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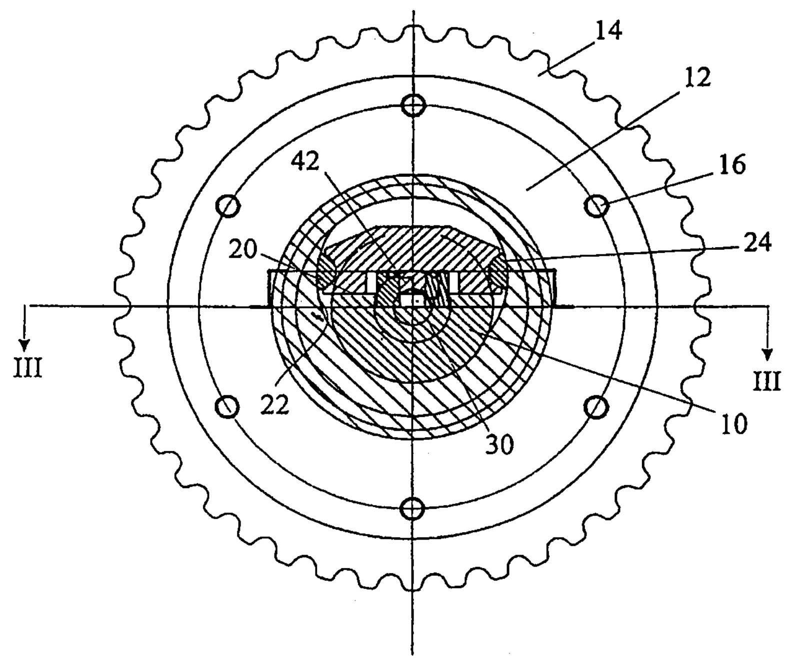

(57) Abstract

A phase change mechanism is disclosed for varying the phase of a drive member (12) relative to a driven member (10), the two members being rotatable about a common rotational axis. The mechanism comprising a yoke (22) fast in rotation with one member (10) and having a contoured inner surface, a transverse pin (18) rotatable with the other member (10) and having opposite ends (24) engaging the inner surface of the yoke in a plane offset from the rotational axis, an axially displaceable actuating rod (30) and means (36, 38) coupling the transverse pin (18) to the actuating rod (30) to cause the transverse pin to move from side to side and rotate the members (10, 12) relative to one another in response to axial displacement of the actuating rod (30).

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PHASE CHANGE MECHANISM

Field of the invention

The present invention relates to a phase change mechanism for an engine camshaft to enable the valve timing of the engine to be varied to suit different operating conditions.

Background of the invention

As is well known, valve timing has a significant effect on engine performance and the optimum setting varies with engine operating conditions. To optimise performance under different operating conditions, it is necessary to be able to vary the valve timing. Complex systems have been proposed that vary the duration of valve events, this being equivalent to using a cam with a different profile, while other systems only vary the phase of a camshaft acting on one set of valves relative to the engine crankshaft and/or relative to a second camshaft acting on the remaining valves.

Various phase change mechanisms have been proposed in the past but they have suffered from various problems. Some, though feasible, have been costly to implement while other have developed excessive friction or not proved to be reliable. Furthermore, many could not be fitted as a modification to existing engines as they required much of the valve train and cylinder head to be redesigned.

The Applicants' earlier EP-A-0 733 154 discloses a valve operating mechanism comprising a hollow shaft, a sleeve journalled on the hollow shaft and fast in rotation with a cam, a coupling yoke connected by a first pivot pin to the hollow shaft and by a second pivot pin to the sleeve and means for moving the yoke radially to effect a phase change between the hollow shaft and the sleeve. The means for moving the yoke radially comprise an actuating rod slidably received in the hollow shaft, a cam surface on the actuating rod and a plunger passing through a generally radial bore in the hollow sleeve to cause the yoke to move radially in response to axial movement of the actuating rod.

Object of the invention

The present invention seeks to provide a variant of this phase change mechanism that retains the advantage of an axially slidable actuating rod to effect a phase change but that has a more simple construction.

Summary of the invention

According to the present invention, in its broadest aspect there is provided a phase change mechanism for varying the phase of a drive member relative to a driven member, the two members being rotatable about a common rotational axis, the mechanism comprising a yoke fast in rotation with one member and having a contoured inner surface, a transverse pin rotatable with the other member and having opposite ends engaging the inner surface of the yoke in a plane offset from the rotational axis, an axially displaceable actuating rod and coupling means connecting the transverse pin to the actuating rod to cause the transverse pin to move from side to side and rotate the members relative to one another in response to axial displacement of the actuating rod.

The drive member may for example be a drive pulley or sprocket and the driven member may be a camshaft. However, the roles of the drive and driven members may be reversed and it is possible for the camshaft to act as the drive member and the sprocket as the driven member.

In the ensuing description, the invention will be described with reference to embodiments in which the yoke is fast in rotation, or formed integrally with, the drive pulley. It should however be noted that the yoke may instead be fast in rotation with the camshaft, this being practical when a camshaft journal bearing of large diameter is used.

The present invention differs from EP-A-0 733 154 in that instead of a plunger engaging the yoke in an axial plane and causing the yoke to pivot about an axis offset from the rotational axis, the yoke rotates concentrically and the transverse pin is offset from the axis of rotation.

It is preferred that the transverse pin should be located in a flat formed in the surface of the camshaft such that torque is transmitted directly from the pin to the camshaft.

The coupling means connecting the transverse pin to the actuating rod may conveniently comprise a pair of spaced opposed wedges located in a flat in the surface of the actuating rod and a tooth projecting radially inwards from the pin into the gap between the two wedges.

Conveniently, the tooth of the transverse pin may be of parallelogram cross section to make surface contact with the surfaces of the two wedges.

In order to reduce backlash in the mechanism, it is advantageous to provide a spring to bias one of the wedges in an axial direction and in a sense to reduce the width of the gap between the two edges.

In the preferred embodiment of the invention, the actuating rod is a cylindrical rod located in a blind bore in the end of the camshaft and is connected at its end to the piston of a hydraulic jack.

Brief description of the drawings

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

Figure 1 is a section through a camshaft fitted with a phase change mechanism, taken through a plane passing through the rotational axis,

Figure 2 is section along the line II-II in Figure 1,

Figure 3 is section along the line III-III in Figure 2,

Figure 4 is a section along the line IV-IV in Figure 3, and

Figure 5 is schematic less detailed section similar to that of Figure 1 but showing an alternative embodiment.

Detailed description of the drawings

In Figures 1 to 4, a camshaft 10 is driven by a drive pulley 12 to which a toothed ring 14 is attached by means of bolts 16 to allow the camshaft 10 to be driven from the engine crankshaft by means of a toothed belt. The drive pulley 12 is journalled on the camshaft 10 and is retained axially on the camshaft 10 by being captive between a collar 11 projecting from the camshaft 10 and a washer 13 that is held in place on the camshaft 10 by a circlip 15.

Torque is transmitted from the pulley 12 to the camshaft 10 by means of a phase change mechanism that comprises a transverse pin 18 located in a flat 20 in the camshaft and a yoke 22 fast in rotation with the drive pulley 12. As seen in Figure 2, the pin 18 has at its opposite ends two shoes 24 that engage a contoured inner surface of the yoke 22. The shoes 24 are spring-biased so that the pin 18 simultaneously contacts the yoke 22 and the shoulder of the flat 20 of the camshaft 10 to transmit torque from the yoke 22 to the camshaft 10.

It will be clear also from Figure 2 that the phase of the camshaft 10 relative to the drive pulley 12 depends on the position of the pin 18 and that by moving the pin 18 from side to side in Figure 2 the phase of the camshaft 10 relative to the drive pulley 12 may be changed.

To vary the phase between the camshaft 10 and the drive pulley 12, an axially displaceable actuating rod 30 is located in a blind bore 32 in the end of the camshaft 10. The actuating rod 30 is formed with a flat on which there are located two wedges 36, 38 that are best shown in the sectional plane of Figure 3. The wedges 36 and 38 taper in opposite directions and thus define between them a gap 40 that is inclined relative to the rotational axis. A tooth 42 of the transverse pin 18 is located in the gap 40 such that when the actuating rod 30 is moved axially the pin 18 is moved from side to side. In order to avoid backlash a spring 44, also shown in the section of Figure 4, urges the wedge 38 in an axial direction in a sense to reduce the width of the gap 40 and ensure that the tooth 42 makes surface contact with both wedges 36 and 38 simultaneously.

To bring about axial movement of the actuating rod 30 the end of the latter projecting beyond the front end of the drive pulley 12 is connected to a piston 50 reciprocable within a cylinder 52. The wall of the cylinder 52 is double skinned, there being an annular gap 54 between the inner and outer skins of the cylinder. The double skinned cylinder 52 is formed by inserting one cup of pressed steel into another and a gap 54 remains around the periphery of the inner cup to act as an oil passage, to permit oil to flow to the working chamber lying to the right of the piston 50 as viewed in Figures 1 and 3. The cylinder 52 is mounted in a recess in the front of the drive pulley 12 with its outer skin sealed by an O-ring 70 relative to the recess and is retained within the recess by a circlip 72. The inner skin of the cylinder only contacts the recess at a few points about its periphery, leaving a gap of large through flow cross section through which oil may flow into the working chamber lying to the right of the piston 50, as viewed.

The engine is fitted with a stationary front cover 60 or a spider having supply and return oil passages 62 and 64 leading to a connection socket that fits over the end of the double skinned cylinder 52. Rotary seals 66 and 68 in the cover 60 seal against the inner and outer surfaces of the cylinder 52. In this way, oil is supplied directly from the oil passage 62 to the working chamber shown to the left of the piston 50, while oil passes from the passage 64 through the gap 54 to the working chamber lying the right of the piston 50 as viewed. This configuration allows oil passage of large through flow cross section to be used thereby enabling rapid adjustment of the axial position of the actuating rod 30 and the application of a sufficient force to overcome any frictional force on the actuating rod.

The camshaft of Figure 5 differs from that of Figures 1 to 4 in that a single phase change mechanism is used to alter the phase of two different camshafts relative to the engine crankshaft. The essential difference resides in that the camshaft 10' has two sprockets 12a' and 12b' journalled on it instead of only one. The sprocket 12a' is equivalent to the drive pulley 12 in Figures 1 to 4 and the transmission of torque from the crankshaft through the sprocket 12a' to the camshaft 10' is exactly the same as previously described. The second sprocket 12b' is used to transmit torque from the camshaft 10' to a second camshaft (not shown) by way of a chain or toothed belt. The second sprocket 12b' is coupled to the camshaft 10' by means of a second yoke, transverse pin and wedges on the opposite side of the actuating rod 30' that are essentially those previously described. In this manner, when the actuating rod is displaced axially the sprocket 12a' is phase shifted in one direction while the sprocket 12b' is phase shifted in the opposite direction. This arrangement therefore allows a single hydraulic jack acting on only one actuating rod to bring about a change of phase of one camshaft in one direction relative to the engine crankshaft and a phase change of a second camshaft in the opposite sense.

The two phase changes need not necessarily be equal as the extent of the phase change for a given axial displacement of the actuating rod will depend on the tapering angle of the wedges and it is possible for the two sets of wedges to have different angles of taper.

While the invention has been described only by reference to embodiments in which the phase of an entire camshaft is adjusted in relation to the engine crankshaft, it will be clear that it may alternatively be used to vary the phase of only sections of a camshaft or individual cams, in a manner analogous to that described in EP-A-0 733 154.

CLAIMS

1. A phase change mechanism for varying the phase of a drive member (12) relative to a driven member (10), the two members (10,12) being rotatable about a common rotational axis, the mechanism comprising a yoke (22) fast in rotation with one member (and having a contoured inner surface, a transverse pin (18) rotatable with the other member and having opposite ends (24) engaging the inner surface of the yoke (22) in a plane offset from the rotational axis, an axially displaceable actuating rod (30) and coupling means (36,38) connecting the transverse pin to the actuating rod (30) to cause the transverse pin (18) to move from side to side and rotate the members relative to one another in response to axial displacement of the actuating rod (30).

2. A phase change mechanism as claimed in claim 1, wherein the drive member is a drive pulley or sprocket (12) and the driven member is at least one section of an engine camshaft (10).

3. A phase change mechanism as claimed in claim 2, wherein the yoke (22) is fast in rotation with the drive pulley (12).

4. A phase change mechanism as claimed in claim 1, wherein the drive member is an engine camshaft and the driven member is a drive pulley or sprocket.

5. A phase change mechanism as claimed in claim 4, wherein the yoke is fast in rotation with the camshaft.

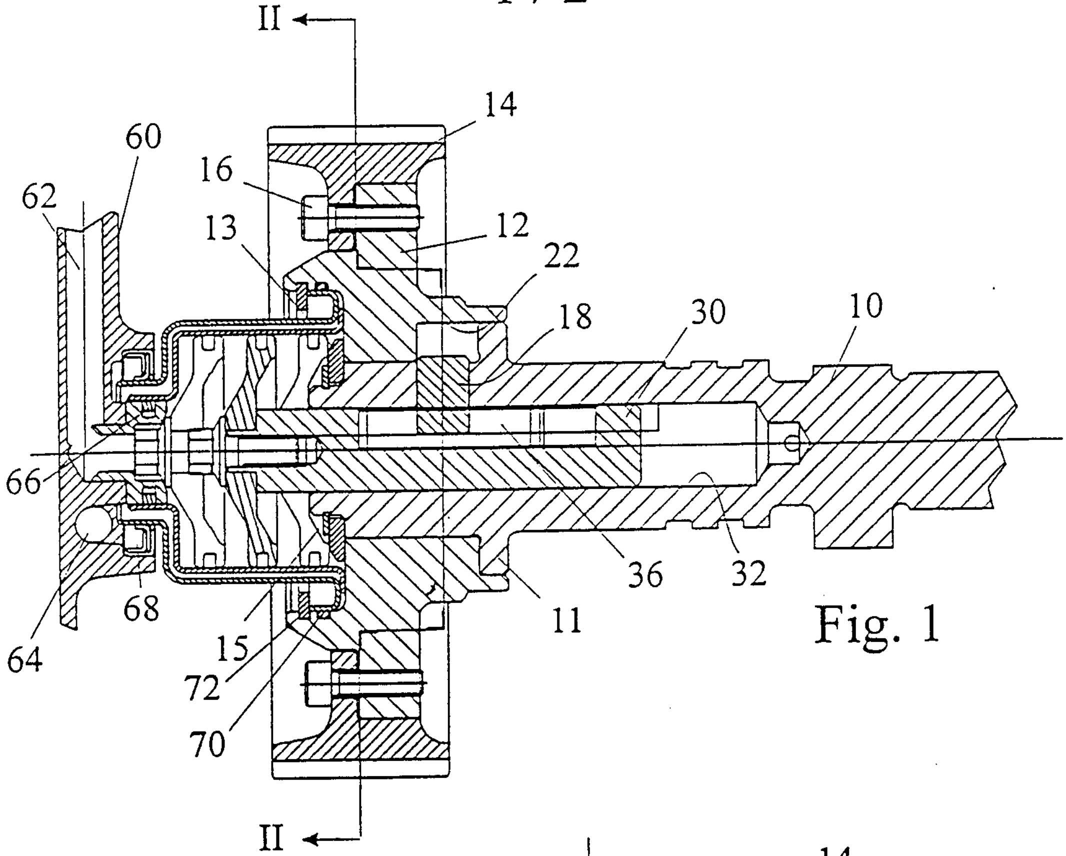
6. A phase change mechanism as claimed in any preceding claim, wherein the transverse pin (18) is located in a flat formed in said one member to enable torque to be transmitted directly from the pin to the said one member.

7. A phase change mechanism as claimed in any preceding claim, wherein the coupling means connecting the transverse pin to the actuating rod comprise a pair of spaced opposed wedges (36,38) located in a flat in the surface of the actuating rod and a tooth (42) projecting radially inwards from the pin into the gap between the two wedges (36,38).

8. A phase change mechanism as claimed in claim 7, wherein the tooth (42) of the transverse pin is of parallelogram cross section in order that it may make surface contact with the surfaces of the two wedges.

9. A phase change mechanism as claimed in claim 7 or 8, wherein a spring (44) is provided to bias one of the wedges (38) in an axial direction and in a sense to reduce the width of the gap between the two edges.

10. A phase change mechanism as claimed in any preceding claim, wherein the actuating rod (30) is a cylindrical rod located in a blind bore in the end of the camshaft and is connected at its end to the piston of a hydraulic jack.


II
14
60
16
62
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36
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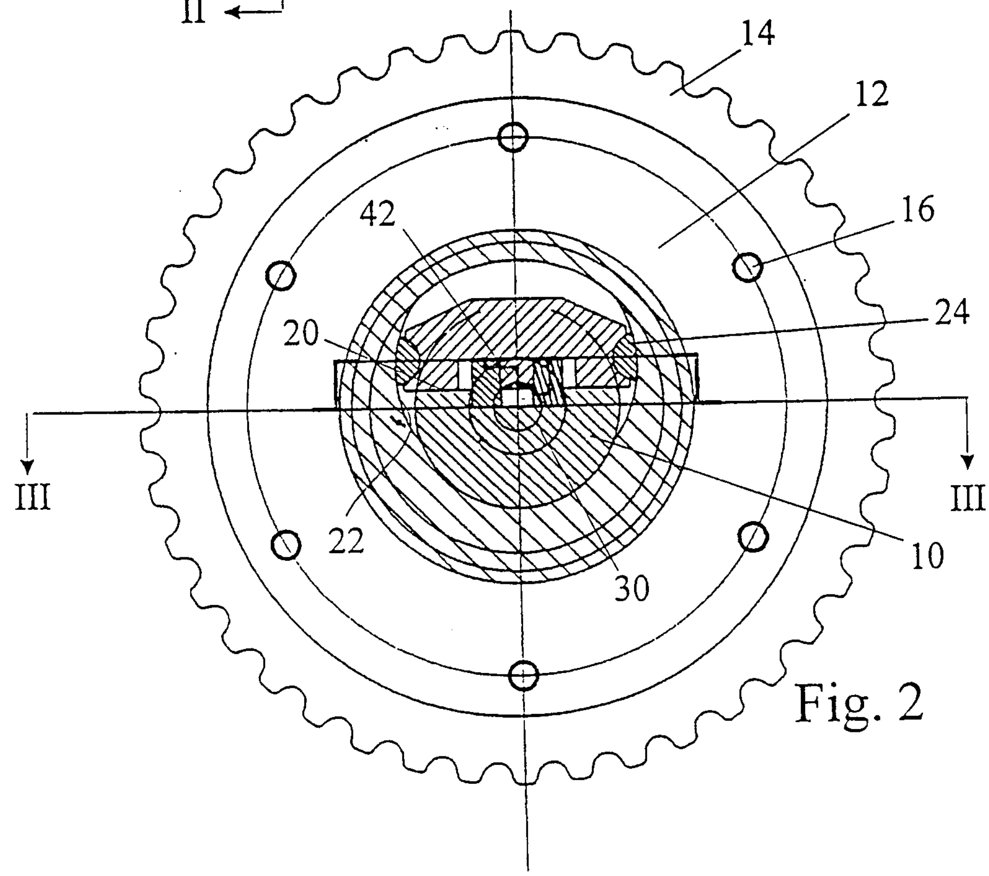
II

Fig. 1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III
III
22
10
30

Fig. 2

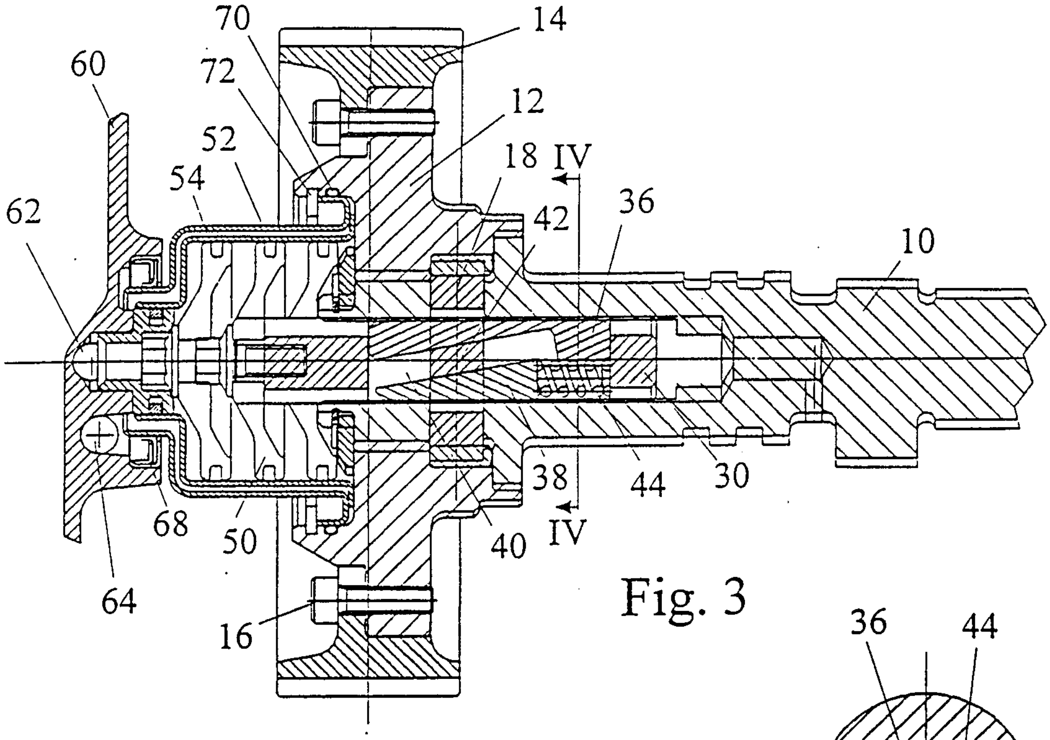
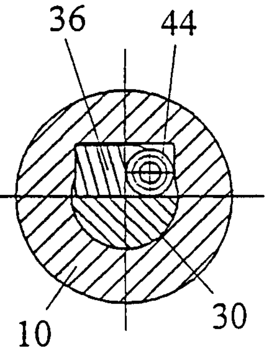


Fig. 3

Fig. 4



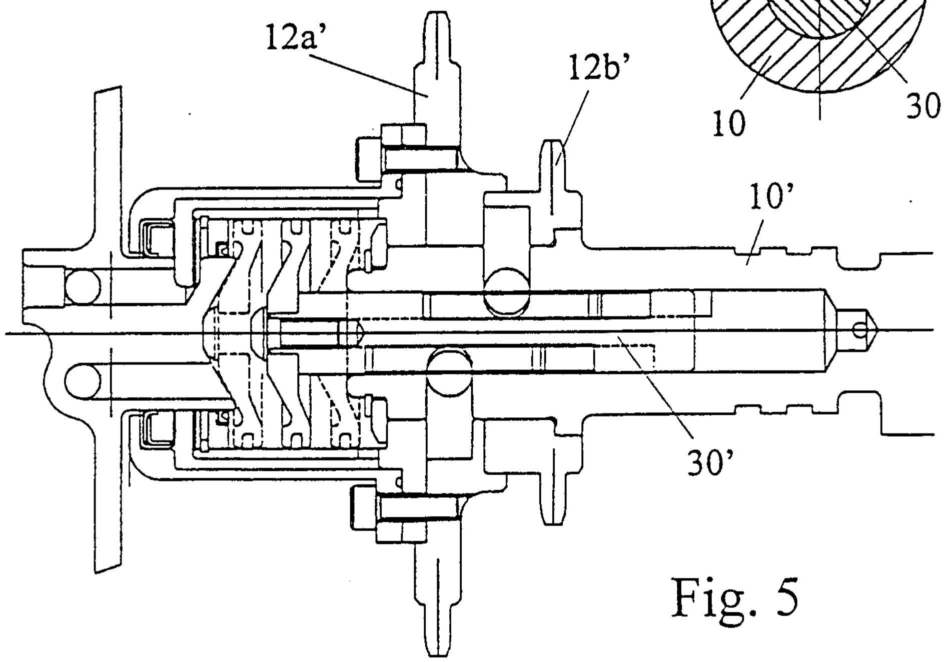


Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/03188

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F01L1/344

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	"MECHADYNE UNVEILS LATEST CAM PHASER RANGE" AUTOMOTIVE ENGINEER, vol. 23, no. 1, January 1998, page 10 XP000730589 see the whole document	1-10
A	EP 0 594 104 A (RANZONI ALDO) 27 April 1994 see the whole document	1
A	EP 0 733 154 A (MECHADYNE LIMITED) 25 September 1996 cited in the application & WO 95 16108 A (MECHADYNE LIMITED) 15 June 1995 see the whole document	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 98/03188

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0594104 A	27-04-1994	NONE	
EP 733154 A	25-09-1996	BR 9408192 A	26-08-1997
		DE 69405250 D	02-10-1997
		DE 69405250 T	19-03-1998
		JP 9506404 T	24-06-1997
		US 5671706 A	30-09-1997
		AT 157427 T	15-09-1997
		ES 2109803 T	16-01-1998
		WO 9516108 A	15-06-1995
CH 222030 A		NONE	