(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 693 985 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.08.2020 Bulletin 2020/33

(51) Int Cl.:
H01H 9/24 *(2006.01)*

(21) Application number: **19156490.5**

(22) Date of filing: **11.02.2019**

(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: **ABB Schweiz AG**
5400 Baden (CH)

(72) Inventors:
- **Schneider, Markus**
  76135 Karlsruhe (DE)
- **Frantisek, Ondrej**
  68542 Heddesheim (DE)

(74) Representative: **Maiwald Patent- und Rechtsanwaltsgesellschaft mbH**
Grünstraße 25
40212 Düsseldorf (DE)

(54) **ACTUATOR FOR A MEDIUM VOLTAGE CIRCUIT BREAKER**

(57) The present invention relates to an actuator for a medium voltage circuit breaker. The actuator comprises a closing shaft (1), and a closing hook (2). The closing shaft has a longitudinal axis. The closing shaft comprises an interaction region at an interaction location along the longitudinal axis. The closing shaft is configured to rotate about the longitudinal axis. In a first state the closing shaft is configured to be at a first rotational position, wherein the closing hook is configured to be in contact with the interaction region such that the closing hook cannot rotate in a first rotational direction. In a second state the closing shaft is configured to be at a second rotational position, wherein the closing hook is configured to rotate in the first rotational direction past the interaction region of the closing shaft. The actuator is configured to transition from the first state to a third state, wherein the closing shaft is configured to rotate from the first rotational position to a third rotational position, wherein the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in a second rotational direction opposite to the first rotational direction.

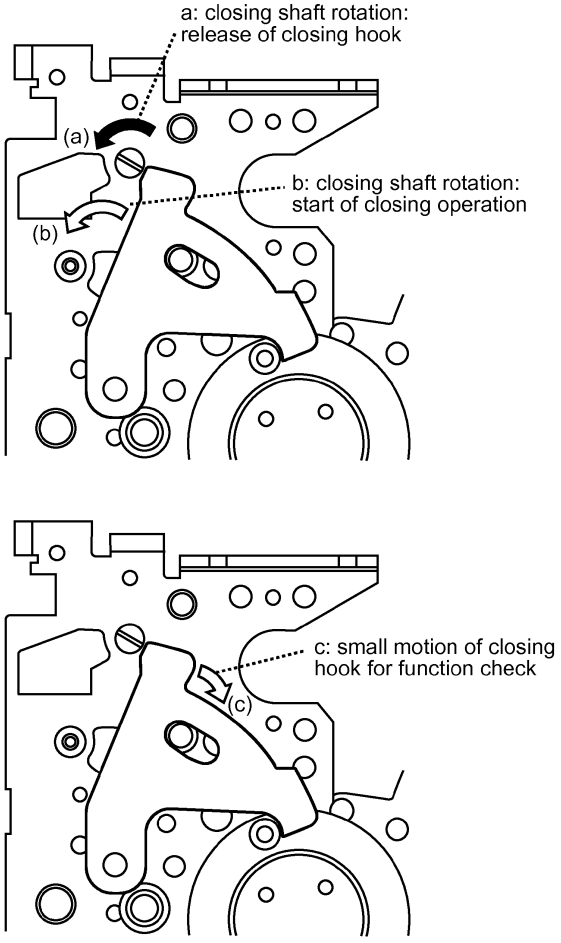


Fig. 2

EP 3 693 985 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to actuators for a medium voltage circuit breaker.

BACKGROUND OF THE INVENTION

[0002] The checking of medium voltage (MV) and low voltage (LV) mechanical actuators for circuit breakers (CB) to establish that they are functioning correctly after a period of nonusage or in a "closed" state, usually is only possible through a regular actuation of the complete CB or equivalent application. checking of only the actuator with respect to its main latching elements and their proper functioning is not possible.

[0003] There is a need to address this issue.

SUMMARY OF THE INVENTION

[0004] Therefore, it would be advantageous to have means to check actuators for circuit breakers without having to activate the complete circuit breaker.

The object of the present invention is solved with the subject matter of the independent claims, wherein further embodiments are incorporated in the dependent claims.

[0005] In a first aspect, there is provided an actuator for a medium voltage circuit breaker, the actuator comprising:

- a closing shaft; and
- a closing hook.

[0006] The closing shaft has a longitudinal axis. The closing shaft comprises an interaction region at an interaction location along the longitudinal axis. The closing shaft is configured to rotate about the longitudinal axis. In a first state the closing shaft is configured to be at a first rotational position, and the closing hook is configured to be in contact with the interaction region such that the closing hook cannot rotate in a first rotational direction. In a second state the closing shaft is configured to be at a second rotational position, and the closing hook is configured to rotate in the first rotational direction past the interaction region of the closing shaft. The actuator is configured to transition from the first state to a third state. In the transition from the first state to the third state the closing shaft is configured to rotate from the first rotational position to a third rotational position, and the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in a second rotational direction opposite to the first rotational direction.

In this manner, if the closing hook does not rotate in the second rotational direction as expected, for example requires more force to rotate, it can be determined that there is a problem with the actuator.

[0007] It is to be noted that the actuator has applicability to low, medium and indeed high voltage applications, with that applicability extending beyond that for circuit breakers. Thus, other low, medium and high voltage systems that require actuation from closed to open states can make use of the actuator provided and described herein.

[0008] In an example, a cross section of the closing shaft at the interaction region comprises a first dimension extending from the longitudinal axis to a first part of the outer surface of the closing shaft at a first angular position. The cross section of the closing shaft at the interaction region comprises a second dimension extending from the longitudinal axis to a second part of the outer surface of the closing shaft at a second angular position. The cross section of the closing shaft at the interaction region comprises a third dimension extending from the longitudinal axis to a third part of the outer surface of the closing shaft at a third angular position. The first dimension is greater than the second dimension and the third dimension is greater than the first dimension. In the first state the closing hook is configured to contact the interaction region of the closing shaft at the first part of the outer surface. In the second state an outer portion of the closing hook is configured to pass in proximity to the second part of the outer surface of the closing shaft in rotating in the first rotational direction past the interaction region of the closing shaft. In the third state, when the closing shaft is configured to be in the third rotational position the closing hook is configured to contact the interaction region of the closing shaft at the third part of the outer surface.

In other words, an eccentricity is used on the closing shaft, that is used to perform a small motion / micro motion of latching elements for an actuator, providing a check function for the actuator.

[0009] In an example, the actuator is configured to transition from the third state to the first state. In the transition from the third state to the first state the closing shaft is configured to rotate from the third rotational position to the first rotational position, and the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in the first rotational direction.

In this way, if the closing hook does not rotate back to the normal holding position as expected, it can be determined that there is a problem with the actuator.

[0010] In an example, the actuator is configured to transition from the first state to the third state without entering the second state.

[0011] In an example, the actuator is configured to transition from the third state to the first state without entering the second state,

[0012] In an example, the closing shaft is configured to rotate in the first rotational direction when the actuator transitions from the first state to the second state.

[0013] In an example, in the transition from the first state to the third state the closing shaft is configured to rotate in the second rotational direction to rotate from the

first rotational position to the third rotational position.

[0014] In an example, in the transition from the first state to the third state the closing shaft is configured to rotate in the first rotational direction to rotate from the first rotational position to the third rotational position.

[0015] In an example, a sensor is configured to detect rotation of the closing hook in the second rotational direction when the closing shaft is configured to rotate from the first rotational position to the third rotational position.

[0016] In an example, a sensor is configured to detect rotation of the closing hook in the first rotational direction when the closing shaft is configured to rotate from the third rotational position to the first rotational position.

[0017] In an example, the same sensor is used to detect both rotations.

[0018] In an example, at least one sensor is configured to measure a force and/or torque required to rotate the closing shaft.

[0019] In an example, an actuating unit for the closing shaft is configured to detect rotation of the closing hook in the second rotational direction when the closing shaft is configured to rotate from the first rotational position to the third rotational position.

[0020] In an example, the actuating unit for the closing shaft is configured to detect rotation of the closing hook in the first rotational direction when the closing shaft is configured to rotate from the third rotational position to the first rotational position.

[0021] In a second aspect, there is provided an actuator for a medium voltage circuit breaker, the actuator comprising:

- an opening shaft; and
- an opening hook.

The opening shaft has a longitudinal axis. The opening shaft comprises an interaction region at an interaction location along the longitudinal axis. The opening shaft is configured to rotate about the longitudinal axis. In a first state the opening shaft is configured to be at a first rotational position, and the opening hook is configured to be in contact with the interaction region such that the opening hook cannot rotate in a first rotational direction. In a second state the opening shaft is configured to be at a second rotational position, and the opening hook is configured to rotate in the first rotational direction past the interaction region of the opening shaft. The actuator is configured to transition from the first state to a third state. In the transition from the first state to the third state the opening shaft is configured to rotate from the first rotational position to a third rotational position, and the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in a second rotational direction opposite to the first rotational direction.

[0022] In this manner, if the opening hook does not rotate in the second rotational direction as expected, for example requires more force to rotate, it can be determined that there is a problem with the actuator.

In an example, a cross section of the opening shaft at the interaction region comprises a first dimension extending from the longitudinal axis to a first part of the outer surface of the opening shaft at a first angular position. The cross section of the opening shaft at the interaction region comprises a second dimension extending from the longitudinal axis to a second part of the outer surface of the opening shaft at a second angular position. The cross section of the opening shaft at the interaction region comprises a third dimension extending from the longitudinal axis to a third part of the outer surface of the opening shaft at a third angular position. The first dimension is greater than the second dimension and the third dimension is greater than the first dimension. In the first state the opening hook is configured to contact the interaction region of the opening shaft at the first part of the outer surface. In the second state an outer portion of the opening hook is configured to pass in proximity to the second part of the outer surface of the opening shaft in rotating in the first rotational direction past the interaction region of the opening shaft. In the third state, when the opening shaft is configured to be in the third rotational position the opening hook is configured to contact the interaction region of the opening shaft at the third part of the outer surface. In other words, an eccentricity is used on the opening shaft, that is used to perform a small motion / micro motion of latching elements for an actuator, providing a check function for the actuator.

[0023] In an example, the actuator is configured to transition from the third state to the first state. In the transition from the third state to the first state the opening shaft is configured to rotate from the third rotational position to the first rotational position, and the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in the first rotational direction.

In this way, if the opening hook does not rotate back to the normal holding position as expected, it can be determined that there is a problem with the actuator.

[0024] In an example, the actuator is configured to transition from the first state to the third state without entering the second state.

[0025] In an example, the actuator is configured to transition from the third state to the first state without entering the second state,

[0026] In an example, the opening shaft is configured to rotate in the first rotational direction when the actuator transitions from the first state to the second state.

[0027] In an example, in the transition from the first state to the third state the opening shaft is configured to rotate in the second rotational direction to rotate from the first rotational position to the third rotational position.

[0028] In an example, in the transition from the first state to the third state the opening shaft is configured to rotate in the first rotational direction to rotate from the first rotational position to the third rotational position.

[0029] In an example, a sensor is configured to detect

rotation of the opening hook in the second direction when the opening shaft is configured to rotate from the first rotational position to the third rotational position.

[0030] In an example, a the sensor is configured to detect rotation of the opening hook in the first direction when the opening shaft is configured to rotate from the third rotational position to the first rotational position.

[0031] In an example, the same sensor is used to detect both rotations.

[0032] In an example, at least one sensor is configured to measure a force and/or torque required to rotate the opening hook.

[0033] In an example, an actuating unit for the opening shaft is configured to detect rotation of the opening hook in the second direction when the opening shaft is configured to rotate from the first rotational position to the third rotational position.

[0034] In an example, the actuating unit for the opening shaft is configured to detect rotation of the opening hook in the first direction when the opening shaft is configured to rotate from the third rotational position to the first rotational position.

[0035] In a third aspect, there is provided an actuator for a medium voltage circuit breaker, the actuator comprising:

- a closing shaft;
- a closing hook;
- an opening shaft; and
- an opening hook.

The closing shaft has a longitudinal axis. The closing shaft comprises an interaction region at an interaction location along the longitudinal axis. The closing shaft is configured to rotate about the longitudinal axis. In a first state the closing shaft is configured to be at a first rotational position, wherein the closing hook is configured to be in contact with the interaction region such that the closing hook cannot rotate in a first rotational direction. In a second state the closing shaft is configured to be at a second rotational position, wherein the closing hook is configured to rotate in the first rotational direction past the interaction region of the closing shaft. The actuator is configured to transition from the first state to a third, wherein the closing shaft is configured to rotate from the first rotational position to a third rotational position, and wherein the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in a second rotational direction opposite to the first rotational direction. The opening shaft has a longitudinal axis. The opening shaft comprises an interaction region at an interaction location along the longitudinal axis. The opening shaft is configured to rotate about the longitudinal axis. In a fourth state the opening shaft is configured to be at a first rotational position, wherein the opening hook is configured to be in contact with the interaction region such that the opening hook cannot rotate in the second rotational direction. In a fifth state the opening shaft is configured to be at a second rotational position, wherein the opening hook is configured to rotate in the second rotational direction past the interaction region of the opening shaft. The actuator is configured to transition from the fourth state to a sixth, wherein the opening shaft is configured to rotate from the first rotational position to a third rotational position, and wherein the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in the first rotational direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Exemplary embodiments will be described in the following with reference to the following drawings:

Fig. 1 shows an example of an actuator;
Fig. 2 shows an example of an actuator;
Fig. 3 shows an example of a closing shaft or an actuator;
Fig. 4 shows an example of an actuator;
Fig. 5 shows an example of an actuator;
Fig. 6 shows an example of a closing shaft of an actuator; and
Fig. 7 shows an example of an actuator.

DETAILED DESCRIPTION OF EMBODIMENTS

[0037] Figs. 1-7 show examples of actuators and relevant parts of those actuator.

One example relates to an actuator for a medium voltage circuit breaker. The actuator comprises a closing shaft 1, and a closing hook 2. The closing shaft has a longitudinal axis. The closing shaft comprises an interaction region at an interaction location along the longitudinal axis. The closing shaft is configured to rotate about the longitudinal axis. In a first state the closing shaft is configured to be at a first rotational position, and the closing hook is configured to be in contact with the interaction region such that the closing hook cannot rotate in a first rotational direction. In a second state the closing shaft is configured to be at a second rotational position, and the closing hook is configured to rotate in the first rotational direction past the interaction region of the closing shaft. Thus the second state involves the closing shaft moving from the first rotational position to the second rotational position thereby releasing the closing hook that can then rotate past the closing shaft. The actuator is configured to transition from the first state to a third state. In the transition from the first state to the third state the closing shaft is configured to rotate from the first rotational position to a third rotational position, and the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in a second rotational direction opposite to the first rotational direction.

[0038] Thus, the actuator has a closing shaft that functions as a locking shaft for closing operation, and the

actuator has a closing hook that functions as a latch for closing operation - a closing latch. The actuator is then configured to enable the operation of the actuator to be simply and conveniently established.

[0039] According to an example, a cross section of the closing shaft at the interaction region comprises a first dimension extending from the longitudinal axis to a first part of the outer surface of the closing shaft at a first angular position. The cross section of the closing shaft at the interaction region comprises a second dimension extending from the longitudinal axis to a second part of the outer surface of the closing shaft at a second angular position. The cross section of the closing shaft at the interaction region comprises a third dimension extending from the longitudinal axis to a third part of the outer surface of the closing shaft at a third angular position. The first dimension is greater than the second dimension and the third dimension is greater than the first dimension. In the first state the closing hook is configured to contact the interaction region of the closing shaft at the first part of the outer surface. In the second state an outer portion of the closing hook is configured to pass in proximity to the second part of the outer surface of the closing shaft in rotating in the first rotational direction past the interaction region of the closing shaft. In the third state, when the closing shaft is configured to be in the third rotational position the closing hook is configured to contact the interaction region of the closing shaft at the third part of the outer surface.

[0040] According to an example, the actuator is configured to transition from the third state to the first state. In the transition from the third state to the first state the closing shaft is configured to rotate from the third rotational position to the first rotational position, and the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in the first rotational direction. However, if the closing hook is not functioning correctly, it may not rotate back and this lack of rotation detected to determine that there is a problem with the actuator.

[0041] According to an example, the actuator is configured to transition from the first state to the third state without entering the second state.

[0042] According to an example, the actuator is configured to transition from the third state to the first state without entering the second state,

[0043] According to an example, the closing shaft is configured to rotate in the first rotational direction when the actuator transitions from the first state to the second state.

[0044] According to an example, in the transition from the first state to the third state the closing shaft is configured to rotate in the second rotational direction to rotate from the first rotational position to the third rotational position.

[0045] According to an example, in the transition from the first state to the third state the closing shaft is configured to rotate in the first rotational direction to rotate from the first rotational position to the third rotational position.

[0046] According to an example, a sensor is configured to detect rotation of the closing hook in the second rotational direction when the closing shaft is configured to rotate from the first rotational position to the third rotational position.

According to an example, a sensor is configured to detect rotation of the closing hook in the first rotational direction when the closing shaft is configured to rotate from the third rotational position to the first rotational position.

[0047] According to an example, the same sensor is configured to detect both rotations.

[0048] According to an example, at least one sensor is configured to measure a force and/or torque required to rotate the closing shaft.

[0049] According to an example, an actuating unit for the closing shaft is configured to detect rotation of the closing hook in the second rotational direction when the closing shaft is configured to rotate from the first rotational position to the third rotational position.

[0050] According to an example, the actuating unit for the closing shaft is configured to detect rotation of the closing hook in the first rotational direction when the closing shaft is configured to rotate from the third rotational position to the first rotational position.

[0051] One example relates to a an actuator for a medium voltage circuit breaker. The actuator comprises an opening shaft 3, and an opening hook 4. The opening shaft has a longitudinal axis. The opening shaft comprises an interaction region at an interaction location along the longitudinal axis. The opening shaft is configured to rotate about the longitudinal axis. In a first state the opening shaft is configured to be at a first rotational position, and the opening hook is configured to be in contact with the interaction region such that the opening hook cannot rotate in a first rotational direction. In a second state the opening shaft is configured to be at a second rotational position, and the opening hook is configured to rotate in the first rotational direction past the interaction region of the opening shaft. Thus the second state involves the opening shaft moving from the first rotational position to the second rotational position thereby releasing the opening hook that can then rotate past the opening shaft. The actuator is configured to transition from the first state to a third state. In the transition from the first state to the third state the opening shaft is configured to rotate from the first rotational position to a third rotational position, and the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in a second rotational direction opposite to the first rotational direction.

[0052] Thus, the actuator has an opening shaft that functions as a locking shaft for opening operation, and the actuator has an opening hook that functions as a latch for opening operation - an opening latch. The actuator is then configured to enable the operation of the actuator to be simply and conveniently established.

[0053] It is to be noted that the first rotational direction

referred to with respect this example can be in a different rotational direction to the first rotational direction referred to with respect to the the first exemplar actuator described with respect to the figures. According to an example, a cross section of the opening shaft at the interaction region comprises a first dimension extending from the longitudinal axis to a first part of the outer surface of the opening shaft at a first angular position. The cross section of the opening shaft at the interaction region comprises a second dimension extending from the longitudinal axis to a second part of the outer surface of the opening shaft at a second angular position. The cross section of the opening shaft at the interaction region comprises a third dimension extending from the longitudinal axis to a third part of the outer surface of the opening shaft at a third angular position. The first dimension is greater than the second dimension and the third dimension is greater than the first dimension. In the first state the opening hook is configured to contact the interaction region of the opening shaft at the first part of the outer surface. In the second state an outer portion of the opening hook is configured to pass in proximity to the second part of the outer surface of the opening shaft in rotating in the first rotational direction past the interaction region of the opening shaft. In the third state, when the opening shaft is configured to be in the third rotational position the opening hook is configured to contact the interaction region of the opening shaft at the third part of the outer surface.

[0054] According to an example, the actuator is configured to transition from the third state to the first state. In the transition from the third state to the first state the opening shaft is configured to rotate from the third rotational position to the first rotational position, and the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in the first rotational direction. However, if the opening hook is not functioning correctly, it may not rotate back and this lack of rotation detected to determine that there is a problem with the actuator.

[0055] According to an example, the actuator is configured to transition from the first state to the third state without entering the second state.

[0056] According to an example, the actuator is configured to transition from the third state to the first state without entering the second state,

[0057] According to an example, the opening shaft is configured to rotate in the first rotational direction when the actuator transitions from the first state to the second state.

[0058] According to an example, in the transition from the first state to the third state the opening shaft is configured to rotate in the second rotational direction to rotate from the first rotational position to the third rotational position.

[0059] According to an example, in the transition from the first state to the third state the opening shaft is configured to rotate in the first rotational direction to rotate from the first rotational position to the third rotational position.

[0060] According to an example, a sensor is configured to detect rotation of the opening hook in the second direction when the opening shaft is configured to rotate from the first rotational position to the third rotational position.

[0061] According to an example, a sensor is configured to detect rotation of the opening hook in the first direction when the opening shaft is configured to rotate from the third rotational position to the first rotational position.

[0062] According to an example, the same sensor is configured to detect both rotations.

[0063] According to an example, at least one sensor is configured to measure a force and/or torque required to rotate the opening hook.

For example, a sensor can be used to indicate or establish the proper functioning of the actuator in the following manner. Associated with the opening hook, the next element in the internal kinematic chain is a so called "opening lever", where the opening hook is touching on the opposite side. This opening lever can therefore be moved, and an additional sensor on, or associated with this second component can be used to indicate the proper functioning of the actuator.

[0064] According to an example, an actuating unit for the opening shaft is configured to detect rotation of the opening hook in the second direction when the opening shaft is configured to rotate from the first rotational position to the third rotational position.

[0065] According to an example, the actuating unit for the opening shaft is configured to detect rotation of the opening hook in the first direction when the opening shaft is configured to rotate from the third rotational position to the first rotational position.

[0066] One example relates to an actuator for a medium voltage circuit breaker. The actuator comprises a closing shaft 1, a closing hook 2, an opening shaft 3, and an opening hook 4. The closing shaft has a longitudinal axis. The closing shaft comprises an interaction region at an interaction location along the longitudinal axis. The closing shaft is configured to rotate about the longitudinal axis. In a first state the closing shaft is configured to be at a first rotational position, and the closing hook is configured to be in contact with the interaction region such that the closing hook cannot rotate in a first rotational direction. In a second state the closing shaft is configured to be at a second rotational position, wherein the closing hook is configured to rotate in the first rotational direction past the interaction region of the closing shaft. Thus the second state involves the closing shaft moving from the first rotational position to the second rotational position thereby releasing the closing hook that can then rotate past the closing shaft.

[0067] The actuator is configured to transition from the first state to a third state. In the transition from the first state to the third state the closing shaft is configured to rotate from the first rotational position to a third rotational position, and the closing hook is configured to be in con-

tact with the interaction region such that the closing hook has been rotated in a second rotational direction opposite to the first rotational direction; wherein, the opening shaft has a longitudinal axis. The opening shaft comprises an interaction region at an interaction location along the longitudinal axis. The opening shaft is configured to rotate about the longitudinal axis. In a fourth state the opening shaft is configured to be at a first rotational position, and the opening hook is configured to be in contact with the interaction region such that the opening hook cannot rotate in the second rotational direction. In a fifth state the opening shaft is configured to be at a second rotational position, and the opening hook is configured to rotate in the second rotational direction past the interaction region of the opening shaft. Thus the fifth state involves the opening shaft moving from the first rotational position to the second rotational position thereby releasing the opening hook that can then rotate past the closing shaft. The actuator is configured to transition from the fourth state to a sixth state. In the transition from the fourth state to the sixth state the opening shaft is configured to rotate from the first rotational position to a third rotational position, and the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in the first rotational direction.

[0068] In an example, a cross section of the closing shaft at the interaction region comprises a first dimension extending from the longitudinal axis to a first part of the outer surface of the closing shaft at a first angular position. The cross section of the closing shaft at the interaction region comprises a second dimension extending from the longitudinal axis to a second part of the outer surface of the closing shaft at a second angular position. The cross section of the closing shaft at the interaction region comprises a third dimension extending from the longitudinal axis to a third part of the outer surface of the closing shaft at a third angular position. The first dimension of the closing shaft is greater than the second dimension of the closing shaft and the third dimension of the closing shaft is greater than the first dimension of the closing shaft. In the first state the closing hook is configured to contact the interaction region of the closing shaft at the first part of the outer surface. In the second state an outer portion of the closing hook is configured to pass in proximity to the second part of the outer surface of the closing shaft in rotating in the first rotational direction past the interaction region of the closing shaft. In the third state, when the closing shaft is configured to be in the third rotational position the closing hook is configured to contact the interaction region of the closing shaft at the third part of the outer surface.

[0069] In an example, the actuator is configured to transition from the third state to the first state. In the transition from the third state to the first state the closing shaft is configured to rotate from the third rotational position to the first rotational position, and the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in the first rotational direction. However, if the closing hook is not functioning correctly, it may not rotate back and this lack of rotation detected to determine that there is a problem with the actuator.

[0070] In an example, the actuator is configured to transition from the first state to the third state without entering the second state.

[0071] In an example, the actuator is configured to transition from the third state to the first state without entering the second state,

[0072] In an example, the closing shaft is configured to rotate in the first rotational direction when the actuator transitions from the first state to the second state.

[0073] In an example, in the transition from the first state to the third state the closing shaft is configured to rotate in the second rotational direction to rotate from the first rotational position to the third rotational position.

[0074] In an example, in the transition from the first state to the third state the closing shaft is configured to rotate in the first rotational direction to rotate from the first rotational position to the third rotational position.

[0075] In an example, a sensor is configured to detect rotation of the closing hook in the second direction when the closing shaft is configured to rotate from the first rotational position to the third rotational position.

In an example, a sensor is configured to detect rotation of the closing hook in the first direction when the closing shaft is configured to rotate from the third rotational position to the first rotational position.

[0076] In an example, the same sensor is configured to detect both rotations.

[0077] In an example,an actuating unit for the closing shaft is configured to detect rotation of the closing hook in the second direction when the closing shaft is configured to rotate from the first rotational position to the third rotational position.

[0078] In an example, the actuating unit for the closing shaft is configured to detect rotation of the closing hook in the first direction when the closing shaft is configured to rotate from the third rotational position to the first rotational position.

[0079] In an example, a cross section of the opening shaft at the interaction region comprises a first dimension extending from the longitudinal axis to a first part of the outer surface of the opening shaft at a first angular position. The cross section of the opening shaft at the interaction region comprises a second dimension extending from the longitudinal axis to a second part of the outer surface of the opening shaft at a second angular position. The cross section of the opening shaft at the interaction region comprises a third dimension extending from the longitudinal axis to a third part of the outer surface of the opening shaft at a third angular position. The first dimension of the opening shaft is greater than the second dimension of the opening shaft and the third dimension of the opening shaft is greater than the first dimension of the opening shaft. In the fourth state the opening hook is configured to contact the interaction region of the open-

ing shaft at the first part of the outer surface. In the fifth state an outer portion of the opening hook is configured to pass in proximity to the second part of the outer surface of the opening shaft in rotating in the second rotational direction past the interaction region of the opening shaft. In the sixth state, when the opening shaft is configured to be in the third rotational position the opening hook is configured to contact the interaction region of the opening shaft at the third part of the outer surface.

[0080] In an example, the actuator is configured to transition from the sixth state to the fourth state, wherein the opening shaft is configured to rotate from the third rotational position to the first rotational position, wherein the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in the second rotational direction. However, if the opening hook is not functioning correctly, it may not rotate back and this lack of rotation detected to determine that there is a problem with the actuator.

[0081] In an example, the actuator is configured to transition from the fourth state to the sixth state without entering the fifth state.

[0082] In an example, the actuator is configured to transition from the sixth state to the fourth state without entering the fifth state,

[0083] In an example, the opening shaft is configured to rotate in the second rotational direction when the actuator transitions from the fourth state to the fifth state.

[0084] In an example, in the transition from the fourth state to the sixth state the opening shaft is configured to rotate in the first rotational direction to rotate from the first rotational position to the third rotational position.

[0085] In an example, in the transition from the fourth state to the sixth state the opening shaft is configured to rotate in the second rotational direction to rotate from the first rotational position to the third rotational position.

[0086] In an example, a sensor is configured to detect rotation of the opening hook in the first direction when the opening shaft is configured to rotate from the first rotational position to the third rotational position.

[0087] In an example a sensor is configured to detect rotation of the opening hook in the second rotational direction when the opening shaft is configured to rotate from the third rotational position to the first rotational position.

[0088] In an example, the same sensor is configured to detect both rotations.

[0089] In an example, an actuating unit for the opening shaft is configured to detect rotation of the opening hook in the first rotational direction when the opening shaft is configured to rotate from the first rotational position to the third rotational position.

In an exymple, the actuating unit for the opening shaft is configured to detect rotation of the opening hook in the second rotational direction when the opening shaft is configured to rotate from the third rotational position to the first rotational position.

[0090] Continuing with the figures, specific features are described that enable the latching elements for both closing an opening an actuator for a circuit breaker to be checked without having to activate the circuit breaker itself. However, the features described can be used to check if latching elements of actuator used for other purposes are functioning correctly, and reference to a circuit breaker is only exemplary.

The control of functionality of todays available, mechanical spring drive actuator variants for MV and LV circuit breakers and comparable applications requires a regular operation of "close" and "open" of the circuit breaker, if the normal function of the actuator needs to be evaluated. This is mainly due to the used latching principles and the design of the actuator as a kinematik gear system, that is designed to reduce the high closing and opening spring forces with several linkage gear stages to a low force on the latching elements and actuation of those. In many of the use-cases, the actautor and its connected circuit breaker is in operating mode and resting in either "closed" or "open" position for longer time periods (up to years) without any operation. Customers or Service Personnel, who want to evaluate a proper actuator function, have no possibility to check by a continuous control of the actuator if it would operate on the next tripping signal, or if parts of the latching elements are sticking and not moving due to e.g. aging effects of metals (corrosion) or the lubricants (higher viscosity) or other damages coming from mechanical deformation. Of main interest are the latching elements, since they are the last elements in the kinematic chain of the linkage gear system and see the lowest actuation forces. The higher forces at the main kinematics of the actuator usually are not effected by aging and sticking, since the forces would immediately break or open such sticky contacts. Once the latching elements are moving, the system is able to operate as planned.

The actuator described with respect to Figs. 1-7 overcomes these issues, where functioning of the actuator can be established without operation of the "open" and "close" of the circuit breaker.

[0091] Fig 1 shows as one example of mechanical actuator types the an actuator with details on the latching elements for closing (parts 1 and 2) and opening (parts 3 and 4). In working conditions, the shown latching elements are contacting and pushed together without any motion over the time of operation of the circuit breaker. Parts have been introduced enabling the latching elements for closing and opening of a mechanical spring drive actuator to be moved without releasing the actuator completely or fully operating the application.

[0092] Fig. 2 shows the intended motion for the example of the closing hook. The top figure shows the regular operation with the closing shaft rotation for releasing the closing hook. For a continuous failure control, the closing hook can be operated in the opposite direction of normal release in order to keep the requiremets on force on the actuation low, as shown at the bottom. A small motion or micromotion of the latching elements can be used to identify a potential failure and indicate the need for a failure

alarm or prevent a failure due to glueing of contacts.

Fig. 3 shows how such a motion can be generated, where the latching elements have been re-designed, introducing an eccentric element on the closing and/or opening shaft as shown as example in Fig. 3 for a closing shaft, but where a similar re-design applies to the opening shaft. The additional eccentric element 5 on the closing shaft is used to generate the necessary micromotion when the circuit breaker is in normal operating mode.

Fig. 4 shows one example of a sequence of the micromotion and the use of the eccentricity on the closing shaft 1. In normal operation as shown in the top left image, the closing hook 2 contacts the closing shaft 1 and is in a latched position. In the checking state as shown in the top right image, the closing shaft 1 is rotated in an opposite direction of the regular release direction, and the closing hook 2 is rotated and checked for its functioning in the latched position. The eccentricity of the closing shaft 1 forces the closing hook 2 to follow the shape in the contact zone and, by this, the closing hook 2 is rotated for a certain angular value, based on the eccentricity design. With an additional sensor (e.g. proximity sensor or angular sensor or a force or torque sensor for example at the position of the operating coil that detects the required force or torque to rotate the shaft) the rotation of the closing hook 2 can be detected. After the check is performed, as shown in the bottom left image the closing shaft is rotated backwards to the original position and the closing hook 2 is following again, since it is driven by the closing spring forces towards the shaft. This is again the normal state where the closing hook 2 is resting on the closing shaft 1 in the latched position. The release of the losing hook is shown in the bottom right image, where the closing shaft 1 is rotated in the release direction, and the closing hook is released and the closing operation is started.

Fig. 5 shows an example of an additional eccentric element on the opening shaft 3. Also for the opening hook 4, an eccentric opening shaft 3 design is used in order to detect the functionality of the latching elements. Similar to the check on closing, as shown in the left image the opening latch is in a normal state with the opening hook 4 resting on the opening shaft 3 in the latched position. As shown in the right hand image, in the check state when the opening shaft 3 is rotated in an opposite direction to the normal release direction the opening hook 4 is rotated and checked for functioning in the latched position where the opening hook has been forced to undertake a small rotation. That motion can be detected with a sensor. Instead of using an additional sensor, the positive feedback or the actuating unit of the shaft (e.g. coil), that reached its end-position during the check state, can be used in order to detect the proper function of the latching elements. Also, a sensor can be used to detect or monitor the force and/or torque required to perform the micromotion, and this can be evaluated against a normal, established, force and/or torque and this can be used to detect or establish the proper functioning of the latching elements.

Fig. 6 shows another design of the eccentric shaft. In this variant of the closing shaft, the eccentricity is introduced in a way, that a rotation of the shaft in the same direction as the usual operating direction is introducing the motion on the latching hook. The additional eccentric element 6 on the closing shaft is used to generate the necessary micromotion when the circuit breaker is in normal operating mode.

In this case, a 2-step-actuation of the shaft is utilized. The working sequence is shown in Fig. 7. In normal state as shown in the top image the closing hook 2 is contacting the closing shaft 1, and is resting in its latched position. In check mode, as shown in the centre image the closing shaft 2 is rotated for a certain value (x degrees) with a special type of 2-step actuator and, by this, pushing and rotating the closing hook 2. For the release of the hook as shown in the bottom image the actuator rotates the closing shaft 1 for the additional value (y degrees) and the actautor can release the circuit breaker to open.

Claims

1. An actuator for a medium voltage circuit breaker, the actuator comprising:

   - a closing shaft (1); and
   - a closing hook (2);

   wherein, the closing shaft has a longitudinal axis;
   wherein, the closing shaft comprises an interaction region at an interaction location along the longitudinal axis;
   wherein, the closing shaft is configured to rotate about the longitudinal axis;
   wherein, in a first state the closing shaft is configured to be at a first rotational position, wherein the closing hook is configured to be in contact with the interaction region such that the closing hook cannot rotate in a first rotational direction;
   wherein, in a second state the closing shaft is configured to be at a second rotational position, wherein the closing hook is configured to rotate in the first rotational direction past the interaction region of the closing shaft; and
   wherein, the actuator is configured to transition from the first state to a third state, wherein the closing shaft is configured to rotate from the first rotational position to a third rotational position, wherein the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in a second rotational direction opposite to the first rotational direction.

2. Actuator according to claim 1, wherein, a cross section of the closing shaft at the interaction region comprises a first dimension extending from the longitu-

dinal axis to a first part of the outer surface of the closing shaft at a first angular position;
wherein, the cross section of the closing shaft at the interaction region comprises a second dimension extending from the longitudinal axis to a second part of the outer surface of the closing shaft at a second angular position;
wherein, the cross section of the closing shaft at the interaction region comprises a third dimension extending from the longitudinal axis to a third part of the outer surface of the closing shaft at a third angular position;
wherein, the first dimension is greater than the second dimension and the third dimension is greater than the first dimension;
wherein, in the first state the closing hook is configured to contact the interaction region of the closing shaft at the first part of the outer surface;
wherein, in the second state an outer portion of the closing hook is configured to pass in proximity to the second part of the outer surface of the closing shaft in rotating in the first rotational direction past the interaction region of the closing shaft; and
wherein, in the third state, when the closing shaft is configured to be in the third rotational position the closing hook is configured to contact the interaction region of the closing shaft at the third part of the outer surface.

3. Actuator according to any of claims 1-2, wherein the actuator is configured to transition from the third state to the first state, wherein the closing shaft is configured to rotate from the third rotational position to the first rotational position, wherein the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in the first rotational direction.

4. Actuator according to any of claims 1-3, wherein, the actuator is configured to transition from the first state to the third state without entering the second state.

5. Actuator according to any of claims 3-4, wherein the actuator is configured to transition from the third state to the first state without entering the second state,

6. Actuator according to any of claims 1-5, wherein the closing shaft is configured to rotate in the first rotational direction when the actuator transitions from the first state to the second state.

7. Actuator according to any of claims 1-6, wherein in the transition from the first state to the third state the closing shaft is configured to rotate in the second rotational direction to rotate from the first rotational position to the third rotational position.

8. Actuator according to any of claims 1-6, wherein in the transition from the first state to the third state the closing shaft is configured to rotate in the first rotational direction to rotate from the first rotational position to the third rotational position.

9. Actuator according to any of claims 1-8, wherein a sensor is configured to detect rotation of the closing hook in the second rotational direction when the closing shaft is configured to rotate from the first rotational position to the third rotational position; and/or the sensor is configured to detect rotation of the closing hook in the first rotational direction when the closing shaft is configured to rotate from the third rotational position to the first rotational position.

10. Actuator according to any of claims 1-9, wherein at least one sensor is configured to measure a force and/or torque required to rotate the closing shaft.

11. Actuator according to any of claims 1-10, wherein an actuating unit for the closing shaft is configured to detect rotation of the closing hook in the second rotational direction when the closing shaft is configured to rotate from the first rotational position to the third rotational position; and/or the actuating unit for the closing shaft is configured to detect rotation of the closing hook in the first rotational direction when the closing shaft is configured to rotate from the third rotational position to the first rotational position.

12. An actuator for a medium voltage circuit breaker, the actuator comprising:

- an opening shaft (3); and
- an opening hook (4);

wherein, the opening shaft has a longitudinal axis;
wherein, the opening shaft comprises an interaction region at an interaction location along the longitudinal axis;
wherein, the opening shaft is configured to rotate about the longitudinal axis;
wherein, in a first state the opening shaft is configured to be at a first rotational position, wherein the opening hook is configured to be in contact with the interaction region such that the opening hook cannot rotate in a first rotational direction;
wherein, in a second state the opening shaft is configured to be at a second rotational position, wherein the opening hook is configured to rotate in the first rotational direction past the interaction region of the opening shaft; and
wherein, the actuator is configured to transition from the first state to a third state, wherein the opening shaft is configured to rotate from the first rotational position to a third rotational position, wherein the opening hook is configured to be in contact with the interaction region such that the opening hook has

been rotated in a second rotational direction opposite to the first rotational direction.

13. Actuator according to claim 12, wherein, a cross section of the opening shaft at the interaction region comprises a first dimension extending from the longitudinal axis to a first part of the outer surface of the opening shaft at a first angular position;
wherein, the cross section of the opening shaft at the interaction region comprises a second dimension extending from the longitudinal axis to a second part of the outer surface of the opening shaft at a second angular position;
wherein, the cross section of the opening shaft at the interaction region comprises a third dimension extending from the longitudinal axis to a third part of the outer surface of the opening shaft at a third angular position;
wherein, the first dimension is greater than the second dimension and the third dimension is greater than the first dimension;
wherein, in the first state the opening hook is configured to contact the interaction region of the opening shaft at the first part of the outer surface;
wherein, in the second state an outer portion of the opening hook is configured to pass in proximity to the second part of the outer surface of the opening shaft in rotating in the first rotational direction past the interaction region of the opening shaft; and
wherein, in the third state, when the opening shaft is configured to be in the third rotational position the opening hook is configured to contact the interaction region of the opening shaft at the third part of the outer surface.

14. Actuator according to any of claims 12-13, wherein the actuator is configured to transition from the third state to the first state, wherein the opening shaft is configured to rotate from the third rotational position to the first rotational position, wherein the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in the first rotational direction.

15. Actuator according to any of claims 12-14, wherein, the actuator is configured to transition from the first state to the third state without entering the second state.

16. Actuator according to any of claims 14-15, wherein the actuator is configured to transition from the third state to the first state without entering the second state,

17. Actuator according to any of claims 12-16, wherein the opening shaft is configured to rotate in the first rotational direction when the actuator transitions from the first state to the second state.

18. Actuator according to any of claims 12-17, wherein in the transition from the first state to the third state the opening shaft is configured to rotate in the second rotational direction to rotate from the first rotational position to the third rotational position.

19. Actuator according to any of claims 12-17, wherein in the transition from the first state to the third state the opening shaft is configured to rotate in the first rotational direction to rotate from the first rotational position to the third rotational position.

20. Actuator according to any of claims 12-19, wherein a sensor is configured to detect rotation of the opening hook in the second direction when the opening shaft is configured to rotate from the first rotational position to the third rotational position; and/or the sensor is configured to detect rotation of the opening hook in the first direction when the opening shaft is configured to rotate from the third rotational position to the first rotational position.

21. Actuator according to any of claims 12-20, wherein at least one sensor is configured to measure a force and/or torque required to rotate the opening hook.

22. Actuator according to any of claims 12-21, wherein an actuating unit for the opening shaft is configured to detect rotation of the opening hook in the second direction when the opening shaft is configured to rotate from the first rotational position to the third rotational position; and/or the actuating unit for the opening shaft is configured to detect rotation of the opening hook in the first direction when the opening shaft is configured to rotate from the third rotational position to the first rotational position.

23. An actuator for a medium voltage circuit breaker, the actuator comprising:

- a closing shaft (1);
- a closing hook (2);
- an opening shaft (3); and
- an opening hook (4);

wherein, the closing shaft has a longitudinal axis;
wherein, the closing shaft comprises an interaction region at an interaction location along the longitudinal axis;
wherein, the closing shaft is configured to rotate about the longitudinal axis;
wherein, in a first state the closing shaft is configured to be at a first rotational position, wherein the closing hook is configured to be in contact with the interaction region such that the closing hook cannot rotate in a first rotational direction;
wherein, in a second state the closing shaft is configured to be at a second rotational position, wherein

the closing hook is configured to rotate in the first rotational direction past the interaction region of the closing shaft;

wherein, the actuator is configured to transition from the first state to a third state, wherein the closing shaft is configured to rotate from the first rotational position to a third rotational position, wherein the closing hook is configured to be in contact with the interaction region such that the closing hook has been rotated in a second rotational direction opposite to the first rotational direction;

wherein, the opening shaft has a longitudinal axis;

wherein, the opening shaft comprises an interaction region at an interaction location along the longitudinal axis;

wherein, the opening shaft is configured to rotate about the longitudinal axis;

wherein, in a fourth state the opening shaft is configured to be at a first rotational position, wherein the opening hook is configured to be in contact with the interaction region such that the opening hook cannot rotate in the second rotational direction;

wherein, in a fifth state the opening shaft is configured to be at a second rotational position, wherein the opening hook is configured to rotate in the second rotational direction past the interaction region of the opening shaft; and

wherein, the actuator is configured to transition from the fourth state to a sixth state, wherein the opening shaft is configured to rotate from the first rotational position to a third rotational position, wherein the opening hook is configured to be in contact with the interaction region such that the opening hook has been rotated in the first rotational direction.

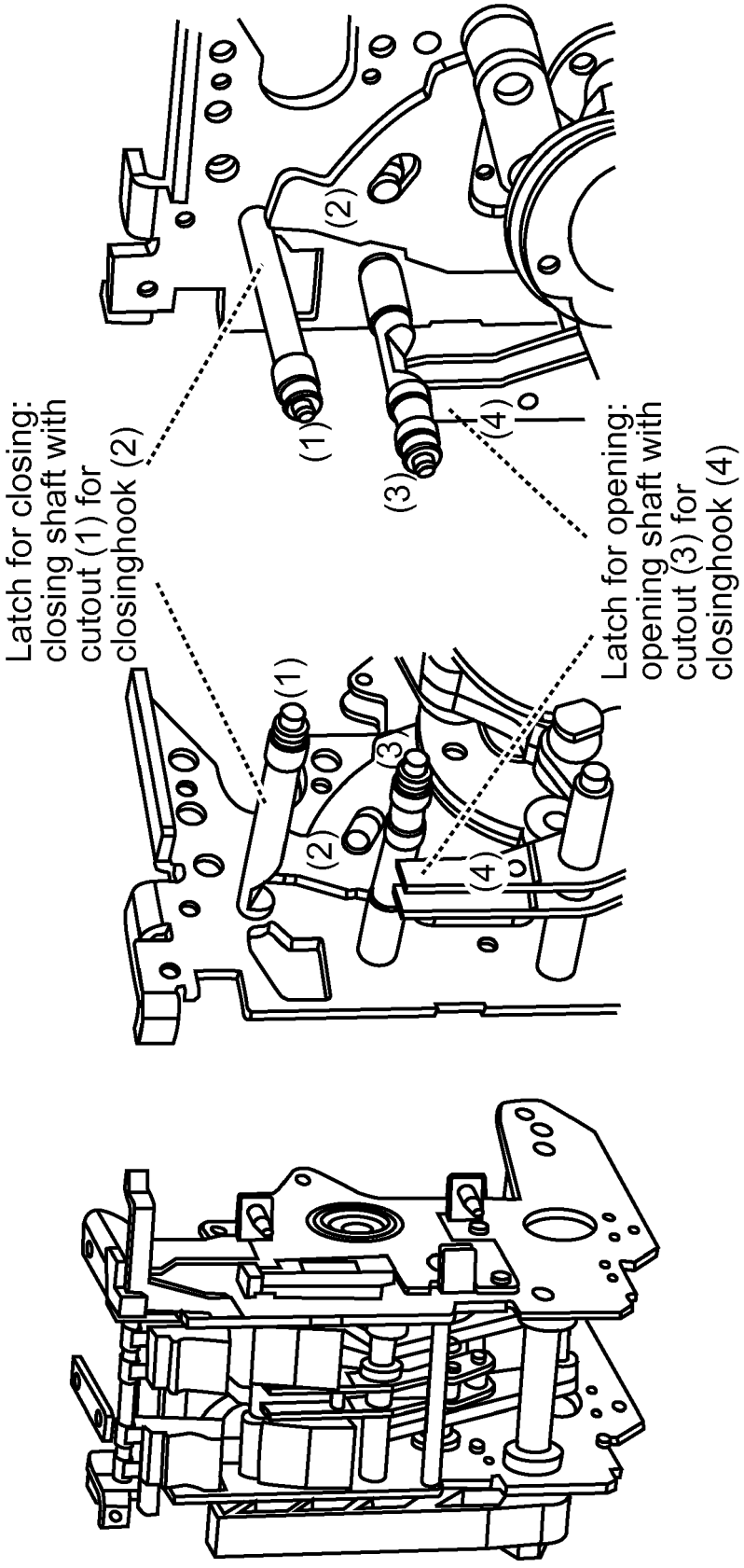

Latch for closing:
closing shaft with
cutout (1) for
closinghook (2)
Latch for opening:
opening shaft with
cutout (3) for
closinghook (4)
(1)
(2)
(3)
(4)

Fig.1

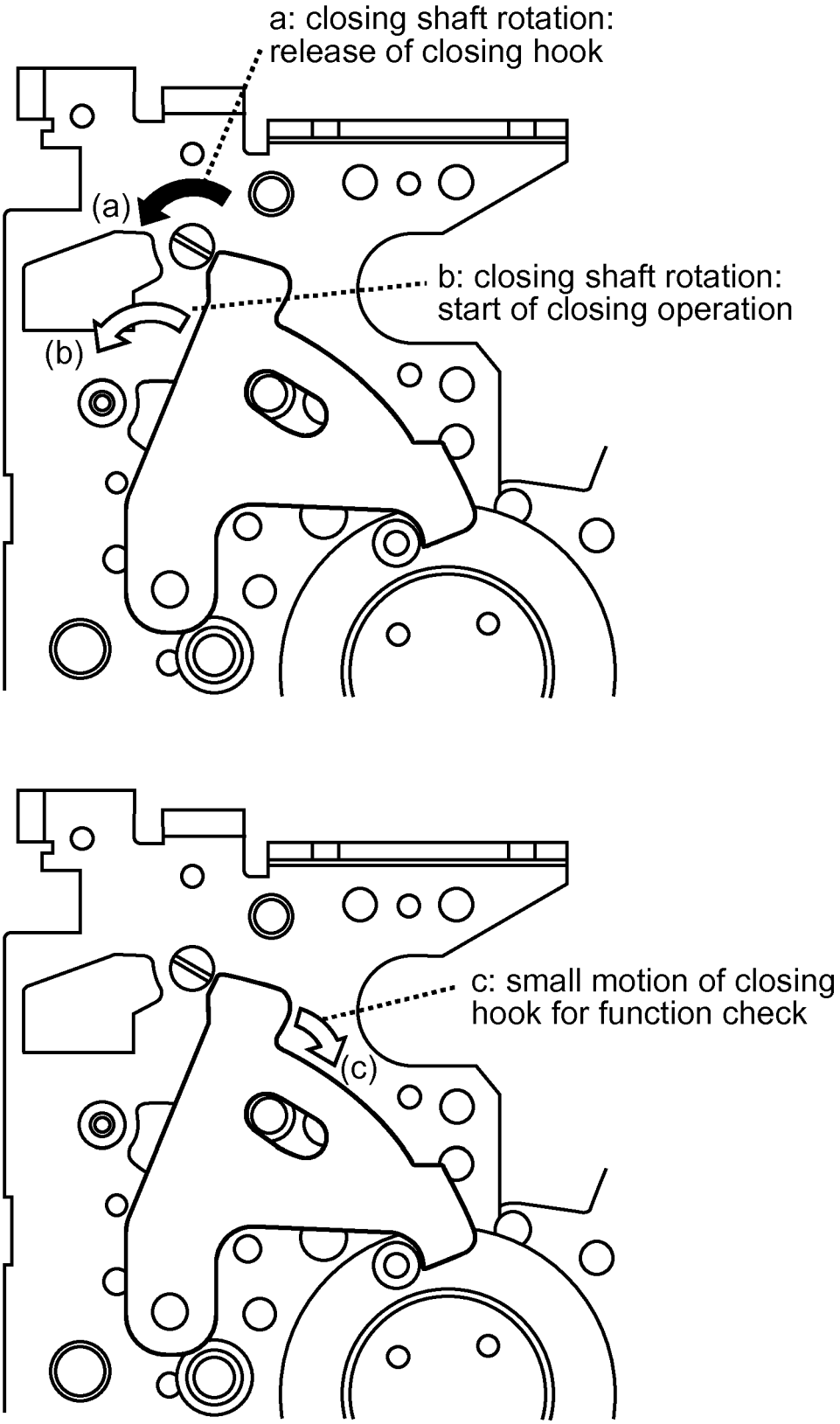
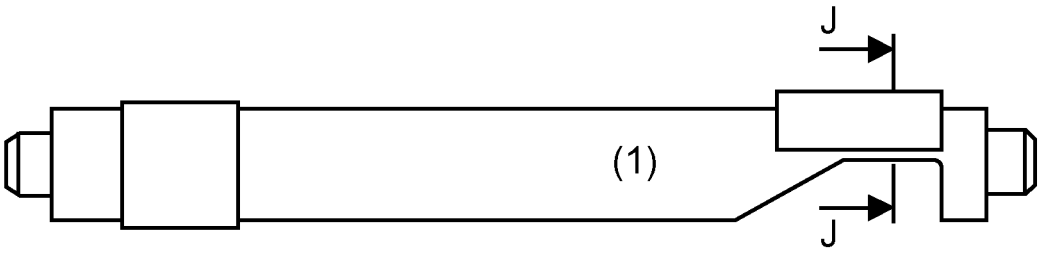
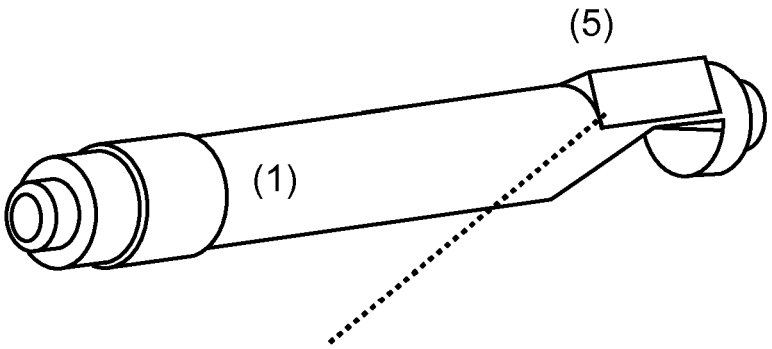
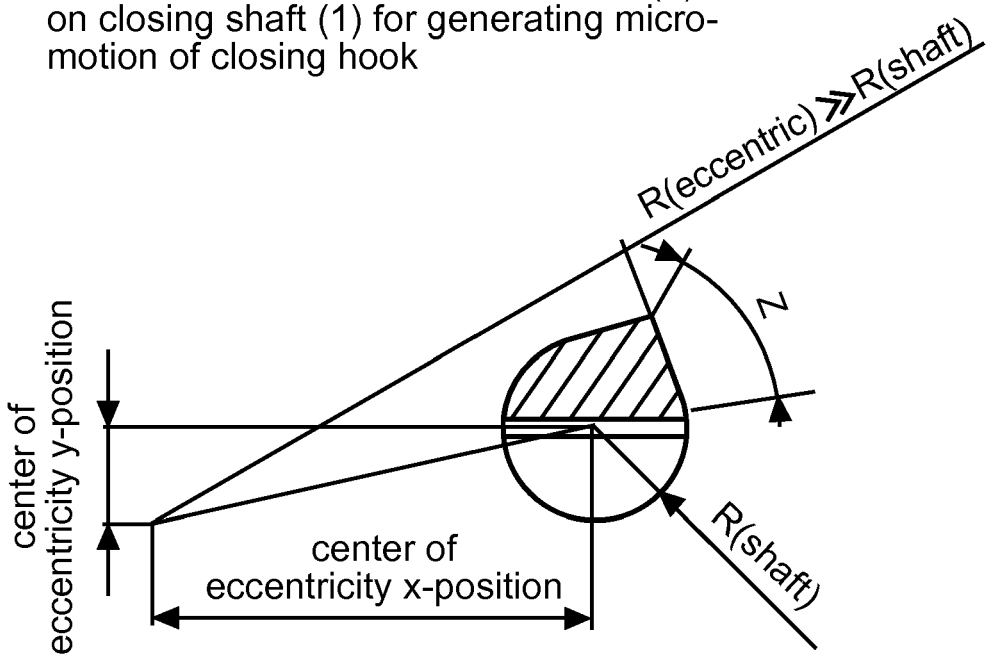

a: closing shaft rotation:
release of closing hook
(a)
b: closing shaft rotation:
start of closing operation
(b)
c: small motion of closing
hook for function check
(c)

Fig. 2





Introduction of an eccentric element (5) on closing shaft (1) for generating micro-motion of closing hook



SCHNITT J-J

Rough sketch of eccentric and round shaped element of shaft

Fig. 3

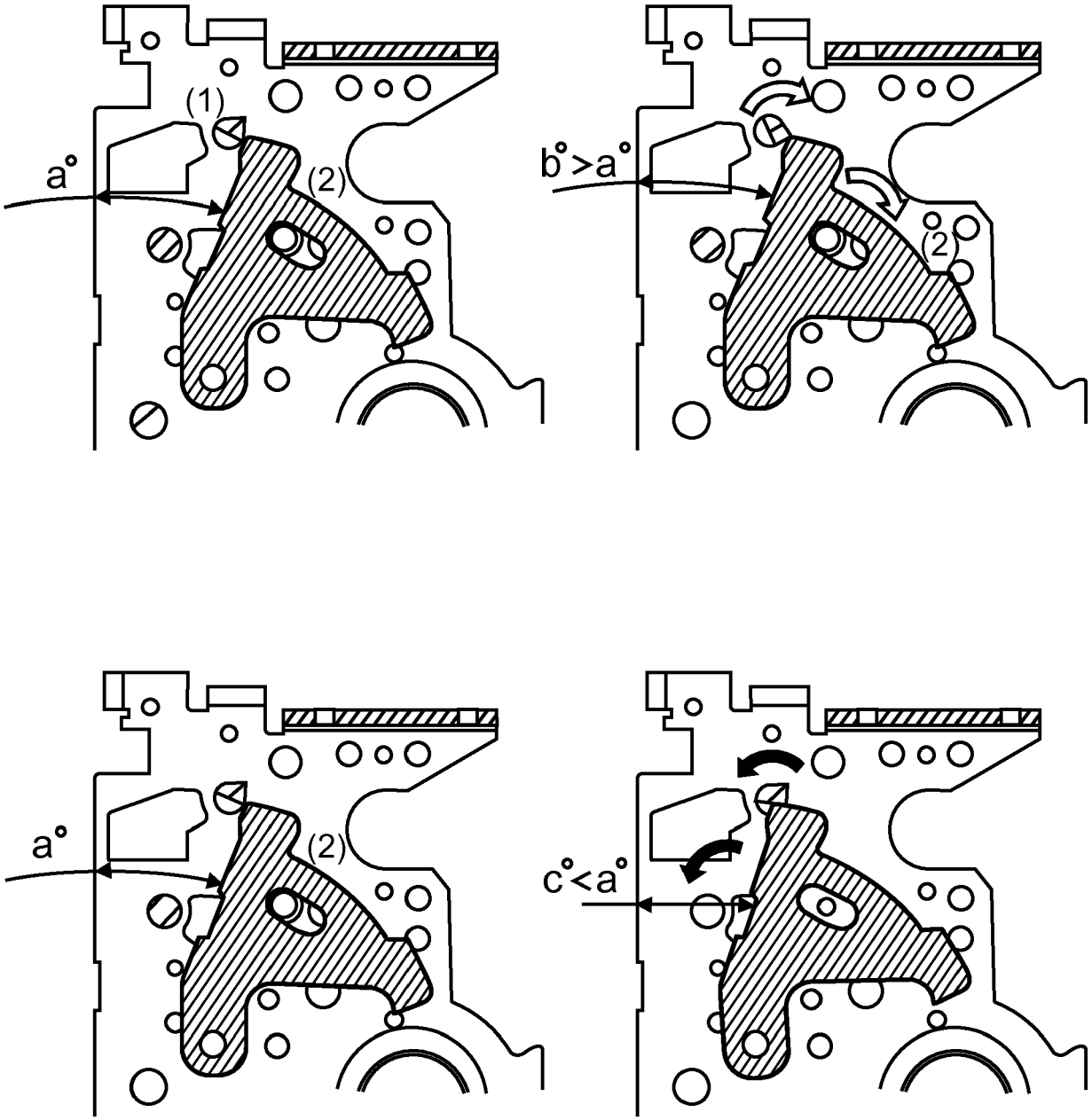


Fig. 4

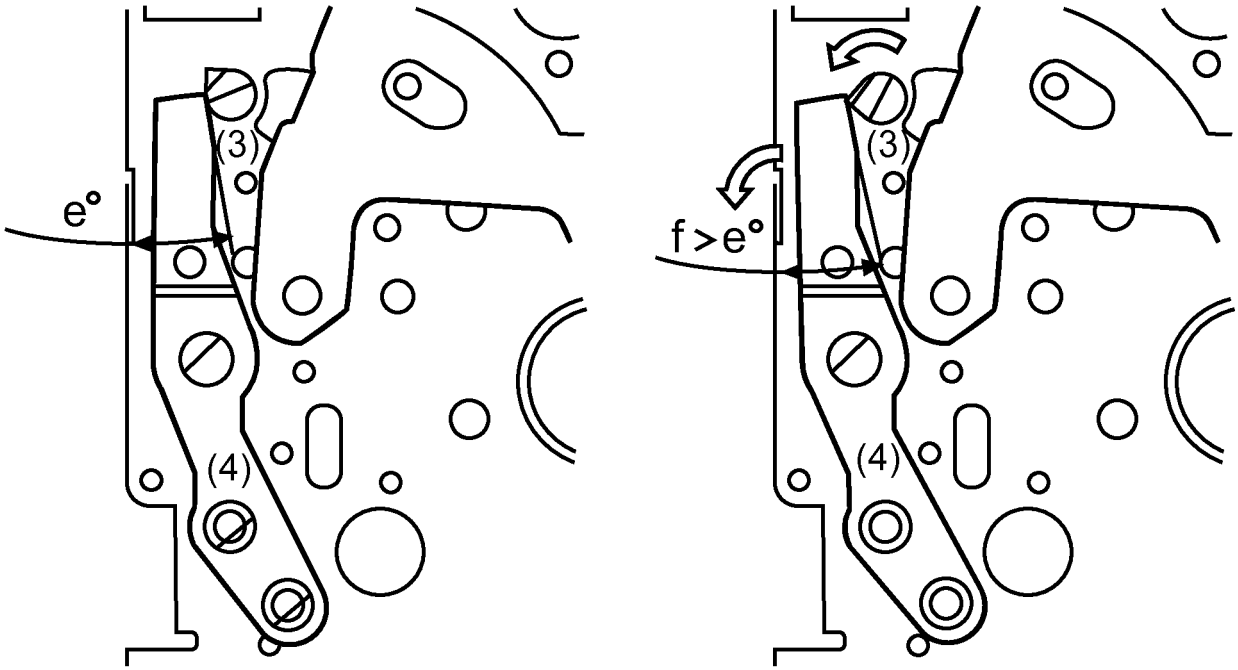
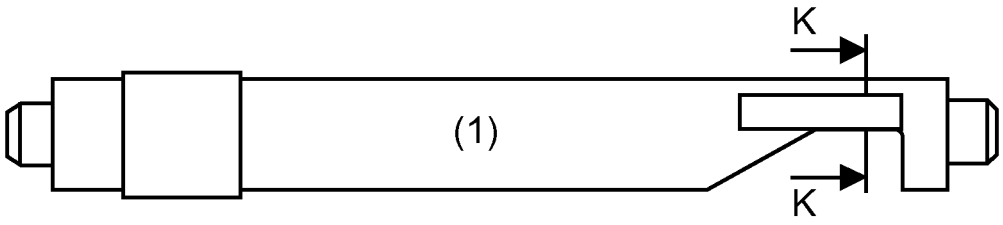
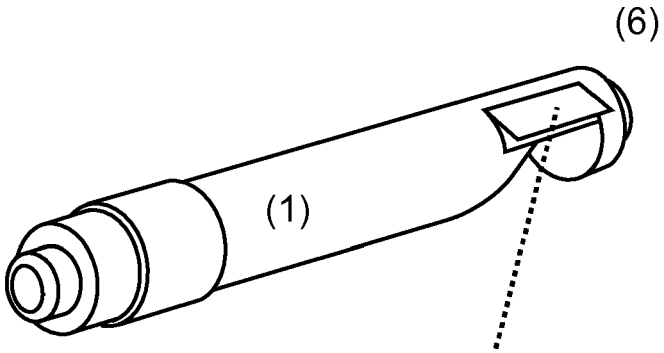
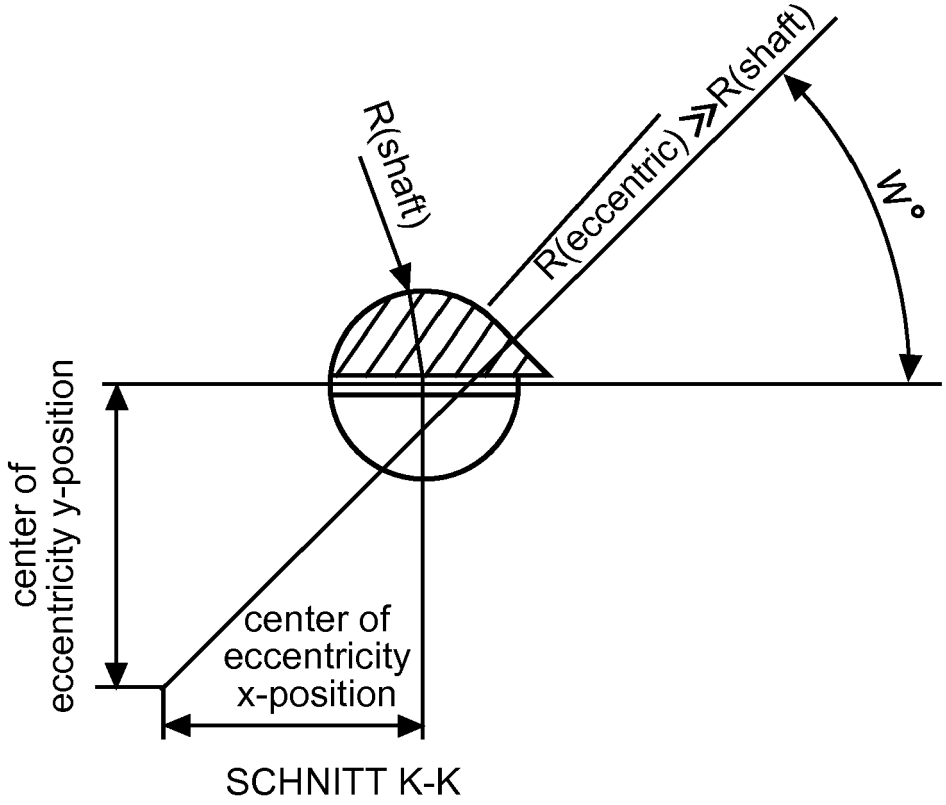


Fig. 5





Introduction of alternative eccentric element (6) on closing shaft (1) for generating micromotion of closing hook



SCHNITT K-K

Fig. 6

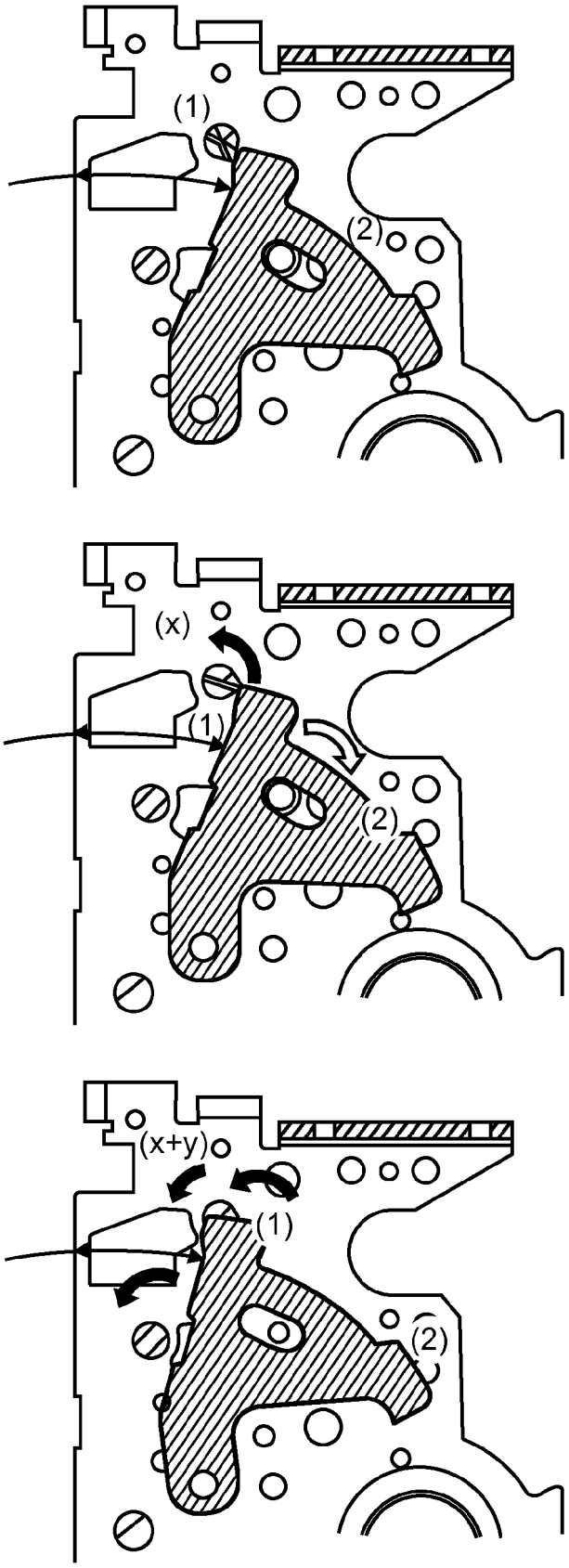


Fig. 7

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 15 6490

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 650 892 A1 (SCHNEIDER ELECTRIC IND SAS [FR]) 16 October 2013 (2013-10-16) * paragraphs [0033] - [0060]; figures 1-8 *	1-23	INV. H01H9/24
X	US 5 929 405 A (WEHRLI III HENRY ANTHONY [US] ET AL) 27 July 1999 (1999-07-27) * column 8, line 66 - column 13, line 60; figures *	1-23	
X	WO 2013/137846 A1 (SIEMENS AG [DE]; WARNE KEVIN R [US]) 19 September 2013 (2013-09-19)	12-20,22	
A	* paragraphs [0026] - [0029]; figures *	1,23	

TECHNICAL FIELDS SEARCHED (IPC)

H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 June 2019	Findeli, Luc

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 15 6490

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.

18-06-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2650892 A1	16-10-2013	CN 103367056 A	23-10-2013
		EP 2650892 A1	16-10-2013
		ES 2522565 T3	17-11-2014
		FR 2989216 A1	11-10-2013
		RU 2013113558 A	10-10-2014
US 5929405 A	27-07-1999	CA 2271314 A1	07-11-1999
		EP 0955651 A2	10-11-1999
		US 5929405 A	27-07-1999
WO 2013137846 A1	19-09-2013	CN 104205275 A	10-12-2014
		EP 2826050 A1	21-01-2015
		US 2015035628 A1	05-02-2015
		WO 2013137846 A1	19-09-2013

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82