simultaneous manner, since ajudstments may be made in this respect. Separate passages may also be provided in the distributor valve 3 for communication with the supply conduit 4 and the modifying device M. The illustrated arrangement was chosen merely for reasons of clarity.

FIGS. 10 and 11 show two modification of a device according to the invention in which additional eliminating means are provided for achieving a modification in the injection law in an intermediate engine speed range N'_1 N'_2 (FIG. 12). In FIG. 10, these additional eliminating means are interposed between the injection pump and the modifying device M and comprise a valve member 50 which is provided for example in the body 20 of the modifying device and receives a key 51 having a radial passage 52. Two diametrally opposed recesses 53, 54 are formed in the periphery of the key and communicate with the passage 52. This key is controlled, for example, by the accelerating lever of the pump through a mechanism (not shown) and is adapted to close the passage of communication up to engine speed N'_1. The elimination of the modifying device at speed N'_2 occurs as described hereinbefore in respect of the device shown in FIG. 3.

In the embodiment shown in FIG. 11, the additional eliminating means comprise a passage 60 formed in the body 20 of the modifying device M in a direction disposed transversely of the communication passage 24. A slide valve 61 is disposed in this passage 60 and a groove 62 is provided in the slide valve. The latter is maintained in equilibrium, on one hand, under the effect of a spring 63 and, on the other hand, under the effect of a pressure which may be, for example, the pressure from the supply pump or transfer pump transmitted by a pipe 64. A conduit 65 for the discharge of leakages is also provided.

It will be understood that this device operates in exactly the same manner as the device shown in FIG. 10. As the delivery pressure of the supply pump or transfer pump is proportional to the speed of the engine, when this pressure reaches a predetermined value, the groove 62 is brought in front of the passage 24 and thus permits the modifying device to come into action as explained hereinbefore.

The foregoing description applies to injection pumps of the "distributing pump" type. It will be understood that the same device can be adapted for multi-cylinder or "in-line" injection pumps with the same advantages. This modification is shown in FIGS. 13 and 14. A pump P' comprises a cylinder 70 defining a delivery chamber 70*a* to which lead a supply conduit 71, an injection conduit 72 controlled by a valve 73 and a conduit 74 connected to a modifying device M. Mounted in the chamber 70*a* are fuel delivery means in the form of a piston 75 having a helical ramp 76 so that the angular position of the piston, governor or regulated by a regulator, determines the effective delivery stroke of this piston. The latter also has a stop recess 77 and a L-shaped passage 78 which opens out laterally in a recess 79 whose upper edge is at a distance h from the upper edge of the piston and whose width and circumferential position are chosen in accordance with the conditions for which the modifying device is desired to operate. The pump cylinder 70 has a cylindrical cavity 80 with which the conduit 74 communicates and which is adapted to receive a hollow end portion 81 equipped with a sealing joint and forming part of the body of the modifying device M.

The operation of this arrangement will be described with reference to FIGS. 13 – 16, FIGS. 15 and 16 showing respectively, as a function of a, corresponding to the angle of rotation of the cam (not shown), the cam law l' and the displacement d' of the piston 35 of the modifying device.

The start of injection occurs in respect of the abscissa $a'1$ (FIGS. 15 and 16). The inlet conduit 71 is then closed and the conduit 74 communicating with the device M is opened. The injecting stage continues until the abscissa point $a'2$ is reached. The fuel, compressed and delivered by the pump piston, is sent, on one hand, to the injector through the valve 73 and, on the other hand, to the modifying device M by way of the passage 78, the recess 79 and the conduit 74. There occur simultaneously: a fuel injection into the engine and a take-off of fuel by the device in accordance with the same procedure as that described hereinbefore. The piston 35 of the device, having moved from its illustrated position, closes at point (a' F $d'1$) the discharge conduit 38 comes in contact with the abutment 23*a* after a travel $d'2$.

The injection is ended by the opening of the conduit 71 by the helical ramp 76. As the piston 35 of the device is against the abutment 23*a*, the discharge passage 38 is closed and the pressure in the chamber 43 cannot be relieved.

Between the abscissae $a'3$ and $a'4$ the supply conduit 71 is opened but the piston 35, although it moves away from the abutment 23*a*, has not yet uncovered the discharge passage 38 so that the fuel taken off during the injection stage can only be restored to the delivery chamber of the pump after the supply stage of the pump. This restoration of fuel can only occur beyond the abscissa point $a'0$ placed after the point $a'4$ where the supply conduit 71 is closed. Beyond this abscissa point $a'0$, the chamber 43 can open and restore the fuel taken off, assuming of course that it concerns an engine operation range in respect of which a correction is made. When the engine speed increases, the manner of eliminating the device is identical to that described hereinbefore, that is to say, the piston 35 does not have sufficient time between two successive delivery strokes to move back beyond the abscissa point $a'0$ and the take-off chamber cannot be discharged, which eliminates the injection law modifying action.

Among the modifications which may be made in the modifying device itself, might be mentioned the following. An additional throttle or constriction may be interposed between the takeoff valve 32 and the piston 35, which results in an improved fuel supply control when fuel is being taken off or deducted.

We claim:

1. An injection device for a compression-ignited internal combustion engine comprising in combination a fuel injection pump and a modifying device having a fuel take-off chamber for modifying the injection law of said injection pump and operative by taking off and restoring fuel, said injection pump comprising a body, means defining a delivery chamber in said body, a first conduit for connection to a fuel supply pump, a second conduit for connection to a fuel injector, a third conduit connected to said modifying device, injection fuel delivery means associated with said delivery chamber and capable of effecting a cyclic supply of fuel to the injector in each injection cycle and comprising first means for putting said delivery chamber alternately in communication with and out of communication with said first conduit, said second conduit and said third conduit during parts of each injection cycle and precluding communication of said delivery chamber simultaneously with said third conduit and with said first conduit, and second means interposed between and controlling communication between said third conduit and said take-off chamber so as to allow fuel to be taken off and transferred from said delivery chamber to said take-off chamber when said first means put said delivery chamber in communication with said third conduit and thereafter retard restoration of the taken-off fuel to said delivery chamber until said first means once again put said delivery chamber in communica-

tion with said third conduit in the following injection cycle.

2. An injection device as claimed in claim 1, wherein said second means comprise a take-off passage between said third conduit and said take-off chamber, and a return passage between said take-off chamber and said third conduit, said take-off passage comprising a first check valve openable to allow passage of taken-off fuel from said third conduit to said take-off chamber and means defining a bore communicating with said take-off chamber and a piston movable in said bore, a constricted passage in said piston and putting said take-off passage in communication with said take-off chamber, said return passage comprising a lateral passage which communicates laterally with said bore, means for opening and closing said lateral passage in accordance with the position of said piston, and a second check valve inserted in said return passage and openable to allow passage of taken-off fuel from said take-off chamber to said third conduit.

3. An injection device as claimed in claim 2, wherein said constricted passage is in the form of a longitudinal bore constricted in the vicinity of an end thereof adjacent said first valve, and said piston has a radial passage and a peripheral recess put in communication with said longitudinal bore by said radial passage.

4. An injection device as claimed in claim 2, wherein said modifying device comprises a hollow body having an end portion secured to said body of the injection pump, a longitudinal passage in said end portion, a valve-carrying unit carrying said first valve and second valve and a piston-carrying unit carrying said piston in said hollow body, a plug closing an end of said hollow body opposed to said end portion and retaining said units and defining said take-off chamber, said valve-carrying unit comprising a first longitudinal passage which is part of said take-off passage and a second longitudinal passage which is part of said return passage, said first valve and said second valve being respectively inserted in said first longitudinal passage and said second lontiguinal passage, said bore being provided in said piston-carrying unit in alignment with said first longitudinal passage.

5. An injection device as claimed in claim 2, comprising means defining abutment faces defining extreme positions of said piston and resiliently yieldable means biasing said piston to a position for opening said discharge passage.

6. An injection device as claimed in claim 4, comprising means defining abutment faces defining extreme positions of said piston and resiliently yieldable means biasing said piston to a position for opening said discharge passage, said abutment faces comprising a face on said piston-carrying unit and a face on a flange on the piston for one direction of piston movement and a face on a part of said plug and an end face of said piston for an opposite direction of movement of said piston.

7. An injection device as claimed in claim 1, further comprising a closing device interposed between said injection pump and said modifying device, said closing device being adapted and arranged to be controlled as a function of a parameter of operation of an engine for which the injection device is intended.

8. An injection device as claimed in claim 7, wherein said closing device is adapted and arranged to be actuated by an acceleration lever of the pump.

9. An injection device for a compression-ignited internal combustion engine comprising in combination a fuel injection pump and a modifying device having a fuel take-off chamber for modifying the injection law of said injection pump and operative by taking off and restoring fuel, said injection pump comprising a body, means defining a delivery chamber in said body, a first conduit for connection to a fuel supply pump, a second conduit for connection to a fuel injector, a third conduit connected to said modifying device, injection fuel delivery means associated with said delivery chamber and capable of effecting cyclic supply of fuel to the injector in each injection cycle and comprising first means for putting said delivery chamber alternately in communication with and out of communication with said first conduit, said second conduit and said third conduit during parts of each injection cycle and precluding communication of said delivery chamber simultaneously with said third conduit and with said first conduit, and second means interposed between and controlling communication between said third conduit and said take-off chamber so as to allow fuel to be taken off and transferred from said delivery chamber to said take-off chamber when said first means put said delivery chamber in communication with said third conduit and thereafter retard restoration of the taken-off fuel to said delivery chamber until said first means once again put said delivery chamber in communication with said third conduit in the following injection cycle, said pump being a distributing pump and said injection fuel delivery means being distributing means comprising a bore in said body of the pump and a rotary distributing element mounted in said bore, said delivery chamber of the pump being partly defined by a bore formed in said rotary distributing element, said first means comprising a radial passage in said rotary distributing element and communicating with said delivery chamber and adapted and arranged to be brought in communication, in the course of rotation of said rotary distributing element, in succession with said first conduit and with said third conduit.

10. An injection device for a compression-ignited internal combustion engine comprising in combination an injection pump and a modifying device having a fuel take-off chamber for modifying the injection law of said injection pump and operative by taking off and restoring fuel, said injection pump comprising a body, a delivery chamber in said body, a first conduit for connection to a fuel supply pump, a second conduit for connection to a fuel injector and communicating with said delivery chamber, and a third conduit connected to said modifying device, injection fuel delivery means disposed in said delivery chamber and capable of effecting a cyclic supply of fuel to the injector in each injection cycle and comprising, first means for putting said delivery chamber alternately in communication with and out of communication with said first conduit and said third conduit during parts of each injection cycle and precluding communication of said delivery chamber simultaneously with said third conduit and with said first conduit, and second means interposed and controlling communication between said third conduit and said take-off chamber so as to allow fuel to be taken off and transferred from said delivery chamber to said take-off chamber when said first means put said delivery chamber in communication with said third conduit and thereafter retard restoration of the taken-

off fuel to said delivery chamber until said first means once again put said delivery chamber in communication with said third conduit in the following injection cycle, said pump being an "in line" pump and said fuel injection delivery means being a pumping element comprising a helical ramp co-operative with said inlet conduit, said first means comprising a passage in said pumping element which passage communicates with said delivery chamber, a recess in a peripheral portion of said pumping element, said passage communicating with said recess and said recess being co-operative with said third conduit.

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