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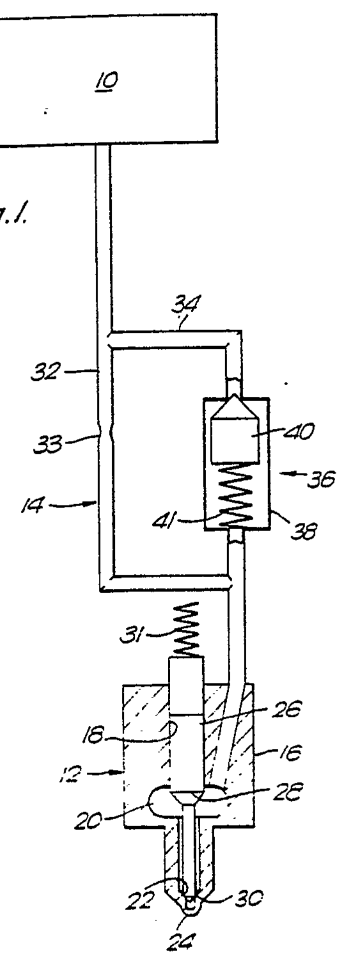
(54) Fuel injection systems.

(57) In fuel injection systems, particularly for diesel engines, there exists a need to provide for two flow rates during the injection cycle. a low and accurate flow rate is initially needed, followed by a high flow rate. It is also desirable to be able to set the pressure at which the nozzle opens and the change-over pressure.

A flow restrictor defines first (32) and second (34) flow paths having high and low degrees of restriction, and a valve (36) in the restrictor operates to maintain the second flow path (34) closed when the pressure upstream thereof is below a preset value.

Fig.1.



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FUEL INJECTION SYSTEMS

This invention relates to fuel injection systems and to injectors and flow restrictors for use in fuel injection systems.

Many diesel engines are noisy at idling speed because of diesel "knock" caused by an excessive increase in pressure at the beginning of the combustion cycle. It is known that diesel knock can be reduced by controlling the flow through the injector so that the rate of injection is reduced at the beginning of the delivery of the fuel. This means that the amount of fuel in the combustion chamber when combustion begins is lower thus reducing diesel knock.

Conventional inwardly opening injectors comprise a nozzle body defining a bore at one end of which is provided a seating surface. Downstream of the seating surface the nozzle body defines one or more spray orifices. A nozzle valve is slidably mounted within the nozzle body and has a seating surface and is urged into sealing engagement with the seating surface of the nozzle body by a valve spring. Inward displacement of the nozzle valve allows fuel to pass to the or each spray orifice. In operation, the nozzle valve prevents flow of fuel through the injector until the pressure supplied to the injector is sufficiently high to lift the nozzle valve. In such injectors, it is found that the degree of restriction presented to the fuel flow as the nozzle valve is displaced inwardly is highly sensitive to the lift of the valve and the range of lift over which the fuel flow is restricted is small.

In our co-pending European Application No. 88301692.5 we disclose an injector in which the geometry of the nozzle valve and the nozzle body adjacent the seating surfaces is modified compared to conventional designs so that, compared to conventional designs, the variation of the degree of restriction as the nozzle valve lifts is lower, and the range of movement during which restriction is obtained is greater.

A need exists for an injection system which provides two flow-rates during the injection cycle, namely a low accurate initial flow and a high flow rate, and which allows setting of the opening pressure of the injector nozzle and the changeover pressure at which the flow rate is changed from a low to a high rate.

According to one aspect of this invention, there is provided a fuel injection system including an injection pump, an injector and flow restrictor means for controlling the flow of fuel injected by said injector, said flow restrictor means defining a first flow path having a relatively high degree of restriction and an alternative second flow path having a relatively low degree of restriction, said flow restrictor means including valve means operable to close said second flow path when the pressure upstream thereof is below a preset pressure.

According to another aspect of the invention, there is provided a restrictor for use in fuel injection systems comprising a body having a bore therein, one end of the bore being a fluid entry opening and the other end of the bore being a fluid exit opening, there being a valve member located in said bore between said openings, the valve member having a central aperture of small cross-sectional area, a land surrounding said area, and flutes surrounding said land, the valve member being biassed in such a direction that it normally engages the land and is lifted therefrom when the applied fluid pressure exceeds a preset value so permitting fluid flow past the flutes.

Preferably, said flow restrictor means includes a restrictor body defining therein a restrictor valve chamber having an inlet, an outlet and a valve seat, and a restrictor valve element associated with said restrictor valve seat for opening or closing said second flow path and having a passage defining said first flow path.

Preferably said restrictor valve element is slidably mounted in said restrictor valve chamber and said second flow path passes adjacent to external flutes provided on said restrictor valve element.

In one embodiment said restrictor body is connected to the fuel inlet of said injector.

In another embodiment, said restrictor valve chamber is formed internally of the injector.

A typical injector includes at least a main body portion having an inlet and an outlet for fuel, and a nozzle portion. In one example the restrictor valve chamber is defined within said main body portion. In another example the restrictor valve chamber is formed in a plate disposed between said main body portion and said nozzle portion.

Non-limiting examples of this invention will now be described in detail, reference being made to the accompanying drawings, in which:-

Figure 1 is a diagram illustrating in schematic form a fuel injection system in accordance with the invention;

Figure 2 is a longitudinal section view of an injector in accordance with the invention, incorporating flow restrictor means coupled to the inlet of the injector;

Figure 3 is a schematic view of the inlet region of the injector showing a first alternative location for the flow restrictor means;

Figure 4 is a schematic view of the nozzle region of the injector showing a second alternative location for the flow restrictor means.

Referring initially to Figure 1, the fuel injection system comprises an injector pump 10 which supplies metered charges of fuel at timed intervals to an injector generally designated 12 via a flow restrictor generally designated 14.

The injector 12 is a conventional, inwardly opening, injector and includes a nozzle body 16 having an internal bore 18, an annular fuel gallery or reservoir 20, a valve seating 22 and a sac 24 defining a plurality of spray orifices (not shown). A nozzle valve 26 is slidably mounted within the bore 18 and includes a pressure receiving surface 28 and a seating surface 30. The nozzle valve is preloaded by a compression spring 31 to a position in which the seating surface 30 sealingly engages the valve seating 22. The preload is set to the initial opening pressure required by the diesel engine, as in the case of a conventional injector.

The flow restrictor 14 defines a first flow path 32 having therein a precisely formed restriction 33, and a second flow path 34 which is unrestricted save for a restrictor valve assembly 36 which prevents flow along the second path at low pressures. The restrictor valve assembly 36 comprises a restrictor valve housing 38 and a restrictor valve element 40 spring-biased by a compression spring 41 to close the inlet to the valve housing 38. Each of the first and second flow paths 32, 34 are connected to the injector 12.

The restriction 33 and the opening pressure of the restrictor valve assembly 36 (referred to herein as the changeover pressure) are selected so that during engine idle, the fuel pressure in the second flow path 36 is below the changeover pressure of the restrictor valve assembly 36 and the fuel passes at a relatively low rate along the first path 32 alone to provide good low speed combustion characteristics. At higher speeds, the fuel pressure in the second flow path 34 will be above the changeover pressure of the restrictor valve assembly 36 so that fuel will pass along both the first and the second flow paths 32, 34. In this condition, the fuel flow is controlled by the spray orifices of the nozzle in the usual fashion.

Referring now to the example shown in Figure 2, the injector is mainly of conventional design including a main body 200 defining an inlet 202 for receiving fuel and a leak-off connection 204 for passing fluid which leaks around the nozzle valve back to the fuel tank. Fuel passing through the inlet 202 passes via internal passages 206 to an annular fuel gallery (not shown) formed in the nozzle body 208. The nozzle body 208 and the nozzle valve 210 (only the upper stem of which is seen in Figure 2) are of conventional design, similar to that shown in Figure 1, and are not therefore described or shown in detail here. The upper end of the stem 210 engages the lower end of a spring support 212 which supports the lower end of a compression spring 214. The compression spring is located within a bore in the main body 200 of the injector and its upper end engages a shim 216. Between the main body 200 and the nozzle body 208 is a disc plate 218. The nozzle body 208 is secured to the main body 200 by a nozzle cap nut 221. The injector as described so far is of generally conventional design.

The injector however is fitted with a flow restrictor 220 which is connected to the inlet 202 of the injector. The flow restrictor 220 comprises a restrictor body 222 having an inlet 224 and an outlet 226. Between the inlet 224 and the outlet 226 is defined a generally cylindrical restrictor valve chamber 228 which slidably receives a restrictor valve element 230. The restrictor valve element 230 has a bore 232 of restricted diameter and includes a generally frusto-conical seating surface 234 for engaging an associated seating surface 236 at the inlet end of the restrictor valve chamber 228. The restrictor valve element also includes a plurality of external flutes 238 which lie radially outside the seal defined between the frusto-conical seating surface 234 and the associated seating surface 236 and which together define a passage having an aggregate sectional area which is much greater than that of the bore 232. A compression spring 240 is located between a sleeve 242 and the restrictor valve element 230 and urges the restrictor valve element into sealing engagement with the sealing surface 236 at the inlet end of the restrictor valve chamber 228. The bore 232 defines a first flow path having a relatively high degree of restriction whilst the flutes 238 together define a second flow path having a relatively low degree of restriction.

In use, fuel delivered at low pressures passes only through the bore 232 defining the first flow path and is thus throttled so that the rate of injection is lowered. At higher pressures the pressure drop generated across the bore 232 causes the restrictor valve element 230 to lift off the seating surface 236 to allow flow along the second flow path as well as the first flow path so the rate of injection is increased. The restrictor valve element 230 has a high differential area so that it stays open after operation and also so that the pressure drop across the restrictor valve element when it is open is minimised. The restrictor valve element 230 is returned to its closed position at the end of injection by the action of the spring 240.

An advantage of using the flow restrictor 220 as shown in Figure 2 is that, during closure of the injector nozzle, the reverse flow out of the nozzle is limited by the restricted diameter bore 232 and so the nozzle will continue to pump fuel because of the volume displaced from the nozzle valve. This will assist in preventing blow back and ensuring a sharp end of injection to give further reductions of smoke.

A further advantage of the arrangement of Figure 2 is that it does not require modification of the nozzle of the injector. The flow restrictor 220 can therefore be retro-fitted to existing injectors without modifying the geometry of the remainder of the injector.

Figures 3 and 4 show alternative locations for the flow restrictor. Figure 3 shows the upper end of an injector of the general type shown in Figure 2 except that the positions of the fuel inlet 202 and the leak-off connection are transposed so that the fuel inlet is at the top of the injector. In this arrangement the flow restrictor is of similar design to that of Figure 2 except that there is no separate restrictor body. Instead, the restrictor valve chamber 228 and its inlet 224 and outlet 226 are formed in the main body 200 of the injector. Other parts of the flow restrictor are similar to those of Figure 2 and are given the same reference numerals and will not be described in detail again.

Figure 4 shows the lower end part of an injector in which the flow restrictor is located in the plate 218 of a conventional injector, in the passage 208 connecting the fuel inlet (not shown) of the injector with the annular fuel gallery (not shown) in the nozzle body 208. The restrictor valve chamber 228 and its inlet and outlet are formed in the plate 218. Other parts of the restrictor are similar to those of Figures 2 and 3 and will not be described in detail.

The arrangement shown in Figure 4 allows a restrictor to be fitted in a conventional injector merely by replacing the conventional plate with one as shown in Figure 4.

The injector nozzles shown in the drawings are of the inwardly opening type and incorporate a sac. It will however be understood that the principles disclosed herein may also be used on other types of inwardly opening nozzles without a sac, such as v.c.o. (valve closed orifice) nozzles, pintle nozzles, as well as on outwardly opening nozzles. It will also be understood that the compression spring 31, 214 which urges the nozzle valve to its closed position may be replaced by other resilient means which urge the nozzle valve to its closed position.

Claims

1. A fuel injection system including an injection pump, an injector and flow restrictor means for controlling the flow of fuel injected by said injector, said flow restrictor means defining a first flow path having a relatively high degree of restriction and an alternative second flow path having a relatively low degree of restriction, said flow restrictor means including valve means operable to close said second flow path when the pressure upstream thereof is below a preset pressure.

2. A fuel injection system according to claim 1 wherein the injector includes a body having a longitudinal axis and a nozzle cap, said body and said cap together supporting an injection nozzle having a body and a nozzle valve, the latter valve in part occupying a space defined by the said body and the said cap and operating to control the exit of fuel from nozzle orifices of the injection nozzle, and wherein the said flow restrictor is received in a bore in the said body, the said bore extending into the said body in a direction transverse to the said longitudinal axis.

3. A fuel injection system according to claim 1 wherein the injector includes a body having a longitudinal axis and a nozzle cap, said body and said cap together supporting an injection nozzle having a body and a nozzle valve, the latter valve in part occupying a space defined by the said body and the said cap and operating to control the exit of fuel from nozzle orifices of the injection nozzles, and wherein the flow restrictor is located in a bore extending from an inlet end of the said injector body to the injection nozzle in thereof.

4. A fuel injection system according to claim 1 wherein the injector includes a body having a longitudinal axis and a nozzle cap, said body and said cap together supporting an injection nozzle having a body and a nozzle valve, the latter valve in part occupying a space defined by the said body and the said cap and operating to control the exit of fuel from nozzle orifices of the injection nozzle, and wherein the injector body includes a disk plate located between the said injector body and the said nozzle body, the disk plate having a bore therein which accommodates the said flow restrictor.

5. A restrictor for use in fuel injection systems comprising a body having a bore therein, one end of the bore being a fluid entry opening and the other end of the bore being a fluid exit opening, there being a valve member located in said bore between said openings, the valve member having a central aperture of small cross-sectional area, a land surrounding said area, and flutes surrounding said land, the valve member being biassed in such a direction that it normally engages the land and is lifted therefrom when the applied fluid pressure exceeds a preset value so permitting fluid flow past the flutes.

6. A diesel engine including a fuel injection system according to any one of claims 1 to 4.

7. A diesel engine including a flow restrictor according to claim 5.

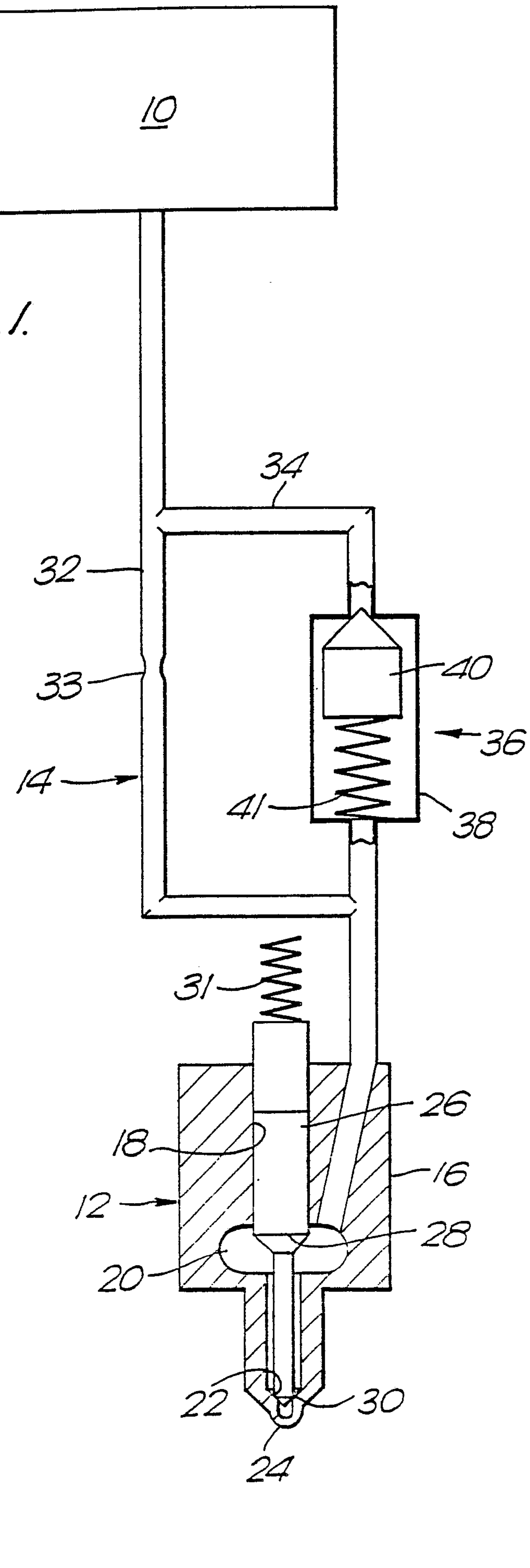

Fig.1.

Fig.2.

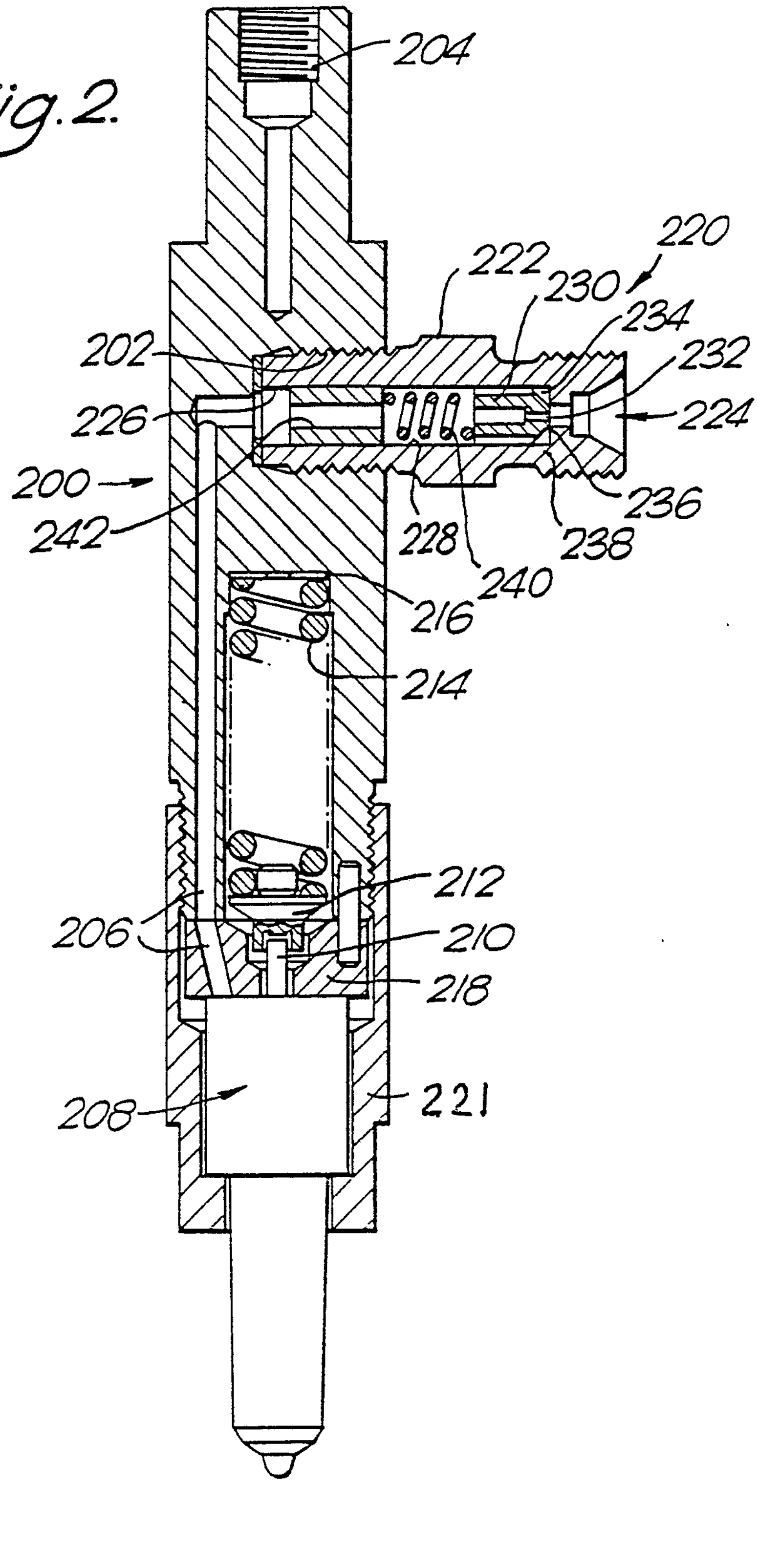
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Fig.3.

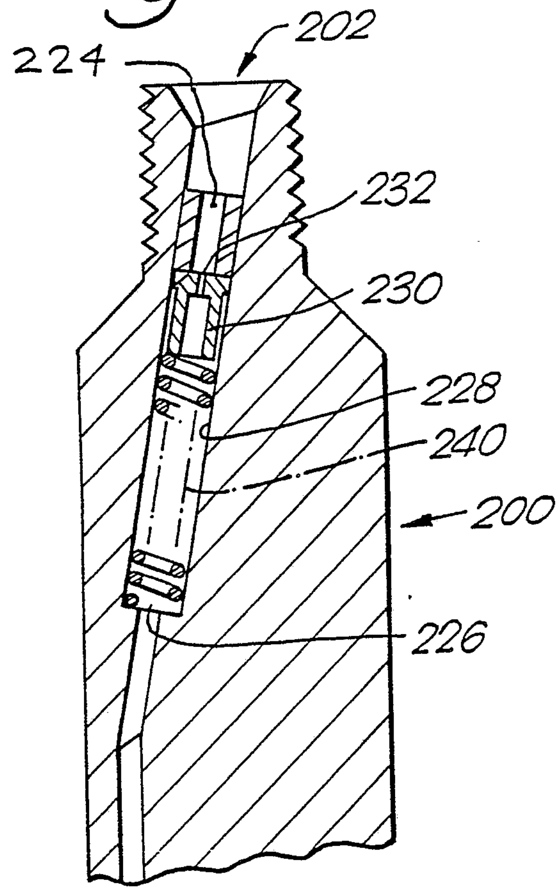
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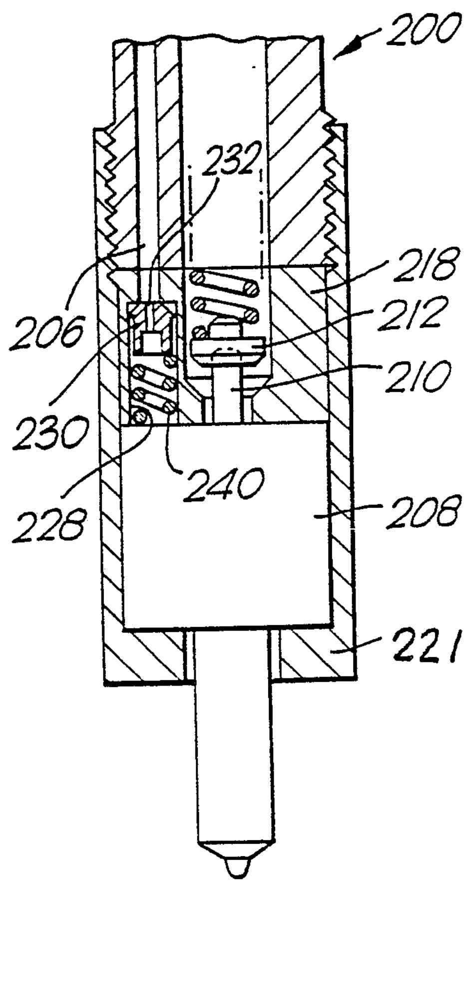
Fig.4.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EUROPEAN SEARCH REPORT

Application Number

EP 89 30 7957

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	US-A-4165838 (NAKAYAMA) * column 1, line 43 - column 4, line 15; figures 1, 1A *	1, 2, 6	F02M45/12
A		3, 5, 7	
X	EP-A-0185308 (KLÖCKNER-HUMBOLDT-DEUTZ) * page 6, line 17 - page 7, line 4 *	1, 3, 6	
A	* page 7, line 30 - page 9, line 31 * * figures 1, 3 *	5, 7	
X	US-A-3342422 (MILLINGTON) * column 2, line 66 - column 4, line 29; figure 2 *	1, 4, 6	
A		5, 7	
X	GB-A-1014131 (RICARDO & CO) * page 3, line 63 - page 5, line 105; figures 1-4 *	1, 4, 6	
X	GB-A-2045863 (DAIMLER-BENZ) * page 2, lines 66 - 104; figure 1 *	1, 6	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
X	GB-A-2054038 (DAIMLER-BENZ) * page 1, line 99 - page 2, line 30; figures 1, 2 *	1, 6	F02M
A	FR-A-2099831 (C.A.V. LIMITED) * page 1, line 22 - page 2, line 11; figure 1 *	1, 6	
A	FR-A-1543814 (C.A.V. LIMITED) * page 1, right-hand column, paragraph 3 - page 3, left-hand column, paragraph 1; figures 1-4 *	1, 6	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 NOVEMBER 1989	FRIDEN C.M.

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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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