(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 992 441 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
04.05.2022 Bulletin 2022/18

(21) Application number: **20835661.8**

(22) Date of filing: **22.06.2020**

(51) International Patent Classification (IPC):
F01M 13/04 *(2006.01)* ***F02D 35/00*** *(2006.01)*
F02F 7/00 *(2006.01)* ***F02B 61/02*** *(2006.01)*
F02B 77/00 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F01M 13/04; F02B 61/02; F02B 77/00; F02D 35/00; F02F 7/00

(86) International application number:
PCT/JP2020/024474

(87) International publication number:
WO 2021/002236 (07.01.2021 Gazette 2021/01)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **01.07.2019 JP 2019122892**

(71) Applicant: **HONDA MOTOR CO., LTD.**
Minato-ku
Tokyo 107-8556 (JP)

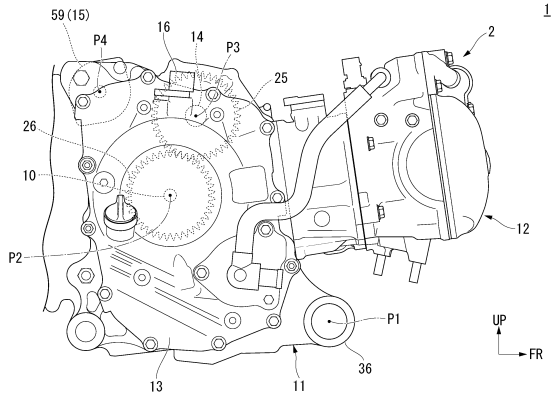
(72) Inventors:
- **TOMIOKA Yusuke**
  Wako-shi, Saitama 351-0193 (JP)
- **KATSUTA Jumpei**
  Wako-shi, Saitama 351-0193 (JP)

(74) Representative: **Dehns**
St. Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

(54) **INTERNAL COMBUSTION ENGINE STRUCTURE**

(57) An internal combustion engine structure includes: a crankshaft (10) that converts reciprocating motion of a piston (24) disposed inside a cylinder (12) of an internal combustion engine (2) to be mounted on a vehicle into rotational motion; a case member (11) that houses the crankshaft (10); a balancer shaft (14) that suppresses vibration of the crankshaft (10); a starting device (15) that starts the internal combustion engine (2); and a detection device (16) that is disposed between the balancer shaft (14) and the starting device (15) in a side view and determines the rotation speed of the crankshaft (10).

FIG. 5



EP 3 992 441 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an internal combustion engine structure.

[0002] Priority of the present invention is claimed on Japanese Patent Application No. 2019-122892, filed July 1, 2019, the content of which is incorporated herein by reference.

BACKGROUND ART

[0003] Conventionally, in an internal combustion engine of a saddle-ride vehicle, a structure including a detection object that rotates integrally with a crankshaft and a detection sensor that generates a pulse signal according to movement of the detection object is known. For example, a structure of Patent Document 1 includes an annular plate-shaped pulser ring (detection object) coupled to a crankshaft coaxially with a rotation axis of the crankshaft, and a pulser sensor (detection sensor) that is oriented toward an annular trajectory of the pulser ring and generates a pulse signal according to movement of the pulser ring.

RELATED ART DOCUMENT

PATENT DOCUMENT

[0004] [Patent Document 1]

SUMMARY

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] By the way, it is required to suppress deflection of a crankshaft from a viewpoint of enhancing the detection accuracy of a detection sensor. On the other hand, it is desirable to dispose the detection sensor at a suitable position.

[0006] Therefore, an object of the present invention is to dispose a detection device at a suitable position while suppressing deflection of a crankshaft in an internal combustion engine structure.

MEANS FOR SOLVING THE PROBLEM

[0007] As a means for solving the above problem, an aspect of the present invention has the following constitutions.

(1) An internal combustion engine structure according to an aspect of the present invention includes: a crankshaft (10) that converts reciprocating motion of a piston (24) disposed inside a cylinder (12) of an internal combustion engine (2) to be mounted on a vehicle into rotational motion; a case member (11) that houses the crankshaft (10); a balancer shaft (14) that suppresses vibration of the crankshaft (10); a starting device (15) that starts the internal combustion engine (2); and a detection device (16) that is disposed between the balancer shaft (14) and the starting device (15) in a side view and determines the rotation speed of the crankshaft (10).

(2) An internal combustion engine structure according to an aspect of the present invention includes: a crankshaft (10) that converts reciprocating motion of a piston (24) disposed inside a cylinder (12) of an internal combustion engine (2) to be mounted on a vehicle into rotational motion; a case member (11) that houses the crankshaft (10); a balancer shaft (14) that suppresses vibration of the crankshaft (10); and a detection device (16) that is disposed between a virtual line (K3) connecting a center (P2) of the crankshaft (10) and a center (P3) of the balancer shaft (14) and a center axis (C1) of the cylinder (12) in a side view and determines the rotation speed of the crankshaft (10).

(3) The internal combustion engine structure according to (1) or (2) may further include: a cover member (13) that covers the case member (11); and a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10), in which the detection device (16) may be disposed near the bearing member (52) within the range of the crankshaft (10) in a vehicle width direction.

(4) An internal combustion engine structure according to an aspect of the present invention includes: a crankshaft (10) that converts reciprocating motion of a piston (24) disposed inside a cylinder (12) of an internal combustion engine (2) to be mounted on a vehicle into rotational motion; a case member (11) that houses the crankshaft (10); a cover member (13) that covers the case member (11); a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10); and a detection device (16) that is disposed near the bearing member (52) within the range of the crankshaft (10) in a vehicle width direction and determines the rotation speed of the crankshaft (10).

(5) The internal combustion engine structure according to any one of (1) to (4) may further include a support member (17) that covers the detection device (16) from at least one direction and supports a plurality of functional components (66).

(6) In the internal combustion engine structure according to any one of (1) to (5), the case member (11) may include a breather chamber (30) having a labyrinth structure, and the detection device (16) may overlap with the breather chamber (30) in a side view.

(7) In the internal combustion engine structure according to any one of (1) to (6), the detection device (16) may be disposed near an orthogonal virtual line (K1) passing through a center (P2) of the crankshaft

(10) and orthogonal to a center axis (C1) of the cylinder (12) in a side view.

(8) The internal combustion engine structure according to any one of (1) to (7) may further include a coupling boss (36) that couples the internal combustion engine (2) and a vehicle body frame (6), in which the detection device (16) may be disposed between a starting device (15) that starts the internal combustion engine (2) and the coupling boss (36) or between a balancer shaft (14) that suppresses vibration of the crankshaft (10) and the coupling boss (36) in a side view.

(9) The internal combustion engine structure according to any one of (1) to (8) may further include a generator (18) having a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), in which the rotor (71) may include a plurality of protrusions (72) formed over an outer periphery of the rotor (71), and the protrusions (72) may be formed on the same plane as the detection device (16) in a virtual plane (S1) orthogonal to the center axis (C2) of the crankshaft (10).

(10) The internal combustion engine structure according to any one of (1) to (9) may further include a generator (18) having a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), in which the rotor (71) may include a disk-shaped bottom plate portion (71c) and a plurality of protrusions (72) formed over an outer periphery of the rotor (71), and the protrusions (72) may be formed on a side of the bottom plate portion (71c).

(11) The internal combustion engine structure according to any one of (1) to (10) may further include a generator (18) having a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), in which the rotor (71) may include a plurality of protrusions (72) formed over an outer periphery of the rotor (71), and the length (HI) of each of the protrusions (72) in a radial direction of the crankshaft (10) may be longer than the length (T1) of each of the protrusions (72) in a peripheral direction of the crankshaft (10).

(12) The internal combustion engine structure according to any one of (1) to (11) may further include: a cover member (13) that covers the case member (11); a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10); and a second bearing member (57) that is provided in the case member (11) and receives the crankshaft (10), in which the detection device (16) may be disposed biased to one side between the bearing member (52) and the second bearing member (57).

(13) The internal combustion engine structure according to any one of (1) to (12) may further include: a cover member (13) that covers the case member (11); a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10); and a generator (18) that is disposed inside the cover member (13) and has a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), in which the rotor (71) may be adjacent to the bearing member (52) in an axial direction of the crankshaft (10).

(14) The internal combustion engine structure according to any one of (1) to (13) may further include: a cover member (13) that covers the case member (11); a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10); and a generator (18) that is disposed inside the cover member (13) and has a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), in which at least a part of the rotor (71) may overlap with the bearing member (52) in an axial direction of the crankshaft (10).

(15) The internal combustion engine structure according to any one of (1) to (14) may further include: a cover member (13) that covers the case member (11); and a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10), in which the cover member (13) may have a bearing fitting portion (53) to which the bearing member (52) is fitted, and one or more extending portions (54) radially extending from the bearing fitting portion (53).

ADVANTAGE OF THE INVENTION

[0008] The internal combustion engine structure according to (1) of the present invention includes: a balancer shaft that suppresses vibration of a crankshaft; a starting device that starts an internal combustion engine; and a detection device that is disposed between the balancer shaft and the starting device in a side view and determines the rotation speed of the crankshaft. As a result, the following effects are exhibited.

[0009] The balancer shaft can suppress deflection of the crankshaft. In addition, a space between the balancer shaft and the starting device can be effectively used as a space in which the detection device is disposed. Therefore, the detection device can be disposed at a suitable position while deflection of the crankshaft is suppressed.

[0010] The internal combustion engine structure according to (2) of the present invention includes: a balancer shaft that suppresses vibration of the crankshaft; and a detection device that is disposed between a virtual line connecting a center of the crankshaft and a center of the balancer shaft and a center axis of the cylinder in a side view and determines the rotation speed of the crankshaft. As a result, the following effects are exhibited.

[0011] The balancer shaft can suppress deflection of the crankshaft. In addition, a space between the virtual line connecting the center of the crankshaft and the center of the balancer shaft and the center axis of the cylinder can be effectively used as a space in which the detection device is disposed. Therefore, the detection device can be disposed at a suitable position while deflection of the

crankshaft is suppressed. In addition, the detection device is disposed at a position where vibration of the crankshaft is neutralized by the balancer shaft, and therefore the detection accuracy of the detection device can be improved.

[0012] The internal combustion engine structure according to (3) of the present invention further includes: a cover member that covers the case member; and a bearing member that is provided in the cover member and receives an end of the crankshaft, in which the detection device is disposed near the bearing member within a range of the crankshaft in a vehicle width direction. As a result, the following effects are exhibited.

[0013] The bearing member can suppress deflection of the end of the crankshaft. Therefore, the deflection of the crankshaft can be more effectively suppressed together with action of the balancer shaft, and therefore the detection accuracy of the detection device can be further improved. In addition, a space near the bearing member can be effectively used as a space in which the detection device is disposed.

[0014] The internal combustion engine structure according to (4) of the present invention includes: a bearing member that is provided in the cover member and receives an end of the crankshaft; and a detection device that is disposed near the bearing member within the range of the crankshaft in a vehicle width direction and determines the rotation speed of the crankshaft. As a result, the following effects are exhibited.

[0015] Since the bearing member can suppress deflection of the end of the crankshaft, the detection accuracy of the detection device can be improved. In addition, a space near the bearing member can be effectively used as a space in which the detection device is disposed. Therefore, the detection device can be disposed at a suitable position while deflection of the crankshaft is suppressed.

[0016] The internal combustion engine structure according to (5) of the present invention further includes a support member that covers the detection device from at least one direction and supports a plurality of functional components. As a result, the following effects are exhibited.

[0017] Since the detection device is covered with the support member from at least one direction, the detection device can be protected from an external factor (for example, a flying stone). In addition, since the support member also has a function of supporting the plurality of functional components, the number of components can be reduced and cost can be reduced as compared with a case where a dedicated protection member for protecting the detection device is separately provided.

[0018] In the internal combustion engine structure according to (6) of the present invention, the case member includes a breather chamber having a labyrinth structure, and the detection device overlaps with the breather chamber in a side view. As a result, the following effects are exhibited.

[0019] A space overlapping with the breather chamber in a side view can be effectively used as a space in which the detection device is disposed.

[0020] In the internal combustion engine structure according to (7) of the present invention, the detection device is disposed near an orthogonal virtual line passing through the center of the crankshaft and orthogonal to the center axis of the cylinder in a side view. As a result, the following effects are exhibited.

[0021] Since the detection device is disposed at a position that is not easily affected by vibration due to reciprocating motion of the piston in a direction along the center axis of the cylinder, the detection accuracy of the detection device can be improved.

[0022] The internal combustion engine structure according to (8) of the present invention further includes a coupling boss that couples the internal combustion engine and a vehicle body frame, in which the detection device is disposed between a starting device that starts the internal combustion engine and the coupling boss or between a balancer shaft that suppresses vibration of the crankshaft and the coupling boss in a side view. As a result, the following effects are exhibited.

[0023] A space between the starting device and the coupling boss in a side view or a space between the balancer shaft and the coupling boss in a side view can be effectively used as a space in which the detection device is disposed.

[0024] The internal combustion engine structure according to (9) of the present invention further includes a generator having a rotor rotatable about a center axis of the crankshaft, in which the rotor includes a plurality of protrusions formed over an outer periphery of the rotor, and the protrusions are formed on the same plane as the detection device in a virtual plane orthogonal to the center axis of the crankshaft. As a result, the following effects are exhibited.

[0025] The detection accuracy of the detection device can be improved as compared with a case where the protrusions are formed on a virtual plane different from the detection device.

[0026] The internal combustion engine structure according to (10) of the present invention further includes a generator having a rotor rotatable about a center axis of the crankshaft, in which the rotor includes a disk-shaped bottom plate portion and a plurality of protrusions formed over an outer periphery of the rotor, and the protrusions are formed on a side of the bottom plate portion. As a result, the following effects are exhibited.

[0027] Since the detection device is less likely to be affected by deflection of the rotor as compared with a case where the protrusions are formed on a side opposite to the bottom plate portion (a distal end side of the rotor), the detection accuracy of the detection device can be improved.

[0028] The internal combustion engine structure according to (11) of the present invention further includes a generator having a rotor rotatable about a center axis

of the crankshaft, in which the rotor includes a plurality of protrusions formed over an outer periphery of the rotor, and the length of each of the protrusions in a radial direction of the crankshaft is longer than the length of each of the protrusions in a peripheral direction of the crankshaft. As a result, the following effects are exhibited.

[0029] The detection accuracy of the detection device can be improved as compared with a case where the length of each of the protrusions in a radial direction of the crankshaft is equal to or shorter than the length of each of the protrusions in a peripheral direction of the crankshaft. Therefore, this is suitable for achieving a self-diagnosis function (for example, OBD2; On Board Diagnosis second generation) of a vehicle. In addition, the number of components can be reduced and the axial length of the crankshaft can be shortened as compared with a structure in which a pulse ring is coupled to a crankshaft.

[0030] The internal combustion engine structure according to (12) of the present invention further includes: a cover member that covers the case member; a bearing member that is provided in the cover member and receives an end of the crankshaft; and a second bearing member that is provided in the case member and receives the crankshaft, in which the detection device is disposed biased to one side between the bearing member and the second bearing member. As a result, the following effects are exhibited.

[0031] Since the detection device is less likely to be affected by deflection of the crankshaft at the time of detection as compared with a case where the detection device is disposed at a central position between the bearing member and the second bearing member, the detection accuracy of the detection device can be improved.

[0032] The internal combustion engine structure according to (13) of the present invention further includes: a cover member that covers the case member; a bearing member that is provided in the cover member and receives an end of the crankshaft; and a generator that is disposed inside the cover member and has a rotor rotatable about a center axis of the crankshaft, in which the rotor is adjacent to the bearing member in an axial direction of the crankshaft. As a result, the following effects are exhibited.

[0033] A space adjacent to the bearing member in the axial direction of the crankshaft can be effectively used as a space in which the rotor is disposed.

[0034] The internal combustion engine structure according to (14) of the present invention further includes: a cover member that covers the case member; a bearing member that is provided in the cover member and receives an end of the crankshaft; and a generator that is disposed inside the cover member and has a rotor rotatable about a center axis of the crankshaft, in which at least a part of the rotor overlaps with the bearing member in an axial direction of the crankshaft. As a result, the following effects are exhibited.

[0035] A space overlapping with the bearing member in the axial direction of the crankshaft can be effectively used as a space in which the rotor is disposed.

[0036] The internal combustion engine structure according to (15) of the present invention further includes: a cover member that covers the case member; and a bearing member that is provided in the cover member and receives an end of the crankshaft, in which the cover member has a bearing fitting portion to which the bearing member is fitted, and one or more extending portions radially extending from the bearing fitting portion. As a result, the following effects are exhibited.

[0037] The bearing fitting portion can firmly hold the bearing member. In addition, the extending portion can increase rigidity of the cover member (a peripheral portion of the bearing fitting portion).

BRIEF DESCRIPTION OF THE DRAWINGS

[0038]

Fig. 1 is a right side view of an internal combustion engine structure according to an embodiment.

Fig. 2 is a view illustrating a state in which a link mechanism and the like are removed from Fig. 1.

Fig. 3 is a cross-sectional view taken along line III-III of Fig. 1.

Fig. 4 is a cross-sectional view taken along line IV-IV of Fig. 2.

Fig. 5 is a right side view illustrating disposition of a balancer shaft and a starting device according to the embodiment.

Fig. 6 is a right side view illustrating a support member according to the embodiment and a peripheral structure of the support member.

Fig. 7 is a right side view illustrating disposition of a detection device and a breather chamber according to the embodiment.

Fig. 8 is a right side view illustrating disposition of the detection device according to the embodiment.

Fig. 9 is a perspective view of a cover member according to the embodiment as viewed from the inside in a vehicle width direction.

Fig. 10 is a right side view illustrating a generator according to the embodiment and a peripheral structure of the generator.

Fig. 11 is a view of the generator according to the embodiment as viewed from a direction along a crank axis.

Fig. 12 is a right side view illustrating disposition of a detection device according to a modification of the embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0039] Hereinafter, an embodiment of the present invention is described with reference to the drawings. Note that directions such as front, rear, left, and right in the following description are the same as directions in a ve-

hicle described below unless otherwise specified. In addition, an arrow FR indicating the front of a vehicle, an arrow LH indicating the left of the vehicle, and an arrow UP indicating the top of the vehicle are illustrated at appropriate positions in the drawings used for the following description.

<Internal combustion engine structure>

[0040] Fig. 1 illustrates a unit swing type power unit to be mounted on a scooter type motorcycle as an example of an internal combustion engine structure 1 including a power source of a saddle-ride vehicle. Hereinafter, the motorcycle may be simply referred to as a "vehicle".

[0041] The power unit 1 includes an engine 2 that is an internal combustion engine, a transmission device 4 that transmits power of the engine 2 to a rear wheel 3 (see Fig. 3), and a swing arm 5 that supports the rear wheels 3. A rear end of the power unit 1 is coupled to a vehicle body frame 6 (specifically, a seat rail (not illustrated)) via a cushion unit (not illustrated). The power unit 1 has a function of a suspension device that swingably couples the rear wheel 3 to the vehicle body frame 6.

[0042] The engine 2 includes: a crankshaft 10 extending in a vehicle width direction; a crankcase 11 (case member) that houses the crankshaft 10; a cylinder portion 12 (cylinder) that protrudes substantially forward (specifically, slightly forward and upward with respect to a horizontal plane) from a front end of the crankcase 11; a cover member 13 that covers the crankcase 11 from a right side; a balancer shaft 14 (see Fig. 5) that suppresses vibration of the crankshaft 10; a starting device 15 (see Fig. 5) that starts the engine 2; a detection device 16 that determines the rotation speed of the crankshaft 10; a support member 17 that supports a plurality of functional components 66; and a generator 18 (see Fig. 3) disposed inside the cover member 13. Hereinafter, a center axis C1 of the cylinder portion 12 along the protruding direction of the cylinder portion 12 is also referred to as a "cylinder axis C1".

[0043] The transmission device 4 includes a power transmission mechanism (not illustrated) that transmits power of the engine 2 to the rear wheel 3 (see Fig. 3), and a transmission case 20 that houses the power transmission mechanism.

[0044] For example, the power transmission mechanism includes a belt type continuously variable transmission mechanism and a reduction gear. Power of the engine 2 is shifted via the power transmission mechanism and transmitted to the rear wheel 3. In the drawing, reference sign 3a denotes a rear wheel axle.

[0045] The transmission case 20 extends rearward from a left side portion of the crankcase 11. An air cleaner 21 that purifies outside air is provided in an upper portion of the transmission case 20.

[0046] The swing arm 5 is coupled to a right side portion of the crankcase 11. The swing arm 5 extends rearward from a rear end of the right side portion of the crankcase 11. The swing arm 5 faces the transmission case 20 across the rear wheel 3 in a vehicle width direction (see Fig. 3). The swing arm 5 is fastened to an upper portion and a lower portion of a rear end of the crankcase 11 with a pair of upper and lower bolts. The swing arm 5 has an opening 5a that exposes an inner surface of the transmission case 20 in a vehicle width direction to a right side in a right side view.

<Crankshaft>

[0047] As illustrated in Fig. 3, the crankshaft 10 is coupled to a piston 24 disposed inside the cylinder portion 12 via a connecting rod 23. The crankshaft 10 converts reciprocating motion along the cylinder axis C1 of the piston 24 into rotational motion. As illustrated in Fig. 5, a crank gear 26 meshing with a balancer gear 25 is attached to the crankshaft 10. Hereinafter, a center of the crankshaft 10 is also referred to as a "crank axial center P2", and a center axis of the crankshaft 10 is also referred to as a "crank axis C2".

<Crankcase>

[0048] As illustrated in Fig. 7, the crankcase 11 has a breather chamber 30 for performing gas-liquid separation of blowby gas inside the crankcase 11. The breather chamber 30 has a labyrinth structure. The breather chamber 30 is formed across a right side portion of the crankcase 11 and the cover member 13. The breather chamber 30 is formed by a peripheral wall 31 of the crankcase 11, a peripheral wall 32 of the cover member 13, and a partition wall 33 extending in a front-rear direction in a side view. The breather chamber 30 is provided from a front end of an upper portion of the crankcase 11 to a front-rear central portion of the upper portion of the crankcase 11 in a side view. The breather chamber 30 has a rear extending portion 34 extending rearward in a side view.

[0049] As illustrated in Fig. 1, the crankcase 11 includes a coupling boss 36 coupled to the vehicle body frame 6. The coupling boss 36 protrudes forward from a front lower portion of the crankcase 11. The coupling boss 36 is swingably coupled to the vehicle body frame 6 (specifically, a bracket 7 coupled to the vehicle body frame 6) via a link mechanism 40.

[0050] In the drawing, reference sign 37 denotes an oil pan that stores lubricating oil, and reference sign 38 denotes a cooling pump that pressure-feeds cooling water to a portion to be cooled in a power unit.

<Link mechanism>

[0051] The link mechanism 40 is disposed below the cylinder portion 12. The link mechanism 40 includes a first link 41 extending in an up-down direction in a side view and a second link 42 extending in a front-rear direction in a side view.

[0052] The first link 41 has a cam shape having a long axis in an up-down direction in a side view. An upper portion of the first link 41 is rotatably coupled to the bracket 7.

[0053] A front end of the second link 42 is rotatably coupled to a lower portion of the first link 41. A rear end of the second link 42 is rotatably coupled to the coupling boss 36. In the drawing, reference sign P1 denotes a rotation center (hereinafter, also referred to as a "boss center") of the second link 42 with respect to the coupling boss 36.

<Cylinder portion>

[0054] As illustrated in Fig. 2, the cylinder portion 12 includes a cylinder block 45 protruding substantially forward from a front end of the crankcase 11, a cylinder head 46 coupled to a front end of the cylinder block 45, and a head cover 47 coupled to a front end of the cylinder head 46. The cylinder head 46 is fastened and fixed together with the cylinder block 45 to a front surface of the crankcase 11 with a plurality of bolts. An intake system component (an intake pipe (not illustrated)) that introduces an air-fuel mixture into a combustion chamber and an exhaust system component (an exhaust pipe (not illustrated)) that discharges gas after combustion from the combustion chamber are coupled to the cylinder head 46.

<Cover member>

[0055] The cover member 13 is coupled to a right side portion of the crankcase 11. The cover member 13 is fastened to the crankcase 11 with a plurality of bolts. The cover member 13 has an insertion hole 50 into which the detection device 16 can be inserted from the outside.

[0056] As illustrated in Fig. 9, the cover member 13 has a plurality of bolt insertion holes 51 formed at intervals along an outer periphery of the cover member 13. As illustrated in Fig. 4, in the cover member 13, a bearing member 52 that receives a right end of the crankshaft 10 is provided. The cover member 13 has a bearing fitting portion 53 to which the bearing member 52 is fitted, and a plurality of extending portions 54 radially extending from the bearing fitting portion 53. The bearing member 52 rotatably supports the right end of the crankshaft 10. For example, the bearing member 52 is a ball bearing. The extending portions 54 protrude inward in a vehicle width direction from an inner surface of the cover member 13 in a vehicle width direction. Note that the number of the extending portions 54 to be disposed is not limited to a plural number, and may be a singular number.

<Balancer shaft>

[0057] As illustrated in Fig. 4, the balancer shaft 14 extends in a vehicle width direction in parallel with the crankshaft 10. Hereinafter, a center of the balancer shaft 14 is also referred to as a "balancer axial center". As illustrated in Fig. 5, a balancer axial center P3 is located substantially above the crank axial center P2 (specifically, slightly forward of the position immediately above the crank axial center P2) in a side view.

[0058] As illustrated in Fig. 4, the balancer shaft 14 is rotatably supported by the crankcase 11 via a bearing 55. For example, the bearing 55 may be a seal bearing or the like having a slight gap for holding oil in the bearing. A balancer gear 25 is attached to the balancer shaft 14 via a damper member 56. The balancer shaft 14 rotates synchronously with the crankshaft 10 via the balancer gear 25 and the crank gear 26. As a result, rotational fluctuation of the crankshaft 10 is canceled to maintain a rotational balance.

<Starting device>

[0059] As illustrated in Fig. 5, the starting device 15 is disposed in a rear upper portion of the crankcase 11. The starting device 15 includes a starter motor 59 for starting the engine 2. Hereinafter, a rotation center P4 of an axial portion of the starter motor 59 is also referred to as a "starter axial center P4". The starter axial center P4 is located behind and above the crank axial center P2 in a side view. The starter axial center P4 is located substantially behind the balancer axial center P3 (specifically, slightly above a position directly behind the balancer axial center P3) in a side view.

<Support member>

[0060] As illustrated in Fig. 6, the support member 17 is attached to an upper portion of the cover member 13. The support member 17 covers the detection device 16 from a right side. The support member 17 is fastened to the cover member 13 with a plurality of bolts. The support member 17 includes a first stay 61 coupled to the cover member 13 and a second stay 62 coupled to the first stay 61.

[0061] The first stay 61 extends in a front-rear direction so as to overlap with an upper portion of the cover member 13 in a side view. A lower portion of the first stay 61 is fastened to the cover member 13 with a pair of front and rear bolts. The first stay 61 has a clamp attachment portion 63 disposed between the pair of front and rear bolts. A hose clamp 65 that supports an intermediate portion of a hose 64 extending in a front-rear direction is attached to the clamp attachment portion 63.

[0062] The second stay 62 extends in a front-rear direction so as to cover the first stay 61 from above in a side view. A lower portion of the second stay 62 is fastened to an upper portion of the first stay 61 with a pair of front and rear bolts. The second stay 62 supports the plurality of functional components 66 such as an ignition coil, a check valve of a secondary air supply device, and a drive sensor thereof.

<Generator>

[0063] As illustrated in Fig. 4, the generator 18 is covered with the cover member 13 from a right side. The generator 18 includes a stator 70 fixed to the cover member 13 and a rotor 71 integrally rotatably fixed to the crankshaft 10.

[0064] The stator 70 has a plurality of coils 70a (see Fig. 10).

[0065] The rotor 71 has a plurality of magnets (not illustrated) radially facing the coil 70a. The rotor 71 is rotatable about the crank axis C2 according to rotation of the crankshaft 10. The rotor 71 is adjacent to the bearing member 52 in an axial direction of the crankshaft 10.

[0066] Apart (central portion) of the rotor 71 overlaps with the bearing member 52 in the axial direction of the crankshaft 10. Note that not only a part of the rotor 71 but also the entire rotor 71 may overlap with the bearing member 52 in the axial direction of the crankshaft 10. That is, at least a part of the rotor 71 may overlap with the bearing member 52 in the axial direction of the crankshaft 10.

[0067] The rotor 71 has a bottomed cylindrical shape or a conical shape coaxial with the crank axis C2. The rotor 71 includes a cylindrical or conical inner cylinder portion 71a located radially inward of the stator 70 and coupled to a right end of the crankshaft 10, a cylindrical or conical outer cylinder portion 71b that covers the stator 70 from radially outward, and a disk-shaped bottom plate portion 71c coupling a vehicle width direction inner end of the inner cylinder portion 71a and a vehicle width direction inner end of the outer cylinder portion 71b.

[0068] As illustrated in Fig. 11, the rotor 71 includes a plurality of protrusions 72 formed over an outer periphery of the outer cylinder portion 71b. The protrusions 72 are formed on the same plane as the detection device 16 on a virtual plane S1 orthogonal to the crank axis C2 (see Fig. 4). The protrusions 72 are formed closer to the bottom plate portion 71c than a distal end side (right end side) of the rotor 71 (see Fig. 4). 34 protrusions 72 are formed at intervals in a peripheral direction. The rotor 71 has a protrusion forming region 73 in which 34 protrusions 72 are formed at intervals of a central angle of 10°, and a protrusion non-forming region 74 in which no protrusion 72 is formed. The protrusion non-forming region 74 is a region for detecting a top dead center and a bottom dead center of the piston 24 (see Fig. 3).

[0069] Hereinafter, the length H1 of the protrusion 72 in a radial direction of the crankshaft 10 is also referred to as a "protrusion height HI", and the length of the protrusion 72 in a peripheral direction of the crankshaft 10 is also referred to as a "protrusion thickness T1". The protrusion height H1 means the distance between an outer peripheral surface of the outer cylinder portion 71b and a distal end of the protrusion 72. The protrusion thickness T1 means the distance between a peripheral direction upstream end and a peripheral direction downstream end of the protrusion 72. As illustrated in Fig. 11, the protrusion height H1 is longer than the protrusion thickness T1 (HI > T1).

[0070] The protrusion 72 includes a rising portion 72c that gently rises from a surface of the outer cylinder portion 71b, a vertical portion 72b that is continuous with the rising portion 72c and extends radially outward of the outer cylinder portion 71b, and a distal end 72a that is substantially orthogonal to an extending end of the vertical portion 72b and extends along a peripheral direction of the outer cylinder portion 71b. In one protrusion 72, the vertical portions 72b facing each other are substantially parallel to each other.

<Detection device>

[0071] As illustrated in Fig. 2, the detection device 16 is inserted into the insertion hole 50 of the cover member 13 from the outside. The detection device 16 is disposed above the crank axial center P2. For example, the detection device 16 is a pulser sensor that generates a pulse signal according to movement of the protrusion 72.

[0072] As illustrated in Fig. 4, the detection device 16 has a distal end 16a (detector) that detects the protrusion 72. The distal end 16a of the detection device 16 is disposed so as to be directed to the crank axial center P2 (see Fig. 2). The detection device 16 outputs an electric signal according to presence or absence of the protrusion 72 detected on an outer periphery of the outer cylinder portion 71b. A detection result of the detection device 16 is sent to an engine control unit (ECU) (not illustrated) which is a control device of the engine 2. For example, the ECU estimates misfire of the engine when the change amount (change amount of angular velocity) of the rotation speed of the crankshaft 10 exceeds a threshold during a preset number of cycles.

[0073] The detection device 16 is disposed between the balancer shaft 14 and the starting device 15 in a side view (see Fig. 5). The detection device 16 is disposed between the balancer axial center P3 and the starter axial center P4 in a side view (see Fig. 5). As illustrated in Fig. 4, the detection device 16 is disposed near the bearing member 52 within the range of the crankshaft 10 in a vehicle width direction. The detection device 16 is disposed closer to the bearing member 52 than a center of a vehicle body (center position in a vehicle width direction). The distal end 16a of the detection device 16 is disposed so as to be directed to the crankshaft 10 supported by the bearing member 52.

[0074] The detection device 16 overlaps with the rear extending portion 34 of the breather chamber 30 in a side view (see Fig. 7). The detection device 16 is disposed between the starting device 15 and the coupling boss 36 in a side view (see Fig. 5). The detection device 16 is disposed between the starter axial center P4 and the boss center P1 in a side view (see Fig. 5).

[0075] The detection device 16 is disposed near an orthogonal virtual line K1 passing through the crank axial center P2 and orthogonal to the cylinder axis C1 in a side

view (see Fig. 8). The range near the orthogonal virtual line K1 means a range of ±30° around the crank axial center P2 with respect to the orthogonal virtual line K1. Here, a clockwise direction in the drawing around the crank axial center P2 with respect to the orthogonal virtual line K1 is defined as plus, and a counterclockwise direction in the drawing is defined as minus. The detection device 16 is disposed in a range of +30° around the crank axial center P2 with respect to the orthogonal virtual line K1 in a side view (see Fig. 8). In the drawing, reference sign K2 denotes a virtual line forming an angle A1 of +30° around the crank axial center P2 with respect to the orthogonal virtual line K1.

[0076] In Fig. 4, reference sign 57 denotes a second bearing member that is provided in the crankcase 11 and receives the crankshaft 10. For example, the second bearing member is a needle bearing. As illustrated in Fig. 4, the detection device 16 is disposed biased to the bearing member 52 between the bearing member 52 and the second bearing member 57. That is, the detection device 16 is disposed closer to the bearing member 52 than the second bearing member 57.

[0077] As described above, the internal combustion engine structure 1 according to the above embodiment includes: the crankshaft 10 that converts reciprocating motion of the piston 24 disposed inside the cylinder portion 12 of the engine 2 to be mounted on a vehicle into rotational motion; the crankcase 11 that houses the crankshaft 10; the balancer shaft 14 that suppresses vibration of the crankshaft 10; the starting device 15 that starts the engine 2; and the detection device 16 that is disposed between the balancer shaft 14 and the starting device 15 in a side view and determines the rotation speed of the crankshaft 10.

[0078] According to this constitution, the balancer shaft 14 can suppress deflection of the crankshaft 10. In addition, a space between the balancer shaft 14 and the starting device 15 can be effectively used as a space in which the detection device 16 is disposed. Therefore, the detection device 16 can be disposed at a suitable position while deflection of the crankshaft 10 is suppressed.

[0079] In the above embodiment, the internal combustion engine structure 1 includes the cover member 13 that covers the crankcase 11 and the bearing member 52 that is provided in the cover member 13 and receives an end of the crankshaft 10, and the detection device 16 is disposed near the bearing member 52 within the range of the crankshaft 10 in a vehicle width direction. As a result, the following effects are exhibited.

[0080] The bearing member 52 can suppress deflection of the end of the crankshaft 10. Therefore, the deflection of the crankshaft 10 can be more effectively suppressed together with action of the balancer shaft 14, and therefore the detection accuracy of the detection device 16 can be further improved. In addition, a space near the bearing member 52 can be effectively used as a space in which the detection device 16 is disposed.

[0081] In the above embodiment, the internal combustion engine structure 1 includes the support member 17 that covers the detection device 16 from a right side and supports the plurality of functional components 66. As a result, the following effects are exhibited.

[0082] Since the detection device 16 is covered with the support member 17 from a right side, the detection device 16 can be protected from an external factor (for example, a flying stone). In addition, since the support member 17 also has a function of supporting the plurality of functional components 66, the number of components can be reduced and cost can be reduced as compared with a case where a dedicated protection member for protecting the detection device 16 is separately provided.

[0083] In the above embodiment, the crankcase 11 includes the breather chamber 30 having a labyrinth structure, and the detection device 16 overlaps with the breather chamber 30 in a side view. As a result, the following effects are exhibited. A space overlapping with the breather chamber 30 in a side view can be effectively used as a space in which the detection device 16 is disposed.

[0084] In the above embodiment, the detection device 16 is disposed near the orthogonal virtual line K1 that passes through the crank axial center P2 and is orthogonal to the cylinder axis C1 in a side view. As a result, the following effects are exhibited.

[0085] Since the detection device 16 is disposed at a position that is not easily affected by vibration due to reciprocating motion of the piston 24 in a direction along the cylinder axis C1, the detection accuracy of the detection device 16 can be improved.

[0086] In the above embodiment, the internal combustion engine structure 1 includes the coupling boss 36 that couples the engine 2 and the vehicle body frame 6, and the detection device 16 is disposed between the starting device 15 that starts the engine 2 and the coupling boss 36 in a side view. As a result, the following effects are exhibited.

[0087] A space between the starting device 15 and the coupling boss 36 in a side view can be effectively used as a space in which the detection device 16 is disposed.

[0088] In the above embodiment, the internal combustion engine structure 1 includes the generator 18 having the rotor 71 rotatable about the crank axis C2, the rotor 71 includes the plurality of protrusions 72 formed over an outer periphery of the rotor 71, and the protrusions 72 are formed on the same plane as the detection device 16 in the virtual plane S1 orthogonal to the crank axis C2. As a result, the following effects are exhibited.

[0089] The detection accuracy of the detection device 16 can be improved as compared with a case where the protrusions 72 are formed on a virtual plane different from the detection device 16.

[0090] In the above embodiment, the rotor 71 includes the disk-shaped bottom plate portion 71c and the plurality of protrusions 72 formed over an outer periphery of the rotor 71, and the protrusions 72 are formed on a side of the bottom plate portion 71c. As a result, the following

effects are exhibited.

[0091] Since the detection device 16 is less likely to be affected by deflection of the rotor 71 as compared with a case where the protrusions 72 are formed on a side opposite to the bottom plate portion 71c (a distal end side of the rotor 71), the detection accuracy of the detection device 16 can be improved.

[0092] In the above embodiment, since the protrusion height H1 is longer than the protrusion thickness T1. As a result, the following effects are exhibited.

[0093] The detection accuracy of the detection device 16 can be improved as compared with a case where the protrusion height H1 is equal to or less than the protrusion thickness T1. Therefore, this is suitable for achieving a self-diagnosis function (for example, OBD2; On Board Diagnosis second generation) of a vehicle. In addition, the number of components can be reduced and the axial length of the crankshaft 10 can be shortened as compared with a structure in which a pulser ring is coupled to the crankshaft 10.

[0094] In the above embodiment, the second bearing member 57 that is provided in the crankcase 11 and receives the crankshaft 10 is included, and the detection device 16 is disposed biased to the bearing member 52 between the bearing member 52 and the second bearing member 57. As a result, the following effects are exhibited.

[0095] Since the detection device 16 is less likely to be affected by deflection of the crankshaft 10 at the time of detection as compared with a case where the detection device 16 is disposed at a central position between the bearing member 52 and the second bearing member 57, the detection accuracy of the detection device 16 can be improved.

[0096] In the above embodiment, since the rotor 71 is adjacent to the bearing member 52 in an axial direction of the crankshaft 10. As a result, the following effects are exhibited.

[0097] A space adjacent to the bearing member 52 in the axial direction of the crankshaft 10 can be effectively used as a space in which the rotor 71 is disposed.

[0098] In the above embodiment, since a part of the rotor 71 overlaps with the bearing member 52 in the axial direction of the crankshaft 10. As a result, the following effects are exhibited.

[0099] A space overlapping with the bearing member 52 in the axial direction of the crankshaft 10 can be effectively used as a space in which the rotor 71 is disposed.

[0100] In the above embodiment, the cover member 13 has the bearing fitting portion 53 to which the bearing member 52 is fitted and the plurality of extending portions 54 radially extending from the bearing fitting portion 53. As a result, the following effects are exhibited.

[0101] The bearing fitting portion 53 can firmly hold the bearing member 52. In addition, the extending portions 54 can increase rigidity of the cover member 13 (a peripheral portion of the bearing fitting portion 53).

<Modification>

[0102] In the above embodiment, an example in which the detection device 16 is disposed between the balancer shaft 14 and the starting device 15 in a side view has been described, but the present invention is not limited thereto. Fig. 12 is a right side view illustrating disposition of the detection device 16 according to a modification of the embodiment. In Fig. 12, the balancer shaft 14 (balancer axial center P3) and the starting device 15 (starter axial center P4) are disposed opposite to those in the above embodiment (see Fig. 5). For example, as illustrated in Fig. 12, the detection device 16 may be disposed between a virtual line K3 connecting the crank axial center P2 and the balancer axial center P3 and the cylinder axis C1 in a side view.

[0103] According to this constitution, the balancer shaft 14 can suppress deflection of the crankshaft 10. In addition, a space between the virtual line K3 connecting the crank axial center P2 and the balancer axial center P3 and the cylinder axis C1 can be effectively used as a space in which the detection device 16 is disposed. Therefore, the detection device 16 can be disposed at a suitable position while deflection of the crankshaft 10 is suppressed. In addition, the detection device 16 is disposed at a position where vibration of the crankshaft 10 is neutralized by the balancer shaft 14, and therefore the detection accuracy of the detection device 16 can be improved.

[0104] In the above embodiment, an example in which the detection device 16 is disposed between the starting device 15 and the coupling boss 36 in a side view has been described, but the present invention is not limited thereto. For example, as illustrated in Fig. 12, the detection device 16 may be disposed between the balancer shaft 14 and the coupling boss 36 in a side view.

[0105] According to this constitution, a space between the balancer shaft 14 and the coupling boss 36 in a side view can be effectively used as a space in which the detection device 16 is disposed.

[0106] In the above embodiment, an example in which the detection device 16 is disposed between the balancer shaft 14 and the starting device 15 in a side view and is disposed near the bearing member 52 has been described, but the present invention is not limited thereto. For example, the detection device 16 does not have to be disposed near the bearing member 52 in a side view. That is, the detection device 16 only needs to be disposed between the balancer shaft 14 and the starting device 15 in a side view.

[0107] On the other hand, the detection device 16 does not have to be disposed between the balancer shaft 14 and the starting device 15 in a side view. For example, the detection device 16 may be disposed near the bearing member 52.

[0108] According to this constitution, the bearing member 52 can suppress deflection of the crankshaft 10. In addition, a space near the bearing member 52 can be

effectively used as a space in which the detection device 16 is disposed. Therefore, the detection device 16 can be disposed at a suitable position while deflection of the crankshaft 10 is suppressed.

[0109] In the above embodiment, an example in which the support member 17 covers the detection device 16 from a right side has been described, but the present invention is not limited thereto. For example, the support member 17 may cover the detection device 16 from above and below and from front and rear. That is, the support member 17 may cover the detection device 16 from at least one direction.

[0110] In the above embodiment, an example in which the detection device 16 is disposed in a range of +30° around the crank axial center P2 with respect to the orthogonal virtual line K1 in a side view has been described, but the present invention is not limited thereto. For example, the detection device 16 may be disposed in a range of -30° around the crank axial center P2 with respect to the orthogonal virtual line K1 in a side view. That is, the detection device 16 only needs to be disposed near the orthogonal virtual line K1 in a side view.

[0111] In the above embodiment, an example in which the detection device 16 overlaps with the breather chamber 30 in a side view has been described, but the present invention is not limited thereto. For example, the detection device 16 may be disposed at a position not overlapping with the breather chamber 30 in a side view.

[0112] In the above embodiment, an example in which the detection device 16 is disposed above the crank axial center P2 has been described, but the present invention is not limited thereto. For example, the detection device 16 may be disposed below the crank axial center P2.

[0113] In the above embodiment, an example in which the protrusion height H1 in the rotor 71 is longer than the protrusion thickness T1 (HI > T1) has been described, but the present invention is not limited thereto. For example, the protrusion height H1 in the rotor 71 may be a length equal to or less than the protrusion thickness T1 (HI $\leq$ T1).

[0114] In the above embodiment, an example in which the link mechanism 40 includes the first link 41 extending in an up-down direction in a side view and the second link 42 extending in a front-rear direction in a side view has been described, but the present invention is not limited thereto. For example, the link mechanism 40 may include only a single link extending in a front-rear direction in a side view. That is, the link mechanism 40 can adopt various aspects as long as the coupling boss 36 is swingably coupled to the vehicle body frame 6.

[0115] In the above embodiment, an example in which the internal combustion engine structure 1 is applied to a scooter type vehicle has been described, but the present invention is not limited thereto. For example, the internal combustion engine structure 1 may be applied to a vehicle other than a scooter type vehicle, such as a motorcycle.

[0116] Note that the present invention is not limited to the above embodiment, and for example, the saddle-ride vehicle includes all vehicles in which a driver sits astride a vehicle body, and includes not only a motorcycle (including a motorized bicycle and a scooter type vehicle) but also a three-wheeled vehicle (also including a vehicle having two front wheels and one rear wheel in addition to a vehicle having one front wheel and two rear wheels). In addition, the present invention is applicable not only to a motorcycle but also to a four-wheeled vehicle such as an automobile.

[0117] Furthermore, the constitution in the above embodiment is an example of the present invention, and various modifications can be made without departing from the gist of the present invention, for example, the components of the embodiment can be replaced with known components.

BRIEF DESCRIPTION OF THE REFERENCE SYMBOLS

[0118]

1 Power unit (internal combustion engine structure)
2 Engine (internal combustion engine)
6 Vehicle body frame
10 Crankshaft
11 Crankcase (case member)
12 Cylinder portion (cylinder)
13 Cover member
14 Balancer shaft
15 Starting device
16 Detection device
17 Support member
18 Generator
24 Piston
30 Breather chamber
36 Coupling boss
52 Bearing member
57 Second bearing member
66 Functional component
71 Rotor
72 Protrusion
C1 Cylinder axis (center axis of cylinder)
C2 Crank axis (center axis of crankshaft)
H1 Protrusion height (length of protrusion in radial direction of crankshaft)
K1 Orthogonal virtual line
K3 Virtual line (virtual line connecting center of crankshaft and center of balancer shaft in side view)
P2 Crank axial center (center of crankshaft)
P3 Balancer axial center (center of balancer shaft)
S1 Virtual plane
T1 Protrusion thickness (length of protrusion in axial direction of crankshaft)

Claims

1. An internal combustion engine structure comprising:

   a crankshaft (10) that converts reciprocating motion of a piston (24) disposed inside a cylinder (12) of an internal combustion engine (2) to be mounted on a vehicle into rotational motion;
   a case member (11) that houses the crankshaft (10);
   a balancer shaft (14) that suppresses vibration of the crankshaft (10);
   a starting device (15) that starts the internal combustion engine (2); and
   a detection device (16) that is disposed between the balancer shaft (14) and the starting device (15) in a side view and determines a rotation speed of the crankshaft (10).

2. An internal combustion engine structure comprising:

   a crankshaft (10) that converts reciprocating motion of a piston (24) disposed inside a cylinder (12) of an internal combustion engine (2) to be mounted on a vehicle into rotational motion;
   a case member (11) that houses the crankshaft (10);
   a balancer shaft (14) that suppresses vibration of the crankshaft (10); and
   a detection device (16) that is disposed between a virtual line (K3) connecting a center (P2) of the crankshaft (10) and a center (P3) of the balancer shaft (14) and a center axis (C1) of the cylinder (12) in a side view and determines a rotation speed of the crankshaft (10).

3. The internal combustion engine structure according to claim 1 or 2, further comprising:

   a cover member (13) that covers the case member (11); and
   a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10), wherein
   the detection device (16) is disposed near the bearing member (52) within a range of the crankshaft (10) in a vehicle width direction.

4. An internal combustion engine structure comprising:

   a crankshaft (10) that converts reciprocating motion of a piston (24) disposed inside a cylinder (12) of an internal combustion engine (2) to be mounted on a vehicle into rotational motion;
   a case member (11) that houses the crankshaft (10);
   a cover member (13) that covers the case member (11);
   a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10); and
   a detection device (16) that is disposed near the bearing member (52) within a range of the crankshaft (10) in a vehicle width direction and determines a rotation speed of the crankshaft (10).

5. The internal combustion engine structure according to any one of claims 1 to 4, further comprising a support member (17) that covers the detection device (16) from at least one direction and supports a plurality of functional components (66).

6. The internal combustion engine structure according to any one of claims 1 to 5, wherein

   the case member (11) includes a breather chamber (30) having a labyrinth structure, and
   the detection device (16) overlaps with the breather chamber (30) in a side view.

7. The internal combustion engine structure according to any one of claims 1 to 6, wherein the detection device (16) is disposed near an orthogonal virtual line (K1) passing through a center (P2) of the crankshaft (10) and orthogonal to a center axis (C1) of the cylinder (12) in a side view.

8. The internal combustion engine structure according to any one of claims 1 to 7, further comprising a coupling boss (36) that couples the internal combustion engine (2) and a vehicle body frame (6), wherein
   the detection device (16) is disposed between a starting device (15) that starts the internal combustion engine (2) and the coupling boss (36) or between a balancer shaft (14) that suppresses vibration of the crankshaft (10) and the coupling boss (36) in a side view.

9. The internal combustion engine structure according to any one of claims 1 to 8, further comprising a generator (18) having a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), wherein

   the rotor (71) includes a plurality of protrusions (72) formed over an outer periphery of the rotor (71), and
   the protrusions (72) are formed on the same plane as the detection device (16) in a virtual plane (S1) orthogonal to the center axis (C2) of the crankshaft (10).

10. The internal combustion engine structure according to any one of claims 1 to 9, further comprising a generator (18) having a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), wherein

the rotor (71) includes:

a disk-shaped bottom plate portion (71c); and
a plurality of protrusions (72) formed over an outer periphery of the rotor (71), and

the protrusions (72) are formed on a side of the bottom plate portion (71c).

11. The internal combustion engine structure according to any one of claims 1 to 10, further comprising a generator (18) having a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), wherein

the rotor (71) includes a plurality of protrusions (72) formed over an outer periphery of the rotor (71), and
a length (HI) of each of the protrusions (72) in a radial direction of the crankshaft (10) is longer than a length (T1) of each of the protrusions (72) in a peripheral direction of the crankshaft (10).

12. The internal combustion engine structure according to any one of claims 1 to 11, further comprising:

a cover member (13) that covers the case member (11);
a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10); and
a second bearing member (57) that is provided in the case member (11) and receives the crankshaft (10), wherein
the detection device (16) is disposed biased to one side between the bearing member (52) and the second bearing member (57).

13. The internal combustion engine structure according to any one of claims 1 to 12, further comprising:

a cover member (13) that covers the case member (11);
a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10); and
a generator (18) that is disposed inside the cover member (13) and has a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), wherein
the rotor (71) is adjacent to the bearing member (52) in an axial direction of the crankshaft (10).

14. The internal combustion engine structure according to any one of claims 1 to 13, further comprising:

a cover member (13) that covers the case member (11);
a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10); and
a generator (18) that is disposed inside the cover member (13) and has a rotor (71) rotatable about a center axis (C2) of the crankshaft (10), wherein at least a part of the rotor (71) overlaps with the bearing member (52) in an axial direction of the crankshaft (10).

15. The internal combustion engine structure according to any one of claims 1 to 14, further comprising:

a cover member (13) that covers the case member (11); and
a bearing member (52) that is provided in the cover member (13) and receives an end of the crankshaft (10), wherein
the cover member (13) has:

a bearing fitting portion (53) to which the bearing member (52) is fitted; and
one or more extending portions (54) radially extending from the bearing fitting portion (53).

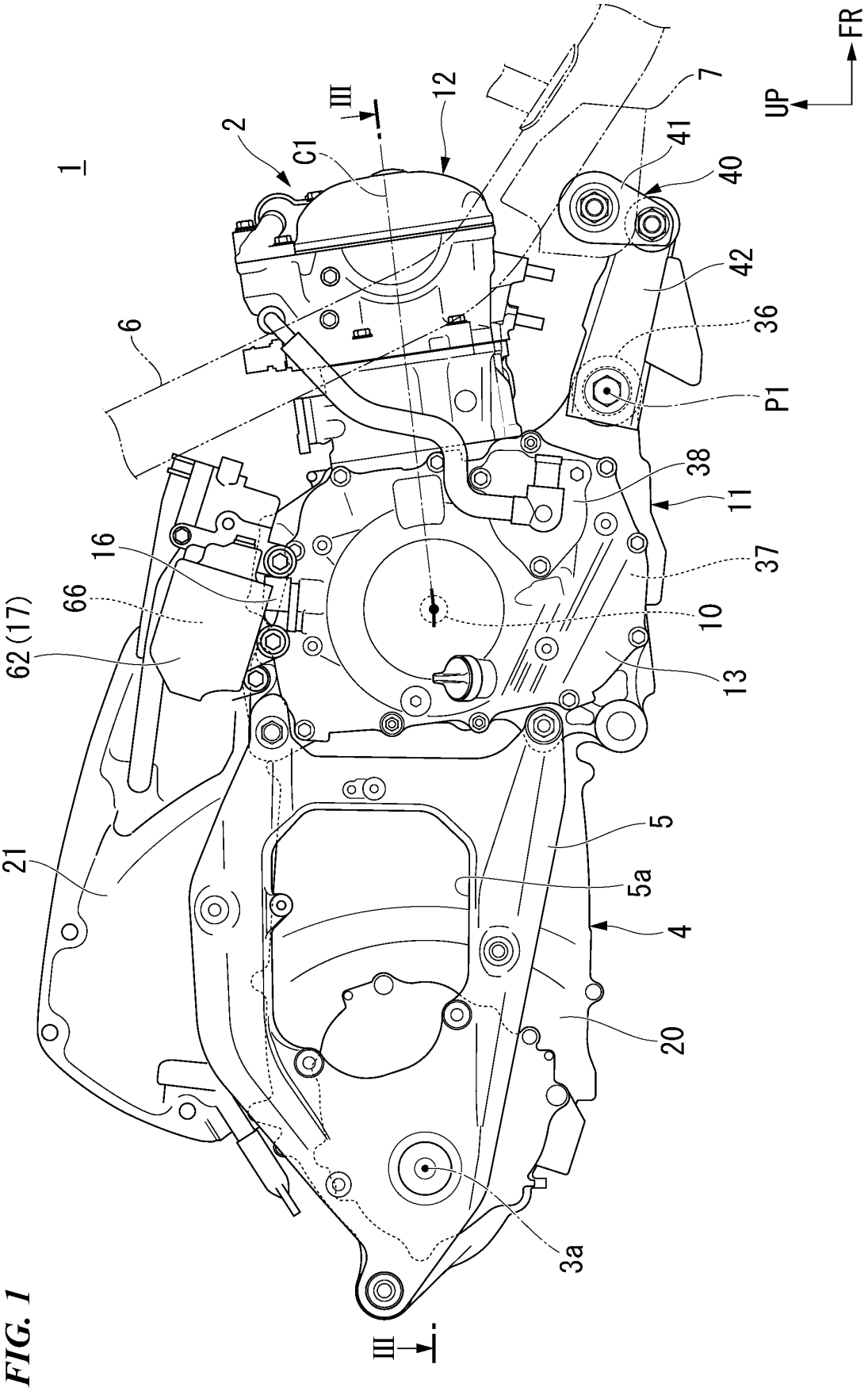

1
2
C1
III
12
7
41
40
42
36
P1
38
11
37
10
13
6
16
66
62 (17)
21
5
5a
4
20
3a
III
UP
FR

FIG. 1

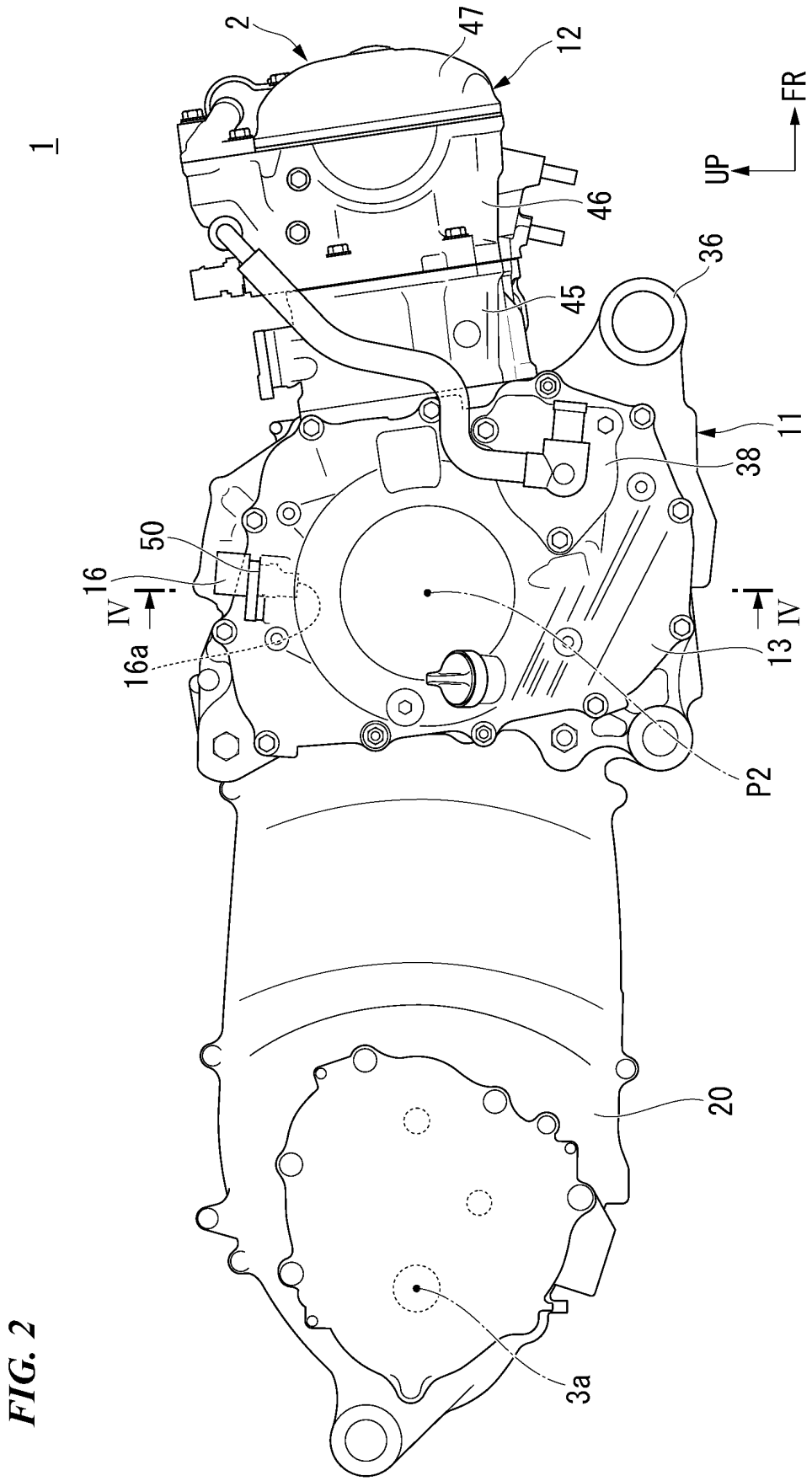


FIG. 2

FIG. 3

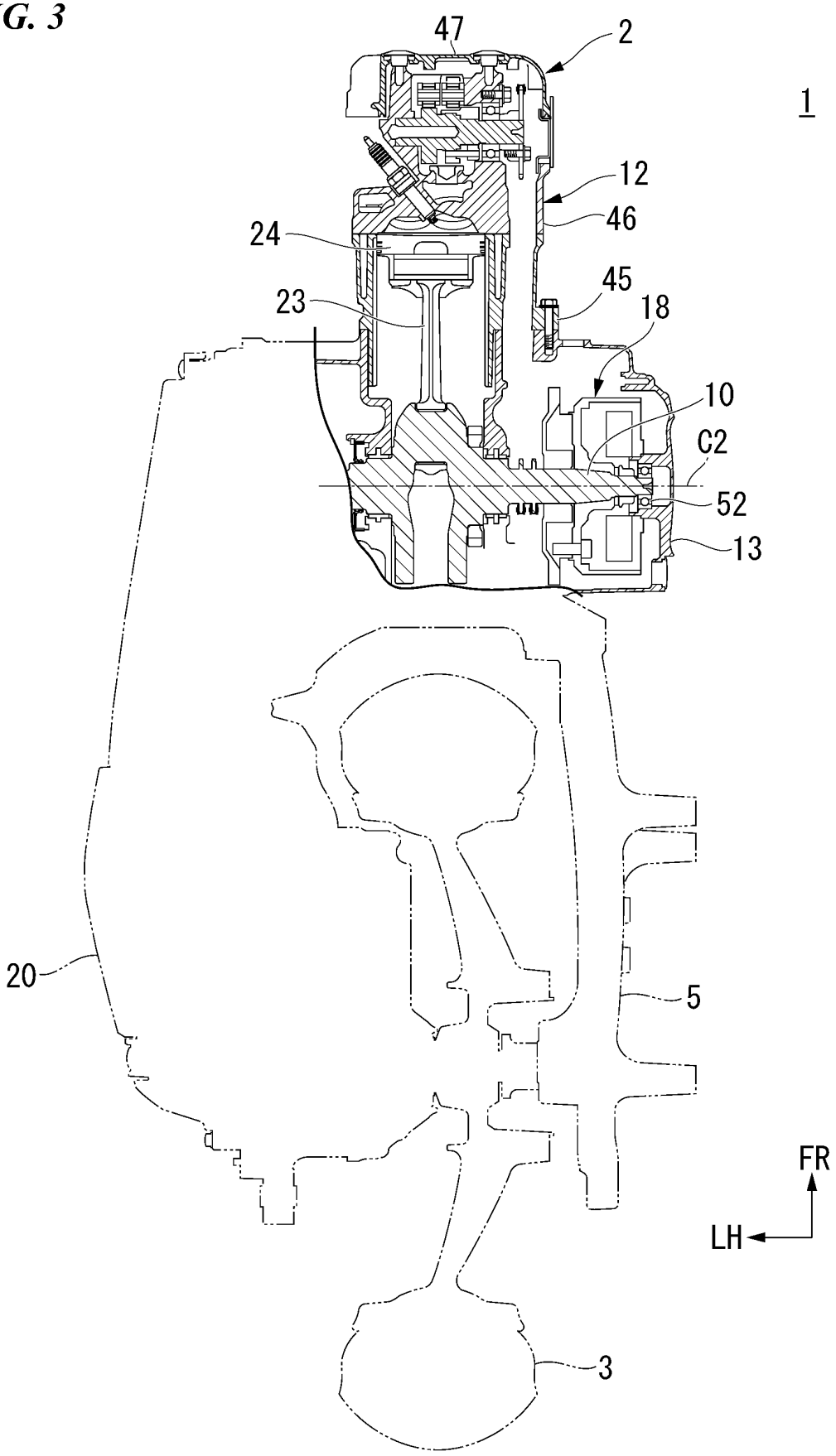
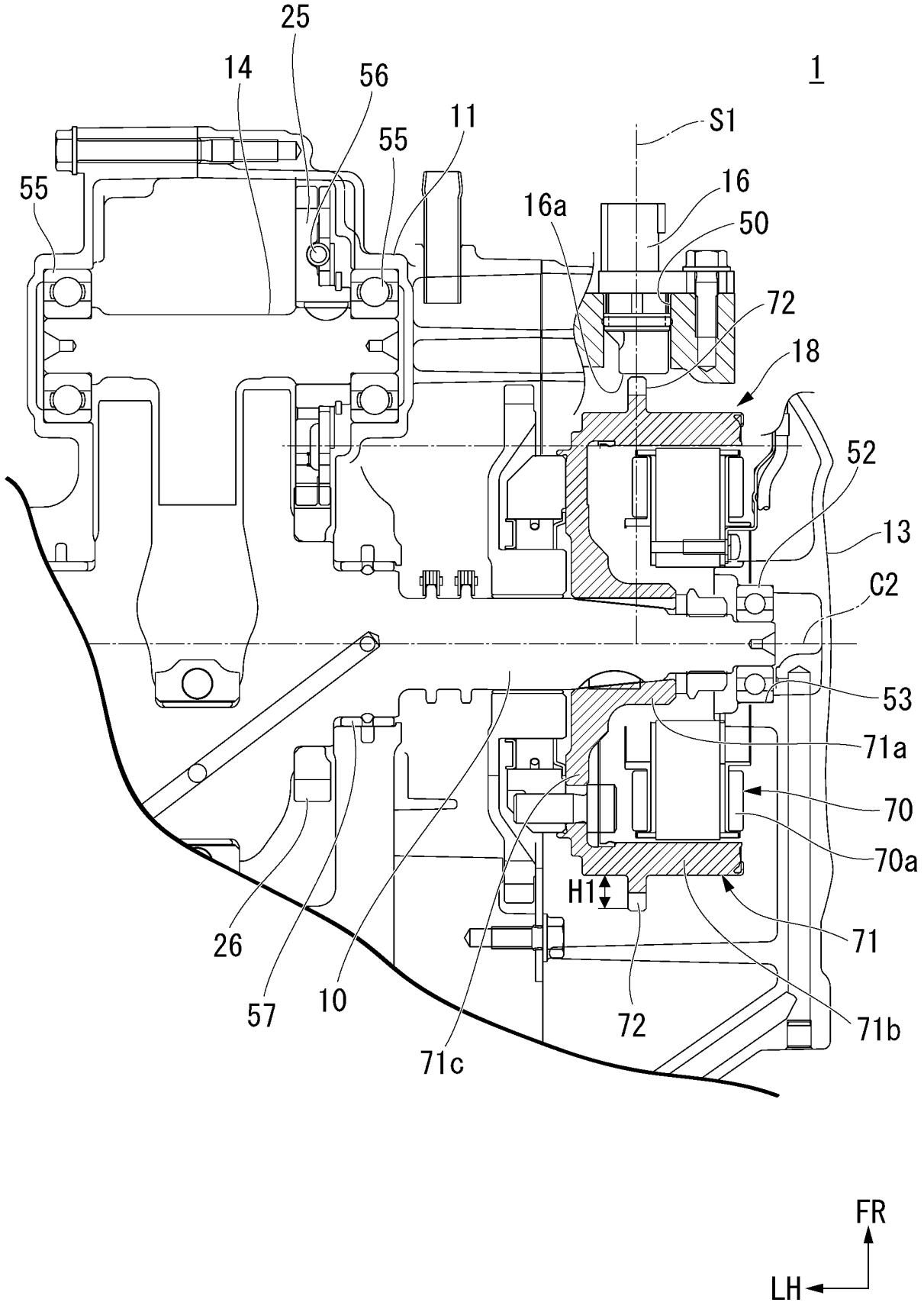


FIG. 4


25
14
56
11
55
1
S1
55
16
16a
50
72
18
52
13
C2
53
71a
70
70a
H1
71
26
57
10
72
71b
71c
FR
LH

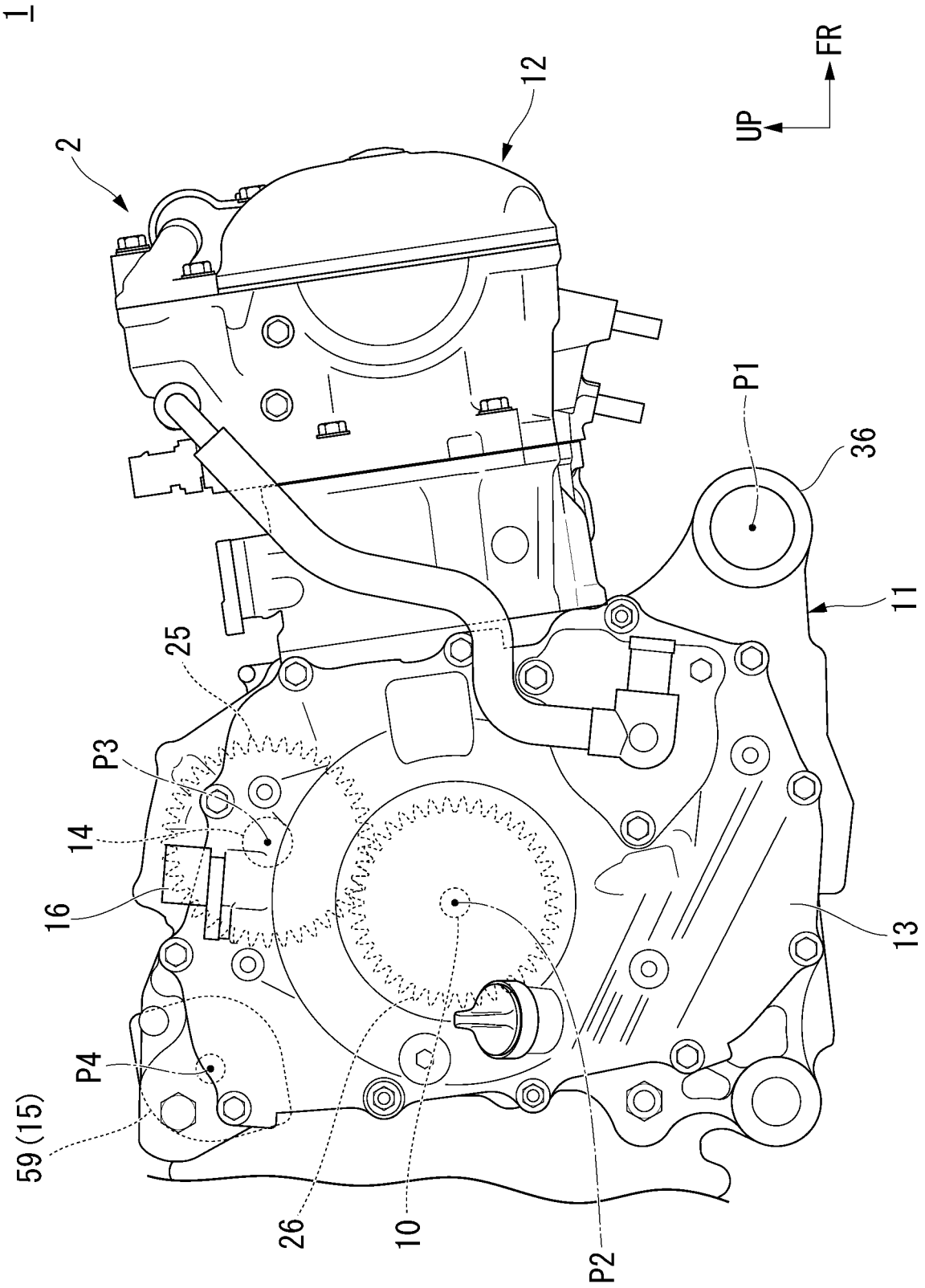


FIG. 5

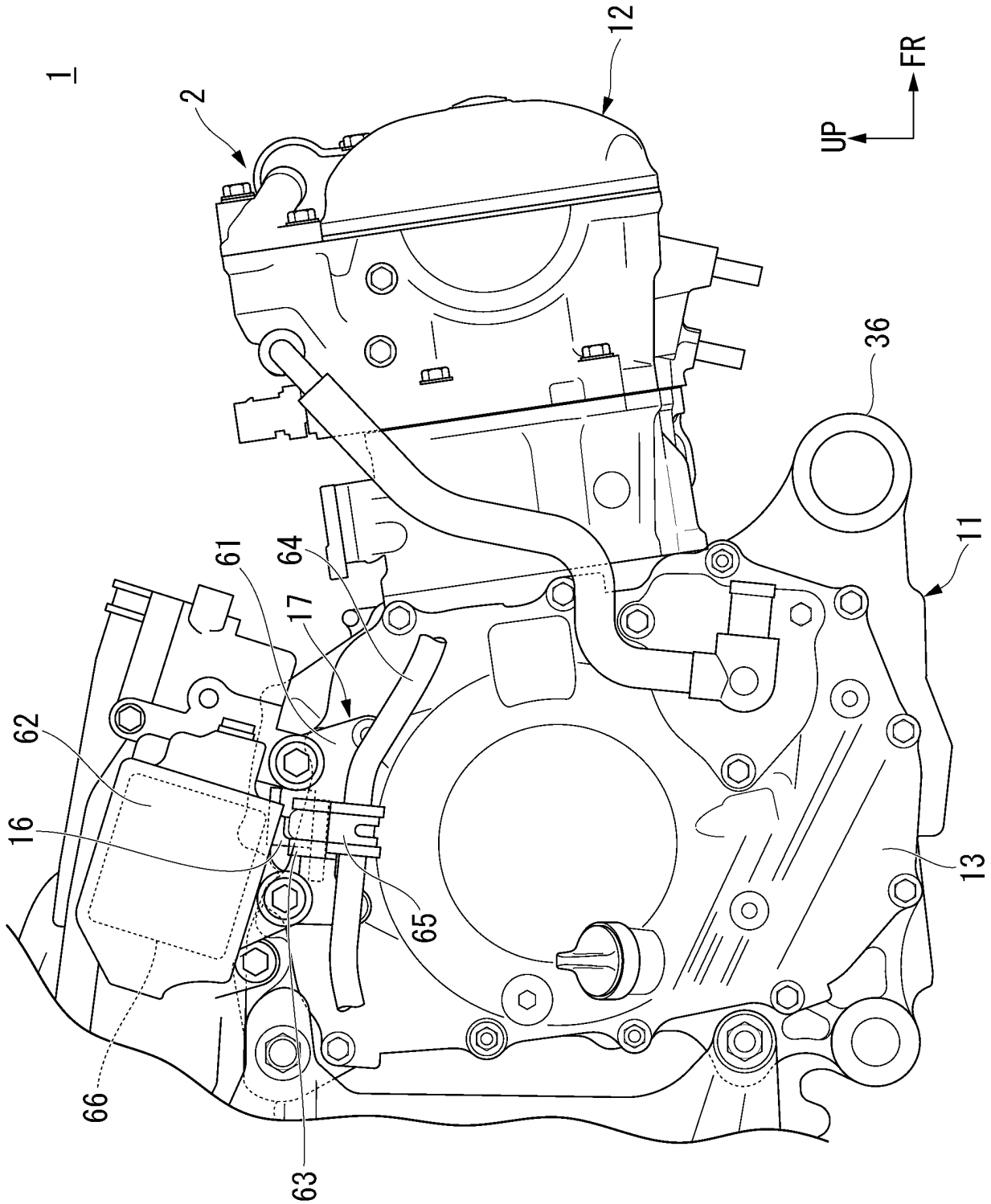


FIG. 6

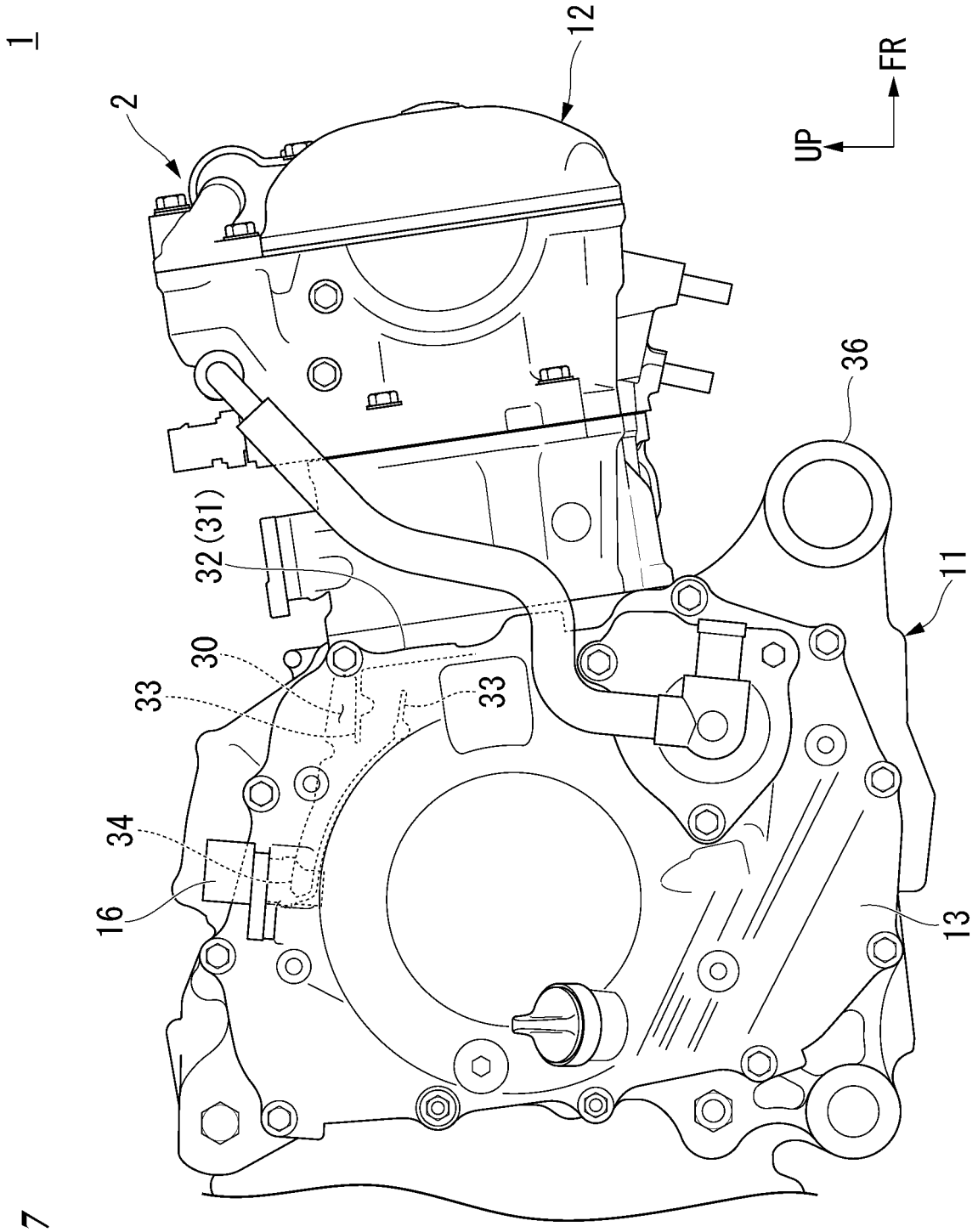


FIG. 7

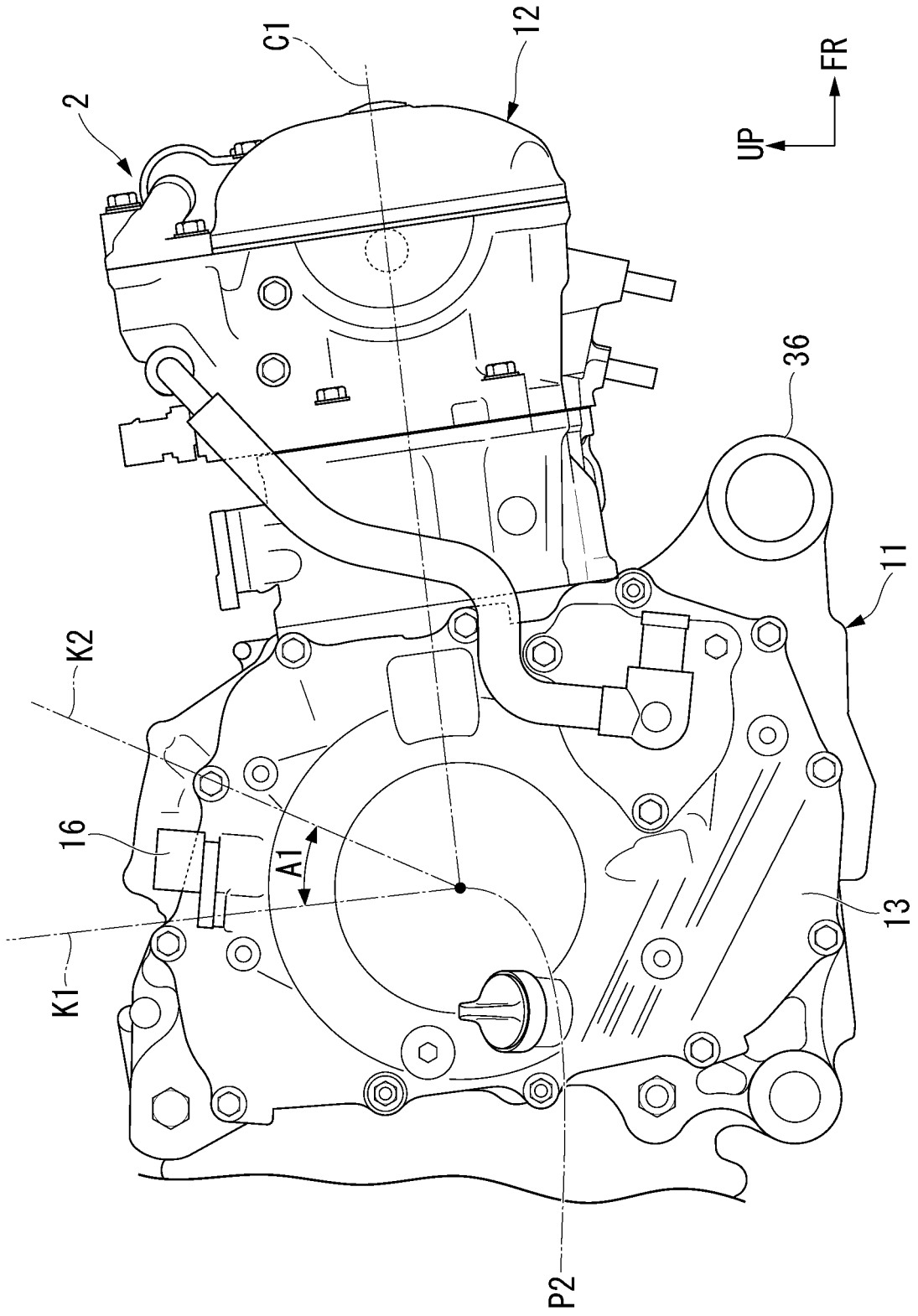
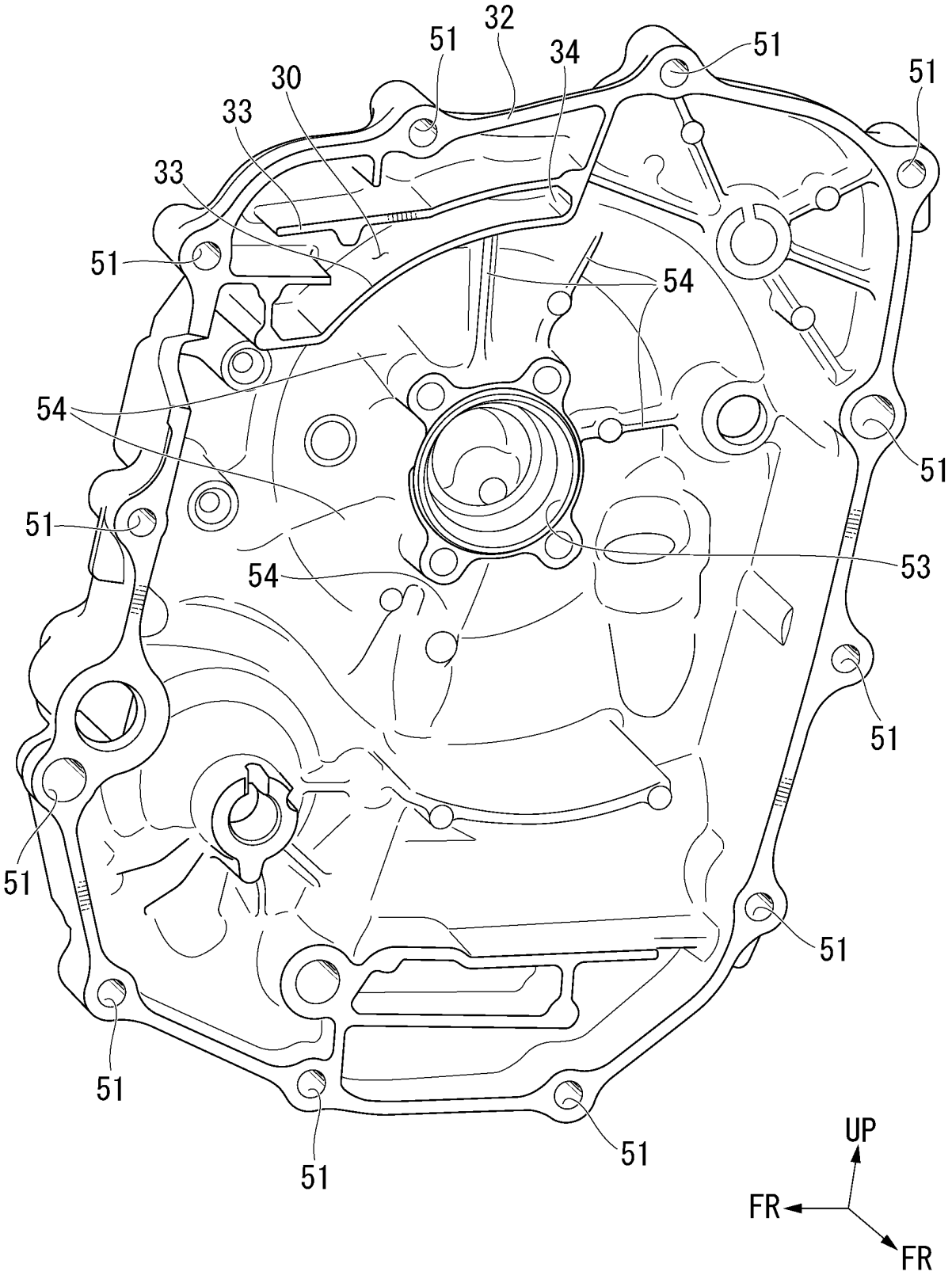


FIG. 8

FIG. 9



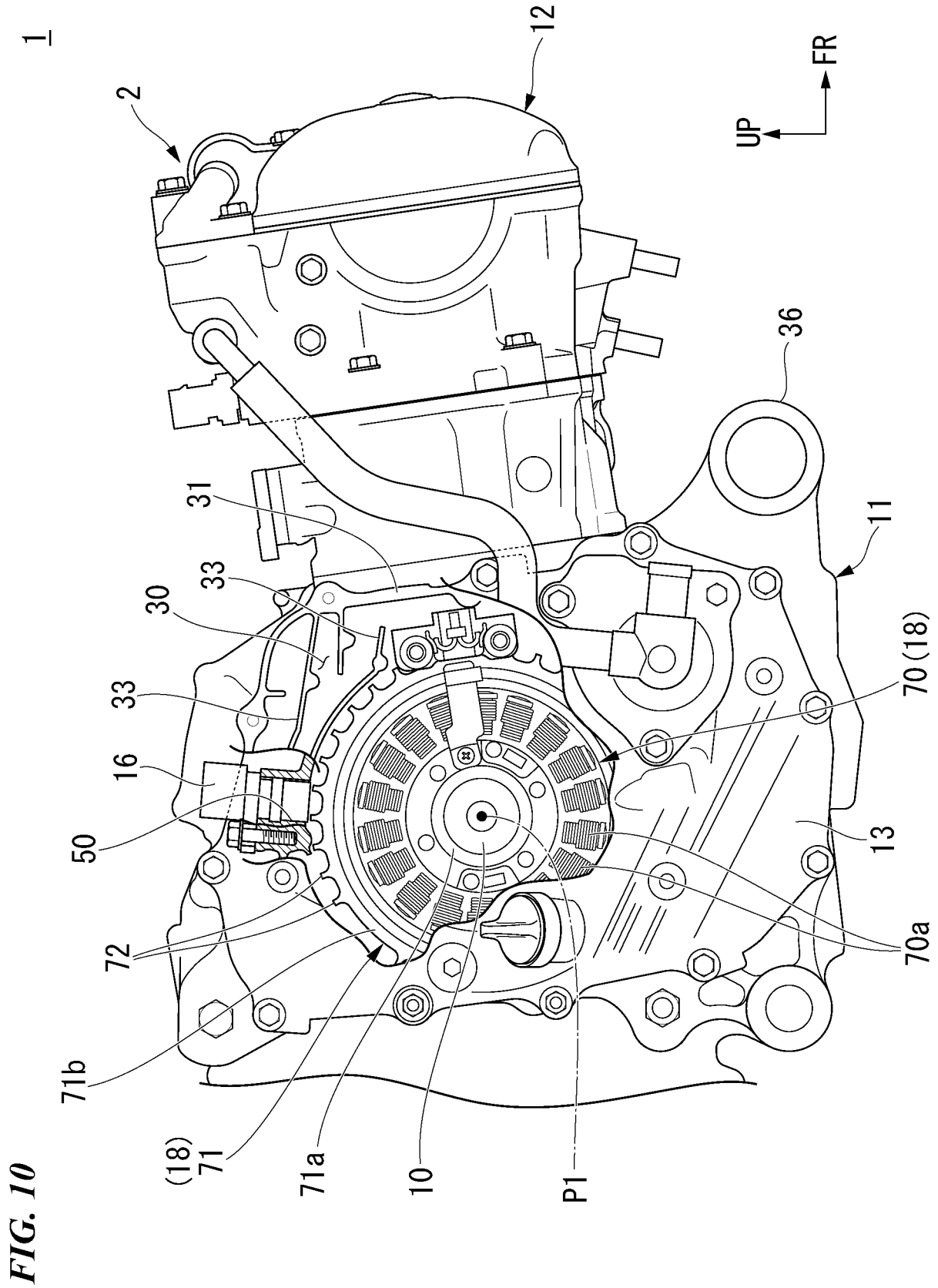
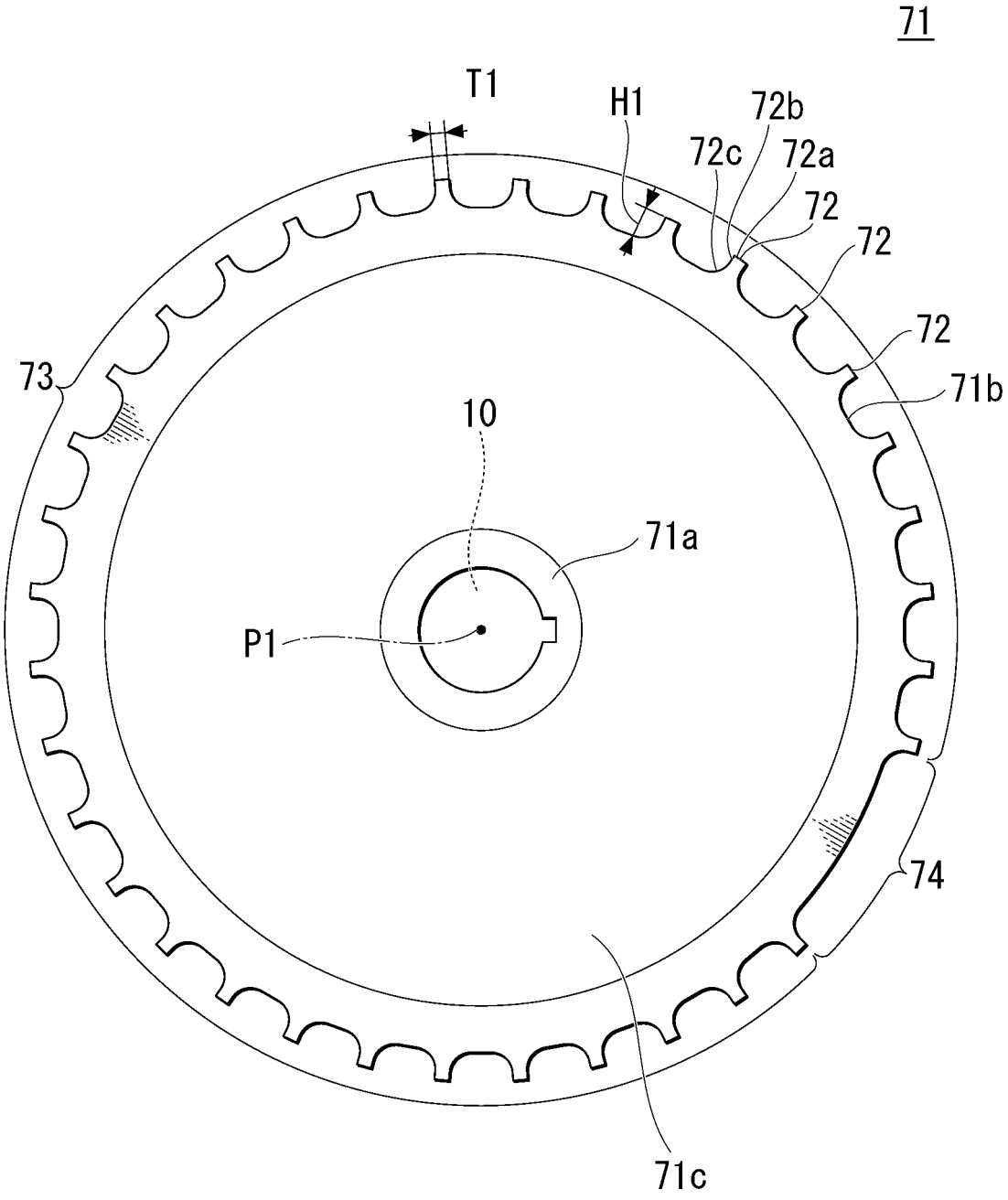


FIG. 10

FIG. 11



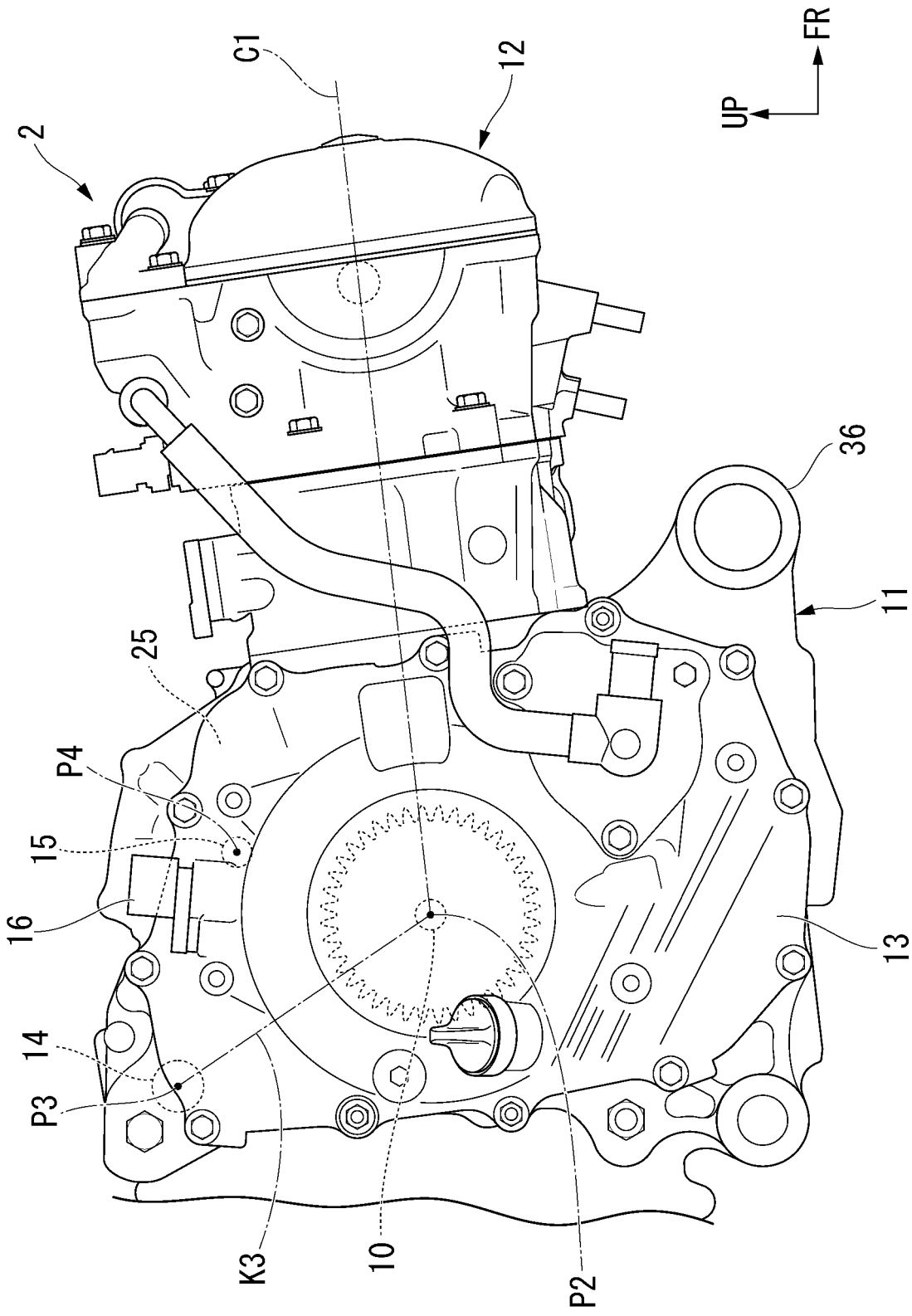


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/024474

A. CLASSIFICATION OF SUBJECT MATTER
F01M 13/04(2006.01)i; F02D 35/00(2006.01)i; F02F7/00(2006.01)i; F02B 61/02(2006.01)i; F02B 77/00(2006.01)i
FI: F02D35/00 362C; F01M13/04 F; F02F7/00 301Z; F02F7/00 K; F02B77/00 L; F02B61/02 C
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
F01M13/04; F02D35/00; F02F7/00; F02B61/02; F02B77/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2008-223593 A (YAMAHA MOTOR CO., LTD.) 25.09.2008 (2008-09-25) paragraphs [0021]-[0051], fig. 1-9	1 2-15
Y	JP 4-203226 A (YAMAHA MOTOR CO., LTD.) 23.07.1992 (1992-07-23) column 4, line 5 to column 13, line 7, fig. 1-3	2-15
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 196046/1987 (Laid-open No. 99977/1989) (HONDA MOTOR CO., LTD.) 05.07.1989 (1989-07-05) page 5, line 9 to page 12, line 8, fig. 7	2-15
Y	WO 2018/173140 A1 (HONDA MOTOR CO., LTD.) 27.09.2018 (2018-09-27) paragraphs [0037]-[0077], fig. 1-8	2-15

☒ Further documents are listed in the continuation of Box C.
☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 August 2020 (21.08.2020)	01 September 2020 (01.09.2020)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/024474

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2018-168966 A (SPECIAL PARTS TAKEGAWA, INC.) 01.11.2018 (2018-11-01) paragraphs [0020]-[0067], fig. 1-5	3-15
Y	JP 2015-28320 A (MITSUBISHI MOTORS CORPORATION) 12.02.2015 (2015-02-12) paragraphs [0022]-[0062], fig. 1-7	3-15
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 184627/1980 (Laid-open No. 107923/1982) (NISSAN MOTOR CO., LTD.) 03.07.1982 (1982-07-03) page 4, line 4 to page 7, line 8, fig. 1-3	3-15
Y	JP 2011-196250 A (HONDA MOTOR CO., LTD.) 06.10.2011 (2011-10-06) paragraphs [0030]-[0072], fig. 1-9	5-15
Y	JP 2011-163249 A (HONDA MOTOR CO., LTD.) 25.08.2011 (2011-08-25) paragraphs [0032]-[0094], fig. 1-11	6-15
Y	JP 2009-67336 A (YAMAHA MOTOR CO., LTD.) 02.04.2009 (2009-04-02) paragraphs [0007]-[0039], fig. 1-7	6-15
Y	JP 2010-127265 A (HONDA MOTOR CO., LTD.) 10.06.2010 (2010-06-10) paragraphs [0015]-[0034], fig. 1-7	6-15
Y	JP 2018-168827 A (HONDA MOTOR CO., LTD.) 01.11.2018 (2018-11-01) paragraphs [0019]-[0043], fig. 1-4	8-15
Y	JP 2001-264113 A (NISSAN DIESEL MOTOR CO., LTD.) 26.09.2001 (2001-09-26) paragraphs [0015]-[0022], fig. 1-7	11-15
Y	JP 2012-197712 A (KUBOTA CORP.) 18.10.2012 (2012-10-18) paragraphs [0019]-[0037], fig. 1-8	11-15
Y	JP 9-42053 A (KUBOTA CORP.) 10.02.1997 (1997-02-10) paragraphs [0009]-[0023], fig. 1-5	15
Y	JP 2002-242756 A (FUJI HEAVY INDUSTRIES LTD.) 28.08.2002 (2002-08-28) paragraphs [0014]-[0045], fig. 1-6	15
A	JP 2014-105626 A (YAMAHA MOTOR CO., LTD.) 09.06.2014 (2014-06-09) paragraphs [0036]-[0090], fig. 1-12	1-15

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/024474

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-163353 A (HONDA MOTOR CO., LTD.) 08.09.2014 (2014-09-08) paragraphs [0019]-[0053], fig. 1-8	1-15
A	JP 63-101539 A (ISUZU MOTORS LIMITED) 06.05.1988 (1988-05-06) page 3, upper right column, line 6 to page 4, lower left column, line 14, fig. 1-7	1-15
A	US 2017/0138254 A1 (GM GLOOBAL TECHNOLOGY OPERATIONS LLC) 18.05.2017 (2017-05-18) paragraphs [0014]-[0039], fig. 1-4	1-15
A	WO 2015/037284 A1 (HONDA MOTOR CO., LTD.) 19.03.2015 (2015-03-19) paragraphs [0028]-[0082], fig. 1-6	1-15
A	JP 2018-168826 A (HONDA MOTOR CO., LTD.) 01.11.2018 (2018-11-01) paragraphs [0021]-[0051], fig. 1-6	1-15

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/024474

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2008-223593 A	25 Sep. 2008	(Family: none)	
JP 4-203226 A	23 Jul. 1992	(Family: none)	
JP 1-99977 U1	05 Jul. 1989	(Family: none)	
WO 2018/173140 A1	27 Sep. 2018	(Family: none)	
JP 2018-168966 A	01 Nov. 2018	(Family: none)	
JP 2015-28320 A	12 Feb. 2015	(Family: none)	
JP 57-107923 U1	03 Jul. 1982	(Family: none)	
JP 2011-196250 A	06 Oct. 2011	(Family: none)	
JP 2011-163249 A	25 Aug. 2011	(Family: none)	
JP 2009-67336 A	02 Apr. 2009	EP 2039911 A2 paragraphs [0020]-[0042], fig. 1-7	
JP 2010-127265 A	10 Jun. 2010	(Family: none)	
JP 2018-168827 A	01 Nov. 2018	US 2020/0049101 A1 paragraphs [0037]-[0061], fig. 1-4	
JP 2001-264113 A	26 Sep. 2001	(Family: none)	
JP 2012-197712 A	18 Oct. 2012	(Family: none)	
JP 9-42053 A	10 Feb. 1997	(Family: none)	
JP 2002-242756 A	28 Aug. 2002	US 2002/0112691 A1 paragraphs [0023]-[0054], fig. 1-6 EP 1233168 A2	
JP 2014-105626 A	09 Jun. 2014	EP 2735878 A1 paragraphs [0013]-[0067], fig. 1-12	
JP 2014-163353 A	08 Sep. 2014	(Family: none)	
JP 63-101539 A	06 May 1988	(Family: none)	
US 2017/0138254 A1	18 May 2017	DE 102016120961 A1 paragraphs [0014]-[0039], fig. 1-4	
WO 2015/037284 A1	19 Mar. 2015	US 2016/0195170 A1 paragraphs [0072]-[0126], fig. 1-6 EP 3045781 A1	
JP 2018-168826 A	01 Nov. 2018	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 2019122892 A **[0002]**