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

(11) EP 1 761 684 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
04.07.2012 Bulletin 2012/27

(21) Application number: **05748585.6**

(22) Date of filing: **02.06.2005**

(51) Int Cl.:
F01L 1/34 (2006.01) ***F01L 1/047*** (2006.01)

(86) International application number:
PCT/GB2005/050078

(87) International publication number:
WO 2006/000832 (05.01.2006 Gazette 2006/01)

(54) **ENGINE WITH VARIABLE VALVE TIMING**
MOTOR MIT VARIABLER VENTILSTEUERUNG
MOTEUR A REGLAGE DE DISTRIBUTION VARIABLE

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

(30) Priority: **29.06.2004 GB 0414514**

(43) Date of publication of application:
14.03.2007 Bulletin 2007/11

(73) Proprietor: **Mechadyne PLC**
Kirtlington,
Oxfordshire OX5 3JQ (GB)

(72) Inventors:
- **LANCEFIELD, Timothy, Mark**
Shipston on Stour Warwickshire CV36 5LZ (GB)
- **LAWRENCE, Nicholas**
Buckingham Buckinghamshire MK18 1GJ (GB)

(74) Representative: **Messulam, Alec Moses**
Harrison IP
1st Floor, Box Tree House
Northminster Business Park
Northfield Lane
York, YO26 6QU (GB)

(56) References cited:
EP-A- 1 234 954
DE-A1- 3 934 848
US-A- 2 349 157
US-A- 5 165 303
US-A- 5 564 380

EP 1 761 684 B1

Description

Field of the invention

[0001] The present invention relates to an internal combustion engine having a phase change mechanism for varying the opening and closing times of the engine valves during the engine operating cycle, that is to say for varying the phase of the cams acting on the valves in relation to the phase of the engine crankshaft.

Background of the invention

[0002] Regardless of whether one wishes to operate an engine for maximum output power, best fuel economy or minimum emissions, the optimum setting of the valve timing will depend on operating conditions, such as speed and load. It has long been recognised therefore that it is desirable to be able to alter the phase of the cams of an engine relative to the crankshaft to suit the prevailing operating conditions.

[0003] To this end, there have previously been proposed numerous phase change mechanisms, herein termed phasers, to rotate the cams relative to the crankshaft while the engine is in operation.

[0004] Some internal combustion engine layouts use the rear end, i.e. the non-driven end, of the camshaft to drive auxiliary devices. Some of these devices, such as the highpressure common rail pumps found in diesel engines, require a high drive torque. This presents a problem when implementing a variable valve timing strategy because it requires the phaser to produce sufficient output torque not only to vary the phase of the cams but also to drive the auxiliary device.

[0005] As an example, some auxiliary devices require a drive torque of up to 40Nm, but, if the phaser runs on engine oil pressure, it may only be able to supply 5Nm. The phaser will therefore be unable to control camshaft phase angle, and the high reaction torque will simply push the phaser to the end of its adjustment range.

Summary of the invention

[0006] With a view to mitigating the foregoing problem, the present invention provides an engine having a crankshaft, a camshaft formed of two concentric rotary members at least one of which carries a group of cams, a transmission train connected to drive a first of the rotary members in fixed phase relationship with the crankshaft, and a phaser for enabling the phase of the second of the rotary members to be varied dynamically relative to the phase of the crankshaft and the first rotary member, characterised in that an auxiliary device is connected to be driven by torque transmitted from the crankshaft through the first rotary member of the camshaft.

[0007] A camshaft for use in a multi-cylinder engine and having two rotary members in the form of an inner shaft which is surrounded by an outer tube carrying at least some of the cams, is known in the prior art, an example being found in EP-A-1 234 954. The present invention uses such a two-part camshaft to overcome the problem encountered in the prior art, by transmitting torque to the auxiliary device through a rotary member of the camshaft that is not driven by a phaser.

[0008] In one embodiment of the invention, the outer tube is fast in rotation with all the cams of the camshaft.

[0009] In an alternative embodiment of the invention, the camshaft is formed with two groups of cams, one of the groups being fast in rotation with the outer tube and the other group being coupled to the inner shaft by means of pins extending into the inner shaft through circumferentially elongated slots in the outer tube.

[0010] The invention may also be used in an engine having two camshafts, in which case several possibilities present themselves. In particular, the second camshaft may be a solid (one-piece) camshaft driven either directly or through a phaser by one of the rotary members of the first camshaft. As a further possibility, the second camshaft may itself comprise two rotary members at least one of which carries a group of cams, wherein one of the rotary members of the second camshaft is driven in synchronism with one of the rotary members of the first camshaft and the second rotary member of the second camshaft is driven by means of a phaser that enables the relative angular position of the two rotary members of the second camshaft to be varied dynamically, so as to allow the phase of at least some of the cam lobes on the second camshaft to be altered with respect to the crankshaft.

Brief description of the drawings

[0011] The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of a flow path to transmit torque from the crankshaft through a camshaft to an auxiliary device such as a diesel fuel pump,

Figure 2 is a similar representation of a torque flow path in an embodiment of the invention,

Figures 3 and 4 are sections through different two-part camshafts that may be used in implementing the invention, and

Figures 5 and 6 are schematic representations of the torque flow paths of two further embodiments of the invention.

Detailed description of the preferred embodiments

[0012] In Figure 1, a camshaft drive 10 transmits torque to a one-piece camshaft 14 through a phaser 12. The camshaft drive 10 consists of the engine crankshaft and transmission train made up of cogs, a belt or a chain that connects a pulley on the crankshaft to the phaser 12. Different types of phaser 12 are known in the prior art and the choice of phaser is not of fundamental importance to the present invention. Essentially, the phaser 12 acts dynamically to shift the phase of the camshaft relative to the engine crankshaft. It can derive its power from an external source, such as a pressurised hydraulic fluid supply or it may rely on the reversal of the reaction torque of the valve train. In the ensuing description, it will be assumed that the phaser is a hydraulically powered so-called vane-type phaser.

[0013] If the camshaft 14 were to be coupled at its rear end to an auxiliary device 16, such as a diesel fuel pump, that presents a high reaction torque, the phaser 12 would not have the power to overcome the reaction torque of the auxiliary device 16 and would become ineffective. For this reason, in a conventional variable phase valve timing system, one could not use the camshaft to power auxiliary devices and another way had to be found to transmit torque from the crankshaft to the auxiliary device.

[0014] In the present invention, as represented in Figure 2, the camshaft 14 is separated into two rotary members, namely a first rotary member 14a driven by the crankshaft and driving any unphased cams, and a second rotary member 14b which drives all the phased cams, that it is to say the cams of which the phase is to be varied relative to the crankshaft. As only the second rotary member 14b lies in the torque output path of the phaser 12, the phaser 12 only has to overcome the reaction torque of the valve train and it is not required to overcome the reaction torque of the auxiliary device 16.

[0015] Figures 3 and 4 show two different two-part camshafts that may be employed in the invention. They differ from one another in that in the case of Figure 3, all the cams are phased and in Figure 4 only some of the cams are phased.

[0016] In Figure 3, the camshaft has an outer tube 50 journalled in bearings (not shown) in the cylinder head. The outer tube 50 acts as the phased rotary member 14b and carries all the cams 54, all of which are therefore phased. The outer tube supports an inner shaft 52, corresponding to the unphased rotary member 14a, which serves to transmit torque to the auxiliary device 16, shown as being a diesel pump.

[0017] The camshaft of Figure 4 once again comprises a journalled an outer tube 60 supporting an inner shaft 62. In this case, however, only some of the cams 64 are mounted on the outer tube 60 in the same way as the cams 54 in Figure 3 and rotate with it. The remaining cams 66 can rotate about the outer tube 60 and are coupled instead for rotation with the inner shaft 62 by means of pins 68 that pass through tangentially elongated slots in the outer tube 60. To avoid the pins passing through cam lobes, each of the cams 66 that rotate with the shaft 62 is formed with an annular extension 66a which receives the pin 68. Figure 4 shows the auxiliary device 16 being driven by the inner shaft 62, but in this embodiment, it is also possible to use either the outer tube 60 to transmit torque to the auxiliary device. In some cases the latter approach may be advantageous because the outer tube 60 has the greater torsional rigidity and because it is directly supported in bearings.

[0018] The phaser 12 shown in Figure 3 and 4, is a vane-type phaser with one driven member, in the form of a camshaft pulley that is rotated by the crankshaft and two drive members. One of the drive members is directly coupled to the driven member, i.e. the camshaft pulley so that its phase does not vary in relation to the engine crankshaft.

[0019] The second drive member of the phaser 12 is connected to a vane rotor carrying vanes that act in the same way as the pistons of hydraulic jacks. As hydraulic fluid is supplied to working chambers on the opposite sides of the vanes, the phase of the vane rotor is shifted in relation to the drive pulley. The vane rotor of the phaser is used to drive the phased member 14b of the camshaft 14, being the outer tube 50 in the embodiment of Figures 3 and 4.

[0020] In the case of an engine with a single camshaft, the camshaft of Figure 4 allows phase shifting of the intake cams without affecting the phase of the exhaust cams.

[0021] The invention can also find application in engines having separate intake and exhaust camshafts. In such a case it is not necessary to resort to the more complex camshaft construction of Figure 4 and all the cams of any one of the camshafts can be carried by the outer tube 14b.

[0022] Figure 5 differs from Figure 2 in that the unphased rotary member 14a of the first camshaft 14 is connected to drive a second, conventional, one-piece camshaft 30. In this case, the phase of the cams carried by the camshaft 30 is fixed relative to the engine crankshaft and torque can be transmitted to auxiliary devices 16 from the rotary member 14a of the first camshaft 14 and/or from the second camshaft 30.

[0023] Figure 6 is a variation on the valve train shown in Figure 5 and differs from it in that the engine has a further phaser 42 arranged between the unphased rotary member 14a of the first camshaft 14 and the second camshaft 30. In this case, the second camshaft 30 may either be a solid one-piece camshaft or a camshaft constructed in the manner shown in Figures 3 and 4. As with the embodiment shown in Figure 5, torque may be transmitted to two auxiliary devices 16a and 16b, the torque to the second device 16b being taken either from the unphased rotary member of the first camshaft 14, as illustrated, or from unphased rotary member of the second camshaft 30 if the latter is constructed in the manner illustrated in Figures 3 and 4.

Claims

1. An engine having a crankshaft, a camshaft (14) formed of two concentric rotary members (50,52) at least one of which carries a group of cams (54), a

transmission train connected to drive a first of the rotary members in fixed phase relationship with the crankshaft, and a phaser (12) for enabling the phase of the second of the rotary members to be varied dynamically relative to the phase of the crankshaft and the first rotary member, **characterised in that** an auxiliary device (16) is connected to be driven by torque transmitted from the crankshaft through the first rotary member of the camshaft.

2. An engine as claimed in claim 1, wherein the engine is a multi-cylinder engine and wherein the two rotary members consist of an inner shaft and a outer tube surrounding the inner shaft.

3. An engine as claimed in claim 2, wherein the outer tube is fast in rotation with all the cams of the camshaft.

4. An engine as claimed in claim 2, wherein the camshaft is formed with two groups of cams, one of the groups being fast in rotation with the outer tube and the other group being coupled to the inner shaft by means of pins extending into the inner shaft through circumferentially elongated slots in the outer tube.

5. An engine as claimed in any preceding claim, wherein the engine has two camshafts, the second camshaft being a solid camshaft driven in synchronism with one of the rotary members of the first camshaft.

6. An engine as claimed in any of claims 1 to 4, wherein the engine has two camshafts, the second camshaft being a solid camshaft coupled by means of a second phaser to one of the rotary members of the first camshaft.

7. An engine as claimed in any of claims 1 to 4, wherein the engine has two camshafts and the second camshaft comprises two rotary members at least one of which carries a group of cams, wherein one of the rotary members of the second camshaft is driven in synchronism with one of the rotary members of the first camshaft and the second rotary member of the second camshaft is driven by means of a phaser that enables the relative angular position of the two rotary members of the second camshaft to be varied dynamically, so as to allow the phase of at least some of the cam lobes on the second camshaft to be altered with respect to the crankshaft.

8. An engine as claimed in claims 5 to 7, wherein the second camshaft is used to provide an unphased drive to an auxiliary device driven by torque transmitted by the crankshaft through the second camshaft.

Patentansprüche

1. Verbrennungsmotor mit einer Kurbelwelle, einer Nockenwelle (14), die aus zwei konzentrischen rotierenden Elementen (50, 52) besteht, von denen mindestens eines eine Gruppe von Nocken (54) trägt, einem Getriebezug, der so verbunden ist, dass er ein erstes von den rotierenden Elementen in fester Phasenbeziehung mit der Kurbelwelle antreibt, und einem Phasenversteller (12), der es ermöglicht, die Phase des zweiten von den rotierenden Elementen in Bezug auf die Phase der Kurbelwelle und des ersten rotierenden Elements dynamisch zu verstellen, **dadurch gekennzeichnet, dass** eine Hilfsvorrichtung (16) so verbunden ist, dass sie von einem Drehmoment, das von der Kurbelwelle über das erste rotierende Element der Nockenwelle übertragen wird, angetrieben wird.

2. Verbrennungsmotor nach Anspruch 1, wobei der Verbrennungsmotor ein Mehrzylinder-Verbrennungsmotor ist, und wobei die beiden rotierenden Elemente aus einer inneren Welle und einem äußeren Rohr, welches die innere Welle umgibt, bestehen.

3. Verbrennungsmotor nach Anspruch 2, wobei das äußere Rohr sich mit sämtlichen Nocken der Nockenwelle schnell dreht.

4. Verbrennungsmotor nach Anspruch 2, wobei die Nockenwelle mit zwei Gruppen von Nocken ausgebildet ist, wobei eine der Gruppen sich schnell mit dem äußeren Rohr dreht und die andere Gruppen mittels Stiften, die durch in Umfangsrichtung verlängerte Schlitze im äußeren Rohr in das Innere der Welle vorragen, mit dem Inneren der Welle verbunden sind.

5. Verbrennungsmotor nach einem der vorangehenden Ansprüche, wobei der Verbrennungsmotor zwei Nockenwellen aufweist, wobei die zweite Nockenwelle eine massive Nockenwelle ist, die synchron mit einem der rotierenden Elemente der ersten Nockenwelle angetrieben wird.

6. Verbrennungsmotor nach einem der Ansprüche 1 bis 4, wobei der Verbrennungsmotor zwei Nockenwellen aufweist, wobei die zweite Nockenwelle eine massive Nockenwelle ist, die mittels eines zweiten Phasenverstellers mit einem der rotierenden Elemente der ersten Nockenwelle verbunden ist.

7. Verbrennungsmotor nach einem der Ansprüche 1 bis 4, wobei der Verbrennungsmotor zwei Nockenwellen aufweist, und die zweite Nockenwelle zwei rotierende Elemente aufweist, von denen mindestens eines eine Gruppe von Nocken trägt, wobei

eines der rotierenden Elemente der zweiten Nockenwelle synchron mit einem der rotierenden Elemente der ersten Nockenwelle angetrieben wird, und das zweite rotierende Element der zweiten Nockenwelle mittels eines Phasenverstellers angetrieben wird, der eine dynamische Änderung der relativen Winkelstellung der beiden rotierenden Elemente der zweiten Nockenwelle ermöglicht, so dass die Phase von mindestens einigen der Nockenerhebungen an der zweiten Nockenwellen in Bezug auf die Kurbelwelle geändert werden können.

8. Verbrennungsmotor nach einem der Ansprüche 5 bis 7, wobei die zweite Nockenwelle verwendet wird, um einen nicht phasenverstellten Antrieb für die Hilfsvorrichtung bereitzustellen, die von einem Drehmoment angetrieben wird, das von der Kurbelwelle über die Nockenwelle übertragen wird.

Revendications

1. Un moteur possédant un vilebrequin, un arbre à cames (14) formé de deux éléments rotatifs concentriques (50, 52) au moins l'un d'entre eux comportant un groupe de cames (54), un mécanisme de transmission raccordé de façon à entraîner un premier des éléments rotatifs en relation de phase fixe avec le vilebrequin, et un dispositif de mise en phase (12) destiné à permettre à la phase du deuxième des éléments rotatifs d'être variée dynamiquement par rapport à la phase du vilebrequin et du premier élément rotatif, **caractérisé en ce qu'**un dispositif auxiliaire (16) est raccordé de façon à être entraîné par un couple transmis à partir du vilebrequin par l'intermédiaire du premier élément rotatif de l'arbre à cames.

2. Un moteur selon la Revendication 1, où le moteur est un moteur multicylindre et où les deux éléments rotatifs se composent d'un arbre interne et d'un tube externe entourant l'arbre interne.

3. Un moteur selon la Revendication 2, où le tube externe est solidaire en rotation avec toutes les cames de l'arbre à cames.

4. Un moteur selon la Revendication 2, où l'arbre à cames est formé de deux groupes de cames, l'un des groupes étant solidaire en rotation avec le tube externe et l'autre groupe étant couplé à l'arbre interne au moyen de goupilles s'étendant dans l'arbre interne au travers de fentes allongées de manière circonférentielle dans le tube externe.

5. Un moteur selon l'une quelconque des Revendications précédentes, où le moteur possède deux arbres à cames, le deuxième arbre à cames étant un arbre à cames solide entraîné en synchronisme avec l'un des éléments rotatifs du premier arbre à cames.

6. Un moteur selon l'une quelconque des Revendications 1 à 4, où le moteur possède deux arbres à cames, le deuxième arbre à cames étant un arbre à cames solide couplé au moyen d'un deuxième dispositif de mise en phase à l'un des éléments rotatifs du premier arbre à cames.

7. Un moteur selon l'une quelconque des Revendications 1 à 4, où le moteur possède deux arbres à cames et le deuxième arbre à cames comprend deux éléments rotatifs au moins l'un d'entre eux comportant un groupe de cames, où l'un des éléments rotatifs du deuxième arbre à cames est entraîné en synchronisme avec l'un des éléments rotatifs du premier arbre à cames et le deuxième élément rotatif du deuxième arbre à cames est entraîné au moyen d'un dispositif de mise en phase qui permet à la position angulaire relative des deux éléments rotatifs du deuxième arbre à cames d'être variée dynamiquement, de façon à permettre à la phase d'au moins certains des lobes de came sur le deuxième arbre à cames d'être modifiée par rapport au vilebrequin.

8. Un moteur selon l'une quelconque des Revendications 5 à 7, où le deuxième arbre à cames est utilisé pour fournir un entraînement non en phase vers un dispositif auxiliaire entraîné par un couple transmis par le vilebrequin par l'intermédiaire du deuxième arbre à cames.

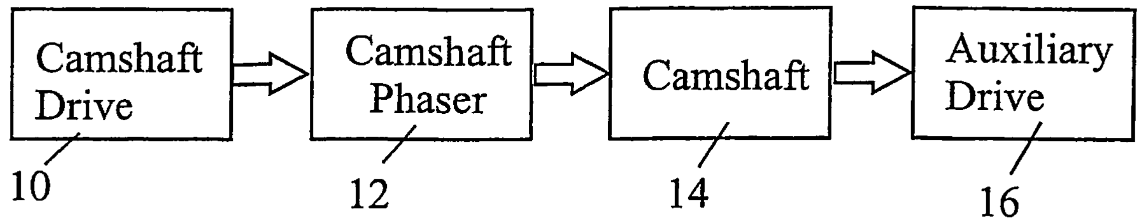

Fig. 1

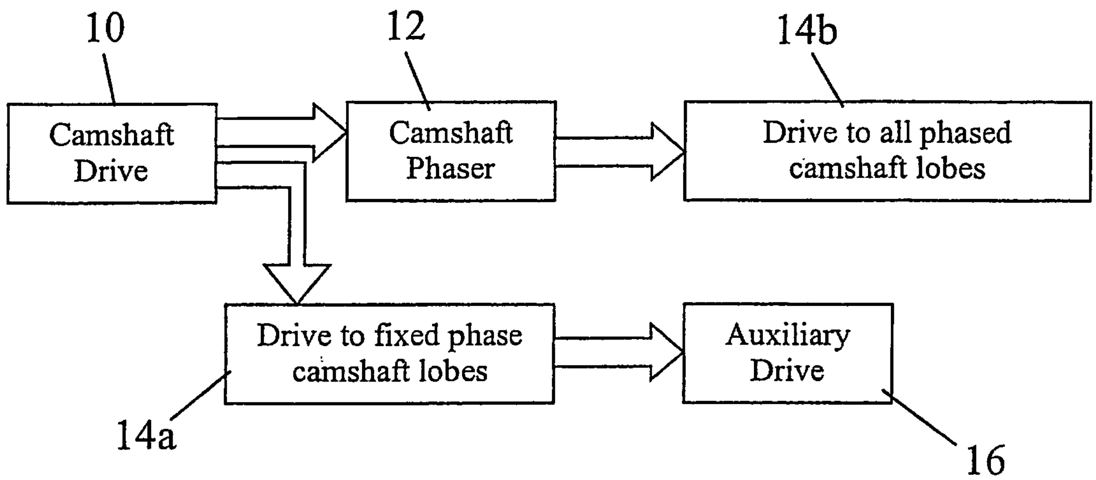

Fig. 2

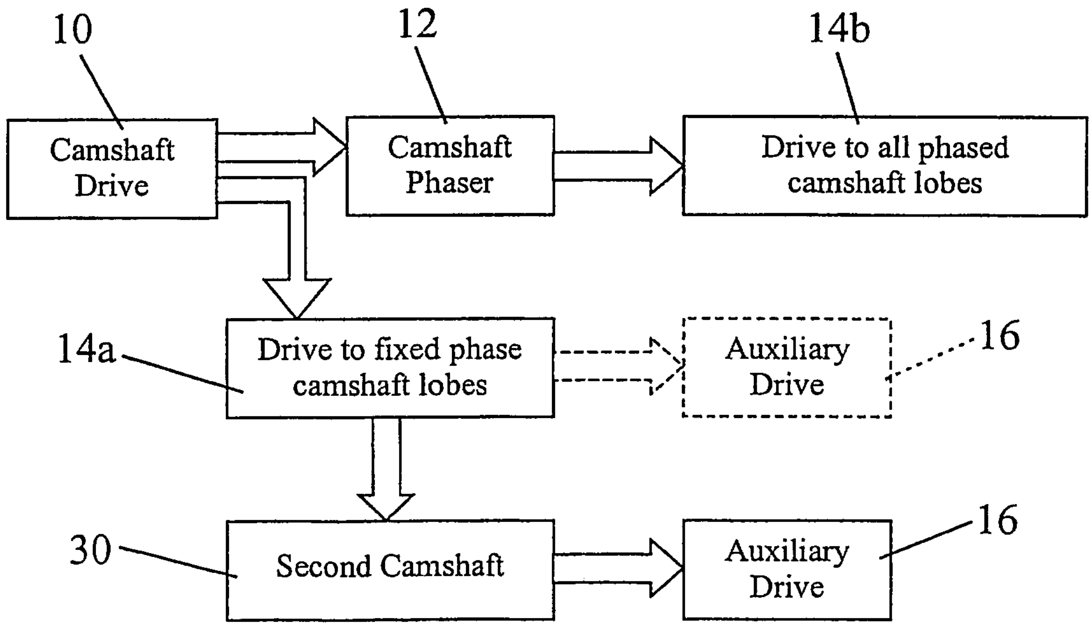

Fig. 5

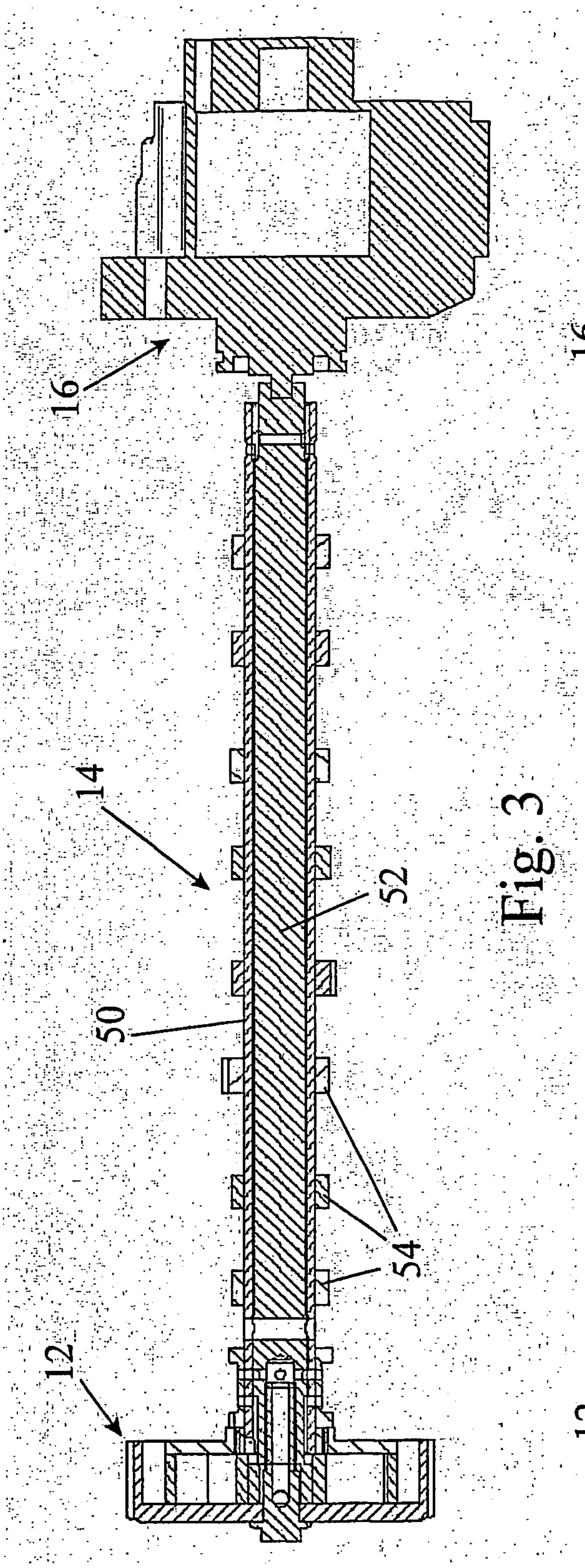

Fig. 3

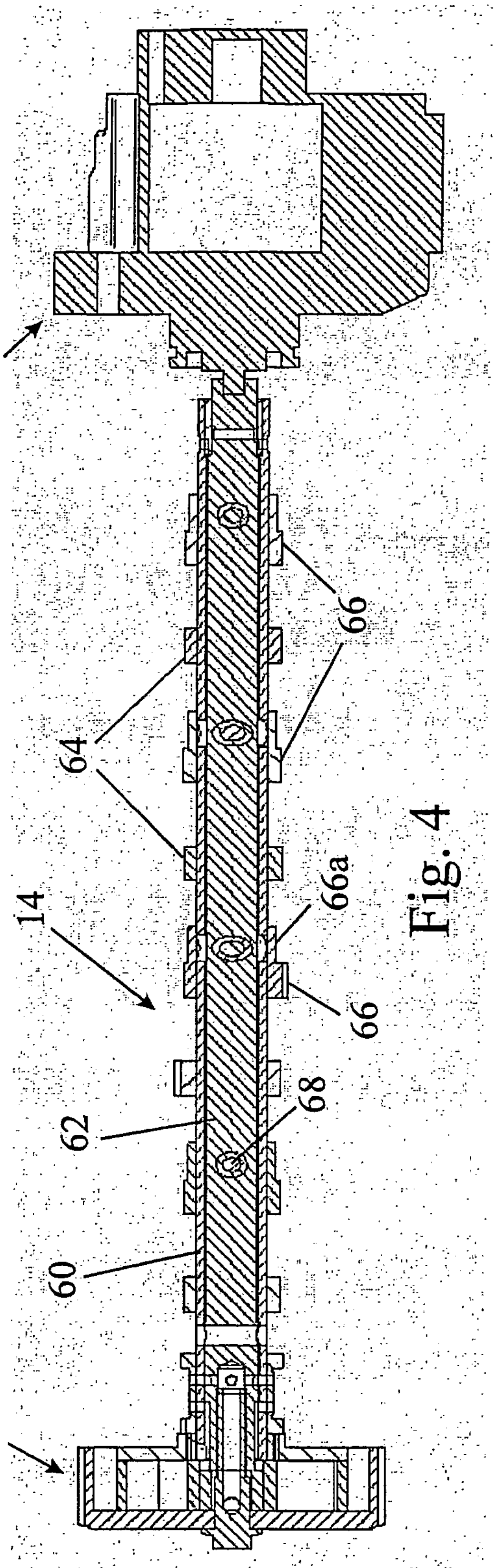

Fig. 4

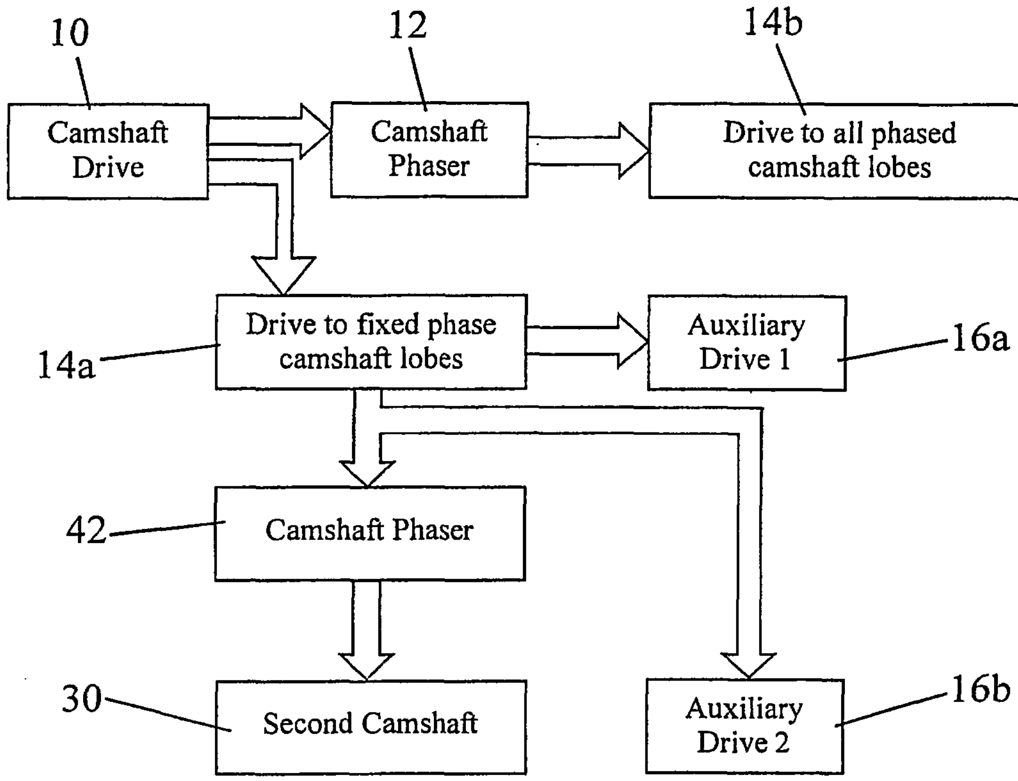
10
12
14b
Camshaft Drive
Camshaft Phaser
Drive to all phased camshaft lobes
Drive to fixed phase camshaft lobes
14a
Auxiliary Drive 1
16a
42
Camshaft Phaser
30
Second Camshaft
Auxiliary Drive 2
16b

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

- EP 1234954 A **[0007]**