



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

(43) Date of publication:
06.09.2017 Bulletin 2017/36

(51) Int Cl.:
F02F 1/00 (2006.01) F02F 7/00 (2006.01)

(21) Application number: **15854472.6**

(86) International application number:
PCT/JP2015/059915

(22) Date of filing: **30.03.2015**

(87) International publication number:
WO 2016/067654 (06.05.2016 Gazette 2016/18)

(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:
MA

- **KUSANO Masamichi**
Nagoya-shi
Aichi 456-8601 (JP)
- **TOKURA Koichi**
Nagoya-shi
Aichi 456-8601 (JP)
- **KITAMURA Shinji**
Nagoya-shi
Aichi 456-8601 (JP)

(30) Priority: **27.10.2014 JP 2014218309**

(74) Representative: **Global IP Europe**
Patentanwaltskanzlei
Pfarrstraße 14
80538 München (DE)

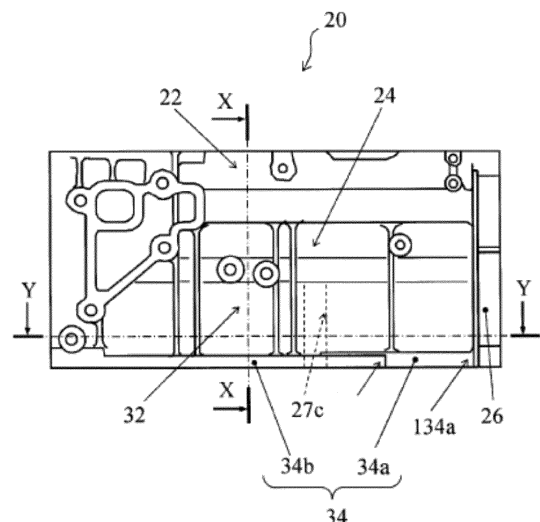
(71) Applicant: **Aichi Machine Industry Co., Ltd.**
Nagoya-shi, Aichi 456-8601 (JP)

(72) Inventors:
• **YANO Yukihiro**
Nagoya-shi
Aichi 456-8601 (JP)

(54) **ENGINE BLOCK AND INTERNAL COMBUSTION ENGINE PROVIDED WITH SAME**

(57) A technique capable of decreasing deformation of an oil pan attaching portion with good weight efficiency is provided. The oil pan rail portion (34) includes a first rail portion (34a) and a second rail portion (34b). A rail height of the first rail portion (34a) is formed higher than a rail height of the second rail portion (34b). A connecting portion (134b) between the first rail portion (34a) and the second rail portion (34b) is connected to a third journal supporting wall (27c) having the highest rigidity among the crank journal supporting walls (27). The rigidity of the first rail portion (34a) becomes larger than the rigidity of the second rail portion (34b) by such a reasonable structure, thus reasonably improving the rigidity of the first rail portion (34a) which tends to be structurally deformed easily. Further, weight increase can also be minimized, because the rail height of the oil pan rail portion (34) is not increased over the entire region along the cylinder row direction.

FIG. 3



Description

Technical Field

[0001] The present invention relates to an engine block including a body portion in which a plurality of cylinders are disposed in-line, a skirt portion connected to one end side of the body portion in a cylinder axial direction and extending in a cylinder row direction, a transmission attaching portion provided at one end side of a cylinder portion and a crankcase portion in the cylinder row direction, and an oil pan attaching portion configured to extend along the cylinder row direction at an end opposite to the side on which the cylinder portion is connected.

Background Art

[0002] In this type of engine block, it has conventionally been proposed to provide an oil pan attaching rail for attaching the oil pan along a cylinder row direction, with a height of the oil pan attaching rail being gradually higher toward the center of the cylinder row direction (e.g., see Patent Literature 1).

[0003] Such an engine block shifts an intrinsic frequency at the center of the oil pan attaching rail in the cylinder row direction, at which vibration reaches a maximum vibration mode, to the high frequency side, thus minimizing weight increase and preventing vibration noise by controlling the vibration mode in a frequency band in ordinary use.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Utility Model H1-176734

Summary of Invention

Technical Problem

[0005] Since a transmission is typically installed on one end side of the engine block in the cylinder row direction, bending stress or torsional stress generated from the transmission acts on the transmission attaching surface side of the engine block. Such an engine block described above would not have sufficient rigidity against bending stress or torsional stress if the height of the oil pan attaching rail is low on the side of the transmission attaching surface, causing deformation of the oil pan attaching rail. In this regard, the engine block described above has room for improvement.

[0006] The present invention has been made in view of the above, and it is an object of the present invention to decrease deformation of an oil pan attaching portion with good weight efficiency.

Solution to Problem

[0007] An engine block and an internal combustion engine provided with the same of the present invention include the following means to achieve the above object.

[0008] According to a preferred mode of the present invention, an engine block includes a cylinder portion, a crankcase portion, a transmission attaching portion, and an oil pan attaching portion. The cylinder portion includes a plurality of cylinders arranged in-line. The crankcase portion is connected to one end side of the cylinder portion in the cylinder axial direction to form a crank chamber. Further, the crankcase portion includes a rigidity improving portion capable of improving rigidity. The transmission attaching portion is provided on one end side of the cylinder portion and the crankcase portion in a cylinder row direction. The oil pan attaching portion is provided along the cylinder row direction at an end portion opposite to the side on which the cylinder portion is connected.

The oil pan attaching portion includes a first portion and a second portion. The first portion extends closer to and is connected to the transmission attaching portion. The second portion extends to a position away from the transmission attaching portion farther than the first portion. The oil pan attaching portion is configured such that a second moment of area of a cross-section of the first portion is larger than a second moment of area of a cross-section of the second portion, each of the cross-sections being perpendicular to the cylinder row direction. The first portion is connected to the rigidity improving portion at the end portion opposite to a connecting portion connected to the transmission attaching portion.

[0009] In the present invention, "connected to one end side of the cylinder portion in the cylinder axial direction" represents a mode in which the crankcase portion is formed integrally at one end side of the cylinder portion in the cylinder axial direction, and also represents a mode in which the cylinder portion and the crankcase portion are formed separately, and the crankcase portion is integrally connected to one end side of the cylinder portion in the cylinder axial direction with fastening members, such as bolts.

[0010] In the present invention, in the oil pan attaching portion, the second moment of area of the cross-section of the first portion perpendicular to the cylinder row direction is larger than the second moment of area of the cross-section of the second portion perpendicular to the cylinder row direction. Thus, the rigidity of the first portion, which is located closer to the transmission attaching portion and easily affected by bending moment or torsional moment, of the oil pan attaching portion can be higher than the rigidity of the second portion located away from the transmission attaching portion.

[0011] Further, weight increase of the entire engine block can be minimized compared to the structure in which the second moment of area of the oil pan attaching portion is increased over the entire region in the cylinder row direction. Since the end portion of the first portion

opposite to the connecting portion connected to the transmission attaching portion is connected to the rigidity improving portion, an extremely high rigidity can be achieved. As a result, the deformation of the oil pan attaching portion caused by the bending moment or the torsional moment can be effectively decreased with good weight efficiency.

[0012] According to another mode of the engine block of the present invention, the crankcase portion includes supporting walls capable of rotatably supporting the crankshaft. The supporting walls are configured to function as the rigidity improving portion.

[0013] In this mode, each of the supporting walls that support the crankshaft is used as the rigidity improving portion, thus minimizing weight increase compared to the structure in which a dedicated rigidity improving portion is provided.

[0014] According to still another mode of the engine block of the present invention, the first portion is connected to a central supporting wall that is the supporting wall disposed in the center of the supporting walls in the cylinder row direction.

[0015] In this mode, the rigidity of a portion of the oil pan attaching portion, which is located in a range from the connecting portion connected to the transmission attaching portion to the center position in the cylinder row direction, can be increased. Thus, the deformation of the oil pan attaching portion due to the bending stress or torsional stress from the transmission can be decreased effectively.

[0016] According to still another mode of the engine block of the present invention, a height of the cross-section of the oil pan attaching portion of the first portion is higher than a height of the cross-section of the second portion, each of the cross-sections being perpendicular to the cylinder row direction.

[0017] In the present mode, the second moment of area of the cross-section, which is perpendicular to the cylinder row direction, of the first portion located closer to the connecting portion can be larger than the second moment of area of the cross-section, which is perpendicular to the cylinder row direction, of the second portion located away from the connecting portion, with the simple structure in which the height of a cross-section is changed. Thus, the deformation of the oil pan attaching portion due to the bending stress or torsional stress generated from the transmission can be decreased without deteriorating manufacturability of the engine block.

[0018] According to still another mode of the engine block of the present invention, the crankcase portion includes, when seen from the cylinder row direction, a skirt portion configured to project from the cylinder portion to become gradually wider in a direction orthogonal to both the cylinder row direction and the cylinder axial direction. The skirt portion has a linear cross-section perpendicular to the cylinder row direction.

[0019] Typically, a height dimension of the cross-section is increased or a complicated shape of the cross-

section is provided in order to increase the second moment of area. When the engine block is formed by casting, a flow rate (kinetic energy) of molten metal decreases in a portion having a cross-section of an increased height or complicated shape, causing enough molten metal to hardly flow downward from such portion.

[0020] In the present mode, the skirt portion located downstream of the oil pan attaching portion, which includes the first portion having an increased second moment of area, has the linear cross-section, thus achieving improved fluidity toward downstream of the oil pan attaching portion, compared to a case in which the skirt portion has a circular arc-shaped cross-section. Although the skirt portion having a linear cross-section has a decreased rigidity of the skirt portion, compared to the case in which the skirt portion has a circular arc-shaped cross-section, the rigidity of the oil pan attaching portion increases to maintain the rigidity of the entire engine block. As a result, both manufacturability and improved rigidity can be achieved.

[0021] According to a preferred mode of the present invention, an internal combustion engine includes the engine block according to any one of the modes described above, and an oil pan attached to the oil pan attaching portion of the engine block. The internal combustion engine is configured to lubricate necessary portions to be lubricated using oil stored in the oil pan.

[0022] The present invention includes the engine block according to any one of the modes described above, so that an effect similar to the effect achieved by the engine block of the present invention can be achieved. For example, an effect of improving rigidity of the oil pan attaching portion with good weight efficiency can be achieved.

Advantageous Effects of Invention

[0023] In the present invention, the deformation of the oil pan attaching portion caused by bending stress or torsional stress by the transmission can be decreased with good weight efficiency.

Brief Description of Drawings

[0024]

Fig. 1 is a schematic view of an internal combustion engine 1 on which an engine block 20 according to an embodiment of the present invention is mounted.

Fig. 2 is a perspective view illustrating an external appearance of the engine block 20 according to the embodiment of the present invention.

Fig. 3 is a side view of the engine block 20, when seen from the side, according to the embodiment of the present invention.

Fig. 4 is a cross-sectional view cut along line X-X of

Fig. 3.

Fig. 5 is a cross-sectional view cut along line Y-Y of Fig. 3.

Description of Embodiment

[0025] A best mode for carrying out the present invention is described below by referring to an embodiment.

Embodiment

[0026] An internal combustion engine 1 provided with an engine block 20 according to an embodiment of the present invention includes, as illustrated in Fig. 1, a cylinder head 2, a rocker cover 4 attached on top of the cylinder head 2, the engine block 20 according to the present embodiment attached under the cylinder head 2, an upper oil pan 6 attached under the engine block 20, and a lower oil pan 8 attached under the upper oil pan 6.

[0027] The engine block 20 according to the present embodiment includes, in an integrally-formed manner, as illustrated in Figs. 2 to 4, a cylinder block portion 22 in which four cylinder bores 22a are formed in-line, a crankcase portion 24 constituting a part of a crank chamber 23, a block-side flange surface portion 26 provided on one end side (right side of Figs. 1 to 3) of the cylinder block portion 22 and the crankcase portion 24 in a cylinder row direction, and an oil pan rail portion 34 to which the upper oil pan 6 can be attached.

[0028] The cylinder block portion 22 is an example constituent component corresponding to a "cylinder portion" of the present invention. The crank chamber 23 is an example constituent component corresponding to a "crank chamber" of the present invention. The block-side flange surface portion 26 is an example constituent component corresponding to a "transmission attaching portion" of the present invention. The oil pan rail portion 34 is an example constituent component corresponding to an "oil pan attaching portion" of the present invention.

[0029] The crankcase portion 24 includes a skirt portion 32, as illustrated in Figs. 2 to 4. The skirt portion 32 projects, when seen from the cylinder row direction as illustrated in Fig. 4, from the cylinder block portion 22 to become gradually wider in a direction orthogonal to both a cylinder row direction and an axial direction of the cylinder bore 22a. That is, the skirt portion 32 projects in left and right directions in Fig. 4.

[0030] The skirt portion 32 has a substantially linearly-shaped cross-section perpendicular to the cylinder row direction. The skirt portion 32 having such a substantially linearly-shaped cross-section can improve fluidity of molten metal in casting the engine block 20. As a result, manufacturability improves.

[0031] The skirt portion 32 having a substantially linearly-shaped cross-section is an example constituent component corresponding to "the skirt portion having a

linearly-shaped cross-section perpendicular to a cylinder row direction" of the present invention.

[0032] Crank journal supporting walls 27 are formed inside the skirt portion 32, as illustrated in Figs. 4 and 5.

5 The crank journal supporting walls 27 include a bearing portion 28 that rotatably supports a journal portion of a crankshaft CS. The crank journal supporting walls 27 are thus configured as partition walls to divide the crank chamber 23 for each cylinder bore 22a. For convenience of explanation, the crank journal supporting walls 27 include, from the left side of Fig. 5, a first journal supporting wall 27a, a second journal supporting wall 27b, a third journal supporting wall 27c, a fourth journal supporting wall 27d, and a fifth journal supporting wall 27e, in this order.

10 **[0033]** In the present embodiment, a thrust plate SP that receives force from the crankshaft CS in thrust direction is attached on both side of third journal supporting wall 27c in the axial direction of the crankshaft CS. Further, counterweights (not illustrated) are disposed at positions sandwiching the third journal supporting wall 27c, among counterweights (not illustrated) disposed on the crankshaft CS, extend in the same direction. As such, the third journal supporting wall 27c receives inertia force larger than inertia forces for the other crank journal supporting walls 27 (the first journal supporting wall 27a, the second journal supporting wall 27b, the fourth journal supporting wall 27d, and the fifth journal supporting wall 27e). Therefore, the third journal supporting wall 27c has a wall thickness larger than the wall thickness of the other crank journal supporting walls 27 (the first journal supporting wall 27a, the second journal supporting wall 27b, the fourth journal supporting wall 27d, and the fifth journal supporting wall 27e).

25 **[0034]** Thus, the third journal supporting wall 27c has rigidity larger than the rigidity of the other crank journal supporting walls 27 (the first journal supporting wall 27a, the second journal supporting wall 27b, the fourth journal supporting wall 27d, and the fifth journal supporting wall 27e). The crank journal supporting wall 27 (the first journal supporting wall 27a, the second journal supporting wall 27b, the third journal supporting wall 27c, the fourth journal supporting wall 27d, and the fifth journal supporting wall 27e) is an example constituent component corresponding to a "rigidity improving portion" and a "supporting wall" of the present invention. The third journal supporting wall 27c is an example constituent component corresponding to a "central supporting wall" of the present invention.

30 **[0035]** The oil pan rail portion 34 is provided integrally at the lower end portion of the skirt portion 32 on both sides (right and left sides of Fig. 4, upper and lower sides of Fig. 5) of the center axis of the crankshaft CS, as illustrated in Figs. 2 to 4. The oil pan rail portion 34 is configured in substantially the same structure on both sides (right and left sides of Fig. 4, upper and lower sides of Fig. 5) of the center axis of the crankshaft CS.

[0036] The oil pan rail portion 34 is formed in a flange-

like shape projecting in a direction orthogonal to the cylinder row direction and the axial direction of the cylinder bore 22a, that is, the right and left directions of Fig. 4. The oil pan rail portion 34 is connected to the block-side flange surface portion 26 at one end side in the cylinder row direction, and extends from the block-side flange surface portion 26 along the cylinder row direction.

[0037] As illustrated in Figs. 2 to 5, the oil pan rail portion 34 includes a first rail portion 34a and a second rail portion 34b. The first rail portion 34a extends closer to the block-side flange surface portion 26 in the cylinder row direction. The first rail portion 34a has a length substantially equivalent to two cylinders along the cylinder row direction from a connecting portion 134a connected to the block-side flange surface portion 26. Specifically, the first rail portion 34a extends in the cylinder row direction from the connecting portion 134a and is connected to third journal supporting wall 27c at a connecting portion 134b.

[0038] The first rail portion 34a is formed so that a rail width gradually increases toward the connecting portion 134a connected to the block-side flange surface portion 26 from the connecting portion 134b connected to the second rail portion 34b. Namely, the first rail portion 34a is formed in a triangular shape in planar view.

[0039] Further, a rail height of the first rail portion 34a is higher than the rail height of the second rail portion 34b, as illustrated in Figs. 3 to 5. The second rail portion 34b is formed continuously from the first rail portion 34a, and located on the side of the first rail portion 34a opposite to the block-side flange surface portion 26. In other words, the second rail portion 34b extends away from the block-side flange surface portion 26. The first rail portion 34a is an example constituent component corresponding to a "first portion" of the present invention. The second rail portion 34b is an example constituent component corresponding to a "second portion" of the present invention. The connecting portion 134a is an example constituent component corresponding to a "connecting portion" of the present invention.

[0040] The block-side flange surface portion 26 projects, when seen along the cylinder row direction as illustrated in Figs. 1 and 2, from the cylinder block portion 22 and the crankcase portion 24 in the direction orthogonal to both the cylinder row direction and the axial direction of the cylinder bore 22a. That is, the block-side flange surface portion 26 projects in right and left directions in Fig. 4. The block-side flange surface portion 26 is formed in a substantially half-circular shape when seen from the direction along the cylinder row direction.

[0041] The upper oil pan 6 includes a body portion 6a and an oil pan-side flange surface portion 6b which is provided on one end side (right side in Fig. 1) of the body portion 6a in the cylinder row direction. The upper oil pan 6 is fastened to the oil pan rail portion 34 of the crankcase portion 24 with bolts, which are not illustrated, so that the upper oil pan 6 and the crankcase portion 24 form the crank chamber 23.

[0042] The oil pan-side flange surface portion 6b projects, when seen along the cylinder row direction, in the direction orthogonal to both the cylinder row direction and the axial direction of the cylinder bore 22a. That is, the oil pan-side flange surface portion 6b projects in the same direction as the direction in which the block-side flange surface portion 26 projects. The oil pan-side flange surface portion 6b is formed in a substantially half-circular shape when seen from the direction along the cylinder row direction. When the upper oil pan 6 is fastened to the crankcase portion 24, the oil pan-side flange surface portion 6b and the block-side flange surface portion 26, which is formed in the substantially half-circular shape, form a transmission attaching surface 50 with a substantially circular shape. The upper oil pan 6 is an example constituent component corresponding to an "oil pan" of the present invention. The transmission attaching surface 50 is an example constituent component corresponding to a "transmission attaching portion" of the present invention.

[0043] The lower oil pan 8 is formed in a bottomed bowl shape to allow storage of lubricant oil in the lower oil pan 8, as illustrated in Fig. 1. The lower oil pan 8 is an example constituent component corresponding to an "oil pan" of the present invention.

[0044] The internal combustion engine 1 as configured above is mounted on a vehicle with the transmission installed on the internal combustion engine 1. Namely, the internal combustion engine 1 is mounted on the vehicle as a power train unit in which the internal combustion engine 1 and the transmission are formed integrally. The power train unit is installed on a vehicle body on both sides of the transmission attaching surface 50. Namely, the power train unit is installed on the vehicle body via an engine mount, which is not illustrated, provided on both the internal combustion engine 1 side and the transmission side.

[0045] When the vehicle with the power train described above mounted thereon starts, the internal combustion engine 1 generates vibration caused by reciprocating motion of pistons (not illustrated) and rotary motion of the crankshaft CS. Such vibration acts on the engine block 20 as bending moment or torsional moment. The engine block 20 also receives the bending moment or the torsional moment via the transmission attaching surface 50 in accordance with driving of the transmission.

[0046] A portion of the engine block 20 in the vicinity of the transmission attaching surface 50 is easily affected by the bending moment or the torsional moment due to the support structure of the power train unit on the vehicle body as described above. When the bending moment or the torsional moment acts on the engine block 20, the first rail portion 34a deforms at the oil pan rail portion 34, which results in forming an opening in the sealing surface sealed with the upper oil pan 6 and deteriorating a sealing characteristic.

[0047] In the engine block 20, however, according to the present embodiment, a rail height of the first rail por-

tion 34a is higher than the other portion (second rail portion 34b). In addition, a rail width of the first rail portion 34a is formed in a triangular shape, in planar view, that gradually increases toward the block-side flange surface portion 26. Thus, the second moment of area of a cross-section, which is perpendicular to the cylinder row direction, of the first rail portion 34a is set to be larger than the second moment of area of a cross-section, which is perpendicular to the cylinder row direction, of the other portion (second rail portion 34b).

[0048] This improves rigidity of the first rail portion 34a that tends to be easily deformed, and effectively decreases the deformation of the first rail portion 34a. Weight increase can also be minimized, because the rail height is not increased over the entire region of the oil pan rail portion 34 along the cylinder row direction.

[0049] The first rail portion 34a is formed over a length substantially equivalent to two cylinders from the connecting portion 134a connected to the block-side flange surface portion 26 in the cylinder row direction. At the same time, the first rail portion 34a is connected to the third journal supporting wall 27c having the largest rigidity among the crank journal supporting walls 27. Thus, the rigidity of the first rail portion 34a can be effectively improved. As a result, the deformation of the oil pan rail portion 34 can be decreased with good weight efficiency.

[0050] The fact that the height of the first rail portion 34a is made higher than the height of the second rail portion 34b might cause a decrease in flow rate of the molten metal in the first rail portion 34a during casting of the engine block 20, causing a decrease in fluidity toward the skirt portion 32 side which is located downstream of the first rail portion 34a in the direction of flow of the molten metal.

[0051] In the present embodiment, however, the skirt portion 32 has the substantially linear cross-section perpendicular to the direction along the cylinder row direction. Thus, the decrease of fluidity toward the skirt portion 32 side can be minimized, and the fluidity toward the skirt portion 32 side can be improved, compared to the case in which the skirt portion 32 has a circular arc-shaped cross-section.

[0052] Although the rigidity of the skirt portion 32 decreases when the skirt portion 32 has the linear cross-section, compared to the skirt portion having the circular arc-shaped cross-section, the rigidity of the engine block 20 as a whole can be maintained by the increase of the rigidity of the oil pan rail portion 34. As a result, improved manufacturability and improved rigidity can both be achieved.

[0053] In the engine block 20 according to the embodiment of the present invention, the oil pan rail portion 34 includes the first rail portion 34a which is connected to and extends closer to the block-side flange surface portion 26, and the second rail portion 34b extending away from the block-side flange surface portion 26 farther than the first rail portion 34a. The second moment of area of the first rail portion 34a is made larger than the second

moment of area of the second rail portion 34b by increasing the rail height of the first rail portion 34a higher than the rail height of the second rail portion 34b. At the same time, the connecting portion 134b between the first and second rail portions 34a and 34b is connected to the third journal supporting wall 27c having the largest rigidity among the crank journal supporting walls 27. Thus, the rigidity of the first rail portion 34a which tends to be structurally deformed easily can reasonably be improved to effectively decrease the deformation of the first rail portion 34a.

[0054] The weight increase can also be minimized, because the rail height is not increased over the entire region of the oil pan rail portion 34 along the cylinder row direction. As a result, the deformation of the oil pan rail portion 34 can be decreased with good weight efficiency. Since the second moment of area of the first rail portion 34a can be increased with the simple structure in which the rail height of the first rail portion 34a is made higher than the rail height of the second rail portion 34b, the structure of the engine block 20 itself does not become complicated. Namely, the manufacturability of the engine block 20 does not decrease.

[0055] In the present embodiment, the rigidity of the third journal supporting wall 27c is made higher than the rigidity of other supporting walls of the crank journal supporting wall 27, but this structure may be changed. For example, the rigidity of the first journal supporting wall 27a, the second journal supporting wall 27b, the fourth journal supporting wall 27d, or the fifth journal supporting wall 27e may be higher than the rigidity of the other journal supporting walls 27. In this case, the connecting portion 134b side of the first rail portion 34a may be connected to the crank journal supporting wall 27 having the highest rigidity among the crank journal supporting walls 27.

[0056] In the present embodiment, the first rail portion 34a is connected to the third journal supporting wall 27c of the crank journal supporting walls 27 at the connecting portion 134b side, but this structure may be changed. For example, the first rail portion 34a may be connected to a portion having a high rigidity, such as a vertical rib 32a provided on the outer surface of the engine block 20. In this case, the vertical rib 32a is an example constituent component corresponding to a "rigidity improving portion" of the present invention.

[0057] In the present embodiment, the second moment of area of the first rail portion 34a is larger than the second moment of area of the second rail portion 34b by simply increasing the rail height of the first rail portion 34a higher than the rail height of the second rail portion 34b. However, this structure may be changed. The first rail portion 34a may have a cross-section in such a shape as to make the second moment of area thereof larger than that of the cross-section of the second rail portion 34b. For example, the first rail portion 34a may have a hollow box-shaped cross-section or a U-shaped cross-section.

[0058] The above embodiment illustrates an example mode to carry out the present invention. The present in-

vention, therefore, is not limited to the structure of the above embodiment.

Reference Signs List

[0059]

1	Internal combustion engine (Internal combustion engine)
2	Cylinder head
4	Rocker cover
6	Upper oil pan (Oil pan)
6a	Body portion
6b	Oil pan-side flange surface portion
8	Lower oil pan (Oil pan)
20	Engine block (Engine block)
22	Cylinder block portion (Cylinder portion)
22a	Cylinder bore
23	Crank chamber
24	Crankcase portion (Crankcase portion)
26	Block-side flange surface portion (Transmission attaching portion)
27	Crank journal supporting wall
27a	First journal supporting wall (Rigidity improving portion, Supporting wall)
27b	Second journal supporting wall (Rigidity improving portion, Supporting wall)
27c	Third journal supporting wall (Rigidity improving portion, Supporting wall, Central supporting wall)
27d	Fourth journal supporting wall (Rigidity improving portion, Supporting wall)
27e	Fifth journal supporting wall (Rigidity improving portion, Supporting wall)
28	Bearing portion
32	Skirt portion (Skirt portion)
32a	Vertical rib (Rigidity improving portion)

34	Oil pan rail portion (Oil pan attaching portion)
34a	First rail portion (First portion)
5 34b	Second rail portion (Second portion)
50	Transmission attaching surface (Transmission attaching portion)
10 134a	Connecting portion (Connecting portion)
134b	Connecting portion
CS	Crankshaft
15 SP	Thrust plate

Claims

1. An engine block, comprising:

a cylinder portion in which a plurality of cylinders are arranged in-line;
a crankcase portion connected to one end side of the cylinder portion in a cylinder axial direction to form a crank chamber;
a transmission attaching portion provided on one end side of the cylinder portion and the crankcase portion in a cylinder row direction; and
an oil pan attaching portion configured to extend along the cylinder row direction at an end portion opposite to the side on which the cylinder portion is connected,
wherein
the crankcase portion is configured to have a rigidity improving portion capable of improving rigidity thereof,
the oil pan attaching portion includes a first portion extending closer to the transmission attaching portion and connected to the transmission attaching portion, and a second portion extending away from the transmission attaching portion farther than first portion,
the oil pan attaching portion is configured such that a second moment of area of a cross-section of the first portion is larger than a second moment of area of a cross-section of the second portion, each of the cross-sections being perpendicular to the cylinder row direction, and
the first portion is connected to the rigidity improving portion at an end portion opposite to the connecting portion connected to the transmission attaching portion.

2. The engine block according to claim 1, wherein the crankcase portion includes supporting walls that

rotatably support a crankshaft, and
the supporting walls are configured to function as
the rigidity improving portion.

3. The engine block according to claim 2, wherein 5
the first portion is connected to a central supporting
wall that is the supporting wall disposed in the center
of the supporting walls in the cylinder row direction.

4. The engine block according to any one of claims 1 10
to 3, wherein
the oil pan attaching portion is configured such that
a height of the cross-section of the first portion is
higher than a height of the cross-section of the sec-
ond portion, each of the cross-sections being per- 15
pendicular to the cylinder row direction.

5. The engine block according to any one of claims 1
to 4, wherein 20
the crankcase portion includes a skirt portion config-
ured, when seen from the cylinder row direction, to
project to become gradually wider in a direction or-
thogonal to both the cylinder row direction and the
cylinder axial direction, and
the skirt portion is configured to have a linearly- 25
shaped cross-section perpendicular to the cylinder
row direction.

6. An internal combustion engine, comprising: 30

the engine block according to any one of claims
1 to 5; and
an oil pan attached to the oil pan attaching por-
tion of the engine block, wherein 35
the internal combustion engine is configured to
perform lubrication of a portion to be lubricated
using oil stored in the oil pan.

40

45

50

55

FIG. 1

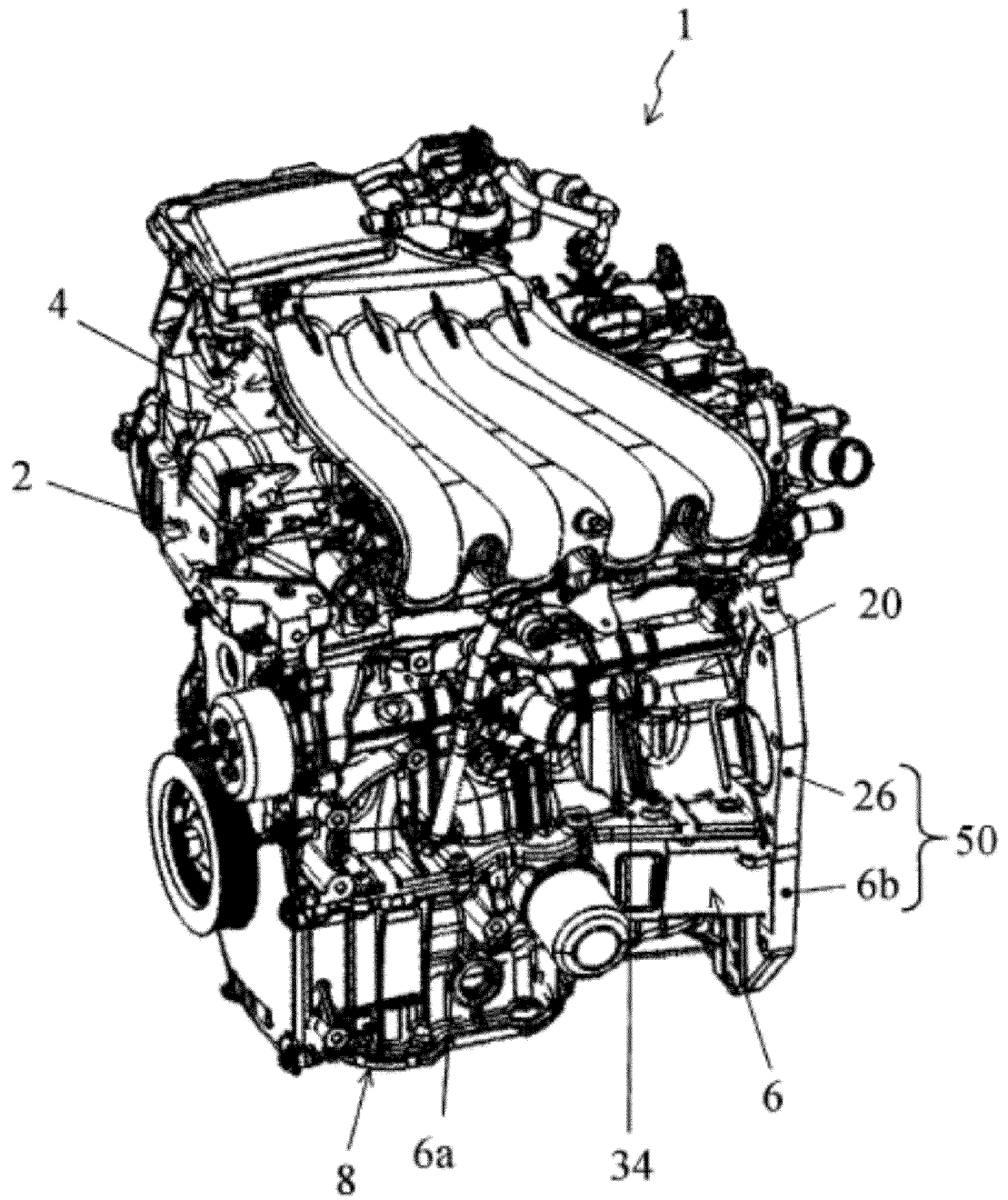


FIG. 2

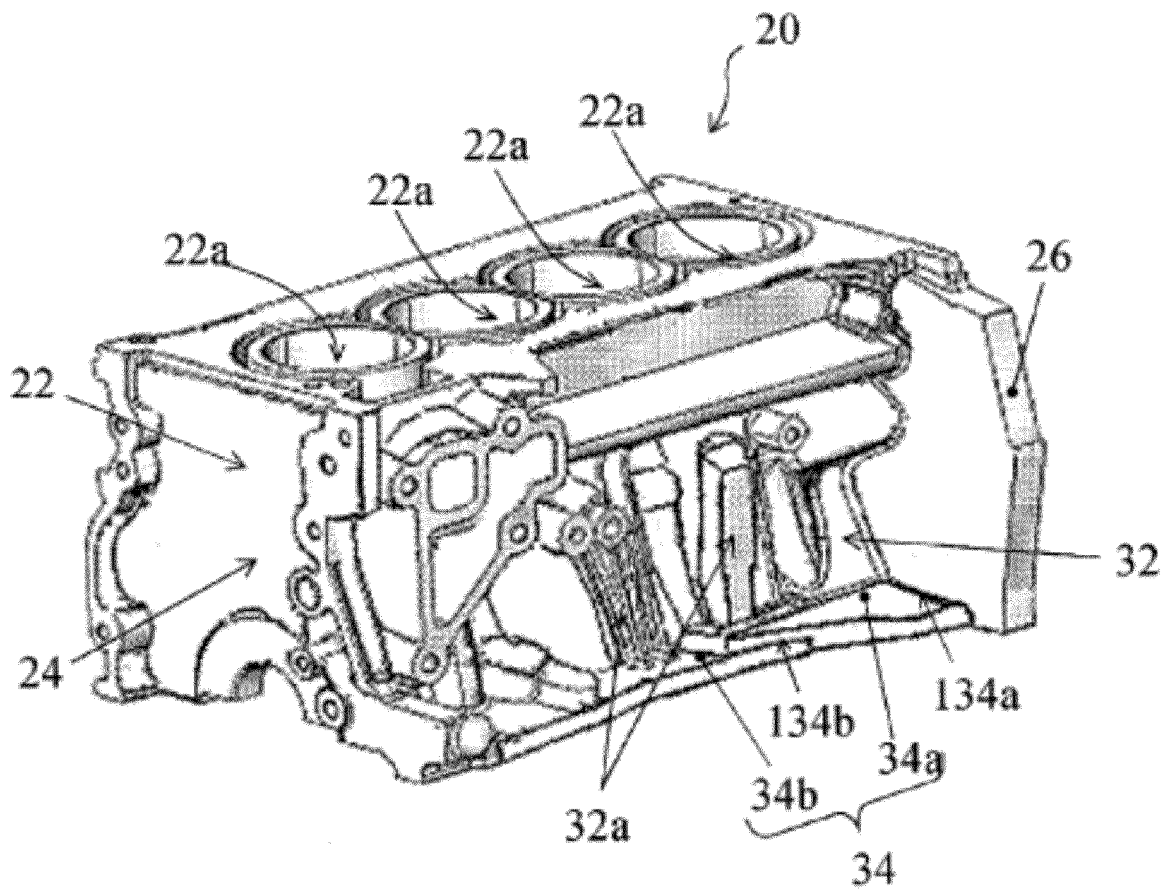


FIG. 3

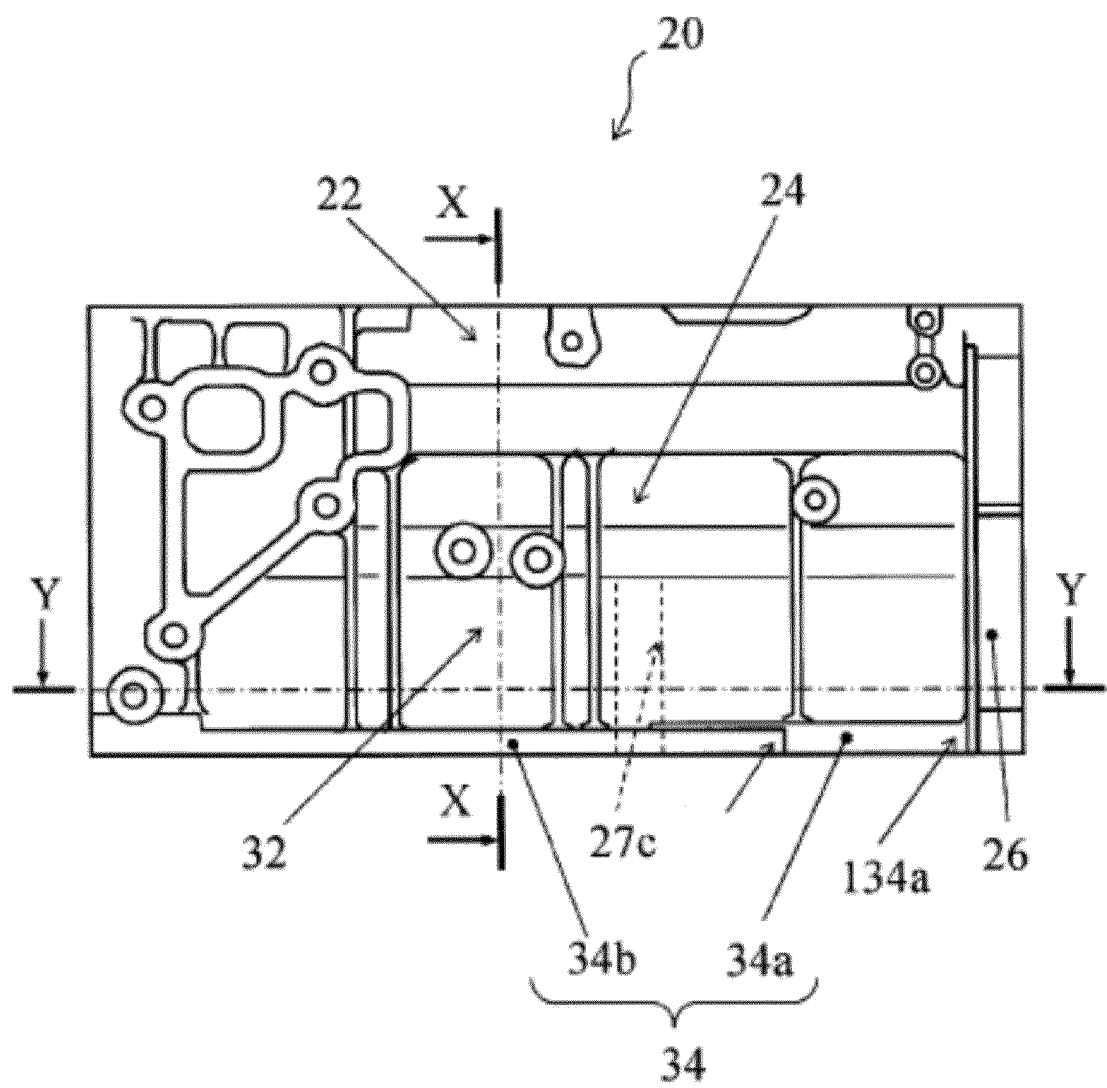


FIG. 4

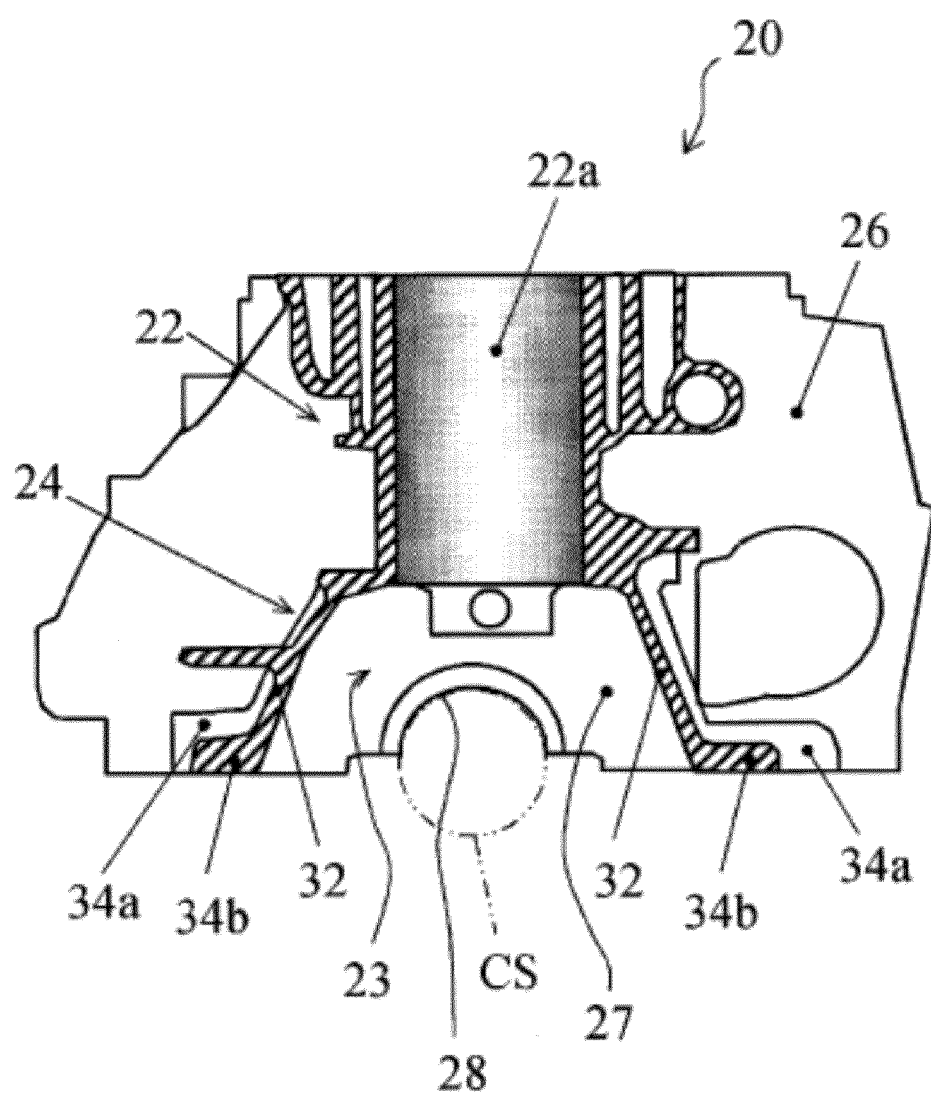
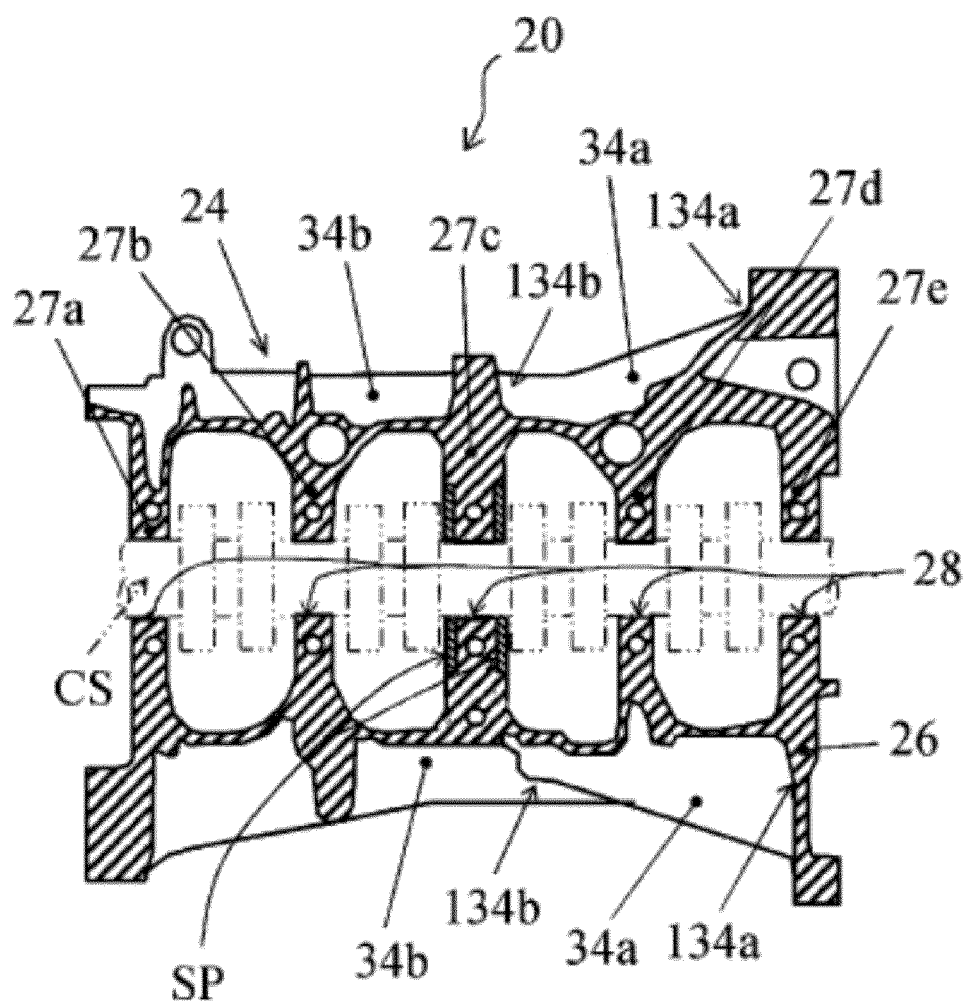


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/059915

A. CLASSIFICATION OF SUBJECT MATTER

F02F1/00(2006.01) i, F02F7/00(2006.01) i

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)

F02F1/00, F02F7/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 158213/1978 (Laid-open No. 73539/1980) (Nissan Motor Co., Ltd.), 21 May 1980 (21.05.1980), page 3, line 6 to page 6, line 2; fig. 1 to 2 (Family: none)	1-4, 6 5
X Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 39559/1982 (Laid-open No. 142347/1983) (Toyo Kogyo Co., Ltd.), 26 September 1983 (26.09.1983), page 3, line 17 to page 7, line 9; fig. 1 to 3 (Family: none)	1-4, 6 5

☒ 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
05 June 2015 (05.06.15)Date of mailing of the international search report
16 June 2015 (16.06.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/059915

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 57-99247 A (Nissan Motor Co., Ltd.), 19 June 1982 (19.06.1982), page 2, upper right column, line 10 to page 3, upper right column, line 12; fig. 2 to 7 & US 4467754 A & EP 54474 A2	1-2, 5-6 3-4
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 169871/1987 (Laid-open No. 74342/1989) (Nissan Motor Co., Ltd.), 19 May 1989 (19.05.1989), page 4, line 13 to page 5, line 13; fig. 3 (Family: none)	1-6
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 104657/1986 (Laid-open No. 10242/1988) (Mazda Motor Corp.), 23 January 1988 (23.01.1988), page 4, line 12 to page 10, line 13; fig. 1 to 6 & US 4793299 A	1-6
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 133788/1981 (Laid-open No. 40538/1983) (Nissan Motor Co., Ltd.), 17 March 1983 (17.03.1983), page 4, line 13 to page 5, line 11; fig. 2 to 3 & US 4473042 A & EP 74120 A2	1-6
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 50319/1980 (Laid-open No. 150837/1981) (Nissan Motor Co., Ltd.), 12 November 1981 (12.11.1981), page 5, line 1 to page 7, line 4; fig. 3 to 5 (Family: none)	1-6

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

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 H1176734 B [0004]