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

(11) EP 1 528 236 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.05.2005 Bulletin 2005/18

(51) Int Cl.[7]: **F02B 75/20**

(21) Application number: **03024732.4**

(22) Date of filing: **29.10.2003**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(71) Applicant: **Ford Global Technologies, Inc.**
Dearborn, Michigan 48126 (US)

(72) Inventors:
- **Rengmyr, Staffan**
416 56 Göteborg (SE)
- **Axelsson, Gunnar**
151 03 Södertälje (SE)
- **Sällström, Göran**
290 60 Kyrkhult (SE)

(74) Representative: **Hellbom, Lars Olof et al**
Albihns Stockholm AB,
Box 5581
114 85 Stockholm (SE)

(54) **An internal combustion engine and a method for producing it**

(57) An internal combustion engine is presented in which the engine block (1) comprises a first (7) and a second (8) engine block part, in contact with each other at a plane of contact (10), located at a distance from a crankshaft (2). An additional shaft (3), supporting a drive member (5) adapted to be driven by the crankshaft (2), is positioned in the plane of contact (10) between the first (7) and second (8) engine block part. A method for producing an internal combustion engine is also presented, comprising the steps of mounting a second engine block part (8) to a first engine block part (7), producing a bore (30) in the engine block (1) for a crankshaft (2) at a distance from a plane of contact (10) between the first (7) and second (8) engine block part, and producing a bore (31) for an additional shaft (3) in said plane of contact (10).

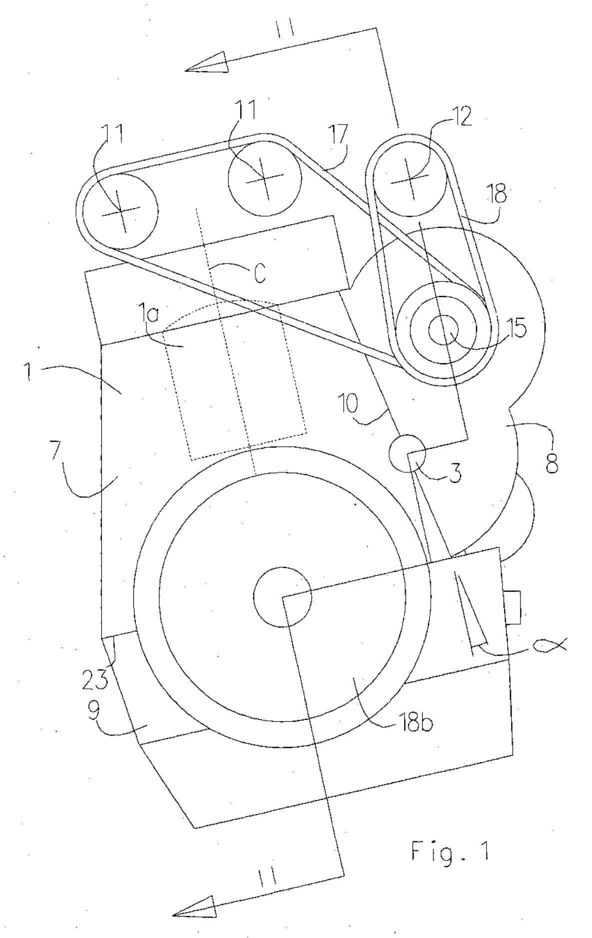

Fig. 1

EP 1 528 236 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an internal combustion engine comprising an engine block, a crankshaft and an additional shaft, supporting a drive member adapted to be driven, directly or indirectly, by the crankshaft. The invention also relates to a method for producing an internal combustion engine, comprising an engine block, a crankshaft and an additional shaft, supporting a drive member adapted to be driven, directly or indirectly, by the crankshaft.

TECHNICAL BACKGROUND

[0002] Traditional internal combustion engines drive auxiliary devices by the crankshaft via chain or belt drives at one end of the engine. However, such drives add to the overall length of the engine, i.e. the dimension in the direction of the cylinder line(s).

[0003] In connection to inline engines, it has been suggested to drive auxiliary devices via an accessory shaft located beside the crankshaft, in order to reduce the length of the engine, see e.g. EP0713960A1, and US4753199. However, in addition to adding to the width of the engine, installing the additional shaft according to any of these solutions is a relatively complicated process requiring additional time and effort during engine manufacturing.

[0004] US5063897 describes an internal combustion engine with inline cylinders, in which a crankshaft and an accessory shaft, gear driven by the crankshaft, are both positioned in a parting plane between an upper and a lower part of the engine block. The parting plane is oriented in an acute angle to a plane parallel with the cylinder bores, in order to reduce a horizontal dimension of the engine in a direction perpendicular to the cylinder line.

[0005] However, the solution in US5063897 still limits the degree of freedom concerning the design of the engine, in particular the location of the accessory shaft in relation to the crankshaft, since the location of the accessory shaft is restricted to the parting plane of the engine block. Also, the acute angle, which the parting plane forms to the cylinder bores, can not be smaller than a certain value due to practical reasons. One reason is that it is complicated, and therefore expensive to produce an engine in which the parting plane forms a relatively small angle to the cylinder bores. Another reason is that the engine block can not have a separating plane intersecting any parts of the cylinders above the crankcase, and therefore, the cylinders form a lower limitation for the angle between the separating plane and the cylinder bores.

SUMMARY

[0006] It is an object of the invention to provide an internal combustion engine, which is compact.

[0007] It is also an object of the invention to reduce noise in driving of auxiliary devices of an internal combustion engine.

[0008] It is also an object of the invention to reduce the risk of failure in driving of auxiliary devices of an internal combustion engine.

[0009] It is also an object of the invention to provide a larger degree of freedom in the design of an internal combustion engine.

[0010] It is also an object of the invention to simplify the production of an internal combustion engine.

[0011] These objects are reached with an internal combustion engine comprising an engine block, a crankshaft and an additional shaft, supporting a drive member, adapted to be driven, directly or indirectly, by the crankshaft, whereby the engine block comprises a first and a second engine block part being in contact with each other at a plane of contact, being located at a distance from the crankshaft, and the additional shaft is positioned with its centerline essentially in the plane of contact between the first and second engine block part.

[0012] Hereby, the additional shaft can be used for driving auxiliary devices, such as fuel and oil pumps, and camshafts, or other apparatuses in a vehicle, at which drive arrangements for such devices and apparatuses can be provided on the side on the engine so that they do not add to the overall length of the engine. Additionally, since the additional shaft is positioned in the plane of contact between the first and second engine block part, and said plane of contact is located at a distance from the crankshaft, a great degree of freedom in the engine design phase regarding positioning the additional shaft is accomplished. As mentioned above, it has been suggested in known art to provide the additional shaft at a plane of contact between two engine parts, being the same as the plane of contact at which the crankshaft is located. Thereby, a vertical separation between the shafts has been accomplished by orienting said plane of contact in an acute angle to the cylinder bore direction. In comparison to this, presenting the additional shaft in a plane of engine block separation at a distance from the crankshaft, the invention provides for the additional shaft being placed at an even greater vertical distance from the crankshaft.

[0013] More specifically, since the additional shaft is positioned in the plane of contact between the first and second engine block part, which plane of contact is located at a distance from the crankshaft, the additional shaft can be positioned relatively far above the crankshaft. Since most engines are less wide closer to the cylinder head than in the region around the crankshaft, the additional shaft being placed closer to the cylinder head will result in the additional shaft and gears etc. contributing less to the overall width of the engine. In turn, this will contribute to the compactness of the engine. In the case of an engine mounted transversally in a vehicle, keeping the width of the engine small allows for providing the vehicle with a large deformation zone in front of the engine.

[0014] In case the crankshaft is mounted in the engine block, the additional shaft being mounted with bearings in the engine block, between two engine block parts, provides for the engine block forming a stiff connection between the two shafts, whereby relative movements of the shafts during engine operation are decreased or minimized, so that a high precision in the relative shaft positions is maintained.

In general, the risk of relative movement between the shafts increases with the power transferred between the shafts. In the case of the drive member being a gear, the shafts being located at a distance other than according to design requirements, or being not parallel, can result in an increase of noise, and also a risk of failure, in a gear set carried by the shafts. The invention provides a stiffness regarding the relative position of the shafts, that makes a high power transfer between the latter possible without the risk of noise or failure occurring in the gear set. Thus, a low noise operation with a reduced risk of failure can be maintained during high power situations occurring in engines provided with, for example, a supercharger or an ISG (Integrated Starter Generator).

[0015] Preferably, the internal combustion engine comprises a further shaft, herein also referred to as a synchronization shaft, mounted in the second engine block part, whereby a first further drive member, fixedly connected to the drive member adapted to be driven by the crankshaft, is adapted to drive a second further drive member supported by the further shaft. Thereby, in production, synchronization parts, including the synchronization shaft and, where the drive members are formed by gears, the synchronization gear, can be mounted in the second engine block part before the latter is mounted finally onto the first engine block part. The synchronization parts include a relatively large number of items, such as gears, shafts, bearings, spacers, etc. The possibility of mounting such parts in the second engine block part before the latter is mounted finally onto the first engine block part simplifies the step of finally mounting the second engine block part to the first engine block part, since less details have to be fitted in this step.

[0016] Preferably, the engine block comprises a third engine block part, the first and the third engine block part being in contact with each other at a substantially flat plane of contact, and in that the crankshaft is positioned with its centerline essentially in the plane of contact between the first and third engine block part. Thereby, a three part cylinder block is provided, whereby the crankshaft and the additional shaft are positioned at separate contact planes. The first engine block part forms an intermediate part between the shafts, which are both biased against the first engine block part. This provides for a high degree of precision and stiffness regarding the relative positions of the shafts, which will reduce noise and the risk of failure during high power situations, as explained above.

[0017] The objects mentioned above are also reached with a method for producing an internal combustion engine, comprising an engine block, a crankshaft and an additional shaft, supporting a drive member adapted to be driven, directly or indirectly, by the crankshaft, comprising the steps of mounting a second engine block part to a first engine block part, producing a bore in the engine block for the crankshaft at a distance from a plane of contact between the first and second engine block part, and producing a bore for the additional shaft with the centerline of the bore essentially in the plane of contact between the first and second engine block part.

[0018] Thus, the bores can be produced at the same production stage, and both in the material of the first engine part, and this ensures a high degree of precision regarding the distance and parallelism between the crankshaft and the additional shaft. As has been explained above, in the case of the drive member being a gear included in a gear set, the high precision regarding the distance and parallelism between the shafts will result in a reduction of noise and risk of gear failure during engine operation, even under high power situations.

DRAWING SUMMARY

[0019] Further advantages of the invention will be mentioned below, where embodiments will be described with the aid of the accompanying drawings, in which

- fig. 1 is a schematic rear view of an internal combustion engine according to one embodiment of the invention,
- fig. 2 is a schematic sectioned side view of a part of the engine in fig. 1, sectioned along the line II-II in fig. 1,
- fig. 3 is a cross-sectional view, the section being oriented along the line III-III in fig. 2, wherein some parts are indicated with broken lines where located behind other parts,
- fig. 4 is a perspective view of an engine block for the engine in fig. 1, and
- fig. 5 is a rear view of the engine block in fig. 3.

DETAILED DESCRIPTION

[0020] Fig. 1 shows an internal combustion engine with six cylinders 1a arranged in a line, and indicated with broken lines in fig. 1. The engine comprises an engine block 1. The engine in fig. 1 is adapted to be mounted transversally in a vehicle, and fig. 1 shows a side of the engine, at which a transmission would be fitted. For this presentation, the longitudinal direction of the engine is defined as being parallel to the line of cylinders. The number of cylinders is not critical to the scope of the invention, i.e. the engine could include any number of cylinders, e.g. three, four or five.

[0021] Referring to fig. 2 and 3, the engine comprises a crankshaft 2 and an additional shaft 3. A first drive member 4, more specifically referred to as a first gear 4, fixedly mounted to the crankshaft 2, is adapted to drive a second drive member, more specifically referred to as a second gear 5, supported concentrically via bearings by the additional shaft 3. Thus, the second gear 5 is adapted to rotate in relation to the additional shaft 3, but the latter is not adapted to rotate in relation to the engine block 1. Alternatively, the second gear could be fixed to the additional shaft 3, and the latter could be biased to the engine block 1 via bearings. As can be seen in fig. 2, the first gear 4 is located on one of the cheeks of a throw 6 of the crankshaft 2, and thus the first 4 and second 5 gear are located inside the engine block 1, between the ends of the crankshaft 2. Within the scope of the invention, the gear set 4, 5 can be located at any suitable place along the crankshaft 2.

[0022] As an alternative to being driven by a direct engagement with the first drive member 4, the second drive member 5 could be a sprocket driven indirectly via a belt or a chain.

[0023] Referring to fig. 3, the engine block 1 comprises a first engine block part 7, a second engine block part 8, and a third engine block part 9. The first and second engine block parts 7, 8 are in contact with each other at a substantially flat plane of contact 10, being located at a distance from the crankshaft 2. The additional shaft 3 is positioned with its centerline essentially in the plane of contact 10 between the first and second engine block part 7, 8.

[0024] Referring to fig. 1 and 2, the additional shaft 3 is used for transferring power to two camshafts 11, and other auxiliary devices in the form of a fuel pump 12 and an alternator 14. In fig. 1 and 2, the camshafts 11 and the fuel pump 12 are indicated only with crosses and broken lines, respectively.

[0025] Referring to fig. 2, a further shaft 15, below also referred to as a synchronization shaft 15, partly housed in the second engine block part 8, is driven by a second further drive member 16b, more specifically referred to as a second further gear 16b and supported by the further shaft 15, being driven by a first further drive member 16a, more specifically referred to as a first further gear 16a and supported by the additional shaft 3. The first further gear 16a is fixedly connected to the second gear 5. In fig. 1, the second further drive member 16b is shown as being driven by the first further drive member 16a directly, but alternatively the second further drive member 16b could be a sprocket driven indirectly by means of a chain or a belt.

[0026] The camshafts 11 are in turn driven by the synchronization shaft 15 via a chain transmission 17, located externally of the engine block 1. The fuel pump 12 is also driven by the synchronization shaft 15 via a chain transmission 18. The chain transmission 17, 18 for the camshafts 11 and the fuel pump 12 are located above a flywheel 18a of the engine, (see fig. 2). The flywheel 18a, located longitudinally between a clutch 18c for the engine drive train and the cylinders, is at least partly housed in the engine block 1. In the example shown in fig. 2 the chain transmission 17 for the camshafts 11 and the chain transmission 18 for the fuel pump 12 are driven by the same shaft, i.e. the further shaft 15. As an alternative, the further shaft 15 could be replaced by two concentric shafts for driving the chain transmission 17 for the camshafts 11 and the chain transmission 18 for the fuel pump 12, respectively.

[0027] Referring to fig. 2 and 3, an oil pump 13 is driven by a sprocket 19a, supported by the additional shaft 3 and fixedly connected to the second gear 5, and a chain transmission 19. Preferably, the oil pump 13 is located in the second engine block part 8. Preferably, a vacuum pump 19b is mounted externally onto the second engine block part 8, and driven by a cam 19c mounted on the oil pump axle (not shown). In engine production, advantageously, the oil pump 13 and the vacuum pump 19b can be mounted into and onto, respectively, the second engine block part 8 before the latter is mounted to the first engine block part 7. This will simplify the production of the engine. Further, a fuel pump could be mounted onto the second engine block part 8 and driven by a cam 19c mounted on the oil pump axle.

[0028] Alternatively, the oil pump 13 could be driven directly by the crankshaft via a gear set.

[0029] Referring to fig. 2, the alternator 14 is driven via a gear 20, an alternator shaft 20a, and an alternator clutch 21, the gear 20 being driven by the second gear 5 on the additional shaft 3. In the example shown in fig. 2 the alternator shaft and the further shaft 15 are separate parts. As an alternative, the alternator 14 could be driven by the further shaft 15, whereby the gear 20 and the alternator shaft 20a could be omitted. Also, as a further alternative, the alternator 14 can be driven by a chain transmission from the additional shaft 3.

[0030] Referring to fig. 2, additional auxiliary devices can be driven via a belt pulley 22 provided on the further shaft 15. As an alternative, the further shaft 15 could be replaced by two concentric shafts, one for driving the chain transmission 17 for the camshafts 11 and the chain transmission 18 for the fuel pump 12, and another for driving additional auxiliary devices via the belt pulley 22.

[0031] As an alternative, the engine could be provided with one or more than two camshafts 11, adapted to be driven by the synchronization shaft 15. Also, the auxiliary devices could be driven by other means than those mentioned above, e.g. using belt drives or gears instead of chain drives, or chain or belt drives instead of gears.

[0032] The additional shaft 3 can be used for transferring power to other auxiliary devices than those mentioned above. For this presentation, the term auxiliary device includes any arrangement on the engine for supporting the process of driving the crankshaft by piston movements in the cylinders resulting from the combustion of the fuel and air mixture. Thus, other examples of auxiliary devices are water pump, engine fan, oil pump, vacuum pump, fuel pump and compressor. However, these examples are not exhaustive, and many other apparatuses or arrangements considered auxiliary devices within the scope of the claims below.

As can be seen in fig. 2, the drive arrangements for the auxiliary devices are provided mainly on the side on the engine so that no parts of these extend significantly beyond the engine block 1. The additional shaft 3 being positioned in the plane of contact 10 between the first and second engine block part 7, 8 allows for an easy process of installing the shaft 3 in the engine block 1, and thereby providing the bearings for the shaft 3.

[0033] Referring to fig. 1, the plane of contact 10 between the first and second engine block part 7, 8 is oriented in an acute angle α to a cylinder bore direction, C, of the engine. Alternatively, the plane of contact 10 between the first and second engine block part 7, 8 could be oriented parallel or substantially parallel to the cylinder bore direction of the engine. As a further alternative to the arrangement shown in fig. 1, the plane of contact 10 between the first and second engine block part 7, 8 could be oriented so that the angle α, as defined in fig. 1, is negative. The acute angle α, or the parallelism between the plane of contact 10 and the cylinder bore direction C, provides for the freedom of the engine designer being extended further, since positioning of the additional shaft 3 could be made, in principle, at any vertical location along the plane of contact 10.

[0034] Referring to fig. 3, the additional shaft 3 is located in a region above the crankshaft 2 and laterally of the cylinders 1a of the engine. This means that the additional shaft 3 with the second gear 5 adds to the width of the engine in a region above the region of the crankshaft 2. The region of the crankshaft 2 is usually a region where most inline engines have their greatest width. The additional shaft 3 being located in a region above the crankshaft 2 means that the overall width of the engine is less affected since the additional shaft 3 is located in a narrower region, closer to the cylinder head.

[0035] The engine is adapted to be mounted in a vehicle so that the cylinder bores (C) are tilted in a direction opposite to the side on which the additional shaft 3 is located, so that the cylinder bore C direction forms an angle β to a vertical axis of the vehicle. In the example depicted in fig. 1, the angle β is about 12°. Where the engine is mounted transversally in the vehicle, this provides for the engine requiring less space in the longitudinal direction of the vehicle, since the distance between the additional shaft 3 and the crankshaft 2 is reduced by the tilting of the engine.

[0036] The first and the third engine block part 7, 9 are in contact with each other at a substantially flat plane of contact 23. The crankshaft 2 is positioned with its centerline essentially in the plane of contact 23 between the first and third engine block part 7, 9.

[0037] Preferably, the production of the internal combustion engine described above includes the steps described below:

[0038] Referring to fig. 4 and 5, preferably the production of the first, second and third engine block part 7, 8, 9 includes an individual casting process for each part. Referring to fig. 5, by facing, the first engine block part 7 is provided with a first flat surface 24 and a second flat surface 25, the second engine block part 8 is provided with a flat surface 26, and the third engine block part 9 is provided with a flat surface 27.

[0039] Dowel pins (not shown) are provided in a region which will include the plane of contact 10 between the two parts 7, 8. Using the dowel pins, the second engine block part 8 is positioned adjacent to the first engine block part 7, whereby the flat surface 26 of the second engine block part 8 is pressed against the first flat surface 24 of the first engine block part 7, forming the plane of contact 10 between the two parts 7, 8. Of course, other means of positioning the parts in relation to each other can be provided. When the second engine block 8 part is positioned according to design requirements in relation to the first engine block part 7, parts of a fastening arrangement, including threaded holes for bolts 28, (see fig. 4), are formed so as to be aligned in the two adjacent parts 7, 8. The second engine block part 8 is then mounted to the first engine block part 7 by means of the fastening arrangement 28.

[0040] In a similar way, the third engine block part 9 is positioned adjacent to the first engine block part 7, whereby the flat surface 27 of the third engine block part 9 is pressed against the second flat surface 25 of the first engine block part 7, forming the plane of contact 23 between the two parts 7, 8, (see fig. 5). Thereupon, parts of a fastening arrangement, including threaded holes for bolts 29, (see fig. 4), are formed so as to be aligned in the two adjacent parts 7, 9, whereupon the third engine block part 9 is mounted to the first engine block part 7 by means of the fastening arrangement 29.

[0041] A bore 30 for the crankshaft 2 is milled in the engine block 1, whereby the center line of the bore is positioned essentially in the plane of contact 23 between the first and third engine block part 7, 9. Similarly, a bore 31 for the additional shaft 3 is milled in the engine block 1, whereby the center line of the bore is positioned essentially in the plane of contact 10 between the first and second engine block part 7, 8. Preferably, the two bores 30, 31 are produced in the same production machine, so that the bore 31 for the additional shaft 3 is produced in the same engine production step as the bore 30 for the crankshaft 2. This makes it possible to obtain a very high precision regarding the distance and parallelism between the bores 30, 31 and hence the two shafts 2, 3.

[0042] Referring to fig. 5, preferably a bore 32 for the further shaft 15 is produced in the same production step as the bores 30, 31 for the camshaft 2 and additional shaft 3. This will make production more effective, and it will also secure a correct distance and parallelism between the additional shaft 3 and the further shaft 15. As a result less noise and a reduced risk of failure will be provided in connection to the gears 16a, 16b working between the additional shaft 3 and the further shaft 15.

[0043] Preferably, after the bore 31 for the additional shaft is produced, the second engine block part 8 is removed from the first engine block part 7, and the further shaft 15 with the second further gear 16b (see fig. 2), and other synchronization parts are mounted to the second engine block part, before the latter is mounted finally onto the first engine block part. When the latter step is performed, synchronization parts 15, 16b will already be mounted in the second engine block part 8, and only the additional shaft 3 has to be fitted when the second engine block part 8 is finally mounted to the first engine block part 7. Additionally, as mentioned above, the oil pump 13 and the vacuum pump 19b can be mounted to the second engine block part 8 before mounting the latter to the first engine block part 7.

[0044] Above, the additional shaft 3 has been described as supporting gears to drive auxiliary devices, such as camshafts and fuel pump. However, the additional shaft 3 could also be used to drive other accessories of a vehicle, such as an air conditioning compressor. The additional shaft can also be connected to an engine transmission, whereby it is used for outputting the engine power to the transmission.

Claims

1. An internal combustion engine comprising an engine block (1), a crankshaft (2) and an additional shaft (3), supporting a drive member (5) adapted to be driven, directly or indirectly, by the crankshaft (2), **characterized in that** the engine block (1) comprises a first (7) and a second (8) engine block part being in contact with each other at a plane of contact (10), being located at a distance from the crankshaft (2), and **in that** the additional shaft (3) is positioned with its centerline essentially in the plane of contact (10) between the first (7) and second (8) engine block part.

2. An internal combustion engine according to claim 1, comprising a further shaft (15), mounted in the second engine block part (8), whereby a first further drive member (16a), fixedly connected to the drive member (5) adapted to be driven by the crankshaft (2), is adapted to drive a second further drive member (16b) supported by the further shaft (15).

3. An internal combustion engine according to claim 1 or 2, wherein the plane of contact (10) between the first (7) and second (8) engine block part is oriented substantially parallel to or in an acute angle (α) to a cylinder bore direction (C) of the engine.

4. An internal combustion engine according to claim 1, 2 or 3, wherein the additional shaft (3) is located in a region above the crankshaft (2) and laterally of the cylinders (1a) of the engine.

5. An internal combustion engine according to claim 4, being adapted to be mounted in a vehicle so that the cylinder bores (1a) are tilted in a direction opposite to the side on which the additional shaft (3) is located.

6. An internal combustion engine according to any of the preceding claims, wherein the engine block (1) comprises a third engine block part (9), the first and the third engine block part (9) being in contact with each other at a plane of contact (23), and in that the crankshaft (2) is positioned with its centerline essentially in the plane of contact (23) between the first (7) and third (9) engine block part.

7. An internal combustion engine according to any of the preceding claims, wherein the additional shaft (3) supports a drive member (19a) adapted to drive, directly or indirectly, an oil pump (13) of the engine.

8. An internal combustion engine according to claim 7, wherein the oil pump (13) is driven via a chain transmission (19).

9. A method for producing an internal combustion engine, comprising an engine block (1), a crankshaft (2) and an additional shaft (3), supporting a drive member (5) adapted to be driven, directly or indirectly, by the crankshaft (2), **characterized by** the steps of mounting a second engine block part (8) to a first engine block part (7), producing a bore (30) in the engine block (1) for the crankshaft (2) at a distance from a plane of contact (10) between the first (7) and second (8) engine block part, and producing a bore (31) for the additional shaft (3) with the centerline of the bore (31) essentially in the plane of contact (10) between the first (7) and second (8) engine block part.

10. A method according to claim 9, wherein the steps of producing a bore (30) in the engine block (1) for the crankshaft (2) and producing a bore (31) for the additional shaft (3) are performed substantially simultaneously.

11. A method according to claim 10, comprising the step of producing, substantially simultaneously as producing the bores (30, 31) for the crankshaft (2) and the additional shaft (3), a bore (32) in the second engine block part (8) for a further shaft (15).

12. A method according to claim 9, 10 or 11, comprising mounting a further shaft (15) to the second engine

block part (8), before a step of finally mounting the second engine block part (8) onto the first engine block part (7), the further shaft (15) being adapted to support a second further drive member (16b) adapted to be driven by a first further drive member (16a), fixedly connected to the drive member (5) which is adapted to be driven by the crankshaft (2).

13. A method according to claim 9, 10, 11 or 12, comprising mounting an oil pump (13) to the second engine block part (8), before a step of finally mounting the second engine block part (8) onto the first engine block part (7).

14. A method according to claim 9, 10, 11, 12 or 13, comprising the step of mounting a third engine block part (9) to the first engine block part (7), and wherein the step of producing a bore (30) for the crankshaft (2) comprises producing a bore (30) for the crankshaft (2) with the centerline of the bore (30) essentially in the plane of contact (23) between the first (7) and third (9) engine block part.

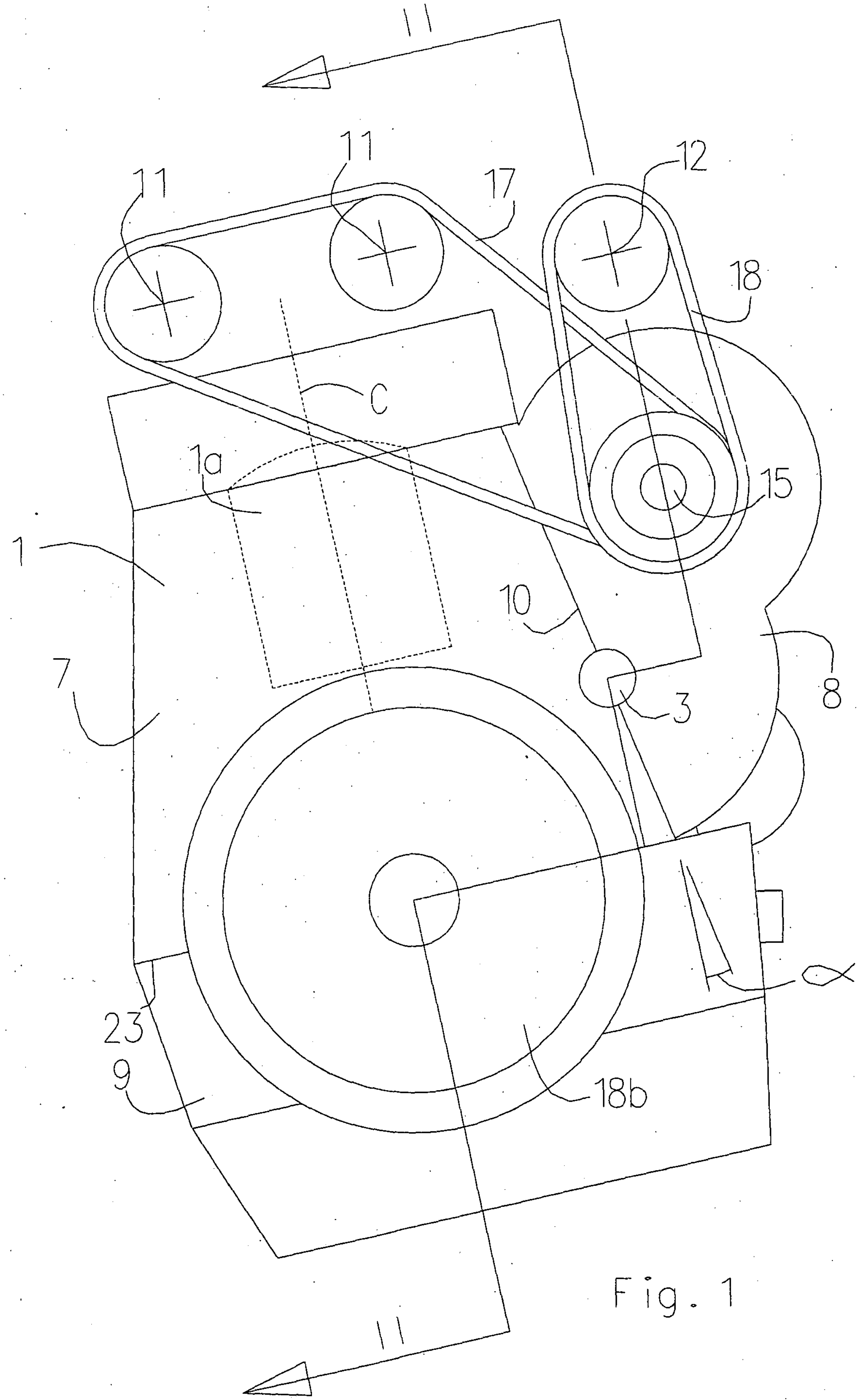

Fig. 1

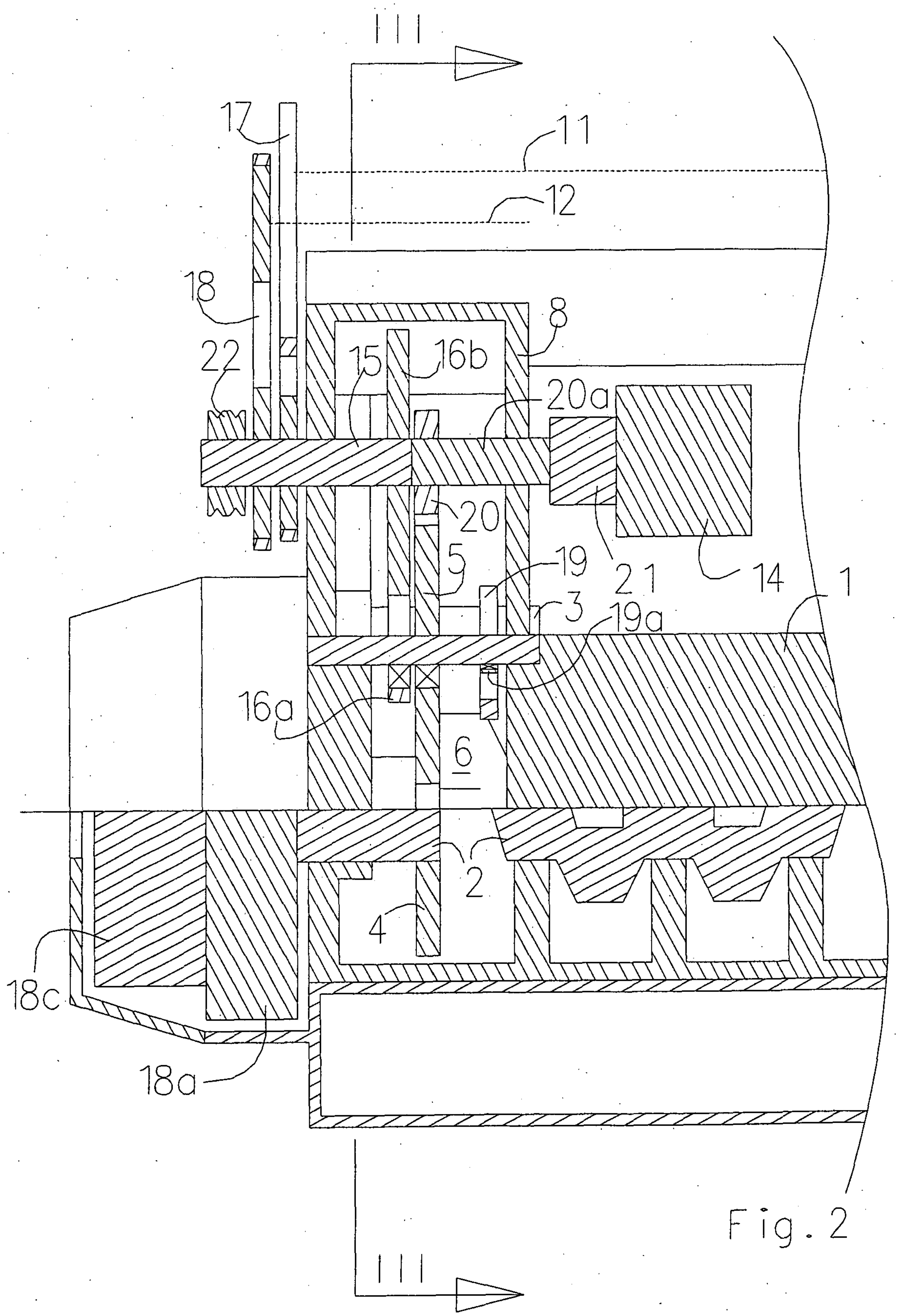
III
17
11
12
18
8
22
15
16b
20a
20
5
19
21
14
1
3
19a
16a
6
2
4
18c
18a
III

Fig. 2

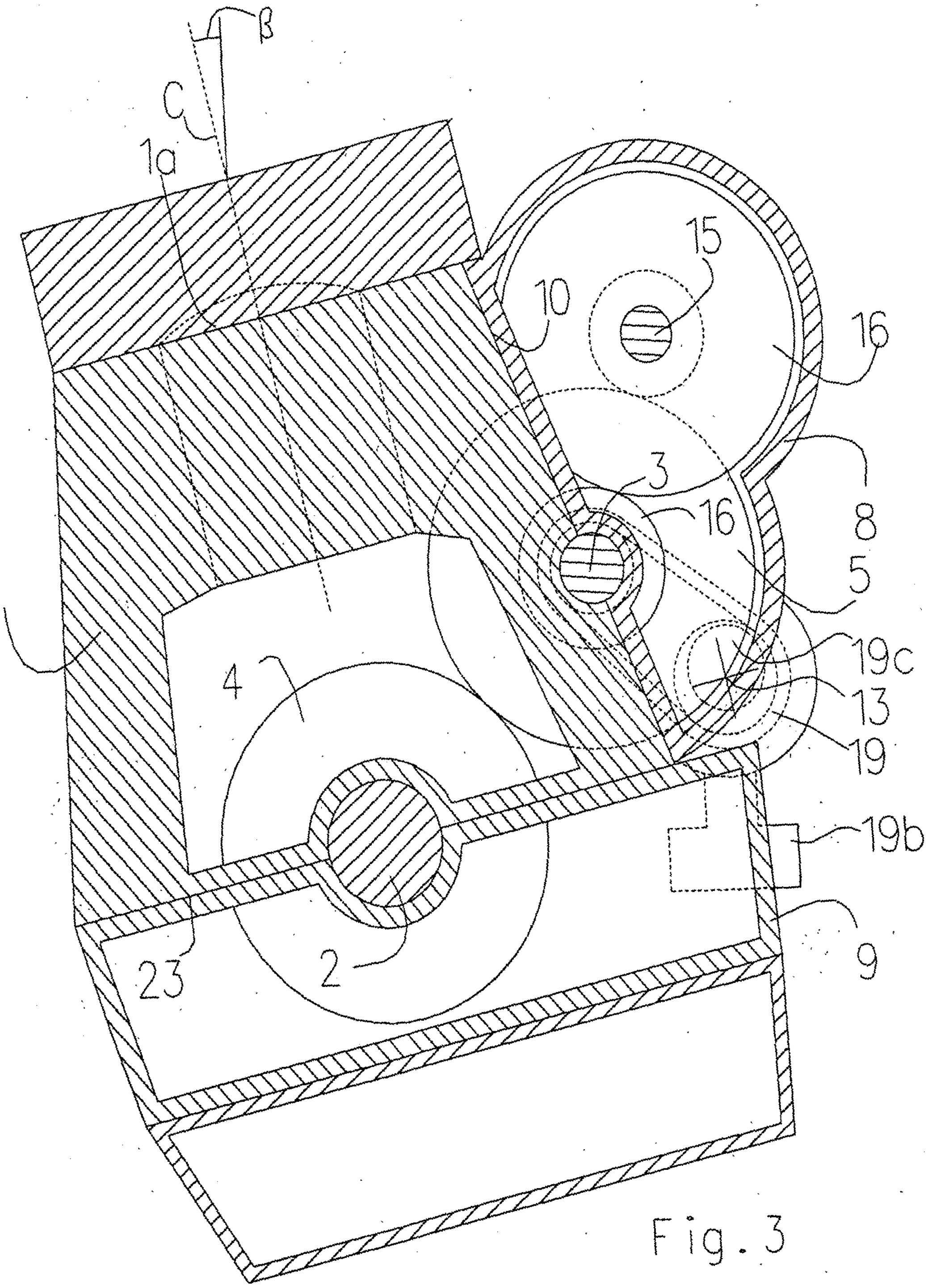

Fig. 3

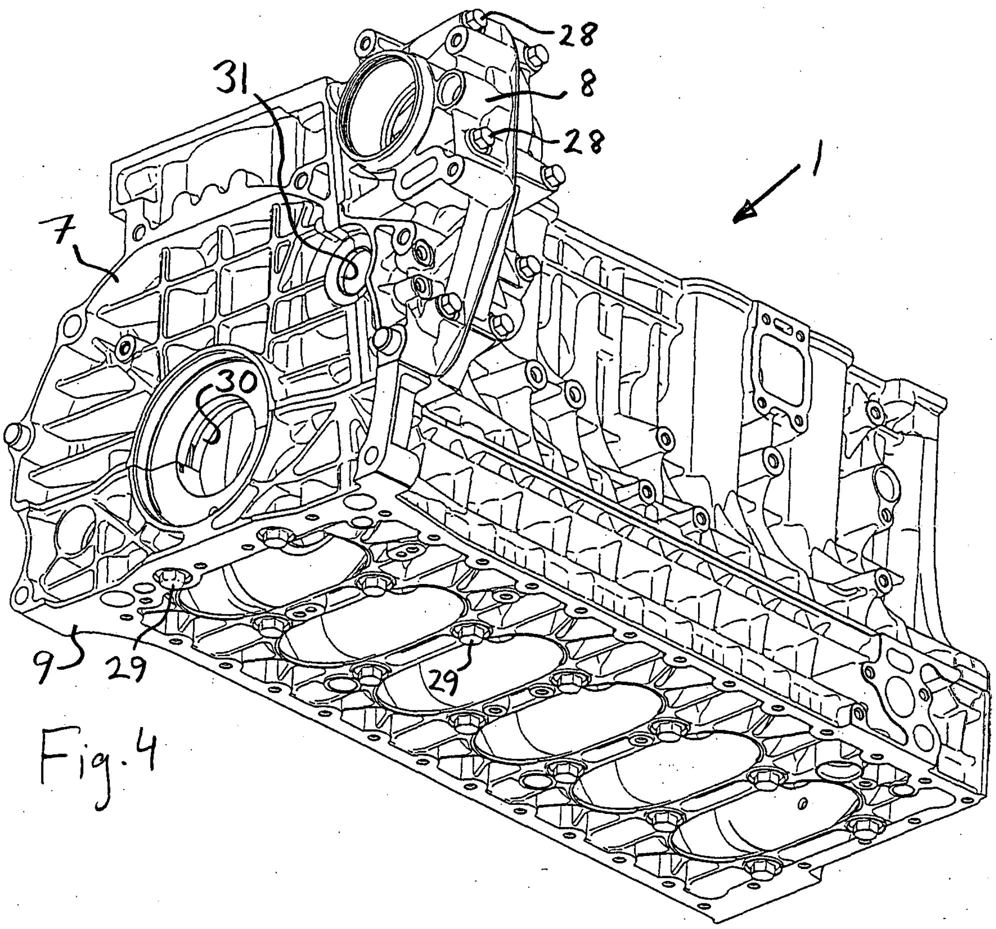

Fig.4

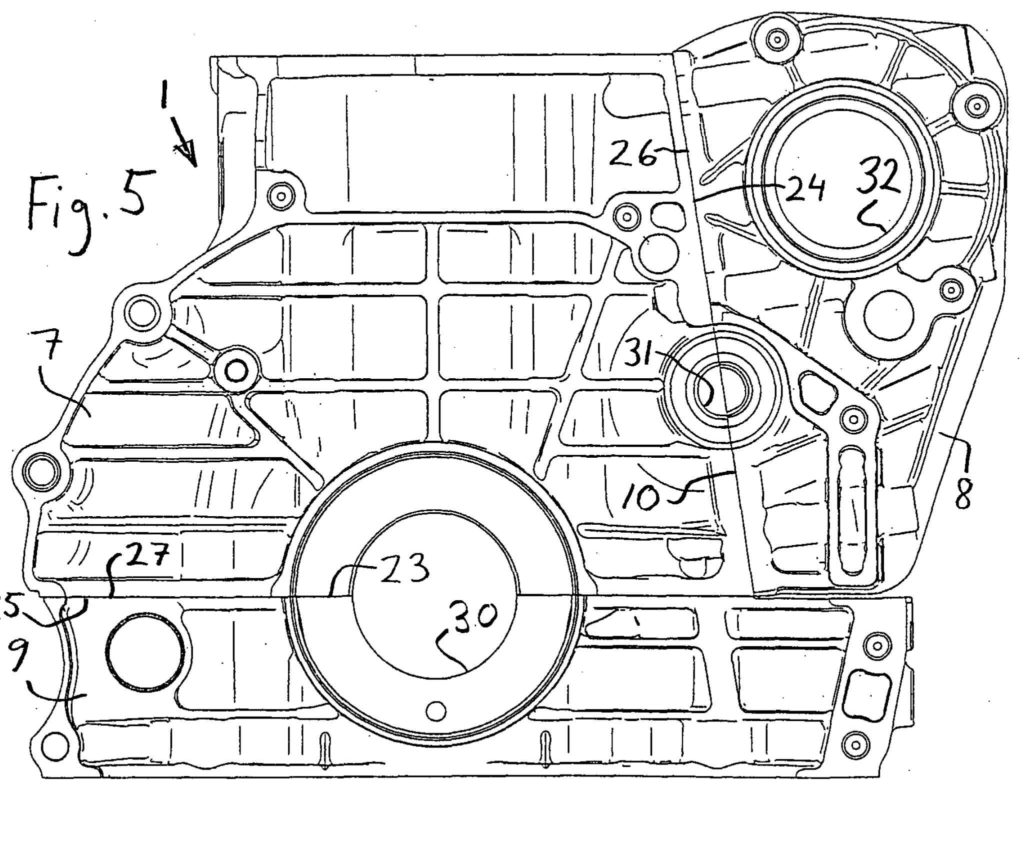

Fig.5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 02 4732

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X A	US 5 873 336 A (UCHIDA MASAHIRO) 23 February 1999 (1999-02-23) * column 1, line 4-6 * * column 4, line 64 - column 5, line 33 * * figures 7,8 * ---	1,3-5 9	F02B75/20
X A	DE 39 06 991 A (VOLKSWAGENWERK AG) 5 October 1989 (1989-10-05) * column 1, line 3-8 * * column 2, line 46-64 * * figure 2 * ---	1,7,8 9	
X A	US 2001/050193 A1 (YAMADA SHINICHI ET AL) 13 December 2001 (2001-12-13) * paragraph [0001] * * paragraphs [0041]-[0043] * * paragraph [0048] * * figure 2 * ---	1 4-6,9	
X A	EP 1 279 858 A (CNH U K LTD ;IVECO UK LTD (GB); CUMMINS ENGINE COMPANY LTD (GB)) 29 January 2003 (2003-01-29) * paragraph [0001] * * paragraph [0017] * * paragraph [0022] * * figures 1-3 * ---	1 2,5,6,9	TECHNICAL FIELDS SEARCHED (Int.Cl.7) F02B F02F F01L B23P
A	US 2 553 935 A (PARKS JAMES R ET AL) 22 May 1951 (1951-05-22) * column 1, line 1-6 * * column 3, line 22-37 * * figures 1-6 * ---	9	
D,A	US 4 753 199 A (MELDE-TUCZAI HELMUT ET AL) 28 June 1988 (1988-06-28) * figure 2 * --- -/--	1	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 April 2004	Paquay, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 02 4732

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,A	US 5 063 897 A (OKUI KAORU ET AL) 12 November 1991 (1991-11-12) * figure 5 * -----	1,9	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 April 2004	Paquay, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 02 4732

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

21-04-2004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5873336 A	23-02-1999	JP 10089147 A	07-04-1998
DE 3906991 A	05-10-1989	DE 3906991 A1	05-10-1989
		FR 2628789 A1	22-09-1989
		IT 1228723 B	03-07-1991
		JP 1273808 A	01-11-1989
US 2001050193 A1	13-12-2001	JP 2001233275 A	28-08-2001
		DE 10108771 A1	13-09-2001
EP 1279858 A	29-01-2003	EP 1279858 A1	29-01-2003
		JP 2003130136 A	08-05-2003
		US 2003106518 A1	12-06-2003
US 2553935 A	22-05-1951	NONE	
US 4753199 A	28-06-1988	AT 402088 B	27-01-1997
		AT 356785 A	15-06-1996
		DE 3641201 A1	11-06-1987
US 5063897 A	12-11-1991	JP 2802440 B2	24-09-1998
		JP 3043628 A	25-02-1991
		DE 69005030 D1	20-01-1994
		DE 69005030 T2	21-04-1994
		DE 69007576 D1	28-04-1994
		DE 69007576 T2	30-06-1994
		DE 69022329 D1	19-10-1995
		DE 69022329 T2	29-02-1996
		DE 69030111 D1	10-04-1997
		DE 69030111 T2	12-06-1997
		DE 69032625 D1	08-10-1998
		DE 69032625 T2	28-01-1999
		EP 0401710 A1	12-12-1990
		EP 0415022 A1	06-03-1991
		EP 0411319 A2	06-02-1991
		EP 0560402 A1	15-09-1993
		EP 0653553 A2	17-05-1995
		ES 2048893 T3	01-04-1994
		ES 2054159 T3	01-08-1994

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82