The pump (5) has at least one cylinder (6) in which slides a piston (16) moved positively in the compression direction and elastically in the intake direction. A compression spring (26) is located between the shutter (21) of an intake valve (19) and the piston (16) to push the shutter (21) elastically into a closed position by exerting elastic force varying according to the position of the piston (16). The shutter (21) has a plate (28) cooperating with a seat (22) on the intake valve (19) and movable parallel to the piston (16); and the compression spring (26) acts on the plate (28) to advance both opening and closing of the intake valve (19).
Published:

— With international search report.
— Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
HIGH-PRESSURE HYDRAULIC FUEL PUMP

TECHNICAL FIELD

The present invention relates to a high-pressure hydraulic pump, in particular an internal combustion engine radial-piston fuel pump.

BACKGROUND ART

As is known, in internal combustion engines, in particular diesel engines, such a pump operates at high pressure, even as high as 1,600 bars, and comprises a group of radial cylinders in which slide respective pistons activated by a common cam. Each piston has a return spring so as to move elastically during the fuel intake stroke, and is associated with an intake valve comprising a shutter which is normally kept closed by another return spring for opening the valve when overcome by the intake fuel pressure.

In one known three-radial-piston pump, each shutter has a plate cooperating with a corresponding seat in the cylinder, and is opened when the intake fuel pressure reaches roughly 5 bars; and the reaction of the three pistons on the drive shaft is normally balanced
sufficiently by the 120° spacing of the pistons.

In known radial-piston pumps, the shutter return spring is unaffected by the piston position. When the pump works at low capacity, e.g. below 30% of maximum, both the drive shaft and the delivery pressure of the various cylinders are subject to unbalance. In fact, the intake valves open with a variable amount of delay, and some may even not open at all, so that the pistons compress different amounts of fuel.

**DISCLOSURE OF INVENTION**

It is an object of the present invention to provide a highly straightforward, reliable high-pressure hydraulic pump designed to eliminate the aforementioned drawbacks typically associated with known pumps.

According to the present invention, there is provided a high-pressure hydraulic pump comprising at least one cylinder in which slides a piston, and actuating means for moving said piston positively in a compression direction; said piston being moved elastically in an intake direction opposite to said compression direction; and an intake valve comprising a shutter being fitted to said cylinder; characterized in that elastic means are provided between said piston and said shutter to push said shutter into a closed position by exerting elastic force varying with the position of said piston in said cylinder, so as to advance opening and closing of said intake valve.

More specifically, in a pump in which the shutter
comprises a plate cooperating with a seat carried by the cylinder, and the plate is movable parallel to the piston, the elastic means comprise a helical compression spring located between the plate and the piston.

**BRIEF DESCRIPTION OF THE DRAWINGS**

A preferred, non-limiting embodiment of the invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a partially sectioned side view of a radial-piston pump in accordance with the invention;
Figure 2 shows a larger-scale detail of Figure 1;
Figure 3 shows an operating diagram of the Figure 1 pump.

**BEST MODE FOR CARRYING OUT THE INVENTION**

Number 5 in Figure 1 indicates as a whole a high-pressure pump for supplying fuel to an internal combustion engine, e.g. a diesel engine. Pump 5 is a radial-piston type, and comprises three cylinders 6 - only one shown in Figure 1 - arranged radially inside a hollow body 7, with the respective axes 120° apart. More specifically, cylinders 6 are formed in one piece with hollow body 7, which is closed by a flange 8.

Pump 5 has a drive shaft 9 integral with an eccentric 11 housed in a central chamber 12 of hollow body 7. Eccentric 11 carries an annular cam for controlling pump 5 and which is defined by a ring 13 rotating on eccentric 11. The outer surface of ring 13 has three flat portions 14 associated with cylinders 6.
and each perpendicular to the axis of the corresponding cylinder 6.

A respective piston 16 slides in each cylinder 6; the outer radial surface of piston 16 defines a compression chamber 15 in cylinder 6; and piston 16 projects from cylinder 6 towards shaft 9, and carries a pad 17 which slides in known manner on the corresponding portion 14 of ring 13. As shaft 9 rotates, ring 13 moves pistons 16 positively and sequentially in the compression direction, i.e. outwards. By means of a spring 18, on the other hand, pad 17 is pushed elastically, together with piston 16, in the intake direction towards the corresponding flat portion 14 of ring 13.

Each piston 16 is associated with an intake valve 19 comprising a shutter 21 cooperating with a seat 22 (Figure 2) formed in a valve body 23 and coaxial with the corresponding cylinder 6. Valve body 23 is integral with cylinder 6 and hence with hollow body 7 (Figure 1), and is fixed to hollow body 7 by a fluidtight ring nut fastening member 24. Each piston 16 is also associated with a delivery valve not shown in the drawings.

According to the invention, elastic means defined by a compression spring 26 are located between piston 16 and shutter 21. More specifically, valve body 23 (Figure 2) is bell-shaped and comprises a substantially cylindrical cavity 27 facing piston 16 and housing part of spring 26. Seat 22 is located inside cavity 27 and is truncated-cone-shaped, flaring towards compression chamber 15.
Shutter 21 comprises a plate 28 integral with a stem 29, which is guided by an axial hole 31 in valve body 23; axial hole 31 has an enlargement 30 communicating with a supply conduit 32 of valve body 23; and conduit 32 communicates with supply channels 33 (Figure 1) carried by hollow body 7 and/or flange 8.

On the side facing stem 29, plate 28 has a truncated-cone-shaped edge 35 complementary in shape to that of seat 22. On the side facing away from stem 29, plate 28 carries a cylindrical projection 34 for securing one end of spring 26. The outer radial surface of piston 16 has a cylindrical appendix 36 smaller in diameter than piston 16; and the other end of compression spring 26 is secured to cylindrical appendix 36 of piston 16.

Pump 5 operates as follows.

When eccentric 11 is in the Figure 1 position, the piston 16 shown in Figure 1 is in the top dead center position and keeps spring 26 compressed. As shaft 9 rotates, eccentric 11, by means of ring 13, allows spring 18 to move piston 16 inwards, thus producing a depression in intake chamber 15 and also slightly decompressing or extending spring 26, which reduces the force exerted on plate 28 of shutter 21 to a value equivalent to 1.8-bar pressure on the bottom surface of plate 28.

When the difference in pressure between supply conduit 32 and compression chamber 15 is greater than the force exerted by the decompressed spring 26, intake valve 19 is opened. Intake valve 19 is thus opened promptly and
in advance with respect to known valves, even in the presence of low fuel pressure or flow in supply conduit 32. Fuel is then drawn along supply channels 33 and conduit 32 in valve body 23. The force exerted by spring 26 on plate 28 of shutter 21 is reduced to minimum at the bottom dead center position of piston 16, but the fuel pressure in chamber 15 remains the same as in supply conduit 32.

Eccentric 11 then begins moving piston 16 positively outwards to begin compressing the fuel in chamber 15. Piston 16 also begins compressing spring 26, which increases the elastic force exerted on plate 28 of shutter 21, which is then closed by the fuel pressure in chamber 15 together with the force exerted by spring 26. Valve 19 is therefore closed promptly and in advance with respect to known valves, thus providing for greater compression efficiency. Compression continues until piston 16 once more reaches the top dead center position.

Figure 3 shows the relative positions of the three pistons 16 and relative shutters 21 of pump 5 in the course of a typical stage in the operation of eccentric 11. In Figure 3, the three cylinders 6 are indicated A, B and C. More specifically, in cylinder 6A, piston 16 is at the start of the intake stroke, close to the top dead center position; and, though shutter 21 is still closed, spring 26 begins extending and reducing the force exerted on shutter 21.

In cylinder 6B, piston 16 moves towards the bottom
dead center position; spring 26 is only slightly compressed; and shutter 21 is opened even in the presence of low fuel pressure in supply channels 33. In cylinder 6C, piston 16 has begun the compression stroke and has also begun to compress spring 26, so that shutter 21 is closed immediately.

The advantages, as compared with the known state of the art, of the pump according to the invention will be clear from the foregoing description. In particular, shutter 21 is opened and closed more rapidly, even with low fuel pressure in the supply conduit; and operation of the pump is balanced and continuous.

Clearly, changes may be made to the pump as described herein without, however, departing from the scope of the accompanying Claims. For example, cylinders 6 may be separate from, and inserted inside holes in, hollow body 7; and each valve body 23 may be fitted to hollow body 7, together with the corresponding cylinder, by means of a fastening plate.

Seat 22 of intake valve 19 may be flat as opposed to truncated-cone-shaped; and the pump may even be a single-piston or multiple-in-line-piston type, and be used for pumping fluids other than engine fuel.
CLAIMS

1) A high-pressure hydraulic pump comprising at least one cylinder (6) in which slides a piston (16), and actuating means (9, 11) for moving said piston (16) positively in a compression direction; said piston (16) being moved elastically in an intake direction opposite to said compression direction; and an intake valve (19) comprising a shutter (21) being fitted to said cylinder (6); characterized in that elastic means (26) are provided between said piston (16) and said shutter (21) to push said shutter (21) into a closed position by exerting elastic force varying with the position of said piston (16) in said cylinder (6), so as to advance opening and closing of said intake valve (19).

2) A pump as claimed in Claim 1, wherein said shutter (21) comprises a plate (28) cooperating with a seat (22) of said intake valve (19); said plate (28) being movable parallel to said piston (16); characterized in that said elastic means comprise a compression spring (26) located between said plate (28) and said piston (16).

3) A pump as claimed in Claim 2, characterized in that said shutter (21) also comprises a stem (29) integral with said plate (28) and extending radially outwards; said stem being guided inside an axial hole (31) of a valve body (23) of said intake valve (19).

4) A pump as claimed in Claim 3, characterized in
that said seat (22) is truncated-cone-shaped, flaring towards said piston (16); said plate (28) having, on the side facing said stem, a truncated-cone-shaped edge (35) complementary to the shape of said seat (22).

5) A pump as claimed in Claim 4, characterized in that said plate comprises, on the opposite side to said stem, a cylindrical projection (34) for securing one end of said spring (26).

6) A pump as claimed in Claim 4 or 5, characterized in that said piston (16) has a cylindrical appendix (36) coaxial with said plate (28) and for securing another end of said spring (26).

7) A pump as claimed in one of Claims 3 to 6, wherein said seat (22) is coaxial with said cylinder (6) and is carried by a valve body (23) fitted to said cylinder (6); said valve body (23) having a supply conduit (32); characterized in that said valve body (23) is bell-shaped for housing at least part of said spring (26).

8) A pump as claimed in one of Claims 3 to 7, characterized in that said axial hole (31) has an enlargement (30) communicating with said supply conduit (32).

9) A pump as claimed in Claim 8, of the radial-piston type for internal combustion engine fuel, comprising a hollow body (7) closed by a flange (8); said hollow body (7) carrying a group of radial cylinders (6) associated with a corresponding group of pistons (16) and
with a corresponding group of intake valves (19); and said pistons (16) being activated by a common eccentric (11); characterized in that each of said valve bodies (23) if fitted inside said hollow body (7) by means of a fluidtight fastening member (24); said fastening member (24) being fittable to said hollow body (7) from the outside.

10) A pump as claimed in Claim 9, characterized in that the supply conduit (32) of each valve body (23) communicates with a supply channel (33) formed in said hollow body (7) and/or in said flange (8).
# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

<table>
<thead>
<tr>
<th>IPC</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>F04B53/10</td>
</tr>
<tr>
<td></td>
<td>F04B1/04</td>
</tr>
<tr>
<td></td>
<td>F02M63/02</td>
</tr>
</tbody>
</table>

According to International Patent Classification (IPC) or to both national classification and IPC.

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

<table>
<thead>
<tr>
<th>IPC</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>F04B</td>
</tr>
</tbody>
</table>

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

- EPO-Internal
- WPI Data
- PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>
| X        | DE 197 29 791 A (BOSCH GMBH ROBERT)  
14 January 1999 (1999-01-14)  
column 4, line 22 - line 27  
column 5, line 35 - column 7, line 30;  
figures 1-7  | 1-10 |
| X        | DE 197 29 790 A (BOSCH GMBH ROBERT)  
14 January 1999 (1999-01-14)  
column 3, line 13 - column 4, line 20;  
figures 1-4  | 1-10 |
| X        | EP 0 933 524 A (MITSUBISHI ELECTRIC CORP)  
4 August 1999 (1999-08-04)  
column 5, line 35 - line 53  | 1,2 |
| P,X      | DE 198 48 035 A (BOSCH GMBH ROBERT)  
20 April 2000 (2000-04-20)  
the whole document  | 1-10 |

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claims(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "X" document member of the same patent family

Date of the actual completion of the international search: 21 March 2001

Date of mailing of the international search report: 28/03/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel: (+31-70) 340-2040, Tx: 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer: Jungfer, J
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EP 0925446 A</td>
<td>30-06-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2001500220 T</td>
<td>09-01-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB 2332484 A</td>
<td>23-06-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2001500593 T</td>
<td>16-01-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 11210598 A</td>
<td>03-08-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 6048180 A</td>
<td>11-04-2000</td>
</tr>
</tbody>
</table>