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

(11) EP 1 234 955 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.08.2002 Bulletin 2002/35

(51) Int Cl.[7]: **F01L 1/356**

(21) Application number: **01000345.7**

(22) Date of filing: **02.08.2001**

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

(30) Priority: **08.08.2000 GB 0019325**

(71) Applicant: **Mechadyne PLC**
Kirtlingdon, Oxfordshire OX5 3JQ (GB)

(72) Inventor: **Methley, Ian,**
OX8 8JL, Witney (GB)

(74) Representative: **Messulam, Alec Moses**
A. Messulam & Co. Ltd.,
43-45 High Road
Bushey Heath, Bushey, Herts WD23 1EE (GB)

(54) Variable event timing mechanism

(57) A mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft (10) rotatable in synchronism with the engine crankshaft, a cam sleeve (12) rotatably mounted on the drive shaft for opening and closing an engine valve and a drive member (14) coupled to the drive shaft and the cam sleeve. The drive member (14) is mounted for rotation about an axis parallel to that of the drive shaft and its axis is variably offset from the drive shaft axis. The extent of the offset of the axis of the drive member (14) serves 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.

In the invention, the means for coupling the drive member (14) for rotation with the drive shaft (10) includes a pin (20) fixedly received in a radial bore (22) in the drive shaft (10). The end of the pin (20) projecting from the drive shaft is pivotably connected to the drive member (14) by means of a link (27) that is pivoted at its respective ends to the pin (20) and drive member (14) about axes that extend parallel to the axis of the drive shaft (10).

As an alternative to the provision of an intermediate drive member that can be moved to an eccentric position, the drive shaft may itself be moved to an eccentric position in relation to the axis of rotation of the cams.

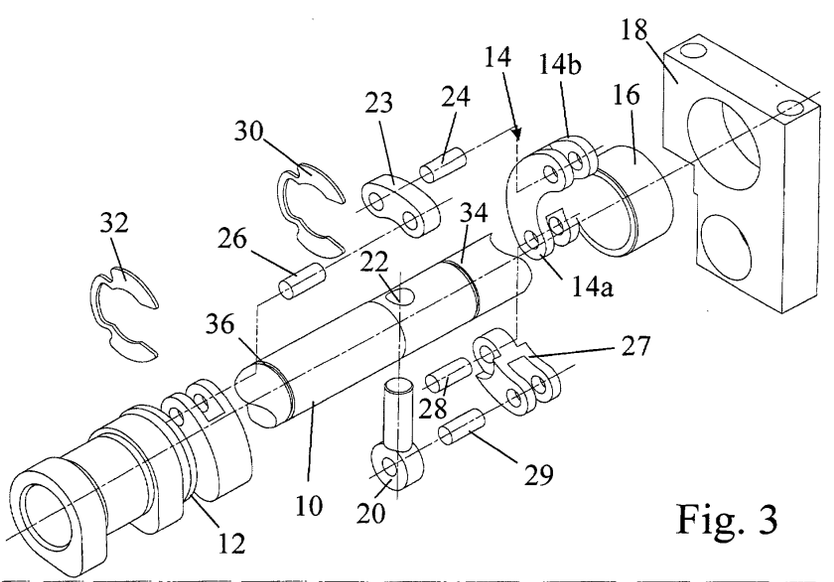


Fig. 3

EP 1 234 955 A1

Description

Field of the invention

[0001] 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

[0002] 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 angle 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.

[0003] 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

[0004] 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 or cylinder head.

Summary of the invention

[0005] 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 means for coupling the drive member for rotation with the drive shaft includes a pin fixedly received in a radial bore in the drive shaft, the end of the pin projecting from the drive shaft being pivotably connected to the drive member by means of a link that is pivoted at its respective ends to the pin and drive member about axes that extend parallel to the axis of the drive shaft.

[0006] Preferably, the drive member may also be 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.

[0007] The drive member may conveniently be 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.

[0008] The ability to adjust the event timing by movement of blocks that are 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.

[0009] As an alternative to providing an intermediate drive member that can be moved to an eccentric position in relation to the cams, it is possible to provide a mechanism in which the drive shaft can itself be moved to an eccentric position in relation to the cams.

[0010] Thus, 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 fixedly received in a radial bore in the drive shaft, the end of the pin projecting from the drive shaft being pivotably connected to the cam sleeve by means of a link that is pivoted at its respective ends to the pin and cam sleeve about axes that extend par-

allel to the axis of the drive shaft.

[0011] In all the embodiments of the invention, the simple provision of a fixed radial pin and an articulated link 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.

Brief description of the drawings

[0012] 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 a view similar to that of Figure 1 with the mechanism rotated through 180°.
Figure 3 is an exploded view of the same mechanism,
Figure 4 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 5 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 6 is a view similar to the view of Figure 3 showing an alternative embodiment of the invention.

Detailed description of the preferred embodiments

[0013] Referring to Figures 1, 2 and 3, 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 5) 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.

[0014] 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.

[0015] 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, a doubly articulated link 27 and a second pin 29 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 second link 23 to the cam sleeve 12. The link 23 is also again 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.

[0016] 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 5 (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.

[0017] 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 10 will vary cyclically during each revolution. Hence the doubly articulated link 23 will pivot at both ends in synchronism with the rotation of the drive shaft 10 causing a rotational oscillation of the drive member 14 around the drive shaft 10.

[0018] The opposite end 14b of the drive member 14 connects to the cam sleeve 12 via the doubly articulated link 23 which also 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 member 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.

[0019] It will be seen from Figure 5 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 5, 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.

[0020] The various blocks 18 for the different valves must all be movable in synchronism with one another and this can be achieved by mounting each block 18, as shown in Figure 4, 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.

[0021] The mounting of the blocks 18 on guide pins 40 in the cylinder head is also advantageous in that it permits lubrication of the various bearing surfaces of the block 18. To this end, as shown in Figure 4, 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.

[0022] 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 embodiment of Figure 6, 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 respects, the two embodiments operate in an analogous manner to one another.

[0023] The embodiment of Figure 6 also has 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 120 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.

[0024] In the embodiment of Figure 6, the coupling between the cam sleeve 112 and the drive shaft 110 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.

Claims

1. A mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft (10) rotatable in synchronism with the engine crankshaft, a cam sleeve (12) rotatably mounted on the drive shaft (10) for opening and closing an engine valve and a drive member (14) coupled to the drive shaft (10) and the cam sleeve (12), wherein the drive member (14) is mounted for rotation about an axis parallel to that of the drive shaft (10) and the axis of the drive member (14) is variably offset from the drive shaft axis, the extent of the offset serving to vary the phase of the cam sleeve (12) 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 drive member (14) for rotation with the drive shaft (10) includes a pin (20) fixedly received in a radial bore (22) in the drive shaft (10), the end of the pin (20) projecting from the drive shaft (10) being pivotably connected to the drive member (14) by means of a link (27) that is pivoted at its respective ends to the pin (20) and drive member (14) about axes that extend parallel to the axis of the drive shaft (10).

2. A mechanism as claimed in claim 1, wherein the drive member (14) is coupled to the cam sleeve (12) by way of a doubly articulated link that is pivotably secured at one end to the drive member (14) and at the other end to the cam sleeve (12).

3. 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.

4. A mechanism as claimed in any preceding claim, wherein the drive member (14) is connected to a cylindrical ring (16) surrounding the drive shaft (10) and journalled in a block (18) 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.

5. A mechanism as claimed in claim 4, wherein each block (18) is mounted on guide pins (40) of which at least one has a bore (42) that communicates with an oil gallery (44) of the engine, the block (18) being formed with further bores which lead from the bore (42) in the guide pin (40) to bearing surfaces of the block.

6. A mechanism for enabling the duration of a valve event in an internal combustion engine to be varied, comprising a drive shaft (110) rotatable in synchronism with the engine crankshaft, a rotatably mounted cam sleeve (112) surrounding the drive shaft (110) with clearance and carrying a cam for opening and closing an engine valve, means (120-128) for coupling the cam sleeve (112) for rotation with the drive shaft (110), and means for moving the cam sleeve (112) and the drive shaft (110) relative to one another between concentric and eccentric positions, the extent of the offset between the axes of rotation of the cam sleeve (112) and the drive shaft

(110) 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 (112) for rotation with the drive shaft (110) includes a pin (120) fixedly received in a radial bore (122) in the drive shaft (110), the end of the pin (120) projecting from the drive shaft (110) being pivotably connected to the cam sleeve (112) by means of a link (123) that is pivoted at its respective ends to the pin (120) and the cam sleeve (112) about axes that extend parallel to the axis of the drive shaft (110).

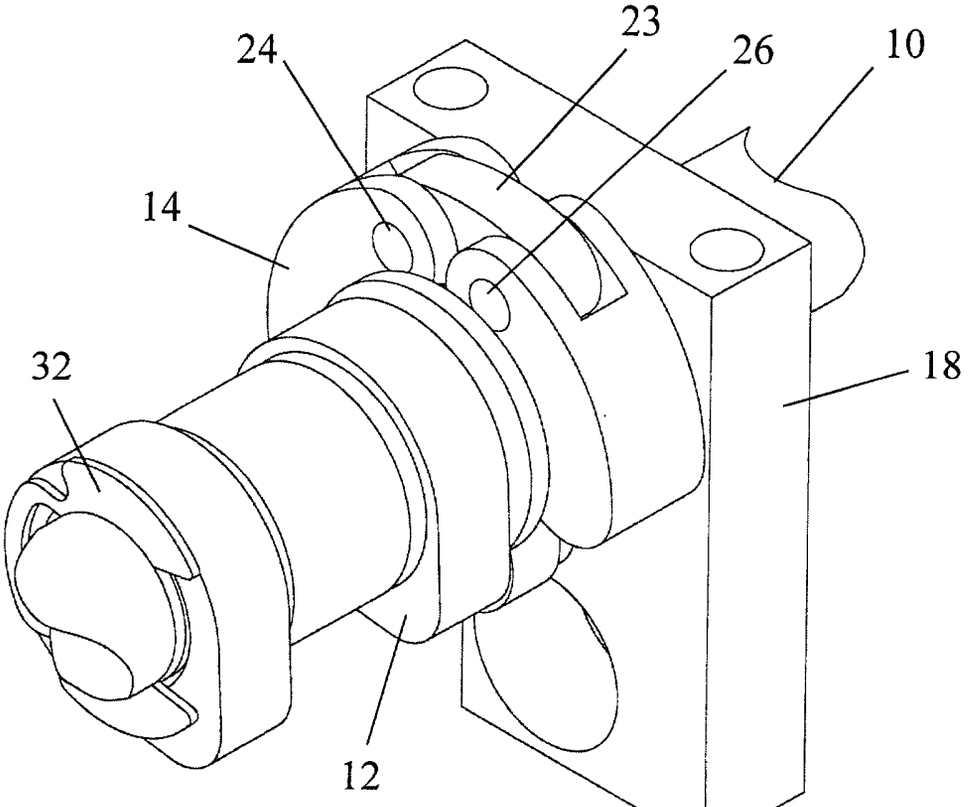


Fig. 1

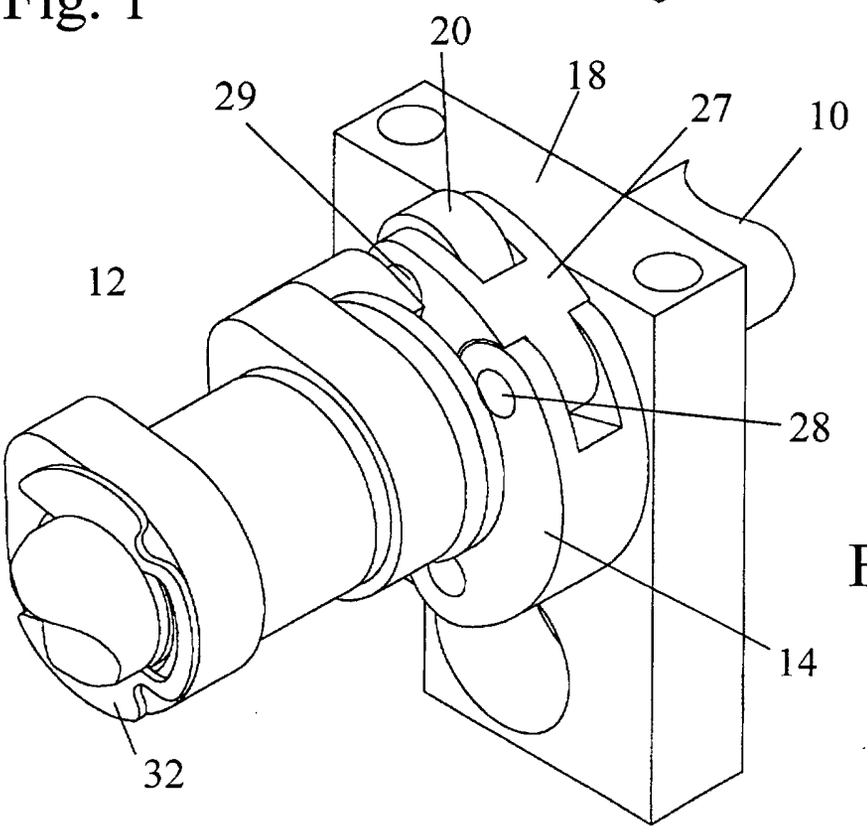


Fig. 2

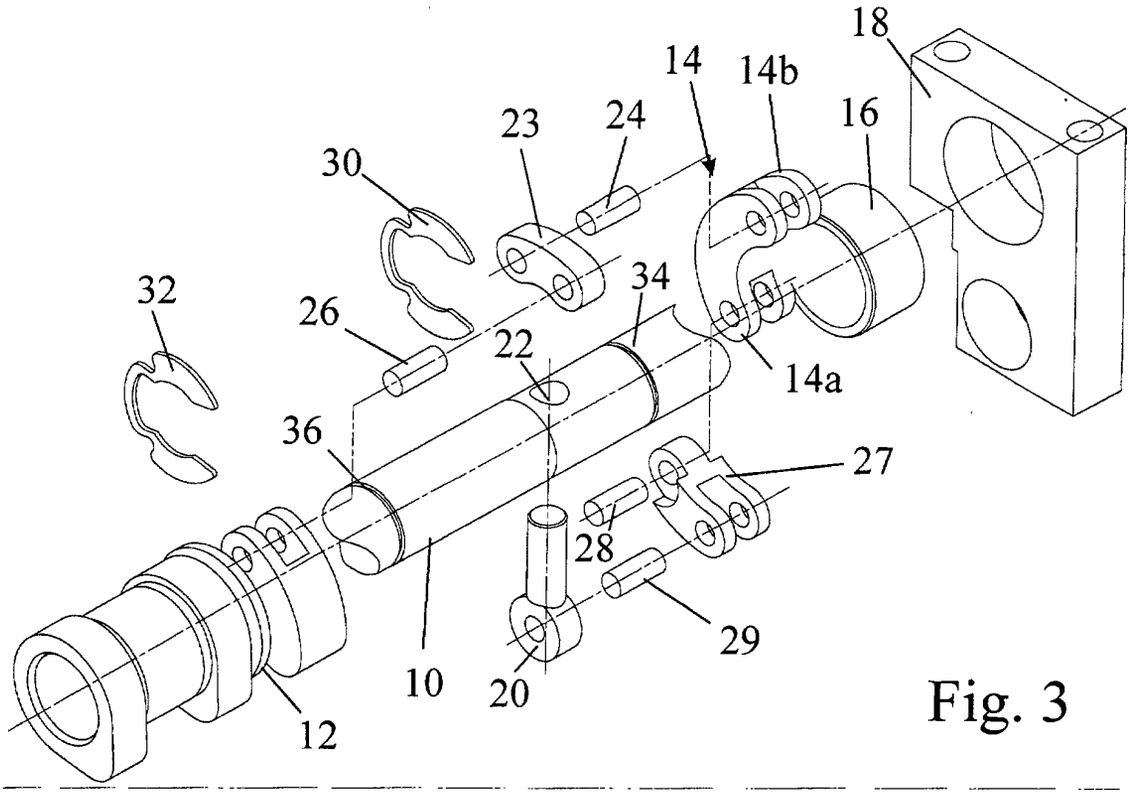

18
14
14b
16
23
24
30
32
26
34
22
14a
36
27
28
29
10
20
12

Fig. 3

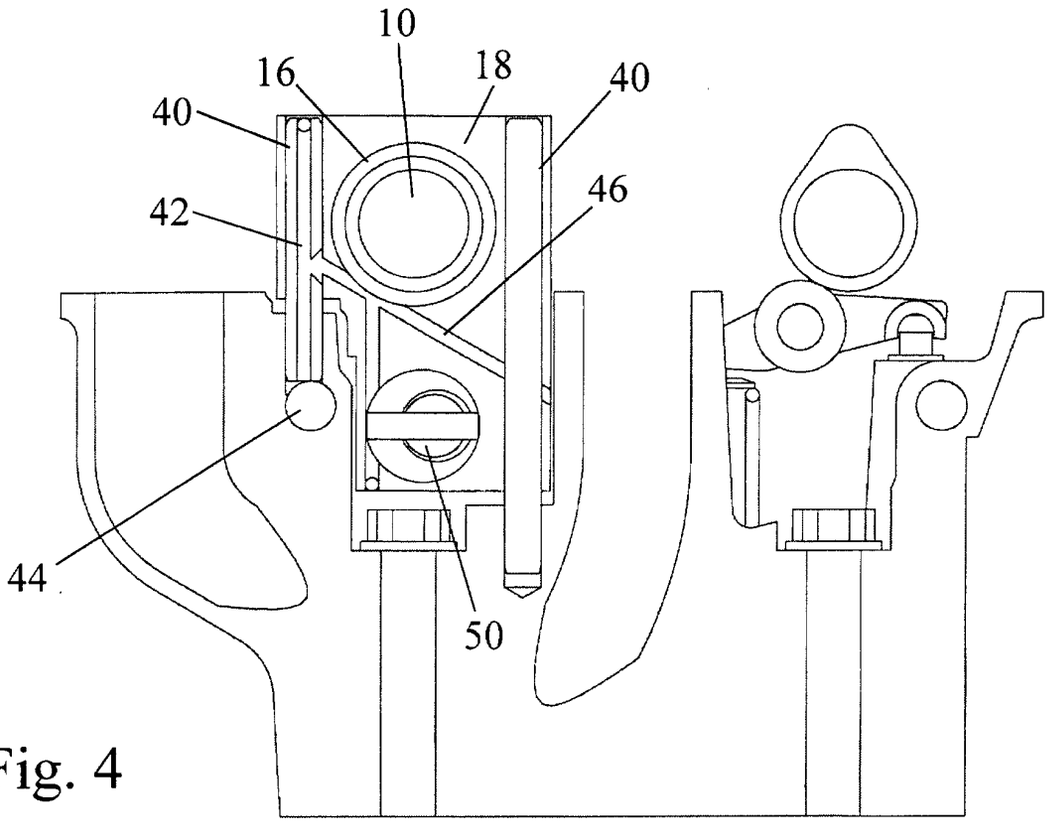
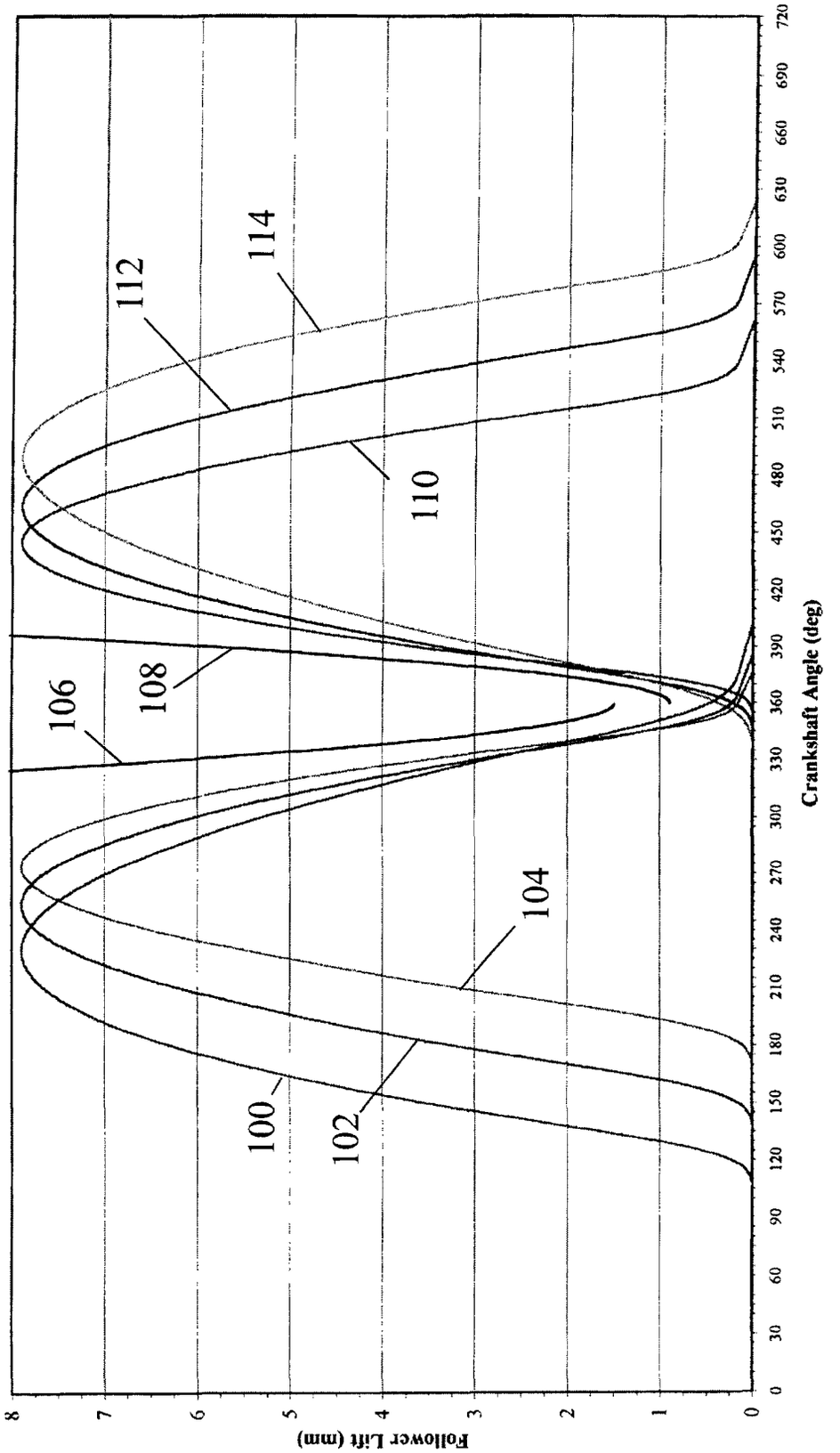

10
16
18
40
40
46
42
44
50

Fig. 4

Fig. 5


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

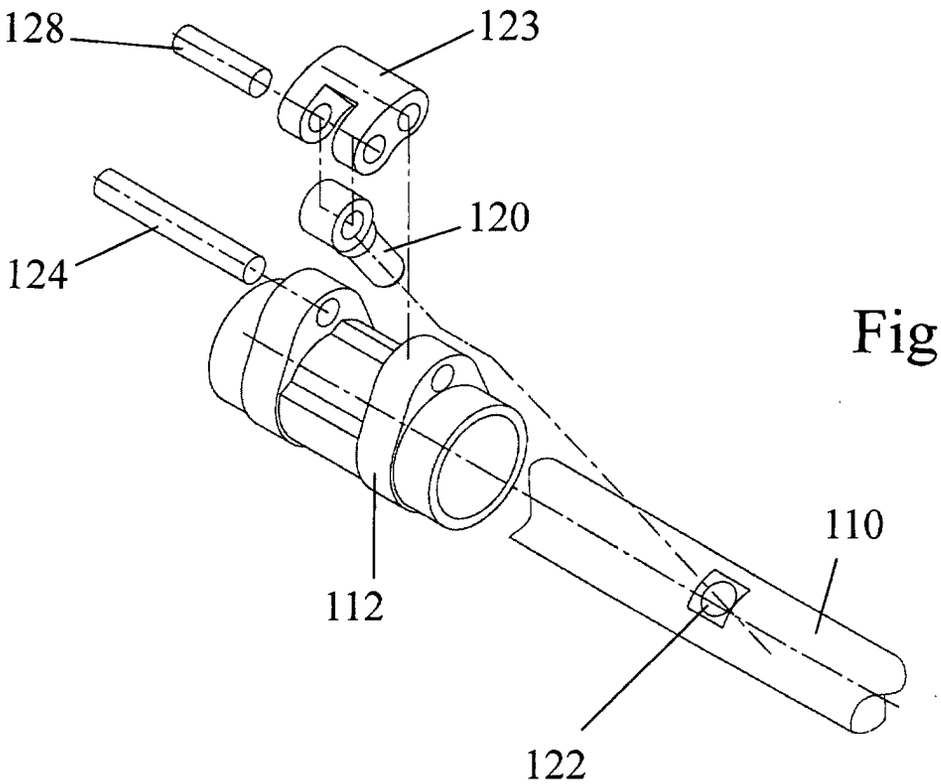


Fig. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 00 0345

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 979 381 A (KOROSTENSKI ERWIN ET AL) 9 November 1999 (1999-11-09)	1	F01L1/356
A	* the whole document *	6	
A	US 5 787 849 A (MITCHELL STEPHEN W) 4 August 1998 (1998-08-04) * the whole document *	6	
A	US 5 687 681 A (HARA SEINOSUKE) 18 November 1997 (1997-11-18) * the whole document *	1-3,6	
A	DE 44 19 557 C (KOROSTENSKI ERWIN) 19 October 1995 (1995-10-19)		

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 January 2002	Klinger, T

CATEGORY OF CITED DOCUMENTS

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

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

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 00 0345

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

09-01-2002

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5979381 A	09-11-1999	DE 19546366 A1	19-06-1997
		AT 191540 T	15-04-2000
		AU 1869597 A	03-07-1997
		WO 9721909 A2	19-06-1997
		DE 59604914 D1	11-05-2000
		EP 0865566 A2	23-09-1998
US 5787849 A	04-08-1998	GB 2307518 A ,B	28-05-1997
US 5687681 A	18-11-1997	JP 9170410 A	30-06-1997
		DE 19643160 A1	24-04-1997
		GB 2306621 A ,B	07-05-1997
		JP 9195737 A	29-07-1997
DE 4419557 C	19-10-1995	DE 4419557 C1	19-10-1995

EPO FORM P0459

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