

[54] **DEVICE FOR REGULATING THE AMOUNT OF FUEL INJECTED BY INJECTION SYSTEMS OF INTERNAL COMBUSTION ENGINES**

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[57] **ABSTRACT**

A device for regulating the amount of injected fuel in injection systems of internal combustion engines, of the kind provided with a spatial cam and a follower, the spatial cam having two degrees of freedom whereas the follower has an additional degree of freedom, means for controlling the displacements of the points of contact of the cam with the follower along a first direction and second means for controlling the relative displacements of said points of contact along a second direction, in which said first named means are an electrical-mechanical transducer having its input associated with the engine mainshaft and a second transducer having its input electrically connected to the output of the first transducer and the output mechanically connected to either of said cam or said follower.

12 Claims, 2 Drawing Figures

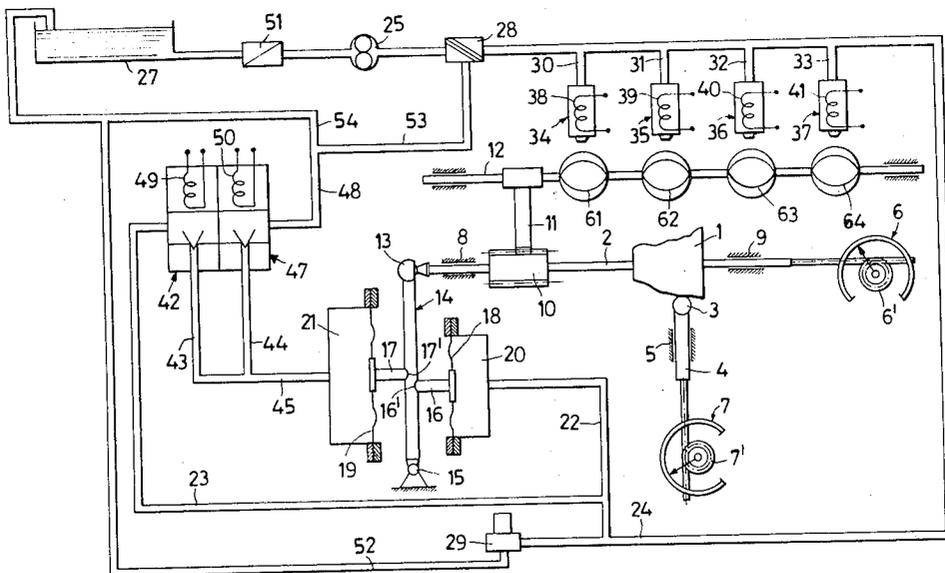
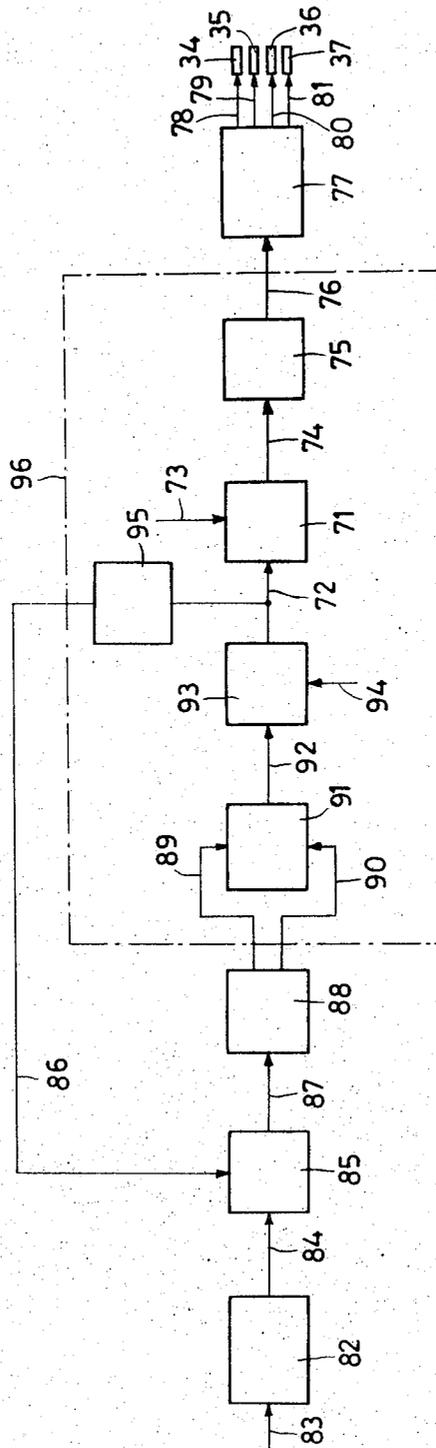


Fig. 1



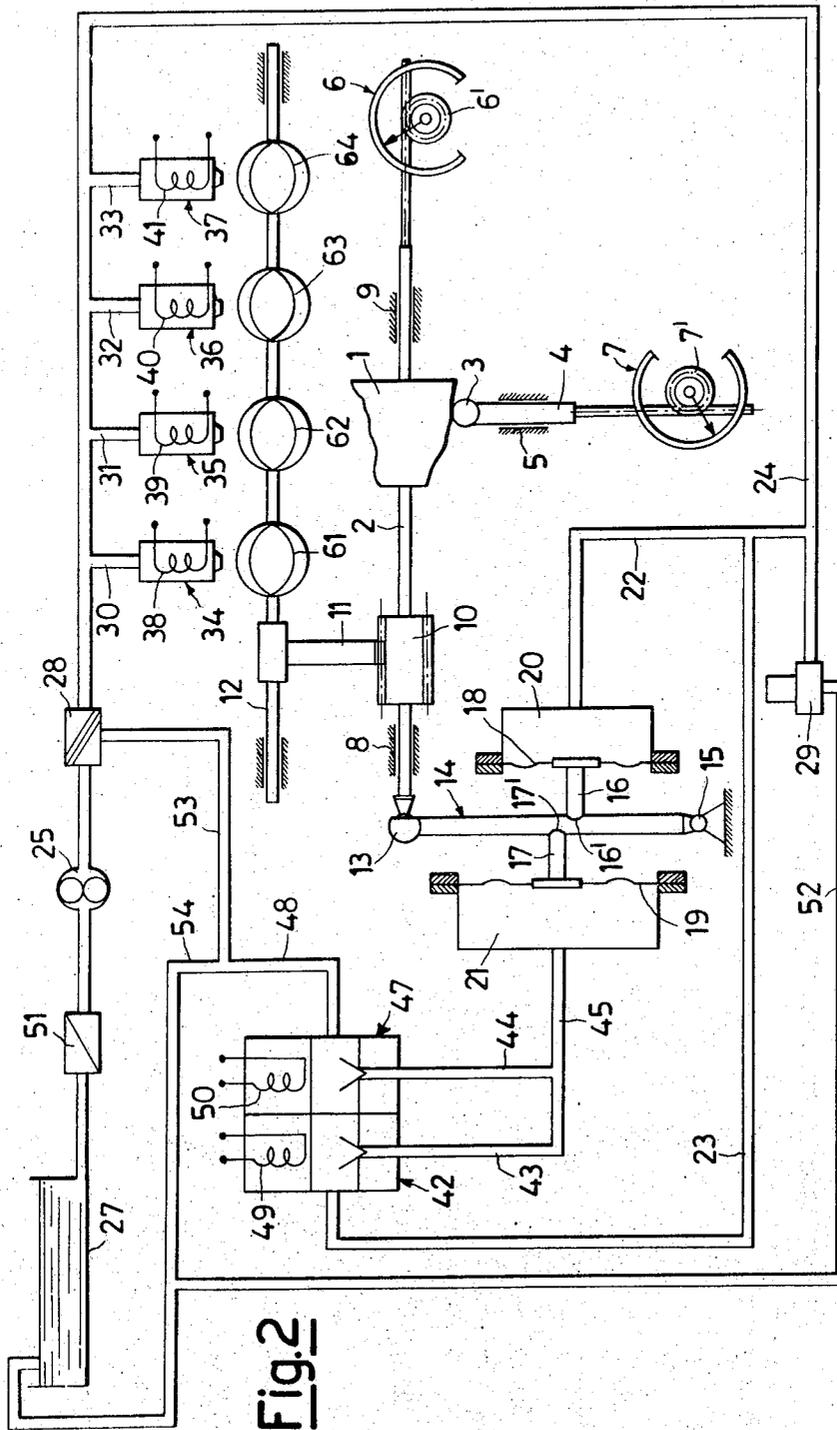


Fig. 2

DEVICE FOR REGULATING THE AMOUNT OF FUEL INJECTED BY INJECTION SYSTEMS OF INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates to a device for regulating the amount of injected fuel in injection systems of internal combustion engines.

In recent years studies and researches have been carried out in connection with the possibility of employing on a motor vehicle the more updated and qualitatively superior injection engines in lieu of the conventional carburetor-equipped engines. Such a trend has been originated by the fact that injection engines, inter alia, afford the twofold advantage of supplying an improved carburation with lesser specific consumption and or reducing the amount of noxious burned fractions as present in exhaust gases. This twofold advantage, which largely compensates the intricacy of the injection system as compared with the conventional carburetors, is mainly due to the possibility of inserting in the injection systems appropriate devices which permit regulating the amount of the injected fuels and thus the air-to-fuel ratio of the mixture, as well as devices which permit varying the injection phase relationship consistently with the engine working conditions.

PRIOR DEVICES

Among the devices used for regulating the amount of injected fuel which are particularly efficient are those which are based on the use of a spatial cam and a follower in engagement with the shaped cam surface, with the relative displacements of the point of contact of the follower with the cam with respect to the cam surface being controlled along two directions which are essentially mutually perpendicular and also perpendicular to the cam rise as a function of the rate of revolution of the engine and the angle of the throttle(s) or a function of the rotational speed and the induction pressure of the engine. The follower, usually through a transducer, supplies a data processing appliance with the information which is necessary for an optimum regulation of the air/fuel mixture ratio. Such information obviously varies as a function of the relative position of the cam and the follower, and thus as a function of the engine rotation speed and the throttle angle and the speed of rotation and the induction pressure, with the shaping of the spatial cam representing the carburation plan of the engine.

To put into practice the regulating devices of the kind referred to above is, however, a serious problem which is the necessity of converting the speed of rotation of the engine into a displacement, either of rotation about an axis, or of translation along the direction of said axis, of the spatial cam or its follower.

Such a conversion, in fact, is usually obtained by means of mechanisms (for example those based on the presence of rotary masses, whose centrifugal force is counteracted the spring bias) which require a mechanical connection with the mainshaft. This approach has, essentially, two shortcomings which are vibrations of a high frequency and a comparatively high amplitude transferred by the great majority of motor vehicle engines (which are almost never perfectly balanced) to the sensitive internal component parts of the regulation devices and, on the other hand, the impossibility of

placing the device in question in a position which is preferred either because it does not create space problems, or because it permits to simplify the mechanisms which are required to translate into cam or follower displacements (either rotations or translations) either of the other two variables which define the particular working conditions of the engine, for example in the vicinity of the intake assembly, as would conversely be advantageous.

OBJECT AND SUMMARY OF THE INVENTION

An object of the present invention is to provide a regulation device of the kind referred to above, in which the conversion of the engine rotational speed into a displacement of the spatial cam or the follower is obtained in such a way as to overcome the above enumerated defects.

Having this object in view, the regulation device according to the invention comprises a first member defined by a spatial cam and a second member defined by a follower maintained in engagement with the spatial cam surface, with said two members being connected to the body of the device so as to allow two degrees of freedom in total to said two members, the follower being allowed an additional degree of freedom so as to be allowed to carry out displacements in the direction of the cam rises, said two degrees of freedom permitting relative displacements of the point of contact of the follower with the cam surface along two corresponding directions which are perpendicular to one another and perpendicular to the cam rises, said follower acting on component parts of the injection system which are enabled to vary the amount of injected fuel as a function of the position of said point of contact with respect to the cam surface, first means controlling, as a function of the engine speed of rotation, the relative displacement of the point of contact with respect to the cam surface along the first of the two directions, and second means controlling the relative displacement along the second of the two directions as a function on either of the other variables which defines the particular working condition of the engine, that is the throttle angle and the negative pressure in the engine intake duct, characterized in that said first means comprise a first mechanical-electrical transducer having its input associated with the mainshaft and a second electrical-mechanical transducer having its input electrically connected to the output of said first transducer and the output mechanically connected to either of said first and second members.

It is apparent that the utilization of electric signals for transferring the information as to the speed of rotation of the engine from the first to the second transducer, and thus from the mainshaft to either the spatial cam or the follower, permits to overcome the above indicated shortcoming which is bound to the engine vibrations. Also the vibrations which can possibly be transferred through the (usually mechanical) connection between the throttle(s) and the spatial cam or the follower, can be easily removed, in fact, by making with a resilient material both the portion of the feeding duct between the body which contains the throttle(s) and the engine head, and also the possible connections between said body and the engine. At the same time, it becomes possible to position the cam-follower assembly in any position which is convenient, for example in the vicinity of the intake assembly. Finally a greater ac-

curacy and rapidity is ensured for the relative displacements between the spatial cam and the follower as a function of speed of rotation of the engine.

These and other features of the present invention, along with the advantages afforded thereby will become apparent from the ensuing detailed description of a practical embodiment of the regulation device according to the invention.

In the ensuing detailed description, which is given by way of nonlimiting example only, reference will be had to the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a logical block diagram of an example of regulation device according to the invention as applied to an electronic injection system and

FIG. 2 shows a detailed diagram of that portion of the device of FIG. 1 which is intended to be consolidated into a single body which is preferably placed in the vicinity of the intake system, that is, of the portion which comprises the spatial cam (which in this case has two degrees of freedom, since it is movable along its axis and rotatable about same), the follower (movable along its own axis), the second transducer and the means which transfer the throttle angle information from the throttles to the spatial cam, with this second variable having been selected in the example in point to define, along with the rotation speed, the working conditions of the engine.

DETAILED DESCRIPTION OF THE INVENTION

The regulation device shown in FIG. 1 essentially comprises a spatial cam and follower unit 71 which provides the combination into a single signal 74 of two mechanical signals 72 and 73, the first of which represents the speed of rotation of the engine, and the second, the throttle angle. At the output of the unit 71, the signal 74 is still a mechanical signal and is converted by the agency of a mechanical-electrical transducer 75 into an electric signal 76, which is applied to the input of a processor 77 adapted to supply necessary actuation signals 78 to 81 to injectors 34 to 37 (in the case in point a four-cylinder engine is assumed). While the mechanical signal 73 is directly obtained starting from the arbor(s) of the throttle(s), the mechanical signal 72 is obtained from the mainshaft (or another shaft rotating therewith) through a chain of processing blocks, which comprises a mechanical-electrical transducer 82 adapted to convert the mechanical signal of the speed of rotation 83 into an electric signal 84: the latter signal is compared, in a comparison block 85, with an electric signal 86 (supplied by a mechanical-electrical transducer 95 having the signal 72 applied to its input) so as to originate a differential or error signal 87, which, as a function of its algebraic sign, controls a distribution block 88 so that this latter emits either of two electric signals 89 and 90 which are active on an electrical-mechanical transducer 91 so as to cause it to emit a mechanical signal 92 which possibly requires to be amplified and a block 93 has been purposely provided therefor.

The assembly comprising the logical blocks 91, 93, 95, 71 and 75 enclosed in chain dotted lines 96 in FIG. 1, is shown in detail in FIG. 2, where, as can be seen, it comprises, above all, a spatial cam 1, whose shaped surface is engaged by a follower 3 integral with a rod 4 which is slidably guided in a bushing and is connected

to a slider 7' of a potentiometer 7 constituting the transducer 75 of FIG. 1. In the example of FIG. 1 rotation potentiometers have been adopted so that the device is so conceived. With linear potentiometers or rheostats, the structure would consequently be changed and it would also be changed if nonresistive transducers are adopted, that is, inductive or capacitive transducers of the linear or rotating type, with their function remaining none the less unaltered. The spatial cam 1 is borne by a shaft 2, which is rotatably and slidably supported by bushings 8 and 9 and is bound as to its axial sliding motion to a slider 6'' of a potentiometer 6' which is the transducer 95 of FIG. 1. To the shaft 2 is keyed a gear 10, in mesh with a toothed sector 11 solid with an arbor 12 of throttles 61-64, a mechanism which could be replaced by a couple of sheaves connected by a toothed belt. At one end of the shaft 2 there is pivoted in addition, at 13, a lever 14 having two hollow spaces 16' and 17' placed at different distances from a pivotal point 15, and in which there are engaged two rods 16 and 17 rigidly connected to the respective movable walls which partially consist of deformable diaphragms 18 and 19 which close respective chambers 20 and 21. The chamber 20 is connected by a duct 22 to a duct 24 which, together with a pressure regulating valve 29, an exhaust duct 52, a fuel tank 27, a filter 51, a pump 25 and a filter 28 from which a by-pass duct 53 is originated, is a part of the hydraulic circuit which provides to feed, via ducts 30-33, injectors 34-37 (controlled by electric windings 38-41 which are intended to receive the control signals 78-81 as delivered by the processor 77 of FIG. 1). From the chamber 21 conversely, starts a duct 45, which branches off into two ducts 43-44, which are connected, by two electromagnetic valves 42 and 47, as controlled by the respective electric windings 49 and 50 intended to receive the electric signals 89 and 90 delivered by the block 88 of FIG. 1, to two ducts 23 and 48, respectively, the first of which merges into the duct 22 and the second into the duct 53 to define a discharge manifold 54 which leads the fuel to tank 27 again.

The operation of the regulation device shown in the drawings is obviously based on the combination of the two mechanical signals 72 and 73 (of axial position and angular position of spatial cam 1, respectively) which determine the position of the cam surface, which from time to time is engaged by the follower 3, that which involves the necessity of converting the electrical signal as obtained in the block 85 from the comparison between the engine speed and the reference speed in a mechanical signal as it occurs in the block 91 and possibly of amplifying said signal. Every variation of the speed of rotation of the engine, in fact, causes, through the transducer 82, a variation of the electric signal 84 and thus compels the comparison block 85 to emit a difference signal 87 whose algebraic sign depends on the fact that the engine speed is either faster or slower than the reference speed. According to the sign of the signal 87, the block 88 emits either signal 89 or 90, thus causing the opening of either electromagnetic valves 42 or 47, respectively. Consistently, the chamber 21 is placed into communication with the feeding duct 23 or with the discharge duct 48 and consequently the pressure is varied which exists within the chamber, with also the thrust imparted by the rod 17 to the lever 14 being varied. Since the contrary thrust exerted by the rod 16 is constant (since it is obviously constant the

pressure in the interior of the chamber 20), the lever 14 is consequently rotated in either direction even small variations of the thrust exerted by the rod 17 are enough to rotate the lever 14 since the surface of the diaphragm 19 is greater than that of the diaphragm 18 and the rod 17 is farther than the rod 16 from the pivotal point 15, thus causing an axial displacement of the shaft 2 and of the cam 1 whose angular position is, conversely, determined as a function of the throttle angle through the intermediary of the toothed sector 11 and the gear 10. The follower 3 is thus engaged at a different point of the cam surface 1, whose different shape produces an axial displacement of the rod 4 and thus the positioning of the slider 7' of the potentiometer 7 in a different angular position, to which corresponds a different value of the electric signal 76 as delivered to the processor 77 and thus a different actuation time of the switches 34-37 as controlled by the processor by means of the signals 78-81. The axial displacement of the shaft 2 is sensed also by the potentiometer 6 which sends to the comparison block 85 the new controlled speed signal 86 which tends to balance the actual speed signal 84.

What we claim is:

1. A device for regulating the amount of injected fuel for injection systems of internal combustion engines, comprising a first member defined by a spatial cam and a second member defined by a follower maintained in engagement with the spatial cam surface, said two members being connected to the body of the device so as to allow two degrees of freedom in total to said two members, the follower being allowed an additional degree of freedom so as to be allowed to carry out displacements in the direction of the cam rises, said two degrees of freedom permitting relative displacements of the point of contact of the follower with the cam surface along two corresponding directions which are perpendicular to one another and perpendicular to the cam rises, said follower acting on component parts of the injection system which are enabled to vary the amount of injected fuel as a function of the position of said point of contact with respect to the cam surface, first means controlling, as a function of the engine speed of rotation, the relative displacement of the point of contact with respect to the cam surface along the first of the two directions, and second means controlling the relative displacement along the second of the two directions as a function of a parameter representative of the throttle angle, the improvement that said first means comprise a first mechanical-electrical transducer, a second electrical-mechanical transducer, a feed-back unit consisting of a third mechanical-electrical transducer and of a comparison element, the input of the first transducer being mechanically coupled to the mainshaft and its output being electrically connected to the comparison element, the input of the third transducer being mechanically coupled to said first member and its output being electrically coupled to said comparison element, the input of said second transducer being electrically coupled to the comparison element, while the output is mechanically coupled to said first member.

2. The regulation device according to claim 1, characterized in that said second control means are sensitive to the throttle angle and the spatial cam, the follower, said second control means and the second transducer are consolidated into a single unit which is me-

chanically connected to the body which contains the throttle(s), the connection between the body and the engine being made of a resiliently deformable material.

3. A device for regulating the amount of injected fuel for injection systems of internal combustion engines, comprising a first member defined by a spatial cam and a second member defined by a follower maintained in engagement with the spatial cam surface, said two members being connected to the body of the device to allow two degrees of freedom in total to said two members, the follower being allowed an additional degree of freedom so as to be allowed to carry out displacements in the direction of the cam rises, said two degrees of freedom permitting relative displacements of the point of contacts of the follower with the cam surface along two corresponding directions which are perpendicular to one another and perpendicular to the cam rises, said follower acting on component parts of the injection system which are enabled to vary the amount of the injected fuel as a function of the position of said point of contact with respect to the cam surface, first means controlling, as a function of the engine speed of rotation, the relative displacement of the point of contact with respect to the cam surface along the first of the two directions, and second means controlling the relative displacement along the second of the two directions as a function of a parameter representative of the throttle angle, the improvement being that said first means comprise a first mechanical-electrical transducer, a second electrical-mechanical transducer, a feed-back unit consisting of a third mechanical-electrical transducer and of a comparison element, the input of the first transducer being mechanically coupled to the mainshaft and its output being electrically connected to the comparison element, the input of the third transducer being mechanically coupled to said first member and its output being electrically coupled to said comparison element, the input of said second transducer being electrically coupled to the comparison element, while the output is mechanically coupled to said first member, a variable volume chamber, a feed of pressurized fluid, a discharge, duct means respectively connecting the chamber with the feed and discharge, said second transducer consisting of the variable-volume chamber connected to the feed of pressurized fluid and to the discharge through said duct means, and means sensitive to the algebraic sign of the difference between the speed electric signal emitted by the first transducer and a reference signal controlling said duct means, so that the duct means be opened alternatively as a function of the sign of said difference.

4. The regulation device according to claim 3, characterized in that it comprises means which produce said reference signal as a function of the relative displacement of the point of contact with respect to the cam surface along the first of the directions aforementioned.

5. The regulation device according to claim 3 characterized in that said chamber is a variable-volume chamber because one of its walls is movable, resilient means being provided which counteract the forces exerted by the pressurized fluid.

6. The regulation device according to claim 3, characterized in that said chamber is a variable volume chamber because one of its walls is movable the forces

exerted on said wall by the pressurized fluid being counteracted by the force originated by the existence of a constant pressure in a second variable-volume chamber.

7. The regulation device according to claim 5, characterized in that in said variable volume chambers the movable wall is formed at least in part by a deformable diaphragm.

8. The regulation device according to claim 6, characterized in that the movable wall of the first chamber has a surface which is higher than that of the movable wall of the second chamber.

9. The regulation device according to claim 7, characterized in that the non-deformable portion of at least one of the movable walls acts by means of a rod on the arm of a displacement-multiplying lever mechanically connected to the spatial cam.

10. The regulation device according to claim 9, characterized in that the rod associated with the diaphragm of the first chamber acts on said lever at a distance from the pivotal point which is greater than that of the rod associated to the diaphragm of the second chamber.

11. A device for regulating the amount of injected fuel for injection systems of internal combustion engines, comprising a first member defined by a spatial cam and a second member defined by a follower maintained in engagement with the spatial cam surface, said two members being connected to the body of the device so as to allow two degrees of freedom in total to said two members, the follower being allowed an additional degree of freedom so as to be allowed to carry out displacements in the direction of the cam rises, said two degrees of freedom permitting relative displacements

of the point of contact of the follower with the same surface along two corresponding directions which are perpendicular to one another and perpendicular to the cam rises, said follower acting on component parts of the injection system which are enabled to vary the amount of injected fuel as a function of the position of said point of contact with respect to the cam surface, first means controlling, as a function of the engine speed of rotation, the relative displacement of the point of contact with respect to the cam surface along the first of the two directions, and second means controlling the relative displacement along the second of the two directions as a function of a parameter representative of the engine intake pressure, the improvement that said first means comprise a first mechanical-electrical transducer, a second electrical-mechanical transducer, a feed-back unit consisting of a third mechanical-electrical transducer and of a comparison element, the input of the first transducer being mechanically coupled to the mainshaft and its output being electrically connected to the comparison element, the input of the third transducer being mechanically coupled to said first member and its output being electrically coupled to said comparison element, the input of said second transducer being electrically coupled to the comparison element, while the output is mechanically coupled to said first member.

12. The regulation device according to claim 11 characterized in that said second control means are sensitive to the pressure in the intake duct and the spatial cam, the follower, said second control means are consolidated into a single unit placed in a desired position with respect to the engine.

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