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

(11) EP 1 752 645 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
26.07.2017 Bulletin 2017/30

(21) Application number: **06016156.9**

(22) Date of filing: **02.08.2006**

(51) Int Cl.:
F02F 7/00 *(2006.01)* ***F02B 67/06*** *(2006.01)*

(54) **Front structure of engine**

Frontaufbau einer Brennkraftmaschine

Structure avant d'un moteur

(84) Designated Contracting States:
DE

(30) Priority: **08.08.2005 JP 2005229031**

(43) Date of publication of application:
14.02.2007 Bulletin 2007/07

(73) Proprietor: **Mazda Motor Corporation**
Aki-gun,
Hiroshima, (JP)

(72) Inventors:
- **Sasada, Takashi, c/o Mazda Motor Corporation**
  Aki-gun, Hiroshima (JP)
- **Hatabu, Atsuhiro, c/o Mazda Motor Corporation**
  Aki-gun, Hiroshima (JP)
- **Mori, Daisuke, c/o Mazda Eng. & Tech. Co. Ltd.**
  Hiroshima-shi, Hiroshima (JP)

(74) Representative: **Laufhütte, Dieter et al**
Lorenz Seidler Gossel
Rechtsanwälte Patentanwälte
Partnerschaft mbB
Widenmayerstraße 23
80538 München (DE)

(56) References cited:
GB-A- 2 228 045 **JP-A- 9 032 521**

EP 1 752 645 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to a front structure of an engine particularly a front structure of an engine with a plurality of auxiliary devices disposed beside an intake-side of the engine body, which are driven by a crankshaft through an auxiliary-devices driving belt.

List of Patent Document (PD)

[0002] [PD 1] Japanese Patent Laid-Open Publication No. 2003-42230

[0003] Heretofore, there has been known a technique of transmitting driving force of a crankshaft to a camshaft through a driving chain to control opening/closing timings of intake/exhaust valves, and additionally utilizing the driving force of the crank shaft for driving a balancer unit adapted to cancel the vibration of the engine body by the imbalance-induced vibration so as to provide enhanced level of engine silence (see the document PD 1).

[0004] PD 1 discloses a mechanism for driving a camshaft and a balancer unit by a driving chain. The mechanism is provided with an intermediate shaft disposed at a front side of a cylinder block and three endless-type driving chains for driving the camshaft and the balancer unit.

[0005] This mechanism is employed by the following reasons. Some engines are designed to drive: a camshaft located at an upper portion of an engine body; a balancer unit located at a lower portion of the engine body; and other auxiliary devices, such as a high-pressure fuel pump disposed beside the engine body, by using a driving chain. In this type of engine, to drive the camshaft, the balancer unit, and the fuel pump by a single driving chain would lead a large loop shape of the driving chain wound around respective ends of the crank, cam, and balancer unit shafts, so that a front portion of the engine would be excessively increased in width. This is one reason why the above mechanism is needed.

[0006] In this connection, with a view to reducing a width of the front portion of the engine, a portion of the driving chain between the adjacent shaft ends might be regulated by guide means in such a manner as to be displaced toward a center of the engine. The driving chain would be bent at a large curvature. Thus, a frictional resistance between the driving chain and the guide means would be increased to cause an increase in mechanical loss.

[0007] Meanwhile, in order to assure the given rotational speed ratios of the balancer unit to the crankshaft (the balancer unit needs to have a rotational speed twice greater than that of the crankshaft) and the camshaft to the crankshaft, chain sprockets attached to the shaft ends should respectively be set in different diameters. In this case, if these sprockets are driven by the same looped chain, some sprockets, particularly the sprocket on the camshaft would essentially be required to have a large diameter. Consequently, the front portion of the engine will be increased in width, and flexibility in layout of devices around the engine would be undesirably restricted. This is another reason why the above mechanism is needed.

[0008] In order to avoid the latter disadvantages, three endless-type driving chains may be employed to drive the camshaft and the balancer unit, and two sprockets different in diameter (number of teeth) are coaxially fixed to the crankshaft and the intermediate shaft, respectively. Then, different chains are wound around the sprockets, respectively. This structure would adjust a gear ratio so as to minimize a diameter of the sprocket at the end of the camshaft.

[0009] In the above engines designed to drive the camshaft and the balancer unit by the crankshaft, the rotational angular phase in each of the shafts should have a given relationship with a phase of the associated driving chain so that each of the shafts are rotated at a given rotational speed ratio to the crankshaft to achieve adequate balancer function and opening/closing timings of the intake/exhaust valves.

[0010] Thus, in an assembling process of the above engine designed to coaxially fix the sprockets different in respectively diameter (number of teeth) to the crankshaft and the intermediate shaft, it is desirable to arrange the sprockets in such a manner as to be visually checked from a front side of the engine to facilitate performing an phase adjusting operation from the front side of the engine.

[0011] Meanwhile, in this type of engine, a chain cover for covering the driving chains is located in front of the driving chains, and a plurality of auxiliary devices are disposed in front of the chain cover and located beside the intake-side of the engine body, in such a manner as to be driven by the crankshaft through an auxiliary-devices driving belt.

[0012] The JP9 032521A describes an oil pump sprocket cover of an internal combustion engine to reduce weight and to reduce the costs by reducing the number of pump installing bolts of an oil pump to be instead in a crankcase one side of an oil pump sprocket cover is fixed to a crankcase, and the other side of the oil pump sprocket cover is fixed to an oil pump.

[0013] When the camshaft and the balancer unit are driven using the plurality of driving chains in the above manner, these driving chains cannot be arranged in the same vertical plane in an axial direction of the crankshaft. Consequently, the chain cover has to be formed in a stepped shape along with respective positions of the driving chains. Thus, an overall length of the engine in its longitudinal direction is inevitably increased by the frontward protrusion of the chain cover.

[0014] As above, depending on an arrangement of the auxiliary devices and the auxiliary-devices driving belt relative to the chain cover, the overall longitudinal length of the engine is increased to cause a problem about increase in restrictions on mountability to an engine compartment of a vehicle.

[0015] Accordingly, it is an object of the present invention to provide a front structure of an engine designed to arrange a plurality of driving chains in a longitudinal direction of the engine, which is capable of facilitating an operation of adjusting a phase between each of the driving chains and a shaft associated with the chain in a wound manner, and reducing an overall longitudinal length of the engine to achieve enhanced mountability to an engine compartment of a vehicle.

[0016] In order to achieve the above object, the present invention provides a front structure of an engine designed to arrange a plurality of auxiliary devices beside an intake-side of an engine body and to drive the auxiliary devices by a crankshaft through an auxiliary-devices driving belt. The front structure is provided with: a balancer-unit in an oil pan; a balancer-unit sprocket on the balancer-unit; a balancer-unit driving chain which is so wound around the balancer-unit sprocket that the balancer-unit is driven by a crankshaft; a pair of camshafts disposed on a cylinder head; an intermediate shaft through which drive force is transmitted from the crankshaft to the camshafts; and a pair of upper and lower camshaft driving chains adapted to couple the crankshaft to the camshafts. The lower camshaft driving chain is arranged behind the upper camshaft driving chain. The engine front structure is further provided with a chain cover which covers a front side of the chains and has upper and lower front parts formed such that the lower front part is depressed toward a cylinder block relative to the upper front part in a longitudinal direction of the engine along with respective front surfaces of the chains. An auxiliary-devices driving belt is disposed in front of the chain cover. A cantilevered arm holding a belt tensioner at a free end thereof and associated with the auxiliary-devices driving belt is disposed in front of the chain cover in such a manner as to overlap with a looped area formed by the lower camshaft driving chain in front view of the engine.

[0017] In the above front structure of the present invention, first and second crankshaft sprockets are coaxially fixed to a front end of the crankshaft, and the lower camshaft driving chain and the balancer-unit driving chain are respectively wound around the first and second crankshaft sprockets. The second crankshaft sprocket for the balancer-unit driving chain is disposed behind the first crankshaft sprocket for the lower camshaft driving chain and is formed to have a larger diameter than that of the first crankshaft sprocket.

[0018] Further, first and second intermediate-shaft sprockets are coaxially fixed to a front end of the intermediate shaft, and the upper and lower camshaft driving chains are respectively wound around the first and second intermediate-shaft sprockets. The second intermediate-shaft sprocket for the lower camshaft driving chain is disposed behind the first intermediate-shaft sprocket for the upper camshaft driving chain and is formed to have a larger diameter than that of the first intermediate-shaft sprocket.

[0019] Thus, a reference position of engagement between the second crankshaft sprocket and the balancer-unit driving chain, a reference position of engagement between the first crankshaft sprocket and the lower camshaft driving chain, and a reference position of engagement between the first intermediate-shaft sprocket and the upper camshaft driving chain, can be visually checked in front view of the engine.

[0020] In addition, the second intermediate-shaft sprocket having a larger diameter than that of the first intermediate-shaft sprocket for the upper camshaft driving chain makes it possible to minimize a diameter of a camshaft sprocket engaged with the upper camshaft driving chain.

[0021] According to the above front structure of the present invention, the chain cover is formed such that the lower front part is depressed toward the cylinder block relative to the upper front part, the chain cover forms a void space formed in a longitudinal direction of the engine. The arm for swingingly moving the belt tensioner can be disposed in the void space of the chain cover defined by the lower front part depressed toward the cylinder block. This makes it possible to apply an adequate tension to the auxiliary-devices driving belt without increasing the overall longitudinal length of the engine.

[0022] As used in this specification, the term of "front" or "front side" of the engine means a position where the chain cover and the auxiliary-devices driving belt are disposed or installed, and the term "longitudinal direction of the engine" means an arranging direction of the cylinders row.

[0023] In one preferred embodiment of the present invention, the chain cover is designed to cover the balancer-unit driving chain and the upper and lower camshaft driving chains, and at least one of the auxiliary devices is disposed beside the oil pan. This engine front structure further includes an idler disposed on a tension part of the auxiliary-devices driving belt which is located between the at least one auxiliary device and the crankshaft. At least a part of the auxiliary-devices driving belt and the idler is disposed to overlap with the balancer-unit driving chain in front view of the engine.

[0024] In another preferred embodiment of the present invention, the lower camshaft driving chain is wound around three sprockets to drive a second auxiliary device disposed beside the engine in cooperation with the intermediate shaft and define a looped area, and the arm of the belt tensioner is disposed to overlap with the looped area formed by the lower camshaft driving chain in front view of the engine.

[0025] In this engine front structure, an intermediate portion of the chain cover may be depressed rearward in conformity to the looped area formed by the lower camshaft driving chain located rearward relative to the frontmost upper camshaft driving chain, so as to define a void space. This void space can be used as an installation space for the arm of the belt tensioner for the auxiliary-devices driving belt, to apply an adequate tension to the auxiliary-devices driving belt without increasing the over-

all longitudinal length of the engine.

[0026] In yet another preferred embodiment of the present invention, the auxiliary devices comprises at least three auxiliary devices including a power generator and an air-conditioning compressor. The three auxiliary devices are arranged vertically and approximately linearly on the side of the intake-side of the engine body. The air-conditioning compressor is disposed beside the oil pan, and the power generator is disposed above the air-conditioning compressor. The remaining auxiliary device is disposed between the air-conditioning compressor and the power generator. The auxiliary-devices driving belt consists of a single auxiliary-devices driving belt adapted to drive the auxiliary devices.

[0027] This arrangement makes it possible to reduce a size of the engine in its width or lateral direction orthogonal to the longitudinal direction.

[0028] In this preferred embodiment, the rest of auxiliary device may be a water pump which is disposed to be driven by an outer surface of the auxiliary-devices driving belt in wound manner.

[0029] This allows the idler function of applying a tension for the auxiliary-devices driving belt to be additionally utilized for driving the water pump.

[0030] In yet another preferred embodiment of the present invention, the engine is designed to be transversely mounted into an engine compartment formed in a front region of a vehicle in such a manner that an axis of the crankshaft extends along a lateral direction of the vehicle.

[0031] According to this preferred embodiment, the engine can be mounted in the engine compartment with a distance capable of preventing a collapsing deformation in a front frame located on each of opposite lateral sides of a vehicle body, i.e., on the side of each of opposite longitudinal ends of the engine, from being hindered in the event of a front-impact collision.

[0032] As above, the present invention makes it possible to facilitate an operation of adjusting a phase between each of the balancer-unit driving chain and the lower camshaft driving chain and a corresponding one of the crankshaft sprockets, and a phase between each of the upper and lower camshaft driving chains and a corresponding one of the intermediate-shaft sprockets.

[0033] In addition, the chain cover can have a lower front part depressed toward the cylinder block relative to an upper front part thereof, and a void space formed in the longitudinal direction of the engine can be used as an installation space for the arm of the belt tensioner. This makes it possible to reduce an overall longitudinal length of the engine so as to achieve enhanced mountability to an engine compartment of a vehicle.

[0034] These and other objects, features and advantages of the invention will become more apparent upon reading the following detailed description along with the accompanying drawings, in which:

FIG. 1 is a front view showing a front structure of an engine, according to one embodiment of the present invention, wherein a chain cover is detached therefrom;

FIG. 2 is a side view showing a plurality of driving chains, a crankshaft, and intake and exhaust camshafts in the engine front structure illustrated in FIG. 1;

FIG. 3 is a front view showing the engine front structure illustrated in FIG. 1, in a state after the chain cover is attached thereto to cover over the driving chains, and a plurality of auxiliary devices and an auxiliary-devices driving belt are attached thereto;

FIG. 4 is a sectional view taken along the line X-X in FIG. 3;

FIG.5 is a side view showing the engine front structure illustrated in FIG. 3; and

FIG. 6 is a plan view showing the engine with the engine front structure illustrated in FIG. 3 in a state after the engine is transversely mounted into an engine compartment formed in a front region of a vehicle in such a manner that an axis of the crankshaft extends along a width or lateral direction of the vehicle.

[0035] With reference to the drawings, one embodiment of the present invention will now be described.

[0036] FIG. 1 is a front view showing a front structure of an engine 1, according to the embodiment, wherein a chain cover 31 (see FIGS. 2 to 4) is detached therefrom. An engine body 1a is provided with a cylinder block 2 having a lower portion rotatably supporting a crankshaft 3, and an oil pan 4 attached to a lower end of the cylinder block 2.

[0037] The engine body 1a also includes a cylinder head 5 mounted on an upper end of the cylinder block 2, and a timing case 6 attached to an front surface of the cylinder block 2.

[0038] In the engine body 1a, a crank journal 7 (see FIG 2) of the crankshaft 3 is supported by an appropriate bearing member fixed to the lower portion of the cylinder block 2.

[0039] The cylinder block 2 in FIG. 1 has a plurality of cylinders (not shown) arranged in a row. Each of the cylinders slidably houses a piston (not shown) connected to a crankpin 8 (see FIG 2) of the crankshaft 2 through a connecting rod (not shown).

[0040] The cylinder head 5 is formed with an intake port and an exhaust port (not shown) which are fluidically communicated with each of the cylinders and provided, respectively, with an intake valve and an exhaust valve (not shown). As shown in FIG. 2, the cylinder head 5 rotatably supports an intake camshaft 11 and an exhaust camshaft 12 provided, respectively, with a plurality of intake cams 9 and a plurality of exhaust cams 10. These intake and exhaust cams 9 and 10 are arranged in conformity to respective positions of the cylinders.

[0041] First and second crankshaft sprockets 3a and 3b are fixed to an axially front end of the crankshaft 3,

and an intake-camshaft sprocket 11a and an exhaust-camshaft sprocket 12a are fixed to an axially front end of the intake camshaft 11 and a front end of the exhaust camshaft 12, respectively.

[0042] The second crankshaft sprocket 3b is disposed closer to the cylinder block 2 than the first crankshaft sprocket 3a, i.e., disposed on a rear side of the first crankshaft sprocket 3a.

[0043] A first intermediate-shaft sprocket 13a is integrally formed in an axially front end of an intermediate shaft 13 located vertically below the intake-camshaft sprocket 11a, i.e., below and in substantially the same vertical plane as the intake-camshaft sprocket 11a. In addition to the first intermediate-shaft sprocket 13a, a second intermediate-shaft sprocket 13b is integrally formed in the intermediate shaft 13 at a position closer to the cylinder block 2 than the first intermediate-shaft sprocket 13a, i.e., at a position on a rear side of the first intermediate-shaft sprocket 13a.

[0044] A lower camshaft driving chain 14 is wound around the first crankshaft sprocket 3a and the second intermediate-shaft sprocket 13b. The lower camshaft driving chain 14 is also wound around a fuel-pump sprocket 15a of a fuel pump 15 disposed beside the engine body 1a. That is, the lower camshaft driving chain 14 is looped around the total three sprockets consisting of the first crankshaft sprocket 3a, the second intermediate-shaft sprocket 13b and the fuel-pump sprocket 15a, in a tensioned manner, to form an approximately triangular shape so as to define a closed planar area serving as a looped area A1.

[0045] A hydraulic tensioner adjuster 16 is disposed on a loose side of the lower camshaft driving chain 14 to apply a tension force to the lower camshaft driving chain 14 from the outside of the looped area A1 through a tensioner lever 18 supported by a pivot shaft 17, so as to allow a tension of the lower camshaft driving chain 14 to be kept at a value capable of adequately transmitting a driving force of the crankshaft 3.

[0046] Further, a guide member 19 is fixedly disposed to restrict a looping position of the lower camshaft driving chain 14 from the inside of the looped area A1 to allow the lower camshaft driving chain 14 to be kept in a given shape.

[0047] An upper camshaft driving chain 20 is wound around the intake-camshaft sprocket 11a, the exhaust-camshaft sprocket 12a and the first intermediate-shaft sprocket 13a, to define a closed planar area serving as a looped area A2.

[0048] A hydraulic tensioner adjuster 21 is disposed on a loose side of the upper camshaft driving chain 20 to apply a tension force to the upper camshaft driving chain 20 from the outside of the looped area A2 through a tensioner lever 22 supported by the pivot shaft 17 shared with the tensioner lever 18, so as to allow a tension of the upper camshaft driving chain 20 to be kept at a value capable of adequately transmitting a driving force of the crankshaft 3.

[0049] Further, a guide member 23 is fixedly disposed on a tension part of the upper camshaft driving chain 20 to restrict a looping position of the upper camshaft driving chain 20 to allow the upper camshaft driving chain 20 to be kept in a given shape.

[0050] The tensioner lever 22 is formed with a plurality of holes 22a. Each of the holes 22a is formed to be aligned, in front view of the engine, with a corresponding one of a plurality of bolt holes 6a formed in the timing case 6, so that a bolt can be inserted into the bolt hole 6a therethrough and fastened to a vehicle body to allow the engine body 1a to be supported by the vehicle body.

[0051] Based on the above mechanism, a driving force of the crankshaft 3 is transmitted to the intake camshaft 11 and the exhaust camshaft 12 by the lower camshaft driving chain 14 and the upper camshaft driving chain 20 through the intermediate shaft 13, to drive the intake and exhaust valves so as to open and close the intake and exhaust ports. The lower camshaft driving chain 14 is disposed closer to the cylinder block 2 than the upper camshaft driving chain 20, i.e., disposed on a rear side of the upper camshaft driving chain 20.

[0052] The engine body 1a is provided with a balancer unit comprising a balancer shaft 24 supported in the oil pan 4 in parallel relation to the crankshaft 3. The balancer shaft 24 consists of a first balancer shaft and a second balancer shaft each having a rotational axis approximately parallel to a rotational axis of the crank shaft 3. The first and second balancer shafts are designed to be rotated at a rotational speed two times greater than that of the crankshaft 3 in opposite directions. In FIG. 1, only one of the balancer shafts is indicated by a solid line.

[0053] A balancer-shaft sprocket 25 is integrally attached to an axially front end of the balancer shaft 24 indicated by the solid line, at a position vertically below the second crankshaft sprocket 3b, i.e., below and in substantially the same vertical plane as the second crankshaft sprocket 3b. That is, the balancer-shaft sprocket 25 is disposed closer to the cylinder block 2 than the first crankshaft sprocket 3a engaged with the lower camshaft driving chain 14, i.e., disposed on a rear side of the first crankshaft sprocket 3a.

[0054] A balancer-shaft driving chain 26 is wound around the balancer-shaft sprocket 25 and the second crankshaft sprocket 3b to define a closed planner area serving as a looped area A3.

[0055] A hydraulic tensioner adjuster 27 is disposed on a loose side of the balancer-shaft driving chain 26 to apply a tension force to the balancer-shaft driving chain 26 from the outside of the looped area A3 through a tensioner lever 29 supported by a pivot shaft 28, so as to allow a tension of the balancer-shaft driving chain 26 to be kept at a value capable of adequately transmitting a driving force of the crankshaft 3.

[0056] Further, a guide member 30 is fixedly disposed on a tension part of the balancer-shaft driving chain 26 to restrict a looping position of the balancer-shaft driving chain 26 to allow the balancer-shaft driving chain 26 to

be kept in a given shape.

[0057] Based on the above mechanism, a driving force of the crankshaft 3 is transmitted to the balancer-shaft sprocket 25 by the balancer-shaft driving chain 26 to drive the balancer unit.

[0058] In the first and second crankshaft sprockets 3a and 3b of the crankshaft 3, the first crankshaft sprocket 3a located on the front side is formed to have a diameter less than that of the second crankshaft sprocket 3b located on the rear side, and to have the number of teeth less than that of the second crankshaft sprocket 3b.

[0059] In the first and second intermediate-shaft sprocket 13a, 13b of the intermediate shaft 13, the first intermediate-shaft sprocket 13a located on the front side is formed to have a diameter than that of the second intermediate-shaft sprocket 13b located on the rear side, and to have the number of teeth less than that of the second intermediate-shaft sprocket 13b.

[0060] As above, the first crankshaft sprocket 3a adapted to output a driving force is formed to have a diameter less (i.e., the number of teeth) than that of the second crankshaft sprocket 3b located on the rear side of the first crankshaft sprocket 3a and adapted to output a driving force.

[0061] Thus, when a driving force of the crankshaft 3 is transmitted to the intake-camshaft and exhaust-camshaft sprockets 11a, 12a to be rotated at a lower speed than that of the crankshaft 3, the driving force of the crankshaft 3 is transmitted from the first crankshaft sprocket 3a having the relatively small diameter and the relatively small number of teeth, directly to the lower camshaft driving chain 14, and then received by the second intermediate-shaft sprocket 13b having the relatively large diameter and the relatively large number of teeth. Then, the driving force is transmitted to the upper camshaft driving chain 20 through the first intermediate-shaft sprocket 13a having the diameter and the number of teeth less than those of the second intermediate-shaft sprocket 13b, to drivingly rotate the intake-camshaft sprocket 11a and the exhaust-camshaft sprocket 12a.

[0062] In this manner, a gear ratio can be adequately adjusted by the intermediate shaft 13 interposed in the drive line from the crankshaft 3 to the intake-camshaft and exhaust-camshaft sprockets 11a, 12a, so as to reduce respective diameters of the intake-camshaft and exhaust-camshaft sprockets 11a, 12a.

[0063] As shown in FIG 1, markings 3c, 3d, 11b, 12b, 13c, 15b and 25a are engraved, respectively, in vicinities of peripheral portions of front surfaces of the first crankshaft sprocket 3a, the second crankshaft sprocket 3b the intake-camshaft sprocket 11a, the exhaust-camshaft sprocket 12a, the first intermediate-shaft sprocket 13a, the fuel-pump sprocket 15a and the balancer-shaft sprocket 25. Correspondingly, markings 14a/14b, 20a/20b/20c, and 26a/26b are engraved, respectively, in front surfaces (along a thickness direction) of the lower camshaft driving chain 14, the upper camshaft driving chain 20 and the balancer-shaft driving chain 26.

[0064] These markings are provided as a marker for allowing a rotational angular phase of each shaft of the engine components/auxiliary devices to be driven by the crankshaft 3 and a phase of the associated driving chain to be adjusted in a given relationship, so as to rotate the shaft at a given rotational speed ratio to the crankshaft 3 and set opening/closing timings of the intake/exhaust valves. For example, as illustrated in FIG. 1, in a state after one of the driving chains is wound around each of the associated sprockets, if positions of the respective markings of the driving chain and the sprocket, it can be determined that they are in an adequate phase relationship.

[0065] In each of the crankshaft 3 and the intermediate shaft 13, the small-diameter sprockets 3a, 13a are disposed on the front side of the corresponding large-diameter sprockets 3b, 13b, as described above. This makes it possible to visually check the positions of the markings 3c, 3d, 13c in front view of the engine body 1a.

[0066] Thus, in an assembling process of the engine body 1a, each of an operation of adjusting a phase between the marking 20a and the marking 13c of the first intermediate-shaft sprocket 13a having a smaller diameter than that of the second intermediate-shaft sprocket 13b, an operation of adjusting a phase between the marking 14a and the marking 3c of the first crankshaft sprocket 3a having a smaller diameter than that of the second crankshaft sprocket 3b, and an operation of adjusting a phase between the marking 26a and the marking 3d of the second crankshaft sprocket 3b, can be smoothly performed without deterioration in visibility due to other sprocket.

[0067] As the result of the above structure and arrangement for reducing the diameters of the intake-camshaft and exhaust-camshaft sprocket 11a, 12a and facilitating the phase adjusting operation, the upper camshaft driving chain 20 located on an upper side of the engine body 1a is disposed at the frontmost position, and the lower camshaft driving chain 14 and the balancer-shaft driving chain 26 are disposed stepwise at respective positions closer to the cylinder block 2 toward a downward direction of the engine body 1a, as shown in FIGS. 1 and 2.

[0068] Particularly, as shown in FIG 2, a void space having a depth in the longitudinal direction is defined below the upper camshaft driving chain 20 and the lower camshaft driving chain 14.

[0069] In the present invention, a chain cover 31 for covering a front side of the driving chains 14, 20 and 26, as shown in FIG. 3, has upper and lower parts formed such that the lower front part is depressed toward the cylinder block 2 relative to the upper front part, along with respective positions of the driving chains 14, 20, and 26 in the longitudinal direction of the engine body 1a, as shown in FIG. 4 which is a sectional view taken along the line X-X in FIG. 3. Further, as shown in FIGS. 3 and 5, the lower void space depressed in the longitudinal direction of the engine body 1a is used as an installation space for a first idler 37, an arm 46 of a belt tensioner

42, and an auxiliary-devices driving belt 43, as will be described in more detail.

[0070] The chain cover 31 is designed to cover a front side of the drive line including the driving chains 14, 20, and 26, and the sprockets 3a, 3b, 11a, 12a, 13a, 13b, 15a, and 25. The structure and function of the chain cover 31 will be described below with reference to FIGS. 3 and 4.

[0071] The chain cover 31 is integrally formed with a mounting seat 32 protruding outward or frontward. The mounting seat 32 serves as a means to support the engine body 1a through a vehicle body-side bracket (not shown) or the like.

[0072] The chain cover 31 has a wall portion formed with a plurality of bolt bosses 33 on a rear surface thereof. Each of the bolt basses 33 protrudes rearward from the rear surface of the wall portion of the chain cover 31, and has a bolt hole 34 and a contact surface 33a adapted to be brought into contact with a front surface of the timing case 6 so as to allow the bolt hole 34 to communicate with a corresponding one of the bolt holes 6a (see FIG. 1) of the timing case 6.

[0073] Two of the bolt bosses 33 each having the bolt hole 34 are disposed at vertically upper and lower positions, and plural sets of the two bolt bosses 33 are formed in line. Each of the bolt holes 34 of the upper the bolt bosses 33 is formed to have one end opened on the side of a front part of the chain cover 31 and located at the mounting seat 34.

[0074] A bolt is inserted from the side of the mounting seat 32 into each of the bolt holes 34 and threadingly fastened with a corresponding one of the bolt holes 6a of the timing case 6.

[0075] As shown in FIG. 3, an auxiliary-devices driving pulley 36 integrally attached to the crankshaft 3 penetrating a bearing hole 35 formed in the chain cover 31, the first idler 37, an air-conditioning compressor 38, a water pump 39, an alternator 40, a second idler 41 and the belt tensioner 42 are disposed in front of the chain cover 31. The auxiliary-devices driving belt 43 is wound around the auxiliary-devices driving pulley 36, and respective pulleys 38a, 39a, and 40a of the auxiliary devices 38, 39, and 40.

[0076] The arm 46 is disposed to extend across the auxiliary-devices driving belt 43 and designed to be swingingly moved about a pivot shaft 46 by driving of a hydraulic tensioner adjustor 44, and the belt tensioner 42 is designed to be selectively moved toward and away from the auxiliary-devices driving belt 43 in conjunction with the swing movement of the arm 46.

[0077] As seen in FIGS. 1 and 3, in this embodiment, the arm 46 of the belt tensioner 42 is disposed in front of the chain cover 31 in such a manner as to overlap with the looped area A1 of the lower camshaft driving chain 14 in front view of the engine, and associated with the auxiliary-devices driving belt 43.

[0078] That is, the arm 46 of the belt tensioner 42 can be installed in the void space defined by the lower portion of the chain cover 31 depressed in the longitudinal direction of the engine body 1a, so as to suppress frontward overhang of the component to reduce an overall longitudinal length of the engine 1, as shown in FIG. 5 which is a side view of the engine in FIG. 3.

[0079] In this manner, an overall longitudinal length of the engine 1 can be reduced to provide enhanced mountability to an engine compartment of a vehicle and enhanced flexibility in engine layout including peripheral devices.

[0080] In this embodiment, as shown in FIG. 3, the air-conditioning compressor 38 as one of the auxiliary devices is disposed beside the oil pan 4, and the first idler 37 is disposed on a tension part of the auxiliary-devices driving belt 43 and located between the air-conditioning compressor 38 and the crankshaft 3. At least a part of the auxiliary-devices driving belt 43 and the first idler 37 is disposed to overlap with the balancer-shaft driving chain 26 in front view of the engine. That is, in the void space defined by the lower portion of the chain cover 31, the first idler 37 is disposed at a position capable of minimizing frontward overhung of the engine 1.

[0081] Further, the arm 46 of the belt tensioner 42 located on a loose side of the auxiliary-devices driving belt 43 is disposed to overlap with the looped area A1 of the lower camshaft driving chain 14 in front view of the engine. Specifically, an intermediate portion of the chain cover 31 is depressed rearward in conformity to the looped area A1 located rearward relative to the looped area A2 of the upper camshaft driving chain 20, so as to define a void space, and the arm 46 of the belt tensioner 42 can be disposed in the void space defined by the intermediate portion of the chain cover 31.

[0082] This makes to possible to apply an adequate tension to the auxiliary-devices driving belt without increasing the overall longitudinal length of the engine 1. Further, the arm 46 of the belt tensioner 42 is disposed to overlap the instruction area A1 extending in an approximately triangular shape. Thus, the arm 46 of the belt tensioner 42 can be disposed apart from the auxiliary-devices driving pulley 36, the first idler 37 and the air-conditioning compressor 38 which are located therebelow. This provides an advantage of being able to extend a range of the swing movement of the arm 46.

[0083] In this embodiment, the alternator 40 required for avoiding installation in wet environments is disposed at an upper position by priority. Then, the air-conditioning compressor 38 is disposed beside of the oil pan 4, and the water pump 39 as an additional or the rest of auxiliary device is disposed between the air-conditioning compressor 38 and the alternator 40 along a vertical direction. This arrangement makes it possible to reduce a size of the engine 1 in its width direction (lateral direction in FIG. 3) orthogonal to the longitudinal direction while particularly satisfying the installation requirement of the alternator 40.

[0084] In this embodiment, the water pump 39 is disposed to be driven by an outer surface of the auxiliary-

devices driving belt 43. This allows the idler function of applying a tension for the auxiliary-devices driving belt 43 to be additionally utilized for driving the water pump 39.

[0085] Generally, it is desirable that a rotor to be driven by the outer surface of the auxiliary-devices driving belt 43 has a low rotational torque and imposes a low load on the auxiliary-devices driving belt 43. In view of this requirement, a water pump 39 is particularly preferable.

[0086] The engine front structure of the present invention, wherein the arm 46 of the belt tensioner 42 is contained in the void space defined by the lower portion of the chain cover 31 to achieve reduction in the overall longitudinal length of the engine 1, may be applied, for example, to an engine designed to be transversely mounted into an engine compartment formed in a front region of a vehicle in such a manner that an axis of a crankshaft 3 extends along a width or lateral direction of the vehicle, as shown in FIG. 6, to provide a particularly significant effect.

[0087] Specifically, the engine 1 is supported by a pair of front frames 47, 47 disposed on opposite lateral (right/left) sides of the engine compartment to extend in a frontward/rearward direction of the vehicle, through the mounting seat 32 (see FIG. 3). As the result of reduction in an overall length L1 of the engine 1 in its longitudinal direction, an overall length L2 (in the lateral direction of the vehicle) of a power unit, as a total sum of the overall length L1 and an overall length (in the lateral direction of the vehicle) of a transmission 48 attached to one end (right end in FIG. 6) of the engine 1, can be reduced.

[0088] Thus, without increasing a size of the vehicle body in the lateral direction of the vehicle, a relatively large distance L3, L4 can be ensured between the engine 1/the transmission 48 and the side frames 47, 47.

[0089] Even if the vehicle body has a collapsing deformation due to collision with an object, and a width L5 of each of the right and left front frames 47, 47 is increased to L5a, the engine 1 will exhibit an effect an advantage of being able to avoid hindering the collapsing deformation in the front frames 47, 47.

[0090] In the above embodiment, the lower camshaft driving chain 14 is wound around the first crankshaft sprocket 3a, the second intermediate-shaft sprocket 13b and the fuel-pump sprocket 15a, in a tensioned manner, to define the instruction area A. Alternatively, the lower camshaft driving chain 14 may be wound around the first crankshaft sprocket 3a and the second intermediate-shaft sprocket 13b to define an instruction area of the lower camshaft driving chain 14, and the balancer-shaft driving chain 26 may be wound around the second intermediate-shaft sprocket 13b, a fuel-pump sprocket 15a having the number of teeth different from that in the above embodiment, and the balancer-shaft sprocket 25, to define an instruction area of the balancer-shaft driving chain 26.

[0091] This arrangement makes it possible to expand the looped area formed by the driving chains disposed closer to the cylinder block 2, and extend the lower front part of the chain cover 31 depressed toward the cylinder block 2 according to the expanded looped area.

[0092] Thus, the void space defined by the lower portion of the chain cover depressed in the longitudinal direction of the engine body 1a can be expanded. This allows a different auxiliary device to be disposed in the expanded void space in addition to the auxiliary devices in the above embodiment.

[0093] Other function/effect in this case is the same as those in the above embodiment.

[0094] Although the present invention has been described in term of specific exemplary embodiments, it will be appreciated that various changes and modifications may be made by those skilled in the art without departing from scope of the invention, defined in the following claims.

Claims

1. Front structure of an engine designed to arrange a plurality of auxiliary devices (38, 39, 40) beside an intake-side of an engine body (1a) and to drive the auxiliary devices (38, 39, 40) by a crankshaft (3) through an auxiliary-devices driving belt (43) comprising:

   a balancer-unit (24) in an oil pan (4);
   a balancer-unit sprocket (25) on the balancer-unit (24);
   a balancer-unit driving chain (26) which is so wound around the balancer-unit sprocket (25) that the balancer-unit (24) is driven by a crankshaft (3);
   a pair of camshafts (11a, 12a) disposed on a cylinder head (5);
   an intermediate shaft (13) through which drive force is transmitted from the crankshaft (3) to the camshafts (11a, 12a); and
   a pair of upper and lower camshaft driving chains (14, 20) adapted to couple the crankshaft (3) to the camshafts (11a, 12a),
   characterized by:

      the lower camshaft driving chain (14) which is arranged behind the upper camshaft driving chain (20);
      a chain cover (31) which covers a front side of the chains (14, 20, and 26) and has upper and lower front parts formed such that the lower front part is depressed toward a cylinder block (2) relative to the upper front part in a longitudinal direction of the engine (1) along with respective front surfaces of the chains (14, 20, and 26);
      an auxiliary-devices driving belt (43) disposed in front of the chain cover (31); and by a cantilevered arm (46) holding a belt ten-

sioner (42) at a free end thereof, associated with the auxiliary-devices driving belt (43), and is disposed in front of the chain cover (31) in such a manner as to overlap with a looped area formed by the lower camshaft driving chain (14) in front view of the engine (1).

2. Front structure as defined in claim 1, wherein:

the chain cover (31) is designed to cover the balancer-unit driving chain (26) and the upper and lower camshaft driving chains (14, 20);
at least one of the auxiliary devices (38, 39, 40) is disposed beside the oil pan (4); and
an idler (37) disposed on a tension part of the auxiliary-devices driving belt (43) which is located between the at least one auxiliary device (38) and the crankshaft (3), and
at least a part of the auxiliary-devices, driving belt (43), and the idler (37) is disposed to overlap with the balancer-unit driving chain (26) in front view of the engine (1).

3. Front structure as defined in claim 1 or 2, wherein:

the lower camshaft driving chain (14) is wound around three sprockets (3a, 13b, 15a) to drive a second auxiliary device (15) disposed beside the engine (1) in cooperation with the intermediate shaft (13) and define a looped area; and
the arm (46) of the belt tensioner (42) is disposed to overlap with the looped area formed by the lower camshaft driving chain (14) in front view of the engine (1).

4. Front structure as defined in one of preceding claims, wherein:

the auxiliary devices (38, 39, 40) comprises at least three auxiliary devices (38, 39, 40) including a power generator and an air-conditioning compressor;
the three auxiliary devices (38, 39, 40) are arranged vertically and approximately linearly on the side of the intake-side of the engine body (1a);
the air-conditioning compressor is disposed beside the oil pan (4);
the power generator is disposed above the air-conditioning compressor;
the remaining auxiliary device is disposed between the air-conditioning compressor and the power generator; and
the auxiliary-devices driving belt (43) is a single auxiliary-devices driving belt (43) adapted to drive the auxiliary devices.

5. Front structure as defined in claim 4, wherein the rest of auxiliary devices (38, 39, 40) is a water pump (39) which is disposed to be driven by an outer surface of the auxiliary-devices driving belt (43) in wound manner.

6. Front structure as defined in either one of claims 1 to 5, wherein the engine body (1a) is designed to be transversely mounted into an engine compartment formed in a front region of a vehicle in such a manner that an axis of the crankshaft (3) extends along a lateral direction of the vehicle.

Patentansprüche

1. Frontaufbau eines Motors, der dazu ausgelegt ist, eine Vielzahl von Hilfsgeräten (38, 39, 40) neben einer Saugseite eines Motorkörpers (1a) anzuordnen und die Hilfsgeräte (38, 30, 40) über einen Hilfsgeräte-Antriebsriemen (43) durch eine Kurbelwelle (3) anzutreiben, umfassend:

eine Ausgleichseinheit (24) in einer Ölwanne (4);
ein Ausgleichseinheit-Kettenrad (25) an der Ausgleichseinheit (24);
eine Ausgleichseinheit-Antriebskette (26), die so um das Ausgleichseinheit-Kettenrad (25) gewickelt ist, dass die Ausgleichseinheit (24) durch eine Kurbelwelle (3) angetrieben wird;
zwei Nockenwellen (11a, 12a), die an einem Zylinderkopf (5) angeordnet sind;
eine Zwischenwelle (13), über die Antriebskraft von der Kurbelwelle (3) auf die Nockenwellen (11a, 12a) übertragen wird; und
zwei obere und untere Nockenwellenantriebsketten (14, 20), die dazu ausgelegt sind, die Kurbelwelle (3) mit den Nockenwellen (11a, 12a) zu koppeln,
gekennzeichnet durch:

die untere Nockenwellenantriebskette (14), die hinter der oberen Nockenwellenantriebskette (20) angeordnet ist;
eine Kettenabdeckung (31), die eine Vorderseite der Ketten (14, 20 und 26) bedeckt und einen oberen und unteren Vorderteil besitzt, die so ausgebildet sind, dass der untere Vorderteil in Richtung zu einem Zylinderblock (2) relativ zu dem oberen Vorderteil in einer Längsrichtung des Motors (1) zusammen mit den jeweiligen Vorderseiten der Ketten (14, 20 und 26) heruntergedrückt wird;
einen Hilfsgeräte-Antriebsriemen (43), der vor der Kettenabdeckung (31) angeordnet ist; und durch

einen freitragenden Arm (46), der an seinem freien Ende einen Riemenspanner (42) hält, mit dem Hilfsgeräte-Antriebsriemen (43) in Verbindung steht und so vor der Kettenabdeckung (31) angeordnet ist, dass er sich in Draufsicht des Motors (1) mit einem durch die untere Nockenwellenantriebskette (14) gebildeten gewundenen Bereich überlappt.

2. Frontaufbau nach Anspruch 1, wobei:

die Kettenabdeckung (31) dazu ausgelegt ist, die Ausgleichseinheit-Antriebskette (26) und die obere und untere Nockenwellen-Antriebskette (14, 20) zu bedecken;
mindestens eines der Hilfsgeräte (38, 39, 40) neben der Ölwanne (4) angeordnet ist; und
ein Zwischenrad (37) an einem Spannteil des Hilfsgeräte-Antriebsriemens (43) angeordnet ist, das sich zwischen dem mindestens einen Hilfsgerät (38) und der Kurbelwelle (3) befindet, und
mindestens ein Teil der Hilfsgeräte, des Antriebsriemens (43) und des Zwischenrads (37) so angeordnet ist, dass er sich in Draufsicht des Motors (1) mit der Ausgleichseinheit-Antriebskette (26) überlappt.

3. Frontaufbau nach Anspruch 1 oder 2, wobei:

die untere Nockenwellenantriebskette (14) um drei Kettenräder (3a, 13b, 15a) gewickelt ist, um ein neben dem Motor (1) befindliches zweites Hilfsgerät (15) in Zusammenarbeit mit der Zwischenwelle (13) anzutreiben und einen gewundenen Bereich zu definieren; und
der Arm (46) des Riemenspanners (42) so angeordnet ist, dass er sich in Draufsicht des Motors (1) mit dem durch die untere Nockenwellenantriebskette (14) gebildeten gewundenen Bereich überlappt.

4. Frontaufbau nach einem der vorhergehenden Ansprüche, wobei:

die Hilfsgeräte (38, 39, 40) mindestens drei Hilfsgeräte (38, 39, 40) einschließlich eines Stromgenerators und eines Klimakompressors umfassen;
die drei Hilfsgeräte (38, 39, 40) vertikal und ungefähr linear auf der Seite der Saugseite des Motorkörpers (1a) angeordnet sind;
der Klimakompressor neben der Ölwanne (4) angeordnet ist;
der Stromgenerator über dem Klimakompressor angeordnet ist;
das übrige Hilfsgerät zwischen dem Klimakompressor und dem Stromgenerator angeordnet ist; und
der Hilfsgeräte-Antriebsriemen (43) ein einzelner Hilfsgeräte-Antriebsriemen (43) ist, der dazu ausgelegt ist, die Hilfsgeräte anzutreiben.

5. Frontaufbau nach Anspruch 4, wobei der Rest der Hilfsgeräte (38, 39, 40) eine Wasserpumpe (39) ist, die so angeordnet ist, dass sie durch eine Außenseite des herumgewickelten Hilfsgeräte-Antriebsriemens (43) angetrieben wird.

6. Frontaufbau nach einem der Ansprüche 1 bis 5, wobei der Motorkörper (1a) so konstruiert ist, dass er quer in einen in einem vorderen Bereich eines Fahrzeugs gebildeten Motorraum eingebaut werden kann, so dass sich eine Achse der Kurbelwelle (3) entlang einer lateralen Richtung des Fahrzeugs erstreckt.

Revendications

1. Structure avant d'un moteur conçue pour installer une pluralité de dispositifs auxiliaires (38, 39, 40) près d'un côté aspiration d'un corps de moteur (1a) et pour entraîner les dispositifs auxiliaires (38, 39, 40) par un vilebrequin (3) au moyen d'une courroie d'entraînement (43) des dispositifs auxiliaires, comprenant :

une unité d'équilibrage (24) dans un carter d'huile (4) ;
un pignon (25) de l'unité d'équilibrage monté sur l'unité d'équilibrage (24) ;
une chaîne d'entraînement (26) de l'unité d'équilibration, qui est enroulée autour du pignon (25) de l'unité d'équilibrage de telle sorte que l'unité d'équilibrage (24) est entraînée par un vilebrequin (3) ;
une paire de vilebrequins (11a, 12a) agencés sur une tête de cylindre (5) ;
un arbre intermédiaire (13) au moyen duquel une force d'entraînement est transmise depuis le vilebrequin (3) aux arbres à cames (11a, 12a) ; et
une paire de chaînes d'entraînement (14, 20) de l'arbre à cames supérieure et inférieure conçues pour coupler le vilebrequin (3) aux arbres à cames (11 a, 12a),
caractérisée par :

la chaîne d'entraînement (14) de l'arbre à cames inférieure, qui est agencée derrière la chaîne d'entraînement (20) de l'arbre à cames supérieure ;
un couvercle de chaîne (31), qui couvre une face avant des chaînes (14, 20 et 26) et pos-

sède des parties avant supérieure et inférieure formées de telle sorte que la partie avant inférieure est enfoncée vers un bloc-cylindres (2) par rapport à la partie avant supérieure dans une direction longitudinale du moteur (1) avec des surfaces avant respectives des chaînes (14, 20 et 26) ;
une courroie d'entraînement (43) des dispositifs auxiliaires située devant le couvercle de chaîne (31) ; et par
un bras en porte-à-faux (46) tenant un tendeur de courroie (42) à une extrémité libre de celui-ci, associé à la courroie d'entraînement (43) des dispositifs auxiliaires, et situé devant le couvercle de chaîne (31) de façon à se chevaucher avec une zone en boucle formée par la chaîne d'entraînement (14) de l'arbre à cames inférieure en vue frontale du moteur (1).

2. Structure avant selon la revendication 1, dans laquelle :

le couvercle de chaîne (31) est conçu pour couvrir la chaîne d'entraînement (26) de l'unité d'équilibrage et les chaînes d'entraînement (14, 20) de l'arbre à cames supérieure et inférieure ;
au moins un des dispositifs auxiliaires (38, 39, 40) est agencé à côté du carter d'huile (4) ; et
un pignon intermédiaire (37) agencé sur un élément tendeur de la courroie d'entraînement (43) des dispositifs auxiliaires, qui est situé entre le au moins un dispositif auxiliaire (38) et le vilebrequin (3), et
au moins une partie des dispositifs auxiliaires, de la courroie d'entraînement (43) et du pignon intermédiaire (37) est agencée pour se chevaucher avec la chaîne d'entraînement (26) de l'unité d'équilibrage en vue frontale du moteur (1).

3. Structure avant selon la revendication 1 ou 2, dans laquelle :

la chaîne d'entraînement (14) de l'arbre à cames inférieure est enroulée autour trois pignons (3a, 13b, 15a) pour entraîner un deuxième dispositif auxiliaire (15) agencé à côté du moteur (1) en coopération avec l'arbre intermédiaire (13) et pour définir une zone en boucle ; et
le bras (46) du tendeur de courroie (42) est agencé pour se chevaucher avec la zone en boucle formée par la chaîne d'entraînement (14) de l'arbre à cames inférieure en vue frontale du moteur (1).

4. Structure avant selon l'une quelconque des revendications précédentes, dans laquelle :

les dispositifs auxiliaires (38, 39, 40) comportent au moins trois dispositifs auxiliaires (38, 39, 40) y compris un générateur d'électricité et un compresseur de climatisation ;
les trois dispositifs auxiliaires (38, 39, 40) sont agencés verticalement et approximativement de manière linéaire sur le côté du côté admission du corps de moteur (1a) ;
le compresseur de climatisation est agencé à côté du carter d'huile (4) ;
le générateur d'électricité est agencé au-dessus du compresseur de climatisation ;
le dispositif auxiliaire restant est agencé entre le compresseur de climatisation et le générateur d'électricité ; et
la courroie d'entraînement (43) des dispositifs auxiliaires est une seule courroie d'entraînement (43) des dispositifs auxiliaires conçue pour entraîner les dispositifs auxiliaires.

5. Structure avant selon la revendication 4, dans laquelle le reste des dispositifs auxiliaires (38, 39, 40) est une pompe à eau (39), qui est agencé pour être entraînée par une surface extérieure de la courroie d'entraînement (43) des dispositifs auxiliaires d'une manière enroulée.

6. Structure avant selon l'une quelconque des revendications 1 à 5, dans laquelle le corps de moteur (1a) est conçu pour être monté de manière transversale dans un compartiment moteur formé dans une zone avant d'un véhicule de telle sorte qu'un axe du vilebrequin (3) s'étend le long de la direction latérale du véhicule.

FIG.1

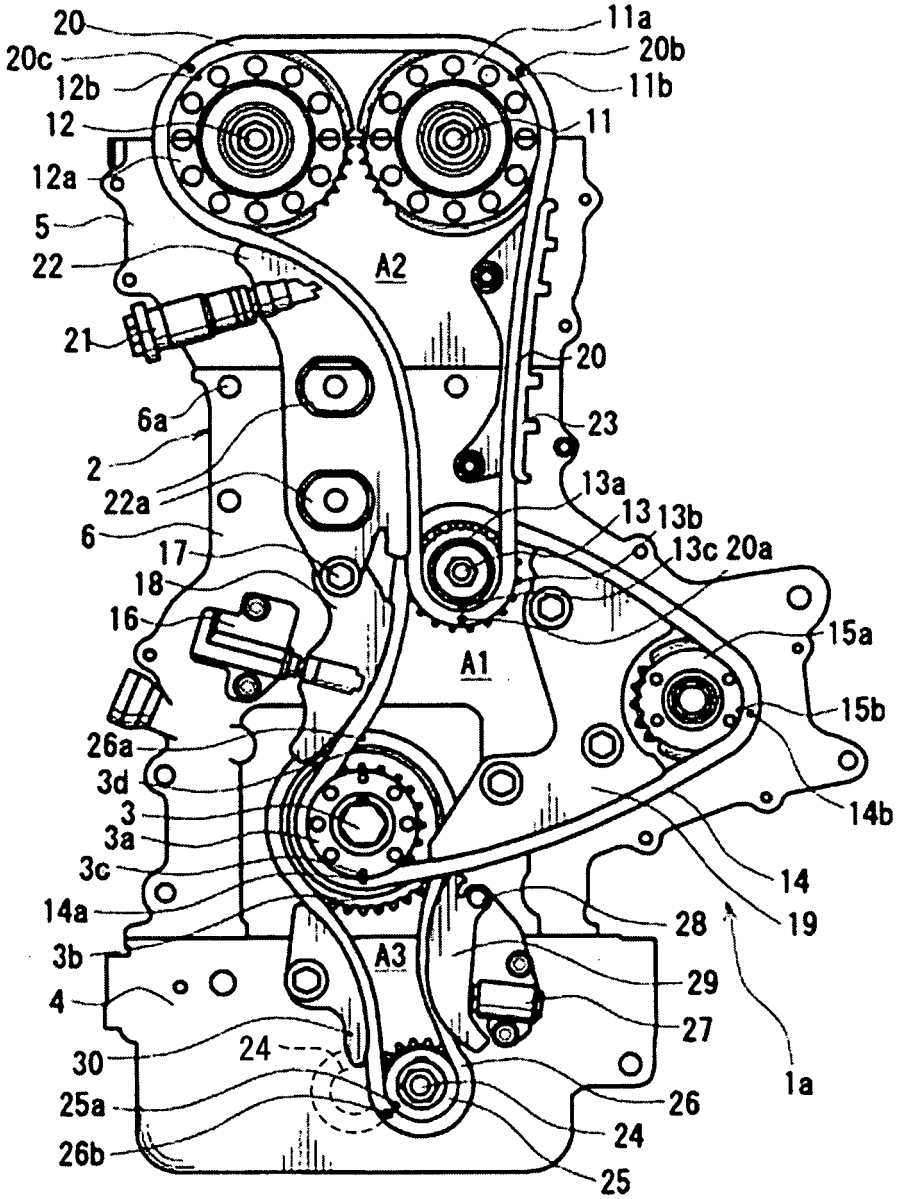

20
20c
12b
12
12a
5
22
21
6a
2
22a
6
17
18
16
26a
3d
3
3a
3c
14a
3b
4
30
25a
26b
11a
20b
11b
11
A2
20
23
13a
13
13b
13c
20a
A1
15a
15b
14b
14
19
28
A3
29
27
24
26
25
1a

FIG.2

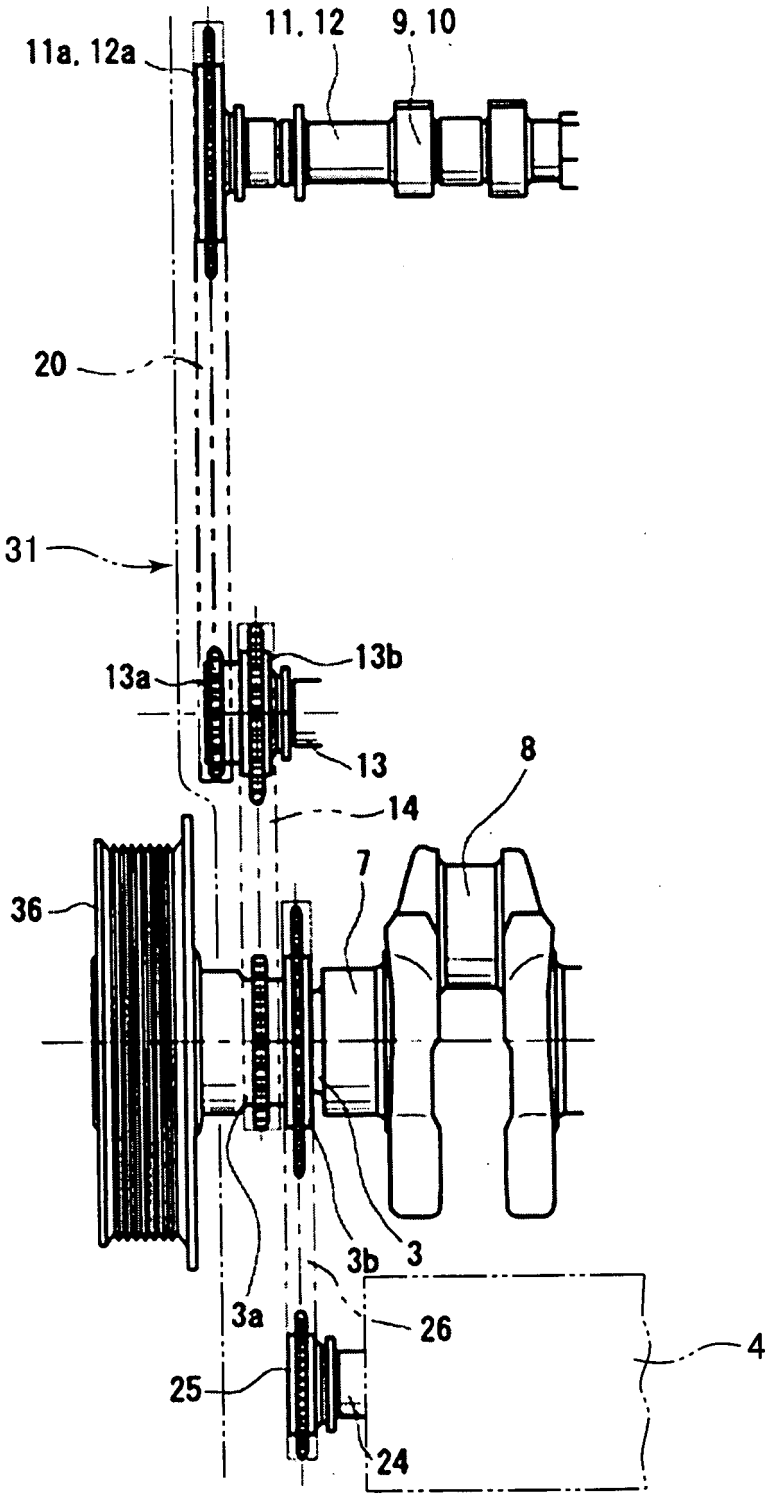


FIG.3

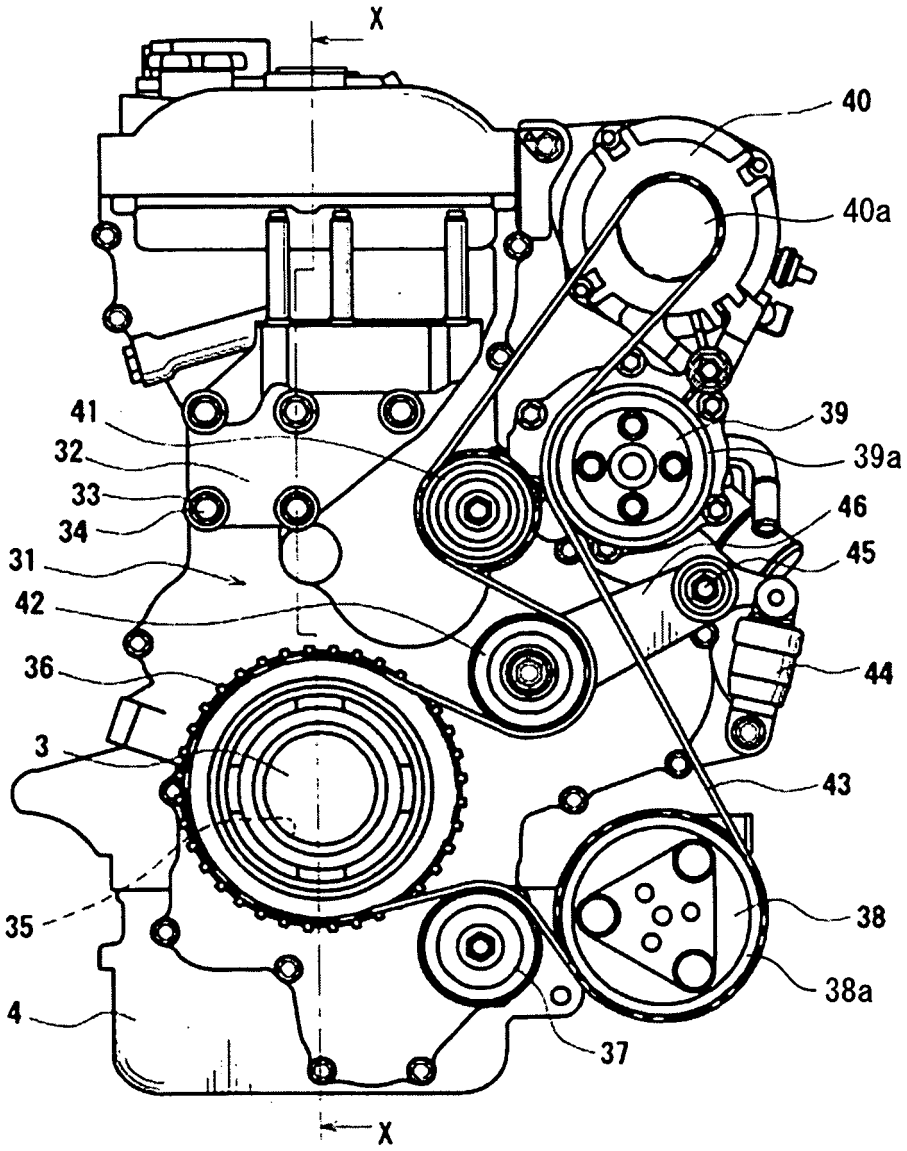


FIG.4

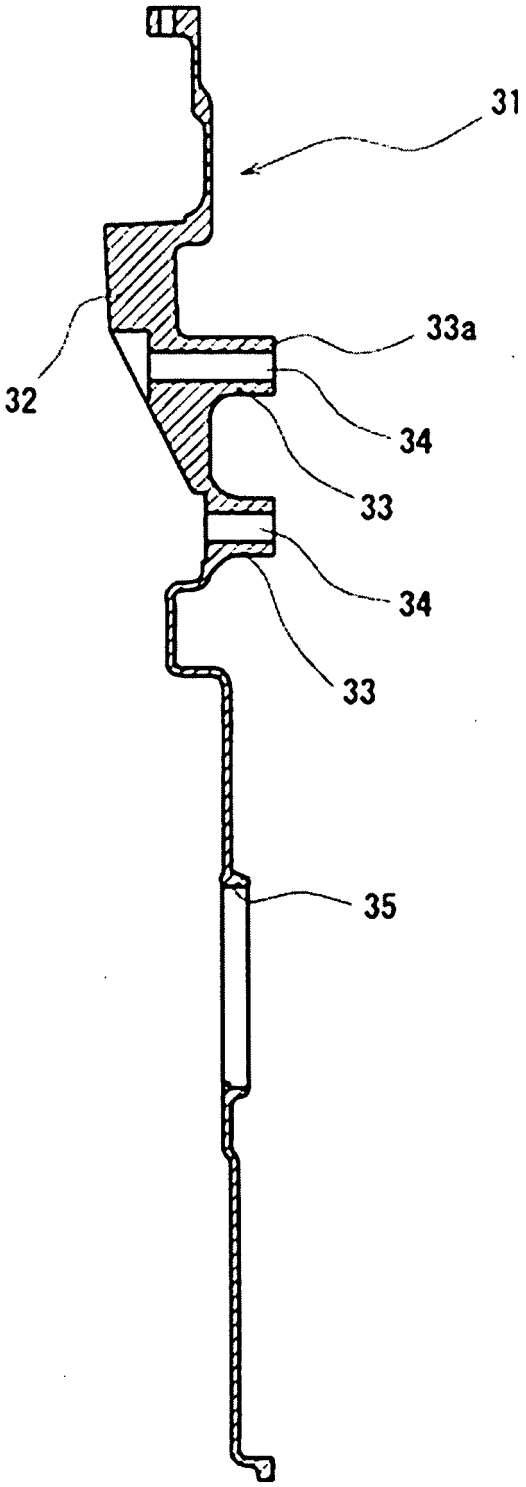


FIG.5

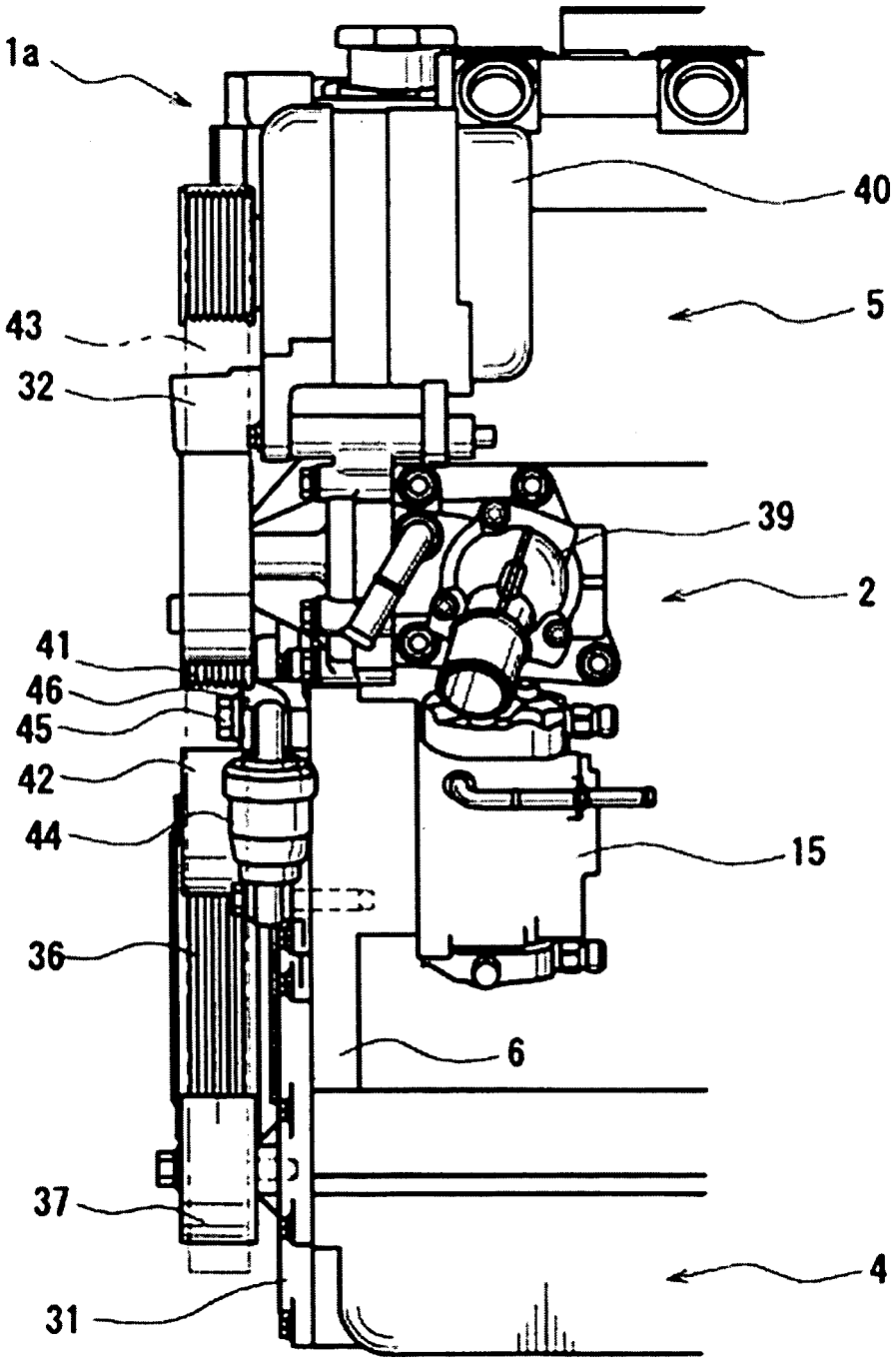
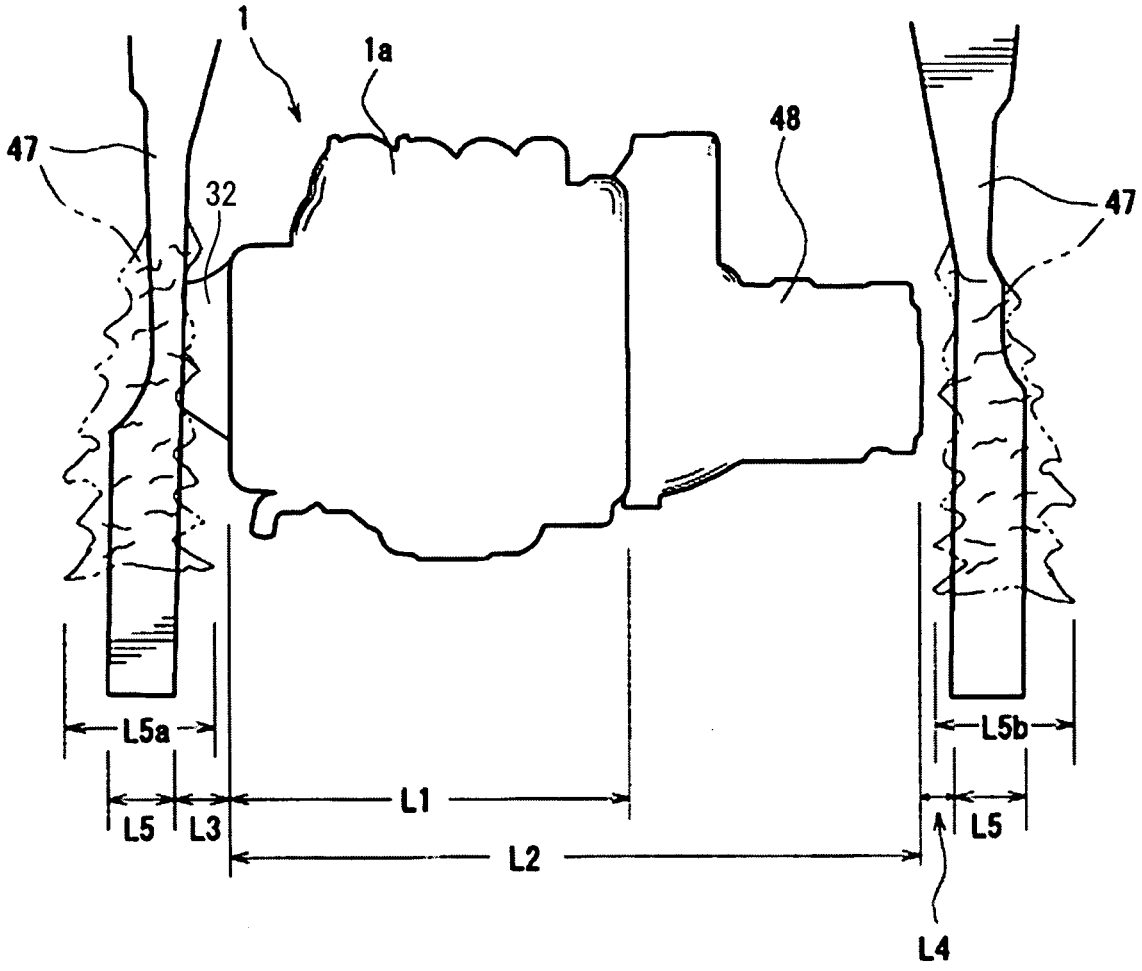


FIG.6



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 2003042230 A **[0002]**
- JP 9032521 A **[0012]**