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GB 1472125 A GB 0412243 A US 4490098 A

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(54) Fuel-injection pump for internal combustion engines

(57) In a fuel-injection pump for an internal combustion engine, a pump piston (1) is reciprocatingly driven by a cam drive and axially guided in a cylinder bore (3) in a cylinder sleeve (7) and defines therein by its front face (9) a pump working chamber (11). The pump piston (1) has on its periphery an oblique control edge (17) which cooperates with a control port (13) in the cylinder bore (3). This control port (13) is in the shape of an oval to cause a small pre-delivery effect (slow rise in pressure) during the commencement of fuel-injection and a sudden opening effect (rapid fall in pressure) at the termination of fuel-injection. The oval port is disposed in an oblique manner in the cylinder sleeve (7) in such a way that its longitudinal axis extends approximately parallel to the oblique control edge (17).

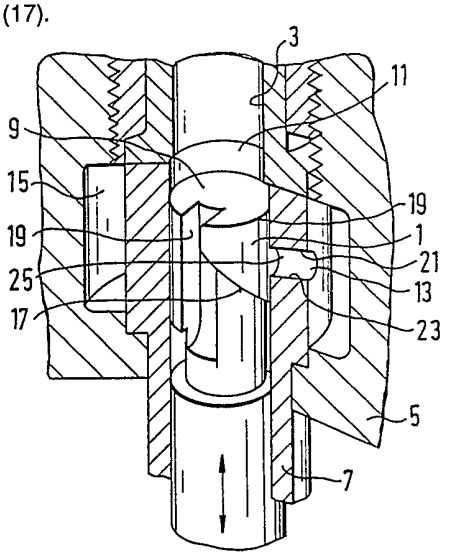

Fig.1

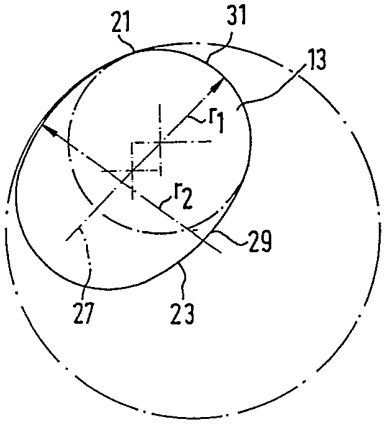

Fig.2

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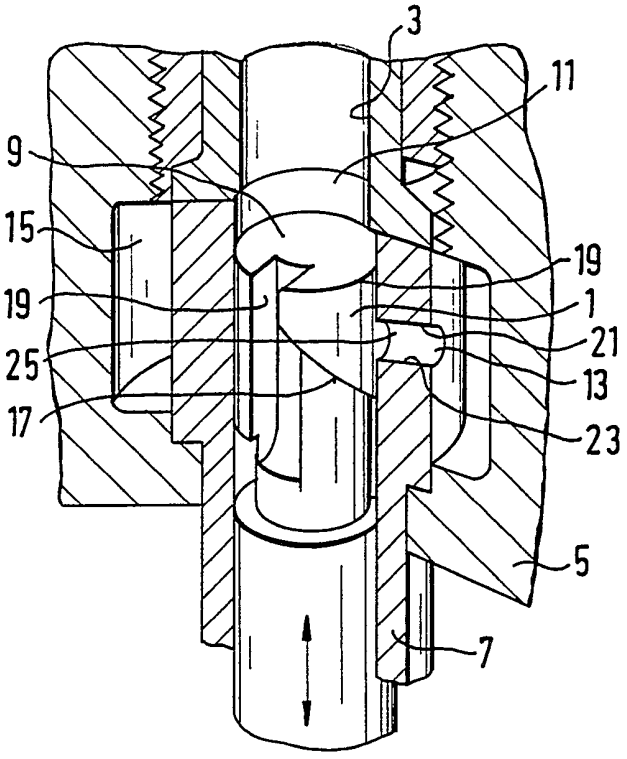


Fig. 1

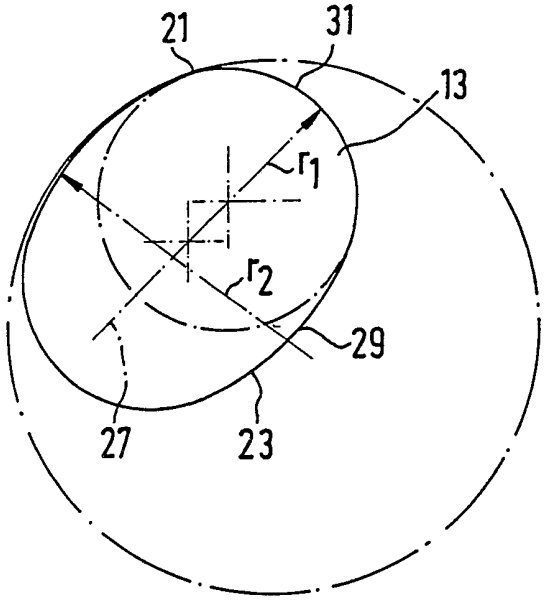
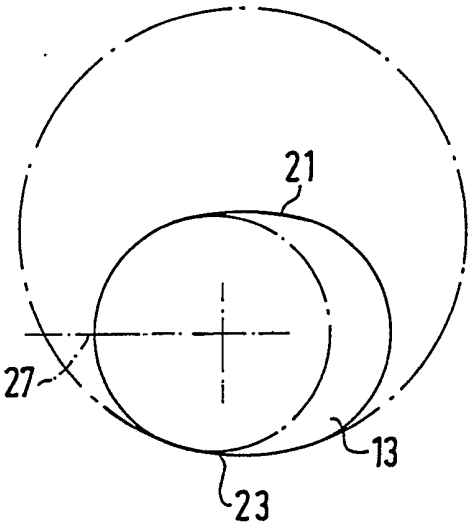


Fig. 2

Fig. 3



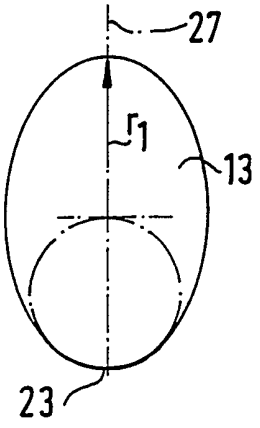


Fig. 4

DESCRIPTION

FUEL-INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

The invention relates to a fuel-injection pumps for internal combustion engines.

In a fuel-injection pump known from DE-PS 33 14 360, a pump piston is axially moved in a cylinder bore in a reciprocating manner by a cam drive. The pump piston defines, by its front face remote from the cam drive, a pump working chamber in the cylinder bore of a cylinder sleeve and the pump working chamber can be supplied with fuel during a part of the pump piston stroke by way of a radial control port in the cylinder sleeve. The pump piston can be rotated by means of a control rod and at its peripheral surface has an oblique control edge which is connected by means of a longitudinal groove to the pump working chamber. The pump piston cooperates, by its oblique control edge, with the radial control port of the cylinder sleeve for the purpose of changing the fuel-injection quantity.

At the same time the contour of the control port is designed in such a way, that the largest possible flow cross section is revealed rapidly during the cut-off process, so that the pump working chamber and a fuel-injection valve, which is connected thereto by way of a fuel-injection line and which protrudes into

the combustion chamber of the internal combustion engine being supplied, are relieved of pressure as quickly as possible, which causes the fuel-injection valve to close rapidly. In addition to this, the control port takes the shape of an egg, which is flattened on its longitudinal side, wherein this flattened side faces the oblique control edge of the pump piston and cooperates with this oblique control edge during the cut-off process. In the case of the known fuel-injection pump, there is, however, also the disadvantage that an extremely steep rise in pressure is produced in the pump working chamber, owing to the fact that the upper end of the control port is designed as an arc of a circle having an extremely large radius, which is closed at the beginning of the fuel-injection by the front face of the pump piston remote from the cam drive. This causes a large quantity of fuel to be injected at the beginning of the combustion in the pump working chamber, this large quantity of fuel combusts suddenly and in this way produces a high load on the components and severe noise emission. It is therefore not possible with the known fuel-injection pump, both at the beginning and also at the termination of the high pressure delivery in the pump working chamber to carry out optimum adjustments to suit the conditions of the internal combustion engine being supplied.

The present invention resides in a fuel-injection pump for an internal combustion engine having a pump piston which is reciprocatingly driven by a cam drive and can be rotated for the purpose of changing the quantity of injected fuel, the pump piston being guided in a cylinder bore and defining therein by means of its front face a pump working chamber, which can be supplied with fuel by way of a radially extending control port in the wall of the cylinder bore, which port cooperates with an oblique control edge on the pump piston for the purpose of terminating the fuel-injection, the contour of the exit surface of the radial control port in the cylinder bore being of a uniform oval shape.

This has the advantage, that it is possible, by means of the oval form of the control port, for the pressure to rise slowly at the beginning of the high pressure delivery and also for the pressure in the pump working chamber to be relieved rapidly at the end of the high pressure delivery.

At the same time, the control port can be disposed obliquely in an advantageous manner in such a way, that its longitudinal axis extends approximately parallel to the oblique control edge of the pump piston. In this way, when closing the control port by

means of the front face of the piston, the original small circular radius remains effective, which produces a slight pre-delivery effect.

This pre-delivery effect occurs by virtue of slowly closing the connection between the low pressure chamber and the pump working chamber, wherein a part of the fuel located in the pump working chamber is urged back into the low pressure chamber, at the beginning of the delivery stroke of the pump piston, by way of the flow cross section of the control port which is still open. This flowing-away process, during which the pressure in the pump working chamber does not increase considerably, lasts until the flow cross section at the control port is closed and/or almost closed, which initiates the commencement of the high-pressure delivery. At the same time, the closing characteristic of the control port by virtue of the front face of the pump piston is of particular importance. If the control port is closed quite suddenly, as would occur in the case of the upper control edge of the control port progressing almost parallel to the control edge of the pump piston, the pressure in the pump working chamber builds up suddenly, the fuel rapidly achieves the fuel-injection pressure and a large quantity of fuel is available immediately for the fuel-injection process.

In contrast to this, for example, a circular arcuate shape of the upper control edge upon crossing-over through the horizontal control edge of the pump piston causes the flow cross section at the control port to close slowly. Consequently, the quantity of fuel flowing away out of the pump working chamber is gradually reduced, as a result of which the pressure in the pump working chamber increases slowly, so that the fuel-injection pressure is also achieved slowly and the fuel-injection valve opens gradually. In so doing, initially only a small quantity of injected-fuel flows at the commencement of the high-pressure fuel delivery, by way of the fuel-injection valve flow cross section, which is not completely open at the beginning, for the purpose of injecting fuel into the combustion chamber of the internal combustion engine being supplied, followed in the case of a fully opened fuel-injection valve flow cross section almost immediately by the entire fuel-injection quantity.

This small quantity of pre-injection fuel at the commencement of the high pressure delivery has at the same time the advantage, that this can be completely processed in the combustion chamber and thus a small quantity of fuel initially combusts at the commencement of the combustion in the combustion

chamber, and rises during the further progression and a gradual rise in pressure is produced in this way in the combustion chamber of the internal combustion engine.

The described pre-delivery effect is at the same time particularly noticeable at the lower rotational speeds by reason of the inertia of the fuel, whereas at the higher rotational speeds, the relatively small flow cross section functions as a restrictor during the closing process immediately prior to commencing to close the control port fully, so that the delivery rate and therefore the rate of the rise in pressure in the high-pressure range accelerates in this range of rotational speed, with the rate of closing of the control port by virtue of the control edge of the pump piston.

The large radius of the flat side of the oval-shaped control port becomes effective during the cut-off process and this large radius, upon crossing over the oblique control edge of the pump piston, rapidly reveals a large flow cross section. At the same time, the oval shape of the longitudinal side of the control port has the advantage in contrast to a straight edge, that the manufacturing tolerances do not have any considerable influence on the accuracy of the cut-off process at the end of the high-pressure delivery with

respect to the parallelism of the control edge at the pump piston and to the edge of the control port which cooperates with this control edge. It is possible by varying the position and the dimensions of the control ports, to fulfil various requirements at the control ports. In this way, it is possible, in an advantageous manner, to achieve a large pre- and post-delivery effect by virtue of positioning the control port such that its longitudinal axis extends parallel to the axis of the pump piston, wherein the post-delivery effect is achieved here by the fact that the cut-off cross section at the end of the high pressure delivery is not opened suddenly, but rather gradually, so that the fuel-injection valve is not relieved of pressure suddenly, as a result of which it closes slowly and a small quantity of fuel is also still injected after the actual end of the high pressure delivery.

If, in the case of a fuel-injection pump which controls the fuel-injection by way of a hump element or a split element, the pre-delivery effect is to be avoided by virtue of the control port, it is advantageous to dispose the oval control port in such a way that its longitudinal axis extends at right angles to the axis of the pump piston. In this way, the pre-fuel injection process at the pump element

side there, is supported by virtue of the extremely large radius of the control port upon closing this control port.

The invention is further described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 is a longitudinal sectional view of a fuel-injection pump;

Fig. 2 illustrates a first embodiment of the shape of the control port in accordance with the invention, wherein this control port is disposed in an oblique manner;

Fig. 3 illustrates a second embodiment of the control port, in which this control port is disposed in a transverse manner; and

Fig. 4 illustrates a third embodiment of the shape of the control port, in which this control port is disposed longitudinally of the pump piston axis.

The fuel-injection pump illustrated in Fig. 1 is of a generally known kind. Only its inventive regions are illustrated. A pump piston 1 is moved by a cam drive (not illustrated) axially in a reciprocating manner in a cylinder bore 3 of a cylinder sleeve 7 installed in a pump housing 5. In so doing, the pump piston 1 defines, by its front face 9 remote from the cam drive, a pump working chamber 11 in the cylinder

bore 3, which chamber is connected during a part of the piston stroke by virtue of a radial control port 13 to a low pressure chamber 15 which is filled with fuel and which surrounds the cylinder sleeve 7. For the purpose of controlling the quantity of fuel injected, the pump piston 1 can be rotated by way of a control rod (likewise not illustrated), and has in its periphery a control recess which cooperates with the control port 13 and which is defined by an oblique control edge 17 and which is connected continuously to the pump working chamber 11 by way of a longitudinal groove 19.

The fuel-injection pump, as illustrated, functions in a known manner, in that, during the intake stroke of the pump piston 1 in the direction towards the bottom dead centre, fuel flows by way of the control port 13 from the low pressure chamber 15 into the pump working chamber 11. During the subsequent delivery stroke, the pump piston 1, by means of its front face 9, closes the control port 13. The boundary edge between front face 9 and the periphery of the pump piston 1 forms a control edge 19 and the fuel high-pressure delivery 3 is initiated when the control edge 19 crosses over the upper edge 21 of the control port 13. The fuel located in the pump working chamber 11 is compressed during the

progress of the further pump stroke. The fuel achieves the fuel-injection pressure and flows by way of a fuel-injection line (not illustrated) and a fuel-injection valve for the purpose of injecting fuel into the combustion chamber of the internal combustion engine being supplied. When the oblique control edge 17 crosses over the lower edge 23 of the control port 13, the connection between the highly pressurised pump working chamber 11 and the low pressure chamber 15 is opened, so that the high pressure in the pump working chamber 11 is relieved and fuel flows away into the low pressure chamber 15. At the same time, the pressure in the fuel-injection system drops again below the necessary fuel-injection pressure and the fuel-injection valve closes. It is possible at the same time by rotating the pump piston 1, to control the point in time when the control port 13 is opened by virtue of the oblique control edge 17 and therefore to control the quantity of injected fuel. During the described delivery stroke of the fuel-injection pump, the mouth contour 25 in the cylinder bore 3 formed by virtue of the control port 13 is of considerable importance, so both the commencement and also the termination of fuel-injection are controlled by virtue of the control edges 19, 17 at the piston side crossing over the upper and/or lower edge 21, 23 of the control port 13.

In order to be able to produce different fuel-injection characteristics, the shape of the control port 13 is designed in accordance with the invention and as illustrated in Figs. 2 to 4. Fig. 2 illustrates an oval shape of the control port 13, wherein the large radius r2 of the relatively flat longitudinal sides 29 is formed approximately twice the size of the small radius r1, of the almost circular transverse side 31. The longitudinal axis 27 of the control port 13 intersects the transverse sides 31 and extends, in Fig. 2, approximately parallel to the inclination of the oblique control edge 17. In contrast to the known circular control ports, it is possible with this embodiment of the control port 13, to produce both a slow rise in pressure in the pump working chamber 11 by virtue of the circular progression of the upper control edge 21 in the region of the transverse sides 31, and also to produce an extremely large temporary flow cross section at the end of the fuel-injection process, where the oblique control edge 17 is located with the large defining radius r2 overlapping with the lower control edge 23. Consequently, a small pre-injection effect can be combined with its positive effects on the combustion process with a sudden relief in the high pressure

chamber at the end of the fuel-injection process, similar to "rapid spill", which causes the fuel-injection valve to close rapidly. At the same time, the pre-delivery effect, as already described, is achieved by virtue of slowly closing the control port 13, which is caused by the horizontal control edge 19 of the pump piston 1 crossing over the circular upper edge 21, while the rapid relief of pressure is produced by virtue of the sudden temporary opening of a large overlapping cross section between the oblique control edge 17 and the lower control edge 23 of the control port 13, the lower control edge 23 extending almost parallel to the oblique control edge 17.

The contour of the control port 13 illustrated in Fig. 3 differs from that shown in Fig. 2 only in the orientation of the control port 13 in the cylinder bore 7. The oval control port 13 is disposed here in a transverse manner, which means its longitudinal axis 27 extends at a right angle to the axis of the pump piston. This has the advantage that a sudden closing at the commencement of the high pressure delivery is guaranteed by virtue of the almost horizontal design of the upper edge 21 of the control port 13, which is necessary, for example, during measures carried out at the element side for the purpose of the pre-delivery and therefore for the purpose of the pre-injection,

wherein the quantity of pre-injected fuel is controlled by way of recesses at the pump piston 1 and in the cylinder bore 3. The cut-off process is carried out similarly to that described with reference to Fig. 2, by suddenly opening the control port 13 by virtue of the flow cross section which is larger with respect to time, in comparison with a circular-shaped control port 13, as a result of the large radius r2 of the lower edge 23 of the control port 13.

In the third embodiment illustrated in Fig. 4, the oval control port 13 is disposed longitudinally, which means that its longitudinal axis 27 extends parallel to the axis of the pump piston. A large pre- and post-delivery effect is achieved here intentionally, wherein it is possible by way of designing the small radii r1 to adjust both the filling of the pump working chamber 11 and also the pressure reduction at the termination of delivery optimally to suit the requirements of the internal combustion engine being supplied, in this case mainly chamber engines.

It is therefore possible with the embodiments of control ports described with reference to Figs. 2 to 4, to fulfil the most varied of requirements of the function of the control port during the closing and opening processes, wherein these contours remain easily controllable from the manufacturing point of view.

CLAIMS

1. A fuel-injection pump for an internal combustion engine having a pump piston which is reciprocatingly driven by a cam drive and can be rotated for the purpose of changing the quantity of injected fuel, the pump piston being guided in a cylinder bore and defining therein by means of its front face a pump working chamber, which can be supplied with fuel by way of a radially extending control port in the wall of the cylinder bore, which port cooperates with an oblique control edge on the pump piston for the purpose of terminating the fuel-injection, the contour of the exit surface of the radial control port in the cylinder bore being of a uniform oval shape.

2. A fuel-injection pump according to claim 1, in which the oval-shaped control port is disposed obliquely in such a manner, that its longitudinal axis extends parallel to the oblique control edge of the pump piston.

3. A fuel-injection pump according to claim 1, in which the large radius of the relatively flat longitudinal sides of the oval control port is substantially twice the size of the small radius of the round transverse sides which intersect the longitudinal axis.

4. A fuel-injection pump according to claim 1, in which the longitudinal axis of the oval control port extends parallel to the axis of the pump piston.

5. A fuel-injection pump according to claim 1, in which the longitudinal axis of the oval control port extends at a right angle to the axis of the pump piston.

6. A fuel-injection pump for an internal combustion engine, constructed and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

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Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

GB 9307276.7

Relevant Technical fields

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(ii) Int Cl (Edition 5) F02M 59/26

Search Examiner

B W DENTON

Databases (see over)

(i) UK Patent Office

(ii) ONLINE : WPI

Date of Search

11 MAY 1993

Documents considered relevant following a search in respect of claims 1-6

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1472125 (YANMAR) - see original or port 9	1
X	GB 0412243 (SIMMS MOTOR) - see inclined ports 12	1, 2
X	US 4490098 (FREUDENSCHUSS) - see opening 9	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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