



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.05.2007 Bulletin 2007/21

(51) Int Cl.:
F02B 25/06 (2006.01)

(21) Application number: **06124274.9**

(22) Date of filing: **17.11.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **18.11.2005 JP 2005333970**

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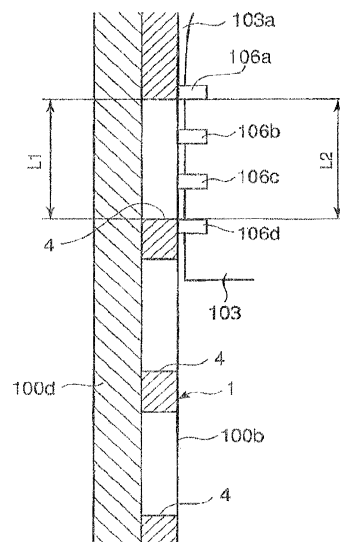
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(54) **Internal combustion engine having scavenging control valve**

(57) The invention aims to provide an internal combustion engine equipped with a scavenging control valve, in which blow-by of combustion gas from the upper annular space above the top piston ring to the scavenging ports is prevented by which reduction in engine performance due to deposition of combustion gas residuum to the scavenge openings and occurrence of piston ring sticking due to deposition of combustion gas residuum to the piston rings can be prevented, and further the amount of working oil to drive the scavenging control valve can be reduced resulting in decreased energy loss for pressurizing the working oil. An annular-shaped scavenging control valve is fitted-in to a fitting face formed on the inner side of the cylinder liner movably in circumferential direction of the cylinder liner for opening and closing said scavenging ports in order to allow scavenge air to be supplied into the cylinder or interrupted, said scavenging control valve has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof, and the scavenge openings of each

stage has a height L_1 which is smaller than a inside distance L_2 between a top piston ring and a bottom piston ring equipped to a piston of the engine as shown in FIG.3.

FIG.3



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention is applied to a large size two-cycle engine having a plurality of scavenging ports arranged in the lower part of the cylinder liner along circumferential direction of the cylinder liner for introducing scavenge air into the cylinder, and relates to an internal combustion engine equipped with a scavenging control valve device which controls scavenging port opening and closing so that scavenge air is supplied into the cylinder when the scavenging control valve is rotated to a position at which scavenge openings of the scavenge control valve communicate to the scavenging ports of the cylinder liner and supply of scavenge air is interrupted when the scavenging control valve is rotated to a position at which the scavenge openings of the scavenge control valve shut the scavenging ports of the cylinder liner.

2. Description of the Related Art

[0002] Generally, large size two-cycle engines adopt uniflow scavenging method, in which scavenging ports are arranged in the lower part of the cylinder liner along circumferential direction thereof, air is introduced into the cylinder when the scavenging ports are opened by the top edge of the piston traveling downward toward the bottom dead center, and the introduced air pushes out combustion gas in the cylinder through exhaust valves provided in the cylinder head.

[0003] In Japanese Laid-Open Patent Application No. 2004-340120 (hereafter referred to as patent literature 1) is disclosed a large size two-cycle diesel engine of uniflow scavenging type, in which an annular-shaped scavenging control valve is fitted-in to either the inner side or outer side of the cylinder liner movably in circumferential direction of the cylinder liner for opening and closing the scavenging ports of the cylinder liner in order to allow scavenge air to be supplied into the cylinder or interrupted.

[0004] In the diesel engine equipped with a scavenging control valve disclosed in the patent literature 1, an annular-shaped scavenging control valve is fitted-in to a fitting face formed in the inner side of the cylinder liner rotatably in circumferential direction, the cylinder liner having a plurality of scavenging ports arranged along circumferential direction thereof for introducing scavenge air into the cylinder, the scavenging control valve having a plurality of scavenge openings arranged along circumferential direction thereof, and the scavenging control valve is moved in circumferential direction of the cylinder liner by means of a scavenging control valve drive device to which supply and drain of working oil is switched by means of an electromagnetic valve, whereby the scavenge openings of the scavenging control valve are

brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction of the cylinder liner to allow scavenge air to be supplied into the cylinder or interrupt.

[0005] However, there are problems to be solved in the conventional art disclosed in the patent literature 1 as mentioned in the following.

[0006] FIG.10 is a partial sectional view of a part near a scavenging port along the cylinder center line of a diesel engine equipped with a conventional scavenging control valve.

[0007] In the drawing, reference numeral 100 is a cylinder liner having scavenging ports not shown in the drawing, 1 is a scavenging control valve having a scavenge opening 4, 103 is a piston, 106 are a plurality of piston rings (four rings in this example) equipped to the piston 103.

[0008] In the diesel engine equipped with a scavenging control valve, scavenging ports of the cylinder liner(not shown in the drawing) and scavenge openings 4 of the scavenging control valve are arranged in one stage respectively, and the height of the scavenge opening 4 is large in order to secure large area of scavenge openings. As a result, the height of the scavenge opening 4 is larger than the distance from the top piston ring to the bottom piston ring.

[0009] Therefore, when the piston 103 moves down and the top piston ring begins to open the scavenge opening 4, combustion gas blows through the upper annular space 103a above the top piston ring and through the scavenge opening 4 to the skirt part of the piston as shown by an arrow T in FIG.10, which causes reduction in engine performance and occurrence of piston ring sticking due to deposition of combustion gas residuum on the piston rings.

[0010] Further, the scavenging control valve 1 is moved in circumferential direction thereof by means of a scavenging control valve drive device to which supply and draining of working oil are switched by an electromagnetic valve so that the scavenge openings of the scavenging control valve are brought into communication or discommunication with the scavenging ports of the cylinder liner, so there is a problem that the amount of working oil used for driving the scavenging control valve drive device is fairly large and energy loss for pressurizing the working oil increases.

[0011] In Journal of Japan institute of marine engine, vol. 31, No. 1, jan. 1996 is disclosed an art to control opening and closing timing of the start valve, fuel valve, inlet valve and exhaust valve. However, this document does not teach a plurality of scavenging ports arranged along circumferential direction and in a plurality of stages in axial direction.

[0012] In Japanese Laid-open Utility Model Application No. 59-56310 is disclosed a scavenging control valve which is fitted on the out side periphery of the cylinder liner and opening and closing of the scavenging ports of

the cylinder liner is controlled by moving the scavenging control valve in axial direction of the cylinder liner.

SUMMARY OF THE INVENTION

[0013] The present invention was made on light of problems mentioned above, an the object of the invention is to provide an internal combustion engine equipped with a scavenging control valve, in which blow-by of combustion gas from the upper annular space above the top piston ring to the scavenge openings of the scavenging control valve is prevented, by which reduction in engine performance due to deposition of combustion gas residuum to the scavenge openings and occurrence of piston ring sticking due to deposition of combustion gas residuum on the piston rings, and further the amount of working oil to drive the scavenging control valve can be reduced resulting in decreased energy loss for pressurizing the working oil.

[0014] To attain the object, the present invention proposes an internal combustion engine equipped with a scavenging control valve, the engine having a plurality of scavenging ports arranged along circumferential direction of its cylinder liner in its lower part for introducing scavenge air into the cylinder, wherein an annular-shaped scavenging control valve is fitted-in to a fitting face formed on either the inner side or outer side of the cylinder liner movably in circumferential direction of the cylinder liner for opening and closing said scavenging ports in order to allow scavenge air to be supplied into the cylinder or interrupted, said scavenging control valve has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof, and the scavenge openings of each stage has a height of L1 which is smaller than a inside distance L2 between a top piston ring and a bottom piston ring equipped to a piston of the engine, i.e. $L1 < L2$.

[0015] In the invention, it is preferable that said scavenging control valve has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof, and height H1 of scavenge openings belonging to the uppermost stage of a plurality of the stages is higher than height H2 of scavenge openings belonging to lower stages below the uppermost stage, i.e. $H1 < H2$.

The invention is characterized in that, in the internal combustion engine, an annular-shaped scavenging control valve which is fitted-in to a fitting face formed on the inner side of the cylinder liner movably in circumferential direction of the cylinder liner, and which has a plurality of scav-

enge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof for opening and closing said scavenging ports in order to allow scavenge air to be supplied into the cylinder or interrupted; and a hydraulic drive means which is provided in the cylinder liner and in the upper part of the scavenging control valve for allowing the scavenging control valve to move in circumferential direction thereof, are provided.

[0016] It is preferable in the internal combustion engine that an annular-shaped scavenging control valve which is fitted-in to a fitting face formed on either the inner side or outer side of the cylinder liner movably in circumferential direction of the cylinder liner, and which has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof for opening and closing said scavenging ports in order to allow scavenge air to be supplied into the cylinder or interrupted; and a hydraulic drive means which is provided in the cylinder liner and in the upper part of the scavenging control valve for allowing the scavenging control valve to move in circumferential direction thereof, are provided; and wherein said hydraulic drive means consists of drive side actuators and return side actuators, to which working oil is supplied and drained by switching an electromagnetic valve, provided along the outer circumference of the scavenging control valve; whereby the scavenging control valve is moved in drive direction and return direction by supplying working oil to and draining from the drive side actuators and return side actuators, and further the actuators are composed as follows:

(1) The drive side actuators for moving the scavenging control valve in drive direction have actuating area larger than that of the return side actuators for moving the scavenging control valve in return direction.

(2) Pressure of working oil supplied to the drive side actuators for moving the scavenging control valve in drive direction is higher than that of working oil supplied to the return side actuator for moving the scavenging control valve in return direction.

[0017] Further, in the invention, it is preferable that;

(1) a means for keeping the scavenging ports open is provided which allows working oil to be supplied to a working oil passage connecting the electromagnetic valve to the drive side actuator so that the scavenging control valve is retained in a position at which the scavenge openings of the scavenging control

valve are communicating to the scavenging ports of the cylinder liner when malfunction occurs in the electromagnetic valve, and

(2) springs are provided instead of the return side actuators for exerting spring force so that the scavenging control valve is retained in a position at which the scavenge openings of the scavenging control valve are communicating to the scavenging ports of the cylinder liner when malfunction occurs in the electromagnetic valve.

[0018] According to the invention, by arranging the scavenge openings of the scavenging control valve in a plurality of stage in axial direction thereof and securing large area for scavenge air passage and making the height H1 of the scavenge openings of each stage to be smaller than the inside distance L1 between the top piston ring and bottom piston ring ($L1 < L2$), some one of a plurality of the piston rings contacts the inner surface of the scavenging control valve all through the circumference thereof in the bridge part between scavenge openings of adjacent stages to make gas seal between scavenge openings of adjacent stages when the piston moves down and piston rings pass by the scavenge openings. Therefore, blow-by of combustion gas from the upper annular space above the top piston ring between the outer periphery of the piston top land and the inner periphery of the scavenging control valve towards the piston skirt can be prevented.

[0019] Therefore, according to the invention, blow-by of combustion gas through the annular space above the top piston ring and through the scavenge openings to the piston skirt is prevented and as a result occurrence of piston ring sticking due to deposition of combustion gas residuum can be prevented, while maintaining high scavenging efficiency by securing large scavenge air passage area by arranging the scavenge openings in a plurality of stages in axial direction to obtain good engine performance.

[0020] Further, when the piston travels downwards and the top piston ring begins to open the scavenge openings of the scavenging control valve in a state the scavenging ports of the cylinder liner are not communicated to the scavenge openings of the scavenging control valve, the uppermost scavenge opening parts are exposed to cylinder pressure relatively higher than that exerting on the scavenge opening parts existing below the uppermost scavenge opening parts, and combustion gas leaks a little to the lower scavenge openings. According to the invention, by determining the height H1 of the uppermost scavenge openings to be smaller than the height H2 of the scavenge openings 4b of the lower stages ($H1 < H2$), leakage of combustion gas from the uppermost scavenge openings can be reduced.

[0021] According to the invention, the lower end of the thin wall part where the scavenge openings are formed of the scavenging control valve can be made to be a free end by providing the hydraulic drive means in the upper

part of the scavenging control valve, downward force exerting on the scavenging control valve by downward travel of the piston does not work as compressing force to the scavenging control valve, thus, buckling deformation of the thinner cylindrical part of the scavenging control valve is prevented.

[0022] It is necessary to increase engine performance that opening speed of the scavenging control valve to open the scavenging ports of the cylinder liner is increased, i.e. the speed of increasing the area communicating the scavenging ports of the external liner part to the scavenge openings of the scavenging control valve is increased in order to attain good scavenging by fresh air, but closing speed of the scavenging control valve is not so influential to engine performance.

[0023] The amount of working oil used to rotate the scavenging control valve is a product of the pressure receiving area of the actuator multiplied by the stroke (circumferential stroke), and power required to supply working oil is a product of working oil pressure multiplied by the amount of working oil, so the smaller the pressure receiving area of the actuator is and lower the working oil pressure supplied to the actuator is, the lesser the power to supply working oil to the actuator is.

[0024] In the invention, the actuating area (pressure receiving area) of the drive side actuator 3a for moving the scavenging control valve in valve opening direction (drive direction) is made larger than the actuating area (pressure receiving area) of the drive side actuator for moving the scavenging control valve in valve closing direction (return direction), so target performance of the engine is attained by increasing opening speed of the scavenging ports by increased pressure receiving area of the drive side actuator, whereas the amount of working oil and power to supply working oil to the return side actuator is decreased by decreased pressure receiving area of the drive side actuator 3b. By this, overall efficiency of the engine can be increased.

[0025] Further, the amount of energy needed to drive the scavenging control valve is a product of the amount multiplied by the pressure of the working oil supplied to the actuator, so the lower the working oil pressure is, the smaller the power required for supplying working oil is.

[0026] In the third embodiment, the pressure of the working oil supplied to the drive side actuator is made higher than that supplied to the return side actuator, so target performance of the engine is attained by increasing opening speed of the scavenging ports by increased pressure of working oil supplied to the drive side actuator, whereas power to supply working oil to the return side actuator is decreased by decreased pressure of working oil supplied to the return side actuator. By this, overall efficiency of the engine can be increased.

[0027] According to the invention, by providing a means for keeping the scavenging ports open, working oil is allowed to be supplied to a working oil passage connecting the electromagnetic valve to the drive side actuator so that the scavenging control valve is retained

in a position at which the scavenge openings of the scavenging control valve are communicating to the scavenging ports of the cylinder liner when malfunction occurs in the electromagnetic valve, or by providing springs instead of the return side actuators for exerting spring force so that the scavenging control valve is retained in a position at which the scavenge openings of the scavenging control valve are communicating to the scavenging ports of the cylinder liner when malfunction occurs in the electromagnetic valve when malfunction occurs in the electromagnetic valve, even when malfunction occurs in the electromagnetic valve, the scavenging ports of the cylinder liner are communicated to the scavenge openings of the scavenging control valve, and operation of the engine can be continued without being influenced by the malfunction of the electromagnetic valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

FIG.1 is a sectional view along the cylinder center line of a large size two-cycle engine of the first-sixth embodiments of the present invention showing scavenging ports of the cylinder liner and scavenge openings of the scavenging control valve.

FIG.2 is a sectional view along line B-B in FIG. 1.

FIG.3 is a partial sectional view along the center line near the scavenge openings of the scavenging control valve of the first embodiment of the invention.

FIG. 4 is a partial sectional view as in FIG.3 of the first embodiment for explaining process of controlling opening and closing of scavenging ports of the cylinder liner.

FIG.5A is a partial sectional view of the second embodiment of the invention along line B-B in FIG.1, and FIG.5B is a sectional view along line C-C in FIG. 5A.

FIG.6 is a sectional view of the third embodiment of the invention along line A-A in FIG.1.

FIG.7A is an enlarged detail in part of FIG.6 showing the third embodiment.

FIG.7B is an enlarged detail of another embodiment of the third embodiment showing the construction of actuating part to rotate the scavenging control valve.

FIG.8 is a partial sectional view of the forth embodiment of the invention along line A-A in FIG.1.

FIG.9 is a partial sectional view of the fifth embodiment of the invention along line A-A in FIG. 1.

FIG.10 is a partial sectional view of a part near a scavenging port along the cylinder center line of a diesel engine equipped with a conventional scavenging control valve.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0029] Preferred embodiments of the present inven-

tion will now be detailed with reference to the accompanying drawings. It is intended, however, that unless particularly specified, dimensions, materials, relative positions and so forth of the constituent parts in the embodiments shall be interpreted as illustrative only not as limitative of the scope of the present invention.

[0030] FIG.1 is a sectional view along the cylinder center line of a large size two-cycle engine of the first-sixth embodiments of the present invention showing scavenging ports of the cylinder liner and scavenge openings of the scavenging control valve, and FIG.2 is a sectional view along line B-B in FIG.1.

[0031] In FIG.1 and 2, reference numeral 100 is a cylinder liner consisting of an upper liner part 100c and an external liner part 100d, 103 is a piston having piston rings 106 and reciprocating inside the upper liner part 100c and inside a scavenging control valve 1 mentioned later. Reference numeral 105 is a scavenge air chamber.

[0032] Reference numeral 101 indicates a plurality of scavenge ports which are located in the lower part of the cylinder liner 100 at equal spacing along circumferential direction thereof. The scavenge ports 101 are slanted radially in FIG.2, these ports are not limited to be formed radially slanted.

[0033] Reference numeral 1 is an annular-shaped scavenging control valve made of wear-resistant material for controlling opening and closing of the scavenging ports 101. The scavenging control valve 1 is received in the external liner part 100d so that it is fitted rotatably in the inner surface 100a of the external liner part 100d.

[0034] The inner surface 100b of the scavenging control valve 1 is a surface along which the piston rings 106 of the piston slide.

[0035] Scavenge openings 4 of the scavenging control valve 1 are provided to the scavenging control valve 1 along circumferential direction thereof as shown in FIG. 2, the Scavenge openings 4 being the same in number as that of the scavenging ports 101 of the external cylinder liner part 100d.

[0036] The scavenge openings 4 will be positioned as shown in FIG.2 to close the scavenging ports 101 fully at full closed position thereof, and positioned to coincide with the scavenging ports 101 of the external liner part 100d at full admission position thereof.

[0037] The present invention relates to improving the scavenging control valve constructed as mentioned above and relevant parts.

[The first embodiment]

[0038] FIG.3 is a partial sectional view along the center line near the scavenge opening of the scavenging control valve of the first embodiment of the invention, and FIG. 4 is a partial sectional view as in FIG.3 of the first embodiment for explaining process of controlling opening and closing of scavenging ports.

[0039] In the first embodiment, the scavenge openings 4 arranged along the circumferential direction of the scav-

enging control valve 1 are provided in a plurality of stages (three stages in this example) along axial direction. The height L1 of the scavenge openings 4 of each stage is smaller than the inside distance L2 between the top piston ring 106a and bottom piston ring 106d, i.e. $L1 < L2$. Reference numerals 106b and 106c are the second and third piston ring respectively.

[0040] Therefore, in the first embodiment, when the piston 103 travels downwards as shown by arrow S in (1) of FIG.4, the upper edge of the bottom piston ring 106d is above the lower end of the first scavenge opening 4 at the time the lower edge of the piston ring 106a has come to the upper end of the first stage scavenge opening 4, and an upper annular space 103a above the top piston ring (annular space between the inner surface of the scavenging control valve 1 and the outer surface of the piston 103 above the upper end face of the top piston ring 106a) is not communicated to the lower part (skirt part) of the piston 103 and the scavenge air chamber 105.

[0041] Communication of the upper annular space 103a above the top piston ring to the skirt part of the piston 103 and scavenge air chamber 105 is always shut at any position of the piston 103 when it travels downwards.

[0042] According to the first embodiment, by arranging the scavenge openings 4 of the scavenging control valve 1 in a plurality of stages (three stages in this example) in axial direction and determining the height L1 of the scavenge openings of each stage to be smaller than the inside distance L2 between the top piston ring 106a and bottom piston ring 106d, i.e. $L1 < L2$, the combustion gas in the cylinder above the piston 103 can be prevented from blowing through the upper annular space 103a above the top piston ring and through the scavenge openings 4 to the skirt part of the piston and scavenge air chamber 105, while securing large area for scavenge air passage, for scavenge ports of adjacent stages are sealed each other by some of the piston rings 106 always irrespective of the position of the piston 103.

[0043] Herewith, blow-by of combustion gas from the upper annular space 103a above the top piston ring through the scavenge openings 4 to the skirt part of the piston 103 and occurrence of sticking of piston rings 106 (106a-106d) due to deposition of combustion gas residuum on the piston rings can be prevented, while securing large scavenge air passage area by arranging the scavenge openings 4 in a plurality of stages in axial direction for maintaining high scavenging efficiency to obtain good engine performance.

[Second embodiment]

[0044] FIG.5A is a partial sectional view of the second embodiment of the invention along line B-B in FIG.1, and FIG.5B is a sectional view along line C-C in FIG.5A.

[0045] In the second embodiment, among a plurality of scavenge openings 4a, 4b, height H1 of uppermost scavenge openings 4a is smaller than height H2 of the

other scavenge openings 4b of stages below the uppermost stage of scavenge openings 4a, i.e. $H1 < H2$. In the drawings, reference numeral 103 is a piston, and 200 is the center of the cylinder.

[0046] According to the second embodiment, by determining the height H1 of the uppermost scavenge openings 4a to be smaller than the height H2 of the scavenge openings 4b of the lower stages, leakage of combustion gas through the clearance between the inner surface of the external liner part 100d and the outer surface of the scavenging control valve 1 can be reduced when the piston 103 travels downwards and the scavenge openings 4a begin to be opened by the top piston ring 106a.

[Third embodiment]

[0047] FIG.6 is a sectional view of the third embodiment of the invention along line A-A in FIG.1, and FIG. 7A is an enlarged detail in part of FIG.6 showing the third embodiment.

[0048] In FIG. 6 and FIG. 7A, a pressure chamber which functions as a drive side actuator 3a and a pressure chamber which acts as a return side actuator 3b are provided respectively in each space 100b2 formed between adjacent arcuate parts of three arcuate parts protruding from and extending along the outer periphery of the scavenging control valve 1, in other words, at the both end sides of each arcuate part 100b1 at spacing of 60° . The scavenging control valve 1 can be rotated in both directions by allowing working oil to be introduced through drive side entrance/exit openings 100e and discharged through return side entrance/exit openings 100f to and from the pressure chambers by means of electromagnetic valves.

[0049] To be more specific, the drive side entrance/exit opening 100e is opening into the pressure chamber which functions as the drive side actuator 3b provided at the drive side end of the arcuate parts 100b1 and the return side entrance/exit openings 100f is opening into the pressure chamber which functions as the return side actuator 3b provided at the return side end of the arcuate parts 100b1, the openings 100e and 100f are connected to an electromagnetic valve respectively not shown in the drawings, and working oil is introduced or discharged to or from the driving side actuator 3a and return side actuator 3b by switching the electromagnetic valves.

[0050] When working oil is supplied to the actuator 3a through the drive side entrance/exit openings 100e, the scavenging control valve 1 is rotated in the direction indicated by an arrow M and the scavenge openings 4 are communicated to the scavenging ports 101 of the cylinder liner 100d, that is, the scavenging control valve 1 opens the scavenging ports 101. On the other hand, when working oil is supplied to the actuator 3b through the return side entrance/exit openings 100f, the scavenging ports 101 of the cylinder liner 100d are shut by the scavenging control valve 1, that is, the scavenging control valve 1 closes the scavenging ports 101. The end

parts of the drive side actuator 3a and return side actuator 3b are formed to have stepped parts so that pressure receiving area of the actuators can be changed.

[0051] FIG.7B is an enlarged detail of another embodiment of the third embodiment showing the construction of actuating part to rotate the scavenging control valve.

[0052] In the drawing, a pressure chamber which functions as a drive side actuator 3a is formed between a protrusion 100c1 of the cylinder liner 100d protruding from the inner periphery of the cylinder liner 100d and the drive side end of an arcuate part 100b1 protruding from and extending along the outer periphery of the scavenging control valve 1, and a pressure chamber which functions as a return side actuator 3b is formed between a protrusion 100c2 of the cylinder liner 100d protruding from the inner periphery of the cylinder liner 100d and the return side end of the arcuate part 100b1. A plurality of drive side actuators and corresponding return side actuators may be provided. The inside diameter D1 of the protrusion 100c1 is larger than the inside diameter D2 of the protrusion 100c2. The scavenging control valve 1 is rotated in both directions by introducing working oil to the pressure chamber of the drive side actuator 3a and that of the return side actuator 3b respectively. When the scavenging control valve rotates, it slides on the inside diametral surface of the protrusion 100c1 in the drive side and slides on the inside diametral surface of the protrusion 100c2 in the return side. In FIG.7B, rotation position of the scavenging control valve 1 when it has opened the scavenging ports 101 is shown by solid line and when it has closed the scavenging ports 101 is shown by chain line. Working oil leaked through the sliding faces of the scavenging control valve 1 and the inside diametral surfaces of the protrusion 100c1 and 100c2 to the spaces 100b2 is exhausted through leak holes 100g. When the scavenging control valve 1 opens fully the scavenging ports 101, the drive side end 100b1d of the arcuate part 100b1 comes to close contact with the right side end of the protrusion 100c1, and when the scavenging control valve 1 closes fully the scavenging ports 101, the return side end 100b1r of the arcuate part 100b1 comes to close contact with the left side end of the protrusion 100c2, so the drive side end 100b1d and return side end 100b1r are recessed in their outer periphery so that working oil can be introduced to the drive side actuator 3a and return side actuator 3b even when the scavenging control valve 1 fully opened and fully closed.

[0053] As the inside diameter D1 is larger than the inside diameter D2, pressure receiving area A1 of the drive side actuator 3a is larger than the pressure receiving area A2 of the return side actuator 3b.

[0054] When working oil is supplied by controlling the electromagnetic valves to the drive side actuator 3a through the drive side entrance/exit opening 100e and at the same time working oil in the return side actuator 3b is drained through the return side entrance/exit opening 100f, the scavenging control valve 1 is rotated by the drive side actuator 3a in the direction indicated by arrow

M in the drawings, and the scavenge openings 4 are communicated to the scavenging ports 101 (see FIG. 1) of the external liner part 100d, that is, the scavenging control valve 1 opens the scavenging ports.

[0055] When working oil is supplied by controlling the electromagnetic valves to the return side actuator 3b through the return side entrance/exit opening 100f and at the same time working oil in the drive side actuator 3a is drained through the drive side entrance/exit opening 100e, the scavenging control valve 1 is rotated by the return side actuator 3b in the direction opposite to the arrow M in the drawings, and the communication of the scavenge openings 4 to the scavenging ports 101 of the external liner part 100d is shut, that is, the scavenging control valve 1 closes the scavenging ports.

[0056] In the embodiment, the actuators are composed such that the actuation area (pressure receiving area) A1 of the drive side actuator 3a is larger than the actuation area (pressure receiving area) A2 of the return side actuator 3b, i.e. $A1 > A2$.

[0057] It is necessary to increase engine performance that opening speed of the scavenging control valve 1 to open the scavenging ports of the cylinder liner is increased, i.e. the speed of increasing the area communicating the scavenging ports 101 of the external liner part 100 to the scavenge openings 4 of the scavenging control valve 4 is increased in order to attain good scavenging by fresh air, but closing speed of the scavenging control valve 1 is not so influential to engine performance.

[0058] The amount of working oil used to rotate the scavenging control valve 1 is a product of the pressure receiving area of the actuator member multiplied by the stroke (circumferential stroke), so the smaller the pressure receiving area of the actuator is, the lesser the amount of working oil is. Therefore, energy to supply working oil can be reduced by reducing the pressure receiving area of the actuator.

[0059] In the third embodiment, the actuating area (pressure receiving area) A1 of the drive side actuator 3a for moving the scavenging control valve 1 in valve opening direction is made larger than the actuating area (pressure receiving area) A2 of the drive side actuator 3b for moving the scavenging control valve 1 in valve closing direction, so target performance of the engine is attained by increasing opening speed of the scavenging ports by increased pressure receiving area of the drive side actuator 3a, whereas the amount of working oil and power to supply working oil to the return side actuator is decreased by decreased pressure receiving area of the drive side actuator 3b. By this, overall efficiency of the engine can be increased.

[0060] Further, the amount of energy needed to drive the scavenging control valve 1 is a product of the amount multiplied by the pressure of the working oil supplied to the actuator, so the lower the working oil pressure is, the smaller the power required for supplying working oil is.

[0061] In the third embodiment, the pressure of the working oil supplied to the drive side actuator 3a is made

higher than that supplied to the return side actuator 3b, so target performance of the engine is attained by increasing opening speed of the scavenging ports by increased pressure of working oil supplied to the drive side actuator 3a, whereas power to supply working oil to the return side actuator 3b is decreased by decreased pressure of working oil supplied to the return side actuator 3b. By this, overall efficiency of the engine can be increased.

[Fourth embodiment]

[0062] FIG.8 is a partial sectional view of the forth embodiment of the invention along line A-A in FIG. 1.

[0063] In the fourth embodiment, an electromagnetic valve 5 provided for switching supply of working oil to the drive side actuator 3a and the return side actuator 3b is composed such that the scavenging control valve 1 is kept at the rotation position with which the scavenging ports 101 of the cylinder liner 100 are communicated to the scavenge opening 4 when the electromagnetic valve 5 does not actuate. Reference numeral 100e is a drive side entrance/exit opening of working oil, and 100f is a return side entrance/exit opening of working oil.

[0064] According to the fourth embodiment, the scavenging control valve 1 is remained at a position to allow communication of the scavenge openings 4 to the scavenging ports 101 even when malfunction occurs in the electromagnetic valve 5, and operation of the engine can be continued without being influenced by the malfunction of the electromagnetic valve 5.

[Fifth embodiment]

[0065] FIG.9 is a partial sectional view of the fifth embodiment of the invention along line A-A in FIG.1.

[0066] In the fifth embodiment, an electromagnetic valve 51 is provided which allows working oil to be supplied to the drive side actuator 3a when the electromagnetic valve 51 does not actuate, and a spring 11 is provided in stead of the return side actuator 3b, so that the scavenging control valve 1 will be positioned at a position at which the force by the drive side actuator 3a and force by the spring 11 balance with each other.

[0067] According to the fifth embodiment, even when malfunction occurs in the electromagnetic valve 51, the scavenging control valve 1 can be remained at a position to allow communication of the scavenge openings 4 to the scavenging ports 101.

[Sixth embodiment]

[0068] In the sixth embodiment, the upper part of the scavenging control valve 1 is composed as a driving part 100f as shown in FIG.1 and FIGS.6-7, and a hydraulic drive means consisting of the drive side actuator 3a and return side actuator 3b is provided in the driving part 100f.

[0069] According to the sixth embodiment, by provid-

ing the hydraulic drive means in the drive part 100f in the upper part of the scavenging control valve 1, the drive part 100f being formed preferably greater in wall thickness than the part where the scavenge openings 4 are formed, the drive part 100f is increased in rigidity and the lower end of the scavenging control valve can be made to be a free end, so downward force exerting on the scavenging control valve by downward travel of the piston does not work as compressing force to the scavenging control valve, thus, backling deformation of the thinner cylindrical part of the scavenging control valve is prevented.

[0070] According to the present invention, an internal combustion engine equipped with a scavenging control valve device can be provided, in which blow-by of combustion gas from the upper annular space above the top piston ring to the scavenging ports is prevented, by which reduction in engine performance due to deposition of combustion gas residuum to the scavenge openings and occurrence of piston ring sticking due to deposition of combustion gas residuum to the piston rings can be prevented, and further the amount of working oil to drive the scavenging control valve can be reduced resulting in decreased energy loss for pressurizing the working oil.

Claims

1. An internal combustion engine equipped with a scavenging control valve, the engine having a plurality of scavenging ports arranged along circumferential direction of its cylinder liner in its lower part for introducing scavenge air into the cylinder, wherein an annular-shaped scavenging control valve is fitted-in to a fitting face formed on either the inner side or outer side of the cylinder liner movably in circumferential direction of the cylinder liner for opening and closing said scavenging ports in order to allow scavenge air to be supplied into the cylinder or interrupted, said scavenging control valve has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof, and the scavenge openings of each stage has a height of L1 which is smaller than a inside distance L2 between a top piston ring and a bottom piston ring equipped to a piston of the engine ($L1 < L2$).
2. An internal combustion engine equipped with a scavenging control valve according to claim 1, wherein said scavenging control valve has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into

communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof, and height H1 of scavenge openings belonging to the uppermost stage of a plurality of the stages is higher than height H2 of scavenge openings belonging to lower stages below the uppermost stage ($H1 < H2$).

3. An internal combustion engine equipped with a scavenging control valve, the engine having a plurality of scavenging ports arranged along circumferential direction of its cylinder liner in its lower part for introducing scavenge air into the cylinder, wherein are provided an annular-shaped scavenging control valve which is fitted-in to a fitting face formed on the inner side of the cylinder liner movably in circumferential direction of the cylinder liner, and which has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof for opening and closing said scavenging ports in order to allow scavenge air to be supplied into the cylinder or interrupted; and a hydraulic drive means which is provided in the cylinder liner and in the upper part of the scavenging control valve for allowing the scavenging control valve to move in circumferential direction thereof by working fluid pressure.
4. An internal combustion engine equipped with a scavenging control valve, the engine having a plurality of scavenging ports arranged along circumferential direction of its cylinder liner in its lower part for introducing scavenge air into the cylinder, wherein are provided an annular-shaped scavenging control valve which is fitted-in to a fitting face formed on either the inner side or outer side of the cylinder liner movably in circumferential direction of the cylinder liner, and which has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof for opening and closing said scavenging ports in order to allow scavenge air to be supplied into the cylinder or interrupted; and a hydraulic drive means which is provided in the cylinder liner and in the upper part of the scavenging control valve for allowing the scavenging control valve to move in circumferential direction thereof; wherein said hydraulic drive means consists of drive side actuators and return side actuators, to which working oil is supplied and drained by switch-

ing an electromagnetic valve, provided along the outer circumference of the scavenging control valve; whereby the scavenging control valve is moved in drive direction and return direction by supplying to and draining from the drive side actuators and return side actuators, and the actuators are composed such that the drive side actuators for moving the scavenging control valve in drive direction have actuating area larger than that of the return side actuator for moving the scavenging control valve in return direction.

5. An internal combustion engine equipped with a scavenging control valve, the engine having a plurality of scavenging ports arranged along circumferential direction of its cylinder liner in its lower part for introducing scavenge air into the cylinder, wherein are provided an annular-shaped scavenging control valve which is fitted-in to a fitting face formed on either the inner side or outer side of the cylinder liner movably in circumferential direction of the cylinder liner, and which has a plurality of scavenge openings arranged along circumferential direction and in a plurality of stages in axial direction thereof so that the scavenge openings are brought into communication or discommunication with the scavenging ports of the cylinder liner by moving the scavenging control valve in circumferential direction thereof for opening and closing said scavenging ports in order to allow scavenge air to be supplied into the cylinder or interrupted; and a hydraulic drive means which is provided in the cylinder liner and in the upper part of the scavenging control valve for allowing the scavenging control valve to move in circumferential direction thereof; wherein said hydraulic drive means consists of drive side actuators and return side actuators, to which working oil is supplied and drained by switching an electromagnetic valve, provided along the outer circumference of the scavenging control valve; whereby the scavenging control valve is moved in drive direction and return direction by supplying to and draining from the drive side actuators and return side actuators, and pressure of working oil supplied to the drive side actuators for moving the scavenging control valve in drive direction is higher than that of working oil supplied to the return side actuators for moving the scavenging control valve in return direction.
6. An internal combustion engine equipped with a scavenging control valve according to claim 4, wherein a means for keeping the scavenging ports open is provided which allows working oil to be supplied to a working oil passage connecting the electromagnetic valve to the drive side actuator so that the scavenging control valve is retained in a position at which the scavenge openings of the scavenging control valve are communicating to the scavenging ports of the cylinder liner when malfunction occurs in the elec-

tromagnetic valve.

7. An internal combustion engine equipped with a scavenging control valve according to claim 4, wherein springs are provided instead of the return side actuators for exerting spring force so that the scavenging control valve is retained in a position at which the scavenge openings of the scavenging control valve are communicating to the scavenging ports of the cylinder liner when malfunction occurs in the electromagnetic valve.

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FIG. 1

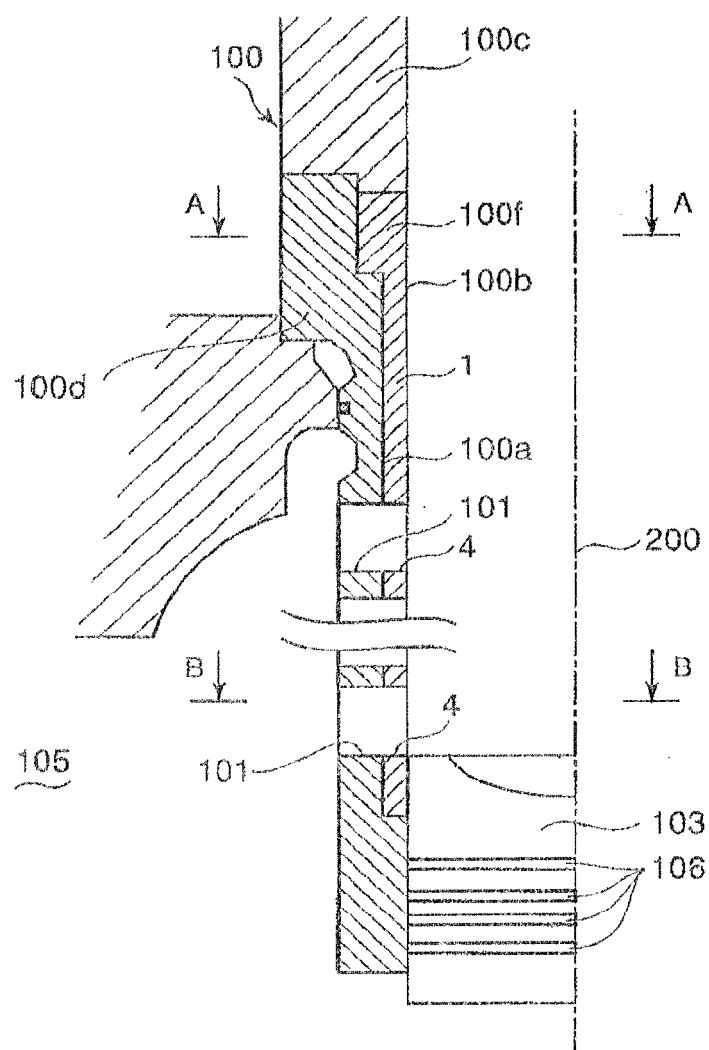


FIG.2

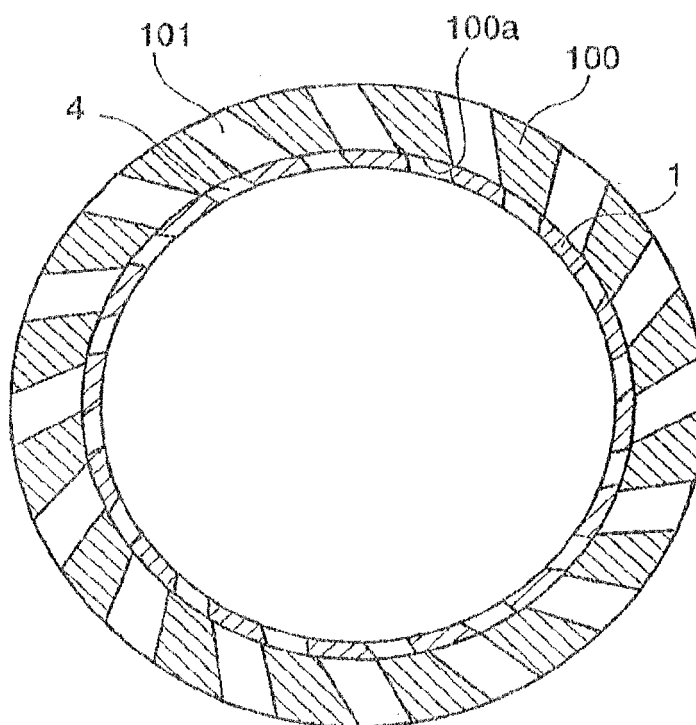


FIG.3

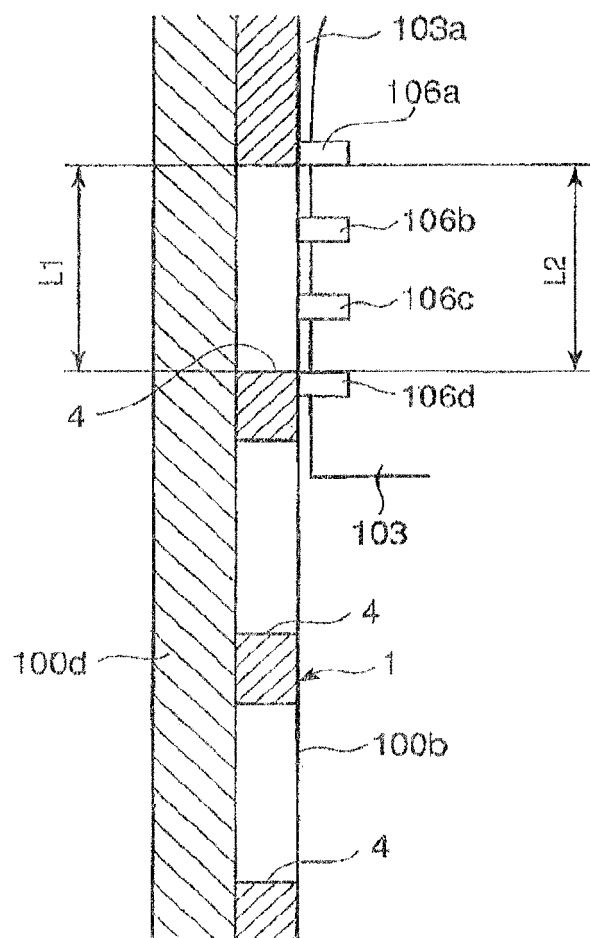


FIG.4

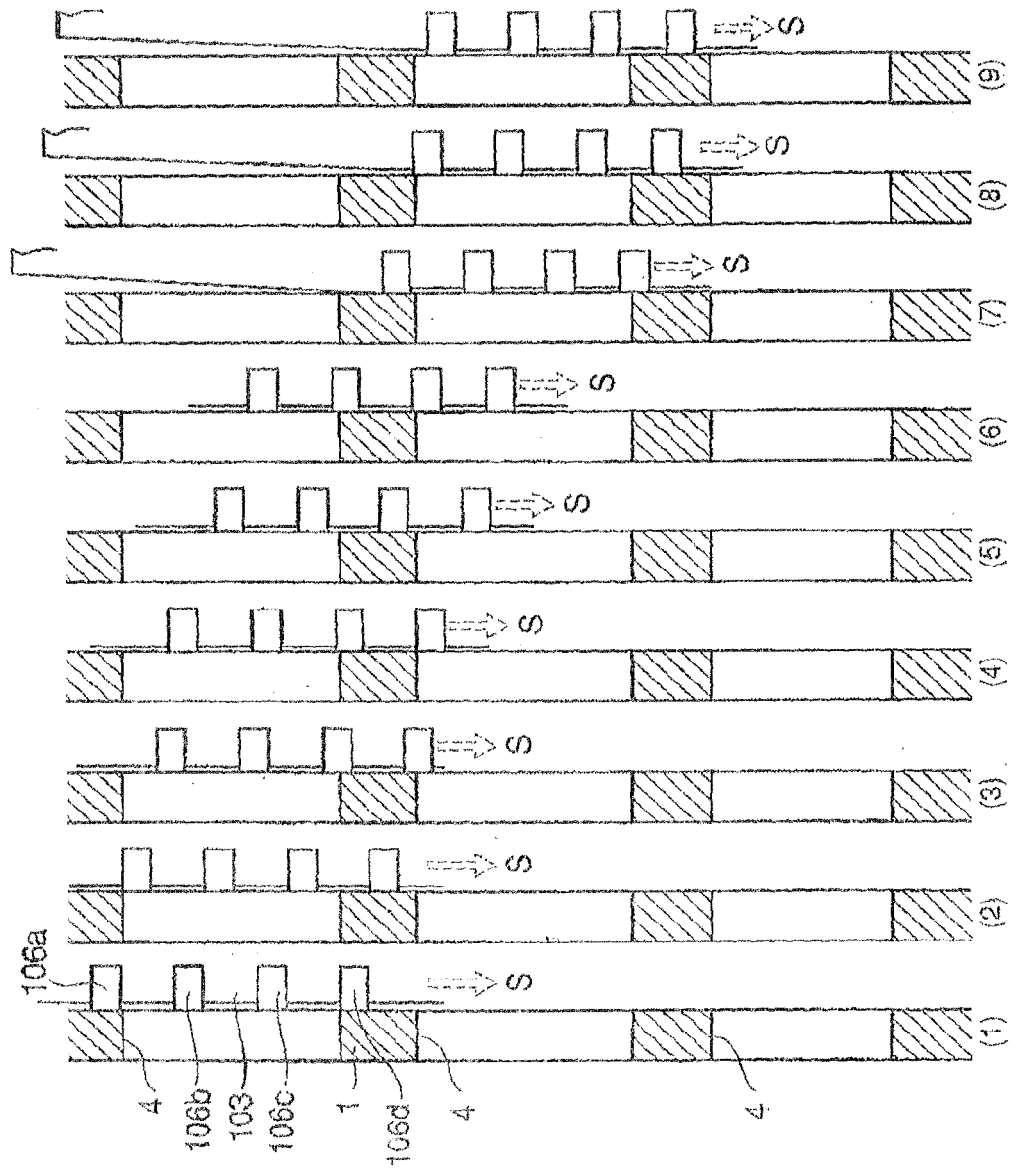


FIG.5A

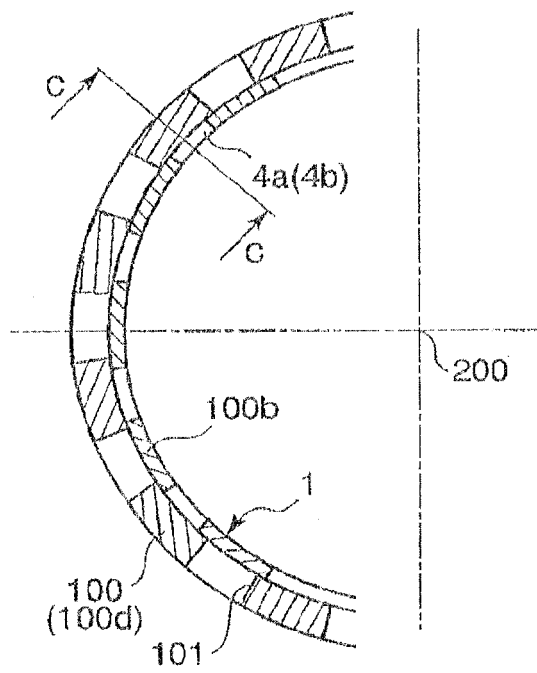
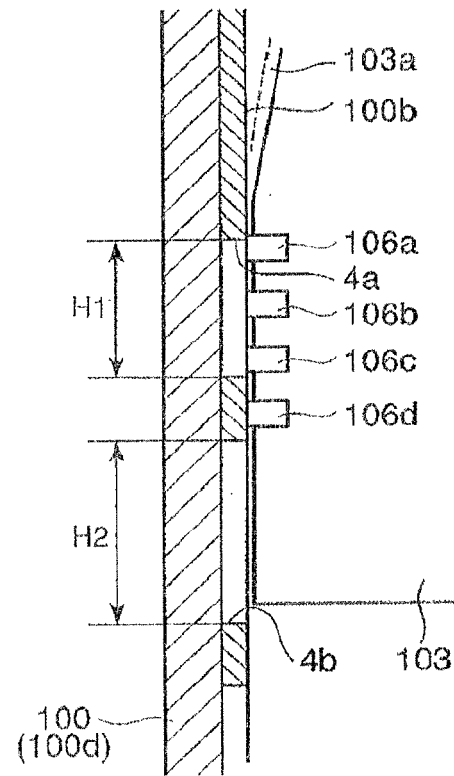


FIG.5B



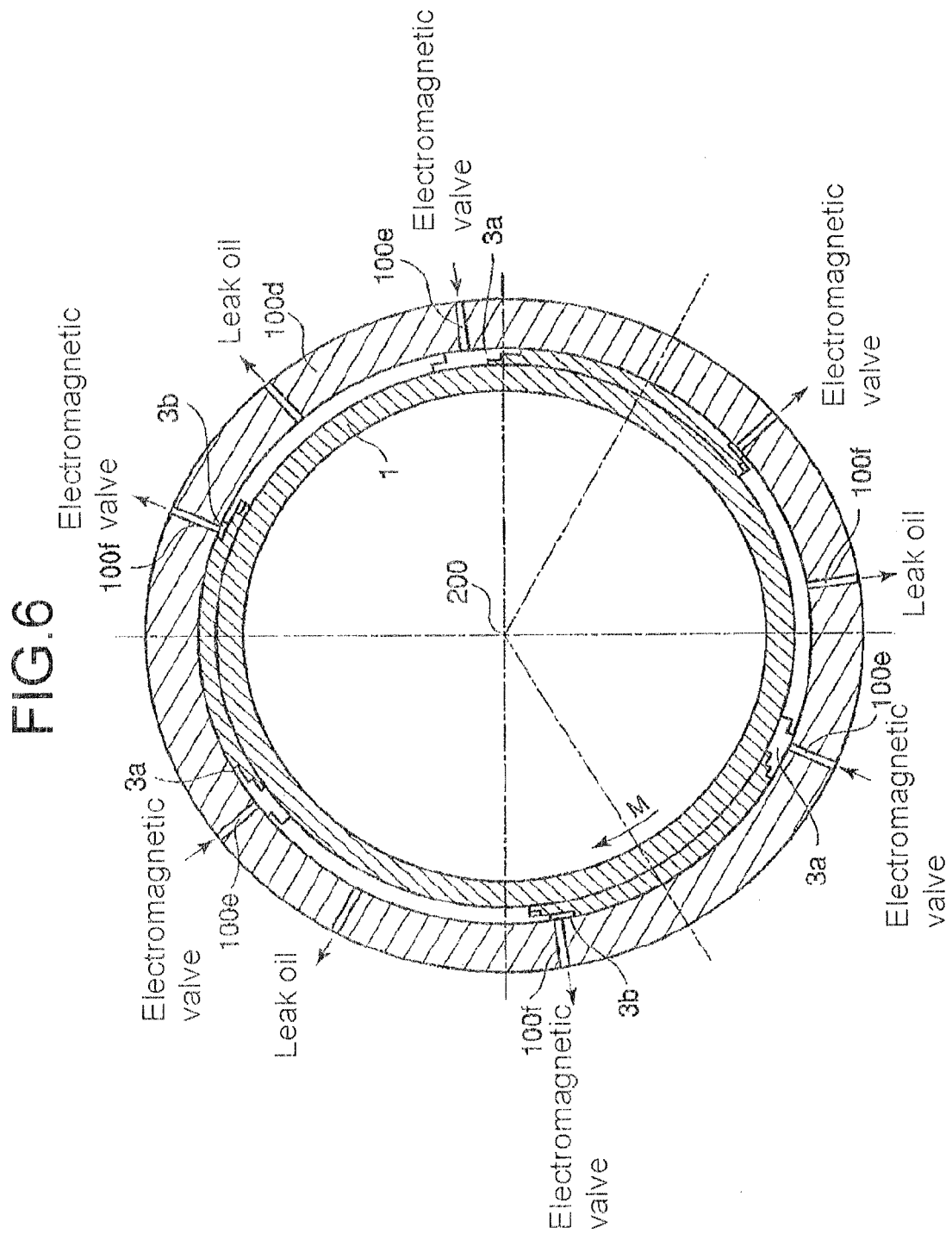


FIG.7A

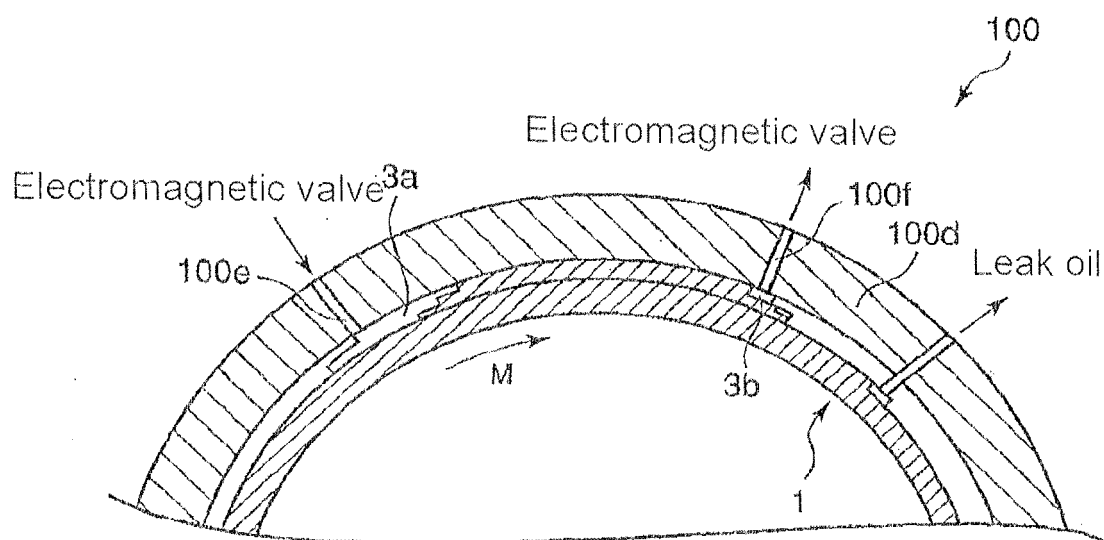


FIG. 7B

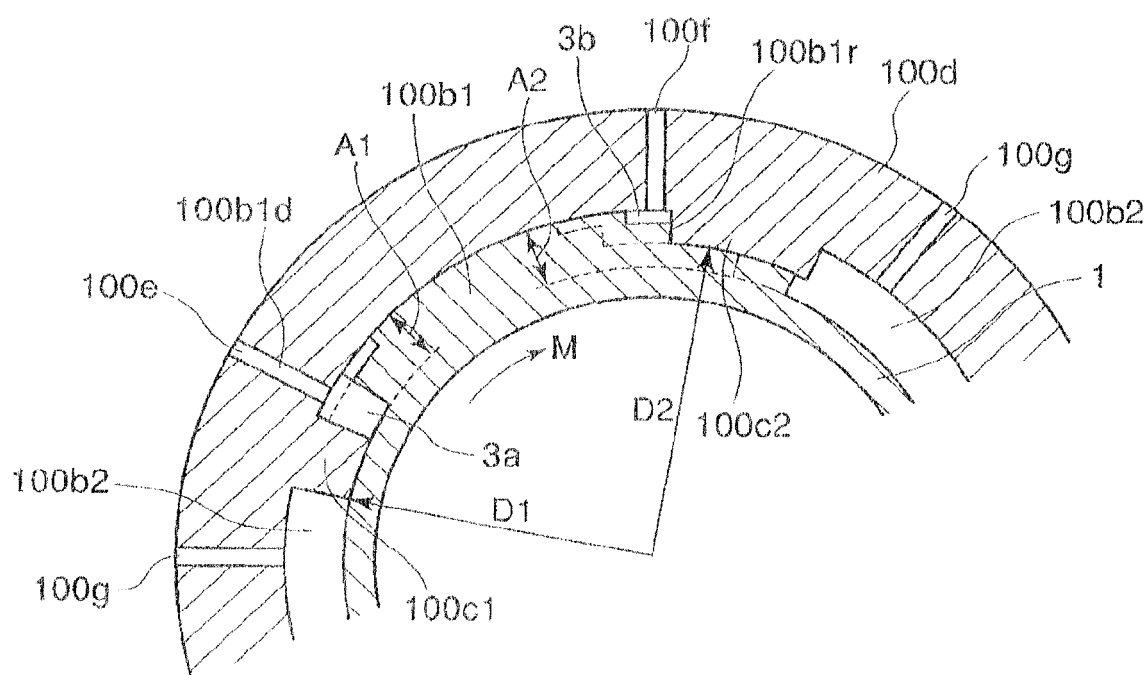


FIG.8

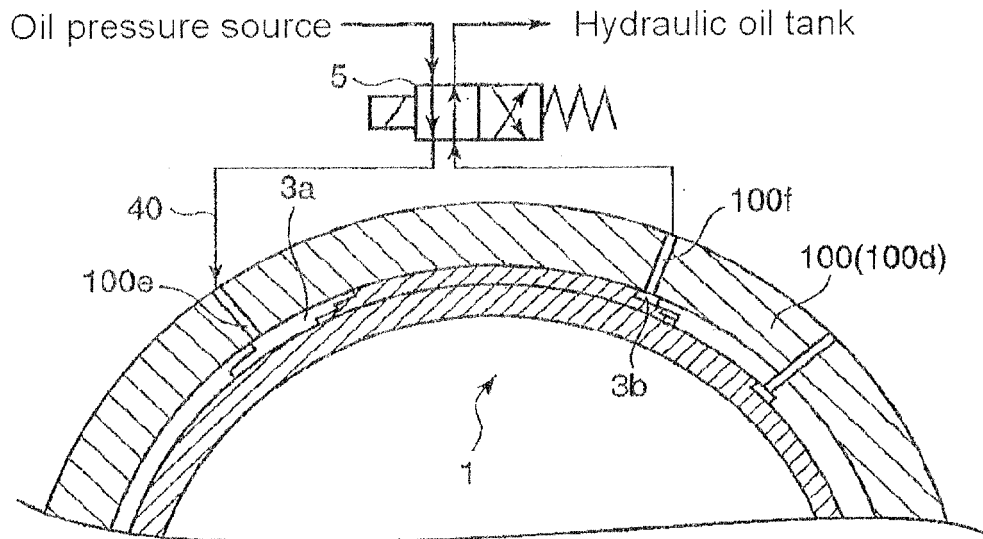


FIG.9

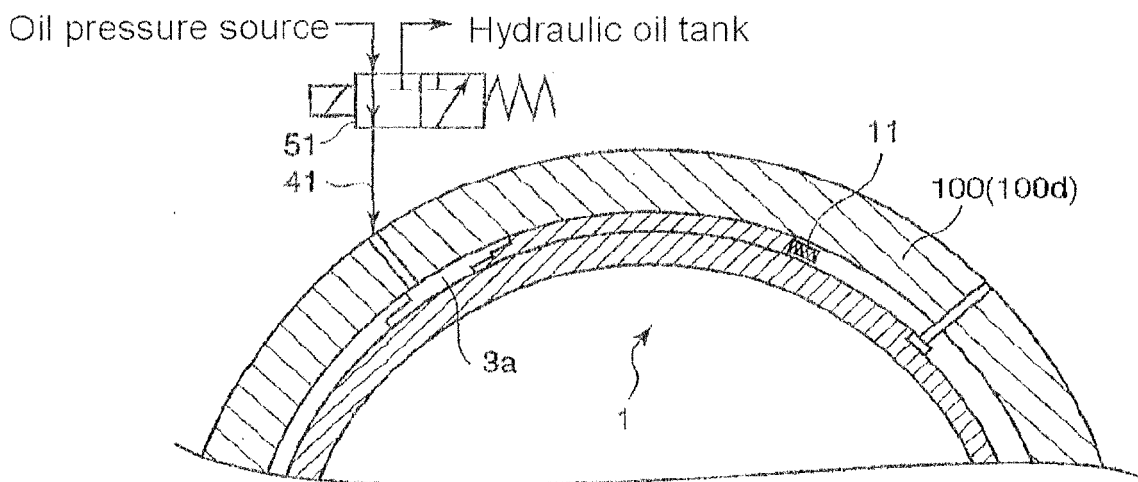
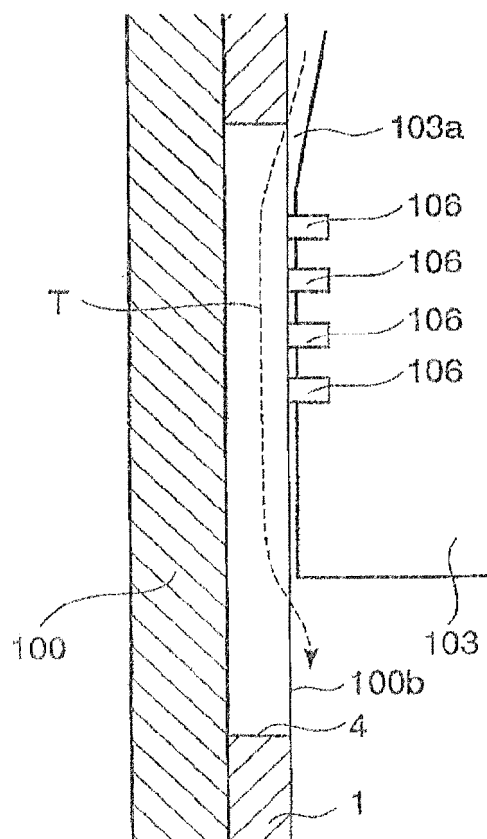


FIG. 10



REFERENCES CITED IN THE DESCRIPTION

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- JP 59056310 U [0012]

Non-patent literature cited in the description

- *Journal of Japan institute of marine engine*, January 1996, vol. 31 (1 [0011])