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(54) **Torque Oscillation Controller**

(57) A magnetic torque oscillation controller for a camshaft (102) comprises first and second magnetic arrays (120, 112) located upon the cylinder head (104) and

camshaft (106) respectively. The first and second magnetic arrays (120, 112) are positioned relative to each other such that a torque oscillation of the camshaft can be either increased or decreased, selectively.

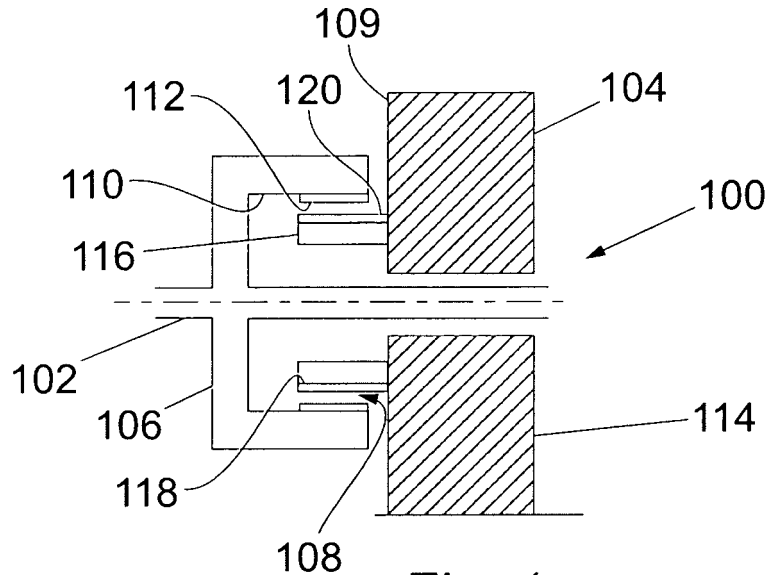


Fig. 1

Description

[0001] This invention relates to a torque oscillation controller. More particularly, but not exclusively, it relates to a torque oscillation controller for a camshaft.

[0002] A camshaft comprises a base circle portion, having a constant radius of curvature, and a cam lobe, having a varying radius of curvature. Thus, the camshaft effects an eccentric path during its rotation.

[0003] A camshaft experiences a high variance of torque during a single revolution. This torque variance occurs during the opening and closing of an engine valve.

[0004] During the opening of an engine valve a valve follower traces a path that follows the surface camshaft. As the valve follower leaves the base circle portion of the camshaft and climbs the cam lobe the camshaft experiences a resistive torque. This resistive torque opposes the rotation of the camshaft. This resistive torque increases as the rotation of the camshaft continues until the apex of the cam lobe is reached, at which point the torque due to the reaction of the valve follower is zero. Subsequent rotation of the camshaft results in a positive torque that acts in the direction of rotation. Thus, the camshaft experiences an oscillatory torque during rotation.

[0005] The effect is exacerbated for multiple cylinder engines as the cycle of oscillatory torque generation occurs at a different point in the revolution of the camshaft for each cylinder.

[0006] A camshaft phaser changes the angular orientation of the camshaft. This adjusts the timing of the intake and exhaust valves in an attempt to maximise optimize performance and economy, and to reduce emissions. A camshaft phase allows variable valve timing in relation to the crankshaft.

[0007] Camshaft torque oscillations cause problems for a number of cam phaser arrangements. For example, hydraulic phasers suffer oil leakage due to the oscillatory instability in the angular position of the rotor caused by the torque oscillations. Oil leakage over time can result in poor lubrication and eventually seizing of the engine. Such oil leakage results in a requirement for a larger oil pump than would otherwise be the case in order to meet the phase timing requirements for a hydraulic phaser.

[0008] Typically, geared phasers, such as those employing helical spline or planetary gears, require backlash protection in order to reduce wear and meet phase angle accuracy requirements. The provision of such backlash protection increases the complexity of construction of such phasers.

[0009] However, camshaft torque oscillation may be desirable for cam torque actuated devices that use those camshaft torque oscillations to meet phase timing requirements. Typically, those camshaft torque actuated devices are used at low speed where the camshaft torque oscillations are sufficient to meet phasing requirements, except where rapid phasing is required.

[0010] According to a first aspect of the present invention there is provided a torque oscillation controller for a

camshaft comprising first and second magnetic elements, the first and second magnetic elements being positionable relative to the other of the first and second magnetic elements, wherein the relative positions of the first and second magnetic elements being arranged to either increase or decrease a torque oscillation of the camshaft.

[0011] The reduction of cam shaft torque oscillations reduces oil leakage from hydraulic phasers.

[0012] Also, it obviates the necessity of backlash protection apparatus associated with phasers using gears, thereby reducing the complexity of manufacture of a phaser.

[0013] Additionally, such an arrangement can be used to increase the magnitude of the torque oscillation to allow more rapid phasing than can be achieved currently, where required.

[0014] The first magnetic element may be located internally of the second magnetic element.

[0015] The first magnetic element may comprise a stator. The stator may comprise a cylinder head.

[0016] The first magnetic element may comprise a first plurality of magnets. The first plurality of magnets may be circumferentially spaced about a surface of an annular disc. The first plurality of magnets may be equiangularly spaced about the circumference of the disc.

[0017] Alternatively, at least one of the first plurality of magnets may be mounted upon a surface of a post. The surface of the disc or the post may comprise a surface facing away from the shaft.

[0018] The second magnetic element may comprise a rotor. The rotor may comprise the camshaft.

[0019] The second magnetic element may comprise a second plurality of magnets. The magnets may be circumferentially spaced about a surface of a disc or a channel. Alternatively, at least one of the second plurality of magnets may be mounted upon a surface of a post.

[0020] Either, or both, of the first and second plurality of magnets may comprise a multiple of the number of cylinders comprising the engine.

[0021] The use of magnets in multiples of the number of cylinders aids balance within the rotating system of thereby aiding smooth rotation of the camshaft.

[0022] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a partial sectional view of a camshaft-cylinder head arrangement of a four cylinder four stroke engine comprising an embodiment of a magnetic torque oscillation controller according to an aspect of the present invention;

Figure 2 is a side elevation of the camshaft-cylinder head arrangement of Figure 1;

Figures 2a and 2b are schematic diagrams detailing the effect upon resultant magnetic fields of the alignment of the stator and rotor magnets of an embodi-

ment of a magnetic torque oscillation controller according to an aspect of the present invention, and of the offsetting said stator and rotor magnets by 22.5°, respectively;

Figure 3 is a graphical representation of camshaft torque oscillation reduction achieved employing an embodiment of a magnetic torque oscillation controller according to an aspect of the present invention; and

Figure 4 is a graphical representation of camshaft torque oscillation enhancement achieved employing an embodiment of a magnetic torque oscillation controller according to an aspect of the present invention.

[0023] Referring now to Figures 1 and 2, a camshaft-cylinder head arrangement 100 comprises a camshaft 102 and a cylinder head 104.

[0024] A tube 106 having a circular cross-section is mounted concentrically with the camshaft 102. An open end 108 of the tube terminated adjacent an outer face 109 of the cylinder head 104. An inner face 110 of the tube 106 has rotor magnets 112 located upon it adjacent the open end 108 of the tube 106. The rotor magnets 112 may comprise permanent magnets. Alternatively, or additionally, the rotor magnets 112 may comprise electromagnets.

[0025] In the preferred embodiment shown in Figure 1 there are eight rotor magnets 112 equiangularly spaced about the circumference of the inner face 110. The use of eight magnets in this arrangement is appropriate for a four cylinder four stroke engine.

[0026] The cylinder head 104 comprises an annular block 114 through which the camshaft 102 passes. An annular wall 116 projects perpendicularly away from the outer face 109 of the cylinder head 104. The annular wall 116 is concentric with the block 114 and has a smaller external radius than the internal radius of the tube 106.

[0027] An exterior surface 118 of the wall 116 has stator magnets 120 located upon it remote from the outer face 109 of the cylinder head 104. In the preferred embodiment shown in Figure 1 there are eight magnets 120 equiangularly spaced about the circumference of the exterior surface 118.

[0028] During manufacture of an engine the camshaft 102 and cylinder head 104 are set in an initial position relative to one another. This initial position determines the timing of valve operation.

[0029] At this initial position that the resultant magnetic field due to the interaction of the rotor magnets 112 and the stator magnets 120 at rest is defined.

[0030] The camshaft 102 rotates with respect to the cylinder head 104 causing relative rotation of the rotor magnets 112 with respect to the stator magnets 120. This relative rotation causes the magnetic interaction of the rotor magnets 112 and the stator magnets 120 to vary.

[0031] Figure 2a shows the effect upon resultant magnetic fields of the alignment of the cylinder head and rotor magnets 104,112 to produce minimum camshaft torque.

[0032] Figure 2b shows the effect upon resultant magnetic fields of offsetting the cylinder head and rotor magnets 104,112 by 22.5° to produce maximum camshaft torque.

[0033] The resultant sinusoidal variation in the magnetic forces exerted between the rotor magnets 112 and the stator magnets 120 either oppose or enhance the torque oscillations experienced by the camshaft 102. This is dependent upon the arrangement of the magnets relative to each other.

[0034] In most cases it is desired to reduce camshaft torque oscillations.

[0035] Referring now to Figure 3, total camshaft torque 302 is due to variable friction and torque oscillations. A magnetic torque 304 is in antiphase with the total camshaft torque oscillations 302. This results in a constant resultant torque 306 acting on the camshaft 102 of less than 5Nm, typically about 0.5Nm - 2Nm at 90°C oil temperature.

[0036] Referring now to Figure 4, total camshaft torque 402 is due to variable friction and torque oscillations. A magnetic torque 404 of approximately the same magnitude as the camshaft torque oscillations is in phase with the camshaft torque oscillations 402. This results in a large resultant torque oscillations 406 acting on the camshaft 102 having a peak height of approximately 30Nm.

[0037] Such an arrangement may be useful where cam actuated torque phasers are used, as the increase in the magnitude the torque oscillation allows rapid phasing.

[0038] It will be appreciated that although described with reference to an engine comprising four cylinders the present invention is equally applicable to an engine having any number of cylinders. The number of magnets provided will vary dependent upon the number of cylinders. The number of magnetic pole pairs required varies with the number of cylinders within the engine. For example an engine comprising six cylinders will require six North-South magnetic pole pairs giving a total of twelve magnets on each of the rotor and stator.

[0039] It will be further appreciate that although described with reference to the application of a radial magnetic torque the present invention is equally applicable to the application of an axial magnetic torque.

Claims

1. A magnetic torque oscillation controller for a camshaft (102) comprising first and second magnetic elements (120, 112), the first and second magnetic elements (120, 112) being positionable relative to the other of the first and second magnetic elements (120, 112), wherein the relative positions of the first and second magnetic elements (120, 112) are arranged to either increase or decrease a torque os-

cillation of the camshaft (102).

2. A controller according to claim 1 first magnetic element (120) is located internally of the second magnetic element (112). 5
3. A controller according to either claim 1, or claim 2, wherein first magnetic element (120) comprises a stator. 10
4. A controller according to claim 3 the stator (120) comprises a cylinder head (104).
5. A controller according to any preceding claim wherein the first magnetic element (120) comprises a first plurality of magnets. 15
6. A controller according to claim 5 wherein the first plurality of magnets are circumferentially spaced about a surface of an annular disc (104). 20
7. A controller according to claim 6 wherein the first plurality of magnets are equiangularly spaced about the circumference of the disc (104). 25
8. A controller according to claim 5 wherein at least one of the first plurality of magnets is mounted upon a surface (118) of a post or a wall (116).
9. A controller according to any one of claims 6 to 8 wherein the surface (118) of the disc (104), the post, or the wall (116), comprises a surface facing away from the camshaft (102). 30
10. A controller according to any preceding claim wherein the second magnetic element (112) comprises a rotor. 35
11. A controller according to claim 10 wherein the rotor comprises the camshaft (102). 40
12. A controller according to any preceding claim wherein the second magnetic element comprises a second plurality of magnets. 45
13. A controller according to claim 12 wherein the second plurality of magnets are circumferentially spaced about a surface of a disc or a channel.
14. A controller according to claim 12 wherein at least one of the second plurality of magnets is mounted upon a surface of a post. 50
15. A controller according to any one of claims 5 to 14 wherein either, or both, of the first and second plurality of magnets comprises a multiple of four magnets. 55

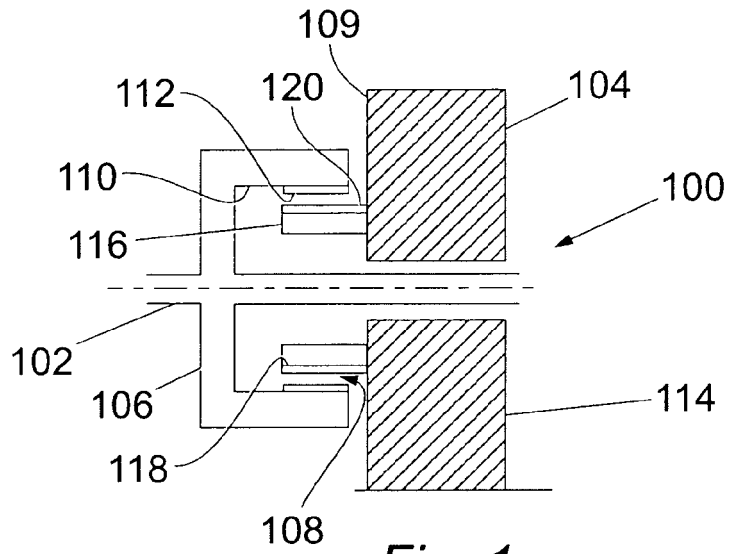


Fig. 1

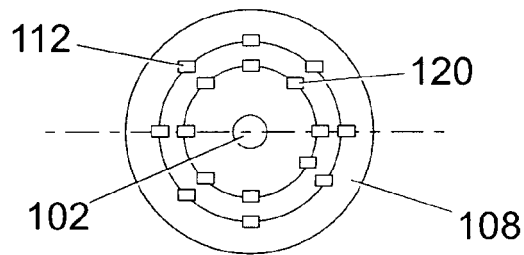


Fig. 2

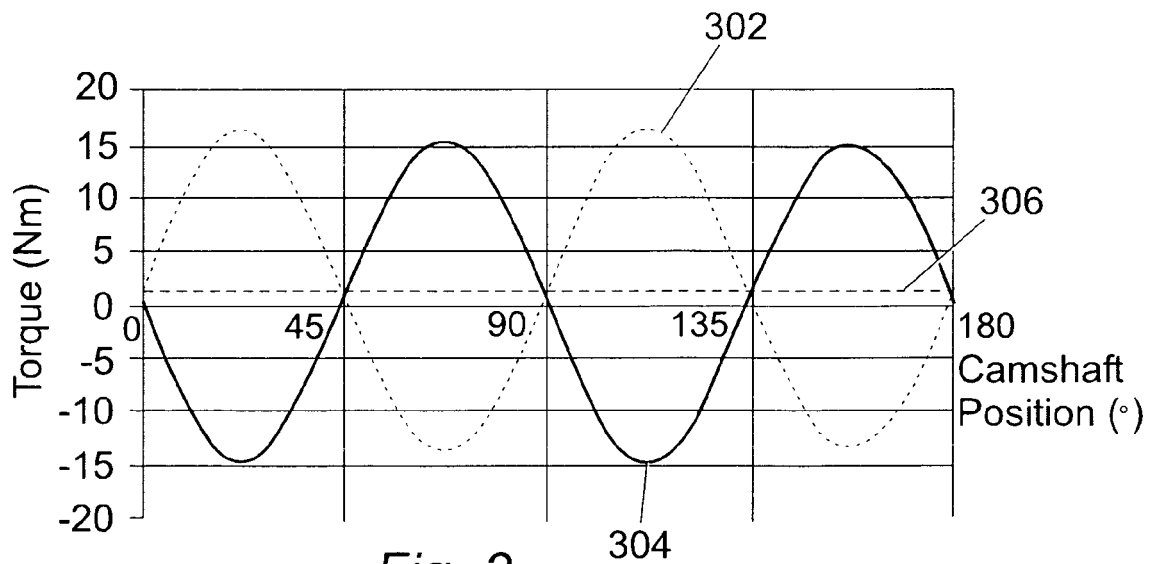


Fig. 3

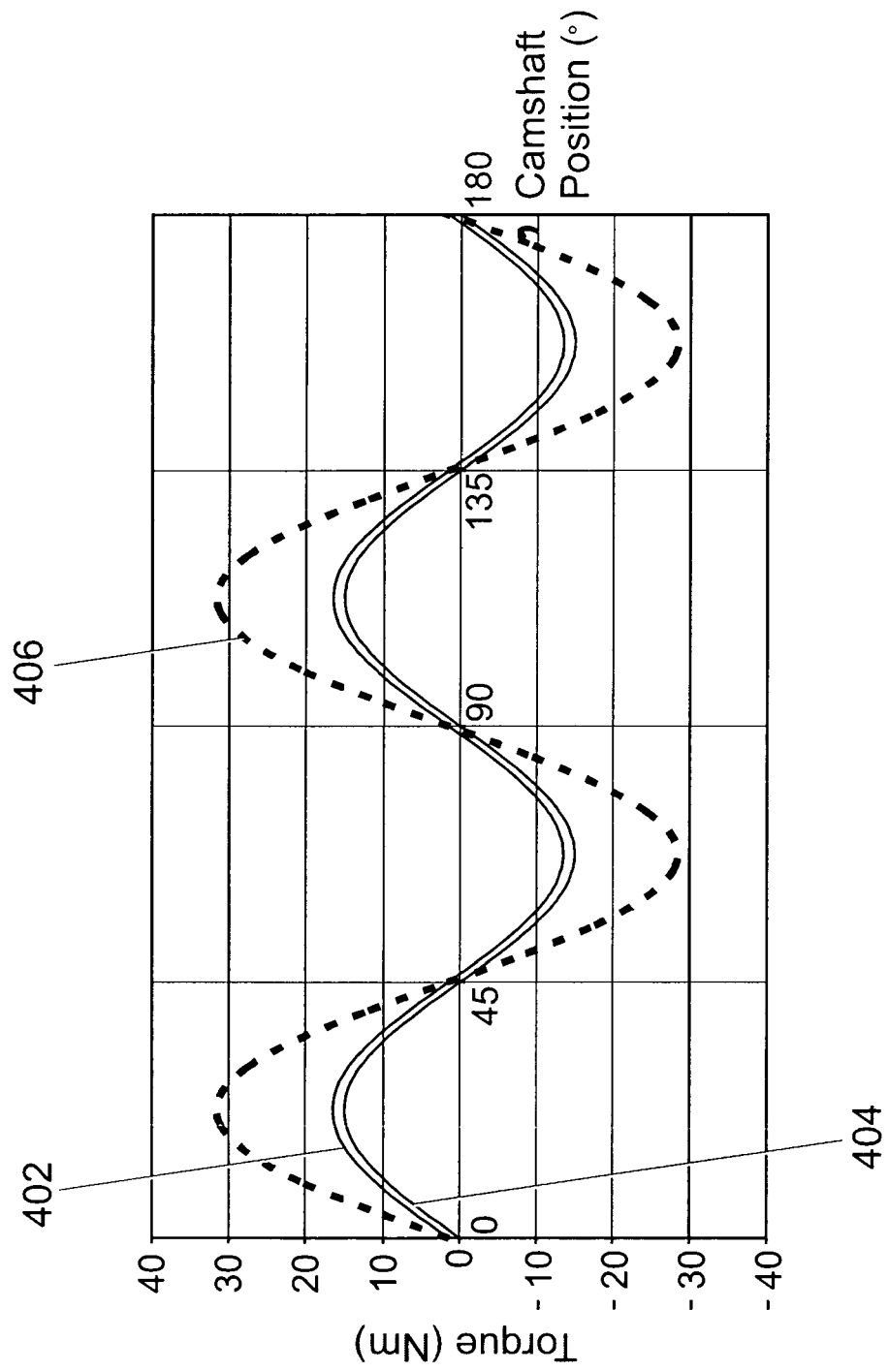


Fig. 4

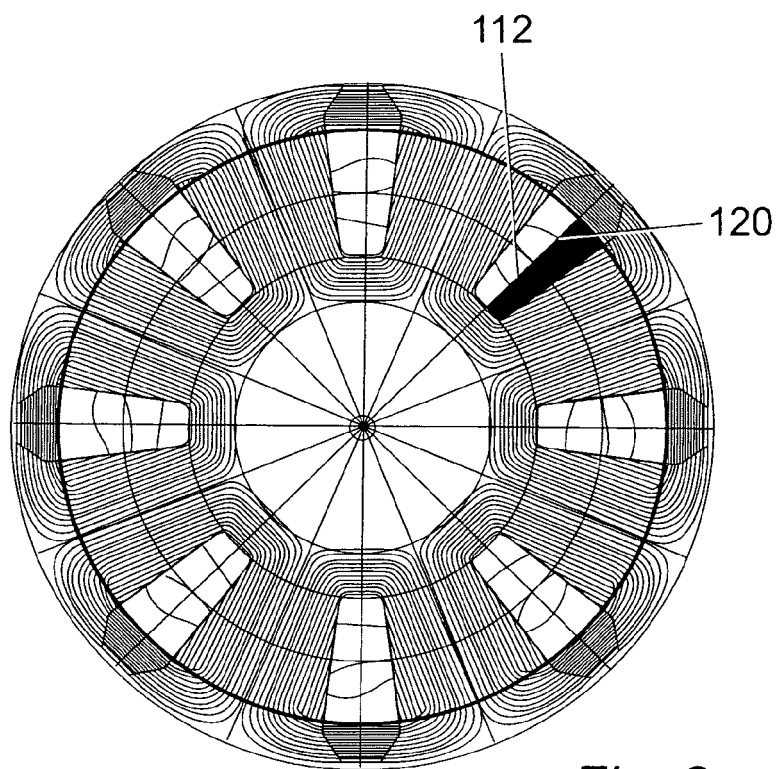


Fig. 2a

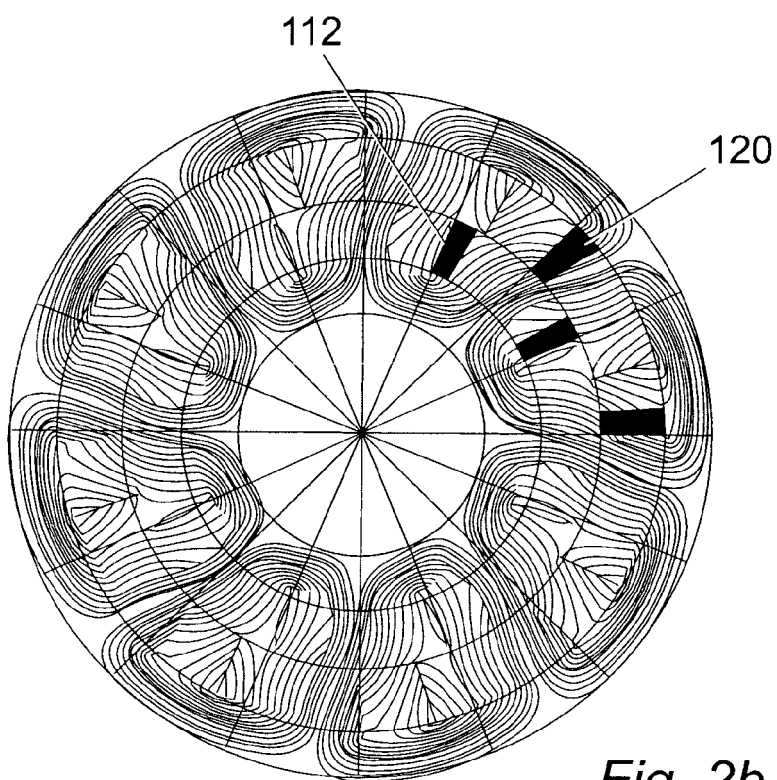


Fig. 2b



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 25 6170

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 10 2004 037261 A1 (INA SCHAEFFLER KG [DE]) 23 March 2006 (2006-03-23) * the whole document *	1	INV. F01L1/344 F01L1/46 F01L1/34
A	GB 1 256 133 A (BRITISH AIRCRAFT CORP LTD [GB]) 8 December 1971 (1971-12-08) * the whole document *	1	
A	US 2005/076867 A1 (TANI HIDEJI [JP]) 14 April 2005 (2005-04-14) * paragraphs [0024] - [0026]; figures *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01L F16F
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 24 May 2007	Examiner Klinger, Thierry
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	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 06 25 6170

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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24-05-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102004037261 A1	23-03-2006	NONE	
GB 1256133 A	08-12-1971	NONE	
US 2005076867 A1	14-04-2005	DE 102004049158 A1	02-06-2005
		JP 2005133708 A	26-05-2005