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F01L 1/356

(52) UK CL (Edition T)
F2U U234 U236 U316 U338
U1S S1820 S1990 S2037

(56) Documents Cited

GB 2306621 A	**GB 2302160 A**
GB 2268248 A	**GB 2263529 A**
GB 2252130 A	**GB 2248483 A**
GB 2165885 A	**WO97/07324 A**
DE 004413406 A	**US 5979381 A**
US 5931128 A	**US 5884592 A**

(58) Field of Search
UK CL (Edition R) **F2U**
INT CL[7] **F01L 1/344 1/356**
Online: WPI EPODOC PAJ

(54) Abstract Title
Variable valve timing mechanism

(57) The mechanism comprises: cam sleeve 12 and drive member 14 mounted about driveshaft 10 with doubly articulated 24, 26 link 23 connecting the drive member and cam sleeve and pin 20 arranged in radial driveshaft bore 22. The drive member rotation axis is defined by journal 16 rotating in block 18 which is slidable vertically relative to the driveshaft bearing mounting surface so that the axis is parallel and variably offset relative to the driveshaft axis. Drive is passed through the pin, driving member and link to the cam sleeve and offset between the axes results in oscillation superimposed on rotation of the camsleeve. Alternatively: the camsleeve axis may be offset to the driveshft; the pin may slide in either driveshaft or camsleeve bores; coupling elements connecting the drive member and cam sleeve may intersect a common plane normal to the driveshaft axis.

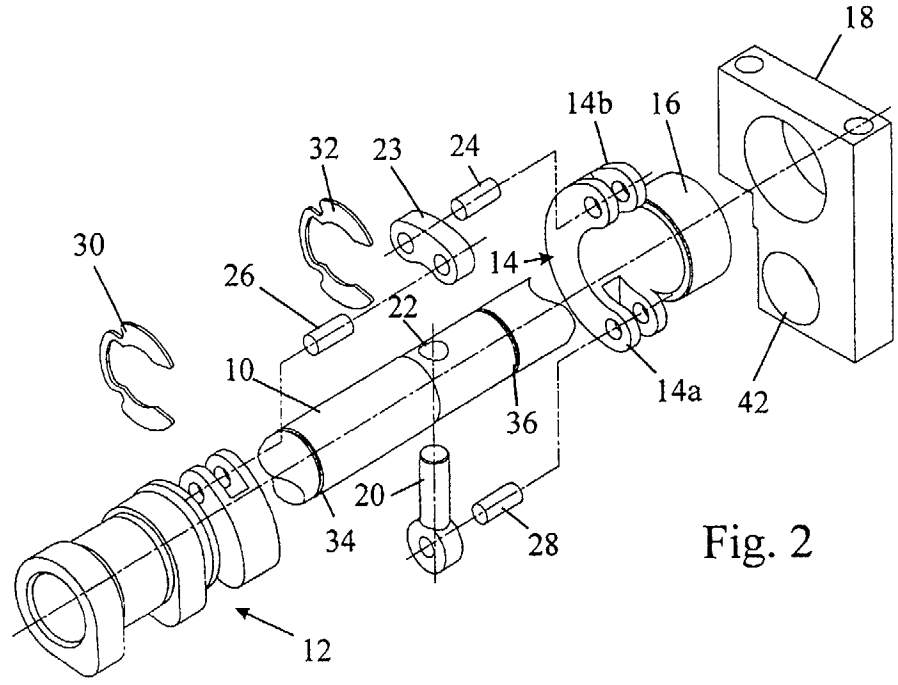


Fig. 2

GB 2 365 508 A

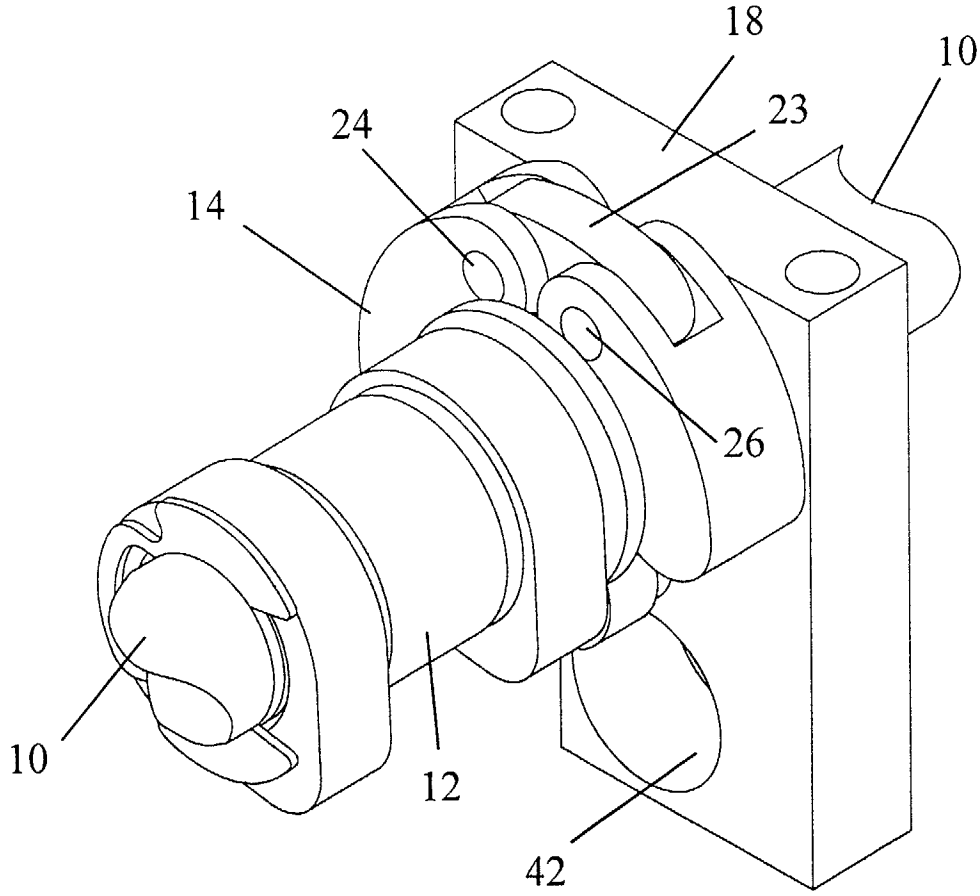

18
10
24
23
14
26
10
12
42

Fig. 1

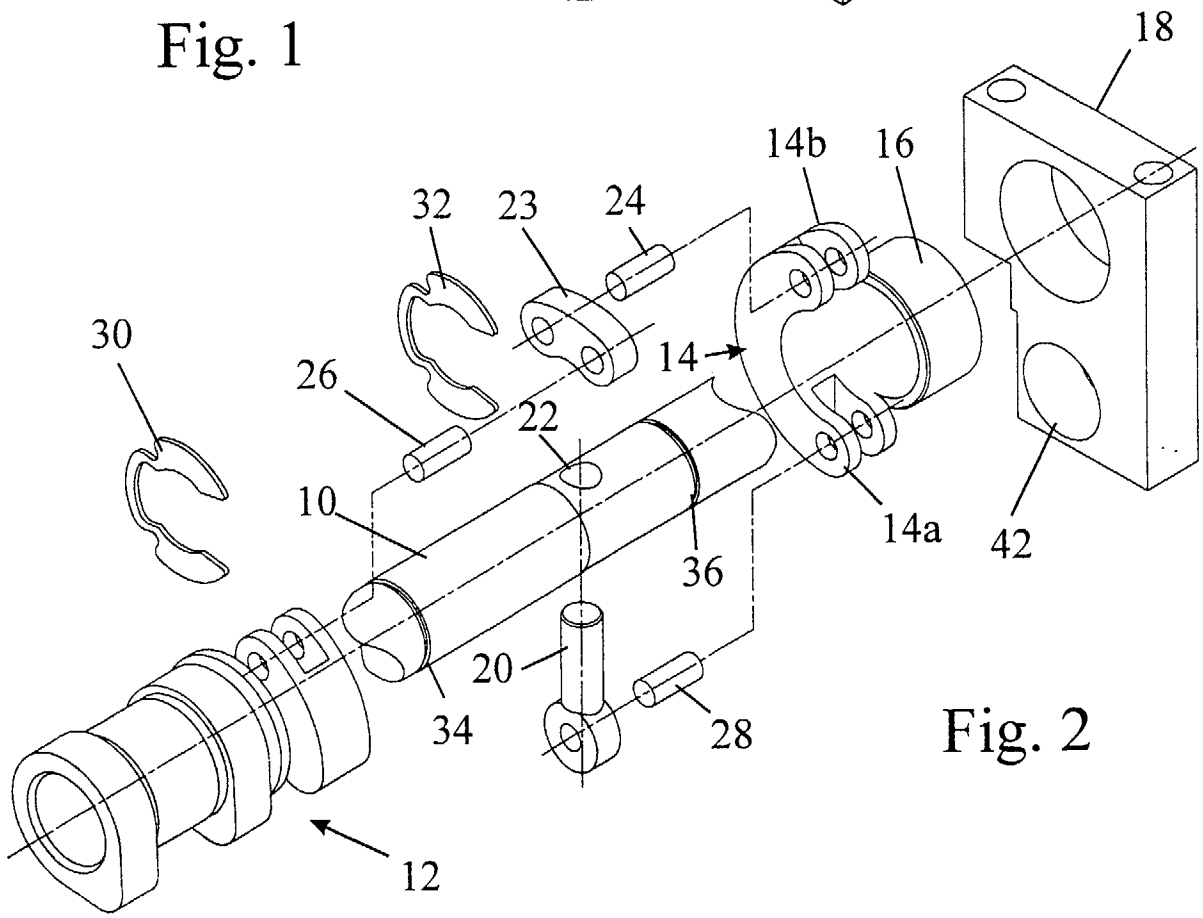
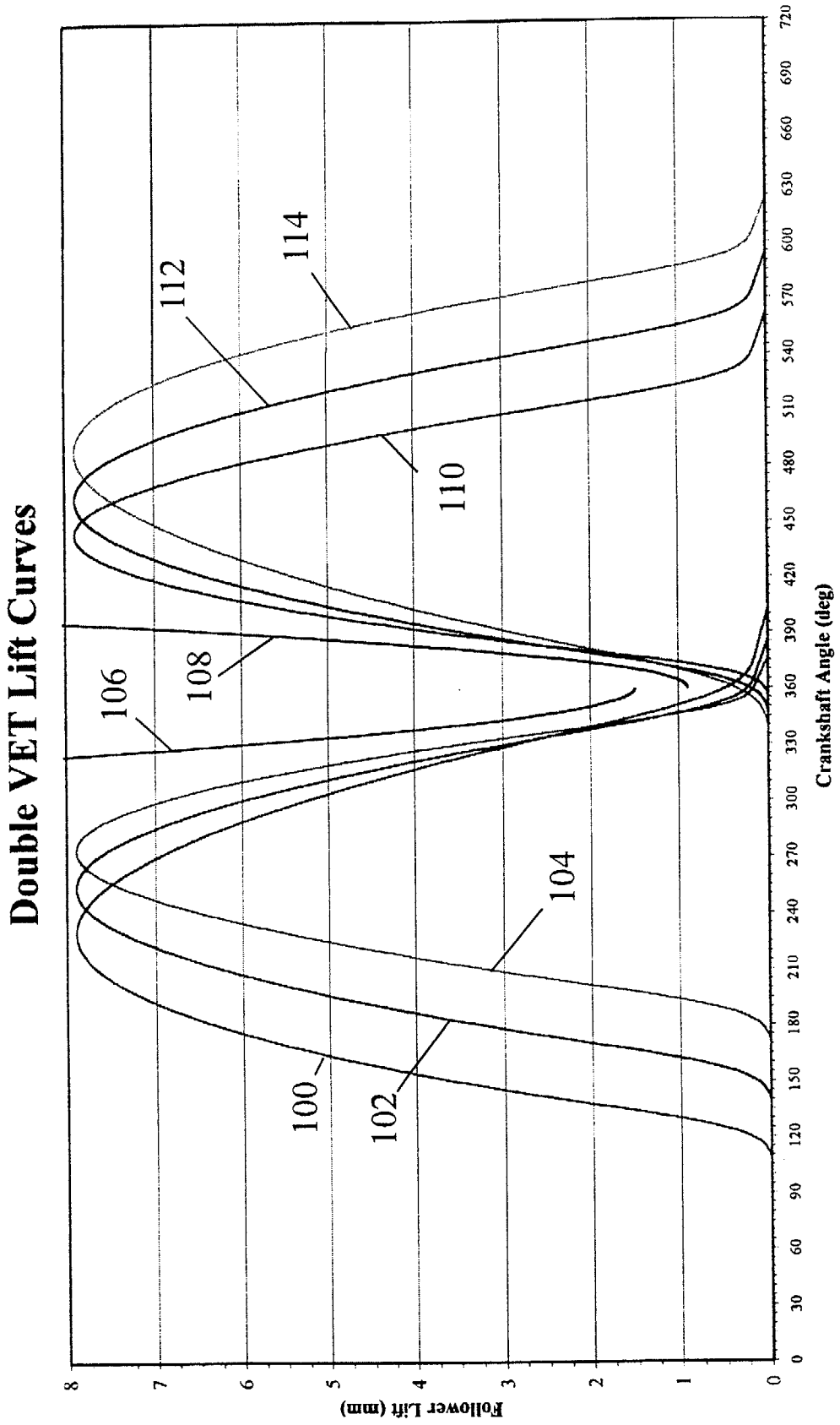

18
14b
16
32
23
24
30
14
26
22
10
14a
42
36
20
34
28
12

Fig. 2

Fig. 4


Double VET Lift Curves
Follower Lift (mm)
Crankshaft Angle (deg)
0
1
2
3
4
5
6
7
8
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
540
570
600
630
660
690
720
100
102
104
106
108
110
112
114

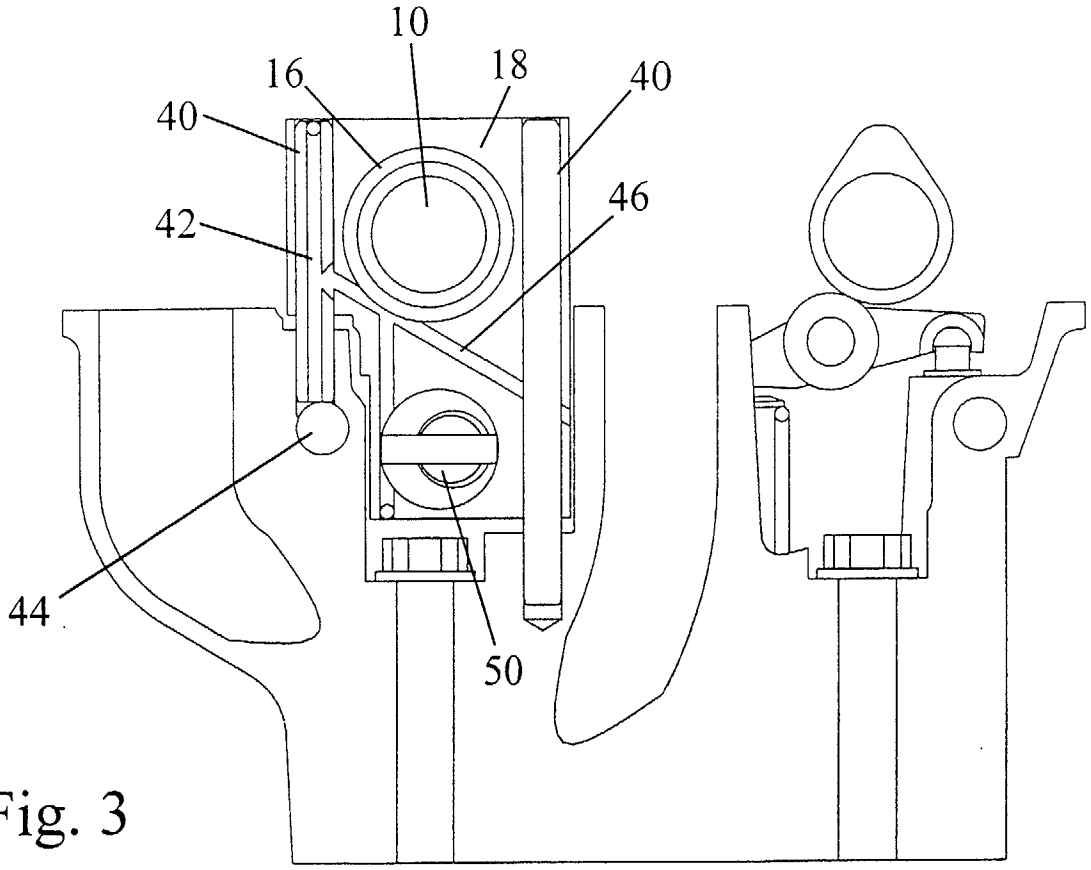


Fig. 3

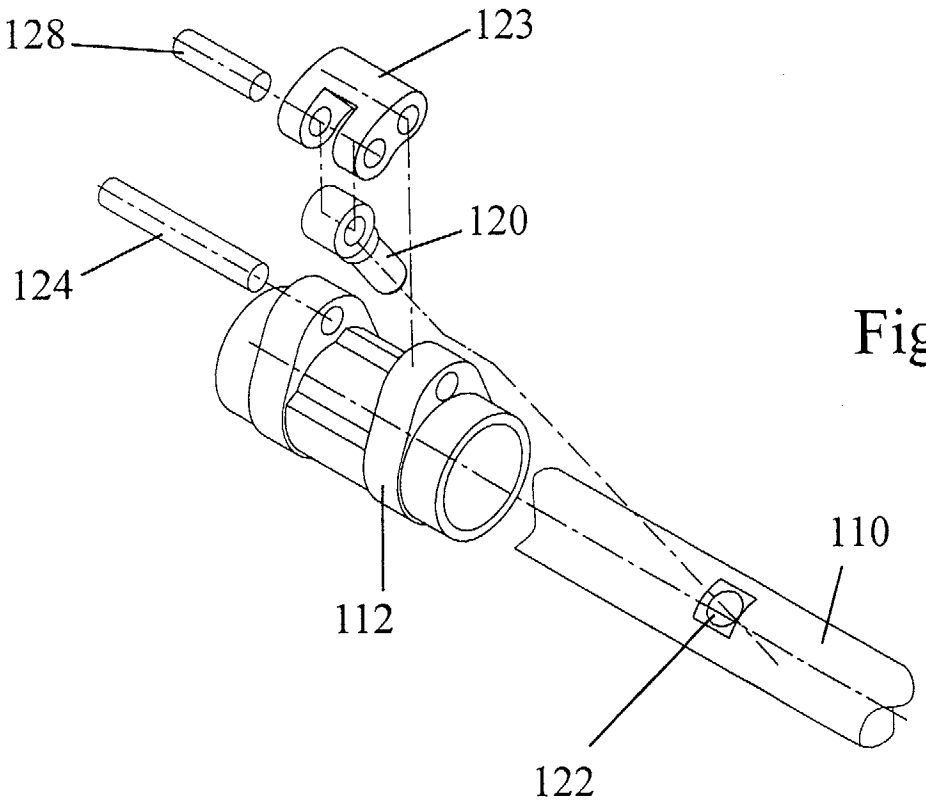


Fig. 5

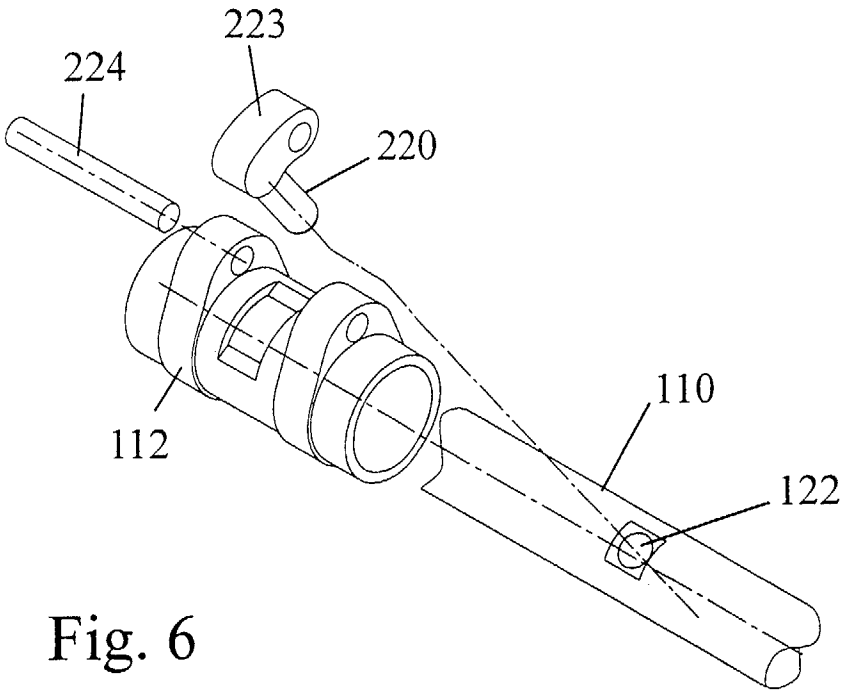


Fig. 6

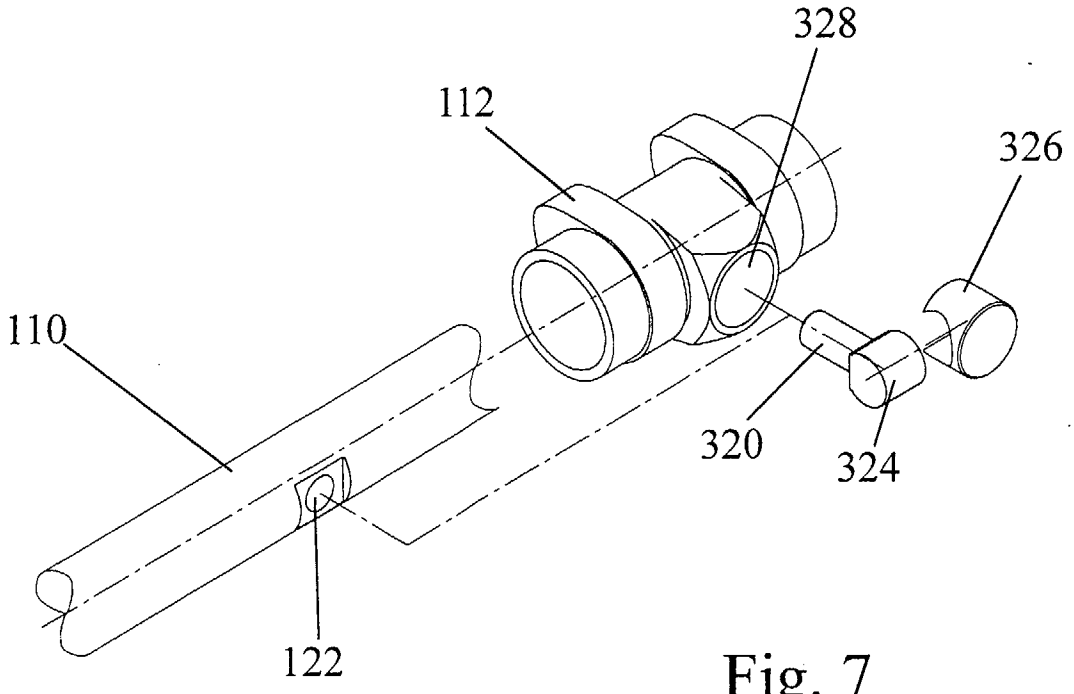


Fig. 7

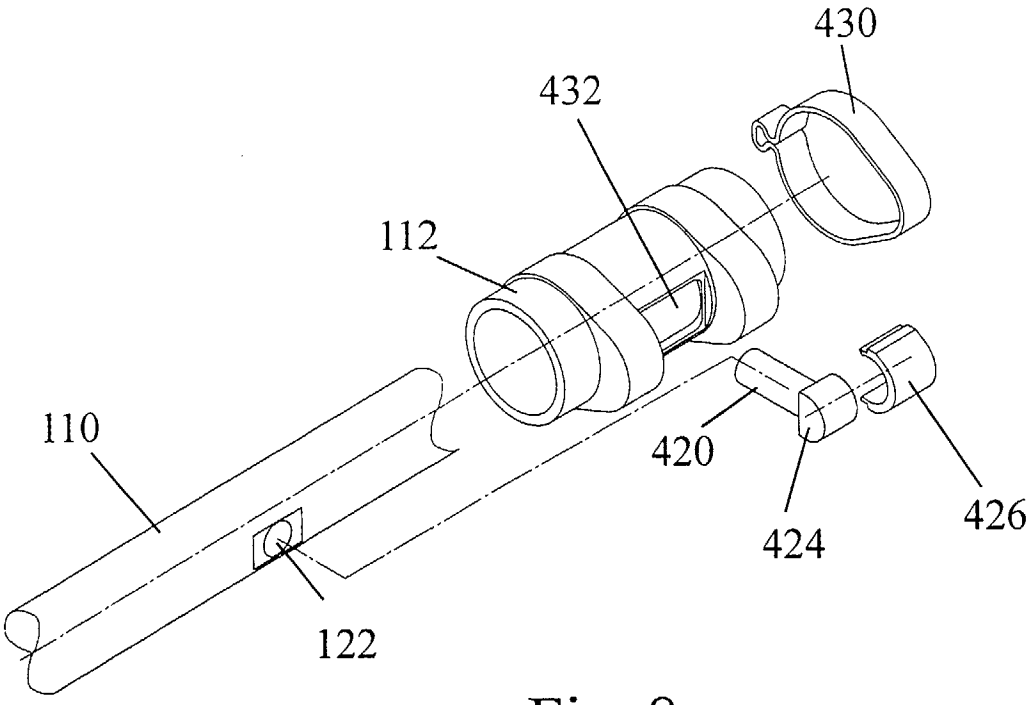


Fig. 8

VARIABLE EVENT TIMING MECHANISM

Field of the invention

The present invention to relates to a mechanism for enabling the duration of a valve event in an internal combustion engine to be varied.

Background of the invention

In an internal combustion engine having cam operated intake and exhaust valves, the duration of a valve event (the proportion of an engine cycle measured in crankshaft angles during which the valve remains open) is determined by the cam profile. Conventionally, internal combustion engines have cams with fixed profiles and the duration of the valve events cannot therefore be modified to suit the engine operating conditions. The valve event durations could not be optimised for performance over the entire load/speed operating range of the engine and instead the fixed cam profiles were selected to provide an acceptable compromise over the engine operating range.

Proposals have in the past been put forward to allow event duration to be varied during engine operation and these can be regarded as falling into two categories. In the first category of variable event timing (VET) mechanisms, the geometry of the cams is variable but the cams always rotate at half crankshaft speed. Such mechanisms tend to be complex and expensive. In the second category, to which the mechanisms of the present invention belong, the cams have fixed profile but their phase is cyclically varied as the engine turns so that during each engine cycle the phase is advanced and retarded relative to the crankshaft. In other words, a variable amplitude oscillation is superimposed on the rotation of the cams so as to vary event duration dynamically.

Object of the invention

In its various aspects, the present invention seeks to provide a variable event timing mechanism that is compact, reliable and capable of being fitted to existing engines without the need for major alterations to the engine block.

Summary of the invention

According to a first aspect of the invention, there is provided a mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft rotatable in synchronism with the engine crankshaft, a cam sleeve rotatably mounted on the drive shaft for opening and closing an engine valve and a drive member coupled to the drive shaft and the cam sleeve, wherein the drive member is mounted for rotation about an axis parallel to that of the drive shaft and the axis of the drive member is variably offset from the drive shaft axis, the extent of the offset serving to vary the phase of the cam sleeve relative to the drive shaft cyclically thereby superimposing a variable amplitude oscillation on the steady rotation of the cam sleeve by the drive shaft to vary the valve event duration, characterised in that the drive member is coupled to the drive shaft by means of a pin received in a radial bore in the drive shaft.

The simple provision of a radial pin as the means for coupling the drive member to the drive shaft makes for a very compact arrangement that is robust and easy to assemble.

If the radial pin is slidably received in the drive shaft, then movement of the pin in its bore will accommodate the eccentric motion of the drive member making it possible to pivot the projecting end of the pin directly on the drive member. It is however alternatively possible for the pin not

to be slidable in the bore in which case its projecting end may be coupled to the drive member by a doubly articulated link.

According to a second aspect of the invention, there is provided a mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft rotatable in synchronism with the engine crankshaft, a rotatably mounted cam sleeve surrounding the drive shaft with clearance and carrying a cam for opening and closing an engine valve, means for coupling the cam sleeve for rotation with the drive shaft, and means for moving the cam sleeve and the drive shaft relative to one another between concentric and eccentric positions, the extent of the offset between the axes of rotation of the cam sleeve and the drive shaft serving to vary the phase of the cam sleeve relative to the drive shaft cyclically thereby superimposing a variable amplitude oscillation on the steady rotation of the cam sleeve by the drive shaft to vary the valve event duration, characterised in that the means for coupling the cam sleeve for rotation with the drive shaft includes a pin received in a radial bore in the drive shaft.

Whereas in the first aspect of the invention, the cam sleeve and the drive shaft always remain concentric and the intermediate drive member is moved to an eccentric position to vary event duration, in the second aspect of the invention the same result is achieved by moving the cam sleeve and the drive shaft relative to one another. Both aspects of the invention however employ the same concept a pin mounted in a radial bore in the drive shaft in the coupling between the cam sleeve and the drive shaft.

According to a third aspect of the invention, there is provided a mechanism for enabling the duration of a valve event in an internal combustion engine to be varied,

comprising a drive shaft rotatable in synchronism with the engine crankshaft, a cam sleeve rotatably mounted on the drive shaft for opening and closing an engine valve and a drive member coupled to the drive shaft and the cam sleeve, wherein the drive member is mounted for rotation about an axis parallel to that of the drive shaft and the axis of the drive member is variably offset from the drive shaft axis, the extent of the offset serving to vary the phase of the cam sleeve relative to the drive shaft cyclically thereby superimposing a variable amplitude oscillation on the steady rotation of the cam sleeve by the drive shaft to vary the valve event duration characterised in that coupling elements connecting the drive member to the drive shaft and the cam sleeve, respectively, intersect a common plane normal to the axis of rotation of the drive shaft.

By positioning the coupling elements connecting the drive member to the cam sleeve and the drive shaft in the same place as one another, one not only achieves a compact mechanism but one avoids forces acting to rock the drive member relative to the drive shaft. In this way the coupling elements are not subjected to any torque that would cause them to wear more rapidly.

According to a fourth aspect of the invention, there is provided a mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft rotatable in synchronism with the engine crankshaft, a cam sleeve rotatably mounted on the drive shaft for opening and closing an engine valve and a drive member coupled to the drive shaft and the cam sleeve, wherein the drive member is mounted for rotation about an axis parallel to that of the drive shaft and the axis of the drive member is variably offset from the drive shaft axis, the extent of the offset serving to vary the phase of the cam sleeve relative to the drive shaft cyclically thereby superimposing a variable amplitude oscillation on the steady

rotation of the cam sleeve by the drive shaft to vary the valve event duration, characterised in that the drive member is connected to a cylindrical ring surrounding the drive shaft and journalled in a block that is mounted for sliding movement towards and away from the surface of the engine to which the pillow blocks supporting the drive shaft bearings are secured.

The ability to adjust the event timing by movement of blocks that mounted on the same surface as the drive shaft bearing pillow blocks once again makes for a compact arrangement and avoids the need for extensive modification to the engine block or cylinder head.

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 perspective assembled view of a mechanism of the invention,

Figure 2 is an exploded view of the same mechanism,

Figure 3 is a section through a cylinder head fitted with the mechanism of Figures 1 and 2, taken in a plane normal to the drive shaft of the mechanism,

Figure 4 is a diagram of valve lift versus crankshaft angle for an engine having a mechanism of the invention fitted to both the intake and exhaust valves, and

Figures 5 to 8 are exploded views similar to the view of Figure 2 showing four further alternative embodiments of the invention.

Detailed description of the preferred embodiments

Referring to Figures 1 and 2, a VET mechanism of a first embodiment of the invention comprises a drive shaft 10 that is driven in the normal manner from the engine

crankshaft. The illustrated mechanism serves to vary event duration and phase in a fixed relationship to one another (as shown in the valve lift diagram of Figure 4) but should it additionally be required to vary the phase of the valve events independently of any change in event duration, then it is possible to incorporate a known phase change mechanism in the pulley driving the drive shaft 10.

The VET mechanism comprises a cam sleeve 12 that is fitted over the drive shaft 10 and can rotate freely relative to it. Drive is transmitted from the drive shaft 10 to the cam sleeve 12 by a crescent shaped drive member 14. At its axial end, the drive member 14 is formed integrally with a ring 16 that is journalled in a block 18. The ring 16 surrounds the drive shaft 10 with clearance and can be moved by sliding the block 18 up and down from a position where it is concentric with the drive shaft 10 to eccentric positions.

Each end of the crescent of the drive member 14 is bifurcated and receives a pivot pin between its jaws. One of the ends 14a is pivotably connected by a pin 28 to a lollipop-shaped element 20 having a stem which is slidably received in a radial bore 22 in the drive shaft 10. The opposite end 14b of the drive member 14 is connected by way of a link 23 to the cam sleeve 12. The link 23 is doubly articulated, being pivotable about a first pin 24 relative to the drive member 14 and about a second pin 26 relative to the cam sleeve 12. Circlips 30 and 32 received in grooves 34 and 36 on the drive shaft 10 serve to retain the cam sleeve 12 and its drive member 14 axially on the drive shaft 10.

When the ring 16 of the drive member 14 is positioned by the block 18 to be concentric with the drive shaft 10, then the cam sleeve 12, the drive shaft 10 and the drive member 14 all rotate in unison without moving relative to one another. This will produce the events represented by

the curves 102 and 112 in Figure 4 (depending on whether the cam acts on an intake or an exhaust valve). The shape of these curves 102 and 112 is determined by the profile of the cam on the cam sleeve 12.

By moving the block 18 either up or down from this position, the ring 16 will be forced to rotate about an axis that is vertically offset from the axis of the drive shaft 10. As a result, as the drive member 14 rotates, the distance of the driven end 14a from the centre of the drive shaft centre will vary cyclically during each revolution. Hence the lollipop-shaped element 20 will move in and out of the bore 22 in synchronism with the rotation of the drive shaft 10 causing a rotational oscillation of the drive member 14 around the drive shaft.

The opposite end 14b of the drive member 14 connects to the cam sleeve 12 via the doubly articulated link 23 which moves during each revolution to compensate for the drive member 14 and cam sleeve 12 having different centres of rotation. This motion causes a further rotational oscillation of the cam sleeve 12 relative to the drive member 14 which superimposes upon the oscillation of the drive shaft 14 around the drive shaft 10 such that the phase of the cam sleeve is varied cyclically as the drive shaft rotates. This will result in the curves 100 and 114 at the extreme of adjustment of the block 18 in one direction and in the curves 104 and 110 at the extreme of adjustment in the opposite direction. Of course, it is possible to set the block 18 to any position between these extremes to give continuous control of the duration of the valve events.

It will be seen from Figure 4 that by suitable selection of the geometry of the mechanism, it is possible to ensure that the opening and closing times of the valves are substantially unaltered and that only the duration of events is modified. In Figure 4, the lines 106 and 108

indicate the position of the piston crown as a function of crankshaft angle to demonstrate that collision between the piston and valves is avoided at all times.

The various blocks 18 for the different valves must all be movable in synchronism with one another and this can be achieved by mounting the block 18 on pins 40 that extend vertically from the cylinder head, i.e. from the face of the cylinder head on which the pillow blocks supporting the drive shaft bearings are mounted. Eccentrics 50 received in the bores 42 in the blocks 18 can be rotated in unison to raise and lower all the blocks 18 simultaneously by the same amount.

The mounting of the blocks 18 on guide pins 40 in the cylinder head is also advantageous in that is permits lubrication of the various bearing surfaces of the block 18. To this end, as shown in Figure 3, one of the guide pins 40 may be formed with a bore 42 that communicates with an oil gallery 44 in the cylinder head. Further bores 46 in the block 18 connected to the bore 42 serve to guide the oil to the bearing surface of the ring 16, to the eccentric 50 and to the outer surfaces of the guide pins 40.

It will be clear to those skilled in the art that a doubly articulated link could also be used to couple a pin fixedly mounted in the bore 22 to the drive member 14.

In the embodiment of Figures 1 to 3, the drive shaft 10 and the cam sleeve 12 are always concentric and they are coupled to one another by an intermediate drive member 14 that can be moved to an eccentric position. By contrast, in the embodiments of Figures 5 to 8, the intermediate drive member is omitted and instead the drive shaft 110 can be moved to an eccentric position relative to the cam sleeve 112. In other respect, all the embodiments operate in any analogous manner to one another. The embodiments of

Figures 5 to 8 also have in common with the embodiment of Figures 1 to 3, the fact that the coupling between the drive shaft 110 and the cam sleeve includes a pin received in a radial bore in the drive shaft 110 and the fact that all the coupling forces acts in the same plane normal to the axis of rotation of the mechanism. The bearing blocks that support the drive shaft may furthermore be constructed in a similar manner to the blocks 18.

In the embodiment of Figure 5, the coupling between the cam sleeve 112 and the drive shaft 110 once again includes a lollipop-shaped pin 120 which is mounted in a radial bore 122 in the drive shaft 110. The projecting end of the pin 120 is connected by a pivot pin 128 to a doubly articulated link 123, the opposite end of which is connected by a pivot pin 124 to the cam sleeve 112. Because the link 123 is articulated at both ends, the pin 120 need not move radially in the bore 122 in the drive shaft 110.

The embodiment of Figure 6 differs from that of Figure 5 in that the pin 220 is rigid with an arm 223 that takes the place of the articulated link 123. A single pivot pin 224 connects the arm 223 to the cam sleeve 112. In this case, the pin 220 is required to reciprocate radially within the bore 122 as the mechanism rotates.

In the embodiment of Figure 7, the pin 320 has a cylindrical head 324 the axis of which lies parallel to the axis of rotation of the mechanism. The head 324 is received in a slide block 326 that is mounted for radial movement in a bore 328 in the cam sleeve 112. In this embodiment, the pin 320 need not move in the bore 122 as the eccentricity can be taken up by radial movement of the slide block 326 in the bore 328 and pivotal movement between the head 324 of the pin 320 and the slide block 326.

Lastly, in the embodiment of Figure 8, the pin 420 again has a part cylindrical head 424 but this is received in a cap 426 that is retained in a cut-out 432 in the cam sleeve 112 by a clamping band 430. In this case, the head 424 of the pin 420 cannot move radially in relation to the cam sleeve 112 and instead the pin 420 must reciprocate within the bore 122 in the drive shaft 110.

CLAIMS

1. A mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft rotatable in synchronism with the engine crankshaft, a cam sleeve rotatably mounted on the drive shaft for opening and closing an engine valve and a drive member coupled to the drive shaft and the cam sleeve, wherein the drive member is mounted for rotation about an axis parallel to that of the drive shaft and the axis of the drive member is variably offset from the drive shaft axis, the extent of the offset serving to vary the phase of the cam sleeve relative to the drive shaft cyclically thereby superimposing a variable amplitude oscillation on the steady rotation of the cam sleeve by the drive shaft to vary the valve event duration, characterised in that the drive member is coupled to the drive shaft by means of a pin received in a radial bore in the drive shaft.

2. A mechanism as claimed in claim 1, wherein the radial pin is slidably received in the drive shaft.

3. A mechanism as claimed in claim 2, wherein the end of the pin projecting from the drive shaft is pivotable mounted directly on the drive member.

4. A mechanism as claimed in claim 1, wherein pin is fixedly mounted in the radial bore in the drive shaft and its projecting end is coupled to the drive member by a doubly articulated link.

5. A mechanism as claimed in any preceding claim, wherein the drive member is coupled to the cam sleeve by way of a doubly articulated link that is pivotably secured at one end to the drive member and at the other end to the cam sleeve.

6. A mechanism as claimed in any preceding claim, wherein the coupling elements connecting the drive member to the drive shaft and the cam sleeve, respectively, intersect a common plane normal to the axis of rotation of the drive shaft.

7. A mechanism as claimed in any preceding claim, wherein the drive member is connected to a cylindrical ring surrounding the drive shaft and journalled in a block that is mounted for sliding movement towards and away from the surface of the engine to which the pillow blocks supporting the drive shaft bearings are secured.

8. A mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft rotatable in synchronism with the engine crankshaft, a rotatably mounted cam sleeve surrounding the drive shaft with clearance and carrying a cam for opening and closing an engine valve, means for coupling the cam sleeve for rotation with the drive shaft, and means for moving the cam sleeve and the drive shaft relative to one another between concentric and eccentric positions, the extent of the offset between the axes of rotation of the cam sleeve and the drive shaft serving to vary the phase of the cam sleeve relative to the drive shaft cyclically thereby superimposing a variable amplitude oscillation on the steady rotation of the cam sleeve by the drive shaft to vary the valve event duration, characterised in that the means for coupling the cam sleeve for rotation with the drive shaft includes a pin received in a radial bore in the drive shaft.

9. A mechanism as claimed in claim 8, wherein the pin is slidable in the radial bore in the drive shaft.

10. A mechanism as claimed in claim 8 or 9, wherein the end of the pin projecting from the drive shaft is

rigidly connected to one end of an arm of which the other pivotably connected to the cam sleeve.

11. A mechanism as claimed in claim 8 or 9, in which the end of the pin projecting from the drive shaft is connected to the cam sleeve by a link that is pivotably connected at its respective ends to the pin and the cam sleeve.

12. A mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft rotatable in synchronism with the engine crankshaft, a cam sleeve rotatably mounted on the drive shaft for opening and closing an engine valve and a drive member coupled to the drive shaft and the cam sleeve, wherein the drive member is mounted for rotation about an axis parallel to that of the drive shaft and the axis of the drive member is variably offset from the drive shaft axis, the extent of the offset serving to vary the phase of the cam sleeve relative to the drive shaft cyclically thereby superimposing a variable amplitude oscillation on the steady rotation of the cam sleeve by the drive shaft to vary the valve event duration, characterised in that the drive member is connected to a cylindrical ring surrounding the drive shaft and journalled in a block that is mounted for sliding movement towards and away from the surface of the engine to which the pillow blocks supporting the drive shaft bearings are secured.

13. A mechanism as claimed in claim 13, wherein the blocks are mounted on guide pins of which at least one has a bore that communicates with an oil gallery of the engine, the block being formed with further bores for leading from the bore in the guide pin to bearing surfaces of the block.

14. A mechanism for enabling the duration of a valve event in an internal combustion engine to be varied,

comprising a drive shaft rotatable in synchronism with the engine crankshaft, a cam sleeve rotatably mounted on the drive shaft for opening and closing an engine valve and a drive member coupled to the drive shaft and the cam sleeve, wherein the drive member is mounted for rotation about an axis parallel to that of the drive shaft and the axis of the drive member is variably offset from the drive shaft axis, the extent of the offset serving to vary the phase of the cam sleeve relative to the drive shaft cyclically thereby superimposing a variable amplitude oscillation on the steady rotation of the cam sleeve by the drive shaft to vary the valve event duration characterised in that coupling elements connecting the drive member to the drive shaft and the cam sleeve, respectively, intersect a common plane normal to the axis of rotation of the drive shaft.

15. A mechanism for enabling the duration of a valve event in an internal combustion engine to be varied constructed and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

INVESTOR IN PEOPLE

Application No: GB 0019325.0
Claims searched: 1-7

Examiner: J. C. Barnes-Paddock
Date of search: 20 November 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F2U

Int Cl (Ed.7): F01L 1/344, 356

Other: Online: WPI EPODOC PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2263529 A	(ATSUGI) See Figure 1 Adjustable eccentricity driving meber 29 connected to drive shaft by sleeve 28 and diametral pin 31.	1
X	WO9707324 A	(KOROSTENSKI et al) See Figures 1 and 2. Cam sleeve 3 driven by variable eccentricity intermediate member 11 joined to camshaft 1 by a radial pin12 in camshaft bore.	1
X	US5979381	(KOROSTENSKI et al) See Figures 1, 1a and 2 and col 4, line 37 to col 5, line 18. Cam sleeve 10 driven by variable eccentricity intermediate member 20 joined to camshaft 1 by a radial pin in camshaft bore.	1
X	US5884592	(KOROSTENSKI et al) See Figures 1, 1a and 2	1
A	GB2165885 A	(AUSTIN ROVER) See Figures 1 and 3. Exemplary adjustable phase cam sleeve arrangement.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Application No:	GB 0019325.0	**Examiner:**	J. C. Barnes-Paddock
Claims searched:	8-11	**Date of search:**	24 April 2001

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): F2U

Int Cl (Ed.7): F01L 1/344, 356

Other: Online: WPI EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2248483 A	(NATIONAL RESEARCH) See Figures 1,2 and page 3, lines 5-19. Eccentric cam sleeve driven by arrangement involving radial pin 21.	8

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Application No: GB 0019325.0 **Examiner:** J. C. Barnes-Paddock
Claims searched: 12, 13 **Date of search:** 24 April 2001

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): F2U

Int Cl (Ed.7): F01L 1/344, 356

Other: Online: WPI EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB2302160 A	(UNISIA) See Figures 1 and 3. Driving member with circular portion in sliding block movable towards and away from engine	12
Y	GB2268248 A	(UNISIA) See Figures 6,9. Driving member 28 with circular portion in pivotally sliding block 34	12
Y	GB2263529 A	(ATSUGI) See Figure 2 Driving member with circular portion in pivotally sliding block.	12
Y	DE4413406 A1	(KOROSTENSKI) See Figure 1 and WPI abstract accession No: 1995-359533 [07]. Sliding eccentric control member 73 suitable for use in a concentric shaft/cam sleeve arrangement.	12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Application No: GB 0019325.0 **Examiner:** J. C. Barnes-Paddock
Claims searched: 14 **Date of search:** 24 April 2001

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): F2U

Int Cl (Ed.7): F01L 1/344, 356

Other: Online: WPI EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2306621 A	(UNISIA) See Figure 9. Drive and sleeve pins 36, 37 intersect normal plane 10-10.	14
X	GB2252130 A	(ROVER) See Figure 3. Pins 39, 42 intersect normal plane in which drive member 36 lies.	14
X	GB2268248 A	(UNISIA) See Figure 9. Pins 26, 30 connecting shaft, drive member and sleeve parallel to shaft axis and so intersect a normal plane.	14
X	GB2263529 A	(ATSUGI) See Figures 1,2 Pins intersect normal plane in which drive member lies.	14
X	US5931128	(MITSUBISHI) See Figures 2 and 3. Pins intersect normal plane in which drive member lies.	14

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.