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(54) VALVE OPERATING DEVICE, IN PARTICULAR FOR AN INTERNAL COMBUSTION ENGINE

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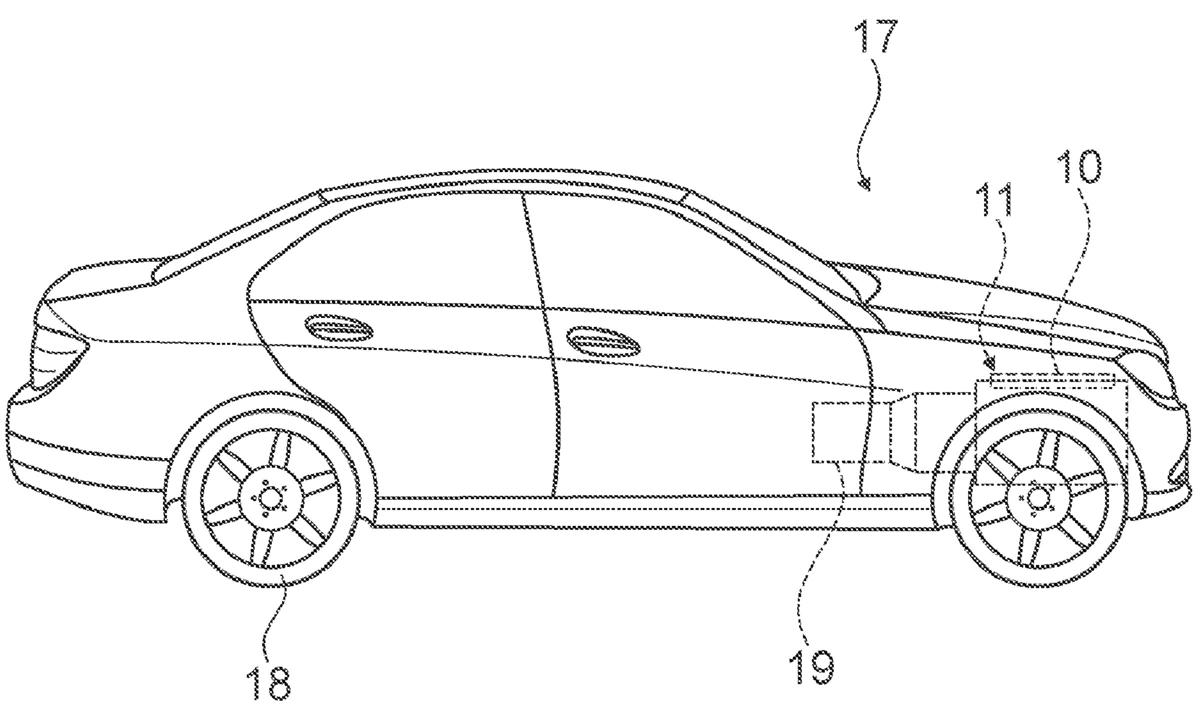
(57) **ABSTRACT**

A valve operating device, in particular for an internal combustion engine, has a camshaft, a cam unit mounted in an axially moveably manner on the camshaft, and an actuator unit which has an actuator for displacing the cam unit on the camshaft. The actuator is periodically mechanically forcibly decoupled during operation.



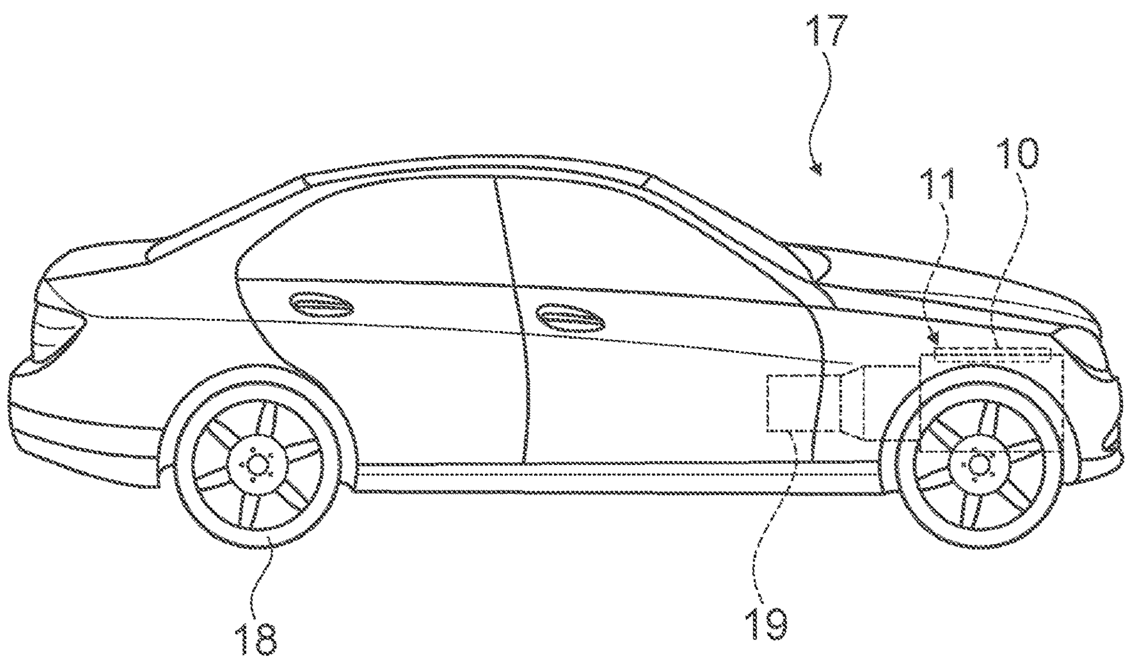
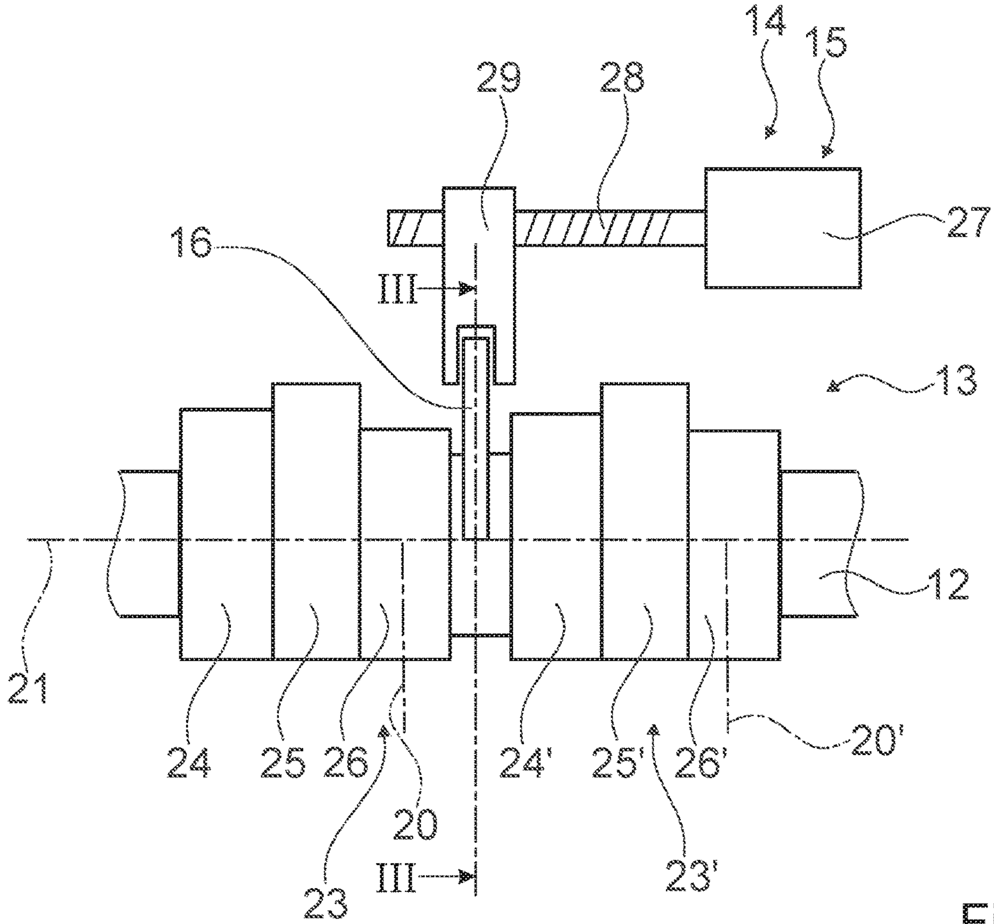


Fig. 1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III

Fig. 2

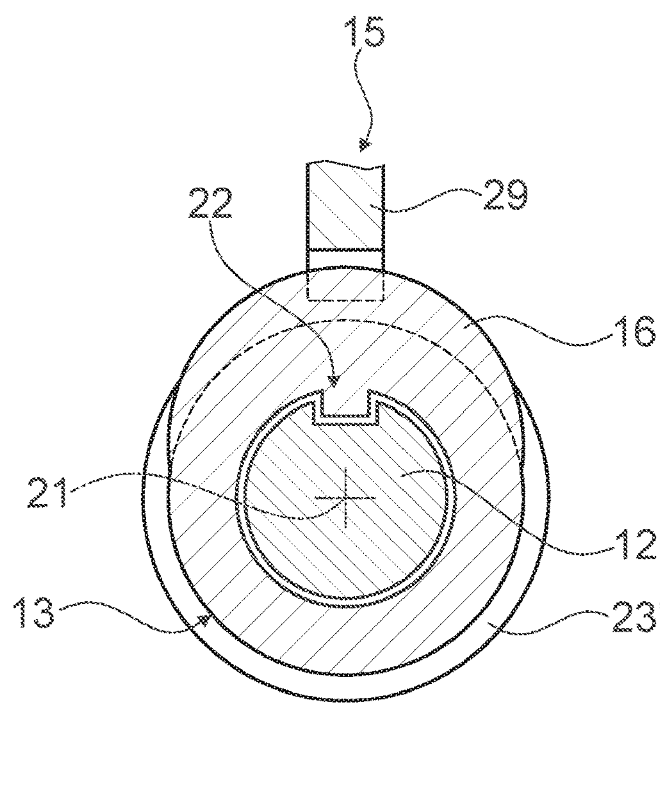
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Fig. 3

VALVE OPERATING DEVICE, IN PARTICULAR FOR AN INTERNAL COMBUSTION ENGINE

BACKGROUND AND SUMMARY OF THE INVENTION

[0001] The invention relates to a valve operating device, in particular for an internal combustion engine, and a motor vehicle having an internal combustion engine which comprises the valve operating device.

[0002] A valve operating device, in particular for an internal combustion engine, is already known from DE 10 2016 012 194, having at least one camshaft, having at least one cam unit mounted axially moveably on the camshaft, and having at least one actuator unit which has at least one actuator for adjusting the cam unit on the camshaft. DE 10 2016 012 194 further comprises a safety device which is provided for triggering a switching operation of a switching unit only in a permissible state. If the safety device fails and an actuator of the switching unit therefore wants to conduct a switching operation at an incorrect time, it can do so. The cam unit can then be moved at an incorrect time, which can result in damage to the valve operating device.

[0003] A valve operating device is also known from JPS6062613A. According to JP 60062613, a shift of the cam piece at the wrong time, in particular when the valves are being operated, should be prevented by means of a mechanism. This must be carried out very solidly, as it must block the large displacement forces generated by the actuators.

[0004] Furthermore, a valve operating device is also known from DE 10 2007 042 932. In normal operation, there is no interaction between a switching medium and a switching unit if switching is not supposed to occur. A safety device is provided to prevent unplanned interaction. If switching is supposed to occur, the interaction of the switching medium with the switching unit must be established beforehand. This process takes a certain amount of time, in particular approximately a quarter of a camshaft revolution. If the switching command takes place too late, almost a complete camshaft revolution must thus be waited for, until a tracking process is possible. In particular at low engine speeds, the driver thus experiences an unpleasant delay when a load is required. In the sport programme of the vehicle, it must either be driven at an increased speed or permanently with the large valve stroke in order to ensure a spontaneous reaction. Both lead to increased consumption.

[0005] In particular, the object of the invention is to provide an advantageously safe and constructively simple valve operating device.

[0006] The invention is based on a valve operating device, in particular for an internal combustion engine, having at least one camshaft, having at least one cam unit mounted axially moveably on the camshaft and having at least one actuator unit which has at least one actuator for adjusting the cam unit on the camshaft.

[0007] It is provided that the actuator is periodically mechanically forcibly decoupled during operation. Preferably, the valve operating device is in particular provided to establish an operative connection between the actuator and the cam unit in the correct angular position at each camshaft revolution, independent of any switching process that may be pending. In this way, an advantageously safe valve operating device can be provided. Advantageously, a valve operating device can be provided that makes a switching process impossible at the wrong time, which makes the valve operating device particularly safe. The design according to the invention makes it possible to dispense with a comparatively large and solid mechanism that would have to block the displacement forces generated by the switching unit. In particular, a valve operating device can be provided, in which the actuator is always in operative connection with the cam unit when a switching is possible, which is in particular the case in every half camshaft revolution. The actuator can therefore implement every switching requirement without delay. In particular, it is possible to forgo, for example, waiting for a pin to be tracked into a link. Furthermore, it is no longer necessary, for example, for the tracking of a pin into a link to be sensed and verified.

[0008] An "internal combustion engine" is to be understood in particular as an engine of a motor- and/or commercial vehicle which, by burning a fuel, such as petrol or diesel, provides a driving energy for driving the corresponding motor- and/or commercial vehicle. A "camshaft" is thereby to be understood in particular as a shaft which is provided for operating several valves of the internal combustion engine and has at least one cam track in each case for operating a valve. It is conceivable that the camshaft is designed as an intake camshaft and is provided to operate intake valves, and also that the camshaft is designed as an exhaust camshaft and is provided to operate exhaust valves. In principle, it would also be conceivable that the camshaft is provided to operate inlet valves and to operate exhaust valves. A "cam track" should be understood in particular as a region running on a periphery of the camshaft, preferably on a periphery of a cam unit, the region forming a valve operating curve for valve operation and/or defining the valve actuation. A "cam unit" is to be understood in particular as a unit which is non-rotatably and preferably axially moveably arranged on a camshaft and, for operating a valve, is provided to apply at least one valve stroke directly or indirectly to the corresponding valve. A "moveably mounted cam unit" is to be understood in particular as a cam unit which is mounted axially on the camshaft and has at least two different cam tracks for a valve to be operated, which preferably have different cam contours. In particular, a "switching unit" is understood to be a unit provided to move a cam unit axially on the camshaft, in order to bring different cam tracks of the cam unit into engagement with the corresponding valve. The switching unit preferably has an actuator and a coupling element connected to the actuator and to the cam unit to be adjusted. An "actuator" is to be understood in particular as a mechatronic component which is provided to convert electrical and/or electronic signals into a movement, in particular, into a rotary and/or linear movement. Here, an actuator is preferably designed as a spindle drive, a pneumatic piston, a hydraulic piston or another actuator that appears useful to a person skilled in the art. This means that the switching unit is in particular provided to shift an axial position of the cam unit. The switching unit for shifting or adjusting the axial position is preferably controlled by a control and/or regulating unit. The term "provided" is to be understood as specially designed, equipped and/or arranged. A "control and/or regulating unit" is to be understood in particular as a unit having at least one electronic control device. An electronic "control device" is to be understood in particular as a unit having a processor unit and having a memory unit as well as having an operating program stored within the memory unit. In principle, the control and/or regulating unit can have several control devices connected to each other, which are preferably provided to communicate with each other via a bus system, in particular a CAN bus system. Depending on the further design, the control and/or regulating unit can also have hydraulic and/or pneumatic components, in particular such as valves. In this context, the statement that the "actuator is periodically mechanically forcibly decoupled during operation" is to be in particular understood to mean that, during operation, an effective connection between the actuator and the cam unit is automatically mechanically interrupted at regular intervals. The decoupling is preferably carried out mechanically without the intervention of a control unit. Particularly preferably, in a forcibly decoupled state, operating the cam unit or a switching operation by the actuator is not technically possible due to a lack of effective connection. The term "periodic" is to be understood in particular as regular intervals, wherein a period can be coupled with a speed of the camshaft. This means, in particular, that a period can change with the speed of the camshaft. This is to be understood, particularly preferably, in regular intervals relative to an angle of rotation and/or an angular position of the camshaft. A "switching operation" is to be understood in particular as an operation in which a cam track engaged with the corresponding valve is switched over to another cam track and this cam track is brought into engagement with the valve. During a switching operation, the unit with the two cam tracks, between which the cam track is moved, is moved axially on the camshaft. A "permissible state" is to be understood in particular as a state of the valve operating device and/or of the internal combustion engine, in which a valve lift switchover can be carried out operationally reliably by switching from one engaged cam track to another cam track.

[0009] It is also provided that the actuator is periodically temporarily decoupled from the cam unit during operation, relative to a rotational speed of the camshaft. Preferably, the actuator is periodically temporarily forcibly decoupled from the cam unit during operation, relative to a rotational angle of the camshaft. Preferably, the actuator is always temporarily forcibly decoupled from the cam unit when the cam unit should not be adjusted, i.e., in particular when at least one valve is being operated by the cam unit. In this way, a valve operating device can be provided which makes it constructively impossible to switch at the wrong time, making the valve operating device particularly safe. In particular, a valve operating device can be provided in which the actuator is always in operative connection with the cam unit when switching is possible.

[0010] Furthermore, the cam unit has an engagement element by means of which the cam unit is coupled to the actuator unit. Preferably, the actuator and the actuating element are in direct operative connection in at least one operating state. The actuator is preferably provided to transmit an adjusting force to the cam unit via the actuating element. In particular, a reliable transmission of an adjusting force to the cam unit can be achieved. In particular, an advantageous mechanical force transmission can be provided. In this context, an "engagement element" is to be understood in particular as an extension running at least partially in the peripheral direction around the cam unit, which is in direct operative connection with the actuator in at least one operating state. Preferably, the engagement element is formed by a gill running at least partially in the peripheral direction around the cam unit.

[0011] It is further provided that the engagement element is partially interrupted along a periphery of the cam unit. Preferably, the engagement element has at least one interruption. Preferably, the at least one interruption extends over at least 5%, preferably at least 15% and particularly preferably at least 25% of a periphery of the cam unit. Particularly preferably, the interruption has an arrangement such that when the interruption faces the actuator, the cam unit is operating a valve. Thus the interruption preferably always faces the actuator when the cam unit should not be adjusted, thus in particular when at least one valve is being operated by means of the cam unit. Preferably, the interruption in a position facing the actuator causes a forced decoupling of the actuator. Preferably, the cam unit is free from an engagement element in the region of the interruption, in this way, a valve operating device can in particular be provided, which makes it impossible to switch at the wrong time, advantageously constructively simple, which makes the valve operating device particularly safe. In particular, a valve operating device can be provided in which the actuator is always in operative connection with the cam unit when switching is possible, which is the case in particular in every half camshaft revolution.

[0012] It is further provided that the actuator is temporarily not engaged with the engagement element during operation. Preferably, the actuator is never engaged with the engagement element when the cam unit is not supposed to be adjusted, i.e., in particular when at least one valve is being operated by means of the cam unit. Preferably, the actuator is not adjusted to disengage from the engagement element. In this way, a valve operating device can in particular be provided, which makes it impossible to switch at the wrong time, advantageously constructively simple, which makes the valve operating device particularly safe. In particular, it may have provided a valve operating device in which the actuator is always in operative connection with the cam unit when a switching is possible, which is particularly the case in every half camshaft revolution. Since the valve operating device does not block an incorrect shifting process as after the SdT, but rather makes it impossible to construct shifting forces at the wrong time, the actuator unit can be dimensioned very easily. Faulty switching operations are prevented very reliably.

[0013] It is also provided that the engagement element is formed by a crescent-shaped gill. This is particularly advantageous for providing an engagement element which has an interruption. In particular, a constructively simple and easy to manufacture engagement element can be provided. A "crescent-shaped gill" is to be understood in particular as a gill which, in a section plane perpendicular to an axis of rotation of the camshaft, has an at least substantially crescent-shaped, in particular crescent moon-shaped, cross-section. Preferably, the gill has a radial height which, starting from a centre of the gill, decreases in particular continuously to zero in both directions of rotation.

[0014] Furthermore, the invention is based on a motor vehicle having an internal combustion engine which comprises the valve operating device.

[0015] Further advantages arise from the following Figure description. An exemplary embodiment of the invention is shown in the Figures. The Figures, the Figure description and the claims include numerous features in combination.

The person skilled in the art will also expediently look at the features individually and combine them into meaningful further combinations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. **1** is a schematic depiction of a motor vehicle having an internal combustion engine which comprises a valve operating device according to the invention, and having a multi-stage transmission in a schematic depiction;

[0017] FIG. **2** is a schematic depiction of the valve drive device according to the invention, having a camshaft, a cam unit and an actuator unit; and

[0018] FIG. **3** shows the valve operating device according to the invention having the camshaft, the cam unit and the actuator unit in a schematic sectional depiction along sectional line III-III of FIG. **2**.

DETAILED DESCRIPTION OF THE DRAWINGS

[0019] FIG. **1** schematically shows a motor vehicle **17**. The motor vehicle **17** comprises a drive train, by means of which the drive wheels **18** not visible in more detail of the motor vehicle **17** are driven. The drive train comprises an internal combustion engine **11**, The internal combustion engine **11** is formed by a combustion motor. Furthermore, the motor vehicle **17** has a multi-stage transmission **19**. The internal combustion engine **11** has a driven crankshaft which is connected to a transmission input element of the multi-stage transmission **19**. The multi-stage transmission **19** is formed by a motor vehicle transmission. The multi-stage transmission **19** forms part of the drive train of the motor vehicle **17**. The internal combustion engine **11** comprises at least one valve operating device **10**. Preferably, the internal combustion engine **11** comprises several valve operating devices **10**. The internal combustion engine **11** is designed as a motor vehicle internal combustion engine which is provided to convert chemical energy into kinetic energy which serves in particular to propel a motor vehicle **17**. The internal combustion engine **11** has several cylinders which each have several valves **20**, **20'**. The internal combustion engine **11** has two valves **20**, **20'**, each designed as inlet valves for one cylinder and two valves each designed as exhaust valves for each cylinder. In principle, it is also conceivable that the internal combustion engine **11** has a different number of valves **20**, **20'**. Here, the valves **20**, **20'** are schematically depicted by their actuation plane in FIG. **2**.

[0020] The valve operating device **10** is provided to actuate the valves **20**, **20'** of the internal combustion engine **11**. The valve operating device **10** has a camshaft **12**. The valve operating device **10** has the camshaft **12** for actuating the valves **20**, **20'**. In FIG. **2**, only part of the camshaft **12**, which is assigned to a cylinder that is not depicted in detail, is depicted. In addition, the valve operating device **10** has another camshaft which is not depicted in detail. The camshaft **12** depicted is, for example, formed as an intake camshaft, and the camshaft not depicted in detail is an exhaust camshaft. In the following, only the part of the camshaft **12** described in FIGS. **2** and **3** is described in more detail. The description can be applied to the part of the camshaft **12** which is not depicted in detail as well as the camshaft not depicted in detail.

[0021] The camshaft **12** is rotatably supported by a camshaft bearing not depicted in detail. For this purpose, the camshaft bearing comprises several support elements fixed to the housing which store the camshaft **12**. Here, the camshaft **12** is rotatably mounted about an axis of rotation **21**. The axis of rotation **21** of the camshaft **12** is aligned substantially in parallel to an axis of rotation of a crankshaft of the internal combustion engine **11**. The camshaft **12** is driven by the crankshaft via a coupling not depicted in detail. The valve operating device **10** comprises one cam unit **13** per cylinder. FIG. **2** shows an example of a cam unit **13**. The cam unit **13** is mounted in an axially moveable manner on the camshaft **12**. The cam unit **13** is non-rotatably coupled to the camshaft **12**. In particular, the cam unit **13** is connected to the camshaft **12** via a toothing **22**. The cam unit **13** is provided for actuating the valves **20**, **20'**. The cam unit **13** has a multi-track cam **23**, **23'** for each valve **20**, **20'**. The cam unit **13** has two multi-track cams **23**, **23'**. Each of the multi-track cams **23**, **23'** has three cam tracks **24**, **24'**, **25**, **25'**, **26**, **26'**. In principle, it is also conceivable that the cam unit **13** has only two or more than three cam tracks **24**, **24'**, **25**, **25'**, **26**, **26'** for each multi-track cam **23**, **23'**. The cam tracks **24**, **24'**, **25**, **25'**, **26**, **26'** each have different contours and thus actuate the respective valve **20**, **20'** with correspondingly different valve strokes. In a first switching position of a cam unit **13**, the first cam tracks **24**, **24'** actuate the respective valve **20**, **20'**. The valves **20**, **20'** are actuated with a medium stroke, for example. In a second switching position of the cam unit **13**, the second cam tracks **25**, **25'** actuate the respective valve **20**, **20'**. The valves **20**, **20'** are actuated with a large stroke, for example. In a third switching position of the cam unit **13**, the third cam tracks **26**, **26'** actuate the respective valve **20**, **20'** (FIG. **2**). The valves **20**, **20'** are actuated with a small stroke, for example. The actuation of a valve **20**, **20'** by a cam track **24**, **24'**, **25**, **25'**, **26**, **26'** is carried out in a manner known to a person skilled in the art.

[0022] Furthermore, the valve operating device **10** has an actuator unit **14**. The valve operating device **10** has an actuator unit **14** for adjusting the cam unit **13** on the camshaft **12** between the three switching positions. The actuator unit **14** has an actuator **15**. The actuator **15** is formed by a shift actuator. The actuator **15** is provided for adjusting the cam unit **13** on the camshaft **12**. The actuator **15** is provided to move the cam unit **13** axially on the camshaft **12** in order to bring the different cam tracks **24**, **24'**, **25**, **25'**, **26**, **26'** of the multi-track cams **23**, **23'** into engagement with the respective valve **20**, **20'**. Here, the actuator **15** is designed as an electronically controlled unit. The actuator **15** comprises an electric motor **27** and a spindle **28**, which can be driven by the electric motor **27** in both directions of rotation. To convert the rotation of spindle **28** into a linear movement, the actuator **15** has a switching element **29**. The switching element **29** is designed as a threaded nut. The switching element **29** has an internal thread not depicted in detail, via which the switching element **29** is supported on the spindle **28**. By rotating the spindle **28** by means of the electric motor **27**, the switching element **29** can be shifted in the axial direction of spindle **28**. Instead of a spindle **28**, a guide rail or a cable device can be used as a support for the switching element **29**. The actuator **15** is arranged in parallel offset to the camshaft **12**.

[0023] The cam unit **13** also has an engagement element **16**. The cam unit **13** is coupled to the actuator unit **14** via the engagement element **16**. The cam unit **13** is coupled to the actuator **15** via the engagement element **16**. The axially moveable switching element **29** of the actuator **15** is operatively connected to the engagement element **16**. The engagement element **16** is designed as a narrow peripheral gill. The actuating element **16** is partially interrupted along a periphery of the cam unit **13**. The actuating element **16** is interrupted in the peripheral direction of the cam unit **13**. Thus in the peripheral direction around the cam unit **13**, the engagement element **16** does not extend completely around the cam unit **13**. The engagement element **16** is designed as a gill. The engagement element **16** is formed by a gill rotating around 180° of the periphery. The engagement element **16** is formed by a crescent-shaped gill. The engagement element **16** is designed as a crescent moon-shaped gill. In principle, however, a different design of the engagement element **16**, which would appear useful to a person skilled in the art, would also be conceivable. The engagement element **16** is designed without an incline in the axial direction and has a constant width in the peripheral direction of the camshaft **12**. The engagement element **16** is arranged between the multi-track cams **23**, **23'** of the cam unit **13**. The switching element **29** is temporarily connected positively to the engagement element **16**. For this purpose, the switching element **29** has a recess in which the engagement element **16** formed as a gill engages. The engagement element **16** forms an interface for applying a displacement force acting in the axial direction to the cam unit **13**. In the exemplary embodiment shown, the displacement force acting in the axial direction is only applied by the actuator **15**. It is independent of a rotational movement of the camshaft **12**.

[0024] The actuator **15** is periodically mechanically forcibly decoupled during operation. During operation, the actuator **15** is periodically temporarily decoupled from the cam unit **13** relative to a speed of the camshaft **12**. During operation, the actuator **15** is periodically temporarily forcibly decoupled from the cam unit **13** relative to an angle of rotation of the camshaft **12**. Furthermore, the actuator **15** is always temporarily forcibly decoupled from the cam unit **13** when the cam unit **13** should not be adjusted, i.e., especially when the valves **20**, **20'** are being operated by the cam unit **13**. The forced decoupling is carried out mechanically by means of the engagement element **16**. The engagement element **16** has the interruption for this purpose. The interruption has such an arrangement that, when the interruption is facing the actuator **15**, the cam unit **13** is actuating the valves **20**, **20'**. The interruption thus always faces the actuator **15** when the cam unit **13** should not he adjusted, especially when at least the valves **20**, **20'** are operated by the cam unit **13**. In a position facing the actuator **15**, the interruption causes a forced decoupling of the actuator **15**. The actuator **15** is therefore temporarily disengaged from the engagement element **16** during operation. The switching element **29** of the actuator **15** is temporarily disengaged from the engagement element **16** during operation. The switching element **29** of the actuator **15** is always disengaged from the engagement element **16** if the cam unit **13** should not be adjusted.

[0025] At each half camshaft revolution—whenever a switchover is mechanically possible the engagement element **16** enables an interaction between the actuator **15** and the cam unit **13**. Whenever an attempt to switch over could lead to damage, no traction between the actuator **15** and the cam unit **13** is possible. This can prevent an incorrectly timed adjustment of the cam unit **13**.

[0026] To actuate the actuator **15**, the valve operating device **10** has a control and regulating unit which is not depicted in detail. The control unit is intended to control the electric motor **27** of the actuator **15** and thereby actuate the actuator **15**. The control and regulating unit is designed as part of a motor control. In principle, it is also conceivable that the control and regulating unit is designed as a separate control unit. By controlling the control and regulating unit, the electric motor **27** of the actuator **15** can he driven in both directions, allowing the switching element **29** to be moved in both axial directions.

LIST OF REFERENCE CHARACTERS

[0027] **10** valve operating device
[0028] **11** internal combustion engine
[0029] **12** camshaft
[0030] **13** cam unit
[0031] **14** actuator unit
[0032] **15** actuator
[0033] **16** engagement element
[0034] **17** motor vehicle
[0035] **18** drive wheel
[0036] **19** multi-stage transmission
[0037] **20** valve
[0038] **21** rotation axis
[0039] **22** toothing
[0040] **23** cam
[0041] **24** cam track
[0042] **25** cam track
[0043] **26** cam track
[0044] **27** electric motor
[0045] **28** spindle
[0046] **29** switching element

1.-**7**. (canceled)

8. A valve operating device for an internal combustion engine, comprising:
- a camshaft;
- a cam unit mounted on the camshaft in an axially moveable manner; and
- an actuator unit which has an actuator for adjusting the cam unit;
- wherein the actuator is periodically mechanically forcibly decoupled during operation and periodically temporarily decoupled from the cam unit relative to a rotational speed of the camshaft;
- wherein the cam unit has an engagement element via which the cam unit is coupled to the actuator unit;
- and wherein a switching element of the actuator is always disengaged from the engagement element when the cam unit is not adjusted.

9. The valve operating device according to claim **8**, wherein the engagement element is partially interrupted along a circumference of the cam unit.

10. The valve operating device according to claim **8**, wherein the actuator is temporarily out of engagement with the engagement element during operation.

11. The valve operating device according to claim **8**, wherein the engagement element is a crescent-shaped gill.

12. A motor vehicle, comprising:
- an internal combustion engine; and
- the valve operating device according to claim **8**.

* * * * *