

Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priority under 35 U.S. C. § 119 with respect to Japanese Patent Application No. 2005-091286 filed on March 28, 2005, the entire content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a balancer of an engine.

2. Description of the Related Art

[0003] In general four-cylinder engines, rotation of a crank shaft becomes unbalanced due to an inertial force resulting from vertical reciprocating motion of a piston, for example. This causes vertical vibrations of the engine. To prevent this, various types of balancers have been proposed and put into practical use. Such balancers have two balance shafts with eccentric balance weights, and the balance shafts are rotated in opposite directions by means of a torque of the crank shaft to suppress the engine vibrations.

[0004] A balancer of this type is disclosed in, for example, Japanese Unexamined Patent Application Publication No. 2001-280110. In this balancer, two balance shafts having eccentric balance weights are rotatably and axially supported to a housing provided in an oil pan below a cylinder block, and covered with the housing not to contact an oil in the oil pan or oil flowing out from the cylinder block. Further, the housing has an opening for discharging an oil residual in the housing after lubrication of a bearing portion of the balance shaft, on the rotating balance shaft. The opening is positioned above an oil level of the oil pan. In the balancer, the bearing portion of the balance shaft is lubricated with an oil supplied through an oil path. In this balancer, an oil in a weight chamber is discharged from an end face extending along a radius direction of the balance weight along with the rotation of the balance shaft through the opening. This aims at well-lubricating the bearing portion of the balance shaft, and preventing the oil from being agitated to thereby minimize a power loss.

[0005] However, the above balancer has a problem in that a clearance between an inner surface of the balance chamber and an outer surface of the balance weight is uniform, so the oil in the weight chamber is only rotated along with the rotation of the balance weight and is hardly discharged from the opening.

SUMMARY OF THE INVENTION

[0006] The present invention has been accomplished to solve the above problem, and accordingly, it is an object of the present invention to provide an engine balancer that facilitates the discharge of an oil.

[0007] In order to attain the above object, an engine balancer according to a first aspect of the present invention includes: a housing attached to a cylinder block; a pair of balance shafts which are axially supported to the housing rotatably in parallel to each other, and one of which receives a transmitted torque of a crank shaft; and a balance weight rotatably provided in a weight chamber formed in the housing together with the balance shafts characterized in that the engine balancer further comprises an oil is supplied to a supporting portion of the balance shafts, an oil discharging path communicating with the weight chamber and the outside is formed in the housing, and a distance between an inner peripheral surface of the weight chamber and the balance shaft is reduced toward an opening of the oil discharging path.

[0008] According to a second aspect of the present invention, in the engine balancer according to the first aspect, the inner peripheral surface has an arc shape as viewed in an axial direction of the balance shaft, and an R center of the arc is offset from an axial center of the balance shaft to gradually reduce the distance between the inner peripheral surface of the weight chamber and the balance shaft toward the opening of the oil discharging path.

[0009] According to a third aspect of the present invention, in the engine balancer according to the first or second aspect, a clearance between the inner peripheral surface of the weight chamber and an outer peripheral surface of the balance weight is gradually reduced to the opening of the oil discharging path, and the minimum value of the clearance is set to 1 to 2 mm.

[0010] According to the balancer as described in the first aspect of the invention, the distance between the inner peripheral surface of the weight chamber and the balance shaft is reduced toward the opening of the oil discharging path, whereby a force acts on the oil that flows along with the rotation of the balance shaft, in such a direction as to compress the oil. The applied pressure pushes the oil flowing along the balance shaft into the oil discharging path. Hence, even when the oil discharging path is filled with the oil, the oil is discharged efficiently from the weight chamber 23 by means of the pressure caused by the clearance and the rotational force of the balance shaft.

[0011] According to the balancer as described in the second aspect of the invention, the R center of the inner peripheral surface is offset from an R center of the balance shaft and an outer peripheral surface to gradually reduce the distance between the inner peripheral surface and the balance shaft toward the opening of the oil discharging path. Accordingly, a curvature of the inner peripheral surface is not uniform, which facilitates machin-

ing. A machining cost is equivalent to that of the balancer having no offset mechanism.

[0012] According to the balancer as described in the third aspect of the invention, the minimum value of the clearance between the inner peripheral surface of the weight chamber and the outer peripheral surface of the balance weight is set to 1 to 2 mm, whereby a friction applied to the balance shaft can be reduced.

[0013] According to the first to third aspects of the invention, it is possible to provide an engine balancer that facilitates discharge of the oil.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a front view of an engine according to an embodiment of the present invention;

Fig. 2 is a side view of the engine according to the embodiment of the present invention;

Fig. 3A is a plan view of a balancer, and Fig. 3B is a side view thereof;

Figs. 4A and 4B are sectional views showing an operation of a balancer; and

Fig. 5 is a characteristic diagram of a friction relative to a clearance.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] Hereinafter, an embodiment of the present invention will be described with reference to the accompanying drawings.

[0016] Fig. 1 is a schematic front view of an engine, and Fig. 2 is a schematic side view of the engine.

[0017] A crank shaft 12 as an output shaft of the engine is supported to a lower end of a cylinder block 11 of the engine, rotatably about an axial line of the shaft 12. The crank shaft 12 is connected with a piston (not shown) through a connecting rod. At the time of starting an engine, the reciprocating motion of the piston in the vertical direction in the figures is converted into the rotation of the crank shaft 12 by means of the connecting rod. Further, a driving gear 13 is rotatably fixed to and integrated with the crank shaft 12.

[0018] An oil pan 14 for storing an oil is fixed below the cylinder block 11. In addition, a balancer 20 is secured inside the oil pan 14 at the lower end of the cylinder block 11. The balancer functions to cancel an inertial force of the piston, which acts thereon in the movement direction of the piston at the time of starting the engine. The cylinder block 11 is attached with an oil pump (not shown) for pushing an oil in the oil pan 14 into each lubricating portion of the engine. As described below, the oil pumped with the oil pump is partially supplied to a lubricating portion of the balancer 20 as well.

[0019] The balancer 20 is made of aluminum alloy or cast iron, and includes a first housing 21 and a second housing 22 that are clamped with each other by means

of a clamp (not shown). In both of the first housing 21 and the second housing 22, recesses 23a and 23b are formed opposite to each other so as to define a weight chamber 23 as mentioned later. Besides, recesses 24a and 24b are formed opposite to each other so as to define a gear chamber 24 separate from the weight chamber 23. A first balance shaft 25 and a second balance shaft 26 (only the first balance shaft 25 is shown in Fig. 2) are rotatably supported between the first housing 21 and the second housing 22.

[0020] The balance shafts 25 and 26 are integrated with balance weights 27 and 28 of substantially semi-circular shape. The balance weights 27 and 28 are arranged in the weight chamber 23 and rotated in the chamber. Incidentally, the balance weights 27 and 28 may be formed separately from the balance shafts 25 and 26, and rotatably and integrally clamped with the shafts 25 and 26 by means of a bolt or the like.

[0021] One ends of the individual balance shafts 25 and 26 protrude into the gear chamber 24, and a first driven gear 31 and a second driven gear 32 arranged in the gear chamber 35 and meshed with each other are fixed thereto, whereby the balance shafts 25 and 26 are rotated in opposite directions.

[0022] The driving gear 13 meshes with the second driven gear 32, and a gear ratio of the driving gear 13 to the second driven gear 32 is set to 2 : 1. Accordingly, the balance shafts 25 and 26 are rotated at a rotational speed twice that of the crank shaft 12. Incidentally, as a method of transmitting a rotational force of the crank shaft 12 to the balance shafts 25 and 26, a chain driving method and a belt driving method may be adopted in addition to the gear driving method.

[0023] As shown in Fig. 3A, the first housing 21 includes an oil discharging path 41 that communicates with an inner space of the weight chamber 23 and the outside of the balancer 20, that is, communicates with an inner space of the oil pan 14 to discharge an oil in the weight chamber 23. As shown in Figs. 4A and 4B, the oil discharging path 41 has an opening 41a in an inner peripheral surface 23c opposite to an outer peripheral surface 27a of the balance weight 27, and has an opening 41b in a side surface 21a of the first housing 21. Incidentally, Figs. 4A and 4B show the oil discharging path 41, but an oil discharging path may be formed on the second balance shaft 26 side.

[0024] As shown in Fig. 4A, the inner peripheral surface 23c of the recess 23a is curved in an arc shape with its center (R center 02) set to the axial line extending along the axial line of the balance shaft 25. On the other hand, the outer peripheral surface 27a of the balance weight 27 is curved in an arc shape with its center (R center 01) set to the axial center of the balance shafts 25 and 26. The R center.02 of the inner peripheral surface 23c is offset from the R center 01 of the balance shaft 25 and the outer peripheral surface 27a. The offset direction is set such that a distance L1 between the inner peripheral surface 23c and the R center 01 of the outer peripheral surface 27a is set.

eral surface 27a as viewed in the vertical direction is shorter than a distance L2 therebetween as viewed in the horizontal direction in Fig. 4A. Accordingly, as shown in Fig. 4B, the distance between the balance shaft 25 and the inner peripheral surface 23c is gradually reduced toward the opening 41a of the oil discharging path 41 in the rotational direction of the balance shaft 25 (counterclockwise direction of Fig. 4B). Likewise, as shown in Fig. 4A, the distance (clearance) between the outer peripheral surface 27a of the balance weight 27 and the inner peripheral surface 23c of the recess 23a is gradually reduced toward the opening 41a of the oil discharging path 41 in the rotational direction of the balance shaft 25.

[0025] The minimum value of the clearance between the balance weight 27 and the inner peripheral surface 23c is determined based on a friction between the balance shaft and the oil in the weight chamber 23. Fig. 5 shows a friction relative to the minimum value of a clearance that varies. As apparent from Fig. 5, it is desirable to set the minimum clearance value to 1 to 2 mm, for example, 1.5 mm.

[0026] In the above structure, when the engine is started, the crank shaft 12 rotates, and its rotational force is transmitted to the second balance shaft 26 through the driving gear 13 and the driven gear 32. The interlocked operation of the driven gear 32 and the driven gear 31 provided to the first balance shaft 25 causes the balance shafts 25 and 26 to rotate in opposite directions, thereby suppressing a vertical vibration and muffled sound resulting from the secondary inertial force of the engine.

[0027] Supporting portions of the balance shafts 25 and 26 of the balancer 20 are supplied with a part of the oil fed from the oil pan 14 and pushed into each lubrication portion of the engine by an oil pump after starting the engine. The oil supplied to the supporting portions partially flows into the weight chamber 23.

[0028] The oil in the weight chamber 23 moves along the balance shaft 25 while being pressed against the side face of the balance weight 27 in the rotational direction, along with the rotation of the balance shaft 25. At this time, the distance between the balance shaft 25 and the inner peripheral surface 23c of the weight chamber 23 is reduced toward the opening of the oil discharging path 41, so a pressure is applied to the oil in such a direction as to compress the passing oil. This pressure pushes the oil into the oil discharging path 41. Hence, even when the oil discharging path 41 is filled with the oil, the oil is discharged efficiently from the weight chamber 23 by means of the pressure caused by the clearance and the rotational force of the balance shaft 25. The same applies to the oil between the inner peripheral surface 23c and the outer peripheral surface 27a of the balance weight 27. Hence, the oil residual between the inner peripheral surface 23c of the weight chamber 23 and the outer peripheral surface 27a of the balance weight 27 is also discharged to the oil discharging path 41 by means of the pressure caused by the clearance and the rotational force.

[0029] As set forth above, the present invention produces the following beneficial effects.

(1) The distance between the balance shaft 25 and the inner peripheral surface 23c is gradually reduced to the opening 41a of the oil discharging path 41 in the rotational direction (counterclockwise direction in the figure) of the balance shaft 25. Accordingly, since the distance between the balance shaft 25 and the inner peripheral surface 23c of the weight chamber 23 is gradually reduced to the opening 41a of the oil discharging path 41, a force acts thereon in such a direction to compress the passing oil. The applied pressure pushes the oil flowing along the balance shaft 25 into the oil discharging path 41. Hence, even when the oil discharging path 41 is filled with the oil, the oil is discharged efficiently from the weight chamber 23 by means of the pressure caused by the clearance and the rotational force of the balance shaft 25.

(2) The R center 02 of the inner peripheral surface 23c is offset from the R center 01 of the balance shaft 25 and the outer peripheral surface 27a, and the distance between the balance shaft 25 and the inner peripheral surface 23c is gradually reduced toward the opening 41a of the oil discharging path 41 in the rotational direction of the balance shaft 25. Accordingly, the curvature of the inner peripheral surface 23c is uniform, which facilitates machining, and a machining cost is equivalent to that of the balancer having no offset mechanism.

[0030] Incidentally, the embodiment of the present invention may be modified as below.

[0031] In this embodiment, the R center 02 of the inner peripheral surface 23c is offset from the axial center of the balance shaft 25 (R center 01 of the outer peripheral surface of the balance weight 27) to gradually change the distance between the inner peripheral surface 23c and the balance shaft 25 and the outer peripheral surface 27a of the balance weight 27. The distance may be changed by the other method. For example, it may be formed into an elliptical shape as view in the axial direction of the balance shaft 25.

[0032] In the above embodiment, the amount and direction of the offset from the axial center of the balance shaft 25 (R center 01) from the R center 02 of the inner peripheral surface 23c may be appropriately changed. For example, the offset amount and direction may be changed in accordance with the position and shaft of the oil discharging path 41.

[0033] It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value rang-

es or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

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Claims

1. An engine balancer comprising a housing (22) at- 10
 tached to a cylinder block, a pair of balance shafts
 (25,26) which are axially supported to the housing
 rotatably in parallel to each other, and one of which
 receives a transmitted torque of a crank shaft, and 15
 a balance weight (27,28) rotatably provided in a
 weight chamber formed in the housing together with
 the balance shafts **characterized in that** the engine
 balancer further comprises:

an oil is supplied to a supporting portion of the 20
 balance shafts,
 an oil discharging path (41) communicating with
 the weight chamber and the outside is formed
 in the housing, and
 a distance between an inner peripheral surface 25
 of the weight chamber and the balance shaft is
 reduced toward an opening (41a) of the oil dis-
 charging path.

2. The engine balancer according to Claim 1, wherein 30
 the inner peripheral surface (23c) has an arc shape
 as viewed in an axial direction of the balance shaft,
 and an R center of the arc is offset from an axial
 center of the balance shaft to gradually reduce the 35
 distance between the inner peripheral surface of the
 weight chamber and the balance shaft toward the
 opening of the oil discharging path.

3. The engine balancer according to Claim 1 or 2, 40
 wherein a clearance between the inner peripheral
 surface of the weight chamber and an outer periph-
 eral surface of the balance weight is gradually re-
 duced to the opening of the oil discharging path, and
 the minimum value of the clearance is set to 1 to 2 45
 mm.

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FIG. 1

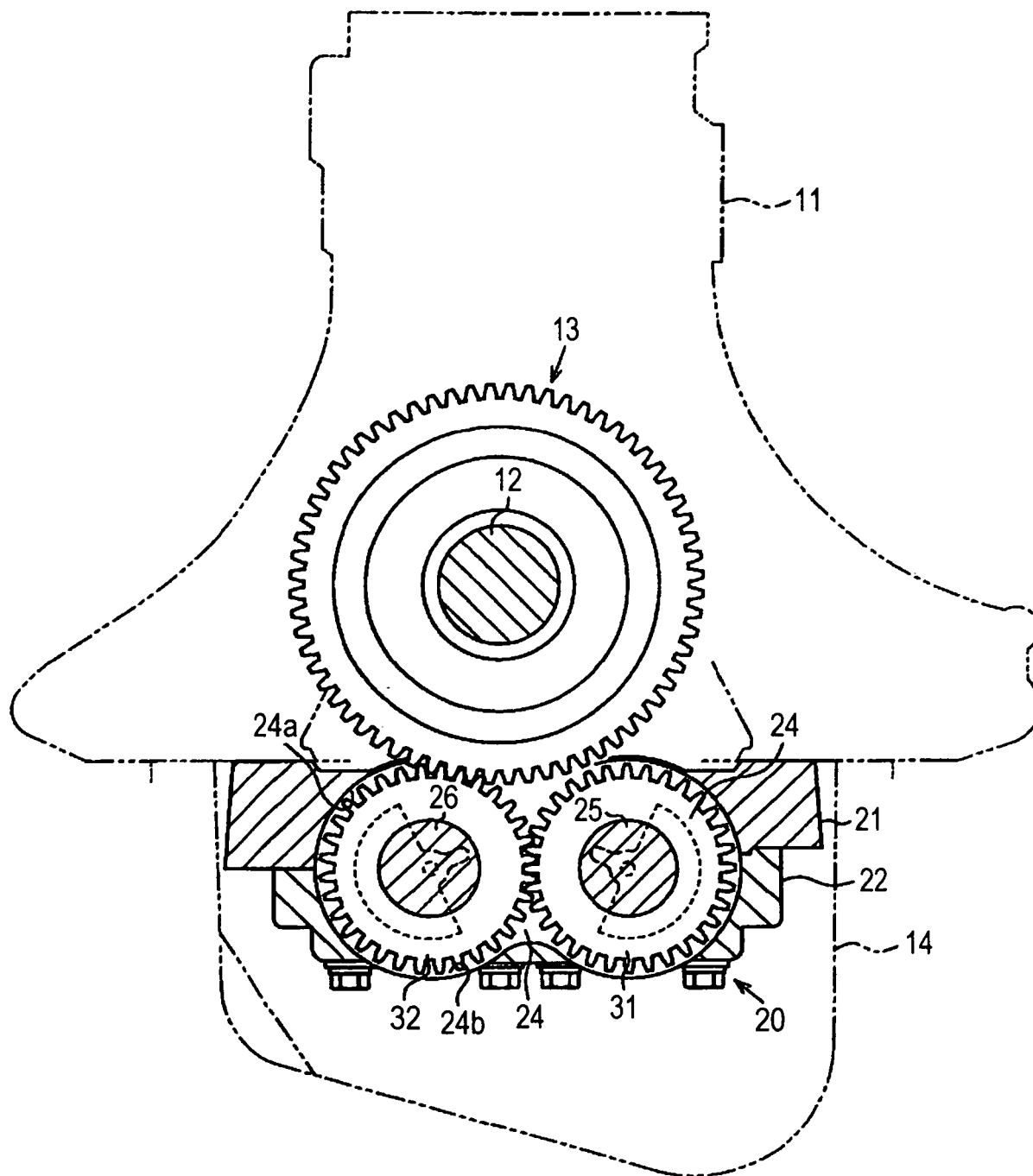


FIG. 2

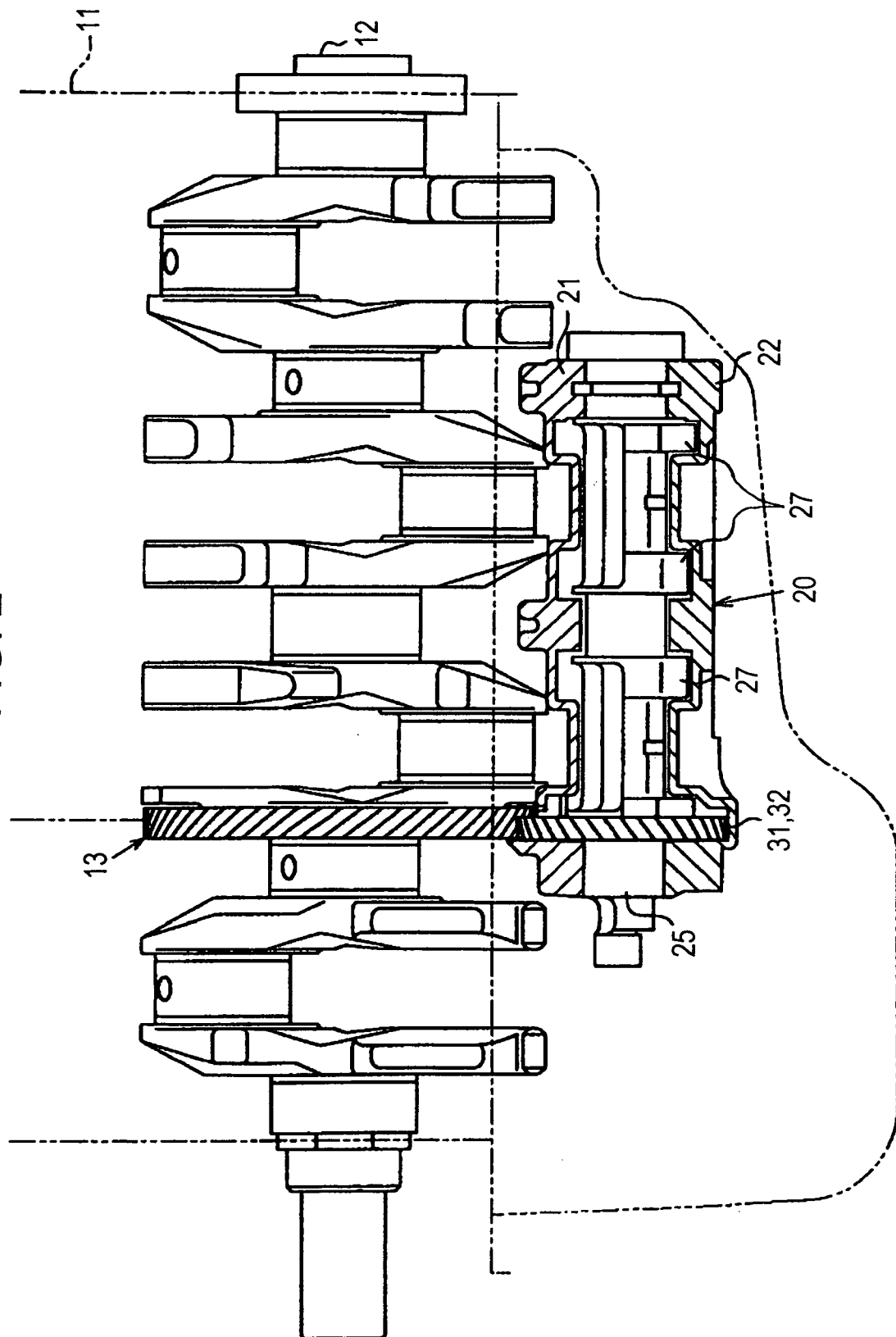


FIG. 3A

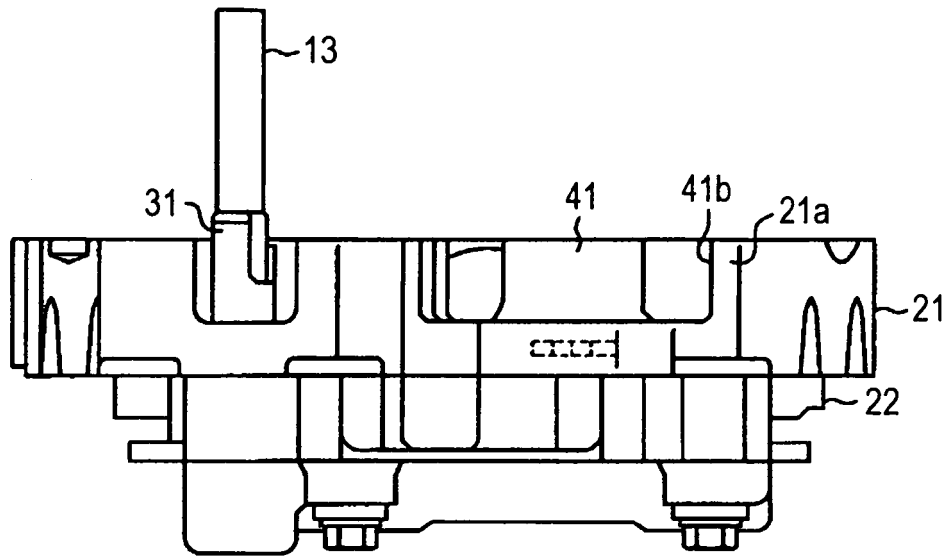


FIG. 3B

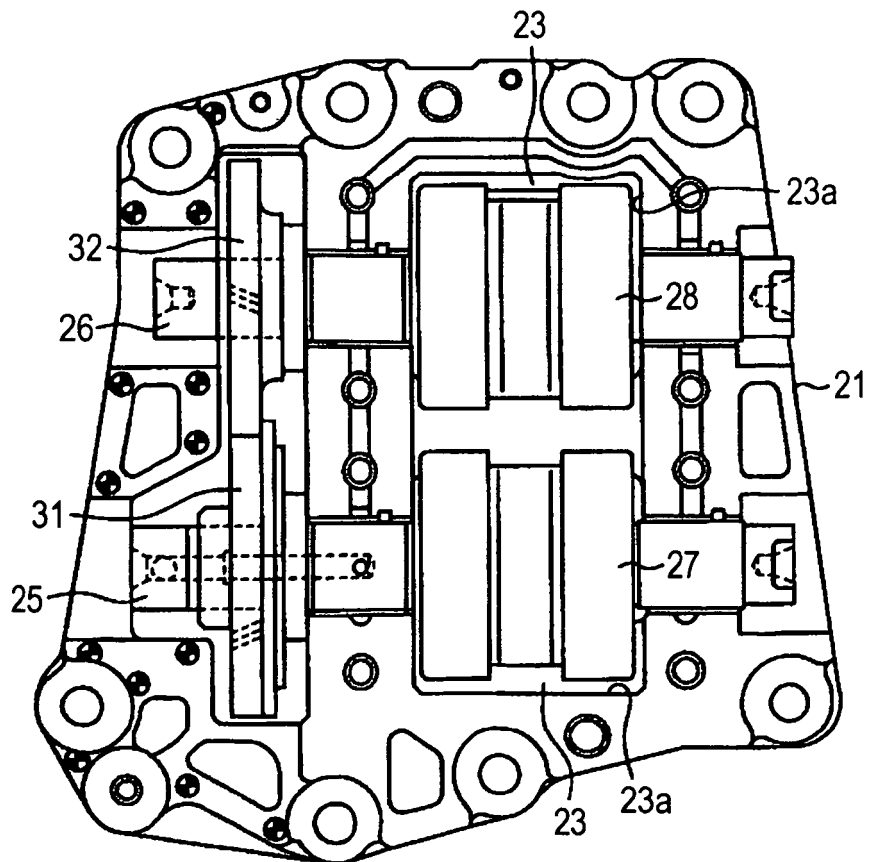


FIG. 4A

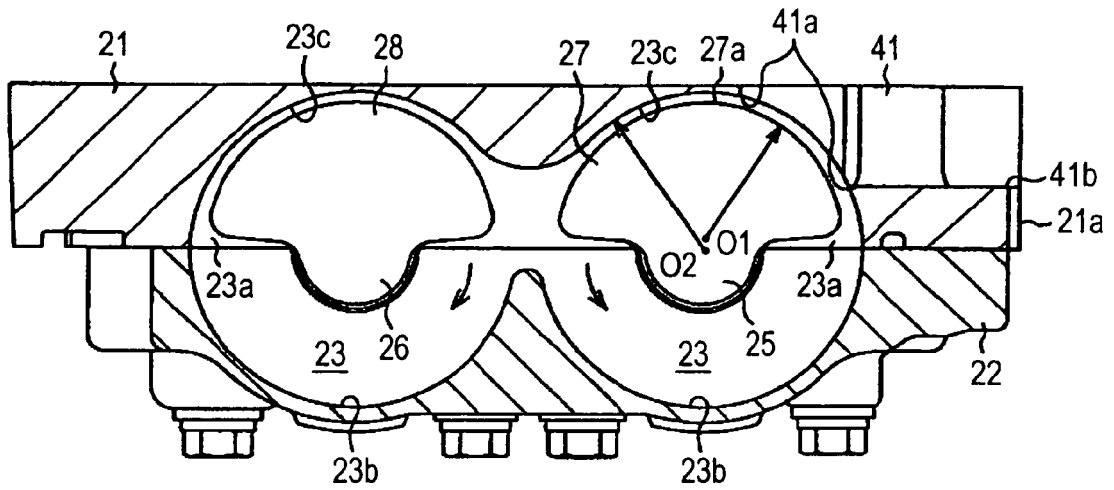


FIG. 4B

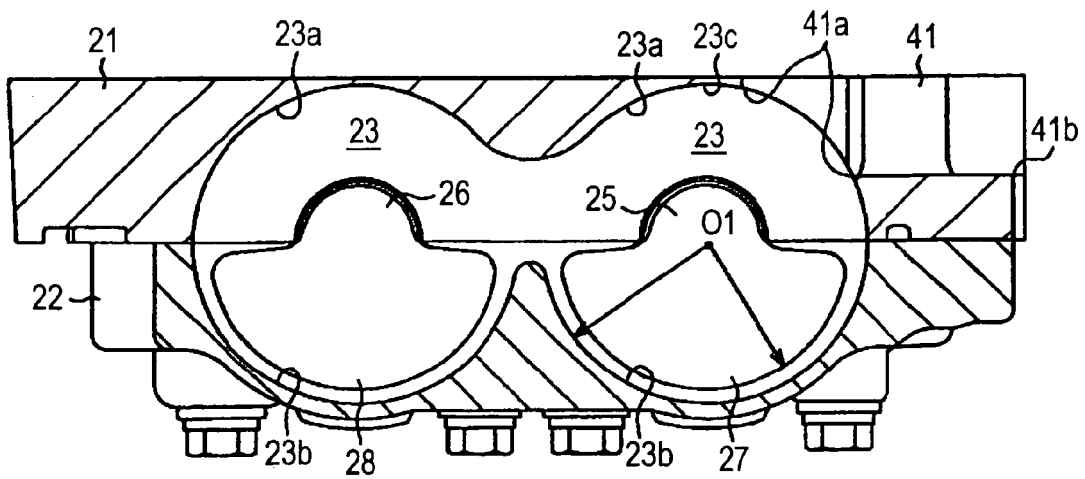
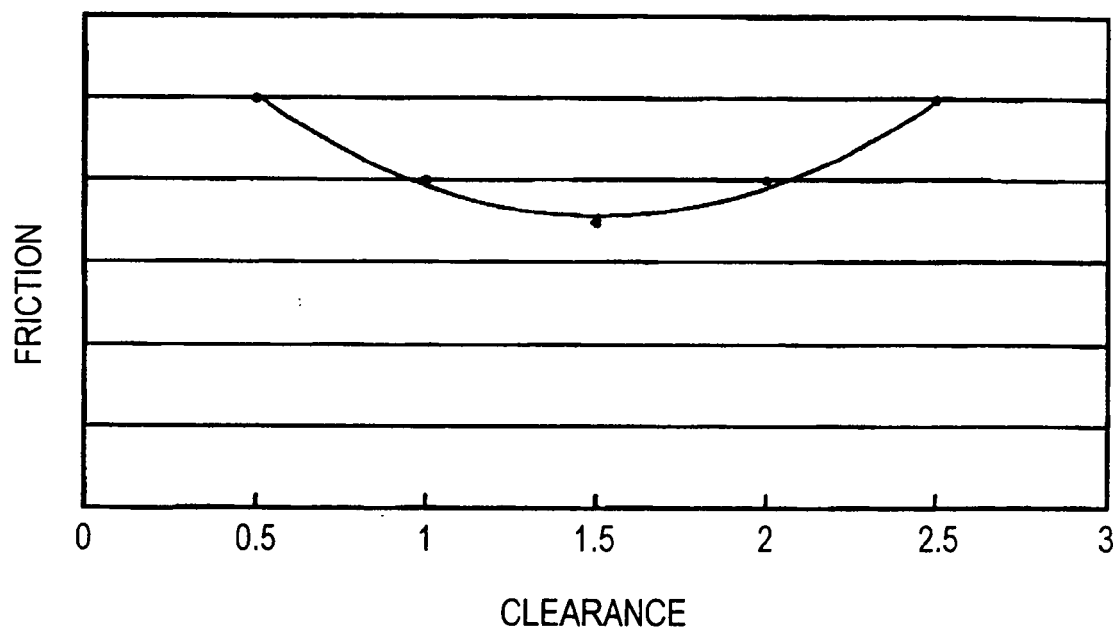


FIG. 5



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005091286 A [0001]
- JP 2001280110 A [0004]