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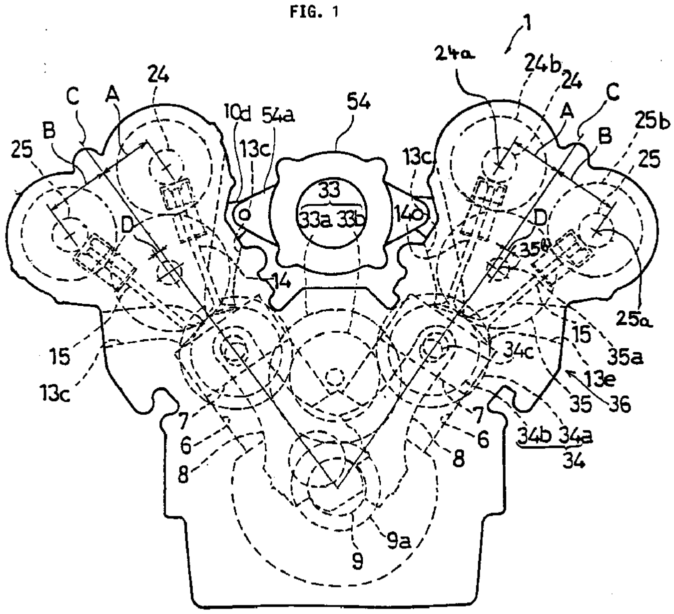
(54) Internal combustion engine

(57) This invention concerns internal combustion engines of the V-type comprising a cylinder block having a pair of cylinder banks disposed in a V-bank arrangement with at least one cylinder bore defined in each cylinder bank, a cylinder head attached to each of the said cylinder banks and a pair of intake and exhaust camshafts rotatably supported in each of said cylinder heads for actuating a plurality of intake valves and exhaust valves respectively. The engine has been improved in that the distance of the axis of the exhaust camshaft from a centre plane containing the cylinder axis of the respective cylinder bank and the axis of the crankshaft is larger than the distance of the respective intake camshaft from the said centre plane, said intake camshafts being disposed at the sides of the cylinder heads facing V-space between the cylinder banks.

FIG. 1



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Description

The present invention relates to an internal combustion engine of the V type comprising a cylinder block having a pair of cylinder banks disposed in a V bank arrangement with at least one cylinder bore defined in each cylinder bank, a cylinder head attached to each of said cylinder banks and a pair of intake and exhaust camshafts rotatably supported in each of said cylinder heads for actuating a plurality of intake valves and exhaust valves respectively.

Nowadays, 5 valve engines comprising 3 intake valves and 2 exhaust valves per cylinder head have been increasingly used in order to improve the charging efficiency and, consequently, the performance of the engine. On the other hand, difficulties arise in distributing such an increasing number of intake and exhaust valves above the combustion chamber of each cylinder of such an engine. For the design of the cylinder head of such an engine care should be taken to keep the height of the engine as low as possible but ensuring a sufficient cooling capacity of the cooling jacket arrangement extending through the cylinder head. In view of the valve operating mechanism for such an engine each intake or exhaust valve comprises a valve lifter at the upper end of the valve stem of each of said valves pushed by the lobes of an associated camshaft and a prebiasing valve spring is installed between a valve retainer secured on the upper portion of each valve stem and a valve spring seat which is provided on an internal wall portion of the cylinder head for each of the intake and exhaust valves.

Engines, such as a 5 valve engine, comprising a larger number of intake valves than of exhaust valves for each cylinder frequently use exhaust valves which, due to their lower number with respect to the intake valves, are designed to be larger in diameter to assure the necessary cross-sections of the exhaust passageways. Accordingly, the mass of such an exhaust valve exceeds those of the intake valve, and exhaust valves heavier than intake valves have been employed in many cases. Moreover, the valve lift of the exhaust valves has been set to be larger than those of the intake valves. In view of the afore-noted conditions the prebiasing valve spring for the exhaust valve requires a larger diameter and a greater spring constant in order to urge the heavier exhaust valve into its closing position without any malfunction and the length of the valve spring needs to be larger than those of the intake valve springs enabling the valve lift of the exhaust valves to be increased. Said increased length adds to considerably increase the total height of the engine.

In any case it is desirable to reduce the height of the engine as far as possible. In view of the afore-mentioned requirements a restraint engine height requires the valve spring seat of the exhaust valve to be lowered to maintain the necessary valve lift. However, a lowered valve spring seat normally consumes some space required for the cooling arrangement of the cylinder head, specifically for the cooling jacket at the exhaust side close to the exhaust gas discharge passageway. Thus, lowering the position of the valve spring seat on the exhaust side results in a smaller cooling jacket at that area and reduced cooling efficiency. Otherwise, the valve lift of the exhaust valve would be insufficient.

Moreover, on the intake valve side the increased number thereof results in a very narrow space being only available in between the adjacent intake valves and the distance between them becomes considerably small which leads to problems in assuring the space for accomodating the valve lifters of the intake valves.

Apart from the afore-noted problems, specifically for V-type engines the camshaft drive mechanism including an intermediate gear, intermediate sprocket or intermediate pulley (depending on the type of transmission being used for driving the camshaft from the crankshaft) should not unnecessarily restrict the space inside of the V-bank for disposing and servicing auxilliaries disposed therein. Accordingly, components of said camshaft drive transmission or casings thereof should not protrude into said space between the two banks of a V-type internal combustion engine.

Accordingly, it is an objective of a present invention to provide an engine of the V type having an improved and more compact layout that increases the space within the V bank arrangement between the pair of cylinder banks, so as to accommodate auxiliary devices therein.

According to the present invention this objective is performed in that the distance of the axis of the exhaust camshaft from a centre plane containing the cylinder axis of the respective cylinder bank and the axis of the crankshaft is larger than the distance of the respective intake camshaft from said centre plane, said intake camshafts being disposed at the sides of the cylinder heads facing the V space between the cylinder banks.

According to a preferred embodiment of the invention an intermediate shaft is associated with each of said cylinder banks for driving the respective pair of intake and exhaust camshafts, each of said intermediate shafts being rotatably supported around an axis that is parallel to the intake and exhaust camshafts and laterally offset with respect to the centre plane of the respective cylinder bank towards the exhaust side thereof.

According to another preferred embodiment of the invention each of said intermediate shafts is provided with an intermediate gear in mesh with a pair of cam gears affixed to the respective pair of intake and exhaust camshafts. Preferably, the intermediate gears are in mesh with a common crankshaft output gear for driving both intermediate gears, said crankshaft output gear being driven by a crankshaft gear attached to the crankshaft.

According to another preferred embodiment of the invention the intermediate shafts are connected with the respective pair of intake and exhaust camshafts via driving belts and connected with the crankshaft via another driving belt.

Further preferred embodiments of the invention are laid down in further dependent claims.

Hereinafter the present invention will be explained and illustrated in greater detail by means of preferred embodiments of the invention in connection with accompanying drawings, wherein:

Fig. 1, is a front view of an internal combustion engine of the V type having a gear camshaft drive mechanism according to a first embodiment of the present invention,

Fig. 2, is a front view of an internal combustion engine of the V type having a belt drive mechanism for the camshafts according to another preferred embodiment of the invention,

Fig. 3, is a schematic front view of an internal combustion engine of the V type having a geared drive mechanism similar to Fig. 1 according to yet another preferred embodiment of the invention,

Fig. 4, is a sectional front view of a right side cylinder head portion of the engine shown in Fig. 3,

Fig. 5, is a plan view of the upper head of the cylinder head of the engine according to the embodiment of Figs 3 and 4.

In the following a V type four cycle internal combustion engine comprising five valves for each cylinder will be explained with reference to the accompanying drawings. First of all, the basic structure of the engine will be explained with reference to Fig. 1.

In Fig. 1, showing schematically a front view of the engine 1, a cylinder block having a pair of cylinder banks disposed in a V bank arrangement is shown. The cylinder block defines a plurality of cylinders or liners 6 arranged in a V as seen in the crankshaft direction shown in Fig. 1. A piston 7 is inserted in each cylinder 6 and is connected through a connecting rod 8 with a crankshaft 9 as usual.

As can be seen from Fig. 1, the valve operating mechanism including an intake camshaft 24 and an exhaust camshaft 25 is designed to avoid any obstruction of the inner space in between the V bank by the housing of the cylinder head for each row of cylinders.

More specifically as indicated in Figures 1 and 2 which show a front view of a V-type 4-cycle engine similar to those of Figure 3 it is indicated that the distance A of an axis 24a of the intake camshaft 24 from a centre plane C containing the axis of the cylinders of the clyinder bank as well as the axis of a crankshaft 9, is said to be smaller than the distance B of the axis 25a of the exhaust camshaft 25 from said plane (c). Similarly, an intermediate chain wheel of the camshaft drive system, such as the intermediate gear 35 adapted to a mesh with a pair of cam gears 24b, 25b affixed to the respective intake and exhaust camshafts 24, 25 is rotatably supported through the cylinder head laterally offset by an amount D from said centre plane C in order to avoid housing portions of the cylinder head to protrude into the V-space adapted to dispose auxiliaries, such as an alternator 54 therein. In this way a compacted engine structure can be obtained wherein the intake camshaft is disposed inwardly close to the V-space of the engine while the exhaust camshaft 25 is disposed along the outside of the cylinder head 4 oppositely with respect to the centre plane C.

In the embodiment according to Figure 1 the valve drive system comprises a gear drive arrangement to drive both the intake and exhaust cam gears 24b, 25b from the intermediate gear 35 disposed on an intermediate gear shaft 35a, which in turn, is driven from another gear wheel drive structure including a crankshaft output gear. Of course the valve operating mechanism and the camshaft drive chain may also not only include gear trains but can also be performed by timing belts or timing chains providing associated transmission elements such as cam sprockets or cam pulleys on the camshafts and using an intermediate sprocket or an intermediate pulley instead of the intermediate gear 35.

The embodiment according to Figure 2 with respect to the asymmetric disposal of camshafts 24, 25 at both side centre plane C as well as in view of the corresponding offset in the amount D of the intermediate pulley 42 corresponds to those of the preceding embodiment of Figure 2. In case of Figure 2 timing belts or timing chains are being used to drive the camshaft 24, 25 via respective cam sprockets or cam pulleys 24b, 25b from the intermediate sprocket or pulley 42b establishing a camshaft drive train connected via the intermediate shaft 35a with another drive train driven from the crankshaft 9 in a conventional manner.

By means of the afore-mentioned structure the accomodating space within the V-shape of the engine for servicing or disposing auxiliaries such as the alternator 54, can be assured contributing to also limit the engine height.

In the following the internal structure of a V type engine will be explained in detail with reference to Figs 3 to 5 showing a third embodiment which has generally the same layout as the preceding embodiments.

In Figure 3 showing schematically front view of the engine 1, a cylinder block 2 is shown connected to a crankcase 3 at its lower end face and comprising a pair of left and right clyinder heads 4 having head covers 5 stuck and fastened on its upper face. The cylinder block 2 defines a plurality of cylinders or liners 6 arranged in V-shape as seen in the crankshaft direction shown in Figure 3. A piston is inserted in each cylinder 6 and is connected through a connecting rod 8 with the crankshaft 9 as usual.

The cylinder head 4 of each clyinder bank of the V-type engine is of a bisectional structure composed of an upper head 11 and a lower head 10, respectively. The lower head 10 defines combustion cavities 12 which, in turn, form a combustion chamber for each cylinder 6 defined by the front face of the respective piston 7 slidably received therein.

As shown in Figure 4 the combustion cavity 12 of the respective cylinder 6 comprises three intake openings 12a, 12b and 12c as well as two exhaust openings 12d and 12e arranged along the periphery of the combustion cavity 12 whereas its centre portion is formed with an inserting hole 12i adapted to accommodate a usual ignition plug therein. The exhaust openings 12d and 12e are lead out to the outside wall 10b of the cylinder head 4 extending along the side periphery of the V-shaped cylinder bank by means of exhaust passages 13d and 13e. The intake openings 12a, 12b and 12c are lead out to a wall 10a of the cylinder head 4 located at the inner side of the V-shaped cylinder bank by means of intake passages 13a, 13b and 13c which joint with one another through an extension portion 11c extending through and upward of the upper head 11. The junction area 13f is shaped to be elliptical with its major diameter oriented in parallel to the crankshaft axis. A mounting hole 11d for receiving a fuel injection valve 30 is provided to extend through a portion of the central intake passage 13b. A slide valve 39 for opening and closing the junction portion 13f is disposed in the extension portion 11c of the intake passages and an air horn 40 is connected to that extension portion 11c. In order to prevent dust or the like from entering into the air horn 40 a cover 41 is provided.

As indicated in Figure 4 a coolant jacket for circulating cooling water from the cylinder block through the cylinder head is shown to be provided in the lower head 10. The cooling water jacket and internal structure of the cylinder head is designed to cover the combustion cavity 12. This cooling water jacket is composed of a water jacket 31a at the intake side ranging from the portion of the intake passages 13a, 13b and 13c to the side of the inside wall 10a of the lower head 10 another cooling jacket 31b disposed at the exhaust side ranging from the portion of the exhaust passages 13d and 13e to the outer side wall 10b of the lower head 10, and of a central cooling jacket 31c substantially extending between the intake passages 13a, 13b, 13c and the exhaust passgages 13d and 13e. The design and disposal of the different sections 31a, 31b, 31c of the water jacket arrangement are clearly shown in Figure 4.

Communicating holes 31e are drilled to communicate the upper portions of both the central cooling jackt 31c and the intake valve cooling jacket 31a and extend laterally offset from the intake Passages 13a and 13c, respectively According to this structure the cooling water of the coolant circuit flows from the cooling water jacket of the cylinder block 2 (not shown) into the cooling jacet 31b at the exhaust side of the cylinder head 4, and subsequentially it flows through the central jacket 31c and into the cooling jacket 31a disposed at the intake side of the cylinder head 4. From the intake side jacket 31a the water is circulated to be discharged through the drain outlet 31d. At the begining of each coolant circulation any air present at the top portion of the central jacket 31c is discharged to the cooling jacket 31a at the intake side through said communicating holes 31e.

The intake and exhaust valves 14, 15 each comprising valve stems 14b, 15b with valve plates 14a, 15a at their lower end portion adapted to open or close the intake openings 12a, 12b, 12c and exhaust openings 12d and 12e, respectively. As can be seen from Fig. 4 and 5 (an also from Fig. 1), the lower portion, i.e., the valve plates 14a of the side intake valves associated with the intake openings 12a and 12c cross the centre plane C containing the axis of the cylinders 6 of the cylinder bank as well as the axis of the crankshaft 9. The upper end portion of the valve stems 14b, 15b of the intake and exhaust valves 14, 15 is disposed in guide holes 11a, 11b, defined in the upper head 11. These guide holes 11a and 11b as shown in greater detail in Figure 5 are formed in a unitary structure respectively establishing a radially connected double structure (exhaust side) or triple structure, (intake side). Accordingly, the diameters of said guide holes 11a, 11b are sufficiently large to eliminate any boundary wall portion between adjacent guide holes 11a, 11b at the intake or exhaust sides. Moreover, cast intake and exhaust inserts 16, 17 form liners for said guide holes 11a, 11b as a reinforcement structure, preferably made of a material different from the material of the cylinder head to provide increased strength of said inserts 16, 17. In this way said intake and exhaust inserts 16 and 17 form slide holes to slidably receive intake and exhaust lifters 18, 19, respectively which are of a bottomed cylinder shape wherein the upper end of each valve stem 14b, 15b is engaged with the respective inside bottom portion of the intake and exhaust lifters 18, 19 through a pad, respectively . Near to the upper end of each valve stem 14b and 15b is installed a spring retainer 20, 21 adapted to retain the urging springs 22, 23 of the intake and exhaust valves 14, 15, respectively. Both valve urging springs 22 and 23 of the intake and exhaust valves 14, 15, respectively, are of a concentric double structure and extend between the retainers 20 and 21 and the associated valve seats 12g and 12h, formed on the lower head 10 of the cylinder head 4, respectively. By means of said valve springs 22 and 23 the intake and exhaust valves 14, 15 are kept urged in a direction for closing the intake and exhaust openings. The intake valves 14 and the exhaust valves 15 of each row of the V-type engine are operated by an intake camshaft 24 and an exhaust camshaft 25, respectively, which establish rotating contact with each intake lifter 18 and each exhaust lifter 19. Bearing portions, formed on the upper head 11 and cam caps fastened through bolts form bearings for both camshafts 24, 25. The intake valve 14 and exhaust valve 15 are moved downwardly by pushing down the intake lifter 18 and exhaust lifter 19 through the related cam lobes of the camshafts 24 and 25, respectively.

As indicated in Figure 4, the outer diameter of the valve spring 22 of the intake valve is set to substantially correspond to the outer diameter of the associated intake lifter 18 and that of the valve spring retainer 20, the position of which is set such that it is disposed adjacent to the lower end of the intake valve lifter 18 so that the upper end of the intake valve spring 22 is positioned substantially at the lower end of the intake lifter 18. The spring seat 12g of the intake valve spring 22 is provided at a correspondingly appropriate position of the internal structure of the lower head 10 of the cylinder head 4. Due to the afore-mentioned arrangement the valve operating mechanism at the intake valve side comprises a structure wherein the valve spring 22 of the intake valve 14 exhibits a double-stacked arrangement on the intake lifter 18.

In this way an enlargement of the diameter of the intake lifter 18 of each of the intake valves 14 can be avoided and, therefore, the intake lifters 18 can be disposed within the available space closely adjacent to one another without any problems.

Moreover, as similarly apparent from Figure 4, the outer diameter of the valve spring 23 of each of the exhaust valves 15 and the corresponding outer diameter of the associated valve spring retainer 21 are set to be somewhat smaller than the inner diameter of the exhaust lifter 17 which, as the intake lifter 18 is of a downwardly opening bottomed cylindrical structure. Further, the height positions of the valve spring retainer 21 of the exhaust valve 15 and the spring seat 12h provided on an internal wall of the lower head 10 of the cylinder head 4 are set such that an upper end portion of the valve spring 23 prebiasing the respective exhaust valve 14 in its closing position projects into the exhaust lifter 17. Accordingly, the valve operating system at the exhaust camshaft side is of a so-called bucket structure in which the upper portion of the valve spring 23 of the exhaust valve is covered by the related exhaust lifter 19 forming a reception space for the upper end of the valve spring 23.

As is apparent from Figure 4, the distance L2 from the axis of the exhaust camshaft 25 to the spring seat 12h of the exhaust valve spring 23 is set to be smaller than the distance L1 from the intake camshaft 24 to the associated valve seat 129 of the intake valve springs 22. Consequently, the distance L2' between the exhaust valve spring seat 12h and the valve seat is said to be larger than the corresponding distance L1' on the intake side while the distance of each axis of the intake and exhaust camshafts 24, 25 to the associated valve seat equals to one another.

Due to this dimensional layout it is possible to design the exhaust side cooling jacket 31b larger while simultaneously keeping the total height of the engine within reasonable limits. Accordingly, the cooling efficiency can be improved as the cooling jacket at the exhaust side of the cylinder head can be enlarged to have a greater cooling capacity than conventionally.

Moreover, in this embodiment of the present invention the number of the intake valves 14 (three) exceeds those of the exhaust valves 15 (two) leading to an increased diameter of the exhaust valve (15) in order to assure the necessary cross section of the exhaust opening area. Moreover, also the valve lift of the exhaust valves 15 is said to be larger than those of intake valves 14. In view of this dimensional aspect (leading to an increased weight of the exhaust valves compared with the intake valves) stronger exhaust valve springs 23 have to be used implying a greater spring constant and a greater length of the exhaust valve spring 23 compared with the intake valve spring 22. According to this arrangement the fear of a higher position of the exhaust camshaft 25 and, consequently, a greater total engine height in result of the structure of disposing the exhaust lifter 19 and the exhaust valve spring 23 is overcome by the upper valve spring receipt structure for the exhaust valve 15. Also the alternative, can be avoided namely to conventionally restrain an increased height of the engine by lowering the valve seats of the exhaust valves in order to provide sufficient space to accommodate the stronger valve springs, which would lead to the detrimental consequence of an insufficient cooling efficiency for the exhaust side of the cylinder head as the seize of the water cooling jacket 31b at the exhaust side would be diminished. A relatively high portion of the valve seat 12h for the exhaust valve spring 23 can be assured by means of employing a so-called bucket structure for the exhaust valve side for enabling the distance L2 between the axis of the exhaust camshaft 25 and the associated valve spring seat 12h of the exhaust valves 15 to be reduced but the distance L2' on the exhaust side between the exhaust opening 12e, 12d and the valve spring seat 12h to be increased, meeting the objectives of low engine height and unaffected cooling efficiency.

At the intake side, preferably the valve spring retainer 20 is disposed close to the lower rim portion of the associated valve lifter 18 in order to keep the necessary diameter of the three closely neighboured valve lifters 18 for the three intake valves 14 in this embodiment to be as low as possible enabling the intake lifters 18 to be disposed without any difficulties providing sufficient space for the insert 16 in the cylinder head without weakening the intrevening area between the bores lined by said insert 16. Specifically, when the cylinder head is made from a light metal alloy, such as aluminium alloy, this problem becomes important.

Also the distance L1 between the axis of the intake cam shift 24 and the associated intake valve spring seat 12g can exceed the corresponding distance L2 on the exhaust side, such a design facilitating the disposal of the intake valve springs 22 is not obligatory but both distances L1 and L2 on the intake and exhaust sides could also be equal to each other. In the latter case the length of the valve springs 23 for the exhaust valve 15 can be further increased and the cooling capabilities of the exhaust side cooling jacket 31b can be improved by increasing the size thereof.

As is apparent from the embodiment of Figures 3-5 as so far explained, the cooling jacket formed in the clyinder head 4 comprises two side jackets 31a, 31b at the intake and exhaust sides of the lower head 10 of the cylinder head 4 as well as central cooling jacket 31c. Moreover, according to one embodiment wherein the distance L2' at the exhaust side exceeds the distance side L1' at the intake side, the exhaust spring seat 12h formed by an integral wall portion of the lower head 10 of cylinder head 4 is more remote from a lower surface 10a of the cylinder head 4 meeting with the clyinder block 2. Thus a greater volume can be assured for the cooling jacket 31b on the exhaust side of the clyinder side 4. Depending on the further design of the cylinder head the volume of the exhaust side cooling jacket 31b may even exceed that of the intake side cooling jacket 31a. Nevertheless, the axis of rotation of intake and exhaust camshafts 24, 25 lie at approximately the same distance above the lower surface 10c of the cylyinder head 4.

In view of the problems of disposing a plurality of intake valves (or exhaust valves) closely neighboured to one another in order to increase the charging efficiency of the engine, for example by using three intake valves (and two exhaust valves) or a further increased number of intake or exhaust valves it is specifically important that the bearing structure for reciprocatingly supporting the valves (comprising lifters 18, 19 at the upper ends of the valve stems of the intake and exhaust valves 14, 15) include inserts or liners 16, 17, received preferably as integral structure in an opening of the cylinder head, said inserts 16, 17 for receiprocatingly supporting the associated lifters 18, 19 of the intake and exhaust valves 14, 15 not only comprising a plurality of bores engaged by the associated lifters of the intake or exhaust valves 14, 15 but they are also made of a material different from those of the cast cylinder head 4. In this way a very strong and reinforced supporting structure is obtained for the valve lifters 18, 19 and multiple valves can be employed on the intake or exhaust side without facing problems of assuring a sufficient strength of the material between adjacent valve lifters at the intake or exhaust side. In this way an improved cylinder head arrangement can be obtained facilitating the use of multiple lifters positioned close to each other, but supported by a strengthened reception structure.

Claims

1. Internal combustion engine of the V-type comprising a cylinder block (2) having a pair of cylinder banks disposed in a V-bank arrangement with at least one cylinder bore (6) defined in each cylinder bank, a cylinder head (4) attached to each of said cylinder banks, and a pair of intake and exhaust camshafts (24, 25) rotatably supported in each of said cylinder heads (4) for actuating a plurality of intake valves (14) and exhaust valves (15), respectively, **characterised in that** the distance (B) of the axis of the exhaust camshaft (25) from a centre plane (C) containing the cylinder axis of the respective cylinder bank and the axis of the crankshaft (9) is larger than the distance (A) of the respective intake camshaft (24) from said centre plane (C), said intake camshafts (24) being disposed at the sides of the cylinder heads (4) facing a V space between the cylinder banks.

2. Internal combustion engine according to claim 1, **characterised in that** an intermediate shaft (35a) is associated with each of said cylinder banks for driving the respective pair of intake and exhaust camshafts (24, 25), each of said intermediate shafts (35a) being rotatably supported around an axis that is parallel to the intake and exhaust camshafts (24, 25) and laterally offset with respect to said centre plane (C) of the respective cylinder bank toward the exhaust side thereof.

3. Internal combustion engine according to claim 1 or 2, **characterised in that** each of said intermediate shafts (35a) is provided with an intermediate gear (35) in mesh with a pair of cam gears (24b, 25b) affixed to the respective pair of intake and exhaust camshafts (24, 25).

4. Internal combustion engine according to claim 3, **characterised in that** the intermediate gears (35) are in mesh with a common crankshaft output gear (33) for driving both intermediate gears (35).

5. Internal combustion engine according to claim 4, **characterised in that** the crankshaft output gear (33) is driven by a crankshaft gear (9a) attached to the crankshaft (9).

6. Internal combustion engine according to claim 2, **characterised in that** the intermediate shafts (35a) are connected with the respective pair of intake and exhaust camshafts (24, 25) via driving belts (42) and connected with the crankshaft (9) via another driving belt.

7. Internal combustion engine according to at least one of claims 1 to 6, **characterised in that** auxiliary devices, particularly an alternator (54) are disposed in the V space defined between said pair of cylinder banks.

8. Internal combustion engine according to at least one of claims 1 to 7, **characterised in that** the intake and exhaust camshafts (24, 25) actuate the intake and exhaust valves (14, 15) via valve lifters (18, 19), valve springs (22, 23) being provided for biasing the intake and exhaust valves (14, 15) towards their closing positions and extending between spring seats (12g, 12h) provided at the cylinder head (4) and spring retainers (20, 21) fixed to the stems (14b, 15b) of the intake and exhaust valves (14, 15), respectively.

9. Internal combustion engine according to claim 8, **characterised in that** the valve spring retainers (20) of the intake valves (14) are disposed close to a lower end of the associated intake valve lifters (18) with the upper end of the intake valve springs (22) retained outside the intake valve lifters (18) at the lower end thereof, while the valve spring retainers (19) of the exhaust valves (15) together with the upper end of the associated exhaust valve springs (23) are accommodated inside the exhaust valve lifters (19).

10. Internal combustion engine according to claim 8 or 9, **characterised in that** the distance (L2') between the exhaust spring seats (12h) and exhaust openings (12e) formed in a lower surface of the cylinder head (4) is greater than the distance (L1') between the intake spring seats (12g) and respective intake openings (12c).

11. Internal combustion engine according to at least one of claims 8 to 10, **characterised in that** the distance (L2) between the axis of the exhaust valve actuating camshaft (25) and the spring seats (121) formed at a lower head (10) of the cylinder head (4) is smaller than or equal to the distance (L1) between the axis of the intake valve actuating camshaft (24) and the spring seats (12g) of the intake valves (14).

12. Internal combustion engine according to at least one of claims 1 to 11, **characterised in that** the cylinder head (4) is provided with a coolant jacket comprising a central cooling jacket (31c) and cooling jackets (31a, 31b) at the intake and exhaust side of the cylinder head, respectively, for circulating coolant through the cylinder head.

13. Internal combustion engine according to at least one of claims 1 to 12, **characterised in that** the axes of rotation of the intake and exhaust camshafts (24, 25) are disposed at approximately the same distance from the lower surface (10a) of the cylinder head (4), the intake and exhaust camshafts (24, 25) being disposed at approximately the same height with respect to the cylinder block (2).

14. Internal combustion engine according to at least one of claims 1 to 13, **characterised in that** three intake valves (14) including a pair of side intake valves and a centre intake valve and a pair of exhaust valves (15) are provided per cylinder, a lower end portion (14a) of said side intake valves crossing said centre plane (C).

FIG. 1

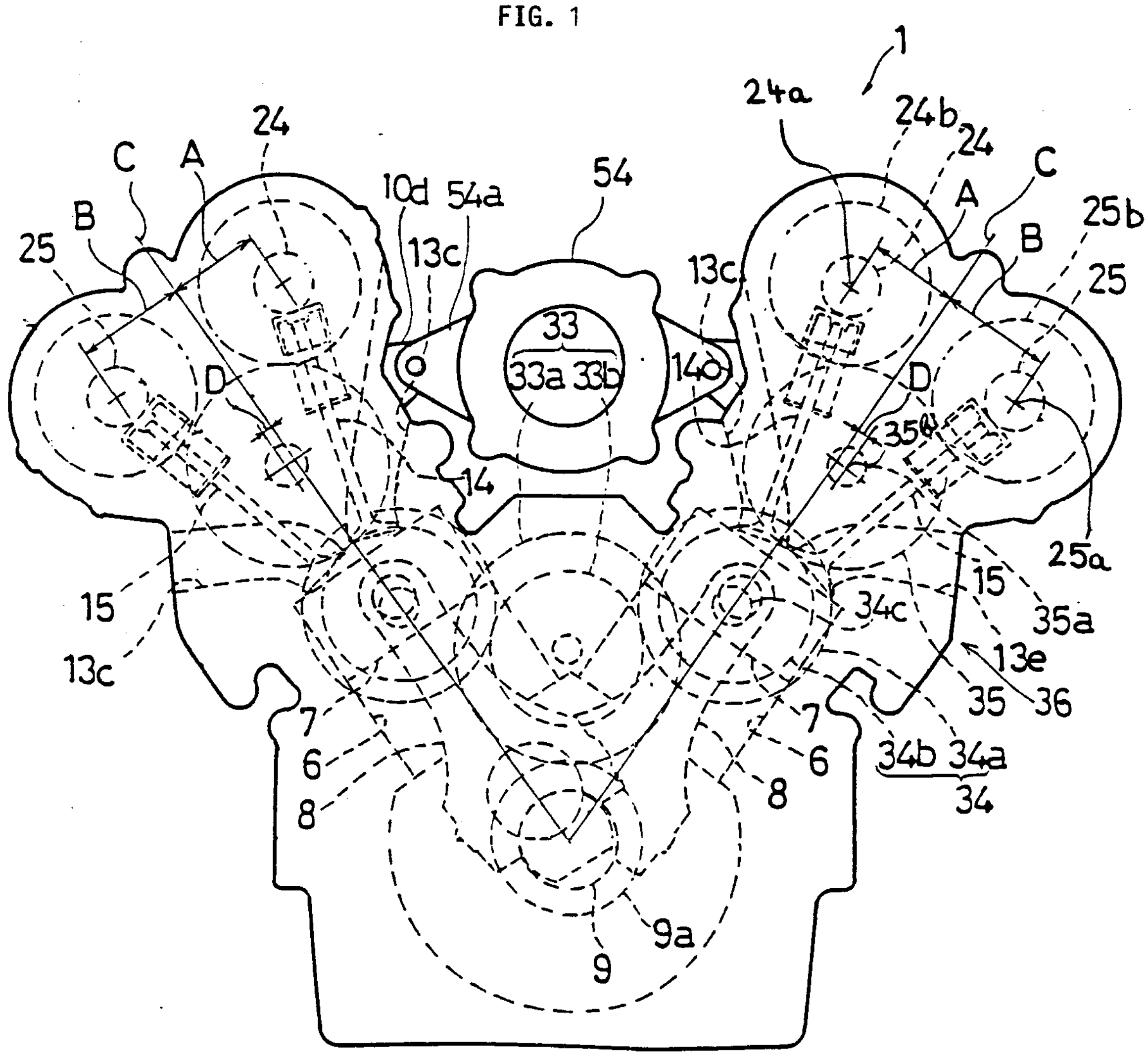
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FIG. 2

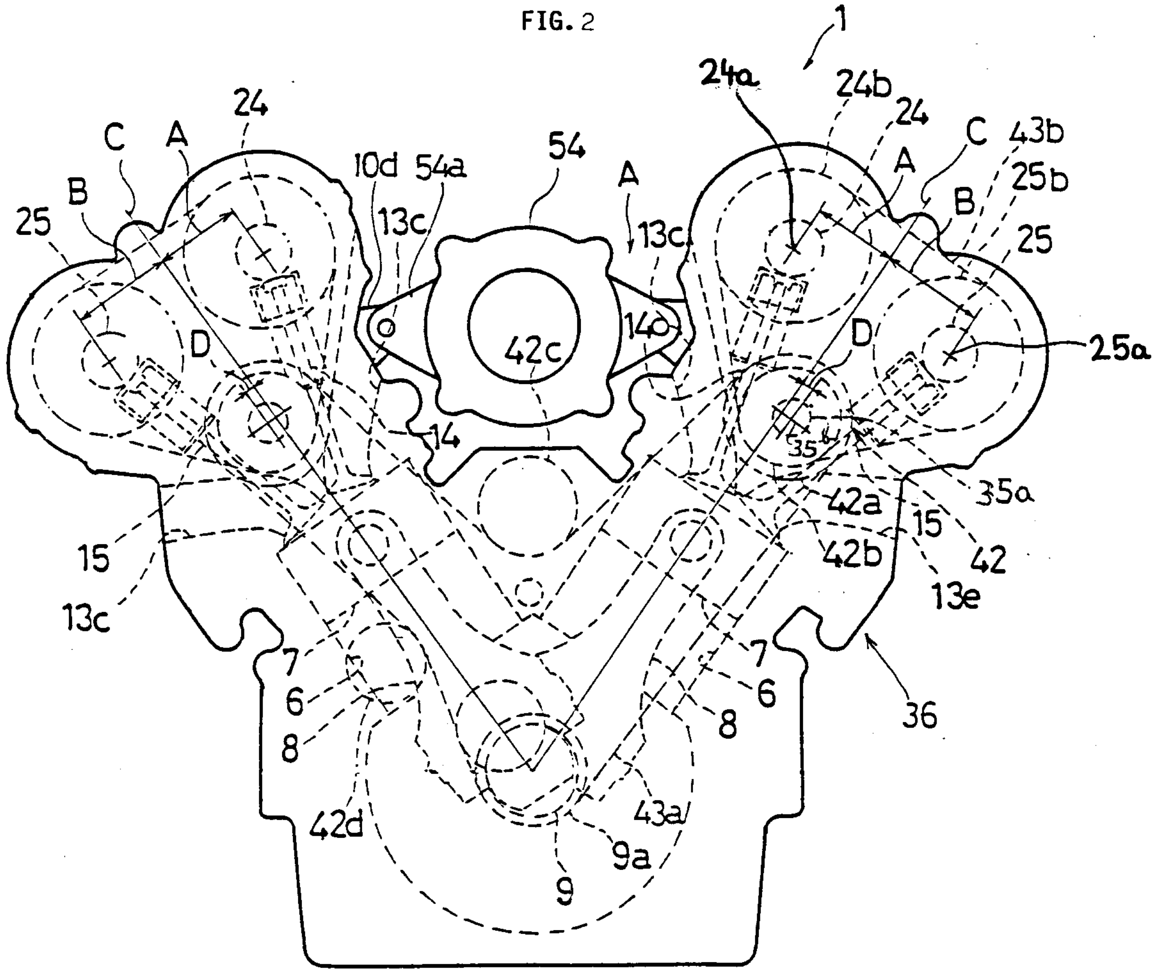
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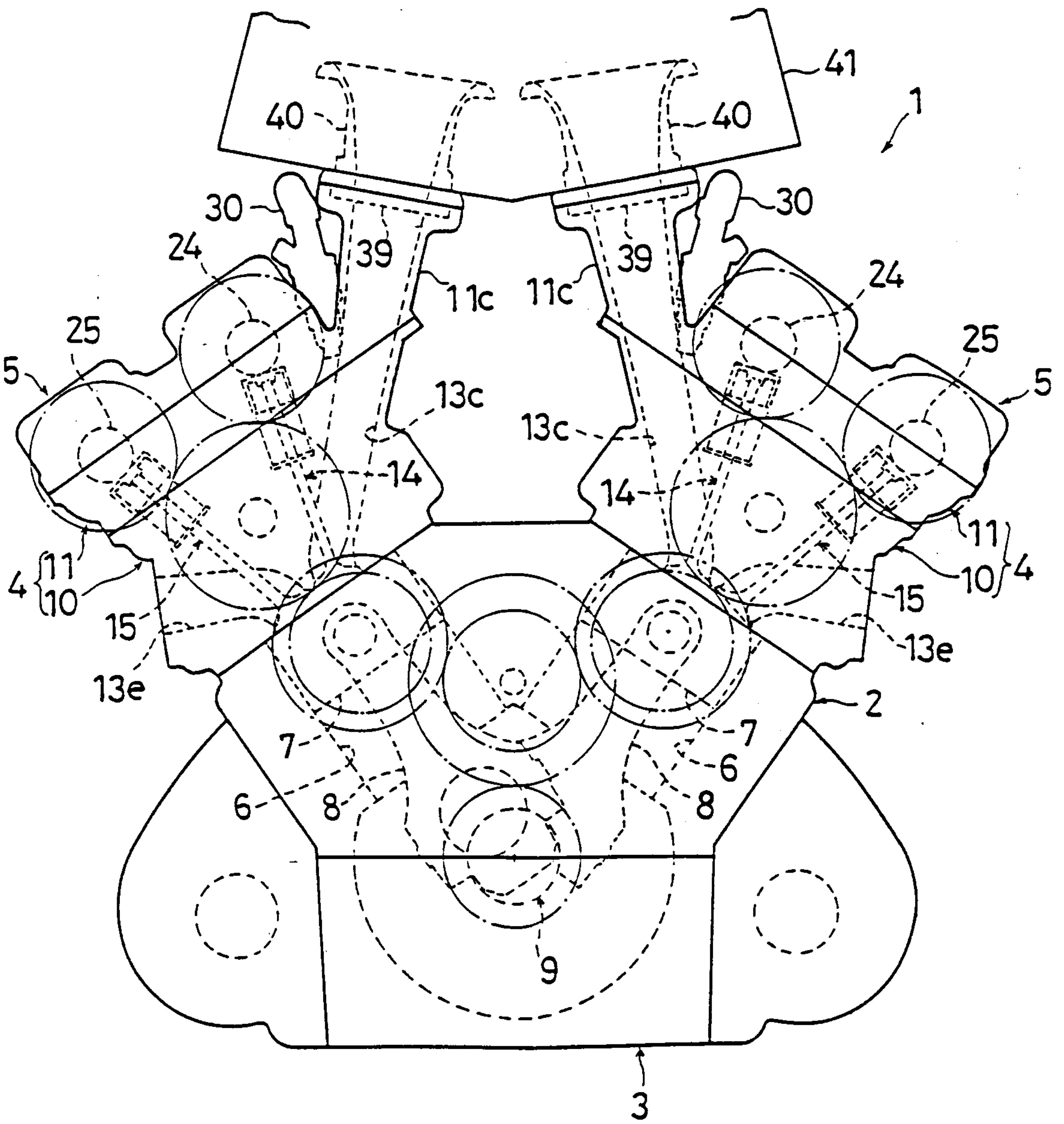
FIG. 3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15
15
13e
13e
2
7
7
6
6
8
8
9
3

FIG. 4

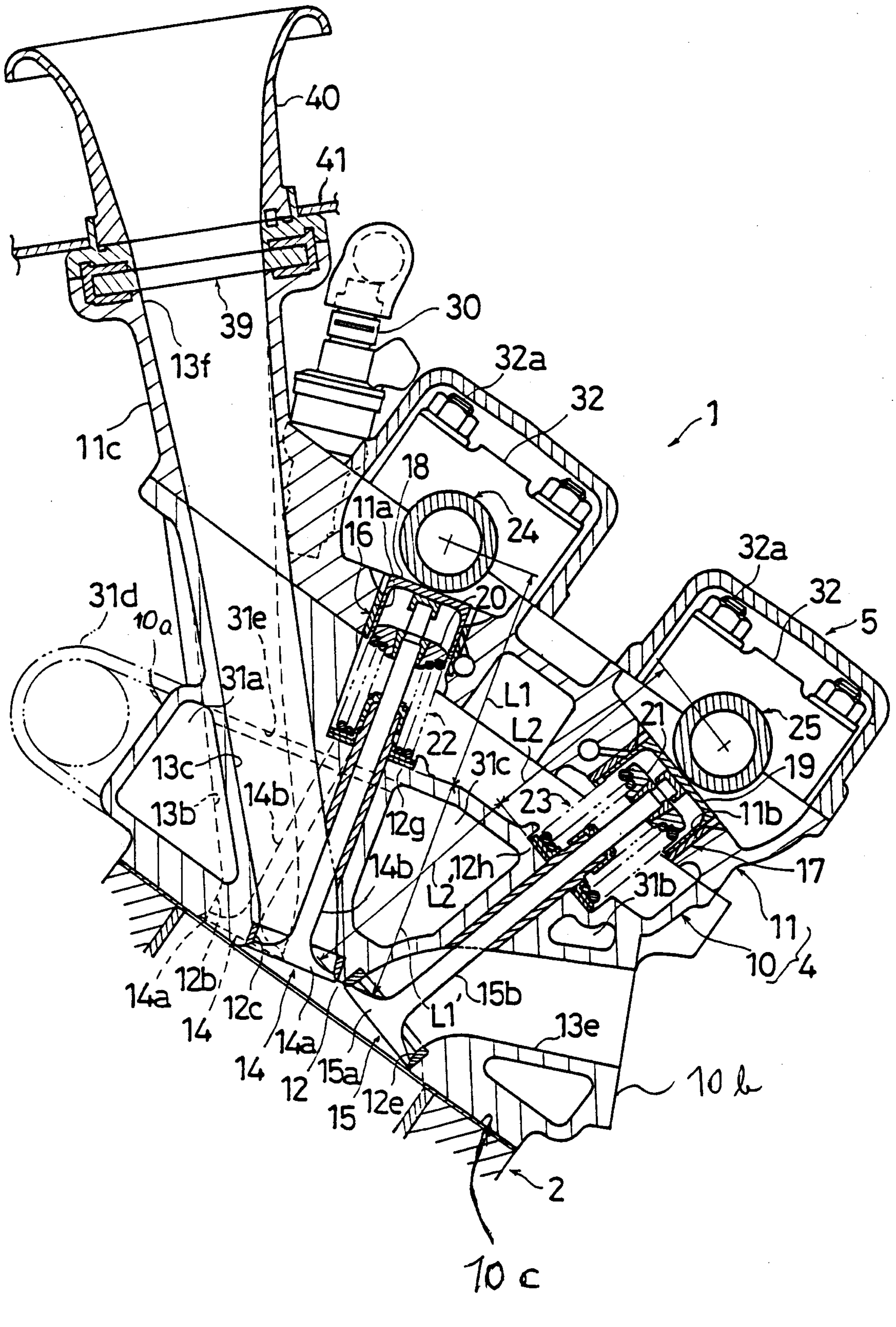
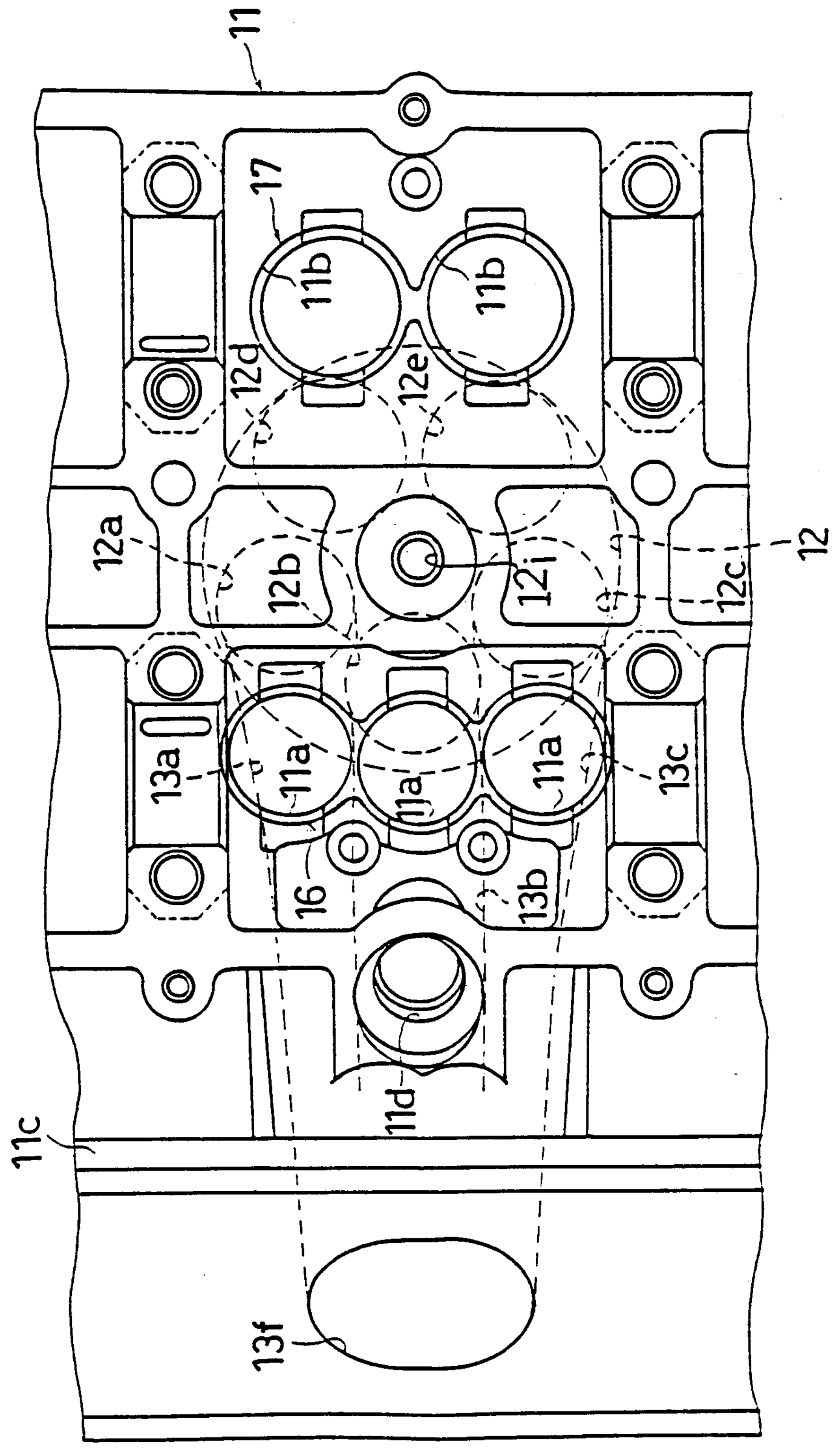

40
41
30
39
13f
32a
32
1
11c
18
11a
24
16
32a
32
5
31d
10a
31e
20
31a
L1
L2
21
25
19
13c
22
31c
23
11b
13b
14b
12g
14b
12h
L2
31b
17
11
10
4
14a
12b
12c
14
14a
14
12
15a
15
12e
L1
15b
13e
10b
2
10c

FIG. 5


11
17
11b
11b
12d
12e
12a
12b
12i
12c
12
13a
11a
11a
11a
13c
16
13b
11d
11c
13f