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(54) CONCENTRIC CAMSHAFT WITH DUAL PHASER INTERFACE

(57) A method is disclosed for mounting a dual phaser on a concentric camshaft to enable torque to be applied from an engine crankshaft to the outer tube of a concentric camshaft. The method comprises securing a bearing ring to an end of the outer tube for rotation with the outer tube, rotatably supporting the concentric camshaft in an engine by retaining the bearing ring within a pillar block, and securing to the bearing ring a dual phaser that includes a hydraulic phaser having an input member driven in use by the engine crankshaft and an output member connected to the bearing ring. In the invention, flow passages are provided in the bearing ring to communicate with passages in the pillar block and to communicate through an axial end face of the bearing ring with passages leading to working chambers of the hydraulic phaser to enable the phase of the outer tube of the camshaft to be advanced and retarded relative to the phase of the engine crankshaft.

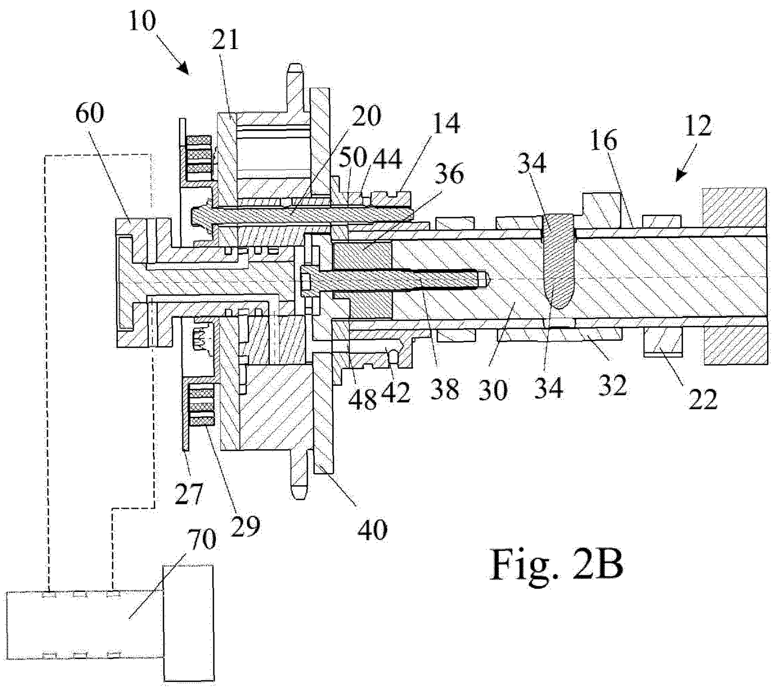

Fig. 2B

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Description

Field of the disclosure

[0001] The present invention relates to a phasing system for acting on two groups of cam lobes of a valve train of an internal combustion engine to change the phases of two groups of lobes independently of one another relative to the phase of the engine crankshaft. The two groups of cam lobes in the present invention are mounted to a concentric camshaft, which comprises an outer tube rotatable with a first group of cam lobes and an inner shaft connected to drive the second group of cam lobes by way of pins that pass through slots in the outer tube.

Background

[0002] The use of phasing systems, herein also termed phasers, is becoming increasingly widespread on both gasoline and diesel engines. Hydraulically operated phasers offer a compact and cost effective solution whilst electrically operated phasers (herein termed E-phasers), offer some functional advantages including:

- Faster response time,
- More consistent response times over all engine operating conditions, particularly low temperatures when oil viscosity reduces the performance of hydraulic phasers, and
- Reduced oil consumption and oil pump power consumption.

[0003] Concentric camshafts are well known that allow the relative timing of two sets of cam lobes to be adjusted, and in combination with a dual phaser they can provide independent control of the timing of the two sets of lobes relative to the engine crankshaft. In a single camshaft engine for example this could allow independent control of intake and exhaust valve timing.

[0004] A hydraulically operated dual phaser in most cases provides an effective solution for operating a concentric camshaft, but in applications with higher functional requirements it can be advantageous for one of the drive outputs of the dual phaser to use an E-phaser.

[0005] In many applications the engine assembly process requires the camshaft to be fitted to the engine and then the dual phaser to be fitted to the camshaft in a separate step. This particularly applies to camshafts designed to be fitted by sliding axially into journal bearings provided in the engine. This type of camshaft typically has bearing surfaces of a larger diameter than the cam lobes and is retained in the engine via an axial retaining plate.

[0006] It is important therefore to have a simple and robust method of connecting the two drive outputs of the dual phaser to the two groups of cam lobes on the concentric camshaft. However, as the construction of a fully hydraulic dual phaser and that of an electric/hydraulic (hybrid) dual phaser can be quite different, they conventionally require different connecting features on the concentric camshaft.

Object of the invention

[0007] The present invention aims to provide a versatile interface that can allow the same camshaft to be connected to either a dual hydraulic phaser or a hybrid phaser after the camshaft has been fitted to an engine.

Summary of the Invention

[0008] According to the present invention, there is provided a method of mounting a dual phaser on a concentric camshaft to enable torque to be applied from an engine crankshaft to the outer tube of a concentric camshaft, which method comprises securing a bearing ring to an end of the outer tube for rotation with the outer tube, rotatably supporting the concentric camshaft in an engine by retaining the bearing ring within a pillar block, and securing to the bearing ring a dual phaser that includes a hydraulic phaser having an input member driven in use by the engine crankshaft and an output member connected to the bearing ring, characterized by providing two groups of flow passages in the bearing ring to communicate with passages in the pillar block, both groups of flow passages communicating through an axial end face of the bearing ring with passages leading to working chambers of the hydraulic phaser to enable the phase of one group of lobes of the camshaft to be advanced and retarded relative to the phase of the engine crankshaft.

[0009] Embodiments of the invention adopt a drive connection interface for a concentric camshaft that is suitable for mounting either a fully hydraulic dual phaser or a hybrid dual phaser. The interface allows either type of dual phaser to be fitted to a camshaft after the camshaft has been mounted in the engine. This allows engine variants to be produced with different types of dual phaser and allows an engine specification to be upgraded without requiring changes to the design of the camshaft or the camshaft mounting in the engine.

Description of the Figures

[0010] The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is an exploded view of first embodiment of the invention showing the assembly a dual phaser to a camshaft,
Figure 1A is an exploded view of the hydraulic dual phaser of Figure 1,
Figure 2A is a view from one end of the dual phaser when assembled to the camshaft,
Figure 2B is a section along the section plane II-II in Figure 2A,

Figure 3 is a view, similar to that of Figure 1, of a second embodiment of the invention,

Figure 4 is a section view, similar to that of Figure 2B, of the second embodiment of the invention,

Figure 5 is a view, similar to that of Figure 1, of a third embodiment of the invention,

Figure 6 is a section view, similar to that of Figure 2B, of the third embodiment of the invention,

Figure 7 is a view, similar to that of Figure 1, of a fourth embodiment of the invention,

Figure 8 is a section view, similar to that of Figure 2B, of the fourth embodiment of the invention.

Detailed description of the drawings

[0011] The construction of a concentric camshaft 12 is already known (see for example GB 2,424,258) and can be understood most readily from the section of Figure 2B. The camshaft 12 has an outer tube 16 and a concentric inner shaft 30. A first set of cam lobes 22 is mounted for rotation with the outer tube 16 and each of the first cam lobes is secured to the outer tube 16, for example by heat shrinking. The cam lobes 32 of a second set are supported by the outer tube 16 but can rotate relative to it. These second cam lobes 32 are driven by the inner shaft 30 via pins 34 that pass through slots in the outer tube 16 that extend circumferentially.

Description of a first embodiment

[0012] Figures 1, 1A, 2A and 2B illustrate the assembly of a hydraulic dual phaser 10 to such a concentric camshaft 12 and the method of providing a drive connection to the two sets of cam lobes 22 and 32.

[0013] The dual hydraulic phaser is shown in the exploded view of Figure 1A. The input member to the dual phaser 10 is a sprocket 11 driven by the engine crankshaft and formed integrally with a stator 13 in the form of a ring with six arcuate cavities 15 that act as the working chamber of the phaser 10. A first output member 21 covering and sealing against one side of the stator 13 is connected to three vanes 23 received in three of the cavities 15. This output member 21 is connected as described below to drive the outer tube 16 of the camshaft. A second output member is formed by an end plate 40 that carries three further vanes 19 received in the remaining three cavities 15 of the stator 13. This output member 40 drives the inner shaft 30 of the camshaft 12. The phaser 10 further includes a timing ring 27 and a spring 29 that biases the phaser towards a predetermined starting position, to set the timing when the engine oil pressure is insufficient to operate the phaser 10.

[0014] The camshaft 12 has a first camshaft bearing ring 14 mounted on the outer tube 16 that is formed with a number of threaded holes 18 into which are received the fasteners 20 for the first drive connection, fixing the first output member 21 of the first phaser to the first set of cam lobes 22.

[0015] The second drive connection is between the second output member 40 of the phaser and the inner shaft 30 that in turn drives the second set of cam lobes 32. This second drive connection is achieved via a drive coupling 36 that can transmit drive torque without imposing any axial constraint between the phaser 10 and the inner shaft 30 of the camshaft 12, and a fastener 38 to secure the axial position of the inner shaft 30 relative to the output member 40 of the second hydraulic phaser.

[0016] The first camshaft bearing ring 14 is formed to receive two sets of fluid channels 42, 44 for controlling the first hydraulic phaser. The first channel 42 communicates with the dual phaser via ports in the front face of the bearing ring 14 and the second channel 44 communicates by annular ports 50 that surround the fasteners 20 of the first drive connection.

[0017] An oil distribution member 60 is received into a bore in the front end of the dual phaser 10 to control a second hydraulic phaser output of which the output drives the inner shaft 30 of the concentric camshaft 12. Figure 2 illustrates diagrammatically how this member 60 communicates with the outputs of an oil control valve 70 mounted separately on the engine.

[0018] The internal construction of a hydraulic dual phaser is known (see for example EP 2094948) and need not be described in detail in the present context. The present invention is not concerned with the inner workings of a dual phaser, be it a dual hydraulic or a dual hybrid phaser, but with the manner in which a dual phaser that includes a hydraulic phaser is mounted to a concentric camshaft.

Description of a second embodiment

[0019] A second embodiment of the invention is illustrated in Figures 3 and 4. The first drive connection, the first camshaft bearing ring and control of the first hydraulic phaser output are all as described with reference to the first embodiment. To avoid repetition, the components of the camshaft have been allocated the same reference numerals throughout this description and equivalent components of the interface in all the embodiments have been allocated reference numerals with the same two least significant digits.

[0020] In the second embodiment, the output member of the second phaser is connected to the second set of lobes via a high-friction washer 146 clamped between the inner shaft 30 of the camshaft 12 and the output member 140 of the second hydraulic phaser by a fastener 138 to secure their axial position. As an alternative to a separate washer 146, a high friction surface could be provided on the end of the inner shaft 30 or on the output member 140 of the second hydraulic phaser.

[0021] A second bearing ring 180 of the concentric camshaft is formed in this second embodiment with a passage 182 to receive pressurised hydraulic fluid which is communicated to the dual phaser 110 via an annular space 184 between the inner shaft 30 and outer tube 16 of the concentric camshaft 12. This hydraulic fluid is then received by ports in the oil distribution member 160 which does not rotate with the camshaft.

[0022] Figure 4 also shows a section through the oil distribution member 160 illustrating that it is in communication with both the inputs and outputs of an oil control valve 170 mounted separately on the engine. The input of the oil control valve receives pressurised fluid originating from the second camshaft bearing ring 180, which fluid is carried through the dual phaser 110 into the fluid distribution member 160. The oil distribution member 160 then receives the outputs of the oil control valve 170 to control the second hydraulic phaser output.

Description of a third embodiment

[0023] A third embodiment of the invention is illustrated in Figures 5 and 6. In this embodiment, the drive connections to the outer tube 16 and the inner shaft 30, the design of the first camshaft bearing ring 14 and the control of the first hydraulic phaser output are all the same as described by reference to the first embodiment.

[0024] As with the second embodiment, the second camshaft bearing ring 280 is formed with a passage to receive pressurised hydraulic fluid which is communicated to the dual phaser 210 via an annular space between the inner shaft 30 and outer tube 16 of the camshaft. In the third embodiment this pressurized fluid is received by an integral oil control valve 270 mounted in a bore of the dual phaser 210. The oil control valve 270 may advantageously include a one-way valve and/or a filter.

[0025] Figure 6 shows that the integral oil control valve 270 receives its input from second camshaft bearing ring 280 to control the second hydraulic phaser output. A solenoid 284 mounted on a stationary part of the engine, coaxially with the dual phaser 210, actuates the integral oil control valve 270 by axial displacement of the valve spool.

[0026] It is also well known from the prior art (Example US 6,971,353) that a control valve can be integrated with the central fixing bolt for a camshaft phaser. It would therefore be possible to combine the functions of the oil control valve 270 and the fastener 238.

Description of a fourth embodiment

[0027] Figures 7 and 8 show the assembly of a hybrid dual phaser 310 to a concentric camshaft 12 and the method of providing a drive connection to the two sets of cam lobes.

The camshaft has a mounting plate 315 fitted to its front bearing 314 via a number of fasteners 317, and this mounting plate provides a number of studs 320 for mounting the dual phaser assembly 310, which can be secured by an equal number of nuts 321, this forming the first drive connection to the outer tube 16 of the camshaft 12.

[0028] The second drive connection between the electric phaser output and the inner driveshaft 30 of the camshaft is achieved via a drive coupling 336 that can transmit drive torque without imposing any axial constraint between the phaser and the inner shaft of the camshaft, and a fixing bolt 338 to secure the axial position of the inner shaft to the electric phaser output.

[0029] The first camshaft bearing ring 314 is formed to receive two fluid channels for controlling the hydraulic phaser output, with both channels communicating with the dual phaser via two sets of ports in the front face of the bearing ring.

[0030] The second camshaft bearing ring 380 is formed to receive lubricating oil, which fills an annular space between the inner shaft 30 and the outer tube 16 of the camshaft and is thereby communicated to the dual phaser 310 to lubricate a gearset 313 of the E-phaser.

[0031] In this embodiment the camshaft outer tube 16 extends through the first camshaft bearing ring 314 in order to provide concentric location of the hybrid dual phaser 310 and accept radial forces of the drive gear/sprocket 311.

[0032] Figure 8 illustrates how an electric motor 375 is mounted to the engine coaxially with the hybrid dual phaser 310 to control the electric phaser.

Claims

1. A method of mounting a dual phaser on a concentric camshaft to enable torque to be applied from an engine crankshaft to the outer tube of a concentric camshaft, which method comprises securing a bearing ring to an end of the outer tube for rotation with the outer tube, rotatably supporting the concentric camshaft in an engine by retaining the bearing ring within a pillar block, and securing to the bearing ring a dual phaser that includes a hydraulic phaser having an input member driven in use by the engine crankshaft and an output member connected to the bearing ring, **characterized by** providing two groups of flow passages in the bearing ring to communicate with passages in the pillar block, both groups of flow passages communicating through an axial end face of the bearing ring with passages leading to working chambers of the hydraulic phaser to enable the phase of one group of lobes of the camshaft to be advanced and retarded relative to the phase of the engine crankshaft.

2. An assembly comprising a concentric camshaft and a dual phaser for mounting to an engine, the camshaft having an outer tube carrying a first set of cam lobes rotatable with the outer tube and a second set of cam lobes that are rotatable relative to the outer tube and are connected for rotation with an inner shaft of the camshaft by pins passing slots in the outer tube and the dual phaser comprising a first, hydraulic, phaser for varying the phase of the first set of cam lobes and having an input member to be

driven in synchronism with a crankshaft of the engine and output member connected to the outer tube of the camshaft and a second phaser having an input member to be driven in synchronism with a crankshaft of the engine and output member connected to the inner shaft of the camshaft so as to enable the phases of both sets of cam lobes to be varied, independently of one another, relative to the engine crankshaft, wherein in order to connect the output member of the first phaser to the outer tube of the camshaft a first bearing ring is secured to an end of the outer tube for rotation therewith, and fixings are provided to secure the dual phaser to the first bearing ring, **characterized in that** two groups of flow passages are provided in the first bearing ring , both groups of flow passages communicating through an axial end face of the bearing ring with passages leading to working chambers of the hydraulic phaser, thereby enabling the phase of one set of cam lobes to be advanced and retarded relative to the phase of the engine crankshaft by hydraulic fluid supplied to the first phaser via the first bearing ring of the camshaft.

3. An assembly as claimed in claim 2, 1 wherein an additional oil supply is provided to the phaser via a second bearing ring of the camshaft, and an annular passage defined between the inner shaft and the outer tube of the camshaft.

4. An assembly as claimed in claim 3, wherein the dual phaser is fitted with an oil control valve that is in communication with the additional oil supply in order to advance/retard the second set of cam lobes depending upon the axial position of the control valve.

5. An assembly as claimed in claim 4, wherein a solenoid is mounted to a stationary part of the engine adjacent to the dual phaser in order to control the axial position of the control valve within the dual phaser.

6. An assembly as claimed in claim 3, wherein the additional oil supply is transmitted through the dual phaser to a control valve mounted on a stationary part of the engine, the control valve serving to advance and retard the second set of cam lobes.

7. An assembly as claimed in claim 6, wherein the dual phaser is a dual hydraulic phaser and wherein the timing of one group of cam lobes is controlled by oil supplied via the first bearing ring and the phase of the other group of cam lobes is controlled by oil supplied into the end of the dual phaser opposite to its camshaft connection from a stationary part of the engine.

8. An assembly as claimed in any of claims 2 to 7, wherein the threaded fastener serves to clamp the output member of the second phaser to the inner shaft of the camshaft.

9. An assembly as claimed in any of claims 2 to 8, wherein a drive coupling is provided to ensure angular alignment between the inner shaft of the camshaft and the output member of the second phaser, the coupling being operative to compensate for any axial misalignment between the inner shaft and the output member of the second phaser.

10. An assembly as claimed in claim 9, wherein a threaded fastener passing through the drive coupling serves to secure the axial position of the inner shaft relative to the output member of the second phaser.

11. An assembly as claimed in claim 10, wherein a high friction surface is provided between the output member of the second phaser and the inner shaft of the camshaft to increase the drive torque capacity.

12. An assembly as claimed in claim 11, wherein the high friction surface is provided by a separate component that is clamped between the output member of the second phaser and the inner shaft of the camshaft to increase the drive torque capacity.

13. An assembly as claimed in any preceding claim, wherein the outer tube of the concentric camshaft extends through the first bearing ring in order to provide a concentric location of the dual phaser.

14. An assembly as claimed in claim 13, wherein radial forces from a drive sprocket / gear serving an as input member to the dual phaser are transferred into the camshaft via the outer tube.

15. An assembly as claimed in any preceding claim, wherein a mounting plate is secured to the front bearing ring of the camshaft via a plurality of threaded fasteners, the dual phaser being secured to this mounting plate.

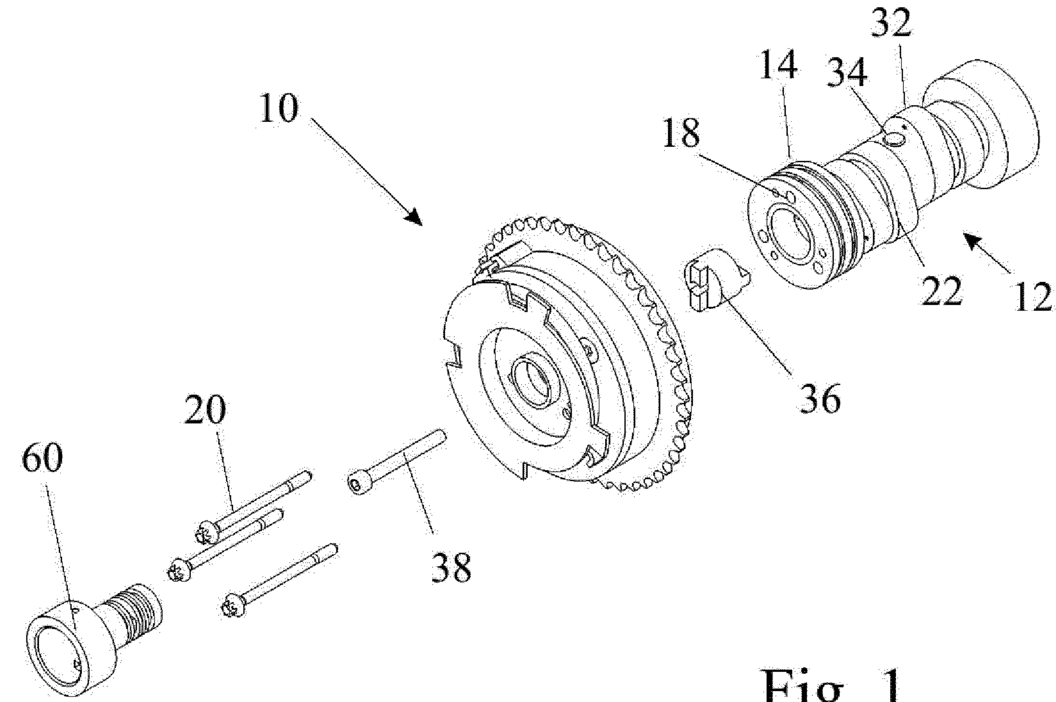

Fig. 1

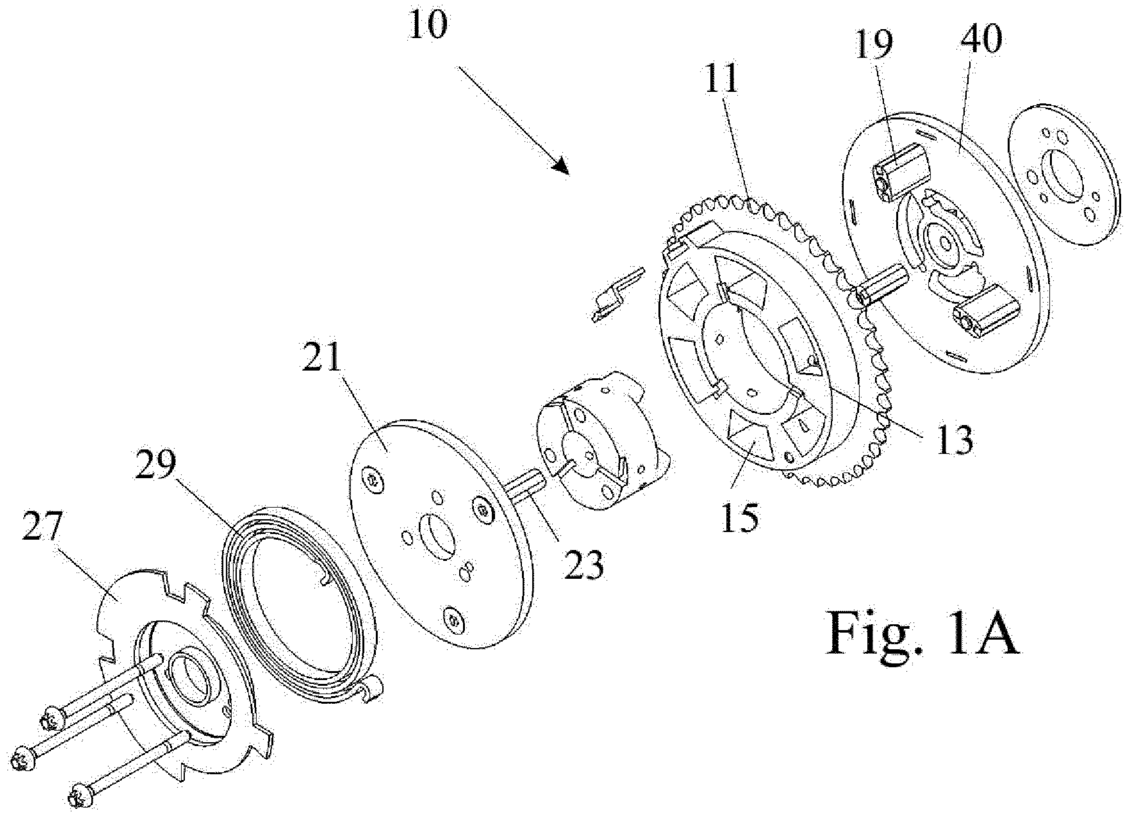

Fig. 1A

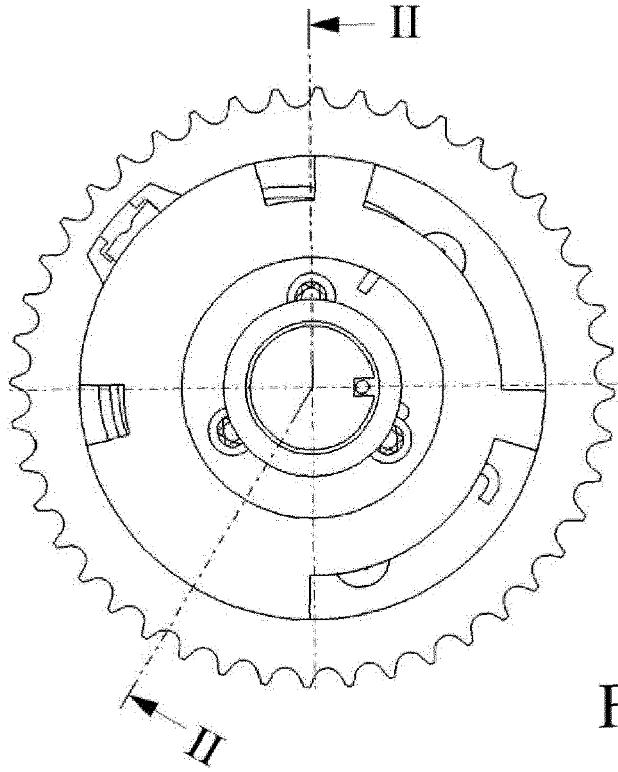

Fig. 2A

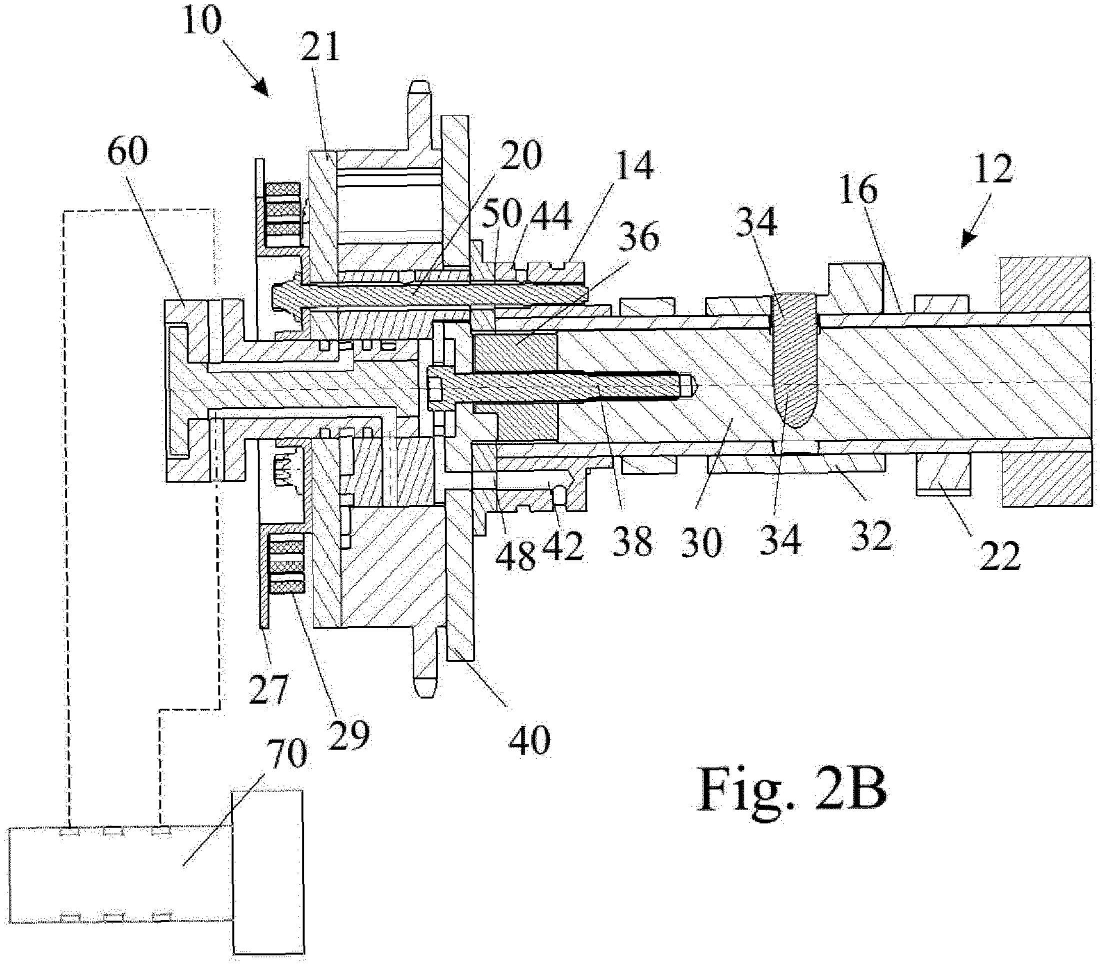

Fig. 2B

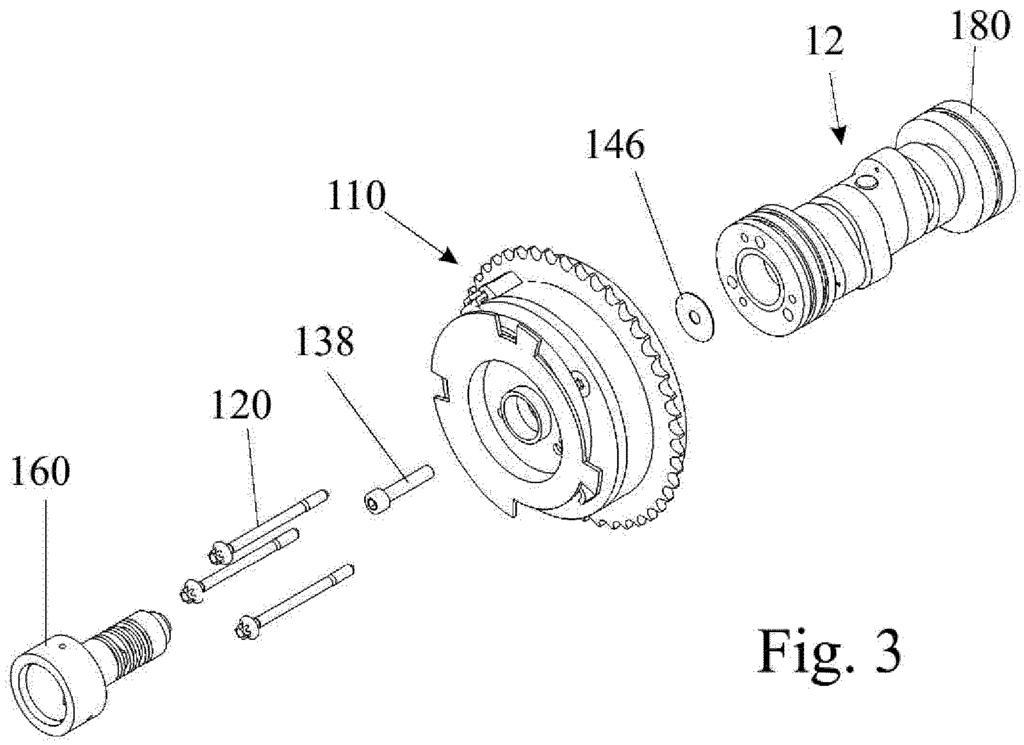
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Fig. 3

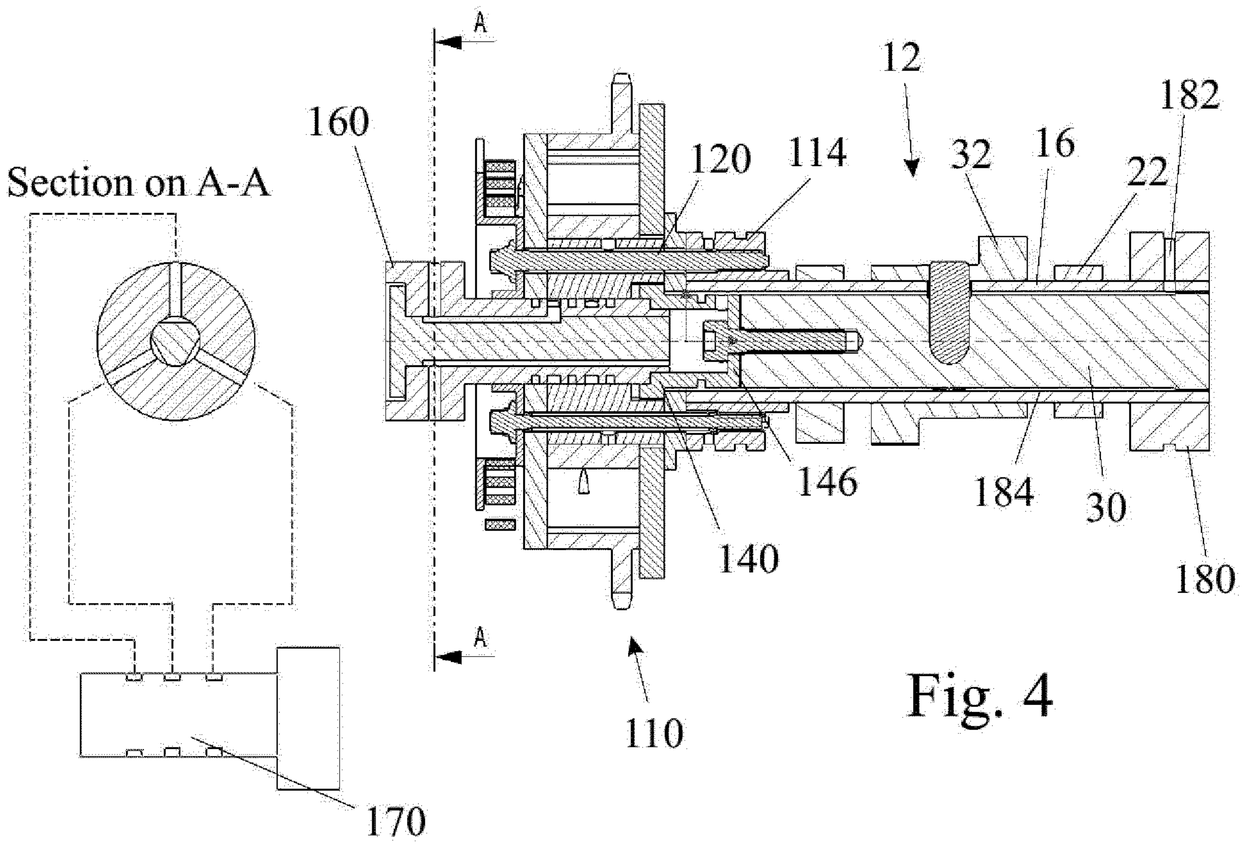
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Fig. 4

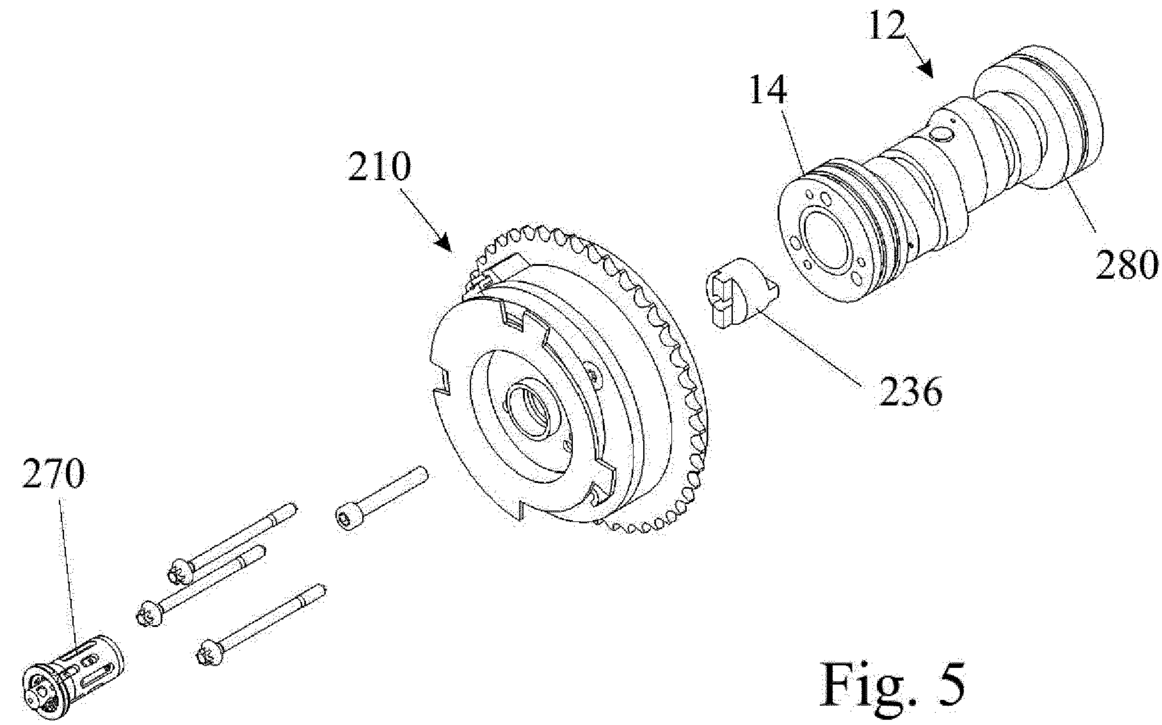

Fig. 5

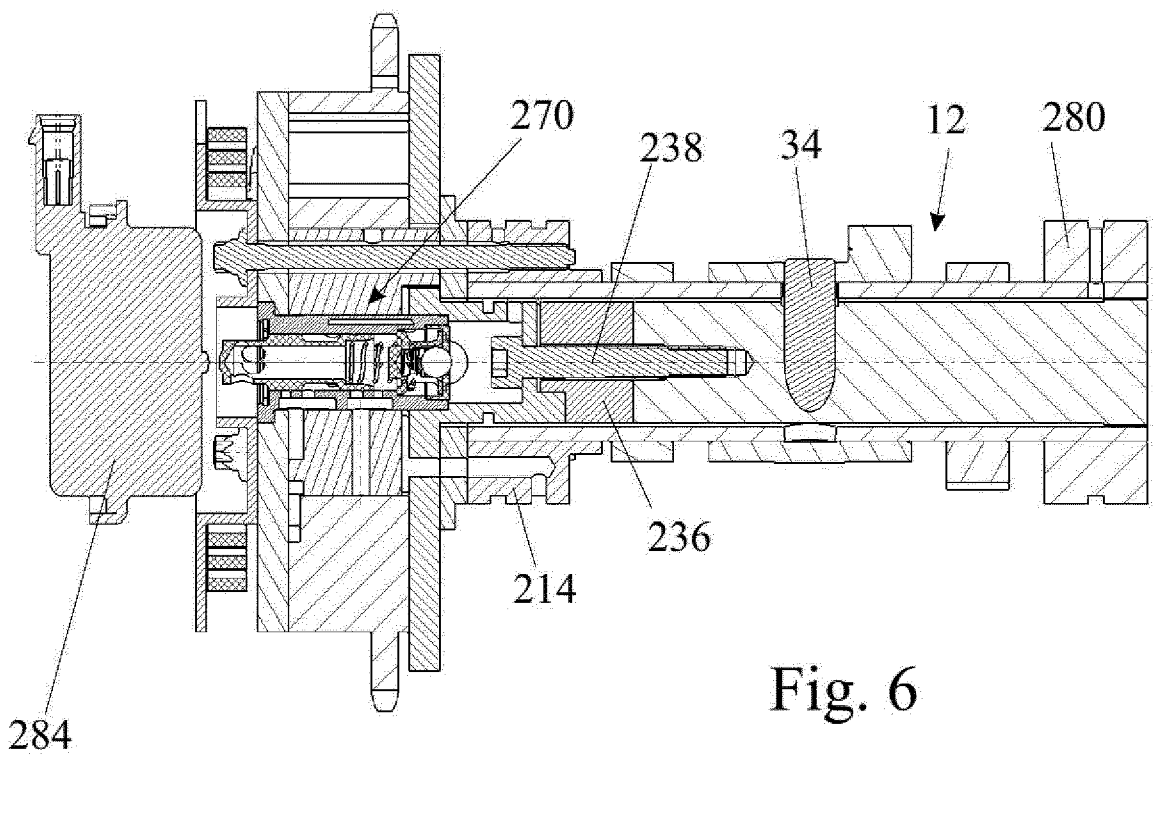

Fig. 6

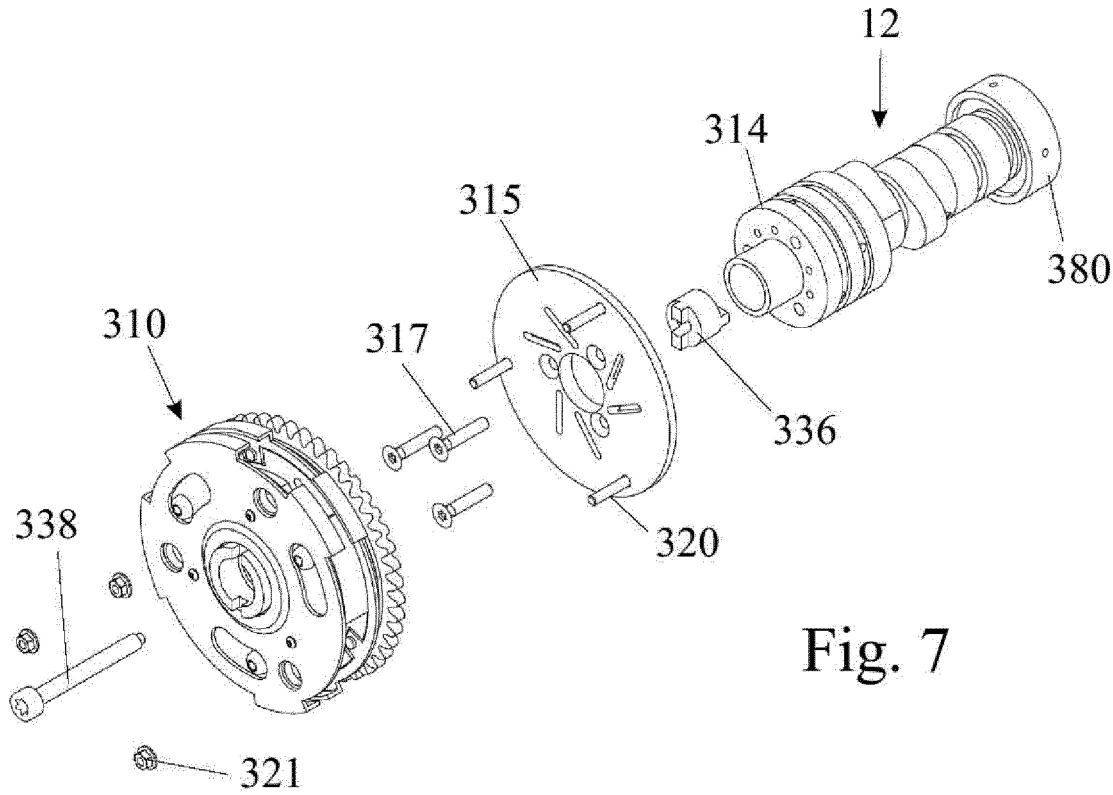
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Fig. 7

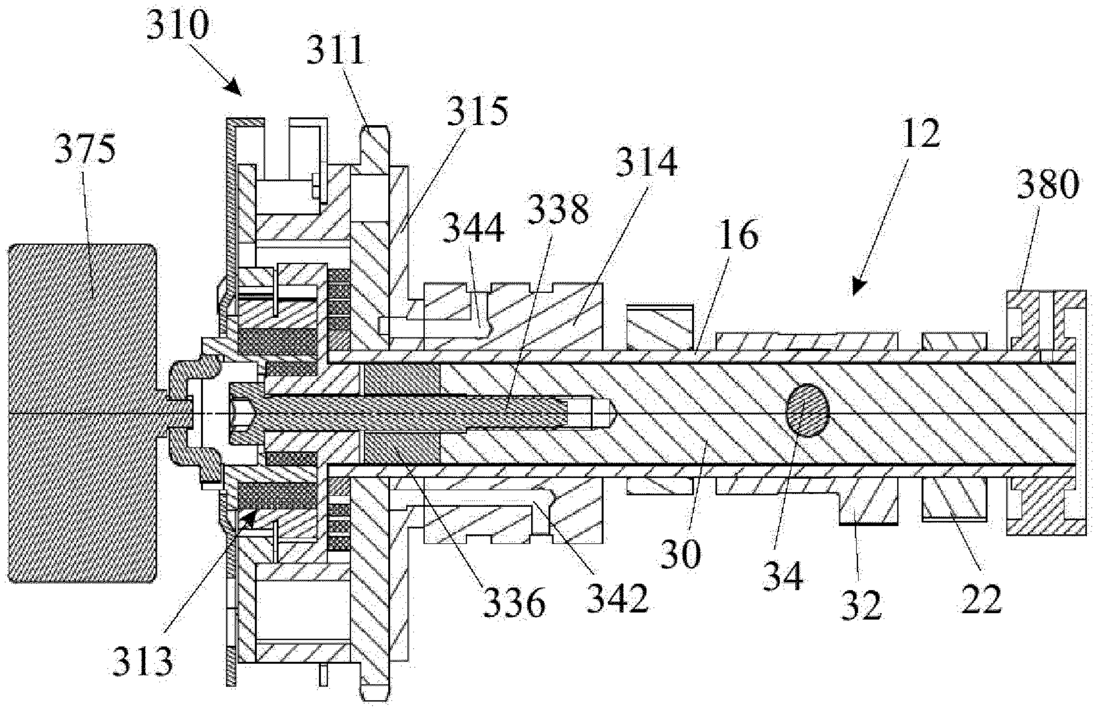
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Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 18 17 0689

DOCUMENTS CONSIDERED TO BE RELEVANT

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Y A	GB 2 432 645 A (MECHADYNE PLC [GB]) 30 May 2007 (2007-05-30) * figures 3,4 *	4-7,15 1,2	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01L

1

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 August 2018	Aubry, Yann

CATEGORY OF CITED DOCUMENTS

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24-08-2018

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

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