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(54) **VALVE TRAIN ASSEMBLY**

(71) Applicant: **Eaton SRL**, Torino (IT)

(72) Inventor: **Jiri Novotny**, Prague (CZ)

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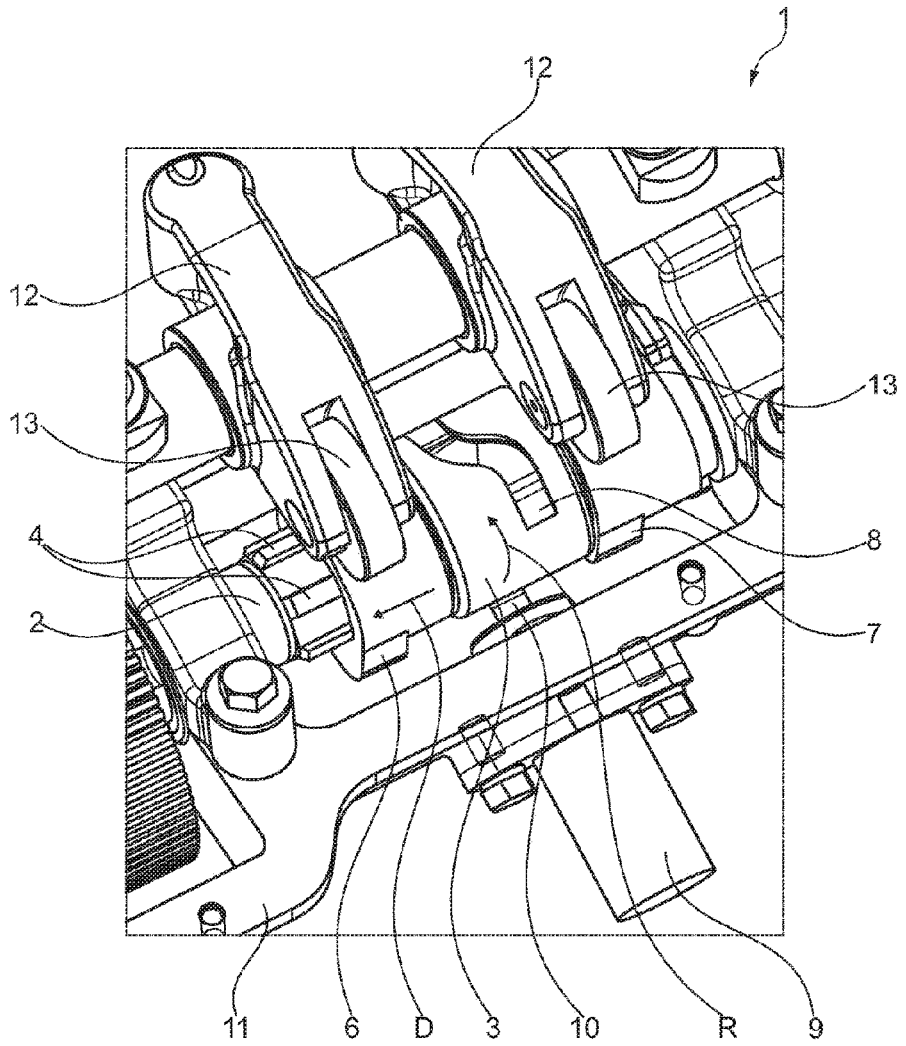
(57) **ABSTRACT**

A valve train assembly has at least a camshaft with at least a first cam body and a second cam body, each axially movable over the camshaft between a first axial position and a second axial position and each earn body being provided with a first cam for controlling a valve in the first axial position and a second cam for controlling the valve in the second axial position; and one or more couplers for coupling the movement of the cam bodies. A first groove extends along a part of the circumference of the first cam body. A second groove extends along a part of the circumference of the second cam body, An engager for engaging alternately the first. and second groove is included, such that either the first cam body is moved to the first axial position or the second cam body is moved to the second axial position.



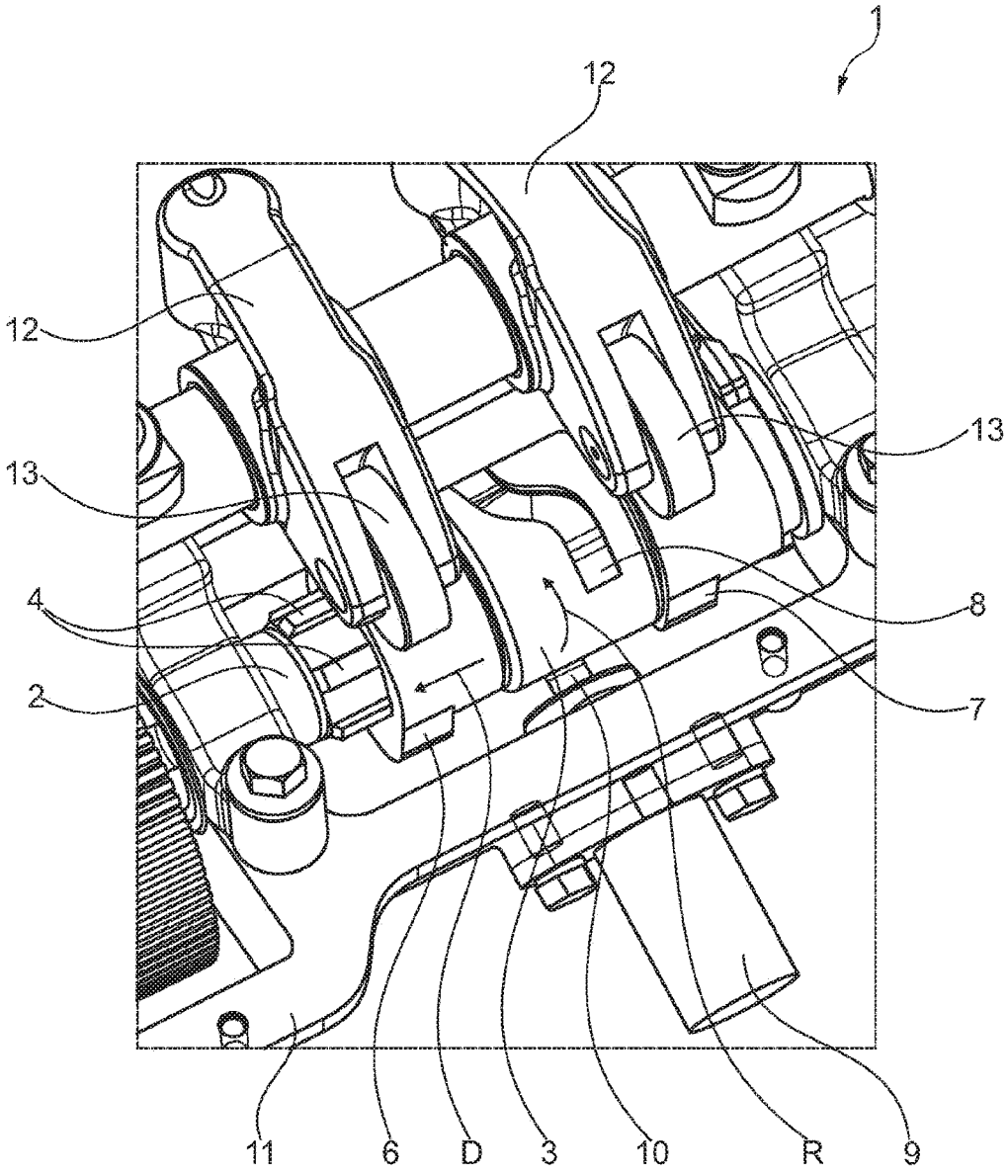


Fig. 1

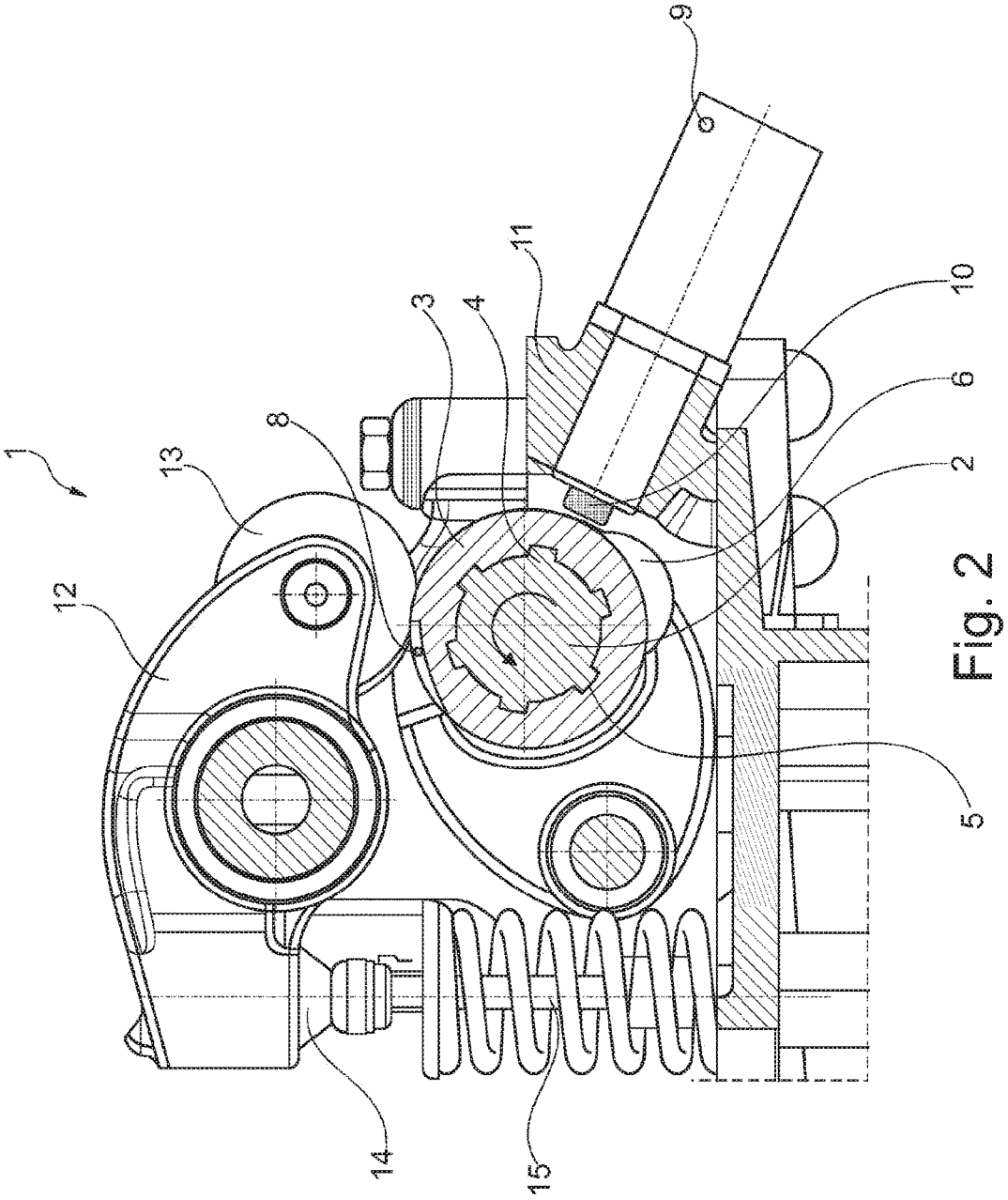


Fig. 2

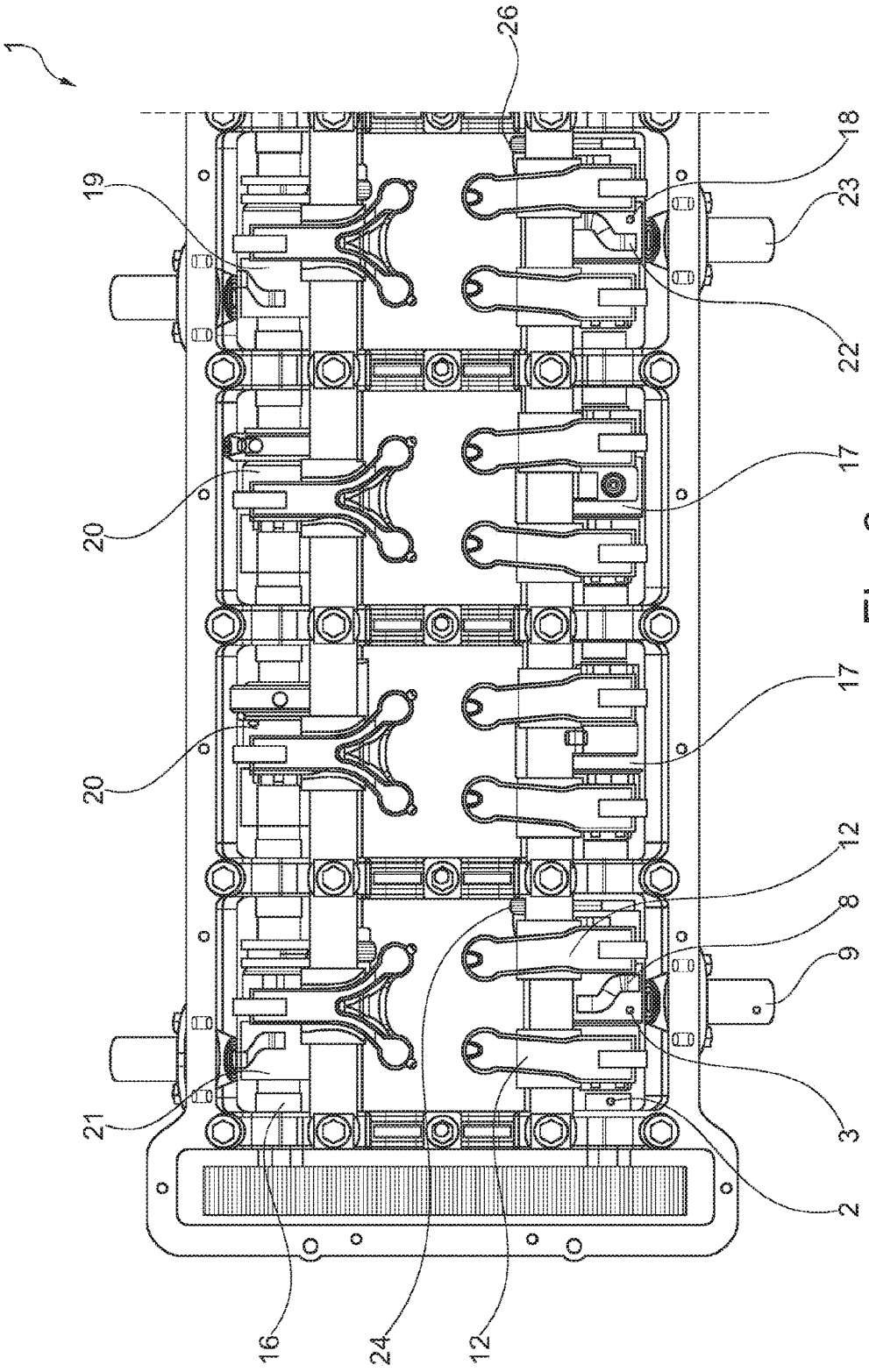


Fig. 3

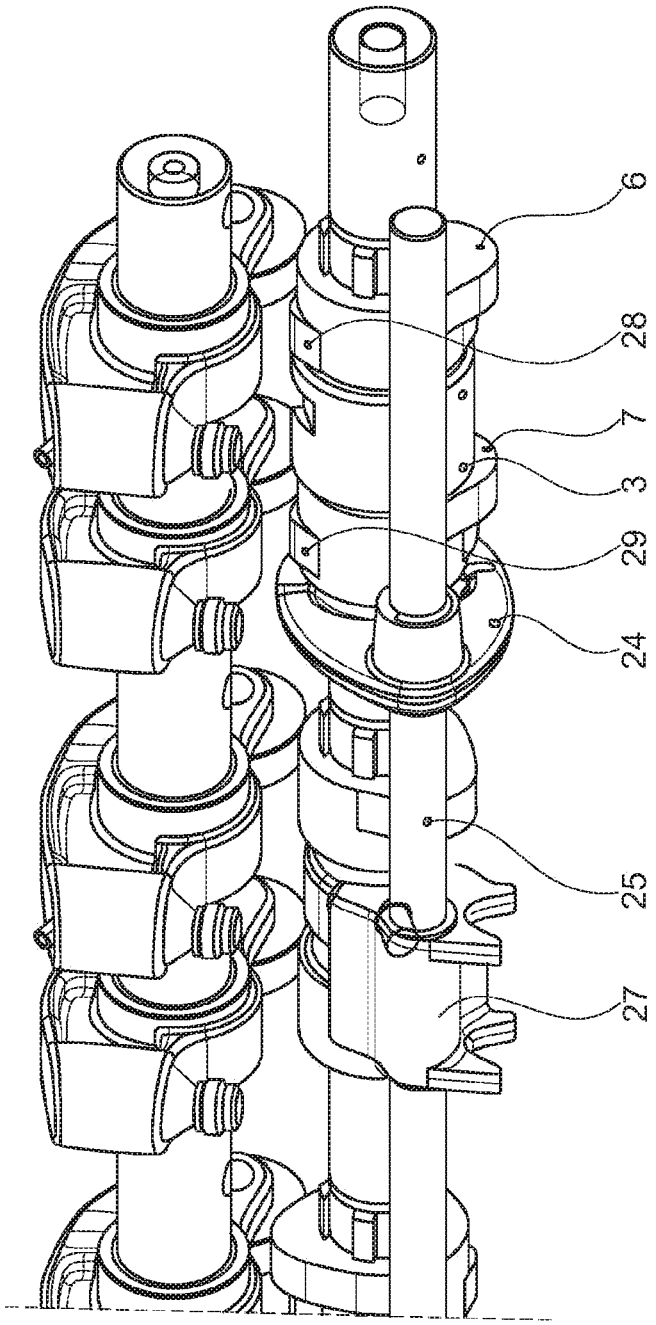


Fig. 4

VALVE TRAIN ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a U.S. national stage application under 35 U.S.C. §371 of International Application No. PCT/EP2015/055507, filed on Mar. 17, 2015, and claims benefit to British Patent Application No. 1404874.8, filed on Mar. 18, 2014. The International Application was published in English on Sep. 24, 2015, as WO 2015/140137 A1 under PCT Article 21(2).

FIELD

[0002] The invention relates to a valve train assembly including at least a camshaft with at least a first cam body and a second cam body.

BACKGROUND

[0003] A valve train assembly is used for an internal combustion engine and has typically at least some of the following elements: valves, rocker arms, push-rods, lifters and camshaft.

[0004] Depending on the type of valve train assembly some or all of the elements of a valve train assembly. For example an internal combustion engine having the camshaft in the engine block, there will also be present push-rods and rocker arms, while with an overhead camshaft, the cams on the camshaft will be in direct contact with the lifters or tappets, which move the valves in the cylinder head.

[0005] It is known to use variable valve timing or variable valve lifting to change the characteristics of an combustion engine, such that performance, emission of the engine or fuel economy is improved.

[0006] A system to achieve this is known as cam shifting. In such a system at least two cams are provided on a cam body for each valve. The two cams have a different profile, such that the timing is different depending on the cam used for the respective valve. By shifting the cam body in axial direction over the camshaft, one can select which cam is used to control the respective valve.

[0007] With such a system it is also possible to put a cylinder in a deactivated mode, by choosing a cam profile for the valves of the cylinders, which keep the valves closed at all time and use compressed air as a spring.

[0008] The valve train assembly according to the preamble is for example known from US2010/0251982. According to this publication, a cam body is provided with cams for two valves of a cylinder. The cam body is also provided with two oppositely curved grooves on the portion between the cams for the two valves. Two solenoid driven pins are also provided, which pins can be engaged with their respective two grooves. When a pin is brought into engagement with the respective groove, the engaged pin, in combination with the rotation of the cam shaft, will push the cam body to a first position in which one of the two cams are used for controlling the valves. By engaging the other pin into the respective groove, the cam body is pushed to another position, in which the other cams are used for controlling the valves.

[0009] The space on the cam body between the cams for the two valves is limited. The grooves and the solenoid driven pins have to be arranged within this limited space, causing severe limitations on the design of the grooves and the solenoid driven pins.

[0010] Furthermore, according to this art, each cylinder should be provided with a cam body for the exhaust cam shaft and a cam body for the intake cam shaft, each cam body being provided with grooves and solenoid driven pins. This makes the valve train assembly complex and prone to malfunctions.

SUMMARY

[0011] An aspect of the invention provides a valve train assembly, comprising: a camshaft including a first cam body and a second cam body, each cam body being axially movable over the camshaft between a first axial position and a second axial position, and each cam body including a first cam configured to control a valve in the first axial position and a second cam configured to control the valve in the second axial position; a coupler configured to couple a movement of the first cam body and the second cam body; a first groove extending along a part of a circumference of the first cam body; a second groove extending along a part of a circumference of the second cam body; and an engager configured to alternately engage the first and second groove, such that either the first cam body is moved to the first axial position or the second cam body is moved to the second axial position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention will be described in even greater detail below based on the exemplary figures. The invention is not limited to the exemplary embodiments. All features described and/or illustrated herein can be used alone or combined in different combinations in embodiments of the invention. The features and advantages of various embodiments of the present invention will become apparent by reading the following detailed description with reference to the attached drawings which illustrate the following:

[0013] FIG. **1** shows a perspective view of part of an embodiment of the valve train assembly according to the invention;

[0014] FIG. **2** shows a cross sectional view of the embodiment of FIG. **1**;

[0015] FIG. **3** shows a top view of cylinder head with the embodiment of the valve train assembly according to FIG. **1**; and

[0016] FIG. **4** shows a second perspective view of part of the embodiment of the valve train assembly according to FIG. **1**.

DETAILED DESCRIPTION

[0017] An aspect of the invention provides a valve train assembly in which the above mentioned disadvantages are reduced or even removed.

[0018] The invention relates to a valve train assembly comprising: at least a camshaft with at least a first cam body and a second cam body, each axially movable over the camshaft between a first axial position and a second axial position and each cam body being provided with a first cam for controlling a valve in the first axial position and a second cam for controlling the valve in the second axial position; and coupling means for coupling the movement of the first cam body and the second cam body

[0019] An aspect of the invention provides a valve train which is characterized by

[0020] a first groove extending along a part of the circumference of the first cam body;

[0021] a second groove extending along a part of the circumference of the second cam body; and

[0022] engagement means for engaging alternately the first and second groove, such that either the first cam body is moved to the first axial position or the second cam body is moved to the second axial position.

[0023] With the valve train assembly according to an aspect the invention the first and second groove are arranged on separate cam bodies, which are coupled together. So, if for example the first groove on the first cam body is engaged and the first cam body is moved to the first axial position, it will also take along the second cam body due to the coupling means.

[0024] When the second groove is engaged on the second cam body, the second cam body will be moved to the second position and take along the first cam body due to the coupling means.

[0025] As a result, the space available on a cam body can be dedicated to a single groove with single engagement means, opposite to the prior art, in which the space available on a cam body was needed for at least two grooves and two engagement means.

[0026] With the valve train assembly according to the invention, it is even possible to use a third cam body with a third groove coupled to the other two cam bodies, such that a three position axial displacement of the cam bodies is possible. Depending on the number of cylinders in the combustion engine, the number of coupled cam bodies can even be further expanded.

[0027] Preferably, the engagement means comprise a first movable pin for engagement in the first groove and a second movable pin for engagement in the second groove. A pin is a simple means to be used for engagement with a groove. The rotation of the cam shaft in combination with the engagement of the groove ensures, that the cam body is moved to the desired position.

[0028] In a preferred embodiment of the valve train assembly according to the invention the engagement means further comprise a solenoid connected to each movable pin for moving the pin into engagement with the respective groove. By using the pin as the core of the solenoid a very compact actuation of the pin can be achieved. Using a permanent magnet solenoid and a ramp at the end of each groove, the solenoid needs to be powered only shortly, to bring the pin into engagement with the groove. The permanent magnet of the solenoid will keep the pin, until the pin is pushed back by the ramp at the end of the groove.

[0029] In a further preferred embodiment of the valve train assembly according to the invention the first groove has in rotation direction an axial direction component towards the side of the second axial position and wherein the second groove has in rotation direction an axial direction component towards the side of the first axial position.

[0030] Because of the combined action of the engagement of the pin in the respective groove and the rotation of the cam shaft and thus the cam body, the cam body will be moved towards the desired position.

[0031] Preferably, the first groove is mirror-symmetrical to the second groove. This ensures that the acceleration and deceleration of the cam body, when one of the grooves is engaged is the same, which will contribute to a smooth-running engine.

[0032] In yet another embodiment of the valve train assembly according to the invention the first cam body and second cam body are substantially cylindrical.

[0033] Preferably, the substantially cylindrical cam bodies comprise at least an axial groove and wherein the cam shaft is provided with at least a corresponding axial rib.

[0034] FIG. **1** shows a perspective view of part of an embodiment of the valve train assembly **1** according to the invention.

[0035] The valve train assembly **1** has camshaft **2** with a cam body **3**. This cam body **3** is substantially cylindrical and axially slidable over the cam shaft **2**. To ensure, that the cam body **3** is rotated along with the cam shaft **2**, axial ribs **4** are arranged on the camshaft **2** and corresponding grooves **5** are arranged in the cylindrical cam body **3**.

[0036] The cam body **3** is provided on both sides with cam lobes **6**, **7**. The center part of the cam body **3** is provided with a curved groove **8**, which extends along a part of the circumference of the center part of the cam body **3**. Due to the curved shape, the groove **8** has also an axial direction component.

[0037] A solenoid **9** operated pin **10** is provided in the wall of a cylinder head **11** and can engage with the groove **8**. When the solenoid **9** is powered and the operating pin **10** engages with the groove **8**, the cam body **3** will be moved in the direction of the arrow D as a result of the rotation in the direction of the arrow R of the cam shaft **2** and the cam body **3**.

[0038] The valve train assembly **1** is furthermore provided with rocker arms **12**, which are each at one end provided with a cam follower **13**, which follows the profile of the cam lobes **6**, **7**. The other end **14** of the cam follower **13** is in contact with the tip of a valve stem **15**, such that the valve **15** is controlled by the cam **6**, **7**.

[0039] In the shown position, the cam follower **13**, follows the profile of the cam **6**, **7**. If the cam body is moved in axial direction D, then the cam follower **13**, will be moving of the surface of the cam body **3**, just next to the cam lobes **6**, **7**. As the cam body **3** is substantially cylindrical, the valve **15** will in this position not be operated and the corresponding cylinder will be deactivated. As shown in FIG. **4**, it is also possible to arrange a second cam lobe **28**, **29** next to the cam lobes **6**, **7**, with a different profile, such that behavior of the valve movement can be altered.

[0040] FIG. **3** shows a top view of cylinder head with the embodiment of the valve train assembly **1** according to FIG. **1**. The cylinder head shown is typically part of a **6**-cylinder combustion engine.

[0041] The valve train assembly **1** has the cam shaft **2**, which is typically used for operating the exhaust valves **15** and a second cam shaft **16** for operating the intake valves.

[0042] Both cam shafts **2**, **16** are provided with a number of cam bodies **3**, **17**, **18**, **19**, **20**, **21**. On the cam shaft **2**, the cam body **3** is provided with the groove and the cam body **18** is provided with a mirror-symmetrical groove **22**. This groove **22** can be engaged by engagement means **23**. When engaged, the groove **22** will cause the cam body **18** to move in the opposite direction of the arrow D.

[0043] The cam bodies **3** and **18** are coupled via forks **24**, **26** connected via a connection rod **25** (see FIG. **4**). When the cam body **3** is moved in the direction D, the forks **24**, **26** and connection rod **25** will take the cam body **18** along. On the other hand, when the cam body **18** is moved in the opposite direction by engagement of the groove **22**, the cam body **3**

will be taken along. In this way it is possible to move the cam bodies **3**, **18** between two positions.

[0044] As the other cam bodies **17** cannot be moved at the same time as the cam bodies **3**, **18** due to the timing of the valves of the different cylinders, a separate mechanism **27** is provided on the connection rod **25**, such that the movement of the cam bodies **17** is delayed with respect to the cam bodies **3**, **18**. Such mechanisms are already known in the prior art.

[0045] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. It will be understood that changes and modifications may be made by those of ordinary skill within the scope of the following claims. In particular, the present invention covers further embodiments with any combination of features from different embodiments described above and below. Additionally, statements made herein characterizing the invention refer to an embodiment of the invention and not necessarily all embodiments.

[0046] The terms used in the claims should be construed to have the broadest reasonable interpretation consistent with the foregoing description. For example, the use of the article "a" or "the" in introducing an element should not be interpreted as being exclusive of a plurality of elements. Likewise, the recitation of "or" should be interpreted as being inclusive, such that the recitation of "A or B" is not exclusive of "A and B," unless it is clear from the context or the foregoing description that only one of A and B is intended. Further, the recitation of "at least one of A, B, and C" should be interpreted as one or more of a group of elements consisting of A, B, and C, and should not be interpreted as requiring at least one of each of the listed elements A, B, and C, regardless of whether A, B, and C are related as categories or otherwise. Moreover, the recitation of "A, B, and/or C" or "at least one of A, B, or C" should be interpreted as including any singular entity from the listed elements, e.g., A, any subset from the listed elements, e.g., A and B, or the entire list of elements A, B, and C.

1: A valve train assembly comprising:

a camshaft including a first cam body and a second cam body, each cam body being axially movable over the camshaft between a first axial position and a second axial position, and each cam body including a first cam configured to control a valve in the first axial position and a second cam configured to control the valve in the second axial position;

a coupler configured to couple a movement of the first cam body and the second cam body;

a first groove extending along a part of a circumference of the first cam body;

a second groove extending along a part of a circumference of the second cam body; and

an engager configured to alternately engage the first and second groove, such that either the first cam body is moved to the first axial position or the second cam body is moved to the second axial position.

2: The assembly of claim **1**, wherein the engager includes a first movable pin configured to engage in the first groove and a second movable pin configured to engage in the second groove.

3: The assembly of claim **2**, wherein the engager further includes a solenoid connected to each movable pin,

wherein the solenoid is configured to move a respective movable pin into engagement with the respective groove.

4: The assembly of claim **1**, wherein the first groove includes, in rotation direction, an axial direction component towards a side of the second axial position, and

wherein the second groove includes, in rotation direction, an axial direction component towards a side of the first axial position

5: The assembly of claim **4**, wherein the first groove is mirror-symmetrical to the second groove.

6: The assembly of claim **1**, wherein the first cam body and second cam body are substantially cylindrical.

7. The assembly of claim **6**, wherein the cam bodies include an axial groove, and

wherein the cam shaft includes a corresponding axial rib.

* * * * *