

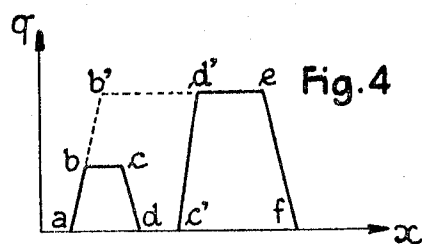
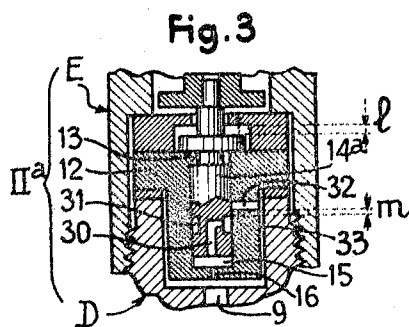
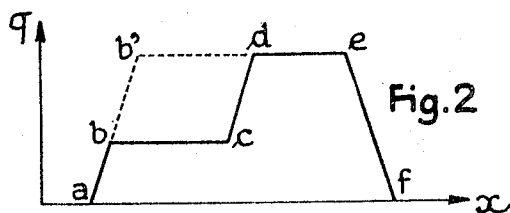
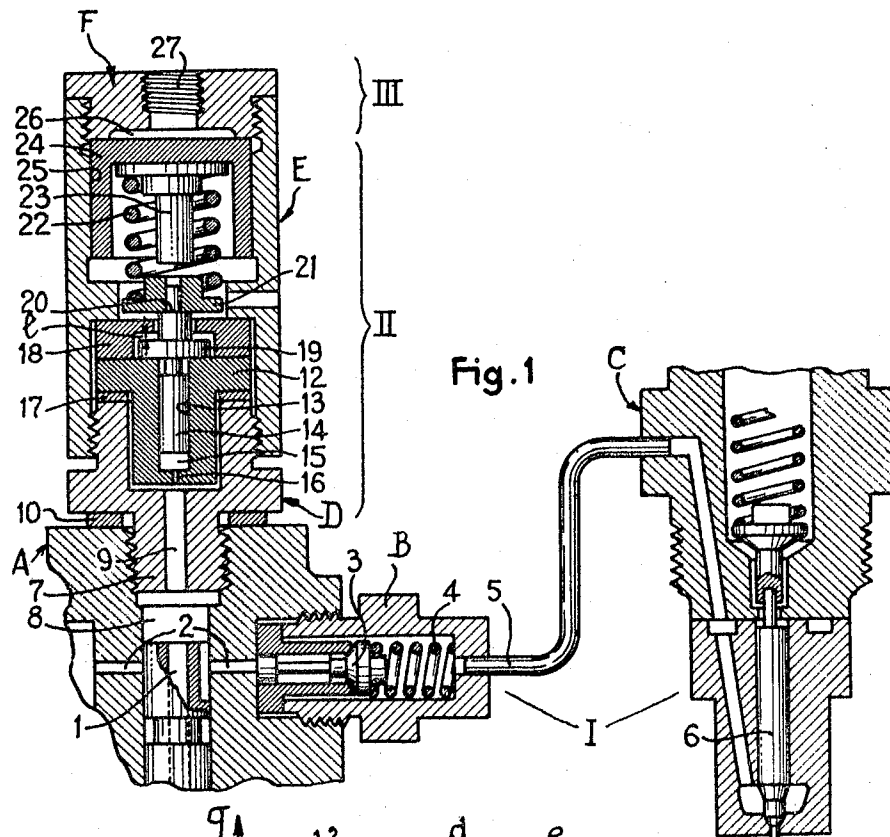
July 22, 1969

M. DANGAUTHIER
FUEL INJECTION DEVICES FOR COMPRESSION
IGNITED INTERNAL COMBUSTION ENGINES

3,456,629

Filed July 28, 1967

3 Sheets-Sheet 1



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Fig.5

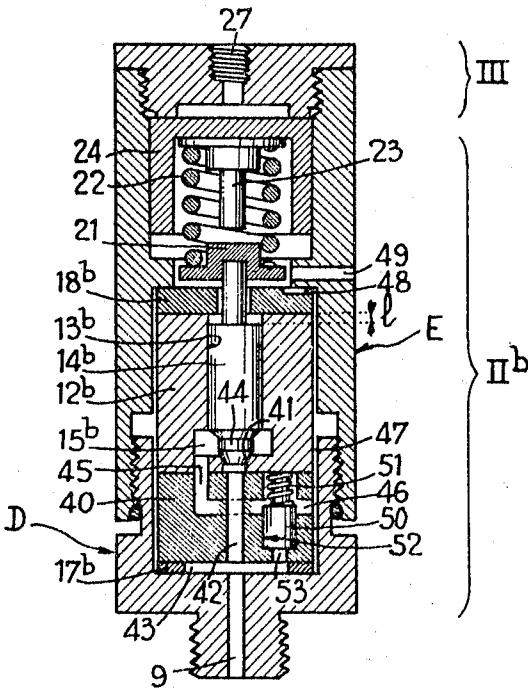
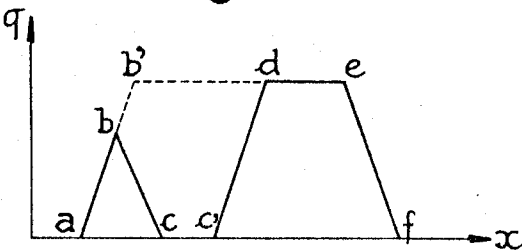


Fig.6



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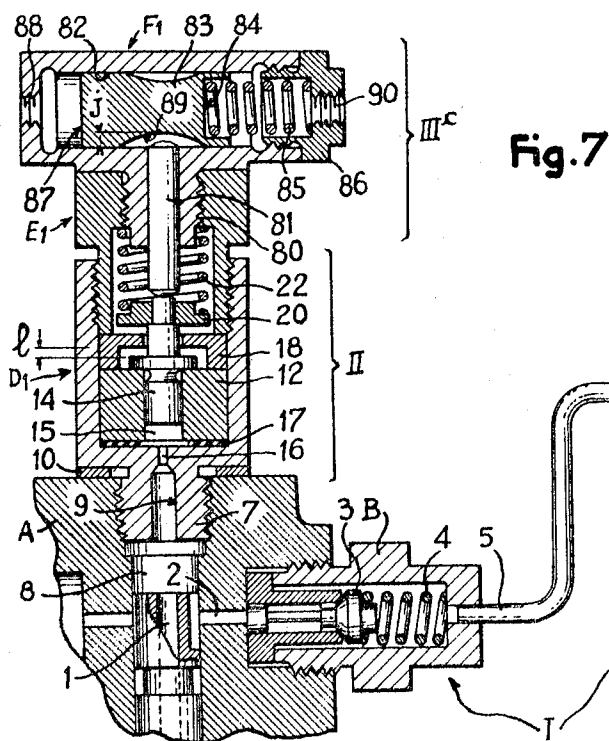


Fig. 7

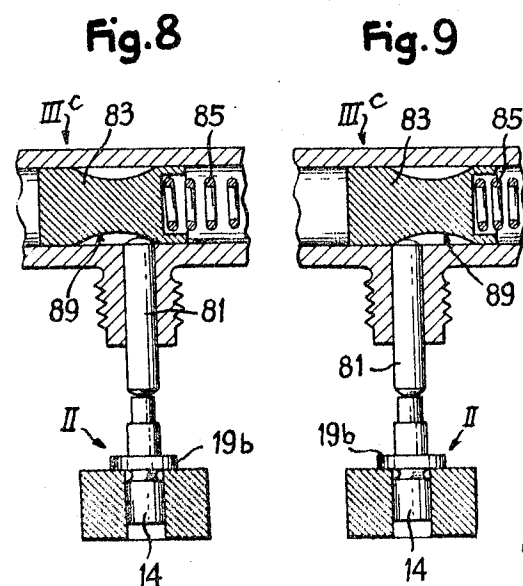


Fig. 8

Fig. 9

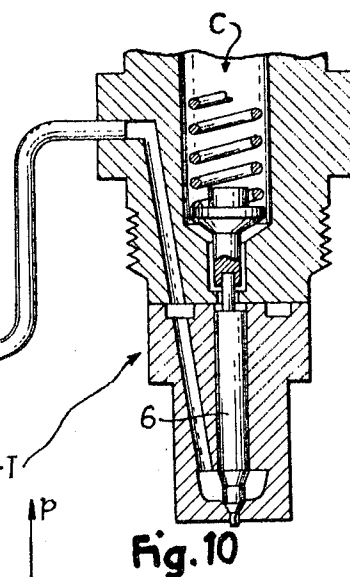


Fig. 10

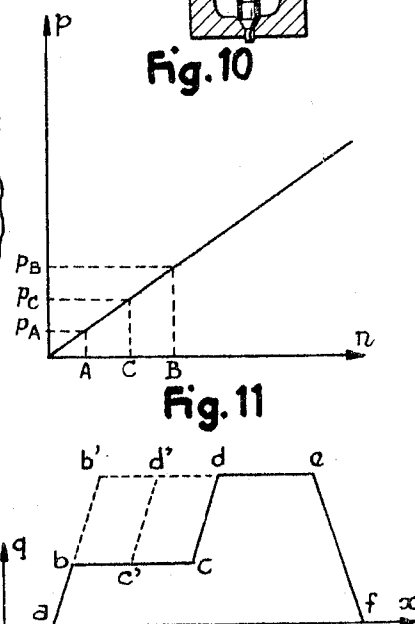


Fig. 11

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FUEL INJECTION DEVICES FOR COMPRESSION IGNITED INTERNAL COMBUSTION ENGINES

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Claims priority, application France, Aug. 1, 1966, 71,613

Int. Cl. F02b 3/10; F02m 39/00; F04d 15/00
U.S. Cl. 123—32 13 Claims

ABSTRACT OF THE DISCLOSURE

A fuel injecting device for a compression-ignited internal combustion engine, said device comprising in combination: a delivery chamber of a fuel feed pump, an injector which communicates with said chamber, an auxiliary deducting device for deducting a portion of the fuel fed by said chamber, said device having a variable-capacity deducting chamber which communicates with said delivery chamber, and means for creating a temporary pressure difference between said two chambers interposed between the deducting chamber and the delivery chamber.

The present invention relates to the injection of fuel in compression-ignited internal combustion engines.

It is known that in these engines, it is of interest to effect a start of injection at a reduced rate so as to in particular reduce the combustion noises.

The object of the invention is to provide an injection device for a compression-ignited internal combustion engine, said device being so improved as to afford a reduced injection rate at the start of injection. According to the invention, said device comprises, in combination with at least one injector which communicates, by way of an injection conduit, with the delivery chamber of an injection pump, an auxiliary deducting device for deducting a portion of fuel and neutralizing means which render the deducting device inoperative in certain conditions of operation of the engine, said deducting device having a variable-capacity deducting chamber which communicates with said delivery chamber by way of means adapted to create a temporary pressure difference between the two chambers.

This means is preferably a calibrated aperture or an opening provided with a valve.

Owing to this means, the fuel enters the deducting chamber and the latter is filled in accordance with a precise law in the first part of the injection, the deducted fuel being returned to the pump after the end of the injection.

Another object of the invention is to provide the auxiliary device for deducting fuel from an injection circuit, said device, considered alone, comprising the deducting chamber and the aforementioned means so as to create a pressure drop.

Further features and advantages of the invention will be apparent from the ensuing description with reference to the accompanying drawings.

In the drawings:

FIG. 1 is an axial sectional view of an improved injection device according to a first embodiment of the invention;

FIG. 2 is a diagram illustrating the operation of the device shown in FIG. 1;

FIG. 3 is a partial view, similar to FIG. 1, of a modification of the auxiliary deducting device;

FIG. 4 is a diagram corresponding to the operation of the injecting device including said modification;

FIG. 5 is a longitudinal sectional view of another embodiment of the corresponding auxiliary device;

FIG. 6 is a diagram relating to the operation of the injection device provided with said modification of the auxiliary deducting device;

FIG. 7 is a longitudinal sectional view of an injection device provided with another auxiliary deducting device, which can be neutralized by a cam, the assembly being shown in the position corresponding to maximum deduction, the eliminating or neutralizing cam being in the withdrawn position;

FIGS. 8 and 9 are similar partial views of the deducting device, corresponding to the two positions of complete neutralization of the device;

FIG. 10 is a graph of the variations in the transfer pressure p , plotted as ordinates as a function of the speed of rotation n of the engine, plotted as abscissae, and

FIG. 11 is a diagram similar to those of FIGS. 2, 4 and 6.

In FIG. 1, the invention is represented as applied to a conventional injection device I comprising an injection pump, only a part A of the body being shown in which is disposed the distributor valve or plunger 1 which slides in a vertical bore. Said body further comprises distribution passages 2 each of which communicates with a chamber of an element B screwed in the body A and containing a check valve 3 having a spring 4. Said valve controls the passage of the fuel in a pipe 5 feeding an injector 6 disposed in an injector carrier generally designated by the reference letter C. This injection assembly is known per se and is completed, in accordance with the invention, by a fuel deducting device II combined with a device III for neutralizing the device II.

A coupling D has a screw-threaded spigot 7 which is engaged in a tapped bore in the body. This coupling is in coaxial relation to the plunger 1 and defines therewith a cylindrical chamber 8. A sealing element 10 is interposed between the body A and the coupling D.

Screwthreadedly engaged on the coupling D, is a generally hollow cylindrical body E. Provided between the elements D and E is a cavity in which is disposed, with radial clearance, a member 12 having an axial bore 13 in which a piston plunger 14 is axially slidable and defines a chamber 15. The latter communicates with the conduit 9 through a constriction constituted by a calibrated orifice 16 having a section which is small relative to the inside diameter of the conduit 5, this section being of the order of a few tenths of a square millimetre.

An annular sealing element 17 is disposed between the coupling D and the member 12.

A generally cylindrical hollow member 18 coaxial with the member 12 accommodates with axial clearance 1, a flange 19 on the piston 14. The head of the piston extends through said member so as to support, by a shoulder 20, a seat 21 for a spring. The seat 21 is axially movable in a bore in the member E and is biased by a spring 22 which tends to apply it against the shoulder 20 of the piston head.

This spring 22 is disposed around a push rod 23 in the cavity of a hollow piston 24 which is slidable in a chamber 25 defined by the end portion of the hollow body E which is closed by a screw-threaded plug F. A chamber 26 formed between the plane wall of the piston 24 and the plug F communicates with an axial conduit (not shown) which is screwed in a tapped hole 27 in the plug F.

The operation of the assembly just described will be examined in the two following cases: idling speed and high speed.

At idling speed, the piston 24, whose function will be explained hereinafter, is constantly in abutting relation to the plug F. At the start of each injection cycle, the fuel which is put under pressure and discharged from the chamber 8 by the plunger 1 flows simultaneously, on one

hand, by way of the bore 9 and the calibrated orifice 16 into the fuel deducting chamber 15 and, on the other hand, by way of the passage 2, the checkvalve 3 and the pipe 5, into the injector 6 and simultaneously raises the piston 14 and opens the injector 6.

This is achieved because the calibrated orifice 16 only allows through a fraction of the fuel delivered by the pump. It will be observed that this calibrated orifice produces, when the fuel passes therethrough, a pressure drop across the orifice, the pressure in the chamber 15 being lower than the delivery pressure of the pump, that is, the injection pressure.

As the piston 14 rises the supply of fuel to the engine by way of the injector 6 therefore results at each instant from the difference between the flow produced by the plunger 1 of the pump and the flow absorbed by the chamber 15. In the course of this first stage the fuel injected is therefore reduced.

The second injection stage starts when the axial displacement of the piston 14 has reached a value corresponding to the axial clearance l . In the course of this second stage the piston is constantly maintained upwardly against the abutment 18 by the pressure of the injection circuit and consequently no more fuel enter the chamber 15 and all of the fuel delivered by the pump is conveyed to the injector.

When the invention period is finished the plunger 1 ceases to deliver fuel; when, the pump is in its suction stage and creates a suction in the chamber 8 and, under the effect of this suction, the injector 6 and the check valve 3 close. As the piston 14 is no longer subjected to any pressure, it returns to its lower position under the effect of the spring 22 and the fuel contained in the chamber 15 which had been deducted at the start of the injection is restored to the injection pump. Thus it was not injected.

On the other hand, at high speeds of rotation, the injection is carried out normally without being affected by the auxiliary deducting device II. The neutralization of the action of the device II is achieved by means of the device III which has a piston 24 whose upper face is subjected to the pressure of the fuel delivered by the feed pump (not shown) of the injection pump. The feed pump is a positive displacement pump having gears or vanes and serves to feed fuel to the cylinder 8 of the pump between each injection. The delivery pressure of this pump is usually modulated by a discharge valve so that this pressure changes in accordance with the speed in a very precise manner. It usually serves to control the automatic advance of the injection and it is employed here for eliminating the effect of the deducting device described hereinbefore within a given range of engine speeds.

For this purpose, the feed pressure is transmitted by way of the aperture 27 to the chamber 28. At low speeds the feed pressure is weak. The force it exerts on the piston 24 is weak and the action of the spring 22 on this piston is preponderant. The piston 24 remains constantly applied against the plug F and does not intervene in the operation of the deducting device II, as described hereinbefore in the case of idling speed.

On the other hand, at relatively high speeds, the transfer pressure overcomes the force of the spring 22. Beyond a given speed this pressure is sufficient for constantly maintaining—even during the injection periods—the piston 14 against the seat 12 through the push rod 23. In these circumstances, in the course of an injection, the volume of the chamber 15 does not change and the flow of the injected fuel is therefore unmodified by the device.

FIG. 2 shows the injection law corresponding to the unit (I-II-III) described in hereinbefore. This graph indicates the variations in the fuel flow q injected plotted as ordinates (cu. mm. per degree of rotation of the crankshaft of the engine) as a function of the number of degrees of the angle of rotation α of this shaft plotted as abscissae. Assuming that the injection law given by the

unit without the deducting device II is represented by the curve $ab'ef$, the new injection law resulting from the addition of the device II corresponds to the curve $abcdef$. The part abc corresponds to the filling of the chamber 15 and the part cd to the end of this stage, normal injection being resumed at d . At high speeds, as the effect of the device II is eliminated, the injection law obviously corresponds to the curve $ab'ef$.

In FIG. 3, a modification IIa of the deducting device according to the invention is shown in part. It differs from the preceding device in that the piston 14a has an axial passage 30 and an annular groove 31, the passage 30 communicating with this groove and with the chamber 13. A radial passage 32 extends through the member 12 and puts the bore 13 in communication with a peripheral gap 33 between the member 12 and the coupling D. The upper edge of the annular groove is at an axial distance m from the lower edge of the passage 32 and this distance is less than the permitted travel l of the piston.

The law of injection obtained in this modification of the auxiliary device IIa is in the first stage identical to that obtained with the device II shown in FIG. 1. When the feed pump delivers fuel, the fuel enters the chamber 15 by way of the calibrated orifice 16. The part abc of the graph shown in FIG. 4 represents this stage. But when, under the action of the pressure of the fuel, the piston rises to an extent exceeding the distance m , the groove 31 communicates with the passage 32 and consequently with the gap 33. Fuel from this gap then enters the groove 31 and thence the chamber 15, by way of the passage 30, without having been throttled. The pressure of the fuel in the chamber 15 rises and reaches the same value as the injection pressure. This increase in pressure causes the piston 14a to rise suddenly to the maximum extent l and a certain drop in pressure of the fuel in the circuit results which could close the injector 6.

The injection therefore decreases rapidly, this stage corresponding with the part cd of the curve shown in FIG. 4. A first injection has therefore occurred.

When the piston 14a has finished its travel l , all the fuel delivered by the pump is conveyed to the injector and the pressure in the injection circuit rises. When the pressure for opening the injector is once more reached, a second injection occurs corresponding to the part $c'd'ef$ of the diagram shown in FIG. 4.

It can be seen that this device IIa permits a double injection if the amount of fuel deducted for a short period of time is enough to produce in the feed pipe of the injector a drop in the pressure of the fuel which is such as to result in the temporary closure of the injector. At high speeds, the result of the deducting device IIa can be neutralized by the device III as in the case of the device shown in FIG. 1.

The auxiliary deducting device IIb shown in FIG. 5 differs slightly from the device shown in FIG. 1.

Clamped between the elements D and E is an assembly comprising the abutment element 18b for determining the end of the travel of the piston 14b and locating member 12b, and auxiliary member 40 and the sealing element 17b. The axial bore 13b of the member 12b communicates with the chamber 15b which in turn communicates with the axial bore 9 of the coupling D by way of a valve seat 41, an axial bore 42 in the auxiliary member 40 and the gap 43 due to the effect of the sealing element 17b. The piston plunger 14b has a lower end 44 which constitutes a valve which is biased against the seat 41 by the action of the spring 22.

The chamber 15 communicates, by way of a conduit 45 in the member 40, an escape aperture 46, escape passages 47, 48, with a discharge orifice 49. The discharge by way of this conduit can be closed by a piston 50 which is biased to its lower opening position by a spring 51, this piston being movable in a bore 52 which intersects the conduit 45 and communicates with the gap 43 by way of an aperture 53.

5

6

The device IIb operates in the following manner:

Let S be the section of the piston 14b, s the section of the valve seat 41, that is, the end of the piston, and F the force exerted by the spring 22.

When, at the start of an injection of fuel, the latter enters the bores 9 and 42, the pressure established therein is exerted on the section s . The values of S and s are so chosen that the pressure $F/s=p$ (termed opening pressure) exceeds the opening pressure p' of the injector and that the pressure $p_1=F/S$ (termed closing pressure) is less than the injector closing pressure p_1 .

When the feed pump starts to deliver fuel to the injection circuit, the pressure of the fuel applied against the piston 50 raises the latter and consequently cuts off the communication between the passage 45 and the escape passage 46. As soon as the pressure p' has been reached, the injector opens and the injection starts until the pressure reaches the value p . This stage corresponds to the part ab of the diagram shown in FIG. 6. The pressure p opens the valve consisting of the piston 14b and the seat 41 and this piston is immediately subjected to the pressure of the fuel over the whole of its section S . It therefore rises suddenly and causes a part of the fuel to flow into the chamber 15b and the passage 45 and this reduces the pressure of the fuel. Consequently, there is a pressure drop in the injection circuit and this closes the injector when the pressure becomes equal to p_1 . This stage corresponds to the part bc of the diagram. As the pump continues to deliver fuel, the injection pressure rises as soon as the piston 14b is stopped in its upper position. The main injection starts when the opening pressure of the injector is once again reached and continues normally in accordance with the curve $c'def$ of the diagram. When the injection has finished, the pressure drop caused by the pump results in the closure of the valve, the piston 14b assuming the lower position. Further, the piston 50 also assumes the lower position so that the passage 45 is put in communication with the escape passage 46. In this way the residual pressure in the chamber 15b and the passage 45 is thus eliminated.

At relatively high speeds, the effect of the deducting device IIb is eliminated, as in the case of the device shown in FIG. 1, by the action of the neutralizing device III, that is, by the feed pressure exerted on the piston 24 through the orifice 27, the push rod 23 maintaining the piston 14b in the lower position thereof.

FIGS. 7-11 relate to a modification of the invention which differs from the embodiments described hereinbefore in respect of the neutralizing means IIIc of the deducting device II.

According to this modification, the injection device I comprises the auxiliary device II for deducting fuel at the start of each injection, and this device, which is identical to that of the first embodiment, is completed by cam means IIIc which neutralizes the deducting device II.

The axial bore 9 communicates with the deducting chamber 15 by way of the calibrated orifice 16 which has a diameter of few tenths of a millimetre. This chamber 15 is formed in the member 12 which is caused to bear (with interposition of a sealing gasket 17) against the bottom of the connection D_1 by a plug E_1 which is screwed into the top end of the connection. This plug bears against the element 12 through the hollow element 18.

The chamber 15 has a variable capacity owing to the action of the piston plunger 14.

The upper end of the piston rod is surmounted by the seat 20 against which the spring 22 bears.

Screwed at 80 in the plug E_1 is a T-shaped body F_1 . Slidable in the stem of the T-shaped body is a push rod 81 which is coaxial with the piston 14 whereas slidable in a bore 82 in the transverse portion of the T-shaped body is a cam 83 whose axis is perpendicular to the axis of the rod 81. This cam 83 is biased on its face 84 by a spring 85

which bears against a plug 86 and subjected on its face 87 to the effect of the pressure produced by the feed pump, the bore 82 being connected by way of an aperture 88 to the feed pump of the injection pump. The cam-piston 83 has in the centre part thereof a surface of revolution 89 which defines in front of the push rod 81 a clearance which is variable in accordance with the axial position of the cam in the bore 82. The maximum value j of the clearance exceeds, or is at least equal to, the maximum possible displacement l of the piston 14.

An aperture 90 discharges leakages of fuel around the piston 14, the push rod 81 and the cam 83.

The operation of the neutralizing device IIIc for example adapted for an injection pump whose pressure p of the feed pump changes in accordance with the speed n as shown in the diagram of FIG. 10 is as follows.

For a speed A which is lower than the idling speed of the engine, for example when the vehicle driven by the engine starts to move off, the pressure p_A is low and the force of the spring 85 on the cam 83 is preponderant. This cam occupies the position shown in FIG. 8 and holds the piston in its extreme lower position and thus renders the deducting device II inoperative.

The same is true in respect of a speed B which is higher than the idling speed of the engine, since the pressure p_B exerts on the left face of the cam 83 a force exceeding the opposing force exerted by the spring 85 so that the cam 83 occupies the position shown in FIG. 9 and the deducting device II is therefore neutralized, as in the preceding case.

In both cases, the injection law is the usual law represented at $ab'ef$ in FIG. 11.

As concerns a speed C in the neighbourhood of idling speed, there is an equilibrium between the force due to the feed pressure p and the opposing force of the spring 85. The cam 83 occupies the position shown in FIG. 7 and, owing to the fact that the clearance j exceeds the clearance l , it allows the normal operation of the deducting device II, which modifies the law of injection in accordance with the curve $abcdef$.

As concerns speeds between A and C or between B and C the position of equilibrium of the cam 83 allows a limited rise of the push rod 81 and consequently of the piston 14 which thus partly neutralizes the deduction. In this case an injection law $abc'd'ef$ is obtained.

Briefly, the preceding assembly modifies the injection law determined by the equipment for which it is adapted solely in the range of speeds in the neighbourhood of idling speed.

The advantage of the neutralizing means IIIc is that it is capable of effectively stopping the fuel deducting piston 14 by taking advantage of the wedging effect of the ramp 89 of the neutralizing cam 83.

Although specific embodiments of the invention have been described, many modifications and changes may be made therein without departing from the scope of the invention as defined in the appended claims.

In the particular case where the injection pump is a distributing pump having a single piston, a single deducting device communicating directly with the cylinder of the pump, upstream of the distributor, produces the desired effect, irrespective of the number of cylinders of the engine.

The deducting device can be employed with or without the auxiliary elements which enable this device to be rendered partly or completely inoperative for certain ranges or engine speeds.

It will be understood that in the last embodiment, the profile of the cam 83 can differ from that illustrated and can permit use of any other neutralizing process. For example, it can allow the deducting device to operate in any selected speed and loading ranges of the engine different from those described.

If desired, the cam 83 can be controlled or shifted

mechanically, electromagnetically or manually, depending on the considered application.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:

1. A fuel injection device for a compression-ignited internal combustion engine, said device comprising in combination: an injection pump having a body defining a delivery chamber, at least an injector which communicates, by way of an injection conduit and a check-valve, with said delivery chamber of the injection pump, an auxiliary deducting device mounted on said body of the injection pump for deducting during an injection stroke a portion of the fuel fed by said delivery chamber and restoring said portion to said delivery chamber during the suction stroke of the pump, said deducting device having a variable-capacity deducting chamber which communicates with said delivery chamber through a passage, restrictor means in said passage for creating a temporary pressure difference between said two chambers and neutralizing means which render said deducting device inoperative in predetermined operating conditions of the engine.

2. A device as claimed in claim 1, wherein said restrictor means comprises a calibrated aperture in said passage interconnecting said two chambers.

3. A device as claimed in claim 2, further comprising a conduit having a non restricted section and interconnecting said two chambers in parallel with said passage, and means ordinarily closing said conduit and rendering said conduit open so that it by-passes said calibrated aperture only after a given variation in the volume of said deducting chamber.

4. A device as claimed in claim 1, wherein said deducting device comprises a body, means for mounting said body on said pump body, a bore in said body which communicates with the delivery chamber of the injection pump, an axially movable piston located in said bore, said piston and said bore defining said deducting chamber, abutment means for the piston to determine the maximum and minimum volumes of said deducting chamber and spring means for urging said piston towards the position thereof corresponding to the minimum volume of the deducting chamber.

5. A device as claimed in claim 4, wherein said restrictor means comprise in combination an aperture putting said delivery chamber in communication with said deducting chamber and a combined valve element and valve seat for closing said aperture, said valve element being connected to said piston of the deducting chamber and said seat having a section which is small relative to the section of said piston.

6. A device as claimed in claim 5 wherein said deducting chamber communicates with an escape orifice, said deducting device further comprising means controlled by the pressure of injection for closing said escape orifice in the course of the injection cycles.

7. A device as claimed in claim 4, wherein said neutralizing means comprise a neutralizing element which is actuated as a function of a given parameter of the engine so as to maintain said movable piston in the position thereof corresponding to the minimum volume of said deducting chamber.

8. A device as claimed in claim 4, wherein the axially movable piston of said deducting chamber bears against the face of a transversely movable cam having a profile which is such as to eliminate any deduction by said deducting chamber for at least one of the operational conditions of the engine.

9. A device as claimed in claim 8, wherein the movable cam is in the equilibrium under the effect of the opposing actions of a spring and a variable force constituting a regulating parameter, the profile of the cam being such that the position of the movable wall defining said deducting chamber varies as a function of said parameter in accordance with a pre-determined law.

10. A device as claimed in claim 9, further comprising a feed pump delivering fuel to the injection pump at a feed pressure which varies in accordance with the speed of the engine and wherein the movable piston of said deducting chamber bears against a transversely movable cam through a push rod, said cam being transversely movable under the opposing actions of said spring and said feed pressure.

11. A device as claimed in claim 10, wherein the arrangement is such that said deducting device is free of any neutralization only in the neighbourhood of the idling speed of the engine.

12. A device as claimed in claim 1, further comprising a feed pump delivering fuel to the injection pump at a feed pressure which varies in accordance with the speed of the engine, said neutralizing means being responsive to said feed pressure and rendering said deducting device inoperative when the speed of the engine reaches a pre-determined value.

13. A device as claimed in claim 12, wherein the neutralizing means comprise a piston subjected in one direction to said feed pressure and in the other direction to the force of an elastically yieldable return means.

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LAURENCE M. GOODRIDGE, Primary Examiner

U.S. Cl. X.R.

103—41; 123—139