



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 707 786 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
04.10.2006 Bulletin 2006/40

(51) Int Cl.:
F02F 3/00 (2006.01) F02B 25/16 (2006.01)

(21) Application number: **04792479.0**

(86) International application number:
PCT/JP2004/015262

(22) Date of filing: **15.10.2004**

(87) International publication number:
WO 2005/059345 (30.06.2005 Gazette 2005/26)

(84) Designated Contracting States:
DE FR GB

(30) Priority: **16.12.2003 JP 2003417619**

(71) Applicant: **Daihatsu Motor Co., Ltd.**
Ikeda-shi, Osaka 563-0044 (JP)

(72) Inventor: **MORINAGA, Yoshiki,**
c/o DAIHATSU MOTOR CO., LTD.
Ikeda-shi,
Osaka 5630045 (JP)

(74) Representative: **Pluckrose, Anthony William et al**
BOULT WADE TENNANT,
Verulam Gardens
70 Gray's Inn Road
London WC1X 8BT (GB)

(54) **TWO-CYCLE INTERNAL COMBUSTION ENGINE**

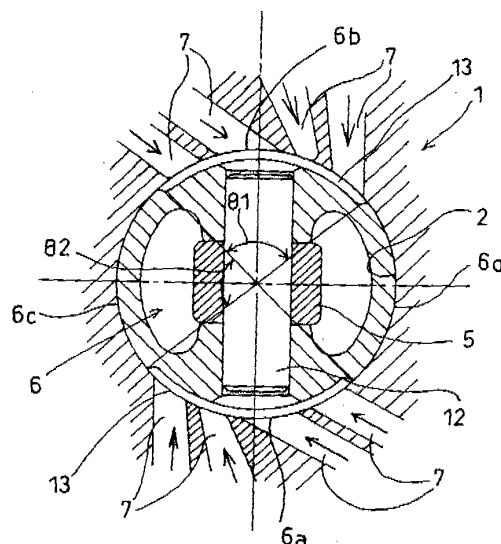
(57) [Problems]

To reduce the consumption of lubricating oil and the wearing in a two-cycle internal combustion engine designed to open or close the opening of a scavenging port 7 to a cylinder 2 or an exhaust port from the cylinder by a piston 6 which reciprocally moves in the cylinder.

[Solving Means]

As viewed in the direction of an axis 2a of the cylinder, the opening of the scavenging port 7 or the discharge port to an inner wall of the cylinder 2 is formed at a portion corresponding to an outer circumferential surface region 6a· 6b, 6b of the piston 6a· 6bt axially opposite ends of a piston pin 12. An oil storage space 13 is defined between the inner wall of the cylinder and the outer circumferential surface region of the piston which corresponds to the opening of the scavenging port or the discharge port so that lubricating oil between the inner wall of the cylinder and an outer circumferential surface region 6c, 6d of the piston on opposite sides of the piston pin 12 across the axis of the piston pin is pushed out into the oil storage space.

FIG. 2



EP 1 707 786 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a two-cycle internal combustion engine.

BACKGROUND ART

[0002] As is conventionally known, typical two-cycle internal combustion engines include a uniflow type in which the scavenging of the cylinder is performed utilizing the scavenging flow from a scavenging port provided at a side surface of the cylinder toward an exhaust port provided at the top of the cylinder, and a loop or transverse flow type in which the scavenging of the cylinder is performed utilizing the scavenging flow which travels from a scavenging port provided at a side surface of the cylinder toward the top of the cylinder and then toward an exhaust port similarly provided at the side surface of the cylinder. In the former type, the scavenging port provided at the side surface of the cylinder opens when the piston comes close to the bottom dead center. In the latter type, both of the scavenging port and the exhaust port provided at the side surface of the cylinder open when the piston comes close to the bottom dead center.

[0003] In these types of two-cycle internal combustion engines, the piston has a cylindrical shape whose outer circumferential surface is free from a recess entirely from the upper end to the lower end. The upper end of the outer circumferential surface of the piston is provided with an upper piston ring which is held in close contact with the inner wall of the cylinder, whereas the lower end of the outer circumferential surface is provided with a lower piston ring which is also held in close contact with the inner wall of the cylinder.

[0004] As disclosed in Patent Document 1, in such conventional two-cycle internal combustion engines, the scavenging port (in the case of the uniflow type) or the scavenging port and the exhaust port (in the case of the loop or transverse flow type) for the cylinder are provided in the inner wall of the cylinder at a portion corresponding to a region of the piston on opposite sides of the piston pin as viewed in the axial direction of the cylinder.

Patent Document 1: JP-U-H05-61440

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] With such a prior-art structure, however, the outer circumferential surface regions of the piston on opposite sides of the piston pin (one of the regions is referred to as a thrust portion, whereas the other one of the regions is referred to as an anti-thrust portion) are strongly pressed with a large thrust force against the portion of the inner wall of the cylinder where the scavenging port or the exhaust port is provided due to the combustion

force in the combustion stroke and the compression force in the compression stroke.

[0006] A considerable amount of lubricating oil scraped away from the inner wall of the cylinder by the upper and the lower piston rings exists on the outer circumferential surface of the piston between the piston rings. Therefore, when the outer circumferential surface regions of the piston on opposite sides of the piston pin are pressed against the inner wall of the cylinder with a large thrust force, part of the lubricating oil is pushed out toward the scavenging port or the exhaust port.

[0007] In this way, in the prior-art structure, a large amount of lubricating oil for the inner wall of the cylinder is pushed toward the scavenging port or the exhaust port.

Therefore, the consumption of the lubricating oil is large, and the lubrication of the inner wall of the cylinder may become insufficient.

[0008] Moreover, in the prior-art two-cycle internal combustion engine, since the outer circumferential surface regions of the piston on opposite sides of the piston pin are pressed with a large thrust force against the portion of the inner wall of the cylinder where the scavenging port or the exhaust port opens, the portion of the inner wall of the cylinder where the scavenging port or the exhaust port is provided and the piston rings are likely to be worn.

[0009] A technical object of the present invention is to provide a two-cycle internal combustion engine which is capable of solving these problems.

Means for Solving the Problems

[0010] To achieve the technical object, according to claim 1 of the present invention, there is provided a two-cycle internal combustion engine comprising a cylinder, and a piston which is reciprocally movable in the cylinder and capable of opening or closing an opening of a scavenging port or a exhaust port into the cylinder. As viewed in the axial direction of the cylinder, the opening of the scavenging port or the discharge port to an inner wall of the cylinder is formed at a portion corresponding to an outer circumferential surface region of the piston at axially opposite ends of a piston pin, and an oil storage space is defined between the inner wall of the cylinder and the outer circumferential surface region of the piston which corresponds to the opening of the scavenging port or the discharge port so that lubricating oil between the inner wall of the cylinder and an outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is pushed out into the oil storage space.

[0011] According to claim 2 of the invention, in the two-cycle internal combustion engine of claim 1, the scavenging port or the discharge port includes a plurality of openings to the inner wall of the cylinder.

[0012] According to claim 3 of the invention, in the two-cycle internal combustion engine of claim 1 or 2, the oil storage space is defined by recessing the outer circum-

ferential surface region of the piston at the axially opposite ends of the piston pin.

[0013] According to claim 4 of the invention, in the two-cycle internal combustion engine of 1 or 2, the outer circumferential surface region of the piston at axially opposite ends of the piston pin is surrounded by two vertical grooves extending axially of the piston, an upper horizontal groove connecting respective upper ends of the vertical grooves to each other, and a lower horizontal groove connecting respective lower ends of the vertical grooves to each other, and the four grooves define the oil storage space.

[0014] According to claim 5 of the invention, in the two-cycle internal combustion engine of claim 3, the oil storage space is so designed as to face the scavenging port or the discharge port even when the piston is positioned at a top dead center.

[0015] According to claim 6 of the invention, in the two-cycle internal combustion engine of claim 4, the oil storage space is so designed as to face the scavenging port or the discharge port even when the piston is positioned at a top dead center.

[0016] According to claim 7 of the invention, in the two-cycle internal combustion engine of any one of claims 1, 2, 5 and 6, the size of the outer circumferential surface region of the piston at axially opposite ends of the piston pin is so set that, as viewed in the axial direction of the cylinder, the central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 120 to 150 degrees, and the size of the outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is so set that, as viewed in the axial direction of the cylinder, the central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 60 to 30 degrees.

[0017] According to claim 8 of the invention, in the two-cycle internal combustion engine of claim 3, the size of the outer circumferential surface region of the piston at axially opposite ends of the piston pin is so set that, as viewed in the axial direction of the cylinder, the central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 120 to 150 degrees, and the size of the outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is so set that, as viewed in the axial direction of the cylinder, the central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 60 to 30 degrees.

[0018] According to claim 9 of the invention, in the two-cycle internal combustion engine of claim 4, the size of the outer circumferential surface region of the piston at axially opposite ends of the piston pin is so set that, as viewed in the axial direction of the cylinder, the central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 120 to 150 degrees, and the size of the outer circumferential surface region of the piston on opposite sides of the piston pin

across the axis of the piston pin is so set that, as viewed in the axial direction of the cylinder, the central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 60 to 30 degrees.

[0019] According to claim 10 of the invention, in the two-cycle internal combustion engine of any one of claims 1, 2, 5, 6, 8 and 9, the engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at the top of the cylinder.

[0020] According to claim 11 of the invention, in the two-cycle internal combustion engine of claim 3, the engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at the top of the cylinder.

[0021] According to claim 12 of the invention, in the two-cycle internal combustion engine of claim 4, the engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at the top of the cylinder.

[0022] According to claim 13 of the invention, in the two-cycle internal combustion engine of claim 7, the engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at the top of the cylinder.

Advantages of the Invention

[0023] In the structure of claim 1, as viewed in the axial direction of the cylinder, the opening of the scavenging port or the exhaust port to the inner wall of the cylinder is formed at a portion corresponding to an outer circumferential surface region of the piston at axially opposite ends of the piston pin. Therefore, the outer circumferential surface regions of the piston on opposite sides of the piston pin across the axis of the piston pin are pressed with a large thrust force against the inner wall of the cylinder at portions where the scavenging port or the discharge port is not formed. In this way, the piston is reliably prevented from being pressed with a large thrust force against the inner wall of the cylinder at the portion where the scavenging port or the discharge port is open. Therefore, it is possible to considerably reduce the wearing of the inner wall of the cylinder at the portion where the scavenging port or the exhaust port is open and the piston rings of the piston.

[0024] In addition to the above arrangement, an oil storage space is defined between the inner wall of the cylinder and the outer circumferential surface region of the piston which corresponds to the opening of the scavenging port or the discharge port so that lubricating oil between the inner wall of the cylinder and an outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is pushed out into the oil storage space. With this arrangement, when the outer circumferential surface regions of the piston on opposite sides of the piston pin across the axis of the piston pin are pressed with a large thrust force against the inner wall of the cylinder, the lubricating oil therebetween is pushed out into the oil storage space and stored in the oil storage space at a reduced pressure.

[0025] Therefore, the lubricating oil is reliably prevented from being pushed toward the scavenging port or the exhaust port due to the strong pressing by the outer circumferential surface regions of the piston on opposite sides of the piston pin across the axis of the piston pin. Therefore, the consumption of the lubricating oil is considerably reduced.

[0026] In claims 2-5, the structure according to claim 1 of the present invention is specified. In the structure of claim 2, the scavenging or exhaust port includes not a single large opening but a plurality of small openings which open at the inner wall of the cylinder. Therefore, the piston ring of the piston is prevented from being caught on the openings, so that the wearing of the piston ring is effectively reduced.

[0027] In the structure of claim 3, the oil storage space is defined by recessing the outer circumferential surface region of the piston at the axially opposite ends of the piston pin. With such a structure, the oil storage space can be provided easily by working the outer circumferential surface of the piston. Further, the existence of the oil storage space reduces the contact area between the inner wall of the cylinder and the outer circumferential surface of the piston, so that the mechanical loss during the reciprocal movement of the piston is advantageously reduced.

[0028] In the structure of claim 4, the outer circumferential surface region of the piston at axially opposite ends of the piston pin is surrounded by two vertical grooves extending axially of the piston, an upper horizontal groove connecting respective upper ends of the vertical grooves to each other, and a lower horizontal groove connecting respective lower ends of the vertical grooves to each other, and the four grooves define the oil storage space. With such a structure, similarly to the structure of claim 2, the oil storage space can be provided easily by working the outer circumferential surface of the piston.

[0029] In the structure of claims 5 and 6, the oil storage space is so designed as to face the scavenging port or the discharge port even when the piston is positioned at a top dead center. With such a structure, the reduction of the consumption of lubricating oil due to the provision of the oil storage space is further promoted.

[0030] In the structure of claims 7-9, the size of the outer circumferential surface region of the piston at axially opposite ends of the piston pin is so set that, as viewed in the axial direction of the cylinder, the central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 120 to 150 degrees. On the other hand, the size of the outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is so set that, as viewed in the axial direction of the cylinder, the central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 60 to 30 degrees. With such a structure, the lubricating oil is reliably prevented from being pushed toward the scavenging port or the exhaust port due to the strong pressing

by the outer circumferential surface regions of the piston on opposite sides of the piston pin across the axis. Therefore, the consumption of the lubricating oil is considerably reduced.

[0031] In the structure of claims 10-13, the two-cycle internal combustion engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at the top of the cylinder. In this instance, since the discharge port is not provided at the inner wall of the cylinder, the consumption of the lubricating oil is small.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

Fig. 1 is a vertical sectional view showing a first embodiment.

Fig. 2 is an enlarged sectional view taken along lines II-II in Fig. 1.

Fig. 3 is a vertical sectional view showing a second embodiment.

Fig. 4 is an enlarged sectional view taken along lines IV-IV in Fig. 3.

Description of Signs

[0033]

- 1 cylinder block
- 2 cylinder
- 2a axis of cylinder
- 3 cylinder head
- 4 crankshaft
- 6 piston
- 6a, 6b outer circumferential surface regions of piston at axially opposite ends of piston pin
- 6c, 6d outer circumferential surface regions of piston on opposite sides of piston pin across axis of piston pin
- 7 scavenging port
- 8 exhaust valve
- 9 exhaust port
- 10, 11 piston ring
- 12 piston pin
- 13 oil storage space

BEST MODE FOR CARRYING OUT THE INVENTION

[0034] Preferred embodiments of the present invention will be described below with reference to the accompanying drawings.

[0035] Figs. 1 and 2 show a first embodiment. In the embodiment shown in Figs. 1 and 2, the invention is applied to a two-cycle internal combustion engine of the uniflow type. In these figures, indicated by reference numeral 1 is a cylinder block including a cylinder 2, and indicated by reference numeral 3 is a cylinder head fastened to the upper surface of the cylinder block 1 so as

to close the top of the cylinder 2. In the cylinder 2 of the cylinder block 1, a piston 6 connected to a crankshaft 4 via a connecting rod 5 is provided to be reciprocally movable in accordance with the movement of the crankshaft.

[0036] The cylinder block 1 is formed with a plurality of scavenging ports 7 for supplying compressed intake air into the cylinder 2. The opening of each of the scavenging ports 7 to the inside of the cylinder 2 opens when the piston 6 moves down to come close to the bottom dead center.

[0037] The cylinder head 3 is formed with an exhaust port 9 provided with an exhaust valve 8 which opens when the piston 6 comes close to the bottom dead center.

[0038] At the upper end of the outer circumferential surface of the piston 6a · 6bt least one upper piston ring 10 is provided in close contact with the inner wall of the cylinder 2. At the lower end of the outer circumferential surface of the piston, at least one lower piston ring 11 is provided also in close contact with the inner wall of the cylinder 2.

[0039] When the piston 6 moves up to the top dead center, the lower piston ring 11 is positioned below the scavenging ports 7. Thus, the lower piston ring 11 prevents each of the scavenging ports 7 from communicating with a crank chamber provided at a lower portion of the cylinder 2.

[0040] As shown in Fig. 2 which is viewed in the direction of the axis 2a of the cylinder 2, the piston 6 is provided with a piston pin 12 (which extends in parallel with the crank shaft 4, as viewed in the direction of the axis 2a of the cylinder 2). The openings of the scavenging ports 7 to the inside of the cylinder 2 are formed in the inner wall of the cylinder 2 at portions corresponding to regions 6a · 6b and 6b of the outer circumferential surface of the piston 6 which are on axially opposite ends of the piston pin 12. That is, the openings are formed at portions which do not correspond to the regions 6c and 6d (thrust portion and anti-thrust portion) of the outer circumferential surface of the piston 6 which are on opposite sides of the piston pin 12 across the axis of the piston pin.

[0041] In this case, the openings of the scavenging ports 7 to the inside of the cylinder 2 are oriented in the tangential direction so that the scavenging air from each of the scavenging ports 7 whirls in the cylinder 2.

[0042] In the first embodiment, the regions 6a · 6b and 6b of the outer circumferential surface of the piston 6 between the upper piston ring 10 and the lower piston ring 11 and on axially opposite ends of the piston pin 12 are partially recessed. Between the recessed surface and the inner wall of the cylinder 2 is defined an oil storage space 13, to which the lubricating oil between the inner wall of the cylinder 2 and each of the regions 6c, 6d of the outer circumferential surface of the piston 6 on opposite sides of the piston pin across the axis thereof is pushed out. In the first embodiment, the opening of each of the scavenging ports 7 faces the oil storage space 13. The oil storage space 13 faces the openings of the scavenging ports even when the piston is positioned at the

top dead center.

[0043] With the above-described structure, the regions 6c, 6d (thrust portion and anti-thrust portion) of the outer circumferential surface of the piston 6, which are on opposite sides of the piston pin 12 across the axis thereof, are pressed with a large thrust force against the inner wall of the cylinder 2 at portions where the scavenging ports 7 are not formed. Therefore, the piston 6 is reliably prevented from being pressed with a large thrust force against of the inner wall of the cylinder 2 the portions where the scavenging ports 7 open.

[0044] Further, when the regions 6c, 6d (thrust portion and anti-thrust portion) of the outer circumferential surface of the piston 6, which are on opposite sides of the piston pin 12 across the axis thereof, are pressed with a large thrust force against the inner wall of the cylinder 2, the lubricating oil therebetween is pushed out toward the oil storage space 13 and stored in the oil storage space 13 at a reduced pressure. Therefore, the lubricating oil is reliably prevented from being pushed into the scavenging ports 7 due to the strong pressing by the regions 6c, 6d (thrust portion and anti-thrust portion) of the outer circumferential surface of the piston 6 on opposite sides of the piston pin 12 across the axis thereof.

[0045] Fig. 3 shows a second embodiment.

[0046] In the second embodiment, the oil storage space 13 is defined by two vertical grooves 13a and 13b extending in the axial direction of the piston 6a · 6bn upper horizontal groove 13c extending along the lower side of the upper piston ring 10 to connect respective upper ends of the two vertical grooves 13a and 13b, and a lower horizontal groove 13d extending along the upper side of the lower piston ring 11 to connect respective lower ends of the two vertical grooves 13a and 13b. With such a structure, the same advantages as those of the first embodiment can be obtained.

[0047] In the forgoing embodiments, the oil storage space is formed by recessing part of the outer circumferential surface of the piston or by forming grooves at the outer circumferential surface of the piston. However, the present invention is not limited to such structures, and the oil storage space between the outer circumferential surface of the piston and the inner wall of the cylinder may be formed by other means.

[0048] Preferably, the size of the regions 6a · 6b and 6b of the outer circumferential surface of the piston 6 on axially opposite ends of the piston pin 12 is so set that, as viewed in the direction of the axis 2a of the cylinder 2, the central angle $\theta 1$ of a sector defined by connecting each of the regions 6a · 6b, 6b and the axis 2a of the cylinder 2 lies in the range of 120 to 150 degrees. Preferably, the size of the regions 6c and 6d of the outer circumferential surface of the piston 6 on opposite sides of the piston pin 12 is so set that, as viewed in the direction of the axis 2a of the cylinder 2, the central angle $\theta 2$ of a sector defined by connecting each of the regions 6c, 6d and the axis 2a of the cylinder 2 lies in the range of 60 to 30 degrees.

[0049] The present invention is not limited to a two-cycle internal combustion engine of the uniflow type and also applicable to an internal combustion engine of the loop or transverse flow type which does not include an exhaust port provided with an exhaust valve on top of the cylinder but includes a scavenging port and a exhaust port arranged to face each other.

[0050] In the two-cycle internal combustion engine of the transverse flow type, the scavenging port and the exhaust port are formed in the inner wall of the cylinder at portions corresponding to axially opposite ends of the piston pin of the piston, respectively, as viewed in the axial direction of the cylinder. Further, in this case, the oil storage space is provided at both of the outer circumferential portions of the piston which correspond to the axially opposite ends of the piston pin.

Claims

1. A two-cycle internal combustion engine comprising a cylinder, and a piston which is reciprocally movable in the cylinder and capable of opening or closing an opening of a scavenging port or an exhaust port into the cylinder,
wherein, as viewed in an axial direction of the cylinder, the opening of the scavenging port or the discharge port to an inner wall of the cylinder is formed at a portion corresponding to an outer circumferential surface region of the piston at axially opposite ends of a piston pin, and wherein an oil storage space is defined between the inner wall of the cylinder and the outer circumferential surface region of the piston which corresponds to the opening of the scavenging port or the discharge port so that lubricating oil between the inner wall of the cylinder and an outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is pushed out into the oil storage space.
2. The two-cycle internal combustion engine according to claim 1, wherein the scavenging port or the discharge port includes a plurality of openings to the inner wall of the cylinder.
3. The two-cycle internal combustion engine according to claim 1 or 2, wherein the oil storage space is defined by recessing the outer circumferential surface region of the piston at the axially opposite ends of the piston pin.
4. The two-cycle internal combustion engine according to claim 1 or 2, wherein the outer circumferential surface region of the piston at axially opposite ends of the piston pin is surrounded by two vertical grooves extending axially of the piston, an upper horizontal groove connecting respective upper ends of the vertical grooves to each other, and a lower horizontal

groove connecting respective lower ends of the vertical grooves to each other, the four grooves defining the oil storage space.

5. The two-cycle internal combustion engine according to claim 3, wherein the oil storage space is so designed as to face the scavenging port or the discharge port even when the piston is positioned at a top dead center.
6. The two-cycle internal combustion engine according to claim 4, wherein the oil storage space is so designed as to face the scavenging port or the discharge port even when the piston is positioned at a top dead center.
7. The two-cycle internal combustion engine according to any one of claims 1, 2, 5 and 6, wherein size of the outer circumferential surface region of the piston at axially opposite ends of the piston pin is so set that, as viewed in the axial direction of the cylinder, a central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 120 to 150 degrees; and
wherein size of the outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is so set that, as viewed in the axial direction of the cylinder, a central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 60 to 30 degrees.
8. The two-cycle internal combustion engine according to claim 3, wherein size of the outer circumferential surface region of the piston at axially opposite ends of the piston pin is so set that, as viewed in the axial direction of the cylinder, a central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 120 to 150 degrees; and
wherein size of the outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is so set that, as viewed in the axial direction of the cylinder, a central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 60 to 30 degrees.
9. The two-cycle internal combustion engine according to claim 4, wherein size of the outer circumferential surface region of the piston at axially opposite ends of the piston pin is so set that, as viewed in the axial direction of the cylinder, a central angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 120 to 150 degrees; and
wherein size of the outer circumferential surface region of the piston on opposite sides of the piston pin across the axis of the piston pin is so set that, as viewed in the axial direction of the cylinder, a central

angle of a sector defined by connecting the region and the axis of the cylinder lies in the range of 60 to 30 degrees.

10. The two-cycle internal combustion engine according to any one of claims 1, 2, 5, 6, 8 and 9, wherein the engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at a top of the cylinder.
11. The two-cycle internal combustion engine according to claim 3, wherein the engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at a top of the cylinder.
12. The two-cycle internal combustion engine according to claim 4, wherein the engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at a top of the cylinder.
13. The two-cycle internal combustion engine according to claim 7, wherein the engine is a two-cycle diesel engine in which the exhaust port from the cylinder is provided at a top of the cylinder.

5

10

15

20

25

30

35

40

45

50

55

FIG. 1

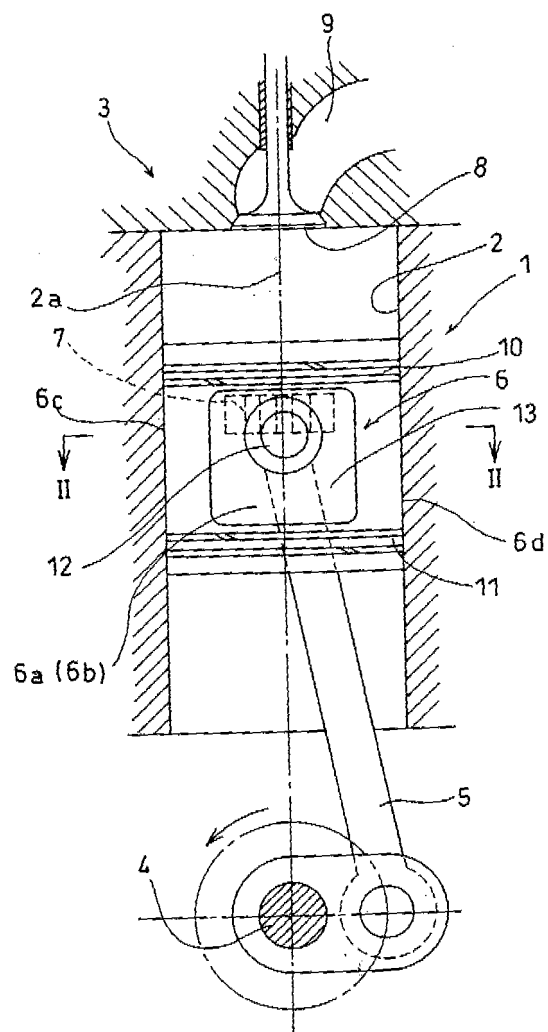


FIG. 2

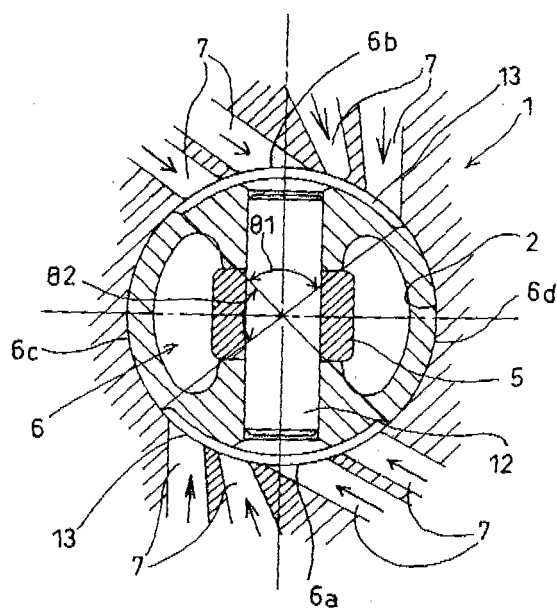


FIG. 3

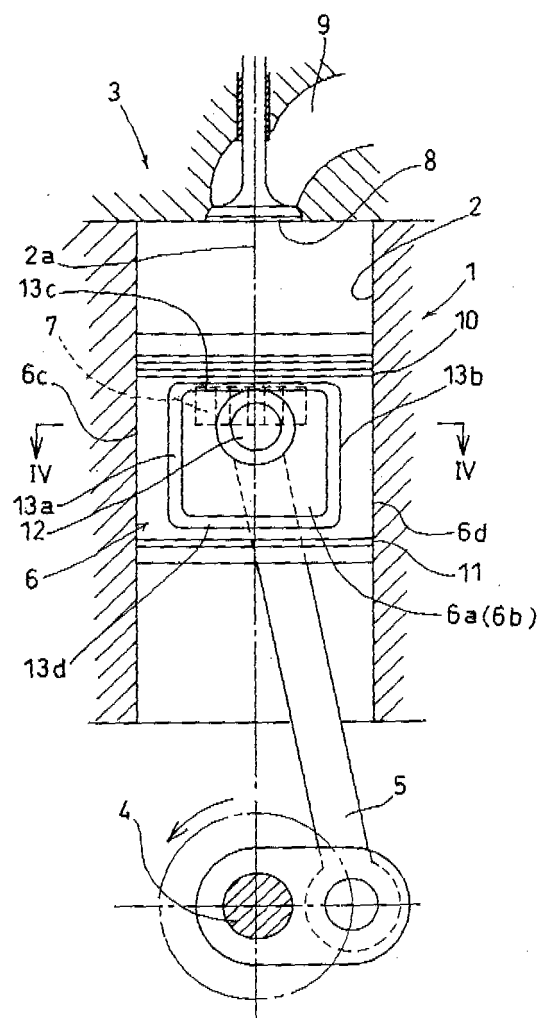
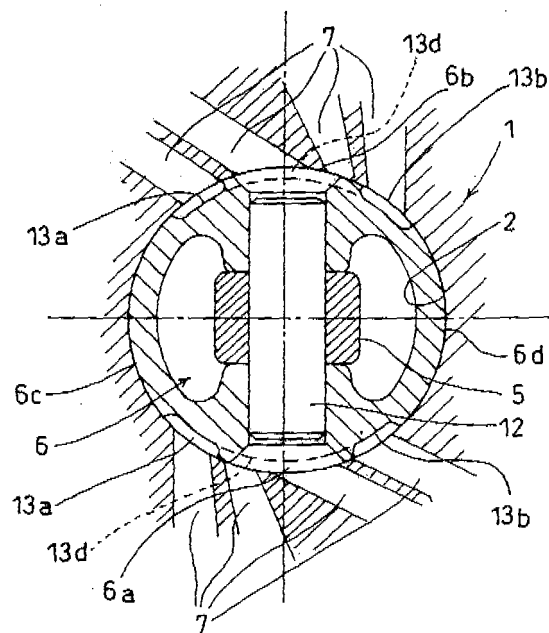


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2004/015262

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ F02F3/00, F02B25/16		
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 F02F3/00-3/28, F02B25/00-25/28, F01M1/00-9/12		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2005 Kokai Jitsuyo Shinan Koho 1971-2005 Jitsuyo Shinan Toroku Koho 1996-2005		
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.
X Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 100311/1982 (Laid-open No. 6940/1984) (Suzuki Motor Co., Ltd.), 17 January, 1983 (17.01.83), Figs. 1 to 5 (Family: none)	1-3, 5 10, 11 4, 6-9, 12, 13
X Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 11318/1991 (Laid-open No. 109252/1992) (Mitsubishi Heavy Industries, Ltd.), 22 September, 1992 (22.09.92), Full text; Figs. 1 to 14 (Family: none)	1-3, 5 10, 11 4, 6-9, 12, 13
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* 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 application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(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 "&" document member of the same patent family		
Date of the actual completion of the international search 11 January, 2005 (11.01.05)		Date of mailing of the international search report 25 January, 2005 (25.01.05)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (January 2004)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP H0561440 U [0004]