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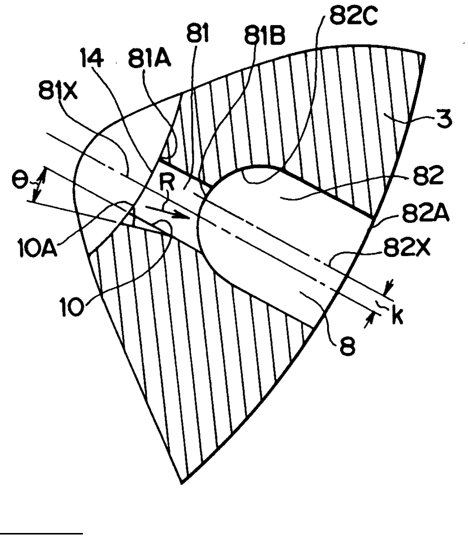
(54) FUEL INJECTION PUMP FOR INTERNAL COMBUSTION ENGINE

(57) In a fuel injection pump (1) which is constituted so as to control incoming and outgoing of fuel to a suction-and-overflow hole (8) in which an early stage control groove (10) is formed with an upper-side control edge portion (11) and a lower-side control edge portion (12) of a pump plunger (4) reciprocating in the inside of a pump plunger bushing (3), a suction-and-overflow hole (8) includes a small-diameter hole (81) having an opening surface (14) to observe the inside of the pump plunger bushing (3) and a large-diameter hole (82) which is communicated with another end (81B) of the small-diameter hole (81), and a bottom portion (10A) of the early stage control groove (10) extends in an upwardly inclined manner in the direction away from the opening surface (14), and an inner surface of a communicating end portion of the large-diameter hole (82) with the small-diameter hole (81) is formed into a spherical surface portion (82C). The high-pressure fuel which is fed to the inside of the large-diameter hole (82) can ensure a large distance between the fed high-pressure fuel and a wall surface of the large-diameter hole (82) due to a spherical surface portion (82C) of the large-diameter hole (82) thus reducing a cavitation erosion effect.

FIG.4



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Description

Technical field

[0001] The present invention relates to a fuel injection pump for an internal combustion engine which can reduce the generation of cavitation erosion.

Background Art

[0002] The inside of a pump chamber of a fuel injection pump for an internal combustion engine assumes an extremely high pressure. As a result, in performing a discharge control of fuel, the pressure vibration having a high pressure peak is generated in a suction-and-overflow hole and an intake chamber and hence, air bubbles or hollow cavities are formed in the inside of the fuel and hollow cavities which are already formed with this high pressure peak rupture. When the rupture of the hollow cavities occurs in the vicinity of a wall portion of the suction-and-overflow hole, the cavitation erosion is generated and a material which forms the pump is worn and when such a phenomenon takes place for a long period, functions of the pump are damaged.

[0003] To overcome this drawback, J-UT-B-7-54618 discloses a pump of a type having the constitution in which an early stage control groove is formed in a wall portion of a suction-and-overflow hole on a lower side opposite to an upper control edge portion, a control edge portion on a lower side of a pump plunger firstly skids on the early stage control groove and, thereafter, the control edge portion on the lower side of a pump plunger skids on a main transverse cross section of the suction-and-overflow hole, wherein a bottom portion of the early stage control groove extends upwardly in an inclined manner in the direction away from a skid surface of the pump plunger.

[0004] According to this proposed constitution, a fuel injection flow which is generated in an early stage flows into the inside of the suction-and-overflow hole along the inclination of the bottom portion. As a result, a hollow cavity which is formed in the inside of the suction-and-overflow hole can be discharged toward the suction-and-overflow hole whereby it is possible to obtain an advantageous effect that the generation of the cavitation erosion which performs undesired actions in the inside of the suction-and-overflow hole can be avoided in these holes or at least reduced.

[0005] However, recently, the use of low-viscosity fuel is increased and, conditions imposed on the use of fuel for cogeneration is becoming strict and hence, depending on the above-mentioned prior art, there may arise a drawback that the cavitation erosion is generated and such drawback occurs due to the use of the fuel injection pump for approximately 3000 to 5000 hours depending on cases.

[0006] It is an object of the present invention to provide a fuel injection pump for an internal combustion engine which can overcome the above-mentioned problems of the related art.

[0007] It is an object of the present invention to provide a fuel injection pump for an internal combustion engine which can further reduce the generation of the cavitation erosion by optimizing a shape of a suction-and-overflow hole formed in a plunger barrel of a fuel injection pump.

DISCLOSURE OF THE INVENTION

[0008] According to the present invention, it is proposed a fuel injection pump for an internal combustion engine in which incoming and outgoing of fuel to at least one suction-and-overflow hole which is formed in a pump plunger bushing are controlled with an upper-side control edge portion and a lower-side control edge portion of a pump plunger reciprocating in the inside of the pump plunger bushing, and an early stage control groove is formed in a wall portion of the suction-and-overflow hole, wherein the suction-and-overflow hole includes a small-diameter hole having an opening which faces the inside of the pump plunger bushing at one end thereof and a large-diameter hole which is communicated with another end of the small-diameter hole, the suction-and-overflow hole is formed in a state that the early stage control groove extends toward the large-diameter hole from the opening of the small-diameter hole, and a bottom portion of the early stage control groove extends in an upwardly inclined manner in the direction away from the opening, and an inner surface of a communicating end portion of the large-diameter hole with the small-diameter hole is formed into a spherical surface. Here, an axis of the large-diameter hole may be displaced from an axis of the small-diameter hole in the direction opposite to the early stage control groove.

[0009] According to the present invention, high-pressure fuel which flows in the inside of the suction-and-overflow hole along the early stage control groove flows into the inside of the small-diameter hole along the inclination of the bottom portion of the early stage control groove and, when the high-pressure fuel is fed to the inside of the large-diameter hole, it is possible to ensure a large distance between the fed high-pressure fuel and a wall surface of the large-diameter hole due to an arcuate bottom surface shape of the large-diameter hole and hence, it is possible to remarkably reduce a cavitation erosion effect attributed to the rupture of a hollow cavity inside the high-pressure fuel whereby the lowering of a lifetime of the fuel injection pump can be effectively suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a cross-sectional view showing one embodiment of the present invention.

Fig. 2 is a cross-sectional view taken along a line A-

A in Fig. 1.

Fig. 3 is a view as viewed from the direction of an arrow B in Fig. 2.

Fig. 4 is a cross-sectional view taken along a line C-C in Fig. 3.

BEST MODE FOR CARRYING OUT THE INVENTION

[0011] To describe the present invention in more detail, the present invention is explained in conjunction with attached drawings.

[0012] Fig. 1 is a cross-sectional view showing one embodiment of a fuel injection pump according to the present invention. The fuel injection pump 1 serves to inject and supply pressurized high-pressure fuel into an internal combustion engine, wherein a pump plunger bushing 3 is fitted into the inside of the casing 2, a plunger chamber 5 is defined by the pump plunger bushing 3 and the pump plunger 4. Numeral 6 indicates a pressure valve and numeral 7 indicates a pressure valve casing, wherein the pressure valve casing 7 is fastened to the casing 2 by bolts. Suction-and-overflow holes 8 for fuel are formed in the pump plunger bushing 3, and suction-and-overflow chambers 9 are formed in the casing 2 in a state that the suction-and-overflow chambers 9 face the suction-and-overflow holes 8 in an opposed manner. Further, an early stage control groove 10 is formed in the suction-and-overflow hole 8.

[0013] An upper-side control edge portion 11 and a lower-side control edge portion 12 are formed in the pump plunger 4, wherein due to the movement of the pump plunger 4 in the axial direction, these upper-side control edge portion 11 and lower-side control edge portion 12 skid on the early-stage control groove 10. In this case, the lower-side control edge portion 12 which defines the completion of supply firstly skids on the early stage control groove 10 which extends in an inclined manner at the time of completion of supply and, thereafter, the whole opening surface 14 of the suction-and-outflow hole 8 is opened. As a result, due to the fuel injection flow which flows in an inclined manner in the early stage, the pressure in the inside of the suction-and-overflow chamber 9 is increased relatively gently. Here, in this embodiment, two sets of suction-and-overflow holes 8 and suction-and-overflow chambers 9 are provided, wherein suction-and-overflow operations of the fuel are performed alternately with the phase difference of 180°.

[0014] Next, the suction-and-overflow hole 8 is explained in conjunction with Fig. 2 to Fig. 4. Here, Fig. 2 is a cross-sectional view taken along a line A-A in Fig. 1, Fig. 3 is a view as viewed from the direction of an arrow B in Fig. 2, and Fig. 4 is a cross-sectional view taken along a line C-C in Fig. 3. The suction-and-overflow hole 8 includes a cylindrical small-diameter hole 81 having an opening surface 14 which has one end 81A thereof opened on a pump plunger 4 side, and a large-diameter hole 82 which has one end 82A thereof opened on a suction-and-overflow chamber 9 side and has a diameter larger than a diameter of the small-diameter hole 81, wherein an inner surface of another end portion of the large-diameter hole 82 is formed into a spherical surface portion 82C which is formed into a spherical shape. Further, another end 81B of the small-diameter hole 81 is communicated with the large-diameter hole 82 in a state that another end 81B faces the inside of the large-diameter hole 82 from a portion of the spherical surface portion 82C which is formed as a bottom surface in another end portion of the large-diameter hole 82.

[0015] In this embodiment, as can be easily understood from Fig .3 and Fig. 4, an axis 81x of the small-diameter hole 81 and an axis 82x of the large-diameter hole 82 are displaced from each other by a predetermined value k. This displacement direction is the direction in which the axis 82x is arranged opposite to the early stage control groove 10 with respect to the axis 81x. The early stage control groove 10 is formed as a trough-like groove having an arcuate cross-sectional bottom surface 10A in a portion of the small-diameter hole 81 and, at the same time, the bottom surface 10A of the early stage control groove 10 is inclined to make an angle θ with respect to the axis 81x (see Fig. 4).

[0016] Next, the manner of operations of suction, pressurizing and injection of the fuel in the fuel injection pump 1 is explained.

[0017] The suction of the fuel is performed in a state that the pump plunger 4 is lowered and the upper-side control edge portion 11 allows the opening surface 14 of the small-diameter hole 81 to open to the plunger chamber 5. When the pump plunger 4 is lifted so that the upper-side control edge portion 11 interrupts the opening surface 14 from the plunger chamber 5, the pressurizing of the fuel in the inside of the plunger chamber 5 starts, and when the lower-side control edge 12 starts opening of the early stage control groove 10, the high-pressure fuel which is obtained by pressurizing the fuel in the inside of the plunger chamber 5 flows into the inside of the suction-and-overflow hole 8 as the fuel injection flow along the early stage control groove 10.

[0018] This fuel injection flow flows along the bottom surface 10A of the early stage control groove 10 and hence, the flow direction assumes a direction indicated by an arrow R which is parallel to the bottom surface 10A (see Fig. 4). As a result, the fuel injection flow which flows in from the small-diameter hole 81 is fed out to the inside of the large-diameter hole 82 vigorously. As mentioned previously, the axes 81x, 82x are displaced from each other by the predetermined value k and, at the same time, spherical surface portion 82C is formed on the bottom surface of another end portion of the large-diameter hole 82 and hence, a large spaces are ensured in front of the fuel injection flow which is fed out into the inside of the large-diameter hole 82.

[0019] Accordingly, by allowing the fuel injection flow to flow into the inside of the suction-and-overflow hole 8, the hollow cavities which are generated in the inside of the high-pressure fuel enter the suction-and-overflow chamber 9 through this ensured large space. As a result, the provability that the hollow cavities which are generated in the high-pressure fuel in the inside of the suction-and-overflow hole 8 rupture in the vicinity of the inner wall surface of the large-diameter hole 82 can be remarkably lowered thus effectively suppressing the generation of the cavitation erosion. Here, when it is possible to ensure a wide space which can reduce the influence of the cavitation erosion in front of the fuel injection flow fed out to the inside of the large-diameter hole 82 due to the spherical surface portion 82C, it is not always necessary to displace the axis 81x and the axis 82x and the predetermined value k may be set to 0.

INDUSTRIAL APPLICABILITY

[0020] As has been described heretofore, the fuel injection pump according to the present invention can effectively prevent the generation of the cavitation erosion in the suction-and-overflow hole and hence, the present invention is useful in improving the fuel injection pump for the internal combustion engine.

Claims

1. A fuel injection pump for an internal combustion engine in which incoming and outgoing of fuel to at least one suction-and-overflow hole which is formed in a pump plunger bushing are controlled with an upper-side control edge portion and a lower-side control edge portion of a pump plunger reciprocating in the inside of the pump plunger bushing, wherein
an early stage control groove is formed in a wall portion of the suction-and-overflow hole, the suction-and-overflow hole includes a small-diameter hole having an opening which faces the inside of the pump plunger bushing at one end thereof and a large-diameter hole which is communicated with another end of the small-diameter hole, the suction-and-overflow hole is formed in a state that the early stage control groove extends toward the large-diameter hole from the opening of the small-diameter hole, and a bottom portion of the early stage control groove extends in an upwardly inclined manner in the direction away from the opening, and an inner surface of a communicating end portion of the large-diameter hole with the small-diameter hole is formed into a spherical surface.

2. A fuel injection pump for an internal combustion engine according to claim 1, wherein an axis of the large-diameter hole is displaced from an axis of the small-diameter hole in the direction opposite to the early stage control groove by a predetermined value.

3. A fuel injection pump for an internal combustion engine according to claim 1, wherein an axis of the large-diameter hole is displaced in a state that the axis of the large-diameter hole is shifted in parallel in the direction opposite to the early stage control grove with respect to an axis of the small-diameter hole.

4. A fuel injection pump for an internal combustion engine according to claim 1, wherein the early stage control groove is a trough-shaped groove having an arcuate bottom surface shape in cross-section.

5. A fuel injection pump for an internal combustion engine according to claim 1, wherein the bottom surface of the early stage control groove makes a predetermined angle with respect to the axis of the small-diameter hole.

FIG.1

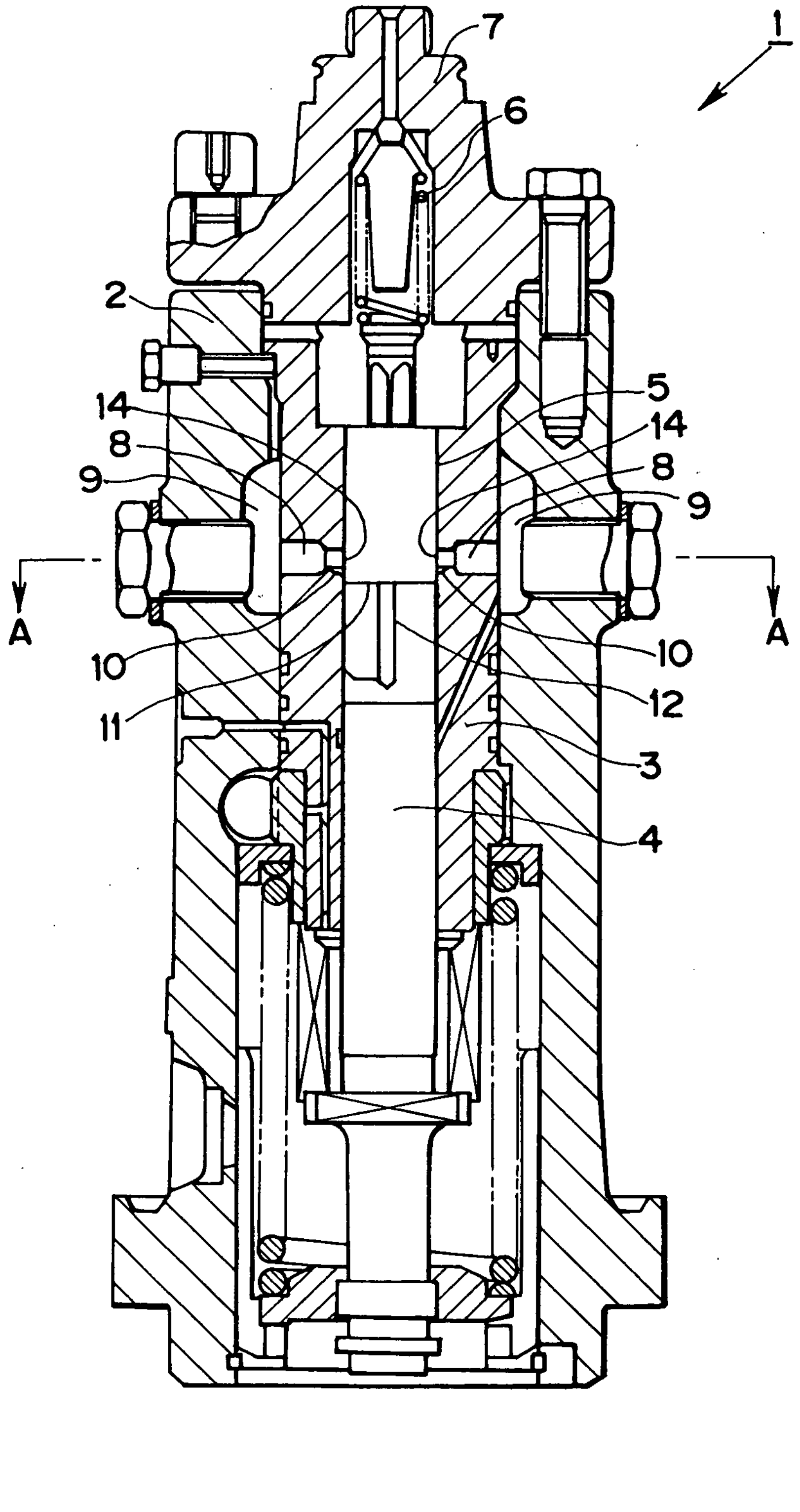


FIG.2

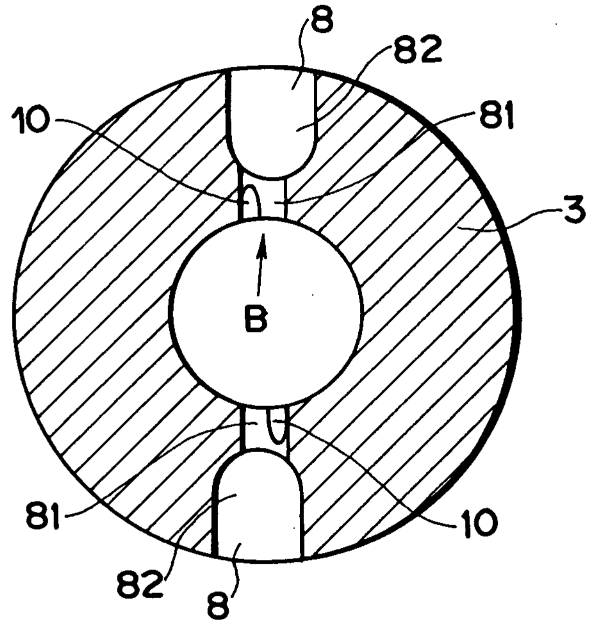


FIG.3

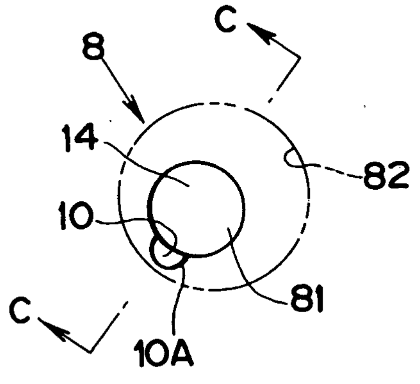
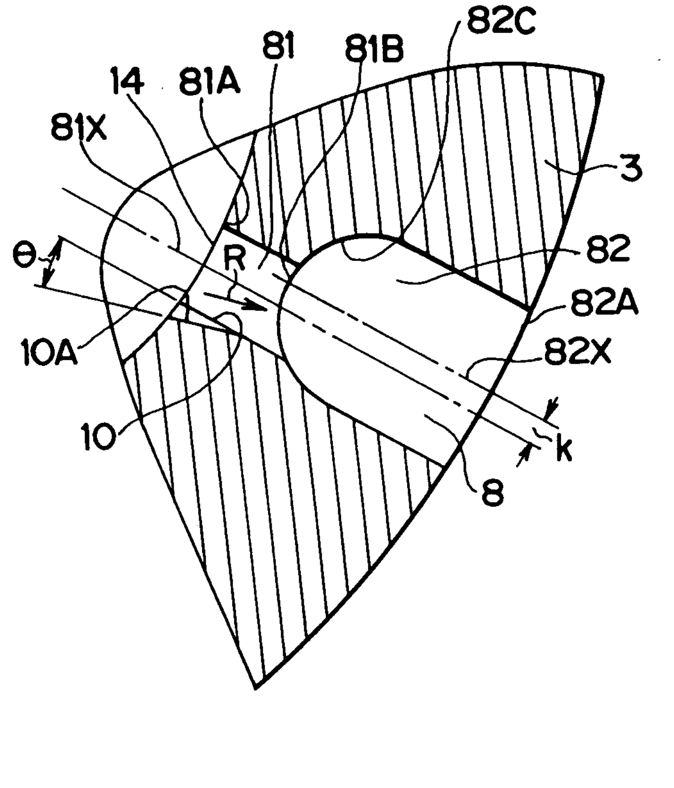


FIG.4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/003664

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F02M59/26

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)
Int.Cl[7] F02M39/00-71/04

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2005
Kokai Jitsuyo Shinan Koho	1971-2005	Toroku Jitsuyo Shinan Koho	1994-2005

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 136145/1989(Laid-open No. 78764/1990) (Robert Bosch GmbH.), 18 June, 1990 (18.06.90), Full text; Figs. 1 to 6 & EP 372211 A1 & DE 384022 A1	1-5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 13319/1986(Laid-open No. 126564/1987) (Mitsubishi Heavy Industries, Ltd.), 11 August, 1987 (11.08.87), Full text; Figs. 1 to 3 (Family: none)	1-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
09 June, 2005 (09.06.05)	28 June, 2005 (28.06.05)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/003664

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 80100/1983(Laid-open No. 184369/1984) (Diesel Kiki Co., Ltd.), 07 December, 1984 (07.12.84), Full text; Figs. 1 to 5 (Family: none)	1-5

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