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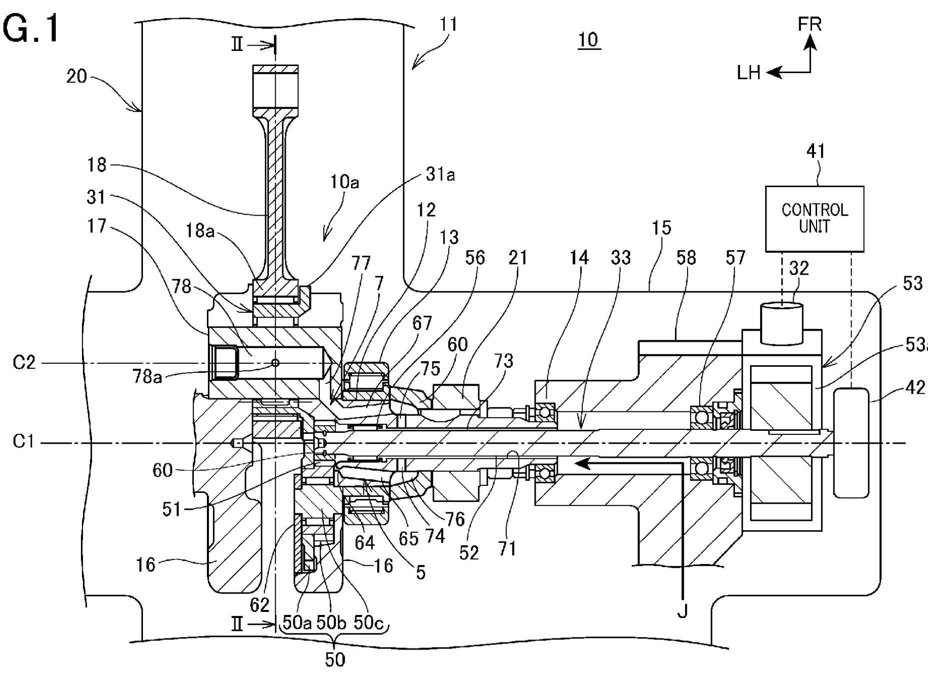
(54) **VARIABLE COMPRESSION-RATIO DEVICE**

(57) An object is to provide oil supply to a variable compression-ratio device. A variable compression-ratio device includes: a gear shaft (52) disposed inside a crankshaft (12) of an internal combustion engine (11) coaxially with the crankshaft (12) and configured to be rotationally driven by a power source (32); an input gear (51) connected to the gear shaft (52); an intermediate gear (50) supported by a crank web (16) of the crankshaft (12) and engaged with the input gear (51); an eccentric cam (31) disposed between a crank pin (17) of the crankshaft (12) and a large end (18a) of a connecting rod (18) and engaged with the intermediate gear (50); and a first oil channel (5) configured to supply lubricating oil to the input gear (51).

FIG.1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to variable compression-ratio devices.

Description of the Related Art

[0002] There has been known a crankshaft support structure of an internal combustion engine including an oil channel for supplying lubricating oil to a crankshaft bearing portion or the like (for example, Japanese Patent Laid-Open No. 2012-36934). There has also been disclosed a configuration of a multi-link variable-compression-ratio engine in which outflow of lubricating oil into the combustion chamber can be prevented, and oil deterioration due to blowby gas containing unburned fuel can be reduced (for example, Japanese Patent Laid-Open No. 2009-503971). Meanwhile, there has been known a variable compression-ratio device in which an eccentric cam is provided between the crank pin of the crankshaft and the large end of the connecting rod, and a motor rotates the eccentric cam to change the distance between the center axis of the large end and the axis of the crankshaft.

[0003] Unfortunately, the above structure does not take supplying oil to the variable compression-ratio device into account.

[0004] The present invention has been made in light of such circumstances, and an object thereof is to provide oil supply to the variable compression-ratio device.

SUMMARY OF THE INVENTION

[0005] An aspect of the present invention is a variable compression-ratio device including: a gear shaft disposed inside a crankshaft of an internal combustion engine coaxially with the crankshaft and configured to be rotationally driven by a power source; an input gear connected to the gear shaft; an intermediate gear supported by a crank web of the crankshaft and engaged with the input gear; an eccentric cam disposed between a crank pin of the crankshaft and a large end of a connecting rod and engaged with the intermediate gear; and a first oil channel configured to supply lubricating oil to the input gear.

[0006] Since the crankshaft is provided with a first oil channel for supplying lubricating oil to the input gear, it is possible to supply oil to an input gear of the variable compression-ratio device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a diagram illustrating the internal structure of a variable compression-ratio device of the present invention;

FIG. 2 is a diagram illustrating a crank pin, an eccentric cam, and their peripheral configurations; and

FIG. 3 is an enlarged view of an input gear and its vicinities of the variable compression-ratio device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0008] Hereinafter, an embodiment of the present invention will be described with reference to the drawings. Note that in the following description, mentioning of directions such as frontrear, right-left, and upper-lower means the same directions as the ones with respect to the vehicle body unless otherwise specified. In each drawing, the symbol FR indicates the front side of the vehicle body, the symbol UP indicates the upper side of the vehicle body, and the symbol LH indicates the left side of the vehicle body.

[0009] FIG. 1 is a diagram illustrating the internal structure of a power unit 10 including a variable compression-ratio device 10a of the present embodiment. This power unit 10 is configured to be mounted on a motorcycle and includes an engine 11 which is an internal combustion engine. The application of this power unit is not limited to motorcycles but may be mounted on various types of saddle-ride vehicle including three-wheeled and four-wheeled ones.

[0010] The engine 11 includes a crank case 15 that supports a crankshaft 12 via a plurality of bearings 13 and 14 so that the crankshaft 12 is rotatable and a cylinder portion 20 that houses a not-illustrated piston connected to the crankshaft 12 via a crank web 16, a crank pin 17, and a connecting rod 18 in this order such that the piston is slidable.

[0011] The crankshaft 12 supports a primary gear 21 engaged with a not-illustrated driven gear. Between this primary gear 21 and the bearing 13 that supports the crankshaft 12 is a primary gear collar 60 for positioning the primary gear 21. FIG. 1 illustrates a horizontal engine 11 in which the cylinder portion 20 protrudes forward horizontally from the crank case 15.

[0012] In FIG. 1, the symbol C1 indicates the axis of the crankshaft 12 supported by the crank case 15. The symbol C2 indicates the axis of the crank pin 17. The axis C1 of the crankshaft 12 and the axis C2 of the crank pin 17 are parallel.

[0013] The variable compression-ratio device 10a includes an eccentric cam 31 between the outer periphery of the crank pin 17 of the crankshaft 12 and the inner periphery of the large end 18a of the connecting rod 18. The variable compression-ratio device 10a also includes a motor 32 that serves as the power source of the eccentric cam 31 and a power transmission mechanism 33 that transmits the power of the motor 32 to the eccentric cam 31.

[0014] The power transmission mechanism 33 includes a gear shaft 52 coaxially disposed inside the crankshaft 12 of the internal combustion engine 11, an input gear 51 connected to an end portion of the gear shaft 52, an intermediate gear 50 supported by the crank web 16 of the crankshaft 12 and engaged with the input gear 51, and the aforementioned eccentric cam 31 engaged with the intermediate gear 50.

[0015] The gear shaft 52 is disposed inside the crankshaft 12 coaxially with the crankshaft 12 and rotatably supported via a pair of bearings 56 and 57. This gear shaft 52 passes through a cover 58 located on the right side of the crankshaft 12 and extends to a position near the motor 32. Inside the cover 58 is provided an oil (indicated by the symbol J in FIG. 1) from a not-illustrated oil pump provided in the power unit 10, and this oil lubricates each of the bearings 56 and 57.

[0016] A driving-side gear portion 53 has a warm gear 53a connected to the proximal end of the gear shaft 52 with a key, and this warm gear 53a reduces the rotation speed of a warm wheel attached to the motor 32 and transmits the rotation to the gear shaft 52. Note that the configuration of the driving-side gear portion 53 is not limited to the one using the warm gear 53a, but a known speed reducing mechanism can be adopted as appropriate. Although this example is based on a case in which the power source is the motor 32, the power source does not necessarily have to be the motor 32.

[0017] The rotation angle of the motor 32 is controlled by a control unit 41 mounted on the motorcycle. This control unit 41 obtains the rotation position of a part of the power transmission mechanism 33 (the rotation position of the gear shaft 52 in this configuration) via a potentiometer 42, and based on the obtained rotation position, this control unit 41 controls the rotation of the motor 32 such that it is at the target position. The control unit 41 is, for example, an electronic control unit (ECU) provided on the motorcycle.

[0018] Next, the eccentric cam 31, the power transmission mechanism 33, and their peripheral configurations will be described.

[0019] FIG. 2 is a cross-sectional view taken along line II-II in FIG. 1, illustrating the crank pin 17, the eccentric cam 31, and their peripheral configurations.

[0020] As illustrated in FIG. 2, the thickness t of the eccentric cam 31 gradually changes in the circumferential direction. When the motor 32 is driven, the power is transmitted to the eccentric cam 31 via the power transmission mechanism 33, the eccentric cam 31 rotates in the circumferential direction.

[0021] At the reference position, the position of the center axis Co of the large end 18a of the connecting rod 18 is in agreement with the position of the axis C2 of the crank pin 17.

[0022] When the eccentric cam 31 rotates, the thickness t of the eccentric cam 31 changes in the circumferential direction, and the position of the center axis Co of the large end 18a of the connecting rod 18 is displaced from the axis C2 of the crank pin 17 to the position of the eccentric axis C_3, which is shifted from the axis C2. This displacement changes the distance between the center axis Co of the large end 18a and the axis C1 of the crankshaft 12, and this changes the stroke of the piston, changing the compression ratio.

[0023] The outer periphery of the eccentric cam 31 has a gear portion 31a, as illustrated in FIG. 1. The gear portion 31a of the eccentric cam 31 engages with a large diameter gear 50a of the intermediate gear 50, and a small diameter gear 50b of the intermediate gear 50 engages with the input gear 51 of the gear shaft 52. The intermediate gear 50 is a double gear including the large diameter gear 50a and the small diameter gear 50b.

[0024] As illustrated in FIG. 2, at least part (a lower half) of the intermediate gear 50 is covered with a cover member 62. The cover member 62 is fastened to the crank web 16 by fasteners 54 such that the intermediate gear 50 is sandwiched between the cover member 62 and the crank web 16. The fasteners 54 function as coming-off prevention parts that prevent the intermediate gear 50 from coming off.

[0025] The peripheral edge portion 62a of the cover member 62 including the lower portion is closely joined to the crank web 16 and sealed with a gasket or a filler.

[0026] The space between the crank web 16 and the cover member 62 serves as an oil sump 63 of lubricating oil. The lubricating oil gathered near the intermediate gear 50 by the oil sump 63 improves the initial lubrication property of the variable compression-ratio device at the time when the internal combustion engine 11 restarts.

[0027] Next, the supply route of the lubricating oil for the variable compression-ratio device 10a will be described.

[0028] As illustrated in FIG. 3, the gear shaft 52 is disposed in a through hole 71 of the crankshaft 12. Between the inner periphery of the through hole 71 of the crankshaft 12 and the outer periphery of the gear shaft 52 is formed an annular third oil channel 73.

[0029] The third oil channel 73 is provided with oil (indicated by the symbol J in FIG. 1) from a not-illustrated oil pump disposed in the power unit 10.

[0030] The third oil channel 73 communicates with a fourth oil channel 74 and fifth oil channel 75 in the form of small holes, formed in the crankshaft 12. The fourth oil channel 74 and the fifth oil channel 75 communicate with an annular sixth oil channel 76. The annular sixth oil channel 76 is formed between the primary gear collar 60 for positioning the primary gear 21 and the outer periphery of the crankshaft 12. Since the sixth oil channel 76 is provided inside the primary gear collar 60, the number of parts forming the oil channel can be reduced, providing effects of improving manufacturing efficiency.

[0031] The sixth oil channel 76 communicates with a first oil guide channel 65 formed in the crankshaft 12 illustrated at a lower portion of FIG. 3 and communicates with a second oil guide channel 67 also formed in the crankshaft 12, illustrated at an upper portion in FIG. 3.

[0032] The first oil guide channel 65 extends being inclined toward the axis C1 of the crankshaft 12 and along the crankshaft 12. At the end portion on the input gear 51 side of the first oil guide channel 65 is provided an orifice 64. The orifice 64 is provided in the crank web 16. The orifice 64 has an opening at a position facing the tooth surface of the input gear 51. It is desirable that the diameter of the orifice 64 be smaller than or equal to 1 mm.

[0033] Lubricating oil provided in the first oil guide channel 65 is provided onto the tooth surface of the input gear 51 of the variable compression-ratio device 10a through the orifice 64. Since lubricating oil is provided through the orifice 64, the amount of lubricating oil is adjusted, and the oil supply can be reliable.

[0034] In addition, since the first oil guide channel 65 is inclined toward the axis C1 of the crankshaft 12, foreign objects contained in lubricating oil tend to stick to the inner peripheral surface of the first oil guide channel 65 by centrifugal force, and thus it is possible to keep the cleanliness of lubricating oil provided to the variable compression-ratio device 10a.

[0035] A "first oil channel 5" is provided at a peripheral portion of the crank web 16 and includes the annular third oil channel 73, the fourth oil channel 74 in the form of a small hole, the annular sixth oil channel 76, the first oil guide channel 65, and the orifice 64.

[0036] Since the above oil channels 74, 65, and 64 are formed by making holes in the crankshaft 12 or the crank web 16, and the sixth oil channel 76 is formed inside the primary gear collar 60, the first oil channel 5 has a simple, compact structure.

[0037] The second oil guide channel 67 extends being inclined toward the axis C1 of the crankshaft and along the crankshaft 12. The second oil guide channel 67 bends in the middle and communicates with a seventh oil channel 77 formed in the crank pin 17 and an eighth oil channel 78 orthogonal to the seventh oil channel 77. The lubricating oil supplied in the eighth oil channel 78 is supplied to the inner peripheral surface of the large end 18a of the connecting rod 18 through a hole 78a. The second oil guide channel 67 is inclined toward the axis C1 of the crankshaft. Hence, foreign objects contained in lubricating oil tend to stick to the inner peripheral surface of the second oil guide channel 67 by centrifugal force. Thus, it is possible to keep the cleanliness of the lubricating oil supplied to the crank pin 17.

[0038] A "second oil channel 7" includes the annular third oil channel 73 provided at a peripheral portion of the crank web 16, the fifth oil channel 75 in the form of a small hole, the annular sixth oil channel 76, the second oil guide channel 67, the seventh oil channel 77, and the eighth oil channel 78.

[0039] Since the above oil channels 75, 67, 77, and 78 are formed by making holes in the crankshaft 12 or the crank web 16, and the sixth oil channel 76 is formed inside the primary gear collar 60, the second oil channel 7 has a simple, compact structure.

(Configurations Supported by Embodiment Described Above)

[0040] The above embodiment supports the following configurations.

[0041] (Configuration 1) A variable compression-ratio device including: a gear shaft disposed inside a crankshaft of an internal combustion engine coaxially with the crankshaft and configured to be rotationally driven by a power source; an input gear connected to the gear shaft; an intermediate gear supported by a crank web of the crankshaft and engaged with the input gear; an eccentric cam disposed between a crank pin of the crankshaft and a large end of a connecting rod and engaged with the intermediate gear; and a first oil channel provided in the crankshaft and configured to supply lubricating oil to the input gear.

[0042] This configuration makes it possible to reliably supply oil to the input gear. In addition, it is possible to supply lubricating oil also to the intermediate gear by utilizing centrifugal force. In other words, it is possible to provide effects of efficiently lubricating each part of the eccentric cam driving mechanism.

[0043] (Configuration 2) The variable compression-ratio device according to Configuration 1, in which the first oil channel is provided at a peripheral portion of the crank web.

[0044] This configuration makes it possible to form the first oil channel with a compact structure.

[0045] (Configuration 3) The variable compression-ratio device according to Configuration 1 or 2, in which the crankshaft is provided with a primary gear collar to position a primary gear, and at least part of the first oil channel is provided inside the primary gear collar.

[0046] This configuration provides effects of reducing the part count and improving the manufacturing efficiency.

[0047] (Configuration 4) The variable compression-ratio device according to any one of Configurations 1 to 3, in which an orifice is provided at an end portion on the input gear side of the first oil channel.

[0048] This configuration makes it easy to adjust the amount of lubricating oil and provides effects of reliably supplying oil to the variable compression-ratio device.

[0049] (Configuration 5) The variable compression-ratio device according to any one of Configurations 1 to 4, in which the first oil channel includes a first oil guide channel inclined relative to the axis of the crankshaft.

[0050] This configuration makes it likely that foreign objects contained in the lubricating oil stick to outer peripheral portions by centrifugal force. This provides effects of making it likely that the lubricating oil led to the variable compression-ratio device is kept clean.

[0051] (Configuration 6) The variable compression-ratio device according to any one of Configurations 1 to 5, further including a second oil channel to supply lubricating oil to the crank pin, in which the second oil channel includes a second oil guide channel inclined relative to the axis of the crankshaft.

[0052] This configuration makes it likely that foreign objects contained in the lubricating oil stick to outer peripheral portions by the centrifugal force. This provides effects of making it likely that the lubricating oil led to the crank pin is kept clean.

[0053] (Configuration 7) The variable compression-ratio device according to any one of Configurations 1 to 6, further including a cover member that covers at least part of the intermediate gear from outside and allows an oil sump to be formed inside the cover member.

[0054] Since with this configuration, lubricating oil is gathered near the intermediate gear when the internal combustion engine restarts, the initial lubrication property of the variable compression-ratio device is improved.

[0055] Note that the above embodiment is for describing an aspect to which the present invention is applied, and thus, the present invention is not limited to the above embodiment.

REFERENCE SIGNS LIST

[0056]

3	eccentric cam driving mechanism
5	first oil channel
7	second oil channel
10	power unit
10a	variable compression-ratio device
11	engine (internal combustion engine)
16	crank web
17	crank pin
18	connecting rod
21	primary gear
31	eccentric cam
50	intermediate gear
51	input gear
52	gear shaft
60	primary gear collar
62	cover member
64	orifice
65	first oil guide channel
67	second oil guide channel
C1	axis of crankshaft

Claims

1. A variable compression-ratio device **characterized by** comprising:

a gear shaft (52) disposed inside a crankshaft (12) of an internal combustion engine (11) coaxially with the crankshaft (12) and configured to be rotationally driven by a power source (32);
an input gear (51) connected to the gear shaft (52);
an intermediate gear (50) supported by a crank web (16) of the crankshaft (12) and engaged with the input gear (51);
an eccentric cam (31) disposed between a crank pin (17) of the crankshaft (12) and a large end (18a) of a connecting rod (18) and engaged with the intermediate gear (50); and
a first oil channel (5) configured to supply lubricating oil to the input gear (51).

2. The variable compression-ratio device according to claim 1, wherein
the first oil channel (5) is provided at a peripheral portion of the crank web (16).

3. The variable compression-ratio device according to claim 1 or 2, wherein

the crankshaft (12) is provided with a primary gear collar (60) to position a primary gear (21), and
at least part of the first oil channel (5) is provided inside the primary gear collar (60).

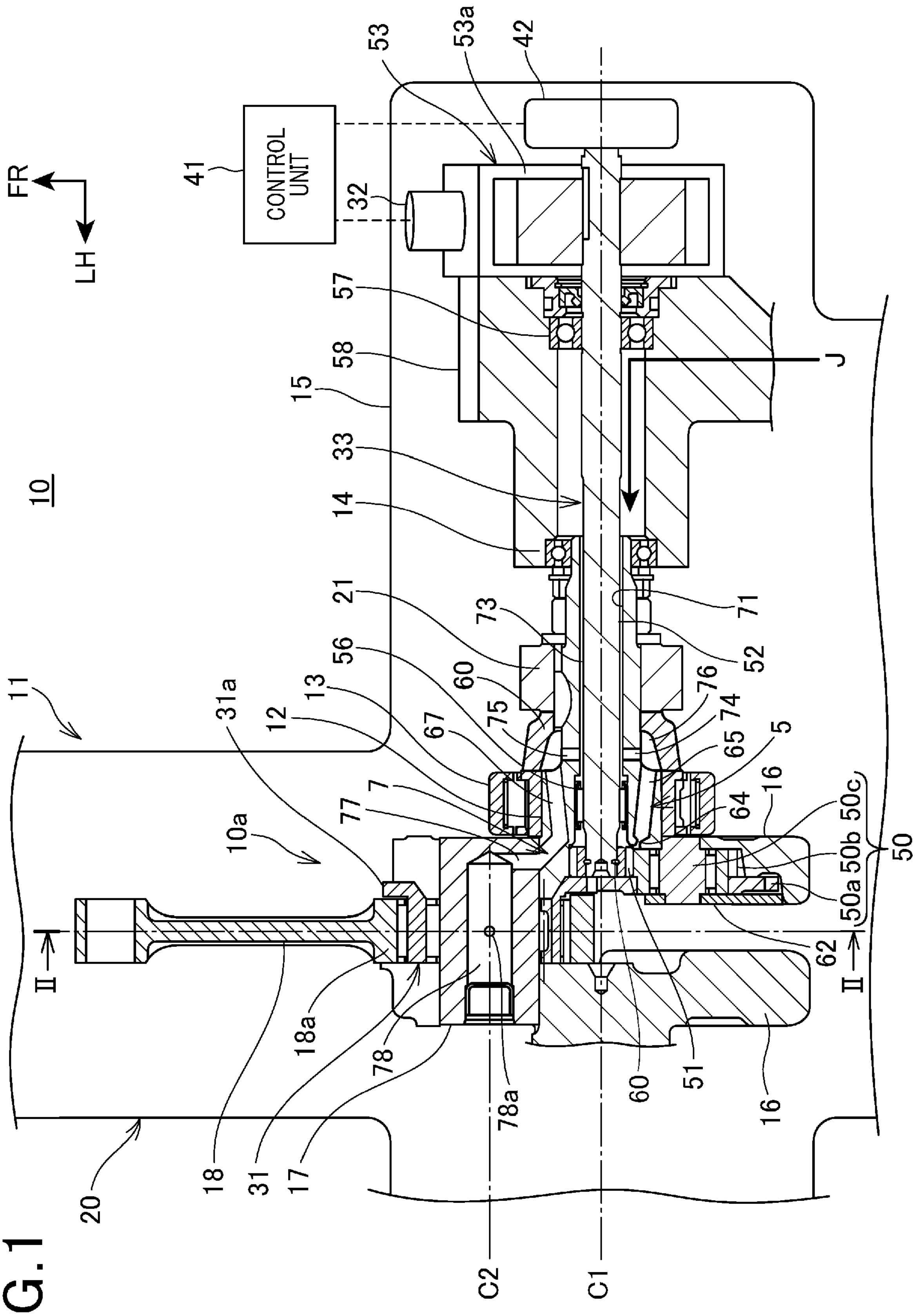
4. The variable compression-ratio device according to any one of claims 1 to 3, wherein
an orifice (64) is provided at an end portion on the input gear (51) side of the first oil channel (5).

5. The variable compression-ratio device according to any one of claims 1 to 4, wherein
the first oil channel (5) includes a first oil guide channel (65) inclined relative to an axis (C1) of the crankshaft (12).

6. The variable compression-ratio device according to any one of claims 1 to 5, further comprising

a second oil channel (7) to supply lubricating oil to the crank pin (17), wherein
the second oil channel (7) includes a second oil guide channel (67) inclined relative to an axis (C_1) of the crankshaft (12).

7. The variable compression-ratio device according to any one of claims 1 to 6, further comprising
a cover member (62) that covers at least part of the intermediate gear (50) from outside and allows an oil sump to be formed inside the cover member (62).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50c
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71
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74
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76
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78
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J
II
C1
C2

FIG.1

FIG.2

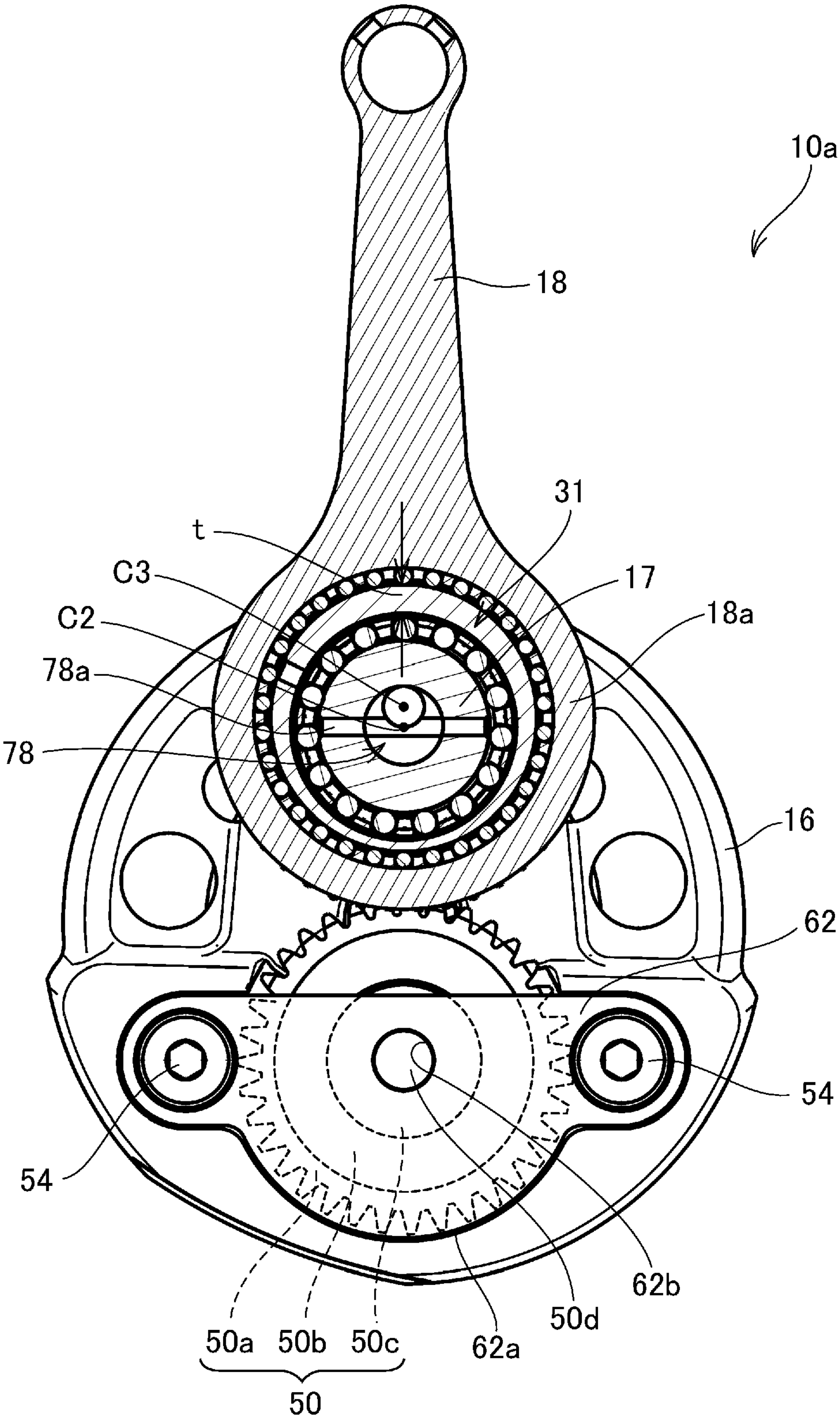
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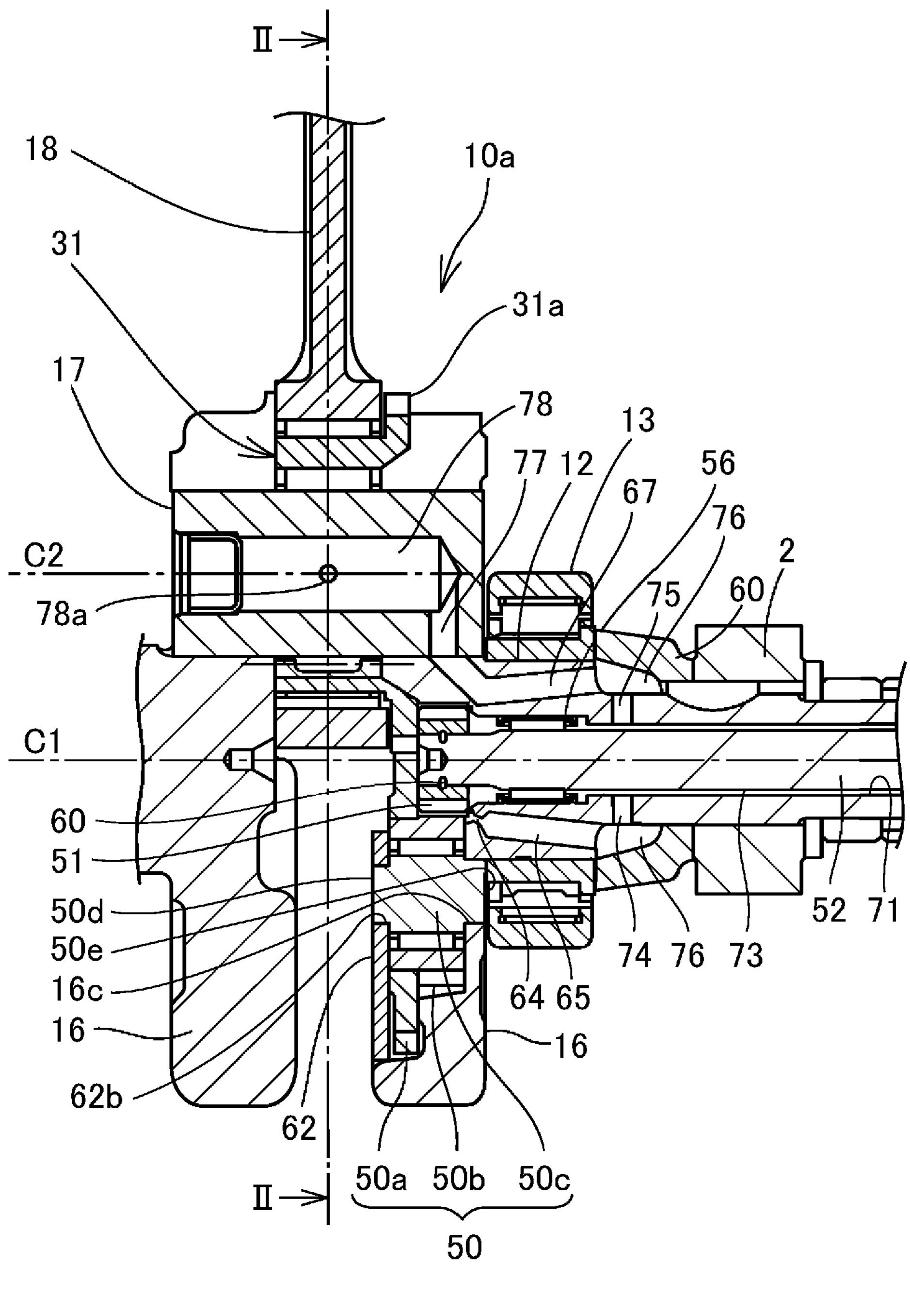
FIG.3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62b
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76
73
64
65
16
50a
50b
50c
50
II

REFERENCES CITED IN THE DESCRIPTION

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