



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**14.06.2023 Bulletin 2023/24**

(21) Application number: **21212949.8**

(22) Date of filing: **07.12.2021**

(51) International Patent Classification (IPC):  
**F01L 1/18** <sup>(2006.01)</sup> **F01L 1/20** <sup>(2006.01)</sup>  
**F01L 1/26** <sup>(2006.01)</sup> **F01L 13/00** <sup>(2006.01)</sup>  
**F01L 13/06** <sup>(2006.01)</sup> **F01L 1/46** <sup>(2006.01)</sup>

(52) Cooperative Patent Classification (CPC):  
**F01L 13/0005; F01L 1/181; F01L 1/205; F01L 1/26;**  
**F01L 13/0063; F01L 13/06; F01L 2001/186;**  
**F01L 2001/467; F01L 2305/00**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB**  
**GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO**  
**PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**  
Designated Validation States:  
**KH MA MD TN**

(71) Applicant: **AVL Hungary Kft.**  
**1115 Budapest (HU)**

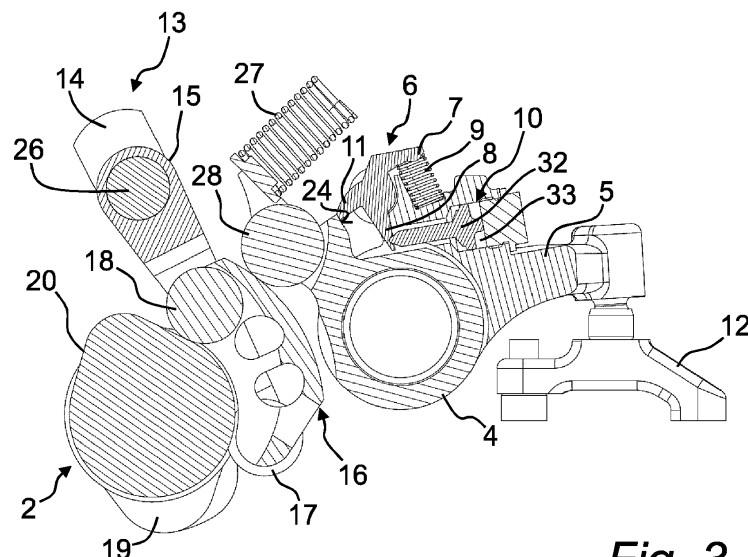
(72) Inventors:  
• **TOTH, Gyula**  
**Nagytarcsa (HU)**  
• **SZEBÉNYI, András**  
**Budapest (HU)**  
• **HEIMLER, Tamás**  
**Dabas (HU)**

(74) Representative: **Hahner, Ralph**  
**Wallinger Ricker Schlotter Tostmann**  
**Patent- und Rechtsanwälte Partnerschaft mbB**  
**Zweibrückenstraße 5-7**  
**80331 München (DE)**

(54) **INTERNAL COMBUSTION ENGINES WITH VARIABLE VALVE ACTUATION**

(57) The invention concerns an internal combustion engine (1) having a camshaft (2) and valves (3), comprising:  
a first rocker arm part (4);  
a second rocker arm part (5), wherein the first rocker arm part (4) and the second rocker arm part (5) are pivotally mounted; and  
a latch (6) for activating a transmission of an actuation motion between the camshaft (2) and at least one valve

(3);  
wherein, in a first rotational position, a latch (6) form-fittingly engages with a contact surface (24) of the first rocker arm part (4) such that a valve actuation motion is transmittable from the camshaft (3) of the internal combustion engine (1) via the first rocker arm part (4) and the second rocker arm part (5), and, in a second rotational position of the latch (6), enables a relative movement of the first rocker arm part (4) and the second rocker arm part (5).



**Fig. 3**

**Description**

**[0001]** The invention concerns an internal combustion engine having a camshaft and valves for charging and discharging combustion chambers comprising a first rocker arm part and a second rocker arm part, wherein the first rocker arm part and the second rocker arm part are pivotably mounted.

**[0002]** Internal combustion engines with variable valve actuation are basically known from the prior art.

**[0003]** Due to the ever-increasing requirements in terms of performance, efficiency and emissions, variable valve actuation, i.e. valve actuation with variable valve lift, are becoming more and more important in reciprocating internal combustion engines, especially in four-stroke and six-stroke reciprocating internal combustion engines.

**[0004]** Variable valve trains can be used to meet the need of internal combustion engine designers and the desire of thermodynamics to alternatively transmit different valve lift curves to one or more valves, in particular depending on the operating situation of the internal combustion engine, whereby both the valve lift and the opening and closing times can be adjusted.

**[0005]** This is generally achieved by a changeover in the transmission path of the valve train. Stroke changeover and stroke shutdown systems with switchable cam followers, such as bucket tappets, roller tappets or rocker arms, are in series production in various applications. The rule here is that for each additional alternative valve stroke, there must also be a corresponding cam as a stroke-generating element - unless the alternative stroke is a zero stroke.

**[0006]** There are different areas of application for the use of valve trains with variable or variable valve lift. Some examples are listed below:

**Stroke switching:** Stroke switching enables the use of at least two different valve lifts depending on the operating point. A smaller valve lift is especially adapted to the part-load range, improving the torque curve and reducing consumption and emissions. The large valve lift can be optimized to further increase performance. A smaller valve lift with lower maximum lift and shorter event length enables a reduction in charge change work (Miller cycle) due to a significantly earlier intake closing time and throttling in the intake tract. Similar results are possible with the Atkinson cycle, i.e., extremely late intake closing. Optimum filling of the combustion chamber still results in a torque increase in the part-load range.

**[0007]** Cylinder deactivation: Cylinder deactivation is used primarily for large-volume, four-stroke engines (for example with four, eight, ten or twelve engine cylinders). In this process, selected engine cylinders are shut down by stroke deactivation at the intake and exhaust valves; complete decoupling from the cam lift takes place. Due to equidistant firing sequences, common V8 and V12 engines can be switched to A4 or R6 engines. The purpose of engine cylinder deactivation is to minimize charge exchange losses and perform an operating point shift toward higher center pressures and thus higher thermodynamic efficiencies, resulting in significant fuel savings.

**[0008]** Engine braking operation: Engine braking systems that enable engine braking operation are becoming increasingly important in vehicle internal combustion engines, especially for commercial vehicles, as they are cost-effective and space-saving auxiliary braking systems that can relieve the wheel brakes, especially on longer downhill journeys. In addition, the increase in the specific power of modern commercial vehicle engines also requires an increase in the braking power to be achieved.

**[0009]** To achieve an engine braking effect, it is known to provide additional macro valves in the engine cylinders of an internal combustion engine, with which so-called decompression braking can be carried out by decompressing the cylinder via the additional engine valves at the end of the compression stroke, particularly in the case of a four-stroke engine or a six-stroke engine. As a result, the work done on the compressed gas escapes via the exhaust system of the internal combustion engine. Furthermore, the internal combustion engine must again expend work to refill the cylinder with gas. Among other things, it is known to generate an engine braking effect via a variable valve train of the actual exhaust valves.

**[0010]** Various systems and concepts are known for changing the valve lift. In particular, it is known to provide a mechanical or hydraulic coupling device between one or more valve actuating elements of a valve actuating device transmitting a cam lift, by means of which a changeover in the transmission path of the valve train can be achieved.

**[0011]** For example, document US 2014/0326212 A1 shows a system for variable valve control, in particular for generating an engine braking effect, which has a "lost motion" device with hydraulically actable locking elements for selectively locking or releasing a valve actuation mechanism so that valve actuation movements are selectively transmitted or not transmitted to one or more valves in order to change the valve lift and thereby generate an engine braking effect. The disclosure of that document is incorporated by reference in the present application.

**[0012]** In document WO 2015/022071 a valve actuating device for actuating at least a first valve of a reciprocating engine, in particular an internal combustion engine, is disclosed, which can be used for engine braking and which comprises a first rocker arm part, a second rocker arm part, and a first switching element for changing the valve lift of the at least one first valve, wherein the first rocker arm part and the second rocker arm part are pivotably mounted and are arranged in such a way that at least one first valve control movement can be transmitted from a first camshaft via the first rocker arm part and the second rocker arm part to the at least one first valve. The disclosure of that document

is incorporated by reference in the present application.

**[0013]** Document WO 2019/025511 A1 relates to a coupling device for a valve actuating device for actuating at least one valve of a reciprocating engine with variable valve lift, in particular for a valve actuating device of a reciprocating internal combustion engine, a valve actuating device and a reciprocating engine. The coupling device comprises a first coupling element, a second coupling element and a locking device. The first coupling element and the second coupling element can be displaced relative to one another at least within defined limits along a first axis. It is possible to block the relative displacement of the two coupling elements with respect to one another along the first axis at least in a first direction by means of the blocking device. The blocking device comprises a blocking element rotatable about the first axis at least in a defined range in the circumferential direction, wherein the relative displacement of the two coupling elements along the first axis is blocked at least in the first direction when the blocking element is in a blocking position. The disclosure of that document is incorporated by reference in the present application.

**[0014]** Document AT 50710/2020 relates to a valve actuating device for actuating a valve of a reciprocating engine, comprising a coupling device with a blocking element which can be brought into a first and second position by means of a mechanical switching device for actuating the coupling device, wherein the valve actuating device transmits an actuating movement for the valve in the first position, and wherein the switching device comprises: a guide rod and a parallel, relatively movable actuating rod; a gate guide element movably mounted on the guide rod for moving the locking element between the positions; a release element coupled to the gate guide element, the gate guide element and the release element being clamped by means of spring elements between two stops of an actuating rod, to each of which a spring element is assigned, the gate guide element and the release element being displaceable with the actuating rod in the direction along and/or parallel to the guide rod, and a blocking element cooperating with the release element, so that in a first state the blocking element, upon displacement of the actuating rod in the axial direction, blocks a displacement of the release element and the link guide element in such a way that spring elements are preloaded, and in a second state a displacement of the release element and link guide element causes actuation of the coupling device. The disclosure of this document is also incorporated by reference in the present application.

**[0015]** It is an object of the invention to provide an improved internal combustion engine with variable valve control. In particular, it is an object of the invention to provide a variable valve actuation for variable valve control which can clock the valve lift changeover precisely.

**[0016]** This object is solved by an internal combustion engine according to the independent patent claims. Advantageous embodiments are claimed in the dependent claims.

**[0017]** An aspect of the invention concerns an internal combustion engine having a camshaft and valves for charging and discharging combustion chambers, comprising:

a first rocker arm part,

a second rocker arm part,

wherein the first rocker arm part and the second rocker arm part are pivotably mounted, and

a latch for activating and deactivating a transmission of an actuation motion between the camshaft and at least one valve,

wherein the latch is pivotably mounted on the second rocker arm part and, in a first rotational position of the latch, form-fittingly engages with a contact surface of the first rocker arm parts such that a valve actuation motion is transmittable from the camshaft of the internal combustion engine via the first rocker arm part and the second rocker arm part to the at least one valve, and, in a second rotational position of the latch, enables a relative movement of the first rocker arm part and the second rocker arm part with respect to each other.

**[0018]** The invention relies on the approach to realize a variable valve actuation by a split rocker arm, wherein a first rocker arm part and a second rocker arm part can be blocked with respect to each other by a pivotable mechanical element. According to the invention, this is realized by a pivotably mounted latch which is fixed to one of the rocker arm parts and form-fittingly engages with a contact surface of the other rocker arm part when in a locked position.

**[0019]** The pivotably mounted latch allows a switching of the variable valve actuation during only one combustion cycle. Furthermore, the latch can be realized that it is itself-locking in the locked position, such that no additional force is needed to keep the latch in its locked position. For example, a nose of the latch and the contact surface cooperating with this nose can be formed in such a manner, that the latch is blocked when being in the locked position.

**[0020]** All in all, the latch provides a simple and easy mechanism to block and unblock the relative movement of a first rocker arm part and a second rocker arm part of a split rocker arm.

**[0021]** In an advantageous embodiment of the internal combustion engine, the latch comprises a first lever and a

second lever extending at least partially in radial direction with respect to a rotational axis of the latch, wherein the second rocker arm part comprises a first spring engaging with the first lever and the first hydraulic or pneumatic means engaging with the second lever, wherein the first hydraulic or pneumatic means works against a spring force to set the rotational position of the latch.

**[0022]** By using a first hydraulic or pneumatic means working against the spring force of the first spring, the switching of the variable valve actuation can be achieved by a comparatively low oil volume flow. Furthermore, by the use of a spring together with a latch engaging form-fittingly with a contact surface, and therefore a relatively small spring force, the pressure to open the blocking mechanism realized by the latch can be kept relatively small, such as only 2 bar and below.

**[0023]** In a further advantageous embodiment of the combustion engine, extremal switch position of the first hydraulic or pneumatic means define the first and second rotational positions of the latch, respectively. Preferably, the latch occupies the first rotational position, in which the first rocker arm part and the second rocker arm part are blocked in movement with respect to each other, if the first hydraulic or pneumatic means is in a relaxed state. This means, that if only a low or zero oil pressure can be provided to the first hydraulic or pneumatic means, a regular engine operation with an activated valve is set as default. This is especially important at engine start when the oil pump of the internal combustion engine does not yet deliver pressure. Ideally, the provision of a pump or reservoir to build up pressure before the engine start can be omitted.

**[0024]** In a further advantageous embodiment of the internal combustion engine, the latch further comprises a first nose extending at least partially in radial direction with respect to a rotational axis of the latch and adapted to engage with the contact surface of the first rocker arm part. The provision of a nose is particularly advantageous in a self-blocking arrangement of the contact surface and the first nose.

**[0025]** In a further advantageous embodiment of the internal combustion engine, the first rotational position and the second rotational position of the latch define a rotation angle of approximately 10 degrees, preferably approximately 5 degrees. With such small rotation angles, only a small movement of the latch is needed to change the operating mode of the rocker arm.

**[0026]** In a further advantageous embodiment of the internal combustion engine, the first rocker arm part engages with the camshaft, and the rocker arm part engages with a valve or a valve bridge.

**[0027]** In a further advantageous embodiment, the internal combustion engine further comprises a phaser unit, the phaser unit comprising a phaser shaft, a phaser lever, and a cart, wherein the cart has a first wheel arrangement engaging with the first cam of the camshaft and a second wheel arrangement engaging with a second cam of the camshaft, wherein the phaser lever connects the phaser shaft of the cart in such a manner that a change of position of the phaser lever changes the rotational position of the cart with respect to the camshaft. By providing the phaser unit, the valve lift curve with respect to the cam angle can be modified. In particular, the timing and the maximum opening of the valve can be modified. This is particularly advantageous during engine warm-up.

**[0028]** In a further advantageous embodiment, the first rocker arm engages with a tread of the cart, and the second rocker arm engages with a valve or a valve bridge.

**[0029]** In a further advantageous embodiment, the internal combustion engine comprises a third rocker arm pivotably mounted besides the first rocker arm and having the same rotational axis as the first rocker arm, wherein the latch has a second nose and a third lever, both extending at least partially in radial direction with respect to a rotational axis of the latch, wherein the latch is pivotably mounted on the second rocker arm part and engages with second pneumatic or hydraulic means of the second rocker arm part and wherein the second nose, in a third rotational position of the latch, form-fittingly engages with a contact surface of the third rocker arm part such that a valve actuation motion is transmittable from the camshaft of the internal combustion engine via the third rocker arm part and the second rocker arm part to the at least one valve. By providing a third rocker arm part connectable by the latch to the second rocker arm part, two independent valve actuation motions from two different cams on the camshaft, for example an intake-cam and an Atkinson-cam can be transmitted independently or in combination to the valve.

**[0030]** In a further advantageous embodiment of the internal combustion engine, an extremal switch position of the second hydraulic or pneumatic means defines the third rotational position of the latch.

**[0031]** In a further advantageous embodiment of the internal combustion engine, the second hydraulic or pneumatic means comprises a second spring and works against the spring force generated by the second spring to set the rotational position of the latch. By this, a control switching of the latch between the first and the second rotational positions and the third rotational position can be realized. The third rotational position can be used for a third function, for example cylinder deactivation.

**[0032]** In a further preferred embodiment of the internal combustion engine, the contact surface and/or the surface of the first and/or second nose is hardened. By this, wear of the stressed surface and nose can be reduced.

**[0033]** In a further preferred embodiment of the internal combustion engine, the first rotational position and the third rotational position of the latch define a rotation angle of approximately 15 degrees, preferably 10 degrees.

## Figures

**[0034]** Further advantages and features of the invention are described in the following specification referring to the Figures. These depict at least partly schematically as follows:

- Figure 1:** An embodiment of an internal combustion engine;
- Figure 2:** a perspective view of a first embodiment with split rocker arm;
- Figure 3:** a sectional view of the split rocker arm according to Figure 2;
- Figure 4a:** an embodiment of a switching mechanism with a latch in a second rotational position;
- Figure 4b:** the switching mechanism according to Figure 4a with the latch in a first rotational position;
- Figure 5:** a perspective view of a second embodiment of a split rocker arm;
- Figure 6:** a side view of the second embodiment of a split rocker arm according to Figure 5;
- Figure 7:** a sectional view of the second embodiment of a split rocker arm according to Figures 5 and 6;
- Figure 8:** a perspective view of a rocker arm with an embodiment of a phaser unit;
- Figure 9:** a side view of the rocker arm with the embodiment of a phaser unit according to Figure 8;
- Figure 10a:** a side view of the embodiment of a phaser shift unit according to Figures 8 and 9 in a first switching state;
- Figure 10b:** a valve lift as a function of a crankshaft angle in the first switching state according to Fig. 10a;
- Figure 11a:** a side view of the embodiment of a phaser shift unit according to Figures 8 and 9 in a second switching state;
- Figure 11b:** a valve lift as a function of a crankshaft angle in the first switching state according to Fig. 11a;
- Figure 12:** an exploded view of a third embodiment of a split rocker arm;
- Figure 13:** a top view of the third embodiment of a split rocker arm according to Figure 12;
- Figure 14:** a sectional view of the third embodiment of a split rocker arm in plane A-A of Figure 13;
- Figure 15:** a sectional view of the third embodiment of a split rocker arm in plane B-B of Figure 13; and
- Figure 16:** a sectional view of the third embodiment of a split rocker arm in plane C-C of Figure 13.

**[0035]** **Figure 1** depicts an embodiment of an internal combustion engine 1 comprising a camshaft 2 for actuating valve 3. Actuation motion is transmitted from camshaft to the valves 3 via a split rocker arm 4/5 comprising a first rocker arm part 4 and a second rocker arm part 5.

**[0036]** **Figure 2** depicts a first embodiment of a split rocker arm 4/5 comprising a phaser shift mechanism 13 for transmitting a valve motion from the camshaft to a valve bridge 12 actuating the valves 3.

**[0037]** The mechanism shown in Figure 2 has a first rocker arm part 4 and a second rocker arm part 5. The second rocker arm part 5 has a pivotable latch 6, which is able to block, depending on its rotational position, a relative movement between the first rocker arm part 4 and the second rocker arm part 5. In the rotational position shown in Figure 2, the latch 6 blocks the relative movement.

**[0038]** Preferably, the latch 6 has a first nose 11 and a first lever 7. As shown in Figure 2, these extend at least partially in radial direction with respect to a rotational axis of the latch 6.

**[0039]** The first rocker arm part 4 cooperates with the phaser shift mechanism, in particular with a cart 16 of a phaser shift mechanism. A cart 16 cooperates with a first cam 19 and a second cam 20 on the camshaft 2. As depicted in Fig. 2, cam 19 may be a two-fold cam, where both cams 19 interact with the cart 16.

**[0040]** On the other hand, the cart 16 is connected via a phaser connection 15 to a phaser lever 14 which is actuated by a phaser shaft 26. When the phaser shaft 26 turns around its axis, the phaser connection 15 converts the rotational movement of the phaser lever 14 in a linear movement of the phaser connection 15 changing the position of the cart 16 with respect to the camshaft 2.

**[0041]** The first rocker arm part 4 is preferably biased by a spring 27 towards the cart 16 and the camshaft 2. This assures that the first rocker arm part 4 stays in contact with the cart 16 as well as the cart 16 stays in contact with the camshaft 2, in particular the first cam 19 and the second cam 20.

**[0042]** **Figure 3** depicts a sectional view of the embodiment of the mechanism according to **Figure 2**.

**[0043]** The elements shown in **Figure 3** are the same as shown in **Figure 2**, however, some details become apparent only from **Figure 3**. For example, it becomes apparent that the second rocker arm part 4 interacts with the cart 16 via a roller 28 being mounted to the first rocker arm part 4.

**[0044]** Furthermore, the cart 16 preferably interacts with the first cam 19 via a first roller 17 being mounted to the cart and with the second cam 20 with a second roller 18 also being mounted to the cart 16.

**[0045]** Additional to the first nose 11 and the first lever 7, latch 6 has a second lever 8. This lever 8 also extends at least partially in radial direction with respect to the rotational axis of the latch 6. While the first nose 11 interacts with a contact surface 24 of the first rocker arm part 4, the first lever 7 interacts with and is biased by a biasing spring 9 and the second lever 8 interacts with piston 32 of a hydraulic or pneumatic means 10.

**[0046]** **Figure 4a** and **Figure 4b** depict an augmented sector of **Figure 3** around latch 6.

**[0047]** **Figure 4a** shows a rotational position of the latch 6 when a relative movement of the first rocker arm part 4 and the second rocker arm part 5 are unblocked.

**[0048]** **Figure 4b** shows a rotational position of the latch 6 when a relative movement of the first rocker arm part 4 and the second rocker arm part 5 is blocked.

**[0049]** In **Figure 4a**, a chamber 33 of the pneumatic or hydraulic means 10 is put under pressure such that the latch 6 rotates clockwise and the spring 9 is biased by the first lever 7.

**[0050]** In **Figure 4b**, the pressure chamber 33 is released of pressure such that the latch 6 turns anti-clockwise by actuation of the spring 9. Thereby, the first nose 11 pivots in a position, where the tip thereof gets into contact with the contact surface 24 of the first rocker arm part 4.

**[0051]** Preferably, the inclination of a phase formed at the tip of the nose 11 and the phase formed by the contact surface 24 are such that latch 6 is self-blocked, if the first rocker arm part 4 and the second rocker arm part 5 are biased towards each other.

**[0052]** **Figures 5, 6 and 7** depict several views of a split rocker arm to get another embodiment of a latch mechanism for a split rocker arm with a first rocker arm part 4 and a second rocker arm part 5 in order to block and unblock a relative movement.

**[0053]** For the shown arrangement, the elements may be identical to the first embodiment of a split rocker arm of the first embodiment depicted in **Figure 3** to **Figure 4b**.

**[0054]** In contrast to the split rocker arm according to the first embodiment, the spring 9 is not supported by the second rocker arm part 5 to push the first lever 7 away from the second rocker arm part 5, but the second rocker arm part 5 according to the second embodiment further has a U-shaped bracket 30 such that spring 9 can be arranged between the U-shaped bracket 30 and the first lever 7 and be supported by the U-shaped bracket 30 in order to bias the lever 7 towards the main body of the second rocker arm part 5. In the shown embodiment, the U-shaped bracket is fixed to the second rocker arm part 5 by two bolts.

**[0055]** In contrast to the first embodiment, the latch 6 of the second embodiment preferably only has one single lever 7.

**[0056]** As is shown in **Figure 7**, the hydraulic or pneumatic means 10 with the piston 32 may be arranged in such a way on the second rocker arm part 5, that it is adapted to exert a force in the contrary direction to the bias of spring 9.

**[0057]** As depicted in **Figure 6**, the split rocker arm 4/5 according to the first embodiment or the second embodiment or any other embodiment may also be used without the phaser shifter 13. In this case, the roller 28 being mounted to the first rocker arm part 4 directly interacts with a cam on the camshaft 2.

**[0058]** **Figure 8** depicts a second embodiment of a phaser unit 13 in a perspective view.

**[0059]** Even though the rocker arm 4 according to **Figures 8 and 9** is not a split rocker arm, the embodiment of the phaser unit 13 may also be applied to the split rocker arms depicted in **Figures 2 to 7**.

**[0060]** **Figure 9** shows a side view of the rocker arm arrangement according to **Figure 8**, where the cart 16 interacts with cam of a camshaft 2. In particular, the first roller 17 interacts with a first cam 19 (not depicted), while a second roller 18 of the cart 16 interacts with a second cam 20.

**[0061]** **Figure 10a** and **Figure 11a** depict two different phaser positions of the cart 16 with respect to the camshaft 2.

**[0062]** In **Figure 10a**, the phaser unit 13 is in a state, in which the cart 16 is in the utmost clockwise position with respect to the camshaft 2.

**[0063]** In **Figure 11a**, the cart 16 of the phaser unit 13 is in the utmost anti-clockwise position with respect to the camshaft 2.

**[0064]** The resulting valve lift curves VL as a function of the crankshaft angle CA is depicted in **Figure 10b** and **Figure 11b**, respectively.

**[0065]** As can be seen from these diagrams, with the position of the cart 16 according Figure 11a, the valve opens earlier and stays open longer in the diagram of Figure 11b. It is advantageous that the total opening duration is longer than in the cart's initial position of Fig. 10a. Since according to the thermodynamics, only about 3mm lift is needed to achieve such a valve opening, a "platform" formed by the diagram in Fig. 11b is sufficient.

**[0066]** While in the valve lift curve according to Figure 10b the interaction of the second cam 20 with the second roller 18 of the cart 16 is predominant for the valve lift, in Figure 11b the first cam 19 (not shown) and its interaction with the first roller 17 of the cart 16 is predominant for the motion of the valve.

**[0067]** **Figure 12** depicts a third embodiment of a split rocker arm.

**[0068]** In contrast to the preceding embodiments, the third embodiment has a third rocker arm part 25. As the first rocker arm part 4, the third rocker arm part 25 can cooperate with the second rocker arm part 5 in order to transmit a valve lift motion from a camshaft to the valves of the internal combustion engine 1. In order to control this additional valve lift motion, the relative movement between the third rocker arm part 25 and the second rocker arm part 5 is blocked and unblocked by the latch 6. For this, the latch 6 has a second nose 21, which can cooperate with a second contact surface 34 of the third rocker arm part 25.

**[0069]** Furthermore, the latch 6 has a third lever 22 to control this motion. As will be explained further below, the first nose 11 and the second nose 21 have different rotational positions with respect to the axis of rotation of the latch 6. By this, only the first valve lift motion of the camshaft 2 (not shown) is transmitted by the first rocker arm part 4 to the second rocker arm part 5, or both, the first valve lift motion and the second valve lift motion of the camshaft 2 (not shown) transmittable by the third rocker arm part 25 to the second rocker arm part 5 is transmitted, depending on the rotational position of the latch 6.

**[0070]** In comparison to the preceding embodiments, the third embodiment of the split rocker arm also has a second spring 29 to bias the third rocker arm part 25 against the cams of the camshaft 2 (not shown).

**[0071]** **Figure 13** is a top view of the third embodiment of the split rocker arm according to Figure 12.

**[0072]** **Figures 14 to 16** are sectional views along different planes of the third embodiment of the split rocker arm being shown in Figure 13.

**[0073]** **Figure 14** is a sectional view in the plane A-A of Figure 13.

**[0074]** As can be seen from Figure 14, the first lever 7 is actuated by a hydraulic or pneumatic means 10a comprising a first pressure chamber 33a and a first piston 32a being arranged to interact with the first lever 7.

**[0075]** **Figure 15** is a sectional view along the plane B-B of Figure 13.

**[0076]** As can be seen from Figure 15, a piston 35 actuated by a first biasing spring 9 is acting on the second lever 8 and biases the same.

**[0077]** **Figure 16** is a sectional view along the plane C-C of Figure 13.

**[0078]** As can be seen from Figure 16, a second hydraulic or pneumatic means 10b is arranged in the second rocker arm part 5 in order to act on the third lever 22 of the latch 6.

**[0079]** For this, the second hydraulic or pneumatic means 10b has a second pressure chamber 33b and a second piston 32b. Furthermore, this second hydraulic or pneumatic means 10b has also a second biasing spring 23 acting on the piston 32b. In order to release the third lever 22 of bias, the second pressure chamber 33b is open ended and the spring biasing the second piston 32b is compressed.

**[0080]** By the arrangement as resulting from Figures 14 to 16, the operational states of the split rocker arm 4/5 described above can be realized.

**[0081]** The operational states of the split rocker arm 4/5 can be summarized as follows for different cycles:

|                   | pressure in 33 a | pressure in 33 b | Contact between 11 and 24 | Contact between 21 and 34 |
|-------------------|------------------|------------------|---------------------------|---------------------------|
| Intake cycle      | no               | no               | yes                       | no                        |
| Atkinson cycle    | yes              | no               | yes                       | yes                       |
| Cyl. deactivation | no               | yes              | no                        | no                        |

**[0082]** The Figs. 14, 15 and 16 show the latch in the regular intake cycle position.

**[0083]** This is the middle position that does not need any oil pressure but defined by the springs 23 and 9.

**[0084]** The rotational torque provided by the force of spring 23 is higher, preferably double, of the rotational torque provided by the spring 9, so the force provided by spring 23 overcomes the force provided spring 9. That is why the latch remains in a well-defined middle position without any oil pressure being applied.

**[0085]** It should be noted that the exemplary embodiments are merely examples which are not intended to limit the

scope of protection, the applications and the structure in any way. Rather, the preceding description provides the person skilled in the art with a guideline for the implementation of at least one exemplary embodiment, whereby various modifications, in particular with respect to the function and arrangement of the described components, can be made without leaving the scope of protection as it results from the claims and these equivalent feature combinations.

## Reference Signs

### [0086]

- |    |    |                              |
|----|----|------------------------------|
| 10 | 1  | Internal combustion engine   |
|    | 2  | Camshaft                     |
|    | 3  | Valve                        |
|    | 4  | First rocker arm part        |
|    | 5  | Second rocker arm part       |
| 15 | 6  | Latch                        |
|    | 7  | First lever                  |
|    | 8  | Second lever                 |
|    | 9  | Spring                       |
|    | 10 | Hydraulic or pneumatic means |
| 20 | 11 | First nose                   |
|    | 12 | Valve bridge                 |
|    | 13 | Phaser unit                  |
|    | 14 | Phaser lever                 |
|    | 15 | Phaser connection            |
| 25 | 16 | Cart                         |
|    | 17 | First wheel arrangement      |
|    | 18 | Second wheel arrangement     |
|    | 19 | First cam                    |
|    | 20 | Second cam                   |
| 30 | 21 | Second nose                  |
|    | 22 | Third lever                  |
|    | 23 | Spring                       |
|    | 24 | First contact surface        |
|    | 25 | Third rocker arm part        |
| 35 | 26 | Phaser shaft                 |
|    | 27 | Spring                       |
|    | 28 | Roller                       |
|    | 29 | Spring                       |
|    | 30 | U-shaped bracket             |
| 40 | 32 | Piston                       |
|    | 33 | Press chamber                |
|    | 34 | Second contact surface       |
|    | 35 | Piston                       |

## Claims

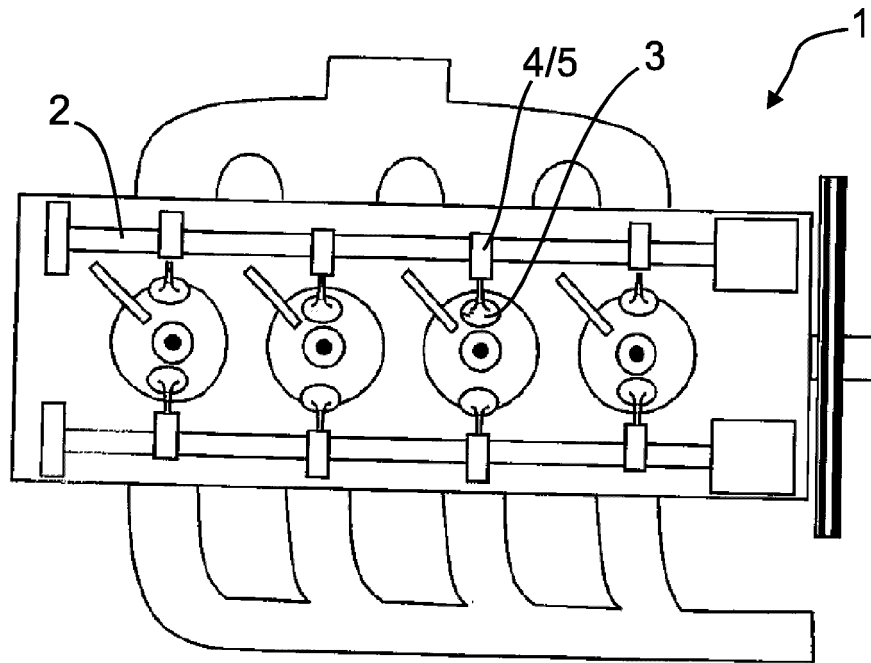
1. An internal combustion engine (1) having a camshaft (2) and valves (3) for charging and discharging combustion chambers, comprising:

a first rocker arm part (4);  
 a second rocker arm part (5), wherein the first rocker arm part (4) and the second rocker arm part (5) are pivotably mounted; and  
 a latch (6) for activating and deactivating a transmission of an actuation motion between the camshaft (2) and at least one valve (3);  
 wherein the latch (6) is pivotably mounted on the second rocker arm part (5) and, in a first rotational position of the latch (6), form-fittingly engages with a contact surface (24) of the first rocker arm part (4) such that a valve actuation motion is transmittable from the camshaft (3) of the internal combustion engine (1) via the first rocker

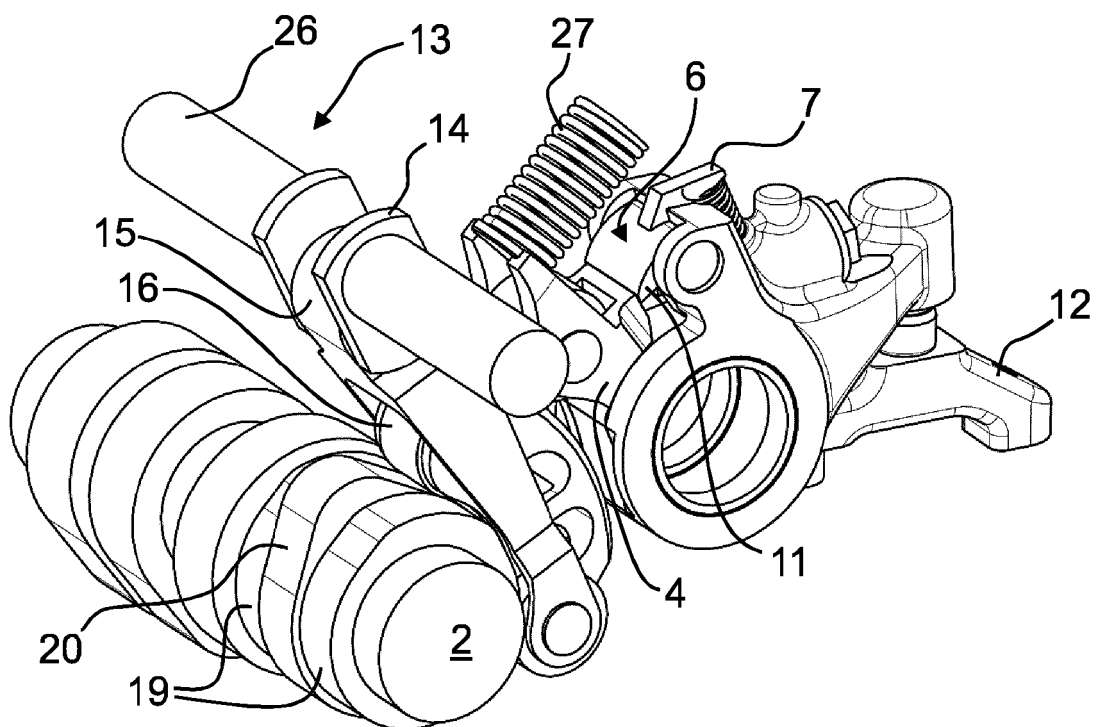


arm part (4) and the second rocker arm part (5) to the at least one valve (3), and, in a second rotational position of the latch (6), enables a relative movement of the first rocker arm part (4) and the second rocker arm part (5) with respect to each other.

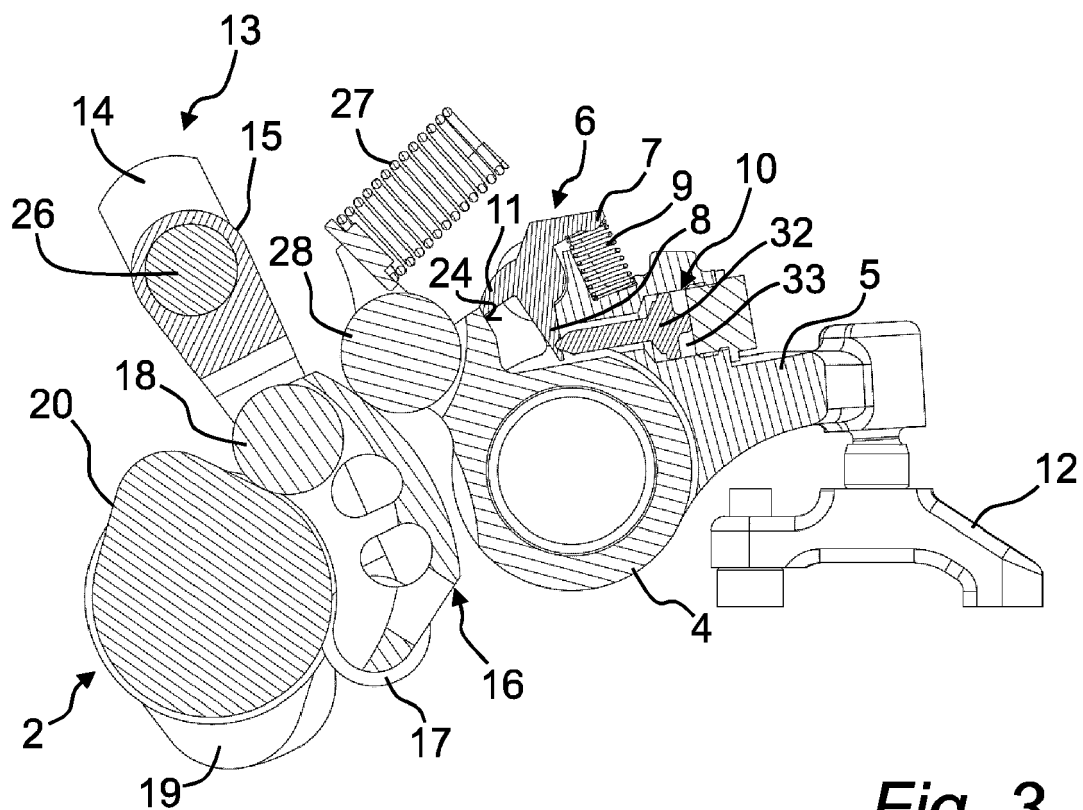
- 5     **2.** Internal combustion engine (1) according to claim 1, wherein the latch (6) comprises a first lever (7) and/or a second lever (8) extending at least partially in radial direction with respect to a rotational axis of the latch (6), and wherein the second rocker arm part (5) comprises a first spring (9) engaging with the first lever (7) and first hydraulic or pneumatic means (10) engaging with the first lever or the second lever (8), wherein the first hydraulic or pneumatic means (10) works against a spring force of the first spring (9) to set the rotational position of the latch (6).  
10
- 3.** Internal combustion engine (1) according to claim 2, wherein extremal switch positions of the first hydraulic or pneumatic means define the first and second rotational positions of the latch (6), wherein the latch preferably occupies the first rotational position if the first hydraulic or pneumatic means is in a relaxed state.
- 15     **4.** Internal combustion engine (1) according to one of claims 1 to 3, wherein the latch (6) further comprises a first nose (11) extending at least partially in radial direction with respect to a rotational axis of the latch (6) and adapted to engage with the contact surface (24) of the first rocker arm part (4).
- 5.** Internal combustion engine (1) according to one of claims 1 to 4, wherein the first rotational position and the second rotational position of the latch (6) define a rotation angle of approximately 10 degrees, preferably approximately 5 degrees.  
20
- 6.** Internal combustion engine (1) according to one of claims 1 to 5, wherein the first rocker arm part (4) engages with the camshaft (3), and the second rocker arm part (5) engages with a valve (3) or a valve bridge (12).  
25
- 7.** Internal combustion engine (1) according to one of claims 1 to 6, further comprising a phaser unit (13), the phaser unit (13) comprising a phaser shaft (26), a phaser lever (14), a phaser connection (15) and a cart (16), wherein the cart (16) has a first wheel arrangement (17) engaging with a first cam (19) of the camshaft (2) and a second wheel arrangement (18) engaging with a second cam (20) of the camshaft (2), wherein the phaser connection (15) connects the phaser shaft (26) with the cart (16) in such a manner that a change of position of the phaser lever (14) changes the rotational position of the cart (16) with respect the camshaft (2).  
30
- 8.** Internal combustion engine (1) according to claim 7, wherein the first rocker arm (4) engages with a tread of the cart (16), and the second rocker arm (5) engages with a valve (3) or a valve bridge (12).  
35
- 9.** Internal combustion engine (1) according to one of claims 1 to 8, comprising a third rocker arm part (25) pivotably mounted besides the first rocker arm part (4) and having the same rotational axis as the first rocker arm part (4), wherein the latch (6) has a second nose (21) and a third lever (22) both extending at least partially in radial direction with respect to a rotational axis of the latch (6), wherein the latch (6) is pivotably mounted on the second rocker arm part (5) and engages with second pneumatic or hydraulic means (23) of the second rocker arm part (5) and wherein the second nose (21), in a third rotational position of the latch (6), form-fittingly engages with a contact surface of the third rocker arm part (25) such that a valve actuation motion is transmittable from the camshaft (2) of the internal combustion engine (1) via the third rocker arm part (25) and the second rocker arm part (5) to the at least one valve (3).  
40
- 45     **10.** Internal combustion engine (1) according to claim 9, wherein an extremal switch position of the second hydraulic or pneumatic means (10b) defines the third rotational position of the latch (6).
- 11.** Internal combustion engine (1) according to claim 9 or 10, wherein the second hydraulic or pneumatic means (10b) comprises a second spring (23) and works against a spring force generated by the second spring (23) to set the rotational position of the latch (6).  
50
- 12.** Internal combustion engine (1) according to one of claims 1 to 11, wherein the contact surface (24, 34) and/or the surface of the first and/or second nose (11, 21) is hardened.
- 55     **13.** Internal combustion engine (1) according to one of claims 1 to 12, wherein the first rotational position and the third rotational position of the latch (6) define a rotation angle of approximately 15 degrees, preferably approximately 10 degrees.



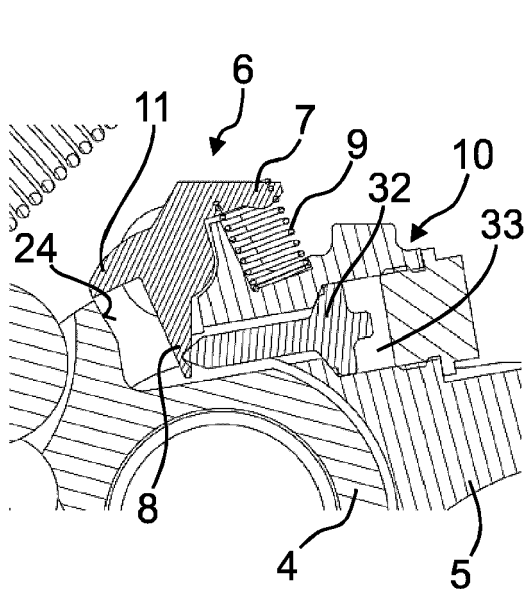
*Fig. 1*



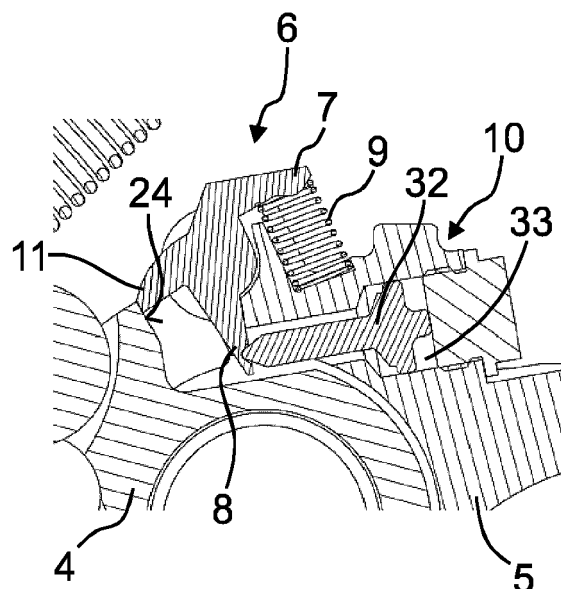
*Fig. 2*



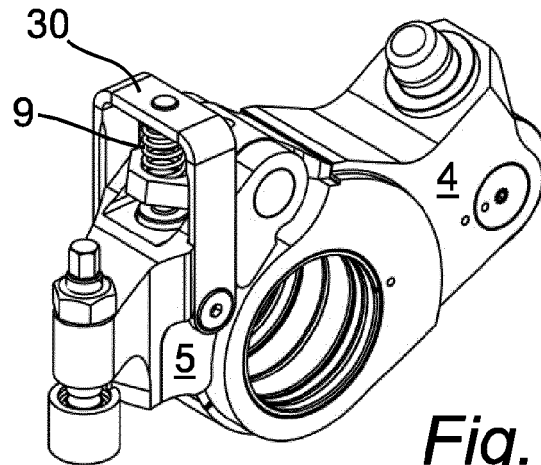
*Fig. 3*



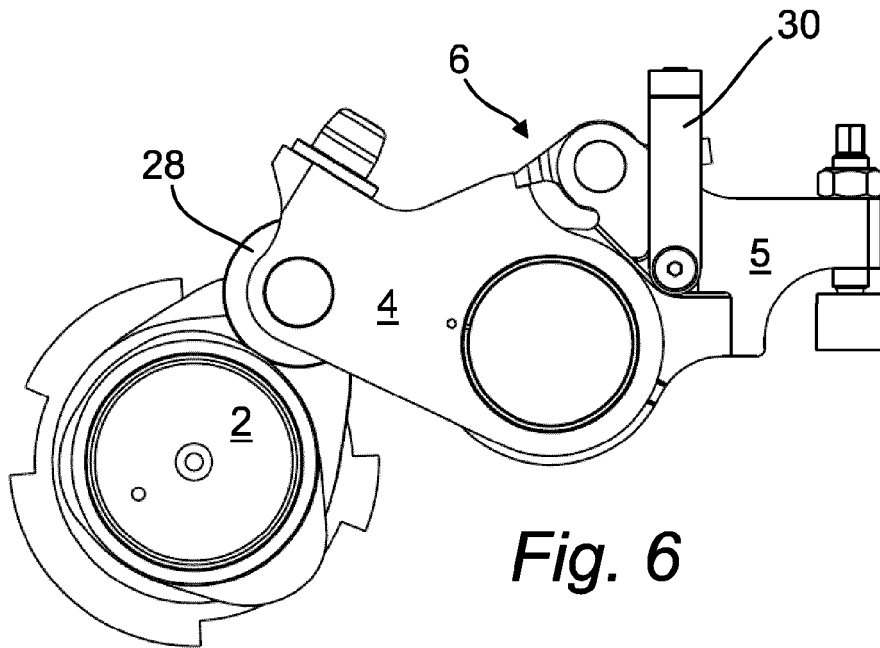
*Fig. 4a*



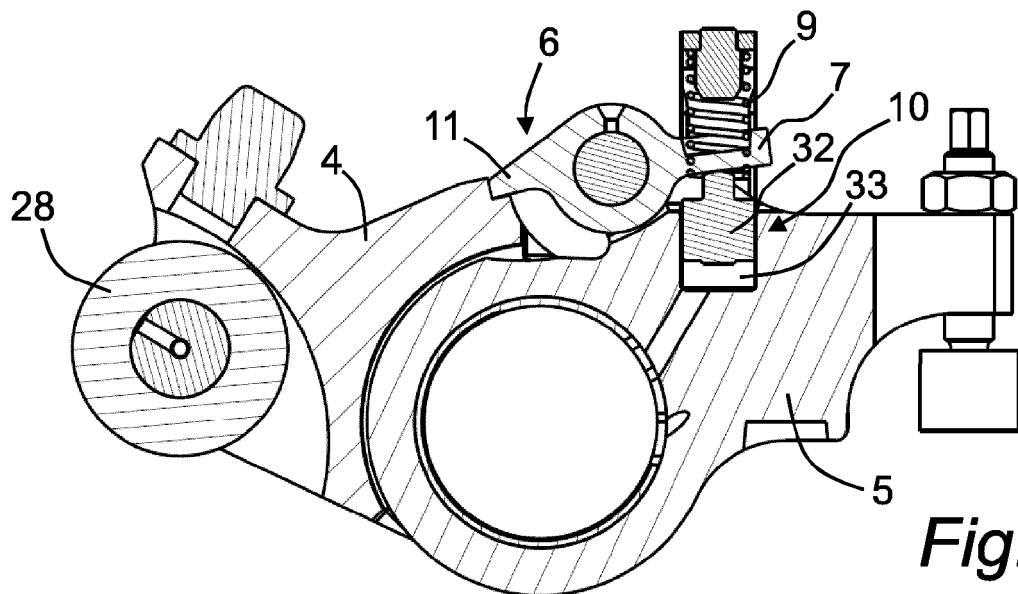
*Fig. 4b*



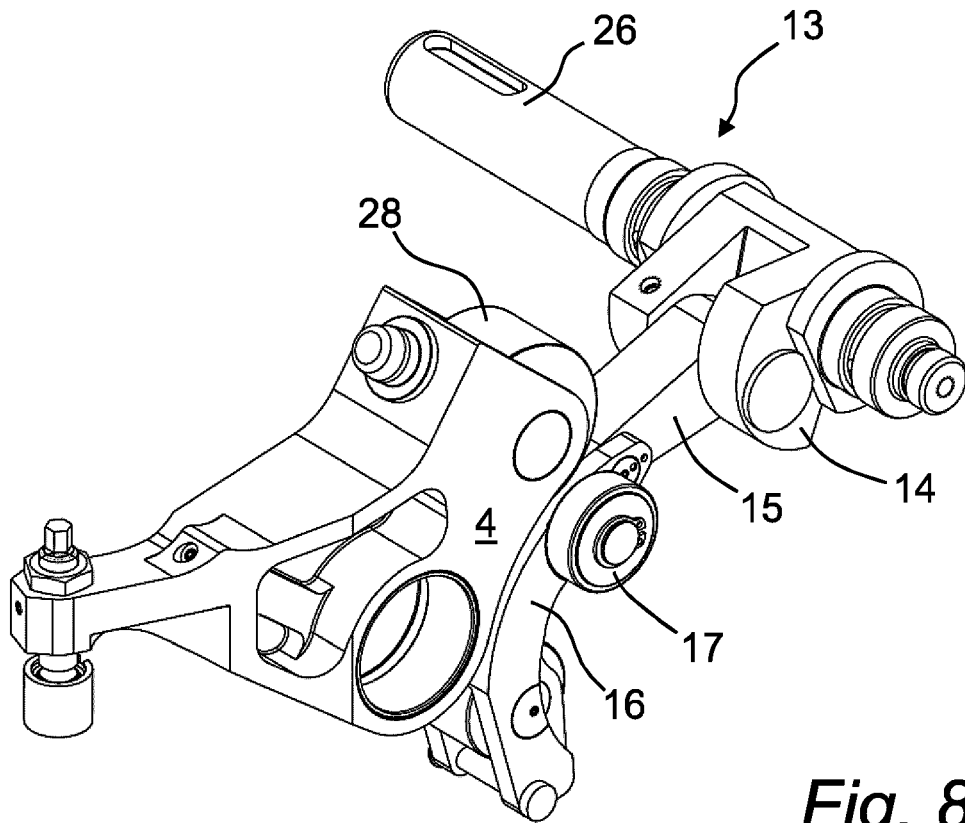
*Fig. 5*



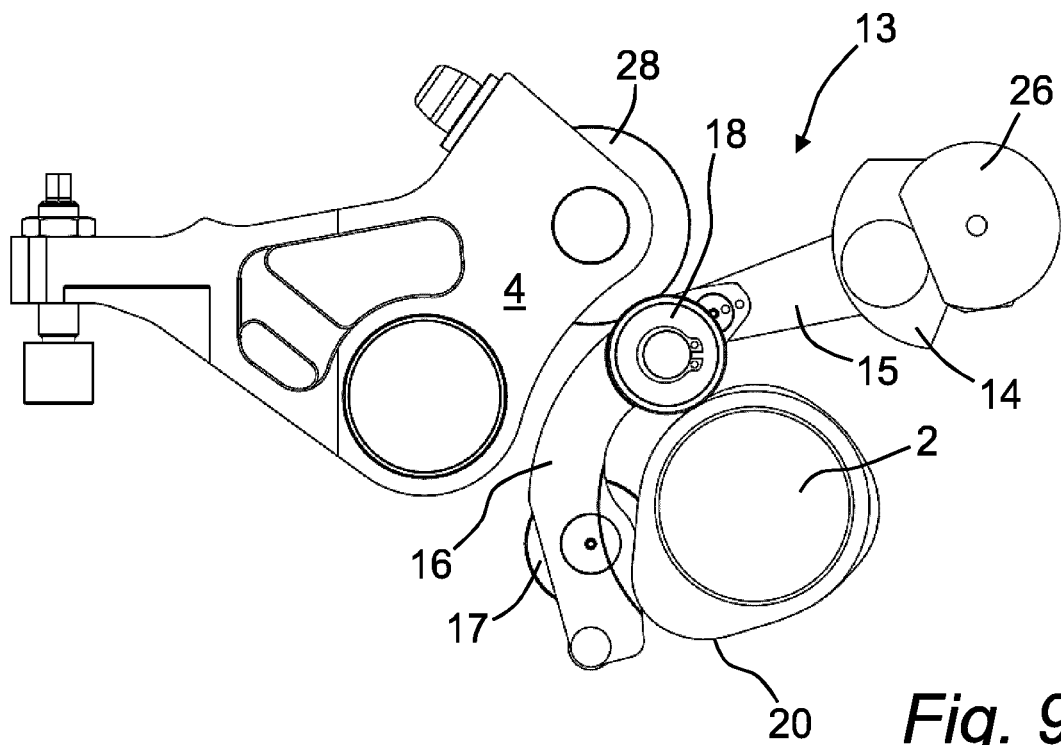
*Fig. 6*



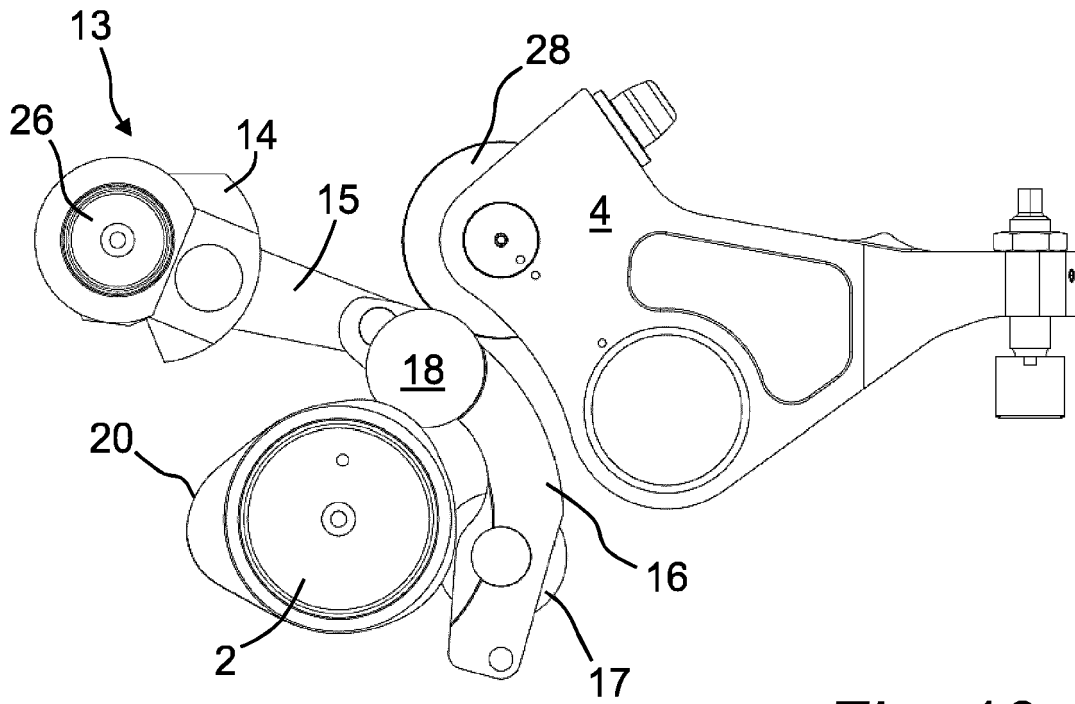
*Fig. 7*



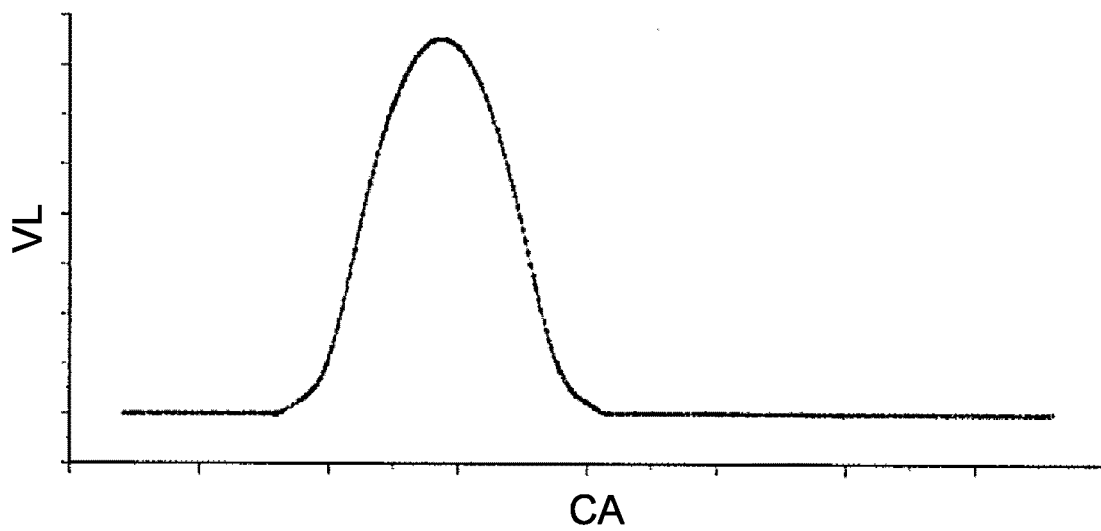
*Fig. 8*



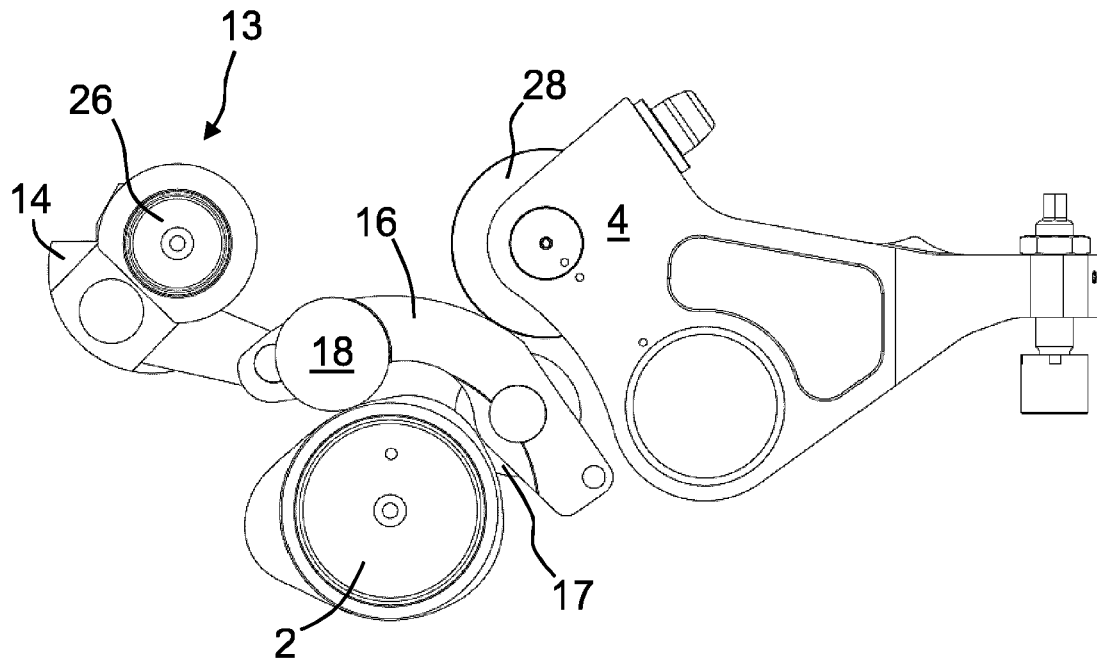
*Fig. 9*



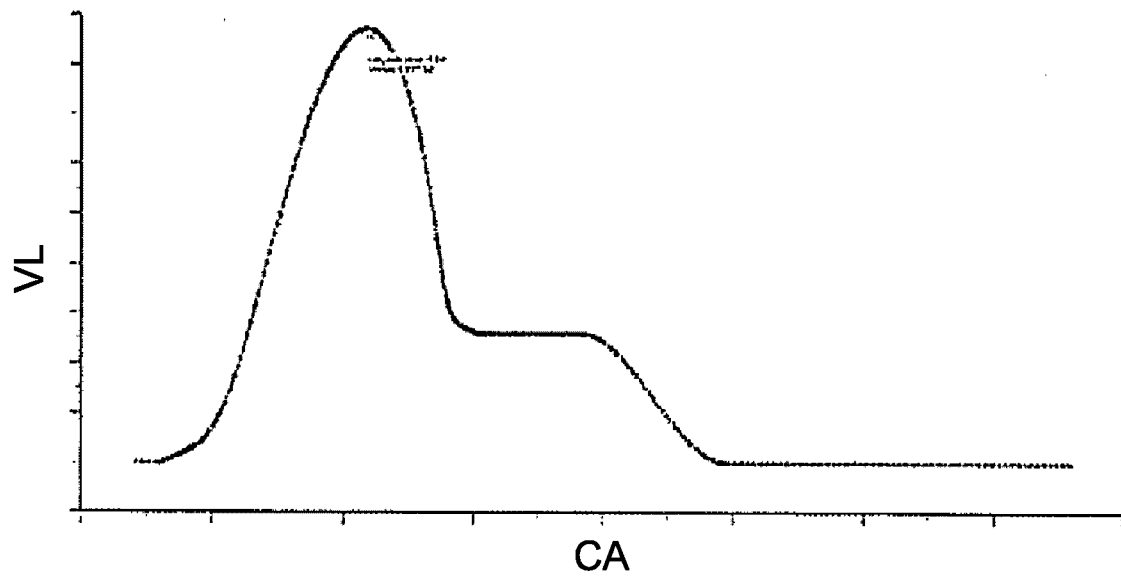
*Fig. 10a*



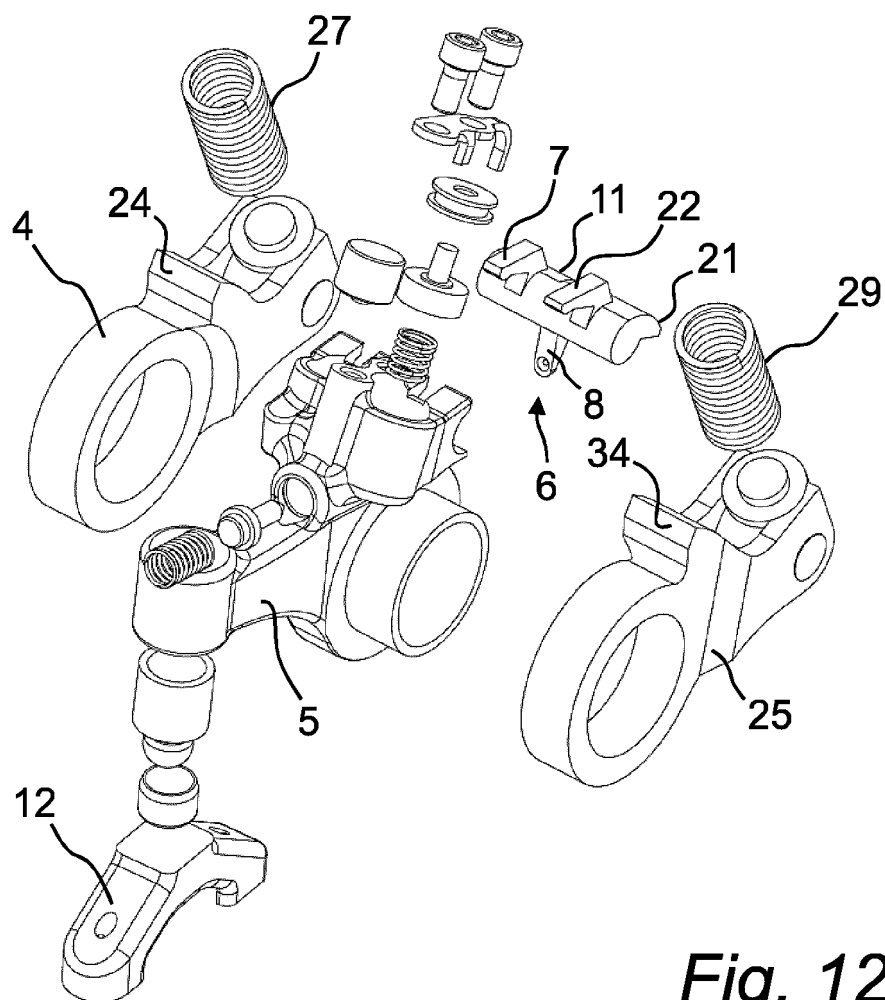
*Fig. 10b*



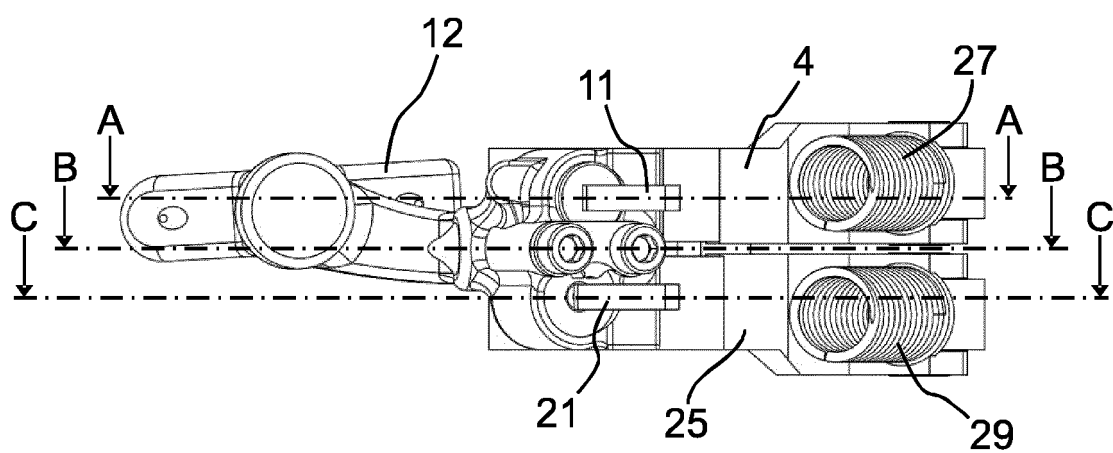
*Fig. 11a*



*Fig. 11b*

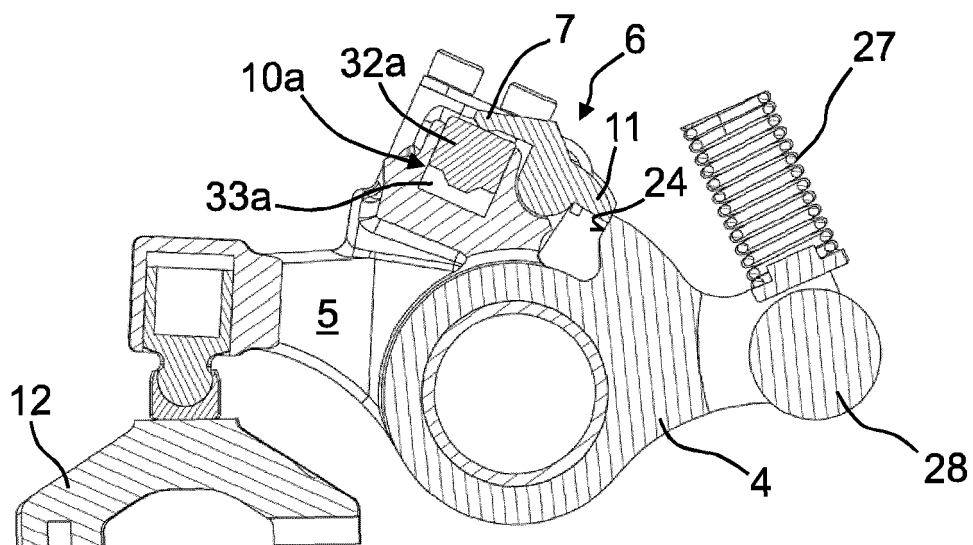


*Fig. 12*

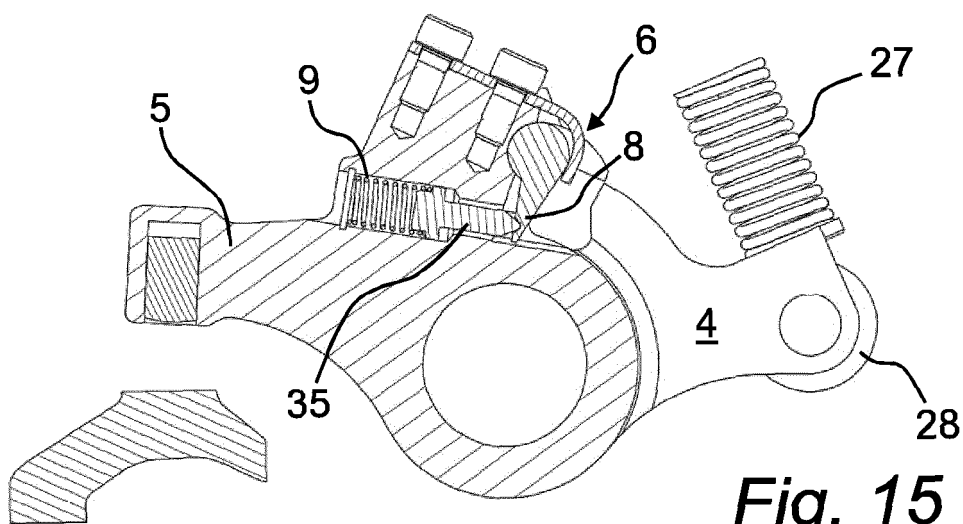


*Fig. 13*

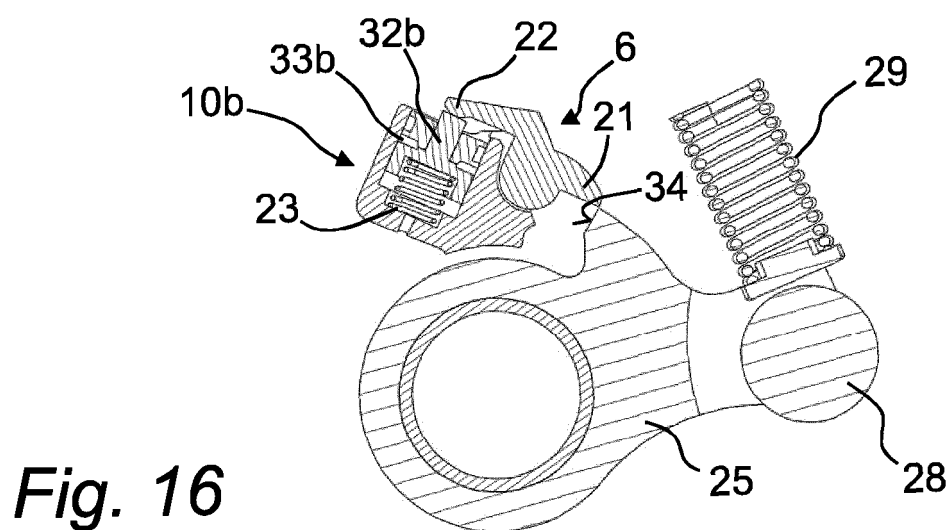




**Fig. 14**



**Fig. 15**



**Fig. 16**

## Application Number

EP 21 21 2949

5

## 10

| Category | Citation of document with indication, where appropriate, of relevant passages                                                        | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC)        |
|----------|--------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------------------------------------|
| X        | US 4 151 817 A (MUELLER ROBERT S [US])<br>1 May 1979 (1979-05-01)                                                                    | 1, 4-6            | INV.<br>F01L1/18                               |
| Y        | * column 2, line 61 - column 4, line 51;<br>figures 1, 4 *                                                                           | 12                | F01L1/20<br>F01L1/26<br>F01L13/00<br>F01L13/06 |
|          | -----                                                                                                                                |                   |                                                |
| X        | WO 2021/083552 A1 (EATON INTELLIGENT POWER LTD [IE])<br>6 May 2021 (2021-05-06)                                                      | 1, 5, 6           |                                                |
| Y        | * paragraphs [0016] - [0029]; figures 1, 3, 4, 6 *                                                                                   | 12                | ADD.<br>F01L1/46                               |
|          | -----                                                                                                                                |                   |                                                |
| X        | US 7 546 822 B2 (TIMKEN US CORP [US])<br>16 June 2009 (2009-06-16)                                                                   | 1, 6              |                                                |
| Y        | * column 4, line 54 - column 7, line 22;<br>figures 6-11 *                                                                           | 7, 8, 12          |                                                |
|          | -----                                                                                                                                |                   |                                                |
| X        | US 5 297 516 A (HARA SEINOSUKE [JP])<br>29 March 1994 (1994-03-29)                                                                   | 1-6,<br>9-11, 13  |                                                |
| Y        | * column 2, line 37 - column 5, line 33;<br>figures 1, 3, 4 *                                                                        | 7, 8, 12          |                                                |
|          | -----                                                                                                                                |                   |                                                |
| Y        | AT 510 527 A1 (AVL LIST GMBH [AT])<br>15 April 2012 (2012-04-15)<br>* page 3 - page 5; figures 6-9 *                                 | 7, 8              | TECHNICAL FIELDS<br>SEARCHED (IPC)             |
|          | -----                                                                                                                                |                   | F01L                                           |
| Y        | US 4 829 647 A (ANDERSON ANTHONY T [US] ET AL)<br>16 May 1989 (1989-05-16)<br>* column 3, line 49 - column 3, line 60;<br>figure 8 * | 12                |                                                |
|          | -----                                                                                                                                |                   |                                                |

The present search report has been drawn up for all claims

50

Place of search

## The Hague

Date of completion of the search

17 May 2022

Examiner

Deseau, Richard

## 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

55

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

EP 21 21 2949

5

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.

17-05-2022

10

15

20

25

30

35

40

45

50

55

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                                                                          | Publication<br>date                                                                                   |
|-------------------------------------------|---------------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| <b>US 4151817 A</b>                       | <b>01-05-1979</b>   | <b>DE 2753197 A1</b><br><b>US 4151817 A</b>                                                                         | <b>22-06-1978</b><br><b>01-05-1979</b>                                                                |
| <b>WO 2021083552 A1</b>                   | <b>06-05-2021</b>   | <b>NONE</b>                                                                                                         |                                                                                                       |
| <b>US 7546822 B2</b>                      | <b>16-06-2009</b>   | <b>EP 1725744 A1</b><br><b>JP 2007526423 A</b><br><b>US 2008149059 A1</b><br><b>WO 2005093224 A1</b>                | <b>29-11-2006</b><br><b>13-09-2007</b><br><b>26-06-2008</b><br><b>06-10-2005</b>                      |
| <b>US 5297516 A</b>                       | <b>29-03-1994</b>   | <b>DE 4235934 A1</b><br><b>GB 2260784 A</b><br><b>JP 3200131 B2</b><br><b>JP H05171909 A</b><br><b>US 5297516 A</b> | <b>29-04-1993</b><br><b>28-04-1993</b><br><b>20-08-2001</b><br><b>09-07-1993</b><br><b>29-03-1994</b> |
| <b>AT 510527 A1</b>                       | <b>15-04-2012</b>   | <b>AT 510527 A1</b><br><b>WO 2012038191 A1</b>                                                                      | <b>15-04-2012</b><br><b>29-03-2012</b>                                                                |
| <b>US 4829647 A</b>                       | <b>16-05-1989</b>   | <b>CA 1315622 C</b><br><b>US 4829647 A</b>                                                                          | <b>06-04-1993</b><br><b>16-05-1989</b>                                                                |

**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- US 20140326212 A1 [0011]
- WO 2015022071 A [0012]
- WO 2019025511 A1 [0013]
- AT 507102020 [0014]