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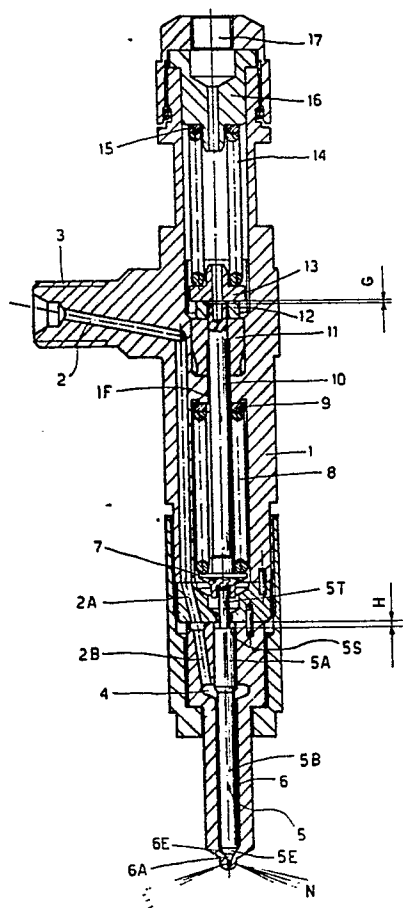
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54 **Double lift fuel injector which can be calibrated and set using normal equipment.**

57 This fuel injector, which can be calibrated and set using normal equipment, consists of an occlusion pin (5) whose lift of aperture can be carried out in sequence with the reactive interwoven of differentiated rigidity springs (8,14) so as to create rates of flow into the combustion chamber which are gradual and appropriate to the power requirements of the engine.



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DOUBLE LIFT FUEL INJECTOR WHICH CAN BE CALIBRATED AND SET USING NORMAL EQUIPMENT.

This invention regards the field of fuel injectors for endothermic engines.

It is a known fact that fuel injectors for endothermic engines, particularly those for diesel engines, consist of a point drilled and directed on the combustion chamber which sprays fuel at high pressure into the chamber at the pre-established time to ensure optimum combustion (output). The capacity of the point to spray (inject) fuel is consequent to the rise of a pin designed to occlude the holes on the point. The pin is made to rise by means of pressure, created by an injection pump on a circular crown; this results from the difference between a lapped part of the pin and a thicker part which serves as a runner for its axial movement.

In fact, this pressure thus creates a force which is greater than that of the antagonistic action of a spring exerting the closing load of the injector and therefore moves the pin with a given opening stroke which is restricted by a normal beat.

In this common type of injector, once the rise of the pin has started, it immediately proceeds to its maximum stroke. In this condition the pin is, in fact, affected by the pressure over the whole of its cross-section and it is therefore subjected to much greater opening forces. The condition of maximum opening also corresponds to the maximum capacity of fuel injected into the combustion chamber.

This therefore implies that there is a risk of sudden large injections even when not required. The injector must be capable of opening even with fuel pressures corresponding to the engine operating at low revs, but this is no reason why it should inject quantities of fuel more suited to much higher revs.

Although fine tuning has restricted the probability of this occurring at serious levels, it is nevertheless still possible. In any case, the traditional injectors have virtually no gradualness and no ability to adjust to the engine revs because of solid residues, so they are often the cause of imperfect combustion which both damages the parts of the engine and pollutes the environment with harmful substances, not to mention the user, due to the waste of fuel.

Despite the fact that everyone in the sector has been aware of the problem for some time, solutions proposed to date have remained at the testing stage, mainly due to their inadequate reliability and/or the high cost involved in production on an industrial scale, due to the complex problems involved in periodic tuning and setting.

The aim of this invention was to design an injector which makes it possible to adapt the amount of fuel injected, in relation to the varying

power required by the engine, more precisely.

A further aim was to design an injector which would carry out injection gradually, giving prolonged combustion to improve thermodynamic performance.

Again, the aim was also to design an injector where the opening would be sensitive to even low pressures.

The detailed description below will show how these and other aims have been achieved in a fuel injector which can be calibrated and tuned using normal equipment. It has an occlusion pin whose lift of aperture can be carried out in sequence with the reactive intervention of differentiated rigidity springs so as to create rates of flow into the combustion chamber which are gradual and appropriate to the power requirements of the engine.

The invention is illustrated purely for indicative purposes and in no way restrictively in the enclosed drawing which shows an injector in longitudinal section using standard technical representations.

With reference to the above-mentioned figure, a fixed body 1 is fitted with canalization 2 connected by means of high pressure hydraulic pipes to a normal injection pump (not included in the drawing) by means of a threaded connector 3. Segments 2A and 2B of canalization 2 extend to a central chamber 4, giving on to a larger cylindrical body 5A of a pin 5 which is extended with its cylindrical body of a lesser diameter 5B inside a chamber 6 where it is housed with play.

Extremity 6E of this chamber is conical and connected to the extremity 5E of the pin, so as to give a hydraulic seal, using the usual high degrees of surface finish.

The tip 6A of the chamber is thus hydraulically isolated and is in communication with the exterior (the combustion chamber of the engine) by means of the usual micro holes which produce nebulization (N).

The pin 5 is fitted with a small-diameter end piece 5T, on which a cap 7 rests, which is pushed by a spring with a cylindrical propeller 8 (shown using standard technical drawing representations). This end piece 5T rises from a flat shoulder surface 5S, to fix a maximum stroke H. This spring 8 rests on a calibrated washer 9 to exert a preload value which can be established with maximum precision. This washer in turn rests on an annular edge protruding with regard to the housing of the spring B, and bordered by a working seat 1F in which a rod 10 integral with pin 5 runs.

The cap 7 is integral with this guiding rod 10, which is housed in a working seat 1F taken, not

only from the fixed body 1, but also from a fixed auxiliary element 11. There is a calibrated ring 12 on this auxiliary element, of a thickness which makes it possible to make play G less than H between its top and the top of the guiding rod.

On this calibrated ring 12, an upper moving cap 13 is pressed on by a spring 14 reacting on a plug 16 integral with the fixed body of the injector, by means of interplacement of a further calibrated washer 15. This plug 16 is drilled in 17 for the usual recirculation towards the fuel "waste" tank, and is made to close the upper cavity to house the spring 14 made in the body 1. Due to the extreme dimensional precision of the various parts, the two springs 8 and 14 are obviously of the type with flattened and ground ends.

Operation of the injector occurs in the following way.

When fuel (diesel, or petrol or other fuel), pushed by an external pump into canalization 2, reaches the central chamber 4, it causes the pin 5 to lift by pressing the spring 8, which has lesser rigidity than that of the spring 14. This lifting obviously causes flow of the fuel into the tip 6A and therefore its being sprayed N into the combustion chamber. The capacity which is thereby given is consequent to the outflow section resulting in the 5E-6E area due to the lifting effect of the pin 5 in the amount defined by the play G, the guiding rod 10 being integral with this pin. This is so until the pin is not given a lifting force capable of pressing the spring 14 too; this lifting force is obviously dependent on the pressure with which the fuel is pumped to the inside of the central chamber 4. When this pressure is reached, the top of the guiding rod 10 lifts the moving cap 13 until it reaches its maximum stroke H, defined by the shoulder surface 5S against the fixed body 1.

Using this solution, the injector opening is therefore under a certain "minimum pressure" with a corresponding limited capacity, until the fuel pressure, according to the engine requirements, reaches another higher level.

At the higher level of pressure the spring 14 starts to give way, which can therefore allow the pin 5 (associated with the rod 10) to carry out a further stroke, up to a total value H.

Whereas in traditional injectors there is practically only one value for the pin stroke, in the type of injector presented here there are two strokes available. This makes it possible to take advantage of injected fuel capacities which can be adapted to the engine performances required, not only by capacity variations linked with the pressure variations, but also by capacity variations consequent to the two different values of the outflow section (play 6E-5E), consequent to the two different strokes which the pin 5 is allowed.

From a purely indicative point of view relative to the size of the values in question, the first degree of opening occurs with a stroke G of 0.05 mm and with a pressure of 170 bat, which is required to overcome the antagonistic action of the spring 8. The injector operates with this stroke until the pressure reaches a value in the region of 350 bar: At this pressure there is sufficient force on the occlusion end (5E) of the pin to overcome the preloading of the spring 14, and therefore to distort it up to a value given by the difference H-G, which could indicatively be 0.2 mm. Whereas the force which initially presses the spring 8 is due to the action of the fuel pressure on the above-mentioned circular crown which demands on the difference between the diameters of the two parts (5A, 5B) of the pin, the force which presses the spring 14 is that due to the pressure action of the fuel on the circular section, which is much greater, of section 5A. This force is also impeded by the co-operation of both the springs 8 and 14. From what has been said, it can, however, be understood that, whereas the first lift of 0.05 is always complete due to the increase in section on which the fuel pressure works once the opening detachment has been carried out, the second lift has a gradual stroke or one proportional to the amount of the fuel pressure itself.

Since the injection capacities which can be obtained in this way are conditioned by the forces exerted by the two springs 8 and 14, the extreme importance of the precision of their preloading can be understood: i.e. the thicknesses of the calibrated washers 9 and 15 on which they rest respectively and which make them up. It is therefore extremely important for an injector to allow these thicknesses to be checked and adjusted to the optimal values with equipment which is easy to come by and using economical methods of intervention.

The play G, for example, can be determined using a traditional comparator acting with its tracer point on the top of the guiding rod 10 and on the top of the calibrated ring 12, so as to obtain their reciprocal level difference.

With regard to the action carried out by the spring 8, calibration of the fuel pressure to which the initial opening of the injector corresponds, is usually carried out empirically; it is done with a manual pump creating a pressure increase within canalization 2 which is controlled by means of a pressure gauge with an auxiliary pointer, which signals the maximum deviation made by the direct measuring pointer. In this way, when the injector opens the pressure drops suddenly and the auxiliary pointer can indicate the pressure at which this opening occurred. To increase this pressure value, it is sufficient to increase the thickness of the calibrated washer 9. As has already been seen,

however, the action of this first opening is limited to very small stroke values (0.05) until the next pressure level is reached (350 bar). In fact, the basic role of the injector is played by the more rigid spring 14, whose distortion gives the pin 5 the possibility to carry out the maximum lift H.

Calibration of this second stage of the injector including spring 14, can be made to advantage in the same simple way already described, taking care to bear in mind the details connected with the presence of the first stage adjusted by the action of the spring 8.

This calibration must be made to give this injector with double lift the capacity to operate with the same pressures with which the traditional injectors with a single lift operate. The preloading force which must be used to make the spring 14 work on its cap 13, and therefore on the head of the guiding rod, is the one which is given by the product of the working pressure considered (350 bar) for the guiding section (5A) of the pin 5. Experimental checking of this value using normal control equipment is problematic: this is due to the fact that, as soon as the initial injection pressure is reached (170 bar), the pin lifts, overcoming the action of the spring 8, and does not allow the pressure looked for to be reached in any significant way, because of the feeble capacity of the manual test pumps normally used.

To avoid these difficulties, the fuel injector with double lift, according to the invention, makes it advantageously possible to know both the preloading value given by the spring 14, notwithstanding the modest performance of the normal control equipment, using the following trick. The injector is dismantled: the spring 8, its calibrated washer 9 and the calibrated ring 12 for resting the cap 13 on are removed from it. Then it is reassembled. Under these conditions the cap 13, pushed by the spring 14, rests directly on the top of the guiding rod 10 which, in turn rests on cap 7, keeping the pin 5 in its closed position. By then proceeding to a normal control using a manual pump and pressure gauge, the pressure is increased until a certain value to cause lifting of the pin or injecting phase. The pressure measured in this way is, however, much greater than the one which would be required during operation with the co-operation of the 1st stage (carried out with the spring 8 and the play G), since under the above conditions it only acts on the surface given by the difference in section of the two areas 5A and 5B of the pin, instead of on the whole surface of the area 5A. This pressure should therefore be multiplied by a coefficient which takes this difference into account. The value obtained is not, however, the real preloading working value, but a value corresponding to a distance between the end planes of the springs 14 which is greater, in

relation to the working one, then the amount of the play G (i.e. 0.05 mm), eliminated by the absence of the calibrated ring 12 in this control.

Therefore, to obtain the real preloading value, with which the spring 14 thus examined operates, a further operation is necessary which takes into account the rigidity of this spring. A further corrective action to the value obtained in this manner is to take into account the lack of action by the spring 8 during this control: the spring 14 must exert a lower preloading value to the one found so far: lower than the same quantity resulting from the pressing action of the spring 8 with the stroke H. From a practical point of view, these operations can be taken as already carried out and shown in special tables or nomograms or synthesising diagrams. What is significant is, however, that with this type of injector it is possible to know, and therefore adjust, the preloading value put on by both the springs 8 and 14 by varying the thicknesses of the special calibrated washers 9 and 15: and this is done to advantage by using the equipment usually available at normal repair workshops.

Claims

1) A fuel injector which can be calibrated and tuned using normal equipment, characterized by an occlusion pin (5) with its opening lift (H) which can be made in sequence (G, H) by means of reactive action of antagonistic springs (8, 14) with differentiated rigidity, to create gradual and adjustable outflow capacities (N) into the combustion chamber according to the power requirements of the engine.

2) An injector as in the previous claim, characterized by the fact that the springs (8, 14), antagonistic to the lift (H) of the pin (5) each operate with their own adjustable preloading value independently (9, 15) by means of a reaction on different areas (16, 1F) of the fixed body (1) of this injector.

3) An injector as in the previous claims, characterized by the fact that the pressing action (H-G) of the spring (14) of successive intervention is carried out by the end of a guiding rod (10) acting on a moving spring-resting cap (13) after having overcome the amount of a play (G), definer of an initial lifting action of opening regulated by another spring (8).

4) An injector as in claim number 3, characterized by a play (G), definer of the initial lifting action of opening carried out by means of a calibrated washer (12) housing the end of the guiding rod (10) inside its hole.

5) An injector as in the previous claims, characterized by the fact that the total stroke of maximum injection opening (H) is limited by shoulders (5S) which are present on the section of pin (5T)

opposite to the closing one (5E) and act on the fixed body (1) of this injector.

6) An injector as in the previous claims, characterized by a fixed body (1) drilled at its ends to make a fixed working housing (1F) for the sliding rod, with a smaller diameter to create reaction shoulders for a calibrated washer (9) to rest the spring (8) on, which regulates the initial opening lift (G).

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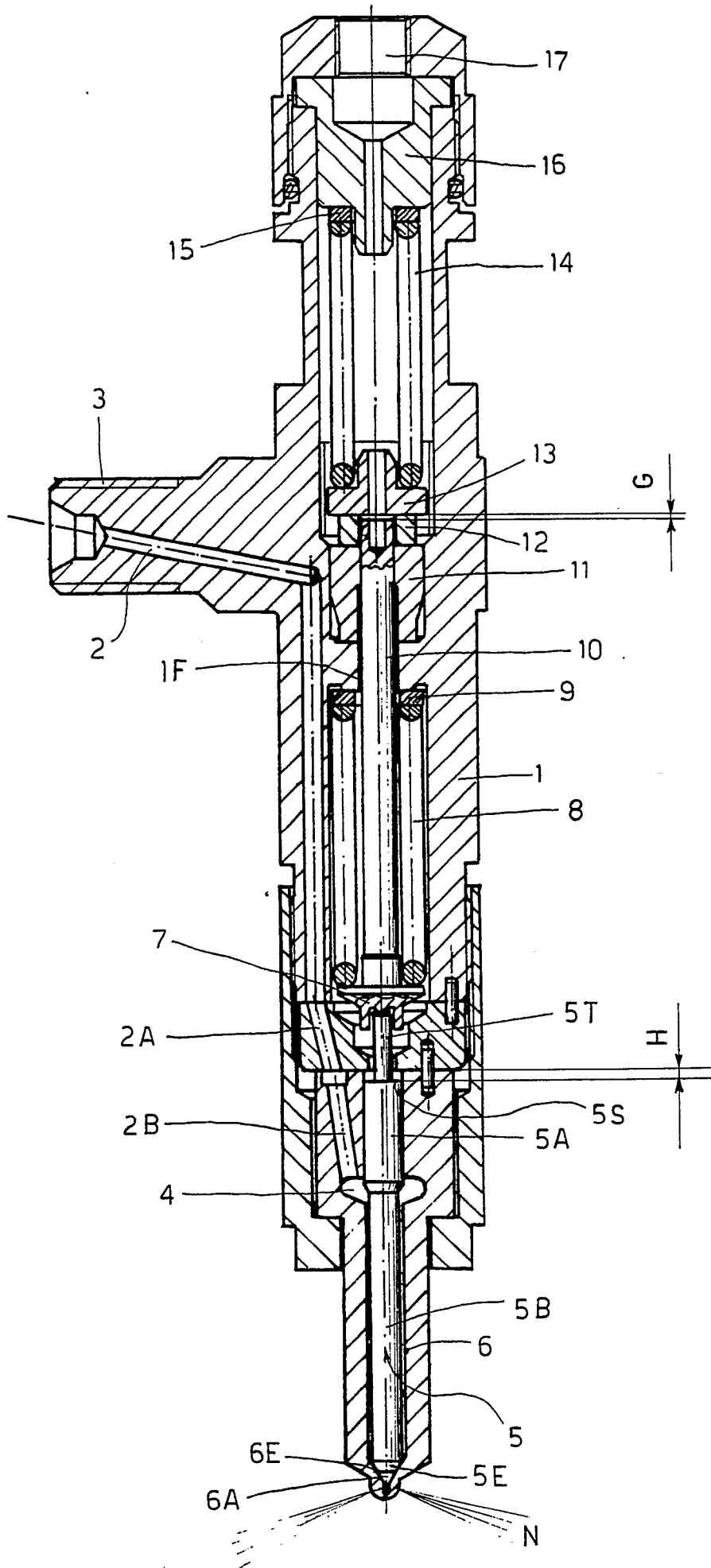
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0239259 (GENERAL MOTORS CORPORATION) * column 9, line 32 - column 11, line 17; figure 2 *	1-3, 5	F02M45/08 F02M61/16
X	--- PATENT ABSTRACTS OF JAPAN vol. 10, no. 381 (M-547)(2438) 19 December 1986, & JP-A-61 171875 (MAZDA MOTOR CORP.) 02 August 1986, * see the whole document *	1-3	
A	---	6	
X	US-A-4390129 (UCHIDA) * column 3, line 51 - column 6, line 68; figures 1-4 *	1, 2, 5	
A	---	3, 4, 6	
X	EP-A-0288207 (LUCAS INDUSTRIES) * column 2, line 6 - column 3, line 50; figure 1 *	1, 2, 5	
A	-----	6	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F02M
Place of search THE HAGUE		Date of completion of the search 11 AUGUST 1989	Examiner FRIDEN C.M.
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