(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 017 872**
A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **80101812.8**

(22) Date of filing: **03.04.80**

(51) Int. Cl.³: **F 02 M 61/20**

(30) Priority: **13.04.79 US 7900231**

(43) Date of publication of application: **29.10.80 Bulletin 80/22**

(84) Designated Contracting States: **BE DE GB**

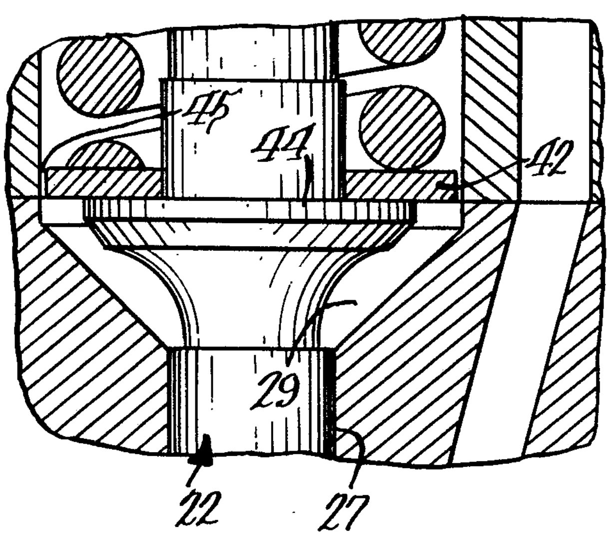
(71) Applicant: **CATERPILLAR TRACTOR CO., 100 Northeast Adams Street, Peoria Illinois 61629 (US)**

(72) Inventor: **Johnson, Clayton Carl, 1519 Hickory Trace, Dunlap Illinois 61525 (US)**

(74) Representative: **Wagner, Karl H., P.O. Box 246 Gewuerzmuehlstrasse 5, D-8000 München 22 (DE)**

(54) **Fuel nozzle check damper.**

(57) A fuel injector includes an injector body (8) having a nozzle (12), a valve seat (40) within the body (8) and closely adjacent the nozzle (12) and a valve (22) within the body (8) movable between positions seated against and spaced from the seat (40). The valve (22) is biased towards the position seated against the seat (40). Fuel is received under pressure and delivered to the valve (22). Responsive to the receipt of fuel under pressure within the body (8), the valve (22) is moved to the position spaced from the seat (40). This invention improves previously known fuel injectors by retarding the rate of movement of the valve (22) in moving from the position spaced from the seat (40) towards the position seated against the seat (40). The retarded rate of movement advantageously reduces nozzle tip breakage and associated undesirable side effects.



EP 0 017 872 A1

Description

Fuel Nozzle Check Damper

Technical Field

This invention relates to a fuel injector for internal combustion engines, and more specifically, to such an injector wherein there is included a spring loaded injector valve.

Background Art

Internal combustion engines which operate on a diesel cycle, and a limited number of internal combustion engines which operate on different cycles, require a fuel injector which provides fuel to the combustion space at an appropriate time in the operating cycle.

One type of fuel injector includes as principal elements a nozzle, an injector valve and a spring to urge the injector valve to a position closing the nozzle. Another type of injector utilizes fuel trapped above the injector valve and compressed as the valve opens to provide the force required to urge the nozzle to the closed position. In either case, a seat for the valve is located within the nozzle or tip of the injector such that only a very small volume of fuel exists downstream of the seat and upstream of the nozzle outlets.

When high pressure fuel is provided to the fuel injector from an engine fuel pump, the injector valve is forced to open and fuel is injected through the nozzle into the combustion space. When fuel pressure from the fuel pump drops, the injector valve is returned to its closed position by the injector valve spring or fuel trapped above the valve and injection of fuel to the combustion space is cut off.

Because the length of the period of injection is quite critical in maximizing performance and operating economy, the valve closing force is typically high so as to effect rapid closing of the valve thereby providing the ability to closely control the length of the injection period by controlling the pressure of fuel supplied by the fuel pump. The high closing force thus causes the valve to engage the seat with a considerable impact.

The impact can be of a magnitude that will create stresses and cause breakage of the nozzle tip through the mechanism of fatigue failure. Failure of the nozzle tip causes metal particles to drop into the combustion space which interfere with the smooth operation of the engine. Also, since the injector valve seat is no longer present, the injector valve cannot stop fuel injection at the proper time. Fuel therefore flows into the combustion space at all times, causing localized engine heating, fuel waste and increased hydrocarbon exhaust emissions.

Even if valve impact is not of a magnitude sufficient to cause nozzle tip breakage, or prior to failure of the nozzle tip, this impact may have detrimental effects on engine performance. The impact can cause rebound of the injector valve from the valve seat, reopening the injector valve. Rebound will allow additional fuel to flow into the combustion space, resulting, to a lesser degree, in the above problems associated with nozzle tip breakage, and may allow combustion gas to enter the fuel injector.

Entry of combustion gas into the fuel injector will cause nozzle fouling and can result in the delay of delivery of fuel to the combustion space since at the beginning of the succeeding injection period these gases must be forced from the nozzle before fuel can be injected.

Disclosure of the Invention

In one aspect of the present invention, there is provided in a fuel injector including a nozzle tip, an injector valve and means to urge the injector valve towards a closed position, means to slow the injector valve as it approaches the closed position, thereby reducing impact forces associated with valve closure.

Consequently, nozzle tip breakage is reduced or eliminated and valve rebound, with its attendant disadvantages, is eliminated.

Brief Description of Drawings

Fig. 1 is a vertical section of a fuel injector made according to one embodiment of the present invention;

Fig. 2 is an enlarged, fragmentary vertical section of the fuel injector;

Fig. 3 is a graph illustrating valve position, stress on the fuel injector valve tip, and fuel pressure in the injector tip as typically found in a prior art fuel injector;

Fig. 4 is a graph illustrating valve position, stress on the fuel injector valve tip, and fuel pressure in the injector tip in a fuel injector made according to one embodiment of the present invention.

Best Mode for Carrying out the Invention

An exemplary embodiment of a fuel injector made according to the invention is illustrated in Fig. 1 and is used in connection with an internal combustion engine (not shown). The injector includes an elongated body 8 which receives fuel supplied to an inlet port 10 at one end of the body 8 and ultimately directs the fuel to a combustion space (not shown) through a nozzle in the form of fuel injector tip orifices 12 located at the opposite end of the body 8.

The fuel inlet port 10 is in fluid communication with the orifices 12 through a fuel passageway 14 located in a fuel line adapter 16, a fuel passage 18 extending through the main body of the fuel injector and a fuel chamber 20 which surrounds the lower portion of a fuel injector valve 22.

At the correct point of the engine operating cycle, high pressure fuel is supplied to the intake port 10 in a conventional fashion and is communicated to the fuel chamber 20. The high pressure fuel in the fuel chamber 20 acts upon a piston surface 24' of the injector valve 22 which is slidably received in a bore 25 in the upper portion of the fuel injector tip 26. A slight clearance 27 (Fig. 2) is provided between a piston portion 24 of the injector valve 22 and the injector tip 26 so that a small amount of fuel may flow past the injector valve 22 and provide lubrication between the valve and the injector tip 26. This lubricating fuel flows into a spring chamber 28 having a lower end 29 and is ultimately returned to the fuel system through return ports 30. Thus, fuel in the chamber 28 will be at low pressure.

Because of the pressure difference between fuel in the fuel chamber 20 and the spring chamber 28, the piston portion 24 and consequently, the injector valve 22, are urged upwardly.

The high pressure of fuel acting against the piston surface 24' causes the compression of a return spring 32, until the end of a spring guide 34 contacts the lower surface of a spacer 36.

As injector valve 22 moves upwardly, a valve tip 38 thereon separates from a valve seat 40 located in the injector tip 26, placing the fuel chamber 20 in fluid communication with the injection tip orifices 12. Fuel from the fuel chamber 20 is thus expelled through the orifices 12 into the engine combustion chamber.

As the pressure of the fuel in the supply line, and thus in the fuel chamber 20, decreases, the force caused by the fuel acting on the piston surface 24' of the injection valve 22 is reduced. When the magnitude of the upward force caused by the fuel decreases below the value of the downward force provided by the return spring 32 and transmitted to the injector valve 22 through a novel check damper 42 to be explained hereinafter and an injector valve shoulder 44, the injector valve 22 will begin to move in a downward direction towards the closed position as shown.

When the valve tip 38 once again contacts the valve seat 40, the injector valve 22 is in its closed position blocking the flow of fuel from the fuel chamber 20 through the orifices 12 and into the engine combustion chamber.

According to the present invention, the check damper 42 is a flat, thin circular spacer and has a close diametral fit with the inner surface of the spring chamber 28. The diametral clearance 45 between the check damper 42 and the inner surface of the spring chamber 28 is typically, though not limited to, .001".

Industrial Applicability

In operation, when it is desired to supply fuel to the engine combustion area, high pressure fuel will be supplied to the intake port 10 in a conventional fashion and a small amount of fuel will flow past the piston portion 24 of the injector valve 22 and fill the spring chamber 28 including the lower end 29, up to the level of the return ports 30.

As fuel pressure is conventionally relaxed by the fuel pump (not shown), the spring 32 will overcome the force caused by the pressure of the fuel and the injector valve 22 will begin to move in a downwardly direction towards the closed position. Since the lower end 29 of the spring chamber 28 is filled with fuel, the injector valve 22 can close only as rapidly as fuel can escape past the check damper 42. By controlling the diametral clearance 45 between the check damper 42 and the inner surface of the spring chamber 28, the rate of fuel flow around the check damper 42, and therefore the velocity of the injector valve 22, may be controlled.

It must be noted that although fuel may flow from the fuel chamber 20 past the injector valve 22 and into the lower end 29 of the spring chamber 28, reverse flow past the valve 22 will be negligible. Reverse fuel flow will be limited because the duration of the injector valve 22 closing stroke is extremely short.

It has been found that the diametral clearance of .001" provides the desired fuel flow rate around the check damper 42 and consequently, the desired injector valve 22 closing velocity. It must be noted, however, that suitable diametral clearance can only be determined in conjunction with other fuel injector parameters, in particular, the return spring's 28 spring rate, friction present between the piston portion 24 of the injector valve 22 and the bore 25 of the injector tip 26, fuel viscosity, and the mass of injector valve 22.

The advantages of providing a fuel injector with the check damper 42 having a close diametral fit on the spring chamber 28 inner surface can readily be ascertained by a comparison of Figs. 3 and 4, the former illustrating valve position, the stress on the injector tip 26 and fuel pressure in the injector tip 26 of a prior art system without the check damper 42 and the latter illustrating the same characteristics of a fuel injector made according to one embodiment of the present invention.

Referring to Fig. 3, the valve position versus time curve 48 shows that, in the typical fuel injector, after the injector valve 22 first closes at the indicated valve closing point 50, the valve will "bounce" or, in other words, reopen and reclose a number of times before finally firmly seating on the injector valve seat 40. These repeated openings of the valve after initially contacting the valve seat 40 is detrimental to engine performance in that it allows additional fuel to enter the combustion space at an undesirable portion of the engine operating cycle thus increasing hydrocarbon exhaust emissions, increasing localized engine heating and wasting fuel.

As can be seen on the curve indicating stress on the valve tip versus time 52, this "bouncing" action is also detrimental to the fuel injector unit itself. The stress curve 52 indicates that repeated openings and closing of the valve tip 38 cause a number of reversing stress cycles to be imposed upon the injector tip 26. Cyclical stresses of the type illustrated by stress curve 52 are known to cause component failure through the mechanism of fatigue failure. It has been observed that cyclical loading eventually causes the portion of injector tip 26 around valve seat 40 to break off which allows direct, uncontrolled fluid communication between fuel chamber 20 and the engine combustion space. The result is that a very large amount of fuel flows into the combustion space whenever fuel is provided to the broken injector, greatly increasing fuel consumption, localized engine temperature and hydrocarbon emissions.

In a fuel injector made according to one embodiment of the present invention, as illustrated in Fig. 4, the problems of fuel waste, increased hydrocarbon exhaust emissions and injector tip breakage are greatly reduced.

As will be seen in the valve position versus time curve 54 of Fig. 4, reduced injector valve velocity allows the injector valve 22 to remain closed after initial contact with valve seat 40. As a result, fuel flow is positively cut off, thereby eliminating the problems associated with fuel leakage indicated above. Cyclical stresses on the injector tip are reduced, as shown in the stress versus time curve 56, thus extending the life of the injector tip 26 and preventing catastrophic fuel loss.

While particular reference has been made to an injector which utilizes a spring 32 to effect closing of the valve 22, it will be recognized that the present invention is equally applicable to injectors which utilize other means, i.e. fuel trapped above the injector valve 22, to provide the required valve closing force.

Other aspects, objects and advantages of this invention may be obtained from a study of the drawings, the disclosure and the appended claims.

Claims

1. A fuel injector comprising:

an injector body (8) including a nozzle (12);

a valve seat (40) within said body (8) and closely adjacent said nozzle (12);

a valve (22, 38) within said body (8) movable between positions seated against and spaced from said seat (40);

means (32) within said body (8) biasing said valve (22) towards said position seated against said seat (40);

means (10, 14, 18,20) in said body for receiving fuel under pressure and delivering said fuel to said valve;

means (24) responsive to the receipt of fuel under pressure within said body (8) for moving said valve (22) to said position spaced from said seat (40); and

means (42) for retarding the rate of movement of said valve (22) in moving from said positions spaced from said seat (40) towards said position seated against said seat (40) at least as said valve (22) approaches said position seated against said seat (40) to thereby reduce the force of impact of said valve (22) against said seat (40).

2. In combination with a fuel injector of the type wherein high pressure fuel forces an injector valve (22) received in an injector body (8) to an open position, allowing fuel to escape into a combustion space, and including means (32) to bias the injector valve (22) to a closed position on a reduction in fuel pressure, the improvement comprising:

means for retarding the rate of movement of said valve (22) in moving from said open position towards said closed position at least as said valve (22) approaches said closed position to thereby reduce the force of impact of said valve (22) against said seat (40).

3. The improved fuel injector of claim 1 or 2 wherein said retarding means is a hydraulic damper (42).

4. The improved fuel injector of claim 1 or 2 wherein said retarding means is a closely controlled diametral clearance (45) between said injector valve (22) and said injector body (18).

5. The improved fuel injector of claim 3 or 4 wherein said retarding means or said hydraulic damper is a flat, relatively thin circular spacer interposed between said biasing means (32) and said injector valve (22) having a maximum diameter which is slightly less than the inside diameter of said injector body (8).

6. A fuel injector comprising:

an injector body (8) including a nozzle (12);

a valve seat (40) within said body (8) and closely adjacent said nozzle (12);

a valve (22) within said body (8) movable within said body (8) between positions seated against and spaced from said seat (40);

means (32) within said body (8) biasing said valve (22) towards said position seated against said seat (40);

means (10, 14, 18, 20) in said body (8) for receiving fuel under pressure and delivering said fuel to said valve (22);

means (24) responsive to the receipt of said fuel under pressure within said body (8) for moving said valve (22) to said position spaced from said seat (40); and

a flat, relatively thin circular spacer (42) interposed between said biasing means (32) and said injector valve (22) having a maximum diameter slightly less than the inside diameter of said injector body (8) for retarding the rate of movement of said valve (22) in moving from said position spaced from said seat (40) towards said position seated against said seat (40) as said valve (22) approaches said position seated against said seat (40) to thereby reduce the force of impact of said valve (22) against said seat (40).

7. A fuel injector comprising

an injector body (8) including a nozzle (12);

a valve seat (40) within said body (8) and closely adjacent said nozzle (12);

a valve (22) within said body (8) movable within said body (8) between position seated against and spaced from said seat (40);

means (32) within said body biasing said valve (22) towards said position seated against said seat (40);

means (10, 14, 18, 20) in said body for receiving fuel under pressure and delivering said fuel to said valve (22);

means (24) responsive to the receipt of said fuel under pressure within said body (8) for moving said valve (22) to said positions spaced from said seat (40); and

a closely controlled diametral clearance between said valve (22) and said injector body (8) for retarding the rate of movement of said valve (22) in moving from said position spaced from said seat (40) towards said position seated against said seat (40) as said valve (22) approaches said position seated against said seat (40) to thereby reduce the force of impact of said valve (22) against said seat (40).

8. The fuel injector as set forth in one or more of the preceding claims, characterized by an injector valve shoulder (44).

9. The fuel injector as set forth in one or more of the preceding claims, characterized in that the diametral clearance (45) between the check damper (42) and the inner surface of the spring chamber (28) is typically .001".

10. The fuel injector as set forth in one or more of the preceding claims, characterized by a slight clearance (27) provided between a piston portion (24) of the injector valve (22) and the injector tip (26).

0017872

1/2

Fig. 1.

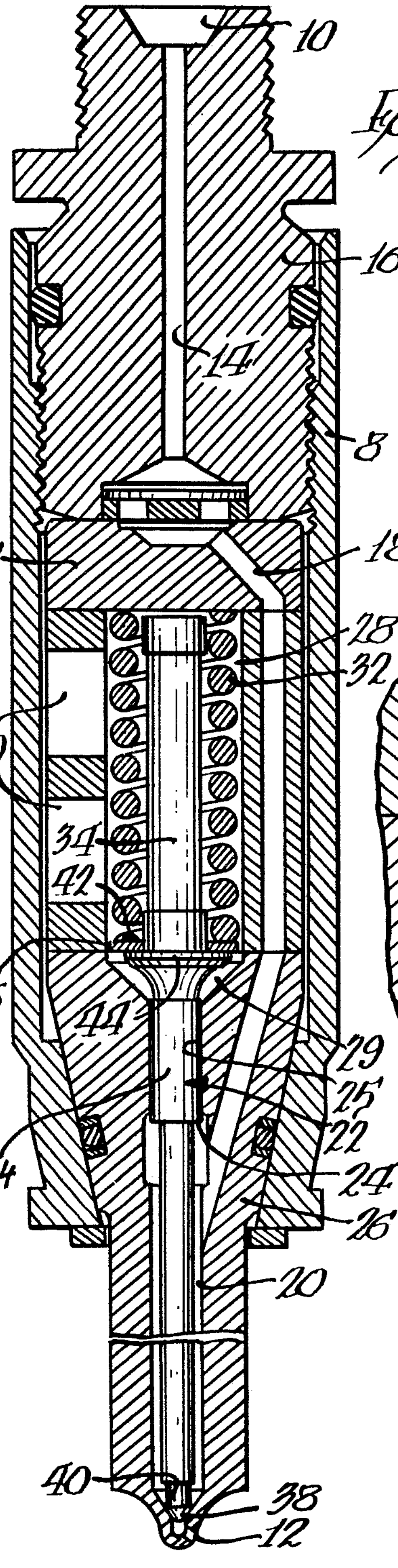
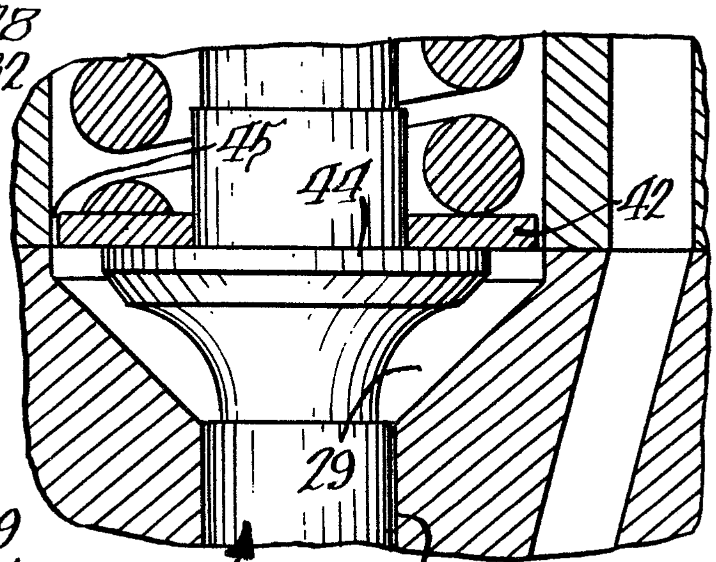


Fig. 2.



0017872

2/2

Fig. 3.

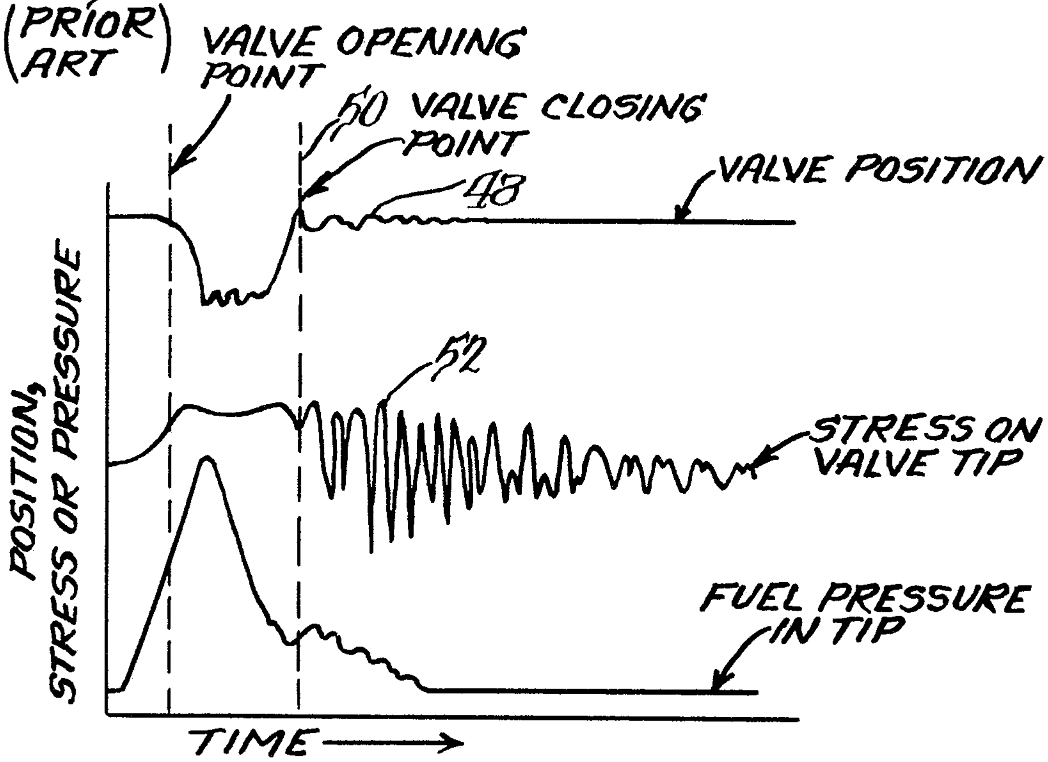
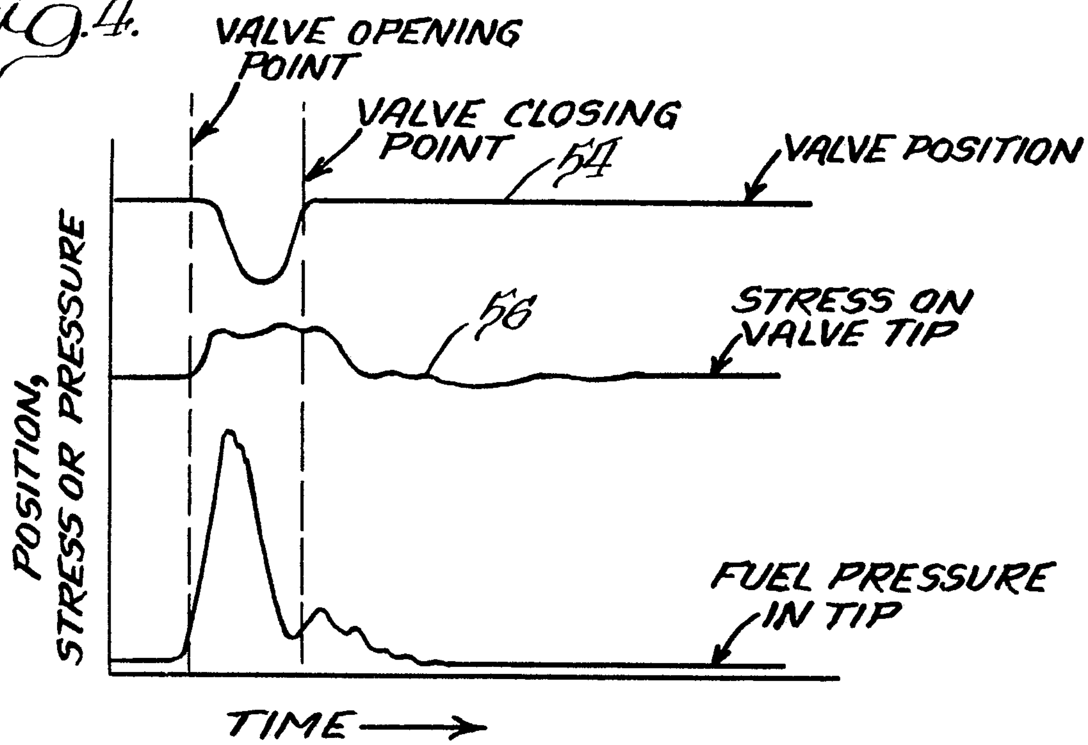


Fig. 4.



0017872

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 80 10 1812

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	GB - A - 1 406 216 (CAV) * Page 1, line 42 to page 2, line 67; figure *	1,2,3 10
X	GB - A - 1 110 102 (RUSTON & HORNSBY) * Page 1, line 63 to page 2, line 82; figure 1 *	1,3-8, 10
	SU - A - 380 858 (LYSHEVSKII) * The whole document; figure *	1,3-8, 10
	US - A - 3 398 936 (DELANO) * Column 2, line 18 to column 4, line 57; figures 1-3 *	1-3,8, 10
	DE - A - 2 120 108 (L'ORANGE) * Page 4, paragraph 5 to end of page 7; figures 1-4 *	1,2,10

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

F 02 M 61/20

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

F 02 M

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17-07-1980	BICHI