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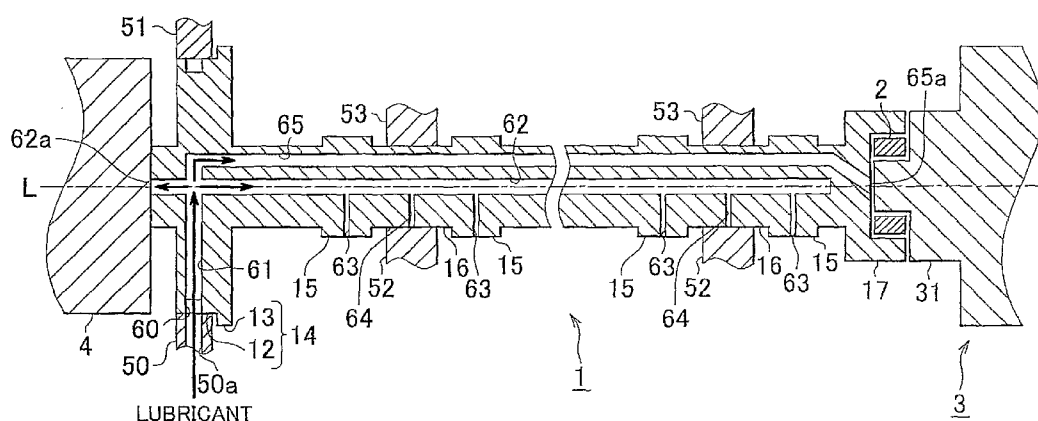
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(54) Title: COUPLING LUBRICATION STRUCTURE



(57) Abstract: A coupling lubrication structure includes a driving shaft of an internal combustion engine; a coupling that connects an end portion of the driving shaft to a driven shaft of a driven element; and a first oil passage and a second oil passage that are formed in the driving shaft, and that extend in the direction, in which the axis of the driving shaft extends, toward the downstream side on which the coupling is provided. A branch passage leading to an engine component that needs lubrication branches off from the first oil passage. The second oil passage leads to the sliding portion of the coupling.



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COUPLING LUBRICATION STRUCTURE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a coupling lubrication structure.

2. Description of the Related Art

[0002] In an internal combustion engine, especially, in an internal combustion engine for a vehicle, negative pressure produced by a vacuum pump is supplied to a brake booster to assist in obtainment of a braking force. In a direct-injection internal combustion engine in which fuel is injected directly into cylinders, the fuel pressurized by a supply pump is supplied to fuel injection valves. When the vacuum pump that supplies negative pressure to the brake booster or the supply pump that supplies the pressurized fuel to the fuel injection valves are driven by the torque of a camshaft, the structure, in which the vacuum pump is provided at one end of the camshaft and the supply pump is provided at the other end of the camshaft, is generally employed. In such structure, a coupling is provided between a pump shaft, which is the driven shaft of the pump, and the camshaft to tolerate the deviation of the axis of the pump shaft from the axis of the camshaft. Japanese Patent Application Publication No. 2004-92621 (JP-A-2004-92621) describes using the Oldham's coupling in such structure.

[0003] Because the rotational speed of a camshaft may fluctuate, friction is produced at a portion at which the camshaft and a coupling are connected to each other (hereinafter, this portion will be simply referred to as a "connection portion"). Accordingly, the connection portion needs to be lubricated. The connection portion may be lubricated by the oil mist floating within a cylinder head cover. However, when a coupling that transfers high torque is used, the oil mist floating within the cylinder head cover may provide only insufficient lubrication to the connection portion. The connection portion may be lubricated by the lubricant supplied from the outside of the coupling by, for

example, an oil jet. However, when a coupling that is rotated at a high speed by the torque transferred from the camshaft is used, the supplied lubricant is dispersed by a centrifugal force. Accordingly, lubrication of the inside of the coupling is likely to be insufficient. If a structure dedicated solely to lubricate the connection portion is provided in an internal combustion engine, the structure of the internal combustion engine may be complicated.

[0004] Therefore, Japanese Patent Application Publication No. 2004-92621 (JP-A-2004-92621) describes the lubrication structure in which an oil passage formed in a camshaft extends to the coupling provided at the end of the camshaft and the lubricant is supplied to the coupling. The lubricant supplied to the coupling is dispersed from the center of the coupling toward the periphery thereof by the centrifugal force generated due to the rotation of the coupling. Accordingly, employing such structure makes it possible to appropriately lubricate the connection portion without an increase in the size of an apparatus, which would be caused if the structure dedicated solely to lubricate the connection portion were provided.

[0005] In the internal combustion engine described above, the vacuum pump is provided at one end of the camshaft and the supply pump is provided at the other end of the camshaft. In this case, the lubricant is supplied to the end of the camshaft, at which the vacuum pump is provided, and then supplied to a first coupling provided between the camshaft and the vacuum pump. Also, part of the lubricant supplied to the camshaft flows through an oil passage formed in the camshaft to be supplied to a second coupling provided between the camshaft and the supply pump. On the upstream side in the oil passage formed in the camshaft, part of the lubricant is supplied to the first coupling. On the downstream side in the oil passage, another part of the lubricant is supplied to the second coupling.

[0006] However, in the above-mentioned structure, in which the lubricant is supplied to the oil passage formed in the camshaft and then supplied to the second coupling, at a position on the downstream side in the oil passage, the inconvenience described below may be caused.

[0007] The lubricant flowing through the oil passage formed in the camshaft is supplied not only to the second coupling for the supply pump but also to, for example, cam lobes and cam journals of the camshaft. Accordingly, the hydraulic pressure at a position on the downstream side in the oil passage formed in the camshaft is lower than the hydraulic pressure at a position on the upstream side in the oil passage. As a result, only a small amount of lubricant may be supplied to the coupling for the supply pump, and, therefore, the coupling may not be sufficiently lubricated.

[0008] Such inconvenience of not being able to sufficiently lubricate a coupling may be caused not only in the structure where a coupling is provided between a supply pump and a camshaft but also in any structures in which a driving shaft of an internal combustion engine and a driven shaft of a driven element are connected to each other via a coupling.

SUMMARY OF THE INVENTION

[0009] The invention provides a coupling lubrication structure for a coupling that connects a driving shaft to a driven shaft of a driven element, the coupling lubrication structure making it possible to supply lubricant to an engine component that needs lubrication through an oil passage formed in the driving shaft as well as to supply a sufficient amount of lubricant to the coupling provided on the downstream side of the oil passage.

[0010] Hereafter, means for achieving the above-described objects and effects thereof will be described. An aspect of the invention relates to a coupling lubrication structure including a driving shaft of an internal combustion engine; a coupling that connects an end portion of the driving shaft to a driven shaft of a driven element; and a first oil passage and a second oil passage that are formed in the driven shaft, and that extend in the direction, in which the axis of the driving shaft extends, toward the downstream side on which the coupling is provided. A branch passage leading to an engine component that needs lubrication branches off from the first oil passage. The second oil passage leads to the sliding portion of the coupling.

[0011] The structure described above includes the first oil passage which is formed in the driving shaft, which extends in the direction, in which the axis of the driving shaft extends, toward the downstream side on which the coupling is provided, and from which the branch passage, which leads to the engine component that needs lubrication, branches off. Accordingly, the lubricant is supplied to the engine component that needs lubrication through the first oil passage. Also, the structure includes the second oil passage that is formed in the driving shaft, that extends in the direction, in which the axis of the driving shaft extends, toward the downstream side on which the coupling is provided, and that leads to the sliding portion of the coupling. Accordingly, it is possible to suppress a decrease in the hydraulic pressure of the lubricant flowing through the second oil passage, which may be caused before the lubricant reaches the coupling. As a result, it is possible to supply the lubricant to the engine component that needs lubrication through the first oil passage formed in the driving shaft as well as to supply a sufficient amount of lubricant to the coupling provided on the downstream side of the first oil passage.

[0012] In the aspect of the invention described above, the downstream side end of the second oil passage may lead to the rotational center of the coupling. Because the coupling is rotated by the torque transferred from the driving shaft, a centrifugal force is applied to the lubricant supplied to the coupling. Accordingly, the lubricant is dispersed from the rotational center of the coupling toward the periphery thereof. As a result, the lubricant is likely to be insufficient particularly in the area near the rotational center of the coupling.

[0013] With this structure, the lubricant flowing through the second oil passage is supplied to the rotational center of the coupling. Accordingly, it is possible to suppress a shortfall in the amount of lubricant present near the rotational center of the coupling.

[0014] In the aspect of the invention described above, the second oil passage may branch off from the first oil passage, at the uppermost-stream position of the first oil passage.

[0015] Because the lubricant flowing through the first oil passage is supplied to the

engine component that needs lubrication, the hydraulic pressure at a position on the downstream side in the first oil passage is lower than the hydraulic pressure at a position on the upstream side in the first oil passage. With the structure described above, because the second oil passage branches off from the first oil passage, at the uppermost-stream position of the first oil passage, the highest possible level of hydraulic pressure is maintained in the second oil passage. Accordingly, it is possible to reliably supply a sufficient amount of lubricant to the coupling provided on the downstream side of the first oil passage.

[0016] In the aspect described above, a passage that leads to the coupling may be only the second oil passage.

[0017] With this structure, the coupling is supplied with the lubricant only from the second oil passage. Accordingly, it is possible to suppress excessive supply of the lubricant to the coupling. The driving shaft may be one of an intake camshaft and an exhaust camshaft. The driven element may be, for example, a supply pump that supplies high-pressure fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The foregoing and further objects, features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein the same or corresponding portions are denoted by the same reference numerals and wherein:

FIG. 1 illustrates the cross-sectional view showing a coupling lubrication structure according to an embodiment of the invention;

FIG. 2 illustrates the front view and the side view showing a medium-diameter portion of an exhaust camshaft in the coupling lubrication structure shown in FIG. 1;

FIG. 3 illustrates the front view and the side view showing the structure of an Oldham's coupling in the coupling lubrication structure shown in FIG. 1;

FIG. 4 illustrates the front view and the side view showing the structure of a driven shaft of a supply pump in the coupling lubrication structure shown in FIG. 1;

FIG. 5 illustrates the perspective view showing the manner in which the exhaust camshaft, the Oldham's coupling and the supply pump are connected to each other in the coupling lubrication structure shown in FIG. 1;

FIG. 6 illustrates the cross-sectional view showing a coupling lubrication structure according to a first modified example of the embodiment of the invention;

FIG. 7 illustrates the cross-sectional view showing a coupling lubrication structure according to a second modified example of the embodiment of the invention; and

FIG. 8 illustrates the cross-sectional view showing a coupling lubrication structure according to a third modified example of the embodiment of the invention.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

[0019] Hereafter, a coupling lubrication structure in an internal combustion engine according to an embodiment of the invention will be described with reference to FIGs. 1 to 5. As shown in FIG. 1, a supply pump 3 is provided at one end of an exhaust camshaft 1, and a vacuum pump 4 is provided at the other end of the exhaust camshaft 1.

[0020] Cams 15 are provided on the exhaust camshaft 1 at predetermined intervals so that the cams 15 correspond to cylinders of the internal combustion engine. Cam journals 16 of the exhaust camshaft 1 are rotatably supported by bearings 52 provided at a cylinder head of the internal combustion engine and bearing caps 53.

[0021] The exhaust camshaft 1 has a large-diameter portion 14 at a position near the end at which the vacuum pump 4 is provided. The large-diameter portion 14 has a large-diameter cam journal 12 and a camshaft sprocket 13. The large-diameter cam journal 12 is rotatably supported by a large-diameter bearing 50 provided at the cylinder head of the internal combustion engine and a large-diameter bearing cap 51. The camshaft sprocket 13 is connected, via a chain, to a crankshaft sprocket that is provided on a crankshaft of the internal combustion engine. The exhaust camshaft 1 is rotated about the axis L by the torque transferred from the crankshaft to the exhaust camshaft 1.

[0022] The exhaust camshaft 1 has a medium-diameter portion 17 at a position near the end at which the supply pump 3 is provided. An Oldham's coupling 2 is provided

between the medium-diameter portion 17 of the exhaust camshaft 1 and a driven shaft 31 of the supply pump 3. The exhaust camshaft 1 and the driven shaft 31 are connected to each other via the Oldham's coupling 2. Namely, the torque of the exhaust camshaft 1, which is a driving shaft, is transferred, via the Oldham's coupling 2, to the driven shaft 31 of the supply pump 3, which is a driven shaft, whereby the supply pump 3, which is a driven element, is driven. The manner in which the exhaust camshaft 1 and the supply pump 3 are connected to each other will be described later in detail.

[0023] The manner in which, oil passages which are formed in the exhaust camshaft 1 and through which the lubricant flows, are formed will be described below. A first oil passage 62, which extends along the axis L, is formed in the exhaust camshaft 1. The first oil passage 62 is open at one end thereof, which is close to the large-diameter portion 14. The open end of the first oil passage 62 is referred to as an opening 62a. Meanwhile, the first oil passage 62 is closed at the other end thereof, which is close to the medium-diameter portion 17. In the large-diameter cam journal 12 of the large-diameter portion 14, a recessed journal groove 60 is circumferentially formed in the outer face of the large-diameter cam journal 12, and a large-diameter journal oil gallery 61, which extends in the radial direction of the large-diameter cam journal 12, is formed on the inner side of the journal groove 60. The journal groove 60 is communicated with the first oil passage 62 through the large-diameter journal oil gallery 61. The journal groove 60 is communicated with an oil passage 50a that is formed in the large-diameter bearing 50.

[0024] In each cam 15 provided on the exhaust camshaft 1, a cam oil gallery 63, which extends from the first oil passage 62 to the outer face of the cam 15, is formed. In each cam journal 16, a journal oil gallery 64, which extends from the first oil passage 62 to the outer face of the cam journal 16, is formed.

[0025] In the exhaust camshaft 1, a second oil passage 65, which extends in the direction in which the axis L extends and in parallel with the first oil passage 62, is formed. The second oil passage 65 is communicated, at one end thereof that is close to the large-diameter portion 14, with the first oil passage 62. The second oil passage 65 is

open at the other end thereof that is close to the medium-diameter portion 17. The position at which the second oil passage 65 is open coincides with the rotational axis of the medium-diameter portion 17. The open end of the second oil passage 65 is referred to as an opening 65a. The second oil passage 65 branches off from the first oil passage 62, at the position at which the first oil passage 62 meets the large-diameter journal oil gallery 61. Namely, the second oil passage 65 branches off from the first oil passage, at the uppermost-stream position of the first oil passage 62. The second oil passage 65 extends from the first oil passage 62 to the opening 65a without having any branches.

[0026] Next, the manner in which the exhaust camshaft 1 and the supply pump 3 are connected to each other will be described. First, the structures of the medium-diameter portion 17 of the exhaust camshaft 1, the Oldham's coupling 2, and the driven shaft 31 of the supply pump 3 will be described in detail with reference to FIGs. 2 to 4.

[0027] FIG. 2 shows the detailed structure of the medium-diameter portion 17 of the exhaust camshaft 1. As shown in FIG. 2, an annular projection 18 is formed at the periphery of the medium-diameter portion 17. Two notches 19 are formed in the annular projection 18. The two notches 19 are apart from each other, in the circumferential direction of the annular projection 18, by an angle of 180 degrees.

[0028] FIG. 3 shows the detailed structure of the Oldham's coupling 2. As shown in FIG. 3, the Oldham's coupling 2 is formed in a thick plate-like shape, and has a substantially-elliptical body 20, and two projections 21 that project from the periphery of the body 20. The two projections 21 are arranged on the same straight line that passes the center of the body 20. A through-hole 22, which has a rectangular cross-section, is formed in the center portion of the body 20. The through-hole 22 passes through the body 20 in the thickness direction thereof.

[0029] FIG. 4 shows the detailed structure of the driven shaft 31 of the supply pump 3. As shown in FIG. 4, the driven shaft 31 has a shaft portion 33, which has a circular cross-section. A connection portion 34 is formed at the end of the shaft portion 33. The connection portion 34 has a rectangular cross-section and extends in the axial direction of the driven shaft 31.

[0030] Next, the manner in which the exhaust camshaft 1 and the supply pump 3 are connected to each other will be described in detail with reference to FIG. 5. The connection between the exhaust camshaft 1 and the supply pump 3 is provided by the medium-diameter portion 17 of the exhaust camshaft 1, the Oldham's coupling 2, and the driven shaft 31 of the supply pump 3.

[0031] As shown in FIG. 5, the Oldham's coupling 2 is inserted in the space defined by the annular projection 18 of the medium-diameter portion 17 of the exhaust camshaft 1. At this time, the projections 21 of the Oldham's coupling 2 are fitted in the notches 29 of the medium-diameter portion 17. Then, the connection portion 34 of the driven shaft 31 is fitted in the through-hole 22 of the Oldham's coupling 2.

[0032] When the exhaust camshaft 1 rotates about the axis L, the Oldham's coupling 2 rotates about the axis L along with the exhaust camshaft 1, because the projections 21 of the Oldham's coupling 2 are fitted in the notches 29 of the medium-diameter portion 17. When the Oldham's coupling 2 rotates about the axis L, the driven shaft 31 rotates about the axis L along with the Oldham's coupling 2, because the connection portion 34 of the driven shaft 31 is fitted in the through-hole 22 of the Oldham's coupling 2.

[0033] In the manner described above, the exhaust camshaft 1 and the driven shaft 31 of the supply pump 3 are connected to each other so that they can rotate together with each other. Next, the coupling lubrication structure in the internal combustion engine will be described with reference to FIG. 1.

[0034] As shown in FIG. 1, when the lubricant is supplied from an oil pump of the internal combustion engine to the oil passage 50a formed in the large-diameter bearing 50, the lubricant is then supplied to the first oil passage 62 through the journal groove 60 and the large-diameter journal oil gallery 61.

[0035] The flow of the lubricant supplied to the first oil passage 62 is split into some flows, at the position at which the first oil passage 62 meets the second oil passage 65, and the lubricant is supplied to engine components that need lubrication. Namely, a part of the lubricant flows through the first oil passage 62 to be supplied to the vacuum pump 4. Another part of the lubricant flows through the first oil passage 62 toward the

downstream side, that is, the Oldham's coupling 2 side to be supplied to the cams 15 through the cam oil galleries 63, and to the cam journals 16 through the journal oil galleries 64. The remaining lubricant flows through the second oil passage 65 toward the downstream side, that is, the Oldham's coupling 2 side to be supplied to the rotational center of the Oldham's coupling 2 through the opening 65a of the second oil passage 65.

[0036] With the lubrication structure described above, the lubricant flowing through the first oil passage 62 is supplied only to the vacuum pump 4, the cams 15, and the cam journals 16 without being supplied to the Oldham's coupling 2. Meanwhile, the lubricant flowing through the second oil passage 65 is supplied only to the Oldham's coupling 2.

[0037] The embodiment of the invention described above produces the following effects. (1) The first oil passage 62 for supplying the lubricant to the cams 15 and the cam journals 16 is formed in the exhaust camshaft 1 along the axis L, and the end thereof on the Oldham's coupling 2 side is used as the downstream side. Accordingly, the lubricant is supplied to the cams 15 and the cam journals 16 through the first oil passage 62. Also, the second oil passage 65 for supplying the lubricant only to the Oldham's coupling 2 is formed in the exhaust camshaft 1 in parallel with the axis L, and the end thereof on the Oldham's coupling 2 side is used as the downstream side. Accordingly, it is possible to suppress a decrease in the hydraulic pressure of the lubricant flowing through the second oil passage 65, which may be caused before the lubricant reaches the Oldham's coupling 2. As a result, it is possible to supply a sufficient amount of lubricant to the Oldham's coupling 2 provided on the downstream side of the first oil passage 62, while supplying the lubricant from the first oil passage 62 formed in the exhaust camshaft 1 to the engine components which need lubrication.

[0038] (2) Because the lubricant flowing through the second oil passage 65 is supplied only to the rotational center of the Oldham's coupling 2, a shortfall in the amount of the lubricant present near the rotational center of the Oldham's coupling 2 is suppressed. (3) Because the second oil passage 65 branches off from the first oil passage 62, at the uppermost-stream position of the first oil passage 62, the highest

possible level of hydraulic pressure is maintained in the second oil passage 65. Accordingly, it is possible to reliably supply a sufficient amount of lubricant to the Oldham's coupling 2 provided on the downstream side of the first oil passage 62.

[0039] (4) Because the Oldham's coupling 2 is supplied with the lubricant only from the second oil passage 65, excessive supply of the lubricant to the Oldham's coupling 2 is suppressed. The embodiment of the invention may be appropriately modified in the following manners.

[0040] According to the embodiment of the invention described above, the second oil passage 65 and the first oil passage 62 are communicated with each other. Alternatively, the structure in which the second oil passage and the first oil passage are not communicated with each other, namely, the structure in which the second oil passage and the first oil passage are formed separately from each other may be employed. FIG. 6 shows the coupling lubrication structure in which the second oil passage and the first oil passage are formed separately from each other. As shown in FIG. 6, in a large-diameter portion 114 of the exhaust camshaft 1, the recessed journal groove 60 and a recessed second journal groove 166 are circumferentially formed in the outer face thereof, and the large-diameter journal oil gallery 61 and a second journal oil gallery 167, which extend in the radial direction of the large-diameter portion 114, are formed. The large-diameter journal oil gallery 61 and the second journal oil gallery 167 are formed on the inner sides of the journal groove 60 and the second journal groove 166, respectively. A first sub-oil passage 150a formed in a large-diameter bearing 150 is communicated with the first oil passage 62 through the journal groove 60 and the large-diameter journal oil gallery 61. The second journal groove 166 is communicated with a second oil passage 165 through the second journal oil gallery 167. A second sub-oil passage 150b formed in the large-diameter bearing 150 is communicated with the second oil passage 165 through the second journal groove 166 and the second journal oil gallery 167. With the structure described above, the first oil passage 62 is supplied with the lubricant only from the first sub-oil passage 150a formed in the large-diameter bearing 150, and the lubricant supplied to the first oil passage 62 is supplied to the cams 15 and the cam

journals 16. Meanwhile, the second oil passage 165 is supplied with the lubricant only from the second sub-oil passage 150b formed in the large-diameter bearing 150, and the lubricant supplied to the second oil passage 165 is supplied to the Oldham's coupling 2.

[0041] According to the embodiment of the invention described above, the lubricant flowing through the second oil passage 65 is supplied to the rotational center of the Oldham's coupling 2. Alternatively, the lubricant flowing through the second oil passage 65 may be supplied to other portion of the Oldham's coupling 2 than the rotational center.

[0042] According to the embodiment of the invention described above, the coupling lubrication structure includes the second oil passage 65 that branches off from the first oil passage 62, at the position at which the first oil passage 62 meets the large-diameter journal oil gallery 61, namely, the uppermost-stream position of the first oil passage 62. Alternatively, as shown in FIG.7, the coupling lubrication structure may include a second oil passage 168 that branches off from the first oil passage 62, at a position downstream of the position at which the first oil passage 62 meets the large-diameter oil gallery 61, namely, at a position that is closer to the Oldham's coupling 2 than the position, at which the first oil passage 62 meets the large-diameter oil gallery 61, is.

[0043] According to the embodiment of the invention described above, the Oldham's coupling 2 is supplied with the lubricant only from the second oil passage 65. Alternatively, as shown in FIG. 8, the Oldham's coupling 2 may be supplied with the lubricant from both a first oil passage 162 and the second oil passage 65.

[0044] According to the embodiment of the invention described above, the Oldham's coupling is employed as the coupling that connects the end of the exhaust camshaft 1 to the driven shaft 31 of the supply pump 3. Alternatively, another type of coupling, for example, a Jaw-flex coupling or a Bellows-coupling may be employed.

[0045] According to the embodiment of the invention described above, the driven element that is connected to the camshaft 1 via the Oldham's coupling 2 is the supply pump 3. Alternatively, the driven element may be another device, such as a vacuum pump, that is driven by the torque transferred from the driving shaft.

[0046] According to the embodiment of the invention described above, the driving shaft is the exhaust camshaft 1. Alternatively, the driving shaft may be an intake camshaft or another shaft.

[0047] According to the embodiment of the invention described above, the lubricant flowing through the second oil passage 65 is supplied only to the Oldham's coupling 2. Alternatively, the lubricant flowing through the second oil passage 65 may be supplied to the engine components that need lubrication. In this case, the number of oil galleries that branch off from the second oil passage may be equal to or less than the number of oil galleries that branch off from the first oil passage. With this structure, it is possible to efficiently suppress a decrease in the hydraulic pressure of the lubricant flowing through the second oil passage 65, which may be caused before the lubricant reaches the Oldham's coupling 2, as compared to related art. Accordingly, it is possible to supply a sufficient amount of the lubricant to the Oldham's coupling 2.

CLAIMS (PCT)

1. A coupling lubrication structure, characterized by comprising:
 - a driving shaft of an internal combustion engine;
 - a coupling that connects an end portion of the driving shaft to a driven shaft of a driven element; and
 - a first oil passage and a second oil passage which are formed in the driving shaft, and which extend in a direction, in which an axis of the driving shaft extends, toward a downstream side on which the coupling is provided, wherein
 - a branch passage leading to an engine component that needs lubrication branches off from the first oil passage, and
 - the second oil passage leads to a sliding portion of the coupling.
2. The coupling lubrication structure according to claim 1, characterized in that the second oil passage leads only to the coupling.
3. The coupling lubrication structure according to claim 1 or 2, characterized in that the second oil passage leads to a rotational center of the coupling.
4. The coupling lubrication structure according to any one of claims 1 to 3, characterized in that
 - the second oil passage leads only to the rotational center of the coupling.
5. The coupling lubrication structure according to any one of claims 1 to 4, characterized in that
 - the second oil passage branches off from the first oil passage.
6. The coupling lubrication structure according to any one of claims 1 to 5, characterized in that

the second oil passage branches off from the first oil passage, at a position between an uppermost-stream position of the first oil passage and a position at which the branch passage, which is closest to the uppermost-stream position, branches off from the first oil passage.

7. The coupling lubrication structure according to any one of claims 1 to 6, characterized in that

the second oil passage branches off from the first oil passage, at the uppermost-stream position of the first oil passage.

8. The coupling lubrication structure according to any one of claims 1 to 7, characterized in that

a passage that leads to the coupling is only the second oil passage.

9. The coupling lubrication structure according to any one of claims 1 to 7, characterized in that

the first oil passage does not lead to the coupling and the second oil passage leads to the coupling.

10. The coupling lubrication structure according to any one of claims 1 to 9, characterized in that

the driving shaft is one of an intake camshaft and an exhaust camshaft, and the driven element is a supply pump that supplies high-pressure fuel.

11. The coupling lubrication structure according to any one of claims 1 to 10, characterized in that

the coupling is an Oldham's coupling.

FIG. 2

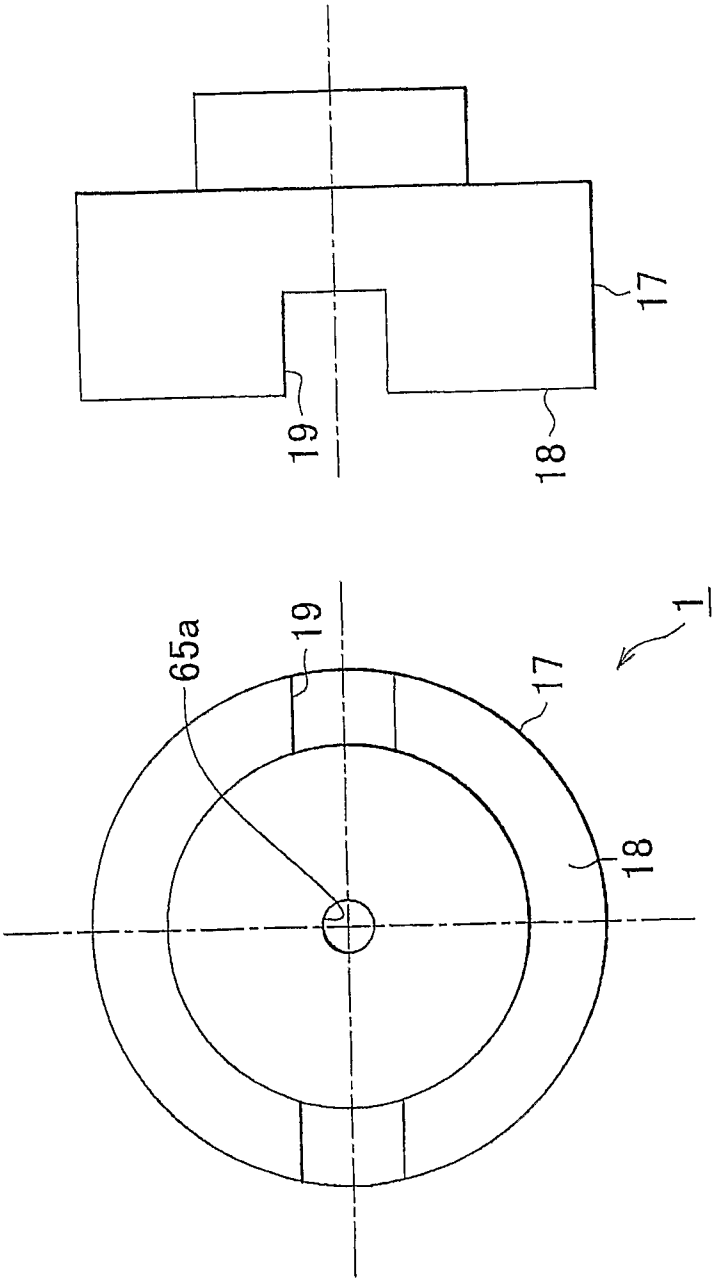


FIG. 3

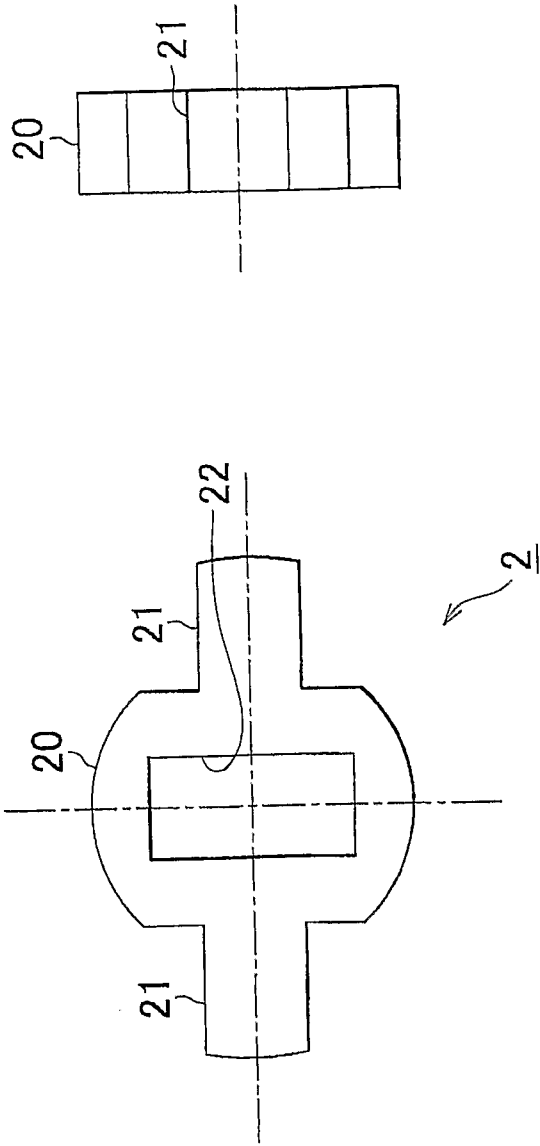


FIG. 4

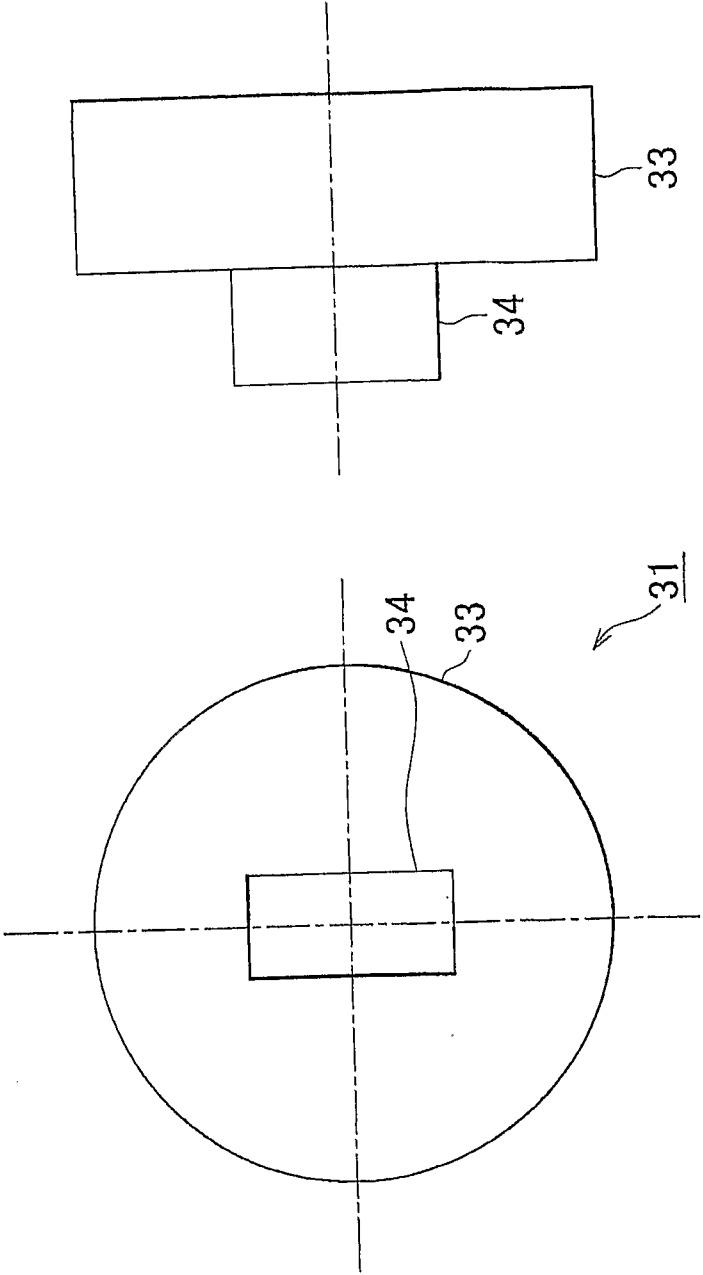


FIG. 5

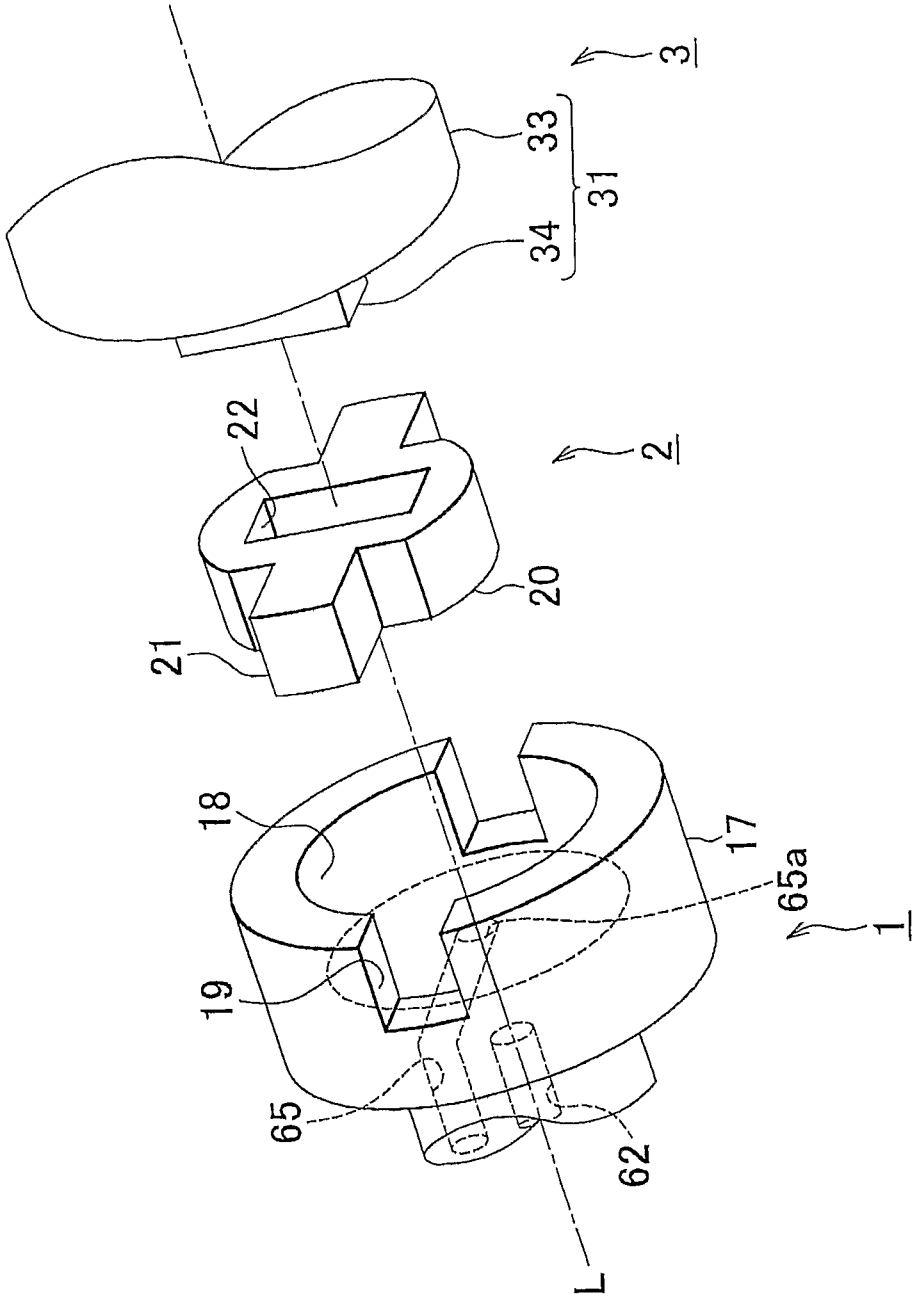


FIG. 7

