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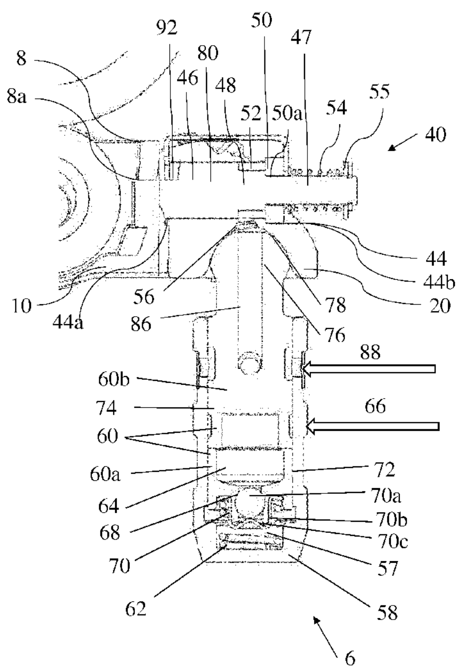

Figure 3b

(57) Abstract: A valve train assembly for providing Exhaust Gas Recirculation (EGR) in a cylinder of internal combustion engine is disclosed. The valve train assembly comprises a rocker arm and a hydraulic lash adjuster (HLA). The rocker arm comprises a first body, a second body mounted for pivotal motion with respect to the first body, and a latch pin moveable between a first position and a second position. The HLA comprises a conduit for suppling hydraulic fluid from a hydraulic fluid supply to the rocker arm in order to move the latch pin from one of the first and second positions to the other of the first and second positions. When the latch pin is in the first position the rocker arm is configured in an EGR active mode and when the latch pin is in the second position the rocker arm is configured in an EGR de-active mode.

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VALVE TRAIN ASSEMBLY

Technical Field

The present invention relates to a valve train assembly, and in particular to a valve train assembly for providing internal Exhaust Gas Recirculation (iEGR) in an internal combustion engine.

Background

With more demanding legislation for Internal Combustion (IC) engines more complex valvetrain assemblies with different functions are required. For diesel engines one of the required functions is an internal Exhaust Gas Recirculation (iEGR). The iEGR function can be achieved with different types of valvetrains with different complexity and different integration costs. Switchable Roller Rocker Arms (RR/A) (also referred to herein as “dual-lift rocker arms”) with external actuation of latching pins (applied to both or just one exhaust position of each cylinder) provides full iEGR functionality for standard Type II valvetrain system with very low integration costs.

Dual lift rocker arms for control of valve actuation by alternating between at least two or more modes of operation are known. Such rocker arms typically involve multiple bodies, such as an inner arm and an outer arm. These bodies are latched together to provide one mode of operation and are unlatched, and hence can pivot with respect to each other, to provide a second mode of operation. Typically, a moveable latch pin is used to switch between the two modes of operation.

WO 2013/156610 A1 [EATON SRL] discloses such a dual lift rocker arm with a moveable latch pin. The default position of the latch pin is unlatched, and it is retained in this position using biasing means. When required, the latch pin is actuated to the latched position using an external actuation mechanism based on a leaf spring. When actuation is required, the leaf spring is controlled to rotate a certain amount so as to engage with a roller of the latch pin, and hence push the latch pin into the latched position.

It is desirable to have alternative, for example more space efficient, actuation mechanisms for actuating the latch pin in such dual-lift rocker arms.

Summary

According to a first aspect of the present invention, there is a valve train assembly for providing Exhaust Gas Recirculation (EGR) in a cylinder of internal combustion engine, the valve train assembly comprising: a rocker arm for operating an engine valve, the rocker arm comprising a first body, a second body and a latch pin, wherein the second body is mounted for pivotal motion with respect to the first body and the latch pin is moveable between a first position in which the latch pin latches the first body and the second body together and a second position in which the first body and the second body are un-latched to allow pivotal motion of the second body relative to the first body; a hydraulic lash adjuster (HLA) for contacting the rocker arm, the hydraulic lash adjuster comprising a conduit for suppling hydraulic fluid from a hydraulic fluid supply to the rocker arm in order to move the latch pin from one of the first and second positions to the other of the first and second positions; wherein, when the latch pin is in the first position the rocker arm is configured in an EGR active mode and when the latch pin is in the second position the rocker arm is configured in an EGR de-active mode.

According to a second aspect of the present invention, there is provided a system comprising the valve train assembly according to the first aspect, and a hydraulic fluid control valve to control the supply of hydraulic fluid to the rocker arm, via the conduit.

Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 illustrates schematically a perspective view of a valve train assembly including a rocker arm;

Figure 2 illustrates another perspective view of the valve train assembly;

Figure 3a illustrates schematically a cross section of the valve train assembly;

Figure 3b illustrates schematically a detail of the cross section of Figure 3a;

Figures 4a and 4b schematically illustrate the valve train assembly at two different points in engine cycle when the inner and outer bodies are latched;

Figures 5a and 5b schematically illustrate the valve train assembly at two different points in engine cycle when the inner and outer bodies are un-latched;

Figure 6 illustrates a graph showing valve lift against cam shaft rotation.

Detailed Description

Figures 1 and 2 illustrate schematically a valve train assembly 1 comprising a rocker arm 2 according to an example. Although the example rocker arm 2 is referred to in the below, it will be appreciated that the rocker arm 2 may be any rocker arm comprising a plurality of bodies that move relative to one another, and which are latched together to provide one mode of operation (first valve-lift mode) and are unlatched, and hence can move with respect to each other, to provide a second mode of operation (second valve-lift mode).

Referring again to the example of Figures 1 and 2, a valve train assembly 1 comprises a rocker arm 2, an engine valve 4 for an internal combustion engine cylinder (not shown) and a hydraulic lash adjustor (HLA) 6. The rocker arm 2 comprises an inner body or arm 8 and an outer body or arm 10. The inner body 8 is pivotally mounted on a shaft 12 which serves to link the inner body 8 and outer body 10 together. A first end 14 of the outer body 10 engages the stem 16 of the valve 4 and at a second end 20 the outer body 10 is mounted for pivotal movement on the lash adjustor 6 which is supported in an engine block (not shown).

The rocker arm 2 is provided with a pair of main lift rollers 22a and 22b rotatably mounted on an axle 24 carried by the outer body 10. One of the main lift rollers 22a is located one side of the outer body 10 and the other of the main lift rollers 22b is located the other side of the outer body 10. The rocker arm 2 is further provided with a secondary lift roller 26, located within the inner body 8 and rotatably mounted on an axle (not visible in Figures 1 and 2) carried by the inner body 8.

A three lobed camshaft 30 comprises a rotatable camshaft 32 mounted on which are first 34 and second 36 main lift cams and a secondary lift cam 38. The secondary lift cam 38 is positioned between the two main lift cams 34 and 36. The first main lift cam 34 is for engaging the first main lift roller 22a, the second main lift cam 36 is for engaging the second main lift roller 22b and the secondary lift cam 38 is for engaging the secondary lift roller 26. The first main lift cam 34 comprises a lift profile (i.e. a lobe) 34a and a base circle 34b, second main lift cam 36 comprises a lift profile 36a and a base circle 36b and the secondary lift cam 38 comprises a lift profile 38a and a base circle 38b. The lift profiles 34a and 36a are substantially of the same dimensions as each other and are angularly aligned. The lift profile 38a is smaller than the lift profiles 34a (both in terms of the height of its peak and in terms of the length of its base) and is angularly offset from them.

The rocker arm 2 is switchable between a dual lift mode which provides two operations of the valve 4 (a valve operation is an opening and corresponding closing of the valve) per engine cycle (e.g. full rotation of the cam shaft 32) and a single lift mode which provides a single operation of the valve 4 per engine cycle. In the dual lift mode, the inner body 8 and the outer body 10 are latched together by a latching arrangement 40 (see Figure 2) and hence act as a single solid body.

With this particular arrangement, the dual lift mode provides a higher main valve lift and a smaller secondary valve lift per engine cycle. The single lift mode provides just the main valve lift per engine cycle. The single lift mode is an example of a first valve-lift mode, and the dual lift mode is an example of a second valve-lift mode of the valve train assembly 1. As will be described in more detail below, in one example, the valve 4 is an exhaust valve and the single lift mode is a normal combustion mode for the cylinder and the dual lift mode is an iEGR mode for the cylinder.

During engine operation in the dual lift mode, as the cam shaft 32 rotates, the first main lift cam's lift profile 34a engages the first main lift roller 22a whilst, simultaneously, the second main lift cam's lift profile 36a engages the second main lift roller 22b and together they exert a force that causes the outer body 10 to pivot about the lash adjuster 6 to lift the valve stem 16 (i.e. move it downwards in the sense of the page) against the force of a valve spring (not shown) thus opening the valve 4. As the peaks of the lift profiles 34a and 36a respectively pass out of engagement with the first main lift roller 22a and the second main lift roller 22b, the valve spring (not shown) begins to close the valve 4 (i.e. the valve stem 16 is moved upwards in the sense of the page). When the first main lift cam's base circle 34b again engages the first main lift roller 22a and the second main lift cam's 36 lift profile engages the second main lift roller 22b the valve is fully closed and the main valve lift event is complete.

As the camshaft 32 continues to rotate, then, the secondary lift cam's lift profile 38a engages the secondary lift roller 26 exerting a force on the inner body

8 which force, as the inner body 8 and the outer body 10 are latched together, is transmitted to the outer body 10 causing the outer body 10 to pivot about the lash adjuster 6 to lift the valve stem 16 against the force of a valve spring (not shown) thus opening the valve 4 a second time during the engine cycle. As the peak of the lift profile 38a passes out of engagement with the secondary lift roller 26 the valve spring (not shown) begins to close the valve 4 again. When the secondary lift cam's base circle 38b again engages the secondary lift roller 26 the valve 4 is fully closed and the second valve lift event for the current engine cycle is complete.

The lift profile 38a is shallower and narrower than are the lift profiles 34a and 36a and so consequently the second valve lift event is lower and of a shorter duration than is the first valve lift event.

In the single lift mode the inner body 8 and the outer body 10 are not latched together by the latching arrangement 40 and hence in this mode, the inner body 8 is free to pivot with respect to the outer body 10 about the shaft 12. During engine operation in the single lift mode, as the cam shaft 32 rotates, when the first main lift cam's lift profile 34a engages the first main lift roller 22a and the second main lift cam's lift profile 36a engages the second main lift roller 22b, the outer body 10 pivots about the lash adjuster 6 and, in an identical way as in the dual lift mode, a main valve lift event occurs. As the camshaft 32 continues to rotate, then, the secondary lift cam's lift profile 38a engages the secondary lift roller 26 exerting a force on the inner body 8. In the single lift mode, however, as the inner body 8 and the outer body 10 are not latched together, this force is not transmitted to the outer body 10 which hence does not pivot about the lash adjuster 6 and so there is no additional valve event during the engine cycle. Instead, as the secondary lift cam's lift profile 38a engages the secondary lift roller 26, the inner body 8 pivots with respect to the inner body 10 about the shaft 12 accommodating the motion that otherwise would be transferred to the outer body 10. A torsional lost motion spring (not shown in Figures 1 and 2) is provided to return the inner body 8 to its starting position relative to the outer body 10, once the peak of the lift profile 38a has passed out of engagement with the secondary lift roller 26.

This arrangement is used to provide switchable Internal Exhaust Gas Recirculation (IEGR) control. The valve 4 is an exhaust valve for an engine cylinder (not shown), the main valve lift acts as the main exhaust lift of a cylinder cycle (i.e a four stroke cycle), and the timing of the secondary valve lift is arranged so that it occurs when an intake valve for that cylinder, controlled by a further rocker arm (not shown) mounted pivotally on a further lash adjuster (not shown) and which pivots in response to an intake cam (not shown) mounted on the cam shaft 32, is open. The simultaneous opening of the intake and exhaust valves in this way ensures that a certain amount of exhaust gas remains in the cylinder during combustion which, as is well known, reduces NOx emissions. Switching to the single lift mode deactivates the IEGR function, which deactivation may be desirable under certain engine operating conditions. As will be appreciated by those skilled in the art, this switchable IEGR control may also be provided if the valve 4 is an intake valve with the timing of the secondary valve lift arranged to occur when an exhaust valve for that cylinder is open during the exhaust part of an engine cycle.

As is best understood from Figure 3a, the secondary lift roller 26 is mounted on a hollow inner bushing/ axle 43 which is supported in apertures (not visible) in the inner body 8. The axle 24 extends through the inner bushing/axle 43 (and hence through the inner roller 26) and the diameter of the axle 24 is somewhat smaller than the inner diameter of the inner bushing/axle 43 to allow movement of the assembly of the inner body 8, axle 43 and inner roller 26 relative to the outer body 10. The main lift rollers 22a and 22b (not visible in Figure 3a) are therefore arranged along a common longitudinal axis and the secondary lift roller 26 is arranged along a longitudinal axis that is slightly offset from this. This arrangement of axles and rollers ensures that the rocker 2 arm is compact and facilitates manufacturing the first and second bodies from stamped metal sheets.

As is best seen from Figure 3b, the latching arrangement 40 comprises a latch pin 80. An open ended latch pin channel or bore 44 is formed in the outer body 10 and extends through the second end 20 of the outer body 10 from a first bore end 44a to a second bore end 44b. The latch pin 80 is slidably disposed in the bore 44, and is slidable between a latched position in which the latch pin 80 extends out of the first bore end 44a so as to latch the inner body 8 and the outer body 10 together, and an unlatched position in which the latch pin 80 does not latch the inner body 8 and the outer body 10 together. A first portion 46 of the latch pin 80 contacts the surface of the outer body 10 defined by the bore 44, a second portion 48 of the latch pin 80 has a diameter less than the diameter of the bore 44, and a third portion 47 of the latch pin has a diameter less than the diameter of the second portion and extends out of the second bore end 44b. The first portion 46 of the latch pin 80 defines an upward facing latch surface 92 for contacting (when the latch pin 80 is in the latched position) a corresponding downward facing latch contact surface 8a of the inner body 8. A seal element 50 is received in the bore 44 and is fixed with respect to the outer body 10. The seal element 50 defines an aperture 50a through which the third portion 47 portion of the latch pin 80 is received and is slidable. A chamber 52 (being a portion of the bore 44) is thereby defined between the seal element 50, the second portion 48 of the latch pin 80, the first portion of the 46 of the latch pin 80, and the outer body 10. The chamber 52 is for receiving pressurised oil via an aperture 56 in a side wall of the outer body 10, the pressurised oil causing the latch pin 80 to slide in the bore 44 from the unlatched position to the latched position (i.e. from right to left in the sense of Figure 3). A biasing means, for example a coil spring 54, is connected at one end to the seal element 50, and at the other end to the third portion 47 of the latch pin 80 via a plate 55 extending around a circumference of the third portion. The spring 54 urges the latch pin 80 to the unlatched position (i.e. to the right in the sense of Figure 3). The default position of the latch pin 80 is therefore unlatched.

As best seen in Figure 3b, the lash adjuster 6 is a hydraulic lash adjuster (HLA). The HLA 6 is used to both accommodate slack between components in the valve train assembly 1, and to deliver pressurised oil to the chamber 52 in the outer body 10 to actuate the latch pin 80.

As best seen in Figure 3b, the HLA 6 comprises a first oil-containing pressure chamber 57 defined between an outer body 58 and a plunger assembly 60 slidably mounted within the outer body 58, and a spring 62 arranged to enlarge the first chamber 57 by pushing the plunger assembly 60 outwardly relative to the outer body 58 to extend the HLA 6 to take up slack in the valve train assembly 1. For example, the outward movement of the plunger assembly 60 relative to the outer body 58 pushes the rocker arm 2 of the valve train assembly 1 away relative to the outer body 58, and any slack in the valve train assembly 1 is thereby removed. The plunger assembly 60 defines a second oil containing pressure chamber 64 which is in fluid communication with the engine's oil supply (not shown) via a first oil feed 66, which oil is delivered at relatively low pressure. An aperture 68 between the first chamber 57 and the second chamber 64 allows oil to flow from the second chamber 64 into the first chamber 57, via a one way valve 70, when the HLA 6 extends. The one way valve 70 comprises a ball 70a captured by a cage 70b and biased by a spring 70c to a position closing the aperture 68. As the plunger assembly 60 moves outwardly, the volume of the first chamber 57 increases and a resulting oil pressure differential across the ball 70a moves it against the bias of the spring 70c, opening the aperture 68 and enabling oil to flow from the second oil chamber 64 into the first oil chamber 57. When the plunger assembly 60 stops moving outwardly, and the oil pressure across the ball 70a equalises, the ball 70a closes the aperture 68 under the action of the spring 70c.

Accordingly, the HLA 6 extends to accommodate any slack in the valve train assembly 1, such as between a cam 34, 36 and a roller 22a, 22b, but, after it is extended, the incompressible oil in the first chamber 57 prevents the plunger assembly 60 being pushed back inwardly of the outer body 58 so that the HLA 6 acts as a solid body. The oil can escape the first chamber 57 only slowly, for example, via a small annular ‘leak-down’ gap 72 defined by closely spaced leak down surfaces of the outer body 58 and the plunger assembly 60. This oil leakage down the leak down surfaces from the first chamber 57 allows the HLA 6 to retract again.

A first portion 60a of the plunger assembly 60 defines the second oil chamber 64, and a second portion 60b of the plunger assembly 60 is adjacent to the first portion 60a. A first end 74 of the second portion 60b contacts the first portion 60a of the plunger assembly 60 and is received in the outer body 58 of the HLA 6. A second end 76 of the second portion 60b extends out beyond the outer body 58, and contacts the outer body 10 of the rocker arm 2 at the end 20. The second end 76 of the second portion 60b is dome-shaped and fits is a correspondingly shaped recess 78 of the outer body 10 of the rocker arm 2. The second portion 60b defines a conduit 86 running from a side wall of the second portion 60b to the apex of the second end 76 of the second portion 60b. The conduit 86 is in fluid communication with a second oil feed 88 which delivers oil of controllable pressure. For example, the second oil feed 88 may be from an oil control valve (not shown) that can be electrically controlled to deliver relatively high pressure oil or relatively low pressure oil to the conduit 86. The conduit 86 is also in fluid communication, via the aperture 56 in the side wall of the outer body 10, with the chamber 52 defined in the outer body 10 of the rocker arm 2. The chamber 52 is therefore in fluid communication with the conduit 86 in the HLA 6 to receive oil from the second oil feed 88. High pressure oil can therefore be controlled to be delivered to the chamber 52 via the conduit 86 defined in the HLA 6 in order to move the latch pin 80 from the unlatched position to the latched position. Conversely, when latching is not required, the oil control valve (OCV) reduces the pressure of the oil in the second oil feed 88, and in turn the latch pin 88 returns to the default unlatched position under the force of the spring 54.

The first oil feed 66 therefore delivers oil to the second oil containing pressure chamber 64 of the HLA 6 in order for the HLA 6 to perform the function of accommodating slack in the valve train 1, and the second oil feed 88 delivers oil of a controllable pressure from an OCV, via the conduit 86 of the HLA 6, to the chamber 52, to control actuation of the latch pin 80 of the rocker arm 2. The HLA 6 may be referred to as a Dual Oil Feed HLA 6.

Figures 4a and 4b illustrate the valve train assembly 1 when the rocker arm 2 is in the single lift mode (i.e. unlatched configuration). For example, the oil control valve (not shown) may be controlled to deliver relatively low pressure oil (or no oil) to the second oil feed 88 (not shown in Figures 4a and 4b). This may be the case when no second valve event is required, that is when no exhaust gas recirculation is required. As a result, there may be oil of relatively low pressure (or no oil) in the chamber 52 of the outer body 10. As a result, the force of the spring 54 acting against the latch pin 80 is sufficient to cause the latch pin 80 to remain in the unlatched position (to the right in the sense of Figures 4a and 4b). In this configuration, the latch pin 80 is positioned so that the latch surface 92 does not extend through the bore end 44a and so does not engage the latch contact surface 8a of the inner body 8. In this configuration, the inner body 8 is free to pivot, with respect to the outer body 10, about the shaft 12 when the secondary roller 26 engages the lift profile 38a and hence there is no additional valve event. It will be appreciated that the amount of movement available to the inner body 8 relative to the outer body 10 (i.e. the amount of lost motion absorbed by the inner body 8) is defined by the size difference between the diameter of the axle 24 and the inner diameter of the inner bushing/axle 43. The torsional spring 67, which is installed over the top of the valve stem 16 and is located inside the inner body 10 by the shaft 12, acts as a lost motion spring that returns the inner body 8 to its starting position with respect to the outer body 10 after it has pivoted.

Figures 5a and 5b illustrate the valve train assembly 1 when the rocker arm 2 is in the dual lift mode (i.e. a latched configuration). For example, the oil control valve (not shown) may be controlled to deliver relatively high pressure oil to the second oil feed 88 (not shown in Figures 5a and 5b). This may be the case, for example, when the second valve event is required, that is, when exhaust gas recirculation is required. As a result, there may be oil of relatively high pressure in the chamber 52 of the outer body 10. The relatively high pressure oil in the chamber 52 exerts a force on the first portion 46 of the latch pin 80 to push the latch pin 80 away from the seal element 50 and out of the first bore end 44a (i.e. to the left in the sense of Figures 4a and 4b). This force is sufficient to overcome the opposing force of the spring 54 acting against the latch pin 80 and hence the latch pin 80 is caused to move forward (i.e. to the left in the sense of Figures 5a and 5b) relative to their positions in the unlatched configuration so that the latch surface 92 does extend through the first bore end 44a so as to engage the latch contact surface 8a of the inner body 8. As explained above, in this configuration, the inner body 8 and the outer body 10 act as a solid body so that when the when the secondary roller 26 engages the lift profile 38a there is an additional valve event, i.e. exhaust gas recirculation occurs.

Advantageously, when the base circle 38b engages the inner bushing/axle 43, the inner bushing axle 43 stops always on the axle 24 which ensures that the orientation of the various components is such that the latch pin 80 is free to move in and out of the latched and unlatched positions.

Figure 4a illustrates the valve train assembly 1 when the rocker arm 2 is in the single lift mode (i.e. the un-latched configuration) at a point in an engine cycle when the main lift rollers 22a and 22b are engaging the respective base circles 34b and 36b of the first main lift cam 34 and the second main lift cam 36. At this point in the engine cycle, the valve 4 is closed.

Figure 4b illustrates the valve train assembly 1 when the rocker arm 2 is in the single lift mode at another point in an engine cycle when the main lift rollers 22a and 22b are engaging the respective peaks of the lift profiles 34a and 36a of the first main lift cam 34 and the second main lift cam 36. At this point in the engine cycle the valve 4 is fully open and the 'maximum lift' of the main valve event is indicated as M.

Figure 5a illustrates the valve train assembly 1 when the rocker arm 2 is in the dual lift mode (i.e. the latched configuration) at a point in an engine cycle when the main lift rollers 22a and 22b are engaging the respective base circles 34b and 36b of the first main lift cam 34 and the secondary lift roller 26 is engaging the base circle 38b of the secondary lift cam 38. At this point in the engine cycle, the valve 4 is closed. Figure 5b illustrates the valve train assembly 1 when the rocker arm 2 is in the dual lift mode at another point in an engine cycle when the main lift rollers 22a and 22b are engaging the respective base circles 34b and 36b of the first main lift cam 34 and the second main lift cam 36 and the secondary lift roller 26 is engaging the peak of the lift profile 38a of the secondary lift cam 38. At this point in the engine cycle the valve 4 is fully open during the additional valve event and the 'maximum lift' of the secondary valve event is indicated as M'.

Figure 6 illustrates a graph in which the Y axis indicates valve lift and the X axis indicates rotation of the cam shaft. In the example of the valve 4 being an exhaust valve, the curve 100 represents the main lift of the exhaust valve during an engine cycle and the curve represents 101 the additional lift of the exhaust valve during the subsequent engine cycle. The curve 102 represents the lift of intake valve (not shown in the figures), during the subsequent engine cycle, operated by an intake rocker arm (again not shown in the Figures) in response to an intake cam (not shown in the Figures) mounted on the cam shaft. It can be seen that the cams are arranged so that in any given engine cycle, the additional smaller opening of the exhaust valve occurs when the intake valve is open to thereby provide a degree of internal exhaust gas recirculation.

As previously mentioned, in an alternative arrangement (not illustrated) the valve 4 is an intake valve rather than an exhaust valve (making the rocker arm 2 an intake rocker arm) and an exhaust rocker arm operates an exhaust valve in response to an exhaust cam mounted on the cam shaft. In this alternative arrangement the cams are arranged so that in any given engine cycle, the additional smaller opening of the intake valve occurs when the exhaust valve is open to thereby provide a degree of internal exhaust gas recirculation.

Although in the above examples referred to the use of oil, it will be appreciated that this need not necessarily be the case, and any hydraulic fluid may be used instead.

Although in the above examples referred to the default position of the latch pin 80 as being unlatched and that oil being supplied to the chamber 52 via the conduit 86 and the second oil feed 88 causes the latch pin to move from the unlatched position (Figures 4a and 4b) to the latched position (Figures 5a and 5b), this need not necessarily be the case, and in other examples the default position of the latch pin 80 may be latched, and oil being supplied to the chamber 52 via the conduit 86 and the second oil feed 88 may instead cause the latch pin 80 to move from the latched position to the unlatched position.

All of the above embodiments are to be understood as illustrative examples of the invention only. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

CLAIMS

1. A valve train assembly for providing Exhaust Gas Recirculation (EGR) in a cylinder of internal combustion engine, the valve train assembly comprising:

a rocker arm for operating an engine valve, the rocker arm comprising a first body, a second body and a latch pin, wherein the second body is mounted for pivotal motion with respect to the first body and the latch pin is moveable between a first position in which the latch pin latches the first body and the second body together and a second position in which the first body and the second body are un-latched to allow pivotal motion of the second body relative to the first body;

a hydraulic lash adjuster (HLA) for contacting the rocker arm, the hydraulic lash adjuster comprising a conduit for suppling hydraulic fluid from a hydraulic fluid supply to the rocker arm in order to move the latch pin from one of the first and second positions to the other of the first and second positions;

wherein, when the latch pin is in the first position the rocker arm is configured in an EGR active mode and when the latch pin is in the second position the rocker arm is configured in an EGR de-active mode.

2. The valve train assembly of claim 1 wherein the rocker arm comprises a latch pin channel in which the latch pin is slidably disposed.

3. The valve train assembly of claim 2 wherein the latch pin channel is in fluid communication with the conduit in the HLA to receive hydraulic fluid from the hydraulic fluid supply in order to move the latch pin from the one of the first and second positions to the other of the first and second positions.

4. The valve train assembly of claim 2 or claim 3 wherein the latch pin channel is formed in the first body.

5. The valve train assembly of claim 4 wherein the latch pin channel is formed in the first body at a first end of the first body, the first end of the first body further defining a first contact region for contacting the HLA.

6. The valve train assembly of any preceding claim further comprising a biasing means for biasing the latch pin latch pin to the one of the first and second positions.

7. The valve train assembly according to claim 6, wherein the biasing means biases the latch pin to the second position, and the rocker arm is arranged such that the supply of hydraulic fluid from the hydraulic fluid supply to the rocker arm moves the latch pin from the second position to the first position against the biasing means.

8. The valve train assembly of any preceding claim wherein a second end of the first body, defines a second contact region for contacting a stem of the exhaust valve.

9. The valve train assembly of any preceding claim wherein the first body comprises first and second members for engaging first and second cam profiles.

10. The valve train assembly of claim 9 wherein the first and second members are rollers mounted either end of a first axle that extends transversely across the first body.

11. The valve train assembly according to claim 9 or claim 10 wherein the second body comprises a third member for engaging a third cam profile.

12. The valve train assembly according to claim 11 wherein the third member is third roller mounted on a second axle.

13. The valve train assembly according to claim 12 when dependent upon claim 10 wherein the first axle extends through an aperture of the second axle.

14. A system comprising the valve train assembly according to any one of claim 1 to claim 13, and

a hydraulic fluid control valve to control the supply of hydraulic fluid to the rocker arm, via the conduit.

15. The system according to claim 14, wherein the hydraulic fluid control valve is controllable to increase a pressure of hydraulic fluid to the rocker arm, via the conduit, in order to move the latch pin from one of the first and second positions to the other of the first and second positions, and is controllable to decrease a pressure of hydraulic fluid to the rocker arm, via the conduit, in order to allow the latch pin to move from the other of the first and second positions to the one of the first and second positions.

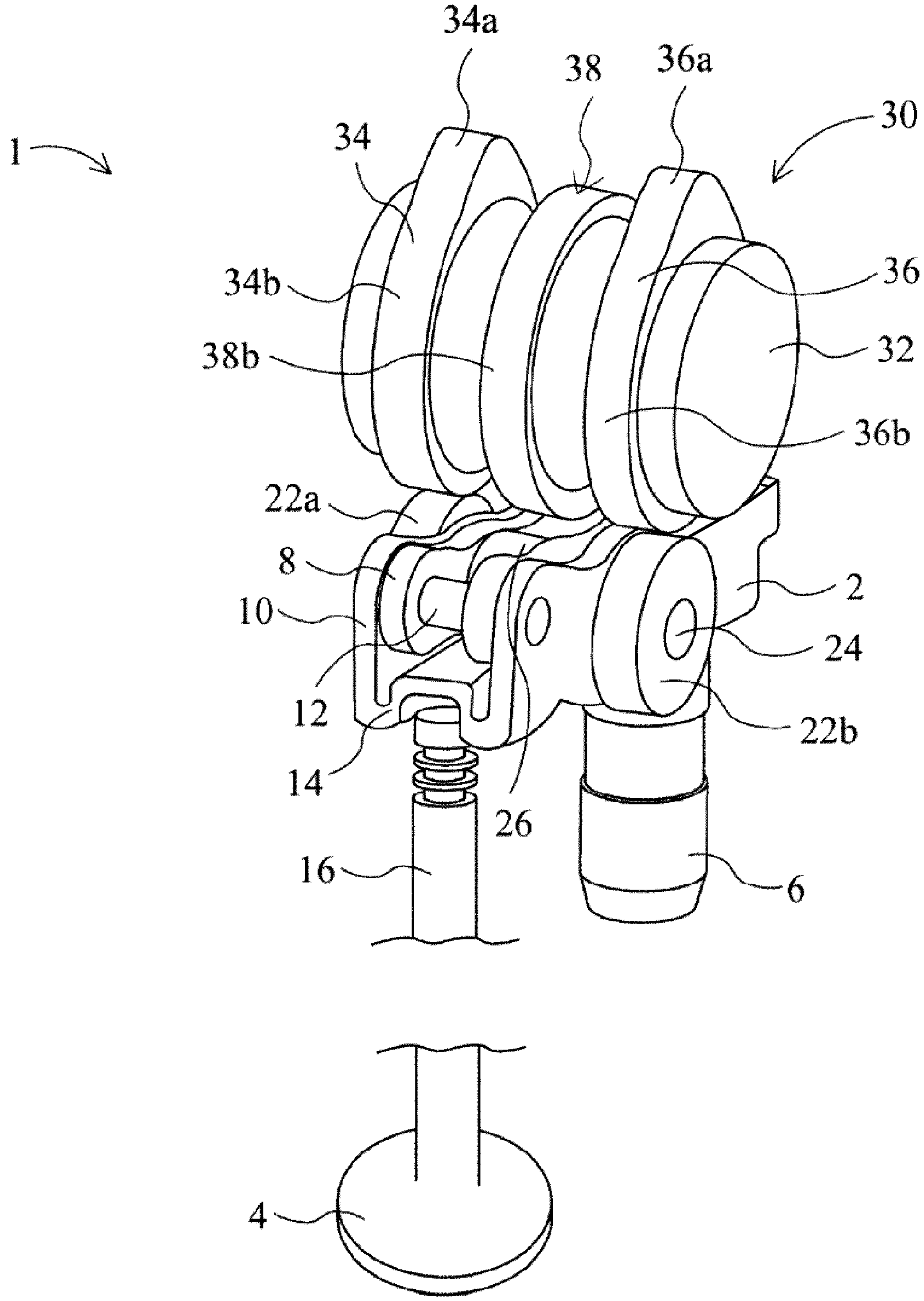
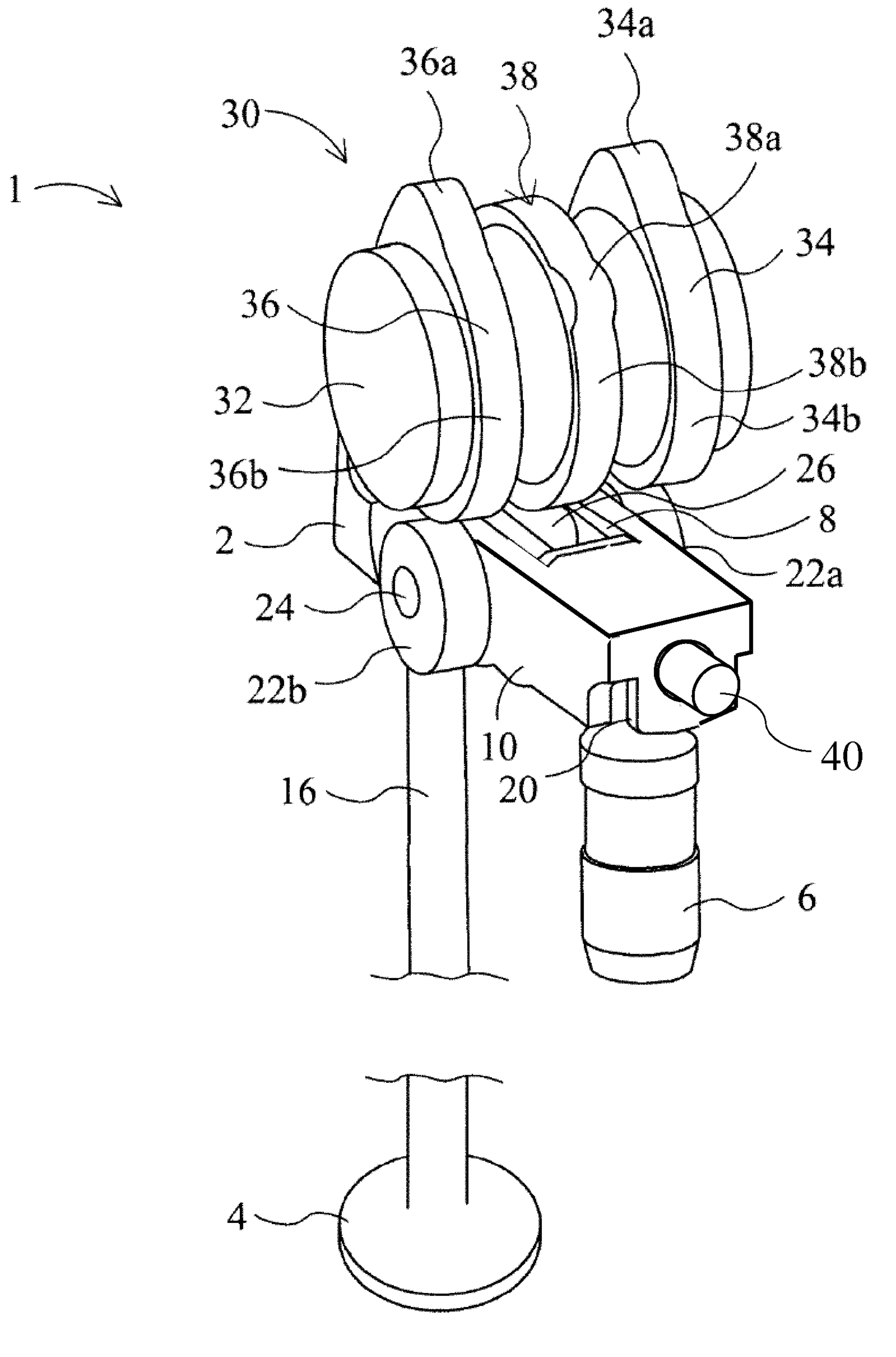


Figure 1


1
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36a
38
34a
38a
34
36
32
38b
34b
36b
26
8
2
22a
24
22b
10
40
20
16
6
4

Figure 2

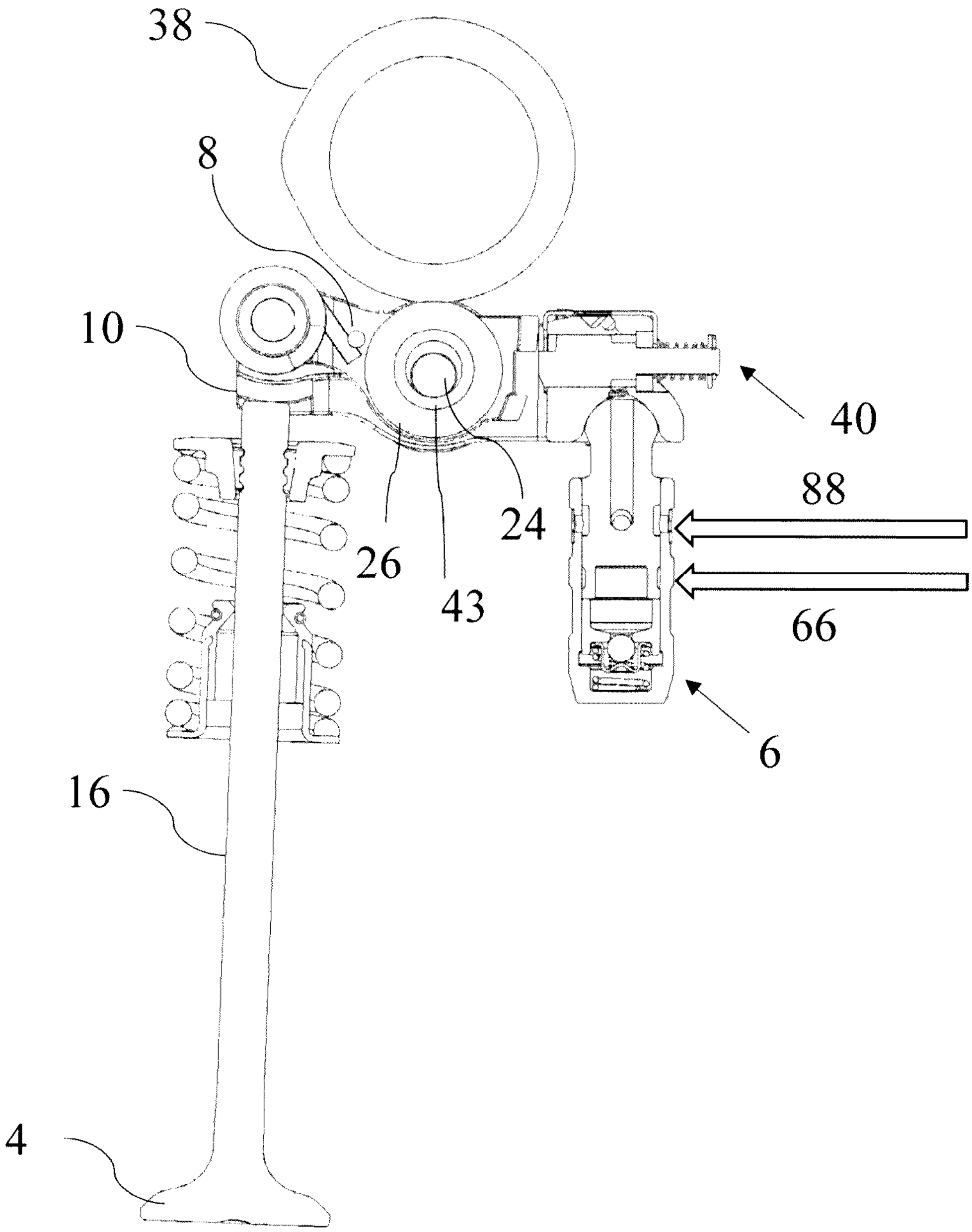
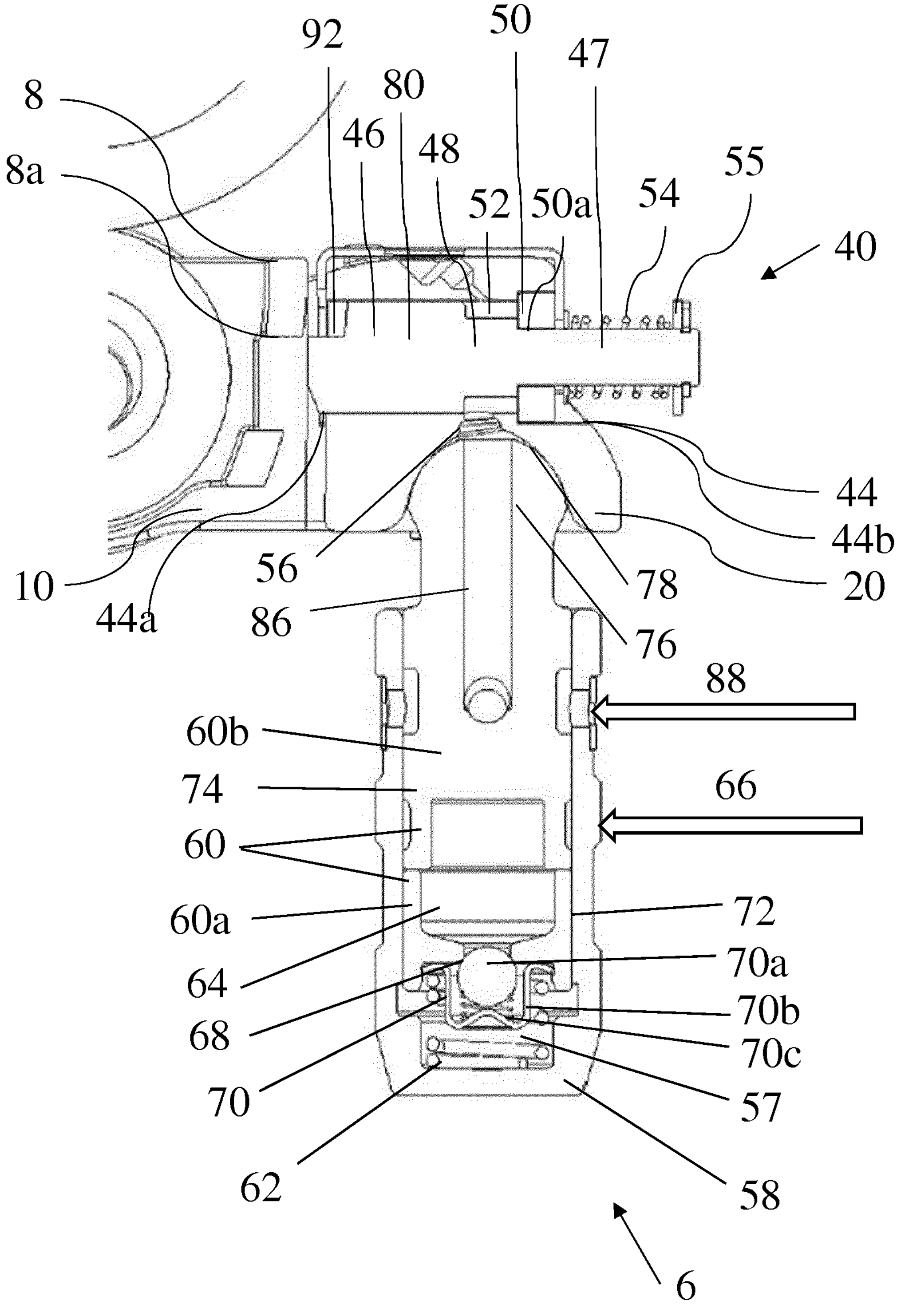


Figure 3a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8a
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50a
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40
44
44b
10
56
78
20
44a
86
76
88
60b
74
66
60
72
60a
70a
64
70b
68
70c
70
57
62
58
6

Figure 3b

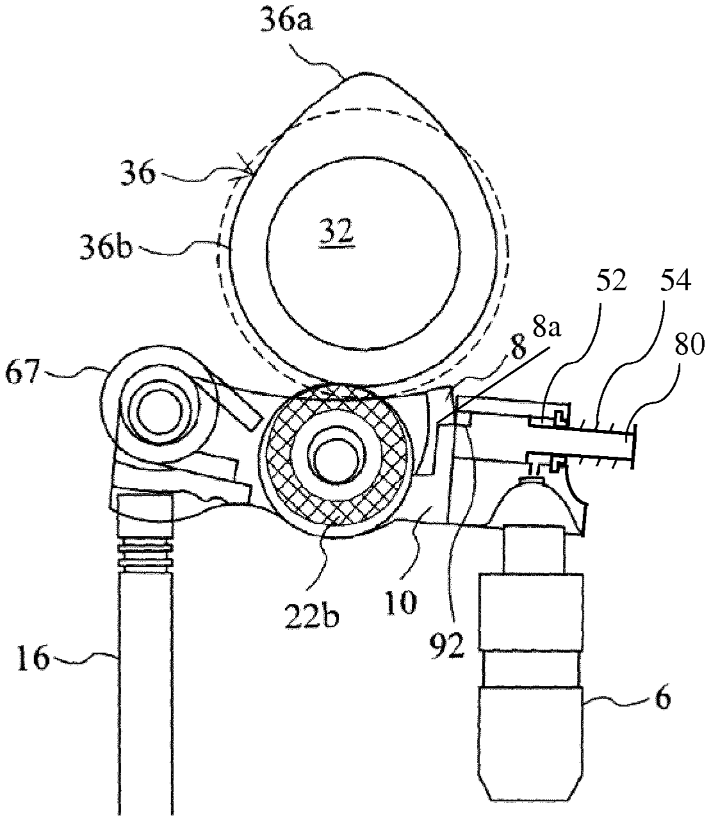

Figure 4a

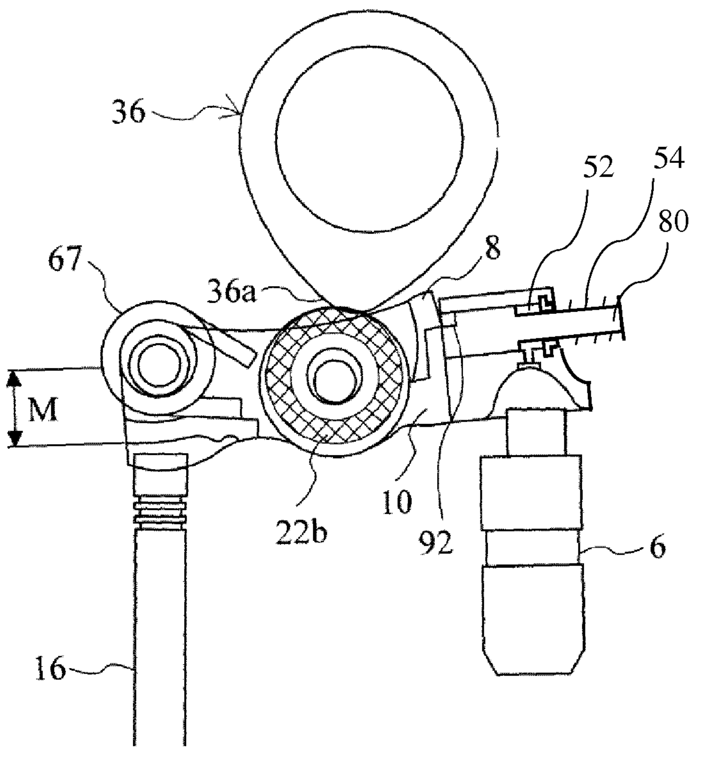

Figure 4b

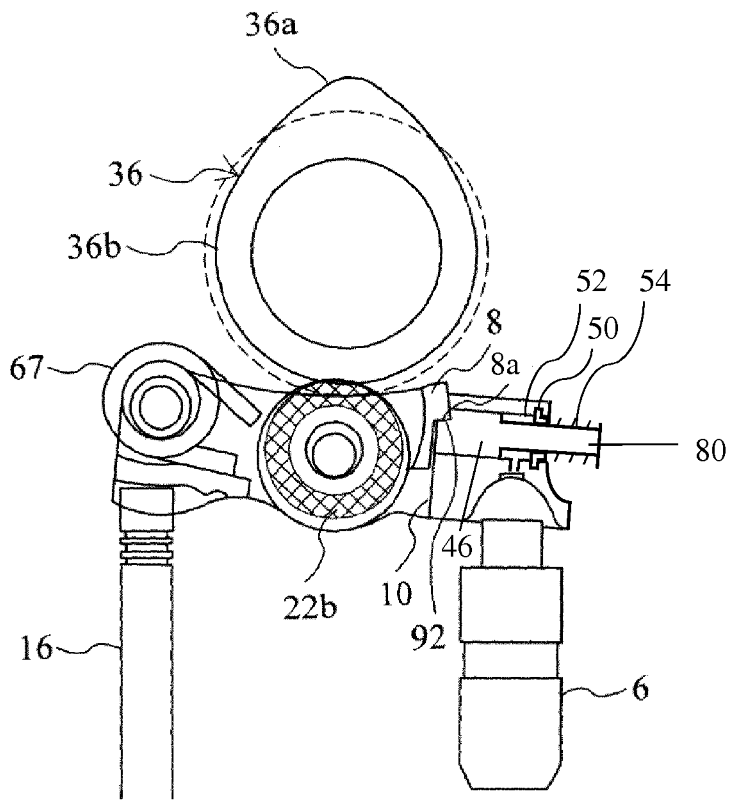

Figure 5a

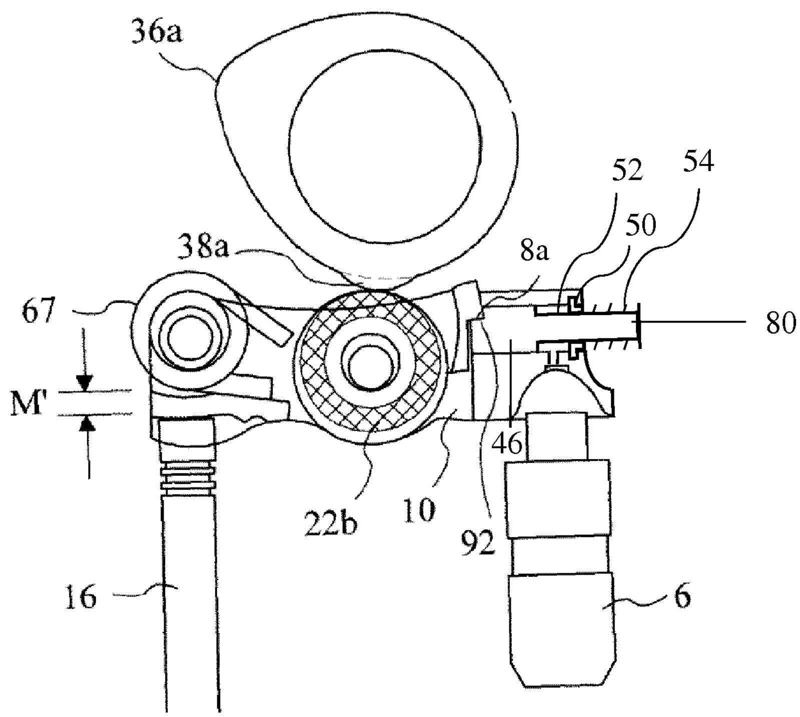

Figure 5b

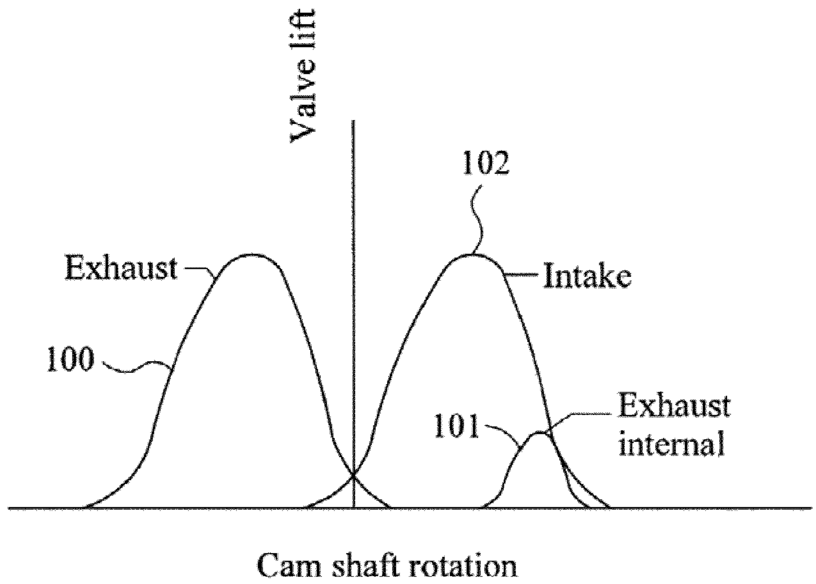
Valve lift
102
Exhaust
Intake
100
Exhaust
internal
101
Cam shaft rotation

Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/074101

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01L1/005 F01L1/46 F01L13/00 F01L1/18
ADD.

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)
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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/144356 A1 (SELLNAU MARK C [US] ET AL) 6 July 2006 (2006-07-06) the whole document -----	1-15
X	EP 2 495 408 A2 (DELPHI TECH INC [US]) 5 September 2012 (2012-09-05) the whole document -----	1-15
X	US 2011/114067 A1 (GONZALEZ DELGADO MANUEL ANGEL [US] ET AL) 19 May 2011 (2011-05-19) the whole document -----	1-15
X	EP 2 770 174 A1 (EATON CORP [US]) 27 August 2014 (2014-08-27) the whole document -----	1-15
X	US 2009/078225 A1 (HENDRIKSMA NICK J [US]) 26 March 2009 (2009-03-26) the whole document -----	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 December 2016	12/12/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Klinger, Thierry

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/074101

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EP 2770174 A1	27-08-2014	CN 104047655 A CN 204082242 U EP 2770174 A1	17-09-2014 07-01-2015 27-08-2014
US 2009078225 A1	26-03-2009	NONE	