



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

(43) Date of publication:
20.08.2014 Bulletin 2014/34

(51) Int Cl.:
F01L 1/04 (2006.01)

(21) Application number: **11873837.6**

(86) International application number:
PCT/JP2011/073339

(22) Date of filing: **11.10.2011**

(87) International publication number:
WO 2013/054395 (18.04.2013 Gazette 2013/16)

(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

(72) Inventor: **YANASE, Yoshinori**
Toyota-shi, Aichi-ken, 471-8571 (JP)

(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA**
Toyota-shi, Aichi-ken, 471-8571 (JP)

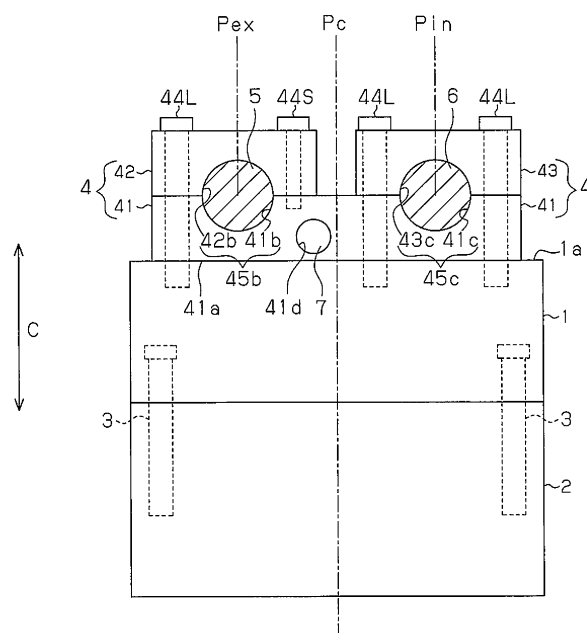
(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

(54) **CAMSHAFT SUPPORT STRUCTURE**

(57) Support bases (4) for supporting camshafts (5, 6) in a rotatable manner are mounted on the cylinder head (1) of an internal combustion engine. The support bases (4) are provided so as to be separated from each other in the axial direction of the camshafts (5, 6). Each of the support bases (4) comprises bearing portions (45b, 45c) which support the camshafts (5, 6) and a through-

hole (41 d) which extends in the axial direction of the camshafts (5, 6). A rod (7) is inserted through the through-holes (41d), and the rod (7) restricts the bearing portions (45b, 45c) from being displaced from positions at which the bearing portions (45b, 45c) are located while the internal combustion engine is stopped and cold.

Fig.2



Description

TECHNICAL FIELD

[0001] The present invention relates to a camshaft support structure that includes support bases, which are mounted on the cylinder head of an internal combustion engine and support camshafts to be freely rotational.

BACKGROUND ART

[0002] Conventionally, this type of camshaft support structure has been proposed in, for example, Patent Document 1. According to the camshaft support structure disclosed in Patent Document 1, the support bases, which support the camshafts to be freely rotational, are provided apart from one another in the axial direction of the camshafts.

[0003] With this structure, the weight of the internal combustion engine is reduced as compared to a structure in which an outer frame for connecting the support bases is provided, as in a ladder-frame camshaft housing, by the weight corresponding to the outer frame.

PRIOR ART DOCUMENTS

[0004]

Patent Documents

Patent Document 1: Japanese Laid-Open Patent Publication No. 2010-209796

SUMMARY OF THE INVENTION

Problems that the Invention is to Solve

[0005] When an engine is operated, the temperature of the cylinder head is increased by receiving heat of exhaust gas, causing the cylinder head to be thermally deformed. Since the support bases are arranged to abut against the cylinder head, the support bases are thermally deformed by receiving heat from the cylinder head. This deteriorates alignment of bearing portions, which are formed in the support bases and support the camshafts. As a result, problems may arise such as an increase in rotational sliding resistance of the camshafts.

[0006] According to the structure disclosed in Patent Document 1, the amount of heat that the support bases receive from the cylinder head is reduced as compared to the structure with the ladder-frame camshaft housing by the amount corresponding to the outer frame. The thermal deformation amount of the support bases is thus reduced to some extent. If, however, the invention is applied to an internal combustion engine in which the exhaust gas temperature is further increased such as an internal combustion engine provided with a forced-induction device, the amount of heat that the support bases receive from the cylinder head is further increased. In

this case, there are limitations in favorably reducing deterioration in the alignment of the bearing portions of the support bases.

[0007] Accordingly, it is an objective of the present invention to provide a camshaft support structure that favorably reduces deterioration in the alignment of bearing portions of support bases, which support camshafts, due to engine operation.

10 Means for Solving the Problems

[0008] Means for solving the above issues and advantages thereof will now be discussed.

[0009] To achieve the foregoing objective and in accordance with one aspect of the present invention, a camshaft support structure mounted on a cylinder head of an internal combustion engine includes support bases for supporting a camshaft to be freely rotational. The support bases are arranged apart from one another in an axial direction of the camshaft. Each support base has a bearing portion, which supports the camshaft, and a through hole, which extends in the axial direction of the camshaft. The through holes receive a rod, which restricts the bearing portions from being displaced from an arrangement position at which the bearing portions are located when the internal combustion engine is stopped and cold.

[0010] With this structure, the bearing portions of the support bases mounted on the cylinder head of the internal combustion engine support the camshaft to be freely rotational. Since the support bases are arranged apart from one another in the axial direction of the camshaft, the contact area between the support bases and the cylinder head is reduced as compared to the structure with an outer frame for connecting the support bases, such as a ladder-frame camshaft housing. This reduces the amount of heat received from the cylinder head, thus reducing thermal deformation of the support bases caused by the received heat.

[0011] Furthermore, with this structure, since the rod is inserted in the through holes formed in the support bases, the support bases are restricted from being thermally deformed by the heat received from the cylinder head.

[0012] The rod is assembled to the cylinder head together with the support bases in a state in which the rod is inserted in the through holes. The cylinder head is assembled to the cylinder block with head bolts. The top surface of the cylinder head is slightly distorted from a flat state due to the axial tightening force of the head bolts. The rod is thus maintained in a state pressed by the inner walls of the through holes, and secured to the support bases.

[0013] The structure thus favorably reduces deterioration in the alignment of the bearing portions of the support bases, which support the camshaft, due to engine operation. The rod is preferably made of material having higher rigidity than the support bases. According to this embodiment, thermal deformation of the support bases is

reduced in an appropriate manner. In a case in which the support bases are made of aluminum alloy, for example, the rod may be made of stainless-steel, which has higher rigidity than the aluminum alloy.

[0014] As a specific structure of the support bases, each support base preferably includes a receiving member, which is mounted on the cylinder head and receives the camshaft, and a cap member, which is mounted on a top surface of the receiving member and forms the bearing portion together with the receiving member. In this case, the through hole is preferably formed in the receiving member.

[0015] In this case, the support bases preferably receive both an exhaust camshaft and an intake camshaft, which each serve as the camshaft, and the through holes are preferably formed closer to the exhaust camshaft than to the intake camshaft.

[0016] In the internal combustion engine, high-temperature exhaust gas is discharged to an exhaust passage through exhaust valves. The thermal deformation of the cylinder head is thus greater in the region closer to the exhaust camshaft. In this point, according to the above embodiment, the through holes in which the rod is inserted are formed closer to the exhaust camshaft than to the intake camshaft. That is, the rod is arranged close to the region of the receiving members of the support bases where the amount of heat received from the cylinder head is great and the degree of thermal deformation is great. The region of the support bases in the vicinity of the exhaust camshaft where the amount of heat received from the cylinder head is great is thus restricted from being thermally deformed in an appropriate manner.

[0017] In the internal combustion engine provided with a forced-induction device, since the temperature of exhaust gas is higher than that without the forced-induction device, the thermal deformation amount of the support bases caused by heat received from the cylinder head is great. Furthermore, in the internal combustion engine provided with a forced-induction device, since the pressure in the cylinders is higher than that without the forced-induction device, the cylinder head is significantly deformed by fluctuation of the pressure in the cylinders of the internal combustion engine. As a result, the deformation amount of the support bases mounted on the cylinder head is increased. As described above, in the internal combustion engine provided with a forced-induction device, although with the camshaft support structure that does not include the outer frame for the support bases, the alignment of the bearing portions of the support bases is likely to deteriorate due to engine operation. Applying the present invention to such an internal combustion engine favorably reduces deterioration in the alignment of the bearing portions of the support bases due to engine operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a plan view illustrating a planar structure of an internal combustion engine according to a first embodiment of the present invention as viewed from above an exhaust camshaft and an intake camshaft; Fig. 2 is a cross-sectional view taken along line A-A of Fig. 1, illustrating a cross-sectional structure of the internal combustion engine; and

Fig. 3 is a side view schematically illustrating a side structure of the top surface of the cylinder head and the support bases mounted on the top surface in the longitudinal direction of the cylinder head.

MODES FOR CARRYING OUT THE INVENTION

[0019] A camshaft support structure of a double overhead camshaft (DOHC) inline 4-cylinder internal combustion engine according to one embodiment of the present invention will now be described with reference to Figs. 1 to 3. The internal combustion engine of the present embodiment is provided with an exhaust driven forced-induction device.

[0020] Fig. 1 shows a planar structure of an internal combustion engine as viewed from above an exhaust camshaft and an intake camshaft. Fig. 2 shows a cross-sectional structure of the internal combustion engine taken along line A-A of Fig. 1.

[0021] A cylinder head 1, which is provided with a valve mechanism including exhaust valves and intake valves, is provided on the top surface of a cylinder block 2 as shown in Fig. 2. The cylinder block 2 and the cylinder head 1 are tightened with head bolts 3 in a known manner (see Figs. 2 and 3).

[0022] An exhaust camshaft 5 provided with exhaust cams 51 for opening and closing the exhaust valves and an intake camshaft 6 provided with intake cams 61 for opening and closing the intake valves are arranged on a top surface 1 a of the cylinder head 1 to be parallel to each other. More specifically, five support bases 4 for supporting the camshafts 5, 6 to be freely rotational are mounted on the top surface 1 a of the cylinder head 1. Only one of the support bases 4 is shown in Fig. 2.

[0023] The support bases 4 are arranged apart from one another in an axial direction L of the camshafts 5, 6 as shown in Fig. 1. More specifically, the support bases 4 are arranged to be perpendicular to the axial direction L of the camshafts 5, 6.

[0024] Each of the support bases 4 includes a receiving member 41 located on the top surface 1 a of the cylinder head 1, and an exhaust side cap member 42 and an intake side cap member 43, which are located on the top surface of the receiving member 41 as shown in Fig. 2. Semi-circular lower recesses 41 b, 41 c are formed on the top surface of each receiving member 41 at positions corresponding to the camshafts 5, 6.

[0025] A semicircular upper recess 42b is formed on the bottom surface of each exhaust side cap member 42 at a position corresponding to the associated lower recess 41 b. Each lower recess 41 b and the associated

upper recess 42b form a circular bearing portion 45b, which supports one of cam journals 5a of the exhaust camshaft 5 (see Fig. 1).

[0026] Furthermore, a semicircular upper recess 43c is formed on the bottom surface of each intake side cap member 43 at a position corresponding to the associated lower recess 41c. Each lower recess 41c and the associated upper recess 43c form a circular bearing portion 45c, which supports one of cam journals 6a of the intake camshaft 6 (see Fig. 1).

[0027] Two bolt holes are formed in each exhaust side cap member 42 and the associated receiving member 41 in an axial direction C of the cylinders with the exhaust camshaft 5 located in between. The receiving member 41 and the exhaust side cap member 42 are tightened to the cylinder head 1 with bolts 44L, 44S inserted in the bolt holes.

[0028] Furthermore, each intake side cap member 43 and the associated receiving member 41 are coupled to the cylinder head 1 with other bolts 44L in the same manner as each exhaust side cap member 42 and the associated receiving member 41.

[0029] In a state in which the support bases 4 are mounted on the cylinder head 1 with the bolts 44L, 44S, the cylinder head 1 is assembled to the cylinder block 2 with the head bolts 3. The cylinder head 1, the cylinder block 2, and the support bases 4 are all made of an aluminum alloy.

[0030] In the present embodiment, a through hole 41d, which extends in the axial direction L of the camshafts 5, 6, is formed in each receiving member 41 as shown in Fig. 2. Each through hole 41d is formed at a position closer to a center position Pex of the exhaust camshaft 5 than to a middle position Pc between the center position Pex of the exhaust camshaft 5 and a center position Pin of the intake camshaft 6 in a direction perpendicular to the axial direction L of the camshafts 5, 6. In other words, the through holes 41d are formed closer to the exhaust camshaft 5 than to the intake camshaft 6.

[0031] A rod 7 made of stainless-steel is inserted in the through holes 41d. That is, the rod 7 is made of material having higher rigidity than the support bases 4. In the present embodiment, the outer diameter of the rod 7 is slightly smaller than the inner diameter of the through holes 41d. The bolts 44S located closer to the rod 7 than to the exhaust camshaft 5 are shorter than the other bolts 44L so as not to interfere with the rod 7.

[0032] Operation of the present embodiment will now be described.

[0033] The camshafts 5, 6 are supported to be freely rotational by the bearing portions 45b, 45c of the five support bases 4 mounted on the cylinder head 1. Since the support bases 4 are located separate from one another in the axial direction L of the camshafts 5, 6, the contact area between the support bases 4 and the cylinder head 1 is reduced as compared to a case in which an outer frame for connecting the support bases is provided, as in a ladder-frame camshaft housing. The

amount of heat received from the cylinder head 1 is thus reduced, which reduces thermal deformation of the support bases 4 caused by receiving heat.

[0034] Since forced induction is performed by the forced-induction device in the internal combustion engine of the present embodiment, the temperature of exhaust gas is increased as compared to the internal combustion engine without a forced-induction device. This increases the thermal deformation amount of the support bases 4 caused by receiving heat from the cylinder head 1. Furthermore, since the pressure in the cylinders is also increased as compared to the internal combustion engine without the forced-induction device, the cylinder head 1 is deformed significantly as the pressure in the cylinders of the internal combustion engine fluctuates. The deformation amount of the support bases 4 mounted on the cylinder head 1 is consequently increased. As described above, in the internal combustion engine provided with the forced-induction device, the alignment of the bearing portions 45b, 45c in the support bases 4 is likely to deteriorate due to engine operation although with the camshaft support structure of the present embodiment that does not include the outer frame for the support bases 4.

[0035] In this respect, since the rod 7 is inserted in the through holes 41d formed in the support bases 4 in the present embodiment, the support bases 4 are favorably restricted from being thermally deformed due to heat received from the cylinder head 1.

[0036] Furthermore, in the internal combustion engine, high-temperature exhaust gas is discharged to the exhaust passage through the exhaust valves. Thermal deformation of the cylinder head 1 is thus increased toward the region close to the exhaust camshaft 5. In this respect, with the above-mentioned structure, the through holes 41d in which the rod 7 is inserted are formed at positions closer to the exhaust camshaft 5 than to the intake camshaft 6. That is, the rod 7 is arranged in the vicinity of the regions in the receiving members 41 of the support bases 4 where the amount of heat received from the cylinder head 1 is great and the degree of thermal deformation is great. Thermal deformation of the receiving members 41 in the vicinity of the exhaust camshaft 5 is thus reduced in an appropriate manner.

[0037] Furthermore, the rod 7 is assembled to the cylinder head 1 together with the support bases 4 in a state in which the rod 7 is inserted in the through holes 41d. The cylinder head 1 is further assembled to the cylinder block 2 with the head bolts 3 in a state in which the support bases 4 and the rod 7 are assembled to the cylinder head 1. In this embodiment, the top surface 1a of the cylinder head 1 is slightly distorted from a flat state due to the axial tightening force of the head bolts 3 as shown in Fig. 3. The rod 7 is thus maintained in a state pressed by the inner walls of the through holes 41d, and secured to the support bases 4. For the illustrative purposes, the distortion of the top surface 1a of the cylinder head 1 is exaggerated and the rod 7 is omitted in Fig. 3.

[0038] The camshaft support structure of the present

embodiment as described above has the following advantages.

(1) The support bases 4 are arranged apart from one another in the axial direction L of the camshafts 5, 6. Furthermore, the bearing portions 45b, 45c, which support the camshafts 5, 6, and the through holes 41 d, which extend in the axial direction L of the camshafts 5, 6, are formed in the support bases 4. The rod 7 is inserted in the through holes 41 d to restrict the bearing portions 45b, 45c from being displaced from the arrangement position at which the bearing portions 45b, 45c are located when the internal combustion engine is stopped and cold. With this structure, in the support bases 4, which support the camshafts 5, 6, the alignment of the bearing portions 45b, 45c is favorably restricted from deteriorating due to engine operation. The state in which the internal combustion engine is stopped and cold refers to a state in which operation of the internal combustion engine is stopped and the influence of heat caused by the previous engine operation can be ignored.

(2) The rod 7 is made of material having higher rigidity than the support bases 4. More specifically, the support bases 4 are made of an aluminum alloy, and the rod 7 is made of stainless-steel, which has higher rigidity than the aluminum alloy. With this configuration, thermal deformation of the support bases 4 is reduced in an appropriate manner.

(3) The through holes 41 d are formed closer to the exhaust camshaft 5 than to the intake camshaft 6. This structure appropriately reduces thermal deformation of the receiving members 41 in the vicinity of the exhaust camshaft 5 where the amount of heat received from the cylinder head 1 is great.

[0039] The camshaft support structure of the present invention is not limited to the structure illustrated in the above described embodiment, but may be modified as follows.

[0040] In the above-described embodiment, the present invention is applied to an internal combustion engine provided with an exhaust driven forced-induction device, that is, a turbocharger. The present invention may, however, be applied to an internal combustion engine provided with an engine driven forced-induction device, or a supercharger.

[0041] In the above-described embodiment and the modified embodiment, the present invention is applied to an internal combustion engine provided with a forced-induction device. The present invention, however, is not only applied to an internal combustion engine provided with a forced-induction device, but may be applied to an internal combustion engine without a forced-induction device. In this case, although the amount of heat the support bases receive from the cylinder head is small as compared to that received by the engine provided with the forced-induction device, the alignment of the bearing

portions of the support bases is favorably restricted from deteriorating due to engine operation in the same manner as the above-described embodiment.

[0042] As in the above-described embodiment, it is preferable that the through holes 41d be formed closer to the exhaust camshaft 5 than to the intake camshaft 6 to prevent thermal deformation of the receiving members 41 in the vicinity of the exhaust camshaft 5 where the amount of heat received from the cylinder head 1 is great. The present invention, however, is not limited to this, but through holes may be formed at, for example, the middle position Pc between the exhaust camshaft 5 and the intake camshaft 6. In this case also, thermal deformation of the receiving members is restricted to some extent.

[0043] In the above-described embodiment, one through hole 41d is formed in each of the support bases 4. Instead, two or more through holes may be formed in each of the support bases 4, and two or more rods may be provided corresponding to the number of the through holes. This further reduces thermal deformation of the support bases.

[0044] The rod 7 made of stainless-steel is illustrated in the above-described embodiment, but the rod may be made of any material that has higher rigidity than the support bases. Description of the Reference Numerals 1...cylinder head, 1 a...top surface, 2...cylinder block, 3...head bolt, 4...support base, 41...receiving member, 41 a...abutment surface, 41 b, 41 c...lower recesses, 41 d...through hole, 42...exhaust side cap member, 42b...upper recess, 43...intake side cap member, 43c...lower recess, 44...bolt, 45b, 45c...bearing portions, 5...exhaust camshaft, 5a...cam journal, 51...exhaust cam, 6...intake camshaft, 6a...cam journal, 61...intake cam, 7...rod.

Claims

1. A camshaft support structure mounted on a cylinder head of an internal combustion engine, the camshaft support structure comprising support bases for supporting a camshaft to be freely rotational, the structure being **characterized in that** the support bases are arranged apart from one another in an axial direction of the camshaft, each support base has a bearing portion, which supports the camshaft, and a through hole, which extends in the axial direction of the camshaft, and the through holes receive a rod, which restricts the bearing portions from being displaced from an arrangement position at which the bearing portions are located when the internal combustion engine is stopped and cold.
2. The camshaft support structure according to claim 1, **characterized in that** the rod is made of material having higher rigidity than the support bases.

3. The camshaft support structure according to claim 1 or 2, **characterized in that** each support base includes a receiving member, which is mounted on the cylinder head and receives the camshaft, and a cap member, which is mounted on a top surface of the receiving member and forms the bearing portion together with the receiving member, and the through hole is formed in the receiving member. 5 10
4. The camshaft support structure according to any one of claims 1 to 3, **characterized in that** the support bases receive both an exhaust camshaft and an intake camshaft, which each serve as the camshaft, and the through holes are formed closer to the exhaust camshaft than to the intake camshaft. 15 20
5. The camshaft support structure according to any one of claims 1 to 4, **characterized in that** the internal combustion engine includes a forced-induction device. 25 30 35 40 45 50 55

Fig.1

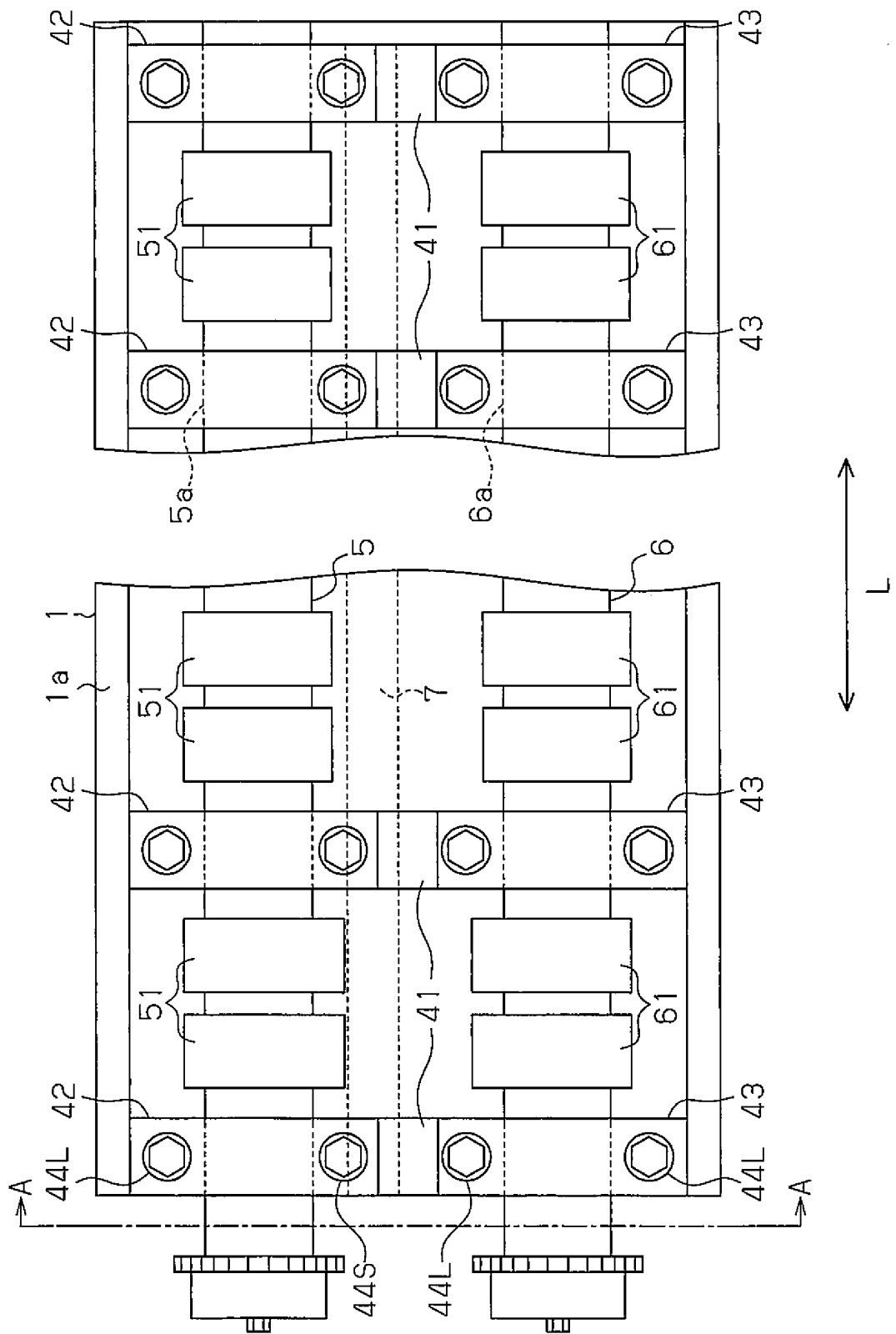


Fig.2

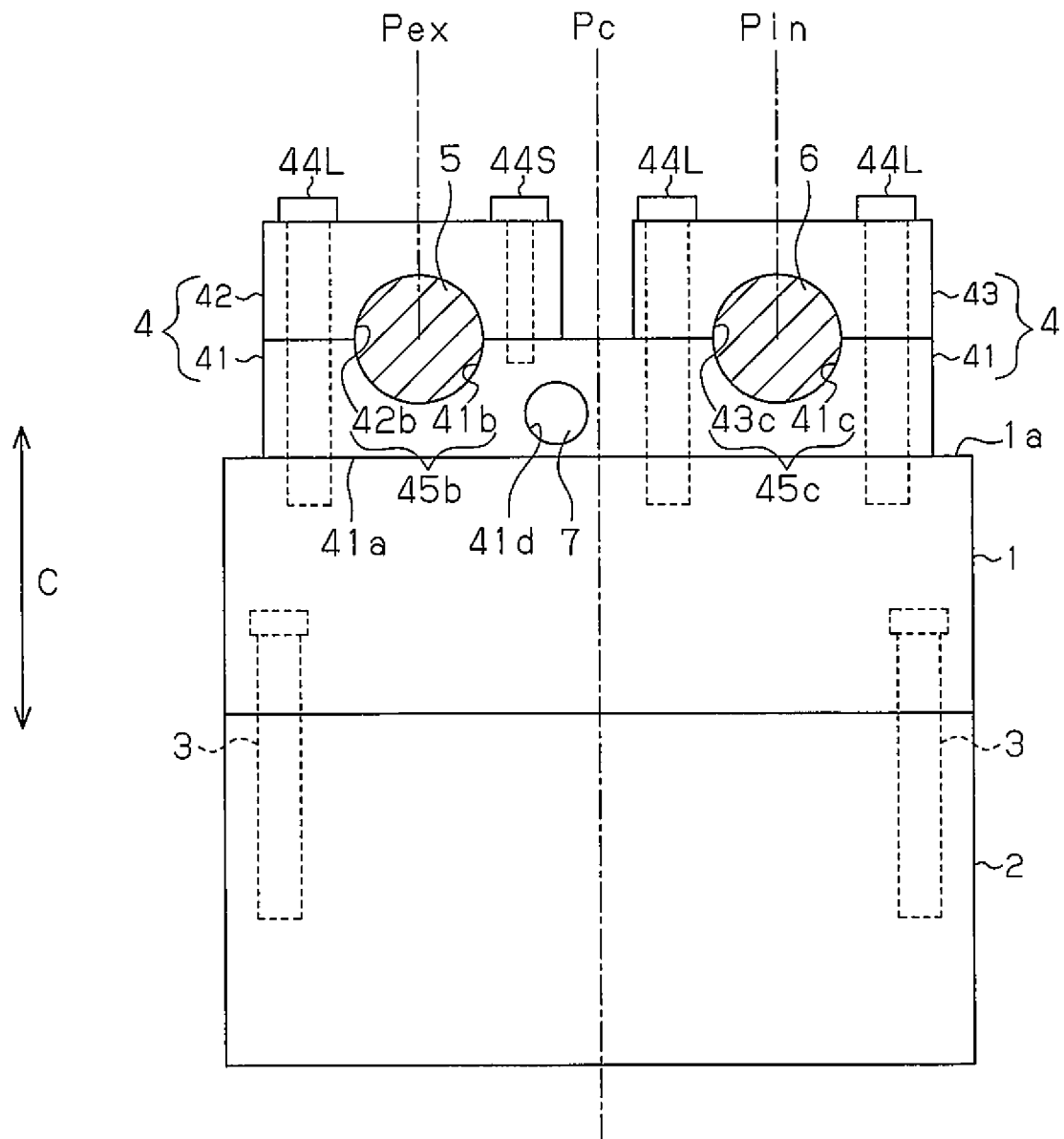
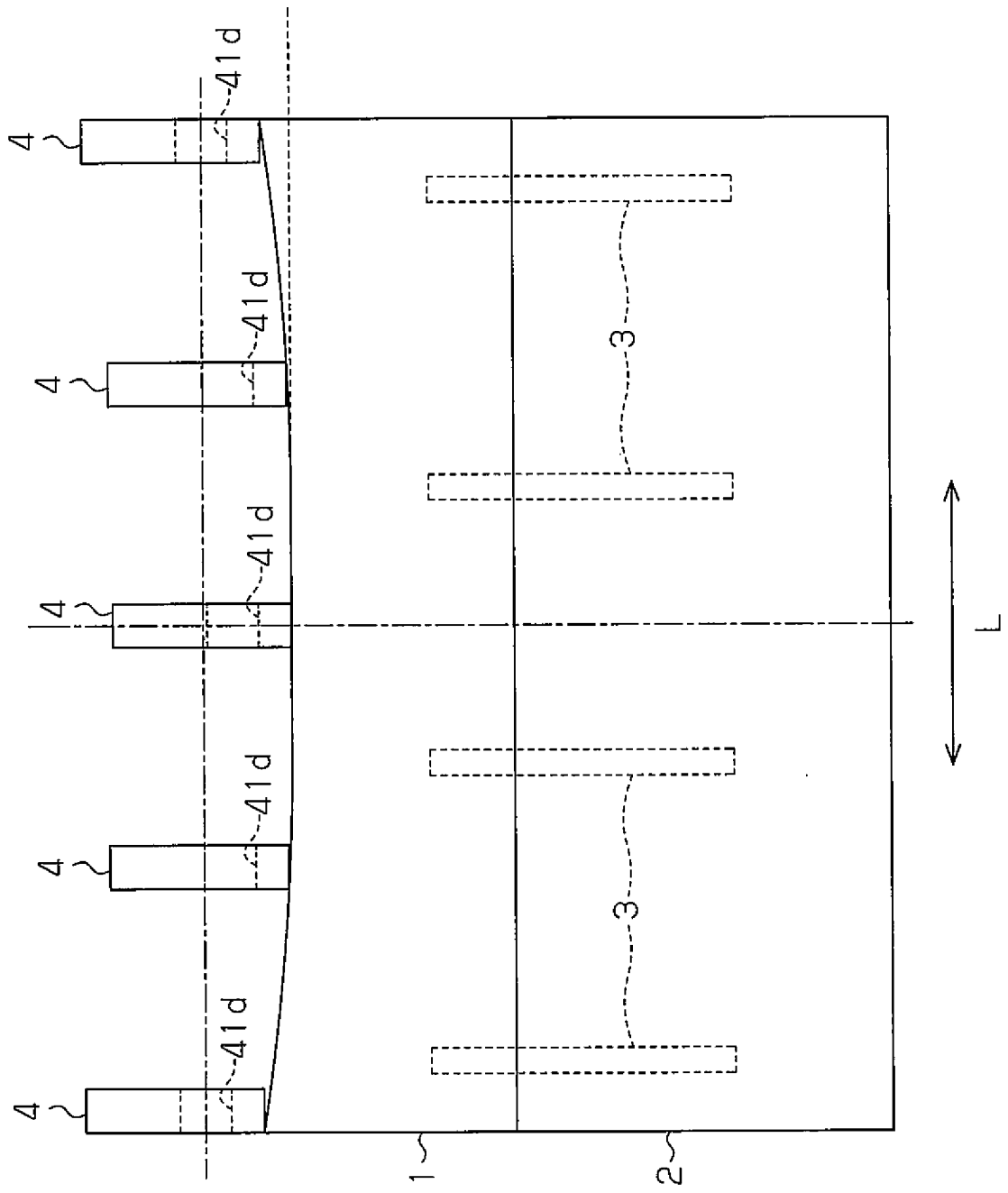


Fig. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/073339

A. CLASSIFICATION OF SUBJECT MATTER
F01L1/04 (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)
F01L1/04

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 1996-2011
Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

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.
Y	JP 58-59306 A (Toyo Kogyo Co., Ltd.), 08 April 1983 (08.04.1983), entire text; all drawings (Family: none)	1-5
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 112626/1984 (Laid-open No. 27905/1986) (Honda Motor Co., Ltd.), 19 February 1986 (19.02.1986), entire text; all drawings & US 4660515 A	1-5

☒ 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
09 December, 2011 (09.12.11)

Date of mailing of the international search report
20 December, 2011 (20.12.11)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/073339

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 2008-303856 A (Toyota Motor Corp.), 18 December 2008 (18.12.2008), fig. 1, 8 (Family: none)	1-5
A	JP 11-351243 A (Hitachi, Ltd.), 24 December 1999 (24.12.1999), paragraphs [0001] to [0008]; fig. 2 to 3 (Family: none)	1-5

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 2010209796 A [0004]