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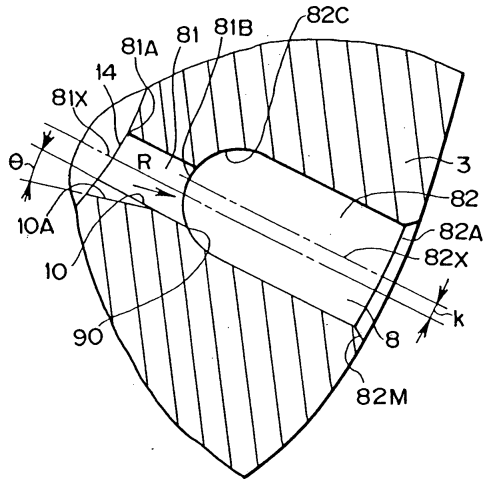
(54) **FUEL INJECTION PUMP FOR INTERNAL COMBUSTION ENGINE**

(57) A fuel injection pump (1) configured such that incoming and outgoing of fuel to at least one inlet-cum-overflow hole (8) formed in a pump plunger bush (3) are controlled by a pump plunger (4) that reciprocally moves inside the pump plunger bush (3), with an early control groove (10) being formed in a wall portion of the inlet-cum-overflow hole (8), wherein the inlet-cum-overflow hole (8) comprises a small diameter hole (81) having in one end (81A) thereof an open surface (14) that looks into the inside of the pump plunger bush (3) and a large diameter hole (82) that is communicated with the other end (81B) of the small diameter hole (81), a bottom portion (10A) of the early control groove (10) slopingly extends upward in a direction away from the open surface (14), an inner surface of the communicating end portion of the large diameter hole (82) that is communicated with the small diameter hole (81) is configured as a curved surface portion (82C), and an open end portion of the large diameter hole (82) is configured as a chamfered end edge (82M), whereby the shape of the inlet-cum-overflow hole (8) is optimized so that the occurrence of cavitation erosion can be further reduced.

FIG.4



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Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] The inside of a pump chamber in a fuel injection pump for an internal combustion engine reaches an extremely high pressure, so pressure vibration having a high pressure peak occurs in an inlet-cum-overflow hole and inside an inlet chamber when fuel is discharge-controlled and, as a result, air bubbles or cavities are formed inside the fuel and cavities that have already formed burst because of this high pressure peak. When such cavities burst near the wall portion of the inlet-cum-overflow hole, cavitation erosion occurs, the material forming the pump wears, and the function of the pump becomes impeded when such action persists for a long period of time.

[0003] In order to eliminate this drawback, a configuration has been disclosed in Japanese Utility Model Gazette No.Zitsukouhei 7-54618 where, in a fuel injection pump of a format where an early control groove is formed in the lower side on the opposite side of an upper control edge portion of the wall portion of the inlet-cum-overflow hole and a lower control edge portion of a pump plunger first slides over the early control groove and thereafter slides over the main lateral cross section of the inlet-cum-overflow hole, a bottom portion of the early control groove is formed so as to slope and extend upward in a direction away from the sliding surface resulting from the pump plunger.

[0004] According to this proposed configuration, the fuel jet that occurs early flows into the inlet-cum-overflow hole along the slope of the bottom portion thereof, and cavities that have formed inside the inlet-cum-overflow hole are discharged towards the inlet-cum-overflow hole, so there can be expected an effect where cavitation erosion, which exerts an adverse action inside the inlet-cum-overflow hole, is circumvented from occurring inside this hole or is at least reduced.

[0005] However, in recent years, the use of low-viscosity fuel has increased and conditions have become stricter because of use towards cogeneration, so cavitation erosion still occurs in the above-described conventional art and, depending on the case, sometimes causes drawbacks during use for about 3,000 to 5,000 hours.

[0006] It is an object of the present invention to provide a fuel injection pump for an internal combustion engine that can solve this drawback in the conventional art.

[0007] It is another object of the present invention to provide a fuel injection pump for an internal combustion engine that can further reduce the occurrence of cavitation erosion by optimizing the shape of an inlet-cum-overflow hole in a plunger barrel of a fuel injection pump.

DISCLOSURE OF THE INVENTION

[0008] According to the present invention, there is proposed a fuel injection pump for an internal combustion engine configured such that incoming and outgoing of fuel to at least one inlet-cum-overflow hole formed in a pump plunger bush are controlled by a pump plunger that reciprocally moves inside the pump plunger bush, with an early control groove being formed in a wall portion of the inlet-cum-overflow hole, wherein the inlet-cum-overflow hole includes a small diameter hole having in one end thereof an opening that looks into the inside of the pump plunger bush and a large diameter hole that is communicated with the other end of the small diameter hole, the early control groove is disposed so as to extend towards the large diameter hole from the opening of the small diameter hole, a bottom portion of the early control groove slopingly extends upward in a direction away from the opening, an inner surface of the communicating end portion of the large diameter hole that is communicated with the small diameter hole has a curved surface shape, and an end edge of an open end portion of the large diameter hole is chamfered.

[0009] According to the present invention, the effect of cavitation erosion resulting from the bursting of cavities within high-pressure fuel can be remarkably reduced and deterioration of the lifespan of the fuel injection pump can be effectively controlled.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a cross-sectional diagram showing an embodiment of the present invention.
FIG. 2 is a cross-sectional diagram along line A-A in FIG. 1.
FIG. 3 is a diagram seen from the direction of arrow B in FIG. 2.
FIG. 4 is a cross-sectional diagram along line C-C in FIG. 3.

BEST MODE FOR IMPLEMENTING THE INVENTION

[0011] The present invention will be described in accordance with the attached drawings in order to describe the invention in greater detail.

[0012] FIG. 1 is a cross-sectional diagram showing an embodiment of a fuel injection pump according to the present invention. A fuel injection pump 1 is for injecting and supplying high-pressure fuel that has been pressurized to an internal combustion engine, 2 is a casing, 3 is a pump plunger bush that is fitted inside the casing 2, 4 is a pump plunger, and 5 is a plunger chamber defined by the pump plunger bush 3 and the pump plunger 4. 6 is a pressure valve and 7 is a pressure valve casing, and the pressure valve casing 7 is screwed to the casing 2.

[0013] A fuel inlet-cum-overflow hole 8 is formed in the

pump plunger bush 3, and an inlet-cum-overflow chamber 9 is formed in the casing 2 so as to face the inlet-cum-overflow hole 8. Additionally, an early control groove 10 is formed in the inlet-cum-overflow hole 8.

[0014] An upper control edge portion 11 and a lower control edge portion 12 are formed in the pump plunger 4, and the upper control edge portion 11 and the lower control edge portion 12 slide over the early control groove 10 because of the motion in the axial line direction of the pump plunger 4. In this case, the lower control edge portion 12 that regulates supply completion first slides over the slopingly extending early control groove 10 during supply completion and thereafter opens an entire open surface 14 of the inlet-cum-overflow hole 8. As a result, the pressure inside the inlet-cum-overflow chamber 9 increases relatively gradually because of the jet of fuel that slopingly flows in early.

[0015] It will be noted that, in the present embodiment, two pairs of the inlet-cum-overflow hole 8 and the inlet-cum-overflow chamber 9 are disposed, so that fuel intake and overflow operation are alternately executed with a phase difference of 180°.

[0016] Next, the inlet-cum-overflow hole 8 will be described with reference to FIG. 2 to FIG. 4. Here, FIG. 2 is a cross-sectional diagram along line A-A in FIG. 1, FIG. 3 is a diagram seen from the direction of arrow B in FIG. 2, and FIG. 4 is a cross-sectional diagram along line C-C in FIG. 3.

[0017] The inlet-cum-overflow hole 8 is disposed with a cylindrical small diameter hole 81 whose one end 81A has the open surface 14 that opens towards the pump plunger 4 and a large diameter hole 82 whose one end 82A opens towards the inlet-cum-overflow chamber 9 and whose diameter is larger than the diameter of the small diameter hole 81, with the inner surface of the other end portion of the large diameter hole 82 serving as a curved surface portion 82C. Additionally, another end 81B of the small diameter hole 81 is communicated with the large diameter hole 82 so as to look inside the large diameter hole 82 from part of the curved surface portion 82C that is formed as a bottom surface on the other end portion of the large diameter hole 82.

[0018] In the present embodiment, as can be easily understood from FIG. 3 and FIG. 4, an axial line 81x of the small diameter hole 81 and an axial line 82x of the large diameter hole 82 are offset a predetermined value k from each other. This offset direction is a direction where the axial line 82x is opposite the early control groove 10 with respect to the axial line 81x.

[0019] The early control groove 10 is formed in part of the small diameter hole 81 as a gutter-like groove having a cross-sectionally circular arc-shaped bottom surface 10A, and the bottom surface 10A of the early control groove 10 slopes so as to form an angle θ with respect to the axial line 81x (see FIG. 4).

[0020] Moreover, an end edge of the open end portion of the large diameter hole 82, that is, an end edge 82M of the one end 82A, is chamfered so as to have a configuration that can alleviate impact force resulting from the bursting of cavities acting on the end edge of the open end portion of the large diameter hole 82, so that instances where the end edge 82M sustains damage because of cavitation erosion can be controlled. In the present embodiment, this chamfering is cornered chamfering, but it may also be round chamfering or another appropriate chamfering.

[0021] Next, operation of fuel intake, pressurization and injection in the fuel injection pump 1 will be described.

[0022] Fuel intake is performed in a state where the pump plunger 4 is lowered and the upper control edge portion 11 opens the open surface 14 of the small diameter hole 81 to the plunger chamber 5. Fuel pressurization inside the plunger chamber 5 is started when the pump plunger 4 rises so that the upper control edge portion 11 blocks the open surface 14 from the plunger chamber 5, and high-pressure fuel obtained as a result of being pressurized inside the plunger chamber 5 when the lower control edge portion 12 begins to open the early control groove 10 flows into the inlet-cum-overflow hole 8 as a fuel jet along the early control groove 10.

[0023] This fuel jet flows along the bottom surface 10A of the early control groove 10, so the flow direction thereof is the direction indicated by arrow R which is parallel to the bottom surface 10A (see FIG. 4). As a result, the fuel jet flowing in from the small diameter hole 81 is swiftly sent inside the large diameter hole 82, but as mentioned previously, because the axial lines 81x and 82x are offset the predetermined value k from each other and the curved surface portion 82C is formed in the bottom surface of the other end portion of the large diameter hole 82, a wide space is ensured in front of the fuel jet sent inside the large diameter hole 82.

[0024] In the present embodiment, the curved surface portion 82C has the shape of part of a sphere to ensure a wide space in front of the fuel jet, but as long as this wide space can be ensured, the shape of the curved surface portion 82C may be any curved surface shape and is not limited to the present embodiment.

[0025] Consequently, cavities occurring inside the high-pressure fuel as a result of the fuel jet flowing into the inlet-cum-overflow hole 8 enter the inlet-cum-overflow chamber 9 through this ensured wide space. As a result, the probability that cavities occurring within the high-pressure fuel inside the inlet-cum-overflow hole 8 will burst in the vicinity of the inner wall surface of the large diameter hole 82 is remarkably lowered and the occurrence of cavitation erosion can be effectively controlled. Moreover, the open end portion of the large diameter hole 82 where cavitation erosion easily occurs is the chamfered end edge 82M, so damage to the open end portion of the large diameter hole 82 can be extremely effectively controlled.

[0026] Moreover, when this type of chamfering is similarly administered in regard also to an end edge 90 of the other end portion 81B of the small diameter hole 81 serving as a boundary between the small diameter hole

81 and the large diameter hole 82, the occurrence of cavitation erosion at the end edge 90 can be effectively controlled and the same effects can be obtained, so the occurrence of cavitation erosion can be even more effectively controlled.

[0027] It will be noted that when a wide space capable of reducing the impact of cavitation erosion can be ensured by the curved surface portion 82C in front of the fuel jet sent inside of the large diameter hole 82, it is not invariably necessary to offset the axial line 81x and the axial line 82x from each other, and the predetermined value k may also be zero.

INDUSTRIAL APPLICABILITY

[0028] As described above, the fuel injection pump for an internal combustion engine according to the present invention can further reduce the occurrence of cavitation erosion and is useful for the improvement of a fuel injection pump for an internal combustion engine.

Claims

1. A fuel injection pump for an internal combustion engine configured such that incoming and outgoing of fuel to at least one inlet-cum-overflow hole formed in a pump plunger bush are controlled by a pump plunger that reciprocally moves inside the pump plunger bush, with an early control groove being formed in a wall portion of the inlet-cum-overflow hole,
wherein the inlet-cum-overflow hole includes a small diameter hole having in one end thereof an opening that looks into the inside of the pump plunger bush and a large diameter hole that is communicated with the other end of the small diameter hole, the early control groove is disposed so as to extend towards the large diameter hole from the opening of the small diameter hole, a bottom portion of the early control groove slopingly extends upward in a direction away from the opening, an inner surface of the communicating end portion of the large diameter hole that is communicated with the small diameter hole has a curved surface shape, and an end edge of an open end portion of the large diameter hole is chamfered.

2. The fuel injection pump for an internal combustion engine of claim 1, wherein an axial line of the small diameter hole and an axial line of the large diameter hole are parallel to each other and are apart a predetermined value from each other.

3. The fuel injection pump for an internal combustion engine of claim 1, wherein an axial line of the small diameter hole and an axial line of the large diameter hole are parallel to each other and are apart a predetermined value from each other in a direction where the axial line of the large diameter hole is opposite the early control groove with respect to the axial line of the small diameter hole.

4. The fuel injection pump for an internal combustion engine of claim 1, claim 2 or claim 3, wherein the early control groove is formed as a gutter-like groove.

5. The fuel injection pump for an internal combustion engine of claim 1, claim 2 or claim 3, wherein an end edge of an end portion of the small diameter hole serving as a boundary between the small diameter hole and the large diameter hole is chamfered.

FIG.1

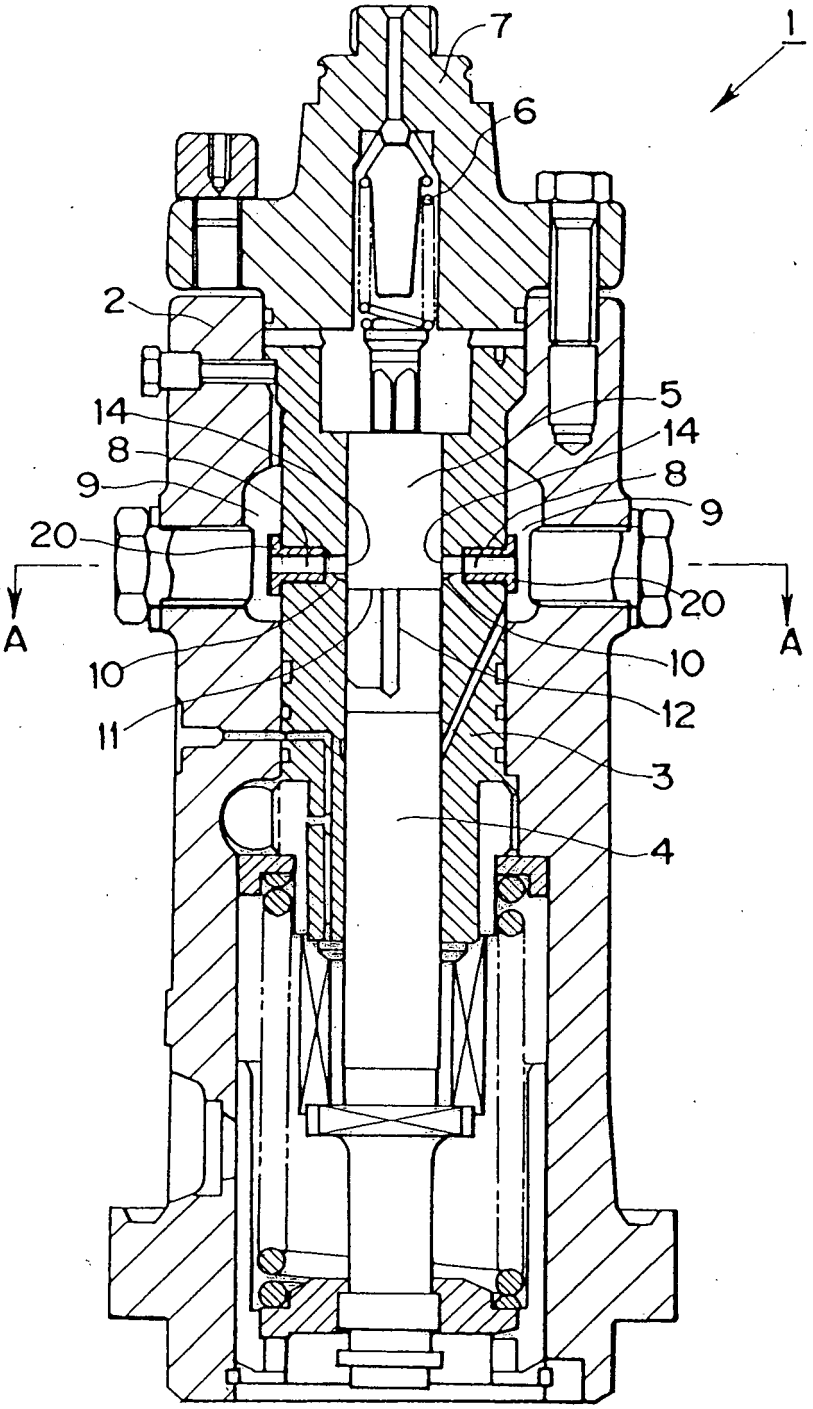


FIG.2

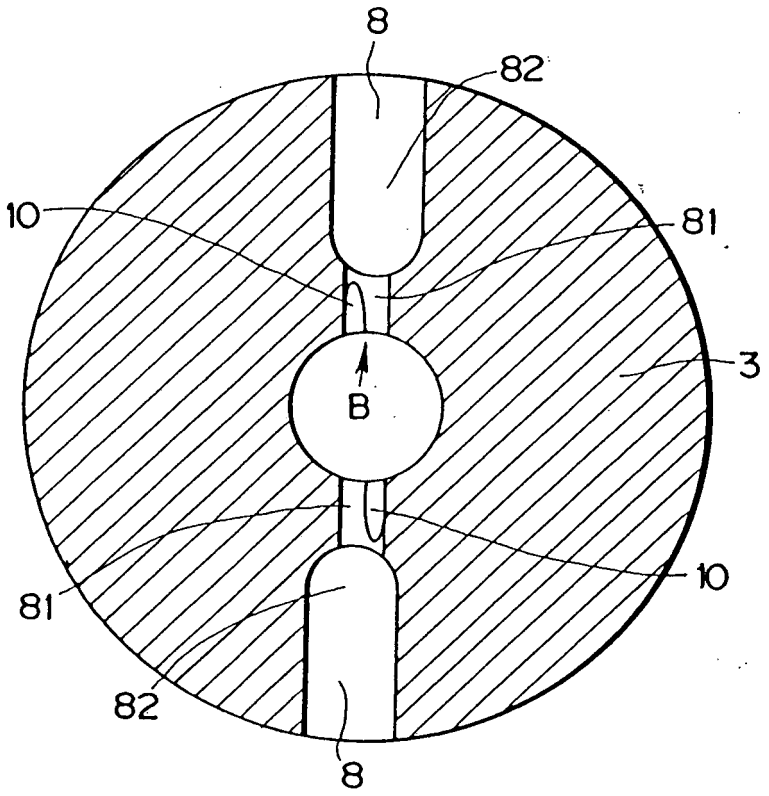


FIG.3

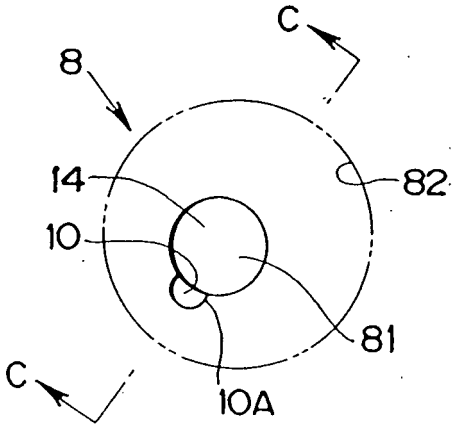
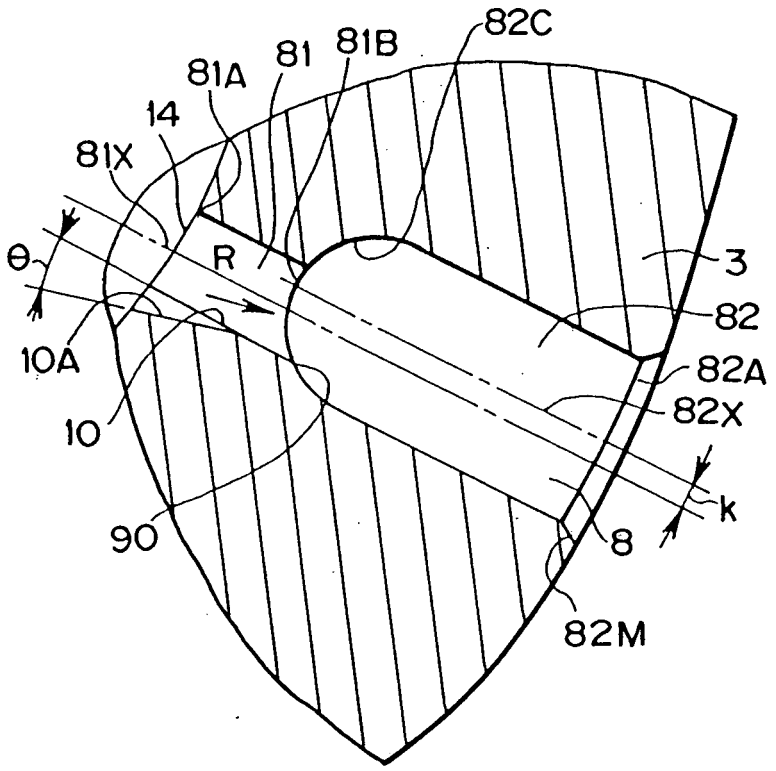


FIG.4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/312936

A. CLASSIFICATION OF SUBJECT MATTER
F02M59/38(2006.01)i, *F02M59/26*(2006.01)i, *F02M59/44*(2006.01)i

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)
F02M59/38, F02M59/26, F02M59/44

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 1996-2006
Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

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.
Y	JP 2974710 B2 (Robert Bosch GmbH.), 10 November, 1999 (10.11.99), Full text; all drawings & GB 2231369 A & DE 003902764 A1	1-5
Y	JP 07-54618 Y2 (Robert Bosch GmbH.), 18 December, 1995 (18.12.95), Full text; Figs. 3, 4 & EP 000372211 A1 & DE 003840022 A1	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
07 August, 2006 (07.08.06)	15 August, 2006 (15.08.06)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 7054618 U **[0003]**