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(54) METHOD AND DEVICE TO INHIBIT MANUAL RE-CLOSING OF THE CONTACTS OF A PROTECTIVE SWITCHING DEVICE

(57) Manual re-closing of a contact of a protective switching device 100 is inhibited as long as an electrical reset has not yet occurred. A trigger mechanism 140 of the switching device is preloaded into a first, preloaded state by manually moving a handle 130, which results in a closed contact state of the switching device. In response to an excess current due to an overload and/or a short circuit or another external trigger input, the trigger mechanism 140 is tripped and transits to a second, tripped state, opening the contact 110 of the switching device. A transition from the second, tripped state back to the first, preloaded state is inhibited despite moving the handle 130, as long as an electrical reset signal indicating re-establishment of a safe condition has not yet occurred. Said electrical reset signal resets the trigger mechanism. The electrically reset trigger mechanism can finally be manually reset to the preloaded state, in which the contact is closed, by moving the handle. A safety motor starter (700) comprises a contactor (710) and a motor protective switching device (720).

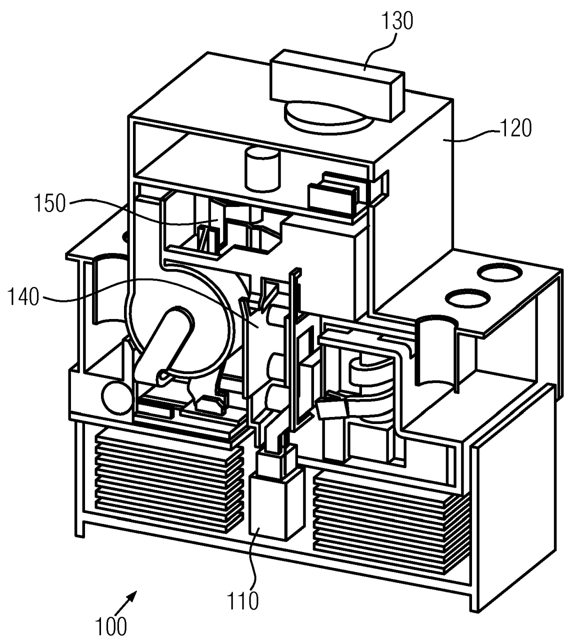

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a method for inhibiting manual re-closing of a contact of a protective switching device as long as an electrical reset has not yet occurred as well as to a protective switching device and a safety motor starter operating according to said method.

BACKGROUND

[0002] In order to protect an electric device such as for example an electric motor from the negative effects of an excess current such as overload and/or a short circuit occurring in the circuit comprising the electric device, a complete safety motor starter including a combination of a protective switching device acting as a power switch and one or more contactors are generally employed.

[0003] In the case of a short circuit, the protective switching device, which may be a circuit breaker or a motor protective switching device (MPSD), interrupts the supply of electric current to the motor in order to avoid permanent damages to the motor by opening a contact of the protective switching device. Said opening of a contact cannot be done by the contactor, if a short circuit occurs, since the response time of the contactor is too slow. While a response time of around 2 ms is needed in the case of a short circuit, the general response time of a contactor is around 50 ms.

[0004] Instead, if the safety motor starter detects an overload using its sensors and its evaluation electronics, the contactor is switched off, while a contact at the protective switching device remains closed. Typical reaction times needed in the case of an overload are tenths of seconds until several minutes, which the contactor can perfectly cope with. Later on, for example after a predetermined amount of time, the contactor may be switched on again remotely via an auto-reset.

[0005] However, it might occur that the main contacts of the contactor are welded as a result of the overload. Hence, the contactor does not switch off and there is still current flowing in the circuit comprising the safety motor starter and the motor.

[0006] In such a situation, in which the contactor fails, the protective switching device is used to open a contact and thus to interrupt the circuit. First, the excess current in the circuit causing the overload is transformed into a trip signal by sensors and evaluation electronics. Said trip signal then acts on a so called trip actuator, which subsequently trips a latch resulting in interrupting the previously closed circuit. Hence, the contact of the protective switching device is opened. Once an operator has solved the problem in the circuit, which had caused the excess current and thus the overload and/or the short circuit and/or has replaced the welded contactor by a new one, and/or has obtained information that the problem in the circuit does not exist anymore, he or she is enabled to reset the latch by manually moving a handle attached to the protective switching device. When the latch is manually reset by the operator into an initial latch state, the open contact of the protective switching device is closed again, so that the normal functioning of the electric device such as for example of the motor can be re-assumed.

[0007] However, the operator might erroneously regard the problem having caused the excess current and thus an overload and/or a short circuit as overcome and/or might have forgotten to replace the welded contactor. If the operator thus moves the handle to reset the latch, the resulting re-closure of the contact of the protective switching device might cause further damage to the electric device such as the motor, which is again exposed to an excess current.

[0008] Therefore, there is a need for a protective switching device and an operation method thereof, which inhibit manual re-closing of the contact of the protective switching device as long as a problem occurring in the circuit persists.

[0009] Hence, it is the object of the present invention to provide a protective switching device, as well as a safety motor starter comprising such a protective switching device, and an operating method thereof allowing safely re-closing an open contact.

[0010] This object is solved by the subject matter of the independent claims. Preferred embodiments are defined by the dependent claims.

SUMMARY

[0011] In the following a summary is provided to introduce a selection of representative concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used in any way that would limit the scope of the appended claims.

[0012] Briefly, the subject matter of the present invention is directed towards a method for inhibiting manual re-closing of a contact of a protective switching device as long as an electrical reset has not yet occurred. In a first step of said method, a trigger mechanism is preloaded into a first, preloaded state by moving a handle from an off-position to an on-position, which results in a closed contact state of the protective switching device. If the trigger mechanism is tripped by a first event, the trigger mechanism transits from the first, preloaded state to a second, tripped state, what results in an open contact state of the protective switching device. Subsequently, a transition of the trigger mechanism from the second, tripped state to the first, preloaded state is inhibited despite moving the handle from a tripped position to the on-position, as long as a second event has not occurred. In response to the occurrence of the second event, the trigger mechanism is electrically reset, so that moving the handle from the tripped position to the on-position results in transitioning of the trigger mechanism from the second, tripped state to the first, preloaded state. Said transition of the trigger mechanism from the second, tripped state to the first, preloaded state further results in a re-closing of the contact of the protective switching device, so that the closed contact state of the protective switching device is achieved. Hereby, said first event is related to an excess current from an overload or a short circuit or another external trigger input, and the second event is related to an electrical reset signal indicating re-establishment of a safe condition.

[0013] Hence, it is an advantage of the present invention to prevent premature manual resetting of a trigger mechanism in a protective switching device, which would result in closing the contact of the protective switching device, although a failure resulting in an excess current still persists in the circuit. Instead, a manual reset of the trigger mechanism by moving a handle results only in closing of the contact of the protective switching device, after the trigger mechanism has been electrically reset by an electrical signal provided by a controlling instance. Therefore, based on the method for operating a protective switching device according to the present invention, an increased security is obtained against erroneously re-exposing an electric device to a damaging excess current by means of a too early re-closing of the contact of the protective switching device.

[0014] In the method according to the present invention, the trigger mechanism is achieved by a trip actuator and a lock containing a latch, a lever and a spring.

[0015] Hence, the step of preloading the trigger mechanism into the first, preloaded state comprises preloading the lock, wherein the spring is compressed and the lever engages with the latch being in an initial latch state.

[0016] Tripping the trigger mechanism by the occurrence of the first event includes the trip actuator interacting with the latch by moving from an initial state into a displaced state, so that the latch is shifted from the initial latch state into a blocked state.

[0017] Moreover, in the method of the present invention, the trigger mechanism is electrically reset by moving the trip actuator back to the initial state in response to the electrical reset signal, so that the latch is reset to move back from the blocked state to the initial latch state.

[0018] In an embodiment of the present invention, the trip actuator comprises a linearly movable plunger in an electromagnetic coil attached to a spring and surrounded by a permanent magnet. A magnetic field of the permanent magnet keeps the plunger in a first position against a force of the spring. In response to the excess current of the first event, the magnetic field of the permanent magnet, which acts on the plunger, is weakened, so that the force of the spring pushes the plunger and thus linearly displaces the trip actuator from the initial state into the displaced state.

[0019] Further, in the method of the present invention, the advantage of linearly displacing the trip actuator consists in tripping the latch and making the lock transit from the first, preloaded state into a relaxed state, so that the contact of the protective switching device is opened.

[0020] In a preferred embodiment of the present invention, electrically resetting the trigger mechanism is performed by applying a voltage of a changed polarity to the trip actuator. Hereby, the voltage, which needs to be applied for electrically resetting the trigger mechanism, is significantly higher than a voltage acting on the trip actuator when the trigger mechanism is tripped. Said high voltage signal provides further security against erroneously resetting the trigger mechanism, although the circuit is still plagued by a failure resulting in an excess current.

[0021] Applying the voltage signal of the changed polarity to the trip actuator results in again strengthening the magnetic field of the permanent magnet and thus moving the linearly movable plunger of the trip actuator back to an initial state. Hence, the latch is reset to move back from the blocked state to the initial latch state.

[0022] In an embodiment of the present invention, the electrical energy needed for applying the voltage of the changed polarity to the trip actuator is hereby taken from an externally charged energy storage.

[0023] In another embodiment of the present invention, electrically resetting the trigger mechanism is performed by a reset actuator. The reset actuator moves the linearly movable plunger of the trip actuator back to the initial state and thus resets the latch to move back from the blocked state to the initial latch state.

[0024] Alternatively, in an embodiment of the present invention, electrically resetting the trigger mechanism may be performed by employing an electric motor moving a spindle on a propeller shaft, wherein the spindle pushes the linearly movable plunger of the trip actuator back to the initial state and thus resets the latch to move back from the blocked state to the initial latch state.

[0025] In still a further embodiment of the present invention, tripping the trigger mechanism causes to release a small finger locking the lock and causing a blocked state of the latch. Electrically resetting the trigger mechanism subsequently comprises retracting said previously released small finger by applying an electric signal to an additional locking finger reset actuator, so that the latch is reset to move back from the blocked state to the initial latch state.In the method according to the present invention, the first event and the second event are monitored by a plurality of sensors.

[0026] Hence, electrically resetting the trigger mechanism is performed by a controller including evaluation electronics analyzing information from the plurality of sensors and subsequently providing an electrical signal.

[0027] In the method of the present invention, preloading the trigger mechanism into the first, preloaded state by moving the handle from the off-position to the on-position comprises inputting mechanical energy, which is being stored in the spring.

[0028] Further, in the method according to the present invention, tripping the trigger mechanism by the first event comprises using the stored mechanical energy of the spring for opening the contact of the protective switching device.

[0029] In the method of the present invention, inhibiting the transition of the trigger mechanism from the second, tripped state to the first, preloaded state despite moving the handle from the tripped position to the on-position as long as a second event has not occurred comprises the lever not engaging with the latch being in the blocked state.

[0030] Moreover, the present invention comprises a protective switching device, which inhibits manual reclosing of a contact as long as an electrical reset has not yet occurred. Said protective switching device comprises at least one trip actuator, a lock comprising a latch, a lever, a spring and an actuating part, a contact connected to the actuating part, a controller connected to a plurality of sensors and a movable handle. The lock of the protective switching device is configured to be preloaded into a first, preloaded state, in which the spring is compressed and the lever engages with the latch in an initial latch state, by moving the handle from an off-position to an on-position, which results in a closed contact state of the protective switching device. The latch is configured to be tripped by a first event moving the trip actuator from an initial state into a displaced state and thus shifting the latch from the initial latch state into a blocked state. Said first event is hereby related to an excess current from an overload or a short circuit or another external trigger input. In response to said first event, the spring is decompressed and the lock is thus configured to transit from the first, preloaded state to a relaxed state resulting in an open contact state of the protective switching device. The lock is further configured to be inhibited to transit from the second, tripped state to the first, preloaded state despite moving the handle from the tripped position to the on-position, since the lever does not engage with the latch being in the blocked state as long as a second event has not occurred on the trip actuator. The latch is finally configured to be electrically reset to move back from the blocked state to the initial latch state in response to the occurring of the second event. The second event is hereby performed by the controller analyzing information from the plurality of sensors and comprises an electrical reset signal indicating re-establishment of a safe condition and moving the trip actuator back to the initial state. Therefore, moving the handle from the tripped position to the on-position results in the lock transitioning from the relaxed state to the first, preloaded state, which further results in a re-closing of the contact of the protective switching device to achieve the closed contact state of the protective switching device.

[0031] Therefore, the present invention advantageously provides a protective switching device, which after opening a contact due to an excess current from an overload and/or a short current and/or another external trigger input cannot be reset into an initial, closed contact state without first obtaining an electrical reset signal indicating a normal, safe state of the circuit. Like this, possible damages to an electric device in the circuit caused by a too early re-closing of the contact of the protective switching device can be efficiently avoided.

[0032] In an embodiment of the present invention, the protective switching device comprises a trip actuator equipped with a linearly movable plunger in an electromagnetic coil, which is attached to a spring and surrounded by a permanent magnet. A magnetic field of the permanent magnet keeps the plunger in an initial state against a force of the spring. In response to the excess current of the first event, the magnetic field of the permanent magnet acting on the plunger is weakened, so that the force of the spring pushes the plunger, which results in a linear displacement of the trip actuator into a displaced state.

[0033] In an embodiment of the present invention, the latch of the protective switching device is configured to be electrically reset by applying a voltage of a changed polarity to the trip actuator.

[0034] In a specific embodiment of the present invention, the applied voltage for electrically resetting the latch of the protective switching device is significantly higher than a voltage acting on the trip actuator when the latch is tripped.

[0035] Further, applying the voltage signal of the changed polarity to the trip actuator of the protective switching device according to the present invention results in again strengthening the magnetic field of the permanent magnet and thus moving the linearly movable plunger of the trip actuator back to the initial state and thus resetting the latch to move back from the blocked state to the initial latch state.

[0036] In the protective switching device according to an embodiment of the present invention, the electrical energy needed for applying the voltage of the changed polarity to the trip actuator is taken from an externally charged energy storage.

[0037] In another embodiment of the present invention, the protective switching device further comprises a reset actuator. The reset actuator electrically resets the latch by moving the linearly movable plunger of the trip actuator back to the initial state and thus resetting the latch to move back from the blocked state to the initial latch state.

[0038] In a further embodiment of the present invention, the protective switching device comprises an electric motor including a spindle movable attached to a propeller shaft. The trigger then is configured to be electrically reset by the spindle pushing the linearly movable plunger of the trip actuator back to the initial state and thus resetting the latch to move back from the blocked state to the initial latch state.

[0039] In another alternative embodiment of the present invention, the protective switching device further comprises a small finger. Said small finger is blocked by the latch in a first, preloaded state of the lock of the protective switching device. When the latch is tripped by a first event, the finger is released and subsequently blocks the latch, so that the latch is kept in a blocked state and the lock of the trigger mechanism is locked. The trigger mechanism is then electrically reset by again retracting said previously released finger by applying an electric signal to an additional locking finger reset actuator. Hence, the latch is again reset to move back from the blocked state to the initial latch state.

[0040] Alternatively, the protective switching device of the present invention may further comprise a second trip actuator being a bimetal element, which is configured to be thermally expanded by the excess current of the first event. Hence, said second bimetal trip actuator may act as a temperature sensor and advantageously allow interrupting the controlled circuit if a temperature exceeds a certain limit.

[0041] The present invention further comprises a safety motor starter, which comprises a contactor and a protective switching device according to the present invention as described above, which allows manually switching the motor on and off and which is connected in series to the contactor. Further, the safety motor starter may be connected to an emergency stop switch, which is configured to open the contactor in response to being pressed by an operator.

[0042] While an overload detected in the circuit comprising the safety motor starter and the motor generally results in switching off the contactor and maintaining the contact of the protective switching device in a closed contact state, a main contact of the contactor may also be welded in response to an overload. Hence, the contactor does not open and the circuit is not interrupted. In said case, according to the present invention, the latch of the protective switching device is configured to be tripped and the lock thus is configured to transit from the first, preloaded state to a relaxed state, which results in an open contact state of the protective switching device.

[0043] As soon as the contactor comprising the welded main contact is replaced by a new contactor, the latch is configured to be electrically reset to move back from the blocked state to the initial latch state. Hereby, the controller recognizes the new contactor by detecting a changed state of an auxiliary contact of the contactor.

[0044] Generally, safety motor starters usually need to comprise at least two contactors in order to guarantee that a circuit remains interrupted when a first contactor is welded due to an excess current, what results in permanently closing a main contact. When however a protective switching device according to the present invention is used in the safety motor starter, there is no need any more for a second contactor for making sure that the circuit remains interrupted as long as the welded first contactor has not been replaced by a new contactor. Hence, it is another advantage of the present invention that at least one contactor can be saved in a safety motor starter compared to prior art systems.

[0045] Other advantages may become apparent from the following detailed description when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046]

Figure 1 is a cut view of a protective switching device inhibiting manual re-closing of a contact as long as an electrical reset has not yet occurred, according to the present invention.

Figure 2A shows a trigger mechanism of the protective switching device of Figure 1 in an initial state.

Figure 2B shows the trigger mechanism of the protective switching device of Figure 1 in a first, preloaded state.

Figure 2C shows the trigger mechanism of the protective switching device of Figure 1 in a second, tripped state.

Figure 2D shows the trigger mechanism of the protective switching device of Figure 1 still in the second, tripped state, with some elements displaced compared to Figure 2C.

Figure 3 shows a top view of the protective switching device comprising the trigger mechanism according to a first embodiment for electrically resetting the trigger mechanism.

Figure 4 shows a top view of the trigger mechanism of a protective switching device applying a different concept for performing the electrical reset operation of the trigger mechanism according to the present invention.

Figure 5 illustrates a small electric motor used for pushing the trip actuator back into an initial state according to an embodiment of the present invention.

Figure 6 shows a top view of a trigger mechanism of a protective switching device according to another alternative embodiment of the present invention for inhibiting manual re-closing of a contact of the protective switching device while a controlled device is in an unsafe state.

Figure 7 shows a block diagram of a safety motor starter according to the present invention, in which a manual re-closing of a contact of the protective switching device is inhibited as long as a welded contactor has not been correctly replaced by a new contactor.

Figures 8A, 8B and 8C show a flow diagram of the method of the present invention for inhibiting manual re-closing of a contact of a protective switching device as long as an electrical reset has not yet occurred.

DETAILED DESCRIPTION

[0047] Figure 1 shows a cut view of a protective switching device 100 according to the present invention, which inhibits manual re-closure of a contact 110 as long as a failure in a circuit has not yet been resolved. Throughout the description, the term protective switching device comprises for example a circuit breaker or a motor protective switching device (MPSD).

[0048] On top of the external cover 120 of the protective switching device 100, a manual handle 130 is attached, which can be moved from an off-position to an on-position in order to switch on a device comprised in the circuit controlled by the protective switching device 100. Such a device generally is a motor, but it is not limited thereto, and may also be an electrical heating element etc. Further, said manual handle 130 also has to be moved by an operator in order to reset the protective switching device 100 into a closed contact state, after a trigger mechanism 140 of the protective switching device 100 has been tripped due to a first event related to an excess current caused by an overload detected automatically in the circuit controlled by the protective switching device 100.

[0049] Figure 1 further illustrates a trip actuator 150 forming part of the trigger mechanism 140, which is displaced in response to a first event and hence causes the tripping of a latch (not shown in Figure 1), which is also included in the trigger mechanism 140 of the protective switching device 100. Said trip actuator 150 may comprise a linearly movable plunger in an electromagnetic coil, which is attached to a spring and surrounded by a permanent magnet (also not shown in Figure 1). Alternatively, the trigger mechanism 140 of the protective switching device 100 may additionally include a bimetal element acting as a second trip actuator, which is bent due to heat produced by an excess current. Hence, said second trip actuator embodied as a bimetal element acts as a temperature sensor and interrupts the circuit containing the protective switching device 100 and the controlled device if temperatures exceed a certain limit.

[0050] The tripping of the latch results in opening the contact 110 of the protective switching device 100. The tripped trigger mechanism 140 cannot be directly reset into a first, preloaded state, in which the contact 110 of the protective switching device 100 is closed, by merely manually moving the handle 130 from a tripped position to an on-position as long as it is not made sure that all components are correctly working again and free from any failures. Different embodiments of said inventive trigger mechanism 140 will be discussed with respect to Figures 3 to 6.

[0051] The description of further features of Figure 1 is omitted for the sake of clarity.

[0052] Figure 2A shows a lock 200, which achieves the trigger mechanism 140 of the protective switching device 100 of Figure 1 together with the trip actuator 150. Said lock 200 comprises a latch 210, a lever 220, a spring 230, an actuating part 240, a movable connecting element 250 connecting the lock to the handle 130 and movable links 260. Said movable links 260 are preferably made of metal and connect the connecting element 250 and thus the handle 130 to the lever 220 and the lever 220 to the actuating part 240. The actuating part 240 is connected to a mounting structure 270 of the protective switching device 100 by means of the spring 230. Said spring 230 allows together with the movable links 260 the preloading and subsequent decompressing of the lock 200. Further, the actuating part 240 of the lock 200, which is connected to the spring 230, is responsible for opening and closing the contact 110 of the protective switching device 100. The handle 130is connected to the lock 200 by means of the movable connecting element 250, which can be displaced by moving the handle 130handle 130, and thus allows interacting with the trigger mechanism 140 by means of the external handle 130.

[0053] It is important to note that the shown lock 200 and latch 210 comprise only one of a plurality of different embodiments for realizing a similar trigger mechanism 140, and that the present invention is not limited to the exact embodiment of the trigger mechanism 140 shown in Figure 2A. Instead, the present invention comprises all kind of triggering mechanisms 160, which provide a functioning similar to the one of the trigger mechanism 140 described with respect to Figures 2A to 2D. Likewise, the movable handle 130 may also be implemented in the form of a push button, a toggle or a pivoting lever, which transits from an off-position to an on-position in response to an input of an operator and which adopts a tripped position in response to a triggering event.

[0054] Figure 2A illustrates the latch 210 in an initial latch state and the lock 200 in a non-preloaded, relaxed initial state, before an action of preloading the lock 200 has occurred. When the latch 210 is in the initial latch state shown in Figure 2A, it is possible to preload the lock 200 into a first, preloaded state, by manually turning the handle 130 from an off-position to an on-position.

[0055] The result of said transition of the lock 200 into a first, preloaded state is illustrated in Figure 2B. As can be seen in Figure 2B, the action of manually moving the handle 130 from an off-position to an on-position has caused the lever 220 to engage with the latch 210, so that the spring 230 is compressed. Hence, the mechanical energy input by a user when moving the handle 130 is stored in the spring 230 of the lock 200.

[0056] At the same time, by preloading the lock 200, the actuating part 240 of the lock 200 working with the contact 110 has been moved up compared to Figure 2A when compressing the spring 230. Therefore, the previously open contact 110 of the protective switching device 100 has been closed (not shown in Figure 2B), so that the protective switching device 100 has reached a closed contact state. The first, preloaded state of the lock 200 shown in Figure 2B corresponds to the normal, closed contact state of the protective switching device 100 during correct and safe operation of a controlled device.

[0057] Figure 2C illustrates the lock 200 being again in the same relaxed state of Figure 2A, whereas the latch 210 of the triggering mechanism 160 is in a second, tripped state. The latch 210 has been shifted into said second, tripped state from the initial latch state by the trip actuator 150 (not shown in any of Figures 2A, 2B, 2C and 2D, respectively) in response to a first event that has acted on the at least one trip actuator 150. Said first event is related to an excess current caused by an overload or a short circuit or to another external trigger input, which has displaced the at least one trip actuator 150 from an initial state to a displaced state. Said another external trigger input may be an input via a network or an input originating from an additional shunt trip or an undervoltage trip accessory.

[0058] The second, tripped state of the latch 210 corresponds to a blocked state of the latch 210, since the latch 210 cannot move back to its initial latch state as long as the trip actuator 150 remains into the displaced state.

[0059] The trip actuator 150 may be for example a trip actuator 150, which comprises a linearly movable plunger in an electromagnetic coil surrounded by a permanent magnet, whose magnetic field keeps the plunger against the force of a spring in a first position. When the first event occurs, an excess current is detected by the sensors and the electronics. A processor subsequently decides whether the trip actuator 150 is tripped or not. If the processor decides that the trip actuator 150 should be tripped in response to the detected excess current, a magnetic field of the permanent magnet acting on the trip actuator 150 is weakened, for example by discharging a capacity. Hence, a magnetic force of the magnetic field holding the plunger in the initial state becomes weaker than the force of the spring, which results in the spring linearly pushing the plunger. This linear movement of the plunger causes a linear displacement of the whole trip actuator 150. When the trip actuator 150 is linearly displaced and thus reaches a displaced state, the latch 210 is tripped and thus shifted into the blocked state, in which it remains as long as the trip actuator 150 is not moved back to its initial state. Tripping the latch 210 causes the lock 200 being relaxed and adopting the same non-preloaded, relaxed state shown in Figure 2A.

[0060] Alternatively, the protective switching device 100 may include additionally a second trip actuator 150, which is composed of a bimetal element. In response to the excess current of the first event, the bimetal element of the second trip actuator 150 is heated up. If the overcurrent supersedes the usual current by more than about 20%, the bimetal element is thermally expanded and bends. Hence, said second trip actuator embodied as a bimetal element acts as a temperature sensor and opens the contact 110 of the protective switching device 100 if temperatures exceed a certain limit. Once the bimetal element cools down again, it bends back and thus again closes the open contact 110 of the protective switching device 100.

[0061] Tripping the latch 210 due to the linear displacement of the trip actuator 150 in response to the occurrence of the first event results in relaxing the lock 200 and thus in decompressing the spring 230 and releasing the mechanical energy stored in the spring 230. The mechanical energy previously stored in the spring 230 is subsequently used for opening the contact 110 of the protective switching device 100. Hence, the protective switching device 100 reaches an open contact state free from damaging overcurrents. This can be seen in Figure 2C by the actuating part 240, which is responsible for opening and closing the contact 110 of the protective switching device 100, being moved down again compared to Figure 2B.

[0062] At the same time, tripping the latch 210 results in the latch 210 dis-engaging from the lever 220, which causes the handle 130 to move automatically from the on-position to a tripped position.

[0063] Figure 2D shows the latch 210 still in the second, tripped state, in which it is blocked by the displaced trip actuator 150 (not shown in Figure 2D). However, compared to Figure 2C, the lever 220 and the connecting element 250 between the handle 130 and the lock 200 are displaced. The lever 220 and the connecting element 250 between the handle 130 and the lock 200 have been moved by an external operator (not shown in Figure 2D) by manually moving the handle 130 from the tripped position to the on-position in an attempt to reset the lock 200 from the relaxed state to the first, preloaded state. Said attempt has however been in vain, since manually moving the handle 130 from the tripped position to the on-position has not resulted in the lever 220 re-engaging with the latch 210 and thus in closing the open contact 110 of the protective switching device 100. The moved handle 130 does not remain in the on-position, but automatically moves back to the tripped position. Hence, as can be seen in Figure 2D, the latch 210 remains in the blocked state regardless of any movement of the movable handle 130 performed by an external operator.

[0064] In some embodiments of the present invention, it is not possible to move the handle 130 directly from the tripped position to the on-position. Instead, such a movement may only be performed via the off-position. However, the result remains the same, i.e. the handle 130 does not remain in the on-position, but automatically moves back to the tripped position.

[0065] Hence, once the latch 210 has been tripped and moved into the blocked state by a first event acting on the trip actuator 150, which has caused the lock 200 to transit from the first, preloaded state of Figure 2B into the relaxed state of Figure 2C, the lock 200 is inhibited to be reset from the relaxed state back to the first, preloaded state by inputting mechanical energy by moving the handle 130. As can be seen in Figure 2D, the reason for inhibiting such a resetting of the lock 200 into the first, preloaded state, in which the contact 110 of the protective switching device 100 is closed, is the latch 210 being in the blocked state, in which it cannot be engaged with the lever 220 by merely moving the handle 130.

[0066] What is thus needed for resetting the lock 200 into a first, preloaded state and thus the protective switching device 100 into a closed contact state, is an outside force acting on the trip actuator 150. Such an outside force acting on the trip actuator 150 should then push the trip actuator 150 back into an initial position, which would result in resetting the latch 210, so that it can move back from the blocked state to the initial latch state.

[0067] By rendering it impossible for an operator to manually reset the lock 200 into a first, preloaded state without the help of an additional outside force acting on the trip actuator 150, it is successfully prevented that an operator manually resets the lock 200 into the first, preloaded state, which corresponds to a closed contact state of the protective switching device 100, although failure conditions may not yet have been resolved in a controlled circuit.

[0068] In the present invention, such an outside force, which generally consists in inputting additional electrical energy into the protective switching device system 100, is provided by an electrical reset signal. Such an electrical reset signal is merely provided if it is made sure that failure conditions do not exist anymore in a circuit, so that a normal operation of the circuit can be safely resumed. The information that a normal operation can be resumed in a controlled circuit is obtained from a controller device, which for example receives an external reset signal provided by an operator by pushing a button either directly at the protective switching device 100 or on a remote control.

[0069] The electrical reset signal provided by the controller subsequently performs a reset operation on the trip actuator 150 and thus on the latch 210. In response to the electrical reset signal, the trip actuator 150 is moved back from the displaced state to the initial state. Removing the trip actuator 150 results in resetting the latch 210 to move back from the blocked state to the initial latch state. Hence, the latch 210 is again in the initial latch state shown in Figure 2A, in which it is feasible to preload the lock 200 by manually moving the handle 130 from the tripped position, either directly or via the off-position, to the on-position.

[0070] By moving the handle 130 from the tripped position to the on-position, the lock 200 is again preloaded, which includes the lever 220 engaging with the latch 210 and the spring 230 being compressed. Hence, the actuating part 240 is moved up again, so that the contact 110 of the protective switching device 100 is automatically re-closed. Finally, the lock 200 reaches again the first, preloaded state illustrated in Figure 2B.

[0071] The present invention comprises four different embodiments for performing the electrical reset operation of the latch 210 and thus of the whole trigger mechanism 140. In what follows, said four embodiments will be discussed with respect to Figures 3 to 6.

[0072] Figure 3 shows a top view 300 of the protective switching device 100 comprising the trigger mechanism 140. In contrast to the side view of the trigger mechanism 140 displayed in Figures 2A to 2D, the actual lock 200 is not clearly visible in Figure 3. However, the trip actuator 150, the lever 220, the latch 210 and the handle 130 are shown in Figure 3. Based on Figure 3, the first concept of the present invention for performing the electrical reset of the latch 210 and thus of the trigger mechanism 140 will be described.

[0073] In the concept of Figure 3, the latch 210 is reset electrically from its blocked state by applying a voltage signal with a changed polarity to the trip actuator 150. The voltage signal of the changed polarity to the trip actuator 150 results in again charging the capacity and hence strengthening the magnetic field of the permanent magnet. Subsequently, the linearly movable plunger 320 of the trip actuator 150 is pushed back to an initial state against the force of the spring by means of the magnetic field of the permanent magnet. Hereby, the voltage signal of the changed polarity is provided by a controller device, when an external reset signal is provided by an operator by pushing a button directly at the protective switching device 100 or on a remote control or when the result of the analysis of information obtained from the plurality of sensors indicates that the controlled circuit may resume its normal operation.

[0074] Once the trip actuator 150 has been removed from its displaced state back to an initial state by the voltage signal of changed polarity, the latch 210 is reset. The latch 210 thus is enabled to move back from its blocked state into the initial latch state, in which the latch 210 can engage with the lever 220 when the handle 130 is manually moved from a tripped position, either directly or via the off-position, to the on-position. Hence, electrically resetting the trip actuator 150 into an initial state causes the latch 210 moving back from the blocked state to the initial latch state, in which a subsequent mechanical reset of the lock 200 into a first, preloaded state becomes feasible.

[0075] The voltage of the electric signal with changed polarity used for resetting the trip actuator 150 to an initial state is preferably chosen to be significantly higher than a voltage that typically acts on the trip actuator 150 in order to displace the trip actuator 150 to the displaced state, to trip the trigger mechanism 140 and thus to open the contact 110 of the protective switching device 100. Generally, a voltage of around 4 V is already sufficient for displacing the trip actuator 150 and thus tripping the latch 210 and making the lock 200 transit from the first, preloaded state to the relaxed state, while a voltage of around 30 V is used in order to perform the reset operation on the trip actuator 150 and thus to reset the blocked latch 210.

[0076] The reason for choosing to perform the electrical reset operation on the trip actuator 150 and thus on the latch 210 merely in response to such a high voltage signal is the increased security against erroneously resetting the trigger mechanism 140. It might be possible that a small voltage signal of changed polarity occurs in the circuit, although the controller has not yet approved a secure state of the controlled circuit. By demanding a higher voltage signal for electrically resetting the trigger mechanism 140, it is made sure that the protective switching device 100 is finally reset into a closed contact state only when the circuit is again in a safe state. The electrical reset signal may thus be a superposition of a first signal necessary for actually moving the trip actuator 150 back to its initial state and a second signal merely serving as an indicator that the reset operation may be safely performed.

[0077] However, alternatively, it is also possible to reset the trip actuator 150 to an initial state by applying an electric signal of a same or even smaller voltage compared to the voltage typically acting on the trip actuator 150 to displace the trip actuator 150 into the displaced state. Such a solution may be for example realized by implementing the trip actuator 150 as a bi-static actuator.

[0078] The electrical energy, which is needed for applying such a - generally rather high - voltage signal to the trip actuator 150, is generally taken from an energy storage included in the protective switching device system 100, which is charged by external sources, in order to be able to provide said large amount of electric energy. Alternatively, said energy storage can be avoided by directly providing a sufficient amount of electrical energy from an external source.

[0079] Figure 4 displays another concept 400 of the present invention for performing the electrical reset operation of the trigger mechanism 140. Compared to Figure 3, Figure 4 additionally shows a second reset actuator 410, which may be for example a linear motor. In response to receiving the electrical signal from the controller indicating that the trigger mechanism 140 may be safely reset, the second reset actuator 410 is switched on and moves the plunger 320 of the trip actuator 150 back to the initial state. Hence, the latch 210 is freed from its blocked state and moves back into the initial latch state, from where a mechanical reset of the lock 200 into the first, preloaded state becomes feasible by manually moving the handle 130 from the tripped position, either directly or via the off-position, back to the on-position.

[0080] Compared to the concept described with reference to Figure 3, a rather small amount of electric energy is sufficient for safely performing the electrical reset operation of the trigger mechanism 140 by resetting the trip actuator 150 back into an initial state, when a second reset actuator 410 is employed. A rather small electric signal is sufficient for switching on the second reset actuator 410, and there is basically no risk that the second reset actuator 410 may be switched on erroneously by an electric signal occurring in the circuit. On the other hand, in the concept described with reference to Figure 4, it is necessary to additionally employ a second reset actuator 410 apart from the trip actuator 150.

[0081] Figure 5 shows an additional reset actuator motor 500, which is used for resetting the trip actuator 150 back to an initial state. The small electric motor 500 shown in Figure 5 moves a spindle 510, which is attached on a propeller shaft 520. Said spindle 510 is further configured to push the plunger 320 of the trip actuator 150 back to the initial state and thus to reset the latch 210 to move back from the blocked state to the initial latch state, if the controller has deemed the circuit to be in a safe state again and has provided an electric signal to the small electric motor 500 of Figure 5.

[0082] Hence, when using the motor 500 for resetting the displaced trip actuator 150, the second reset actuator is realized by the spindle 510, which is an economic and easy to manufacture embodiment of a reset actuator.

[0083] However, moving the trip actuator 150 back to the initial state with the help of the spindle 510 attached to the propeller shaft 520 of the small electric motor 500 of Figure 5 takes around 0.5 seconds. During said rather large amount of time needed for resetting the trip actuator 150, the trigger mechanism 140 of the protective switching device 100 cannot be tripped. It has been however found out that usually time intervals, during which the safety functioning of a protective switching device 100 is not available, should be smaller than 0.4 seconds.

[0084] Alternatively, it is also feasible to directly employ a larger and thus stronger motor 500, which has faster reaction times of less than 0.4 s. Such a fast reacting motor 500 may be also directly employed as the trip actuator 150. Hence, said motor functions as bi-static actuator.

[0085] Figure 6 relates to another alternative embodiment 600, how manually resetting a trigger mechanism 140 and thus re-closing the contact 110 of a protective switching device 100 can be efficiently avoided as long as an electrical reset indicating a safe condition of the controlled circuit has not yet occurred.

[0086] Figure 6 depicts a small finger 610, which is blocked by the latch 210 in a first, preloaded state of the lock 200 of the protective switching device 100. When the latch 210 is tripped by a first event causing an excess current in the controlled circuit, the small finger 610 is released and subsequently blocks the latch 210 itself. Said small finger 610 thus locks the lock 200 by keeping the latch 210 in a blocked state, in which the latch 210 is prevented from re-engaging with the lever 220. Any manual resetting attempts of the triggering mechanism 160 performed by an operator by manually moving the handle 130 from a tripped position to an on-position are unsuccessful until the electric reset of the trigger mechanism 140 performed by the controller results in a small electric signal being applied to an additional locking finger reset actuator 620. Said electric reset signal again retracts the previously released finger 610 and thus resets the trigger mechanism 140. Hence, the blocked latch 210 is enabled to move back from the blocked state to the initial latch state. Subsequently, the lock 200 can be again reset into a first, preloaded state, in which the latch 210 engages with the lever 220 and the contact 110 of the protective switching device 100 is closed by manually moving the handle 130 from a tripped position, either directly or via an off-position, to an on-position.

[0087] Also in the embodiment described with reference to Figure 6, a rather small electric signal is sufficient for safely resetting the trigger mechanism 140, once a controller has confirmed a safe state of the circuit.

[0088] Figure 7 shows a block diagram of the safety motor starter 700 for a motor 730 according to an embodiment of the present invention. Said safety motor starter 700 comprises a protective switching device 720 equivalent to the one previously described with regard to Figures 1 and 2A to 2D. Further, the safety motor starter 700 may comprise an emergency stop switch 740 for manually tripping the trigger mechanism 140 and thus switching the motor 730 off in case of an emergency event. The protective switching device 720 is further connected in series to a contactor 710.

[0089] When an excess current caused by an overload is detected by the sensors and communicated to the evaluation electronics of the controller of the safety motor starter 700, at first the contactor 710 is switched off, while a contact 110 of the protective switching device 720 still remains in a closed contact state. Typical reaction times for switching off the contactor 710 are tenths of seconds up to several minutes depending on the amount of the overload. However, if after switching off the contactor 710, there still flows an electric current in the circuit, the contact 110 of the protective switching device 720 is additionally opened. Subsequently, for example after a predetermined amount of time and/or after an operator has controlled the safety motor starter 700 and resolved any failures in the circuit, the contactor 710 may be switched on again remotely via an auto-reset.

[0090] In case of the first event being related to an excess current caused by a short circuit, on the other hand, the contact 110 of the protective switching device 100 is directly opened, since the contactor 710 reacts too slowly. It is necessary to react in response to an excess current caused by a short circuit within around 2 ms, whereas a typical reaction time of the contactor 710 is around 50 ms. After the occurrence of a short circuit, an operator has to control the whole system and all of its components before resetting the safety motor starter 700. Therefore, a safety handle inhibit according to the present invention cannot be used in the case of an excess current caused by a short circuit.

[0091] Coming back to the case of the first event being an excess current caused by overload, it might occur that the main contacts of the contactor 710 are welded as a result of the overload experienced. Hence, the contactor 710 does not switch off and there is still current flowing in the circuit comprising the safety motor starter 700 and the motor 730.

[0092] Such a welded state of the contactor 710 is detectable by the evaluation electronics of the protective switching device 720, since the auxiliary contacts of the contactor 710, which act as sensors, have not changed their state (e.g. from closed to open) as they however are supposed to do in response to the opening of the main contacts of the contactor 710. Hence, the auxiliary contacts still indicate the contactor 710 as switched on. Therefore, it is recognized by the evaluation electronics of the controller of the protective switching device 720 that the contactor 710 has not switched off the safety motor starter 100 in response to the overload.

[0093] In such a situation, in which the contactor 710 apparently fails, the protective switching device 720 is employed to open the contact 110 and thus to finally interrupt the circuit, as described in detail above with respect to Figures 2A to 2D. Like this, it is guaranteed that the motor 730 is securely switched off.

[0094] In a next step, the welded contactor 710 has to be replaced with a new contactor 710 by an operator. Said replacement of the welded contactor 710 with a new contactor 710 is detected by the evaluation electronics of the controller of the protective switching device 720 due to the changed contact state of the auxiliary contacts of the new contactor 710. Hence, the auxiliary contacts act again as sensors for the controller of the protective switching device 720. Based on the feedback received from the auxiliary contacts, the controller of the protective switching device 720 provides an electric signal for performing the reset operation of the trigger mechanism 140 according to any one of the embodiments described with reference to Figures 3 to 6.

[0095] After the trip actuator 150 has been reset and thus enabled the latch 210 to move back to the initial latch state, the operator is finally enabled to reset the lock 200 of the trigger mechanism 140 into a preloaded state by manually moving the handle 130attached to the protective switching device 720. Hence, the open contact 110 of the protective switching device 720 is closed again, so that the normal functioning of the electric device such as for example of the motor can be re-assumed.

[0096] Therefore, a safety motor starter 700 according to the present invention inhibits that the contact 110 of a protective switching device 720 may be re-closed and thus the motor 730 is switched on again, as long as the welded contactor 710 is not exchanged with a new contactor 710.

[0097] Therefore, according to the present invention, a safety motor starter 700 does not need to comprise a second contactor 710, which makes sure that the system is interrupted when a first contactor 710 is welded due to an excess current caused by an overload until the first contactor 710 is replaced by a new contactor 710. Compared to safety motor starter systems 700 known in the prior art, one of two contactors 710 can be saved by coupling a contactor 710 in series with a protective switching device 720, whose controller detects that the main contacts of the contactor 710 have not been opened and which further inhibits manual re-closing of a contact 110 according to the present invention as long as the welded contactor 710 has not been replaced.

[0098] Apart from by an overload, the contactor 710 may also be switched off and thus the circuit be interrupted by an operator pressing the emergency stop switch 740. Again, it might occur that the contactor 710 does not open and thus interrupt the circuit of the safety motor starter 700 as foreseen in response to pressing the emergency stop switch 740. In such a case, the protective switching device 720 takes over and opens the contact 110.

[0099] Alternatively, the action of pressing the emergency stop switch 740 by an operator may also directly cause a mechanical displacement of the trip actuator 150. Said displacement of the trip actuator 150 causes the latch 210 to be tripped and thus being shifted from the initial latch state into a blocked state. At the same time, the lock 200 transits from the preloaded state to a relaxed state and the contact 110 of the protective switching device 720 is finally opened.

[0100] Figures 8A, 8B and 8C show an interconnected flow diagram describing the main steps of the method of the present invention for inhibiting manual re-closing of a contact 110 of a protective switching device 100 as long as an electrical reset has not yet occurred. Said method is generally characterized by an interplay of actions performed on a handle 130and/or on a trigger mechanism 140 of the protective switching device 100, which then result in either opening or closing of the contact 110 of the protective switching device 100. Therefore, Figures 8A, 8B and 8C are structured into three columns comprising the actions performed on the handle 130handle 130, the trigger mechanism 140 and the contact 110 of the protective switching device 100, respectively.

[0101] The method begins in step 810 with a user manually moving a handle 130of the protective switching device 100 from an off-position to an on-position. By this movement of the handle 130handle 130, mechanical energy is input into the trigger mechanism 140, which is subsequently stored in a spring 230 forming part of the trigger mechanism 140. Hence, the trigger mechanism 140 is manually preloaded 820 into a first, preloaded state. Preloading 820 the trigger mechanism 140 into said first, preloaded state results in closing 830 the contact 110 of the protective switching device 100. Thus, the protective switching device 100 enters into a closed contact state.

[0102] When the trigger mechanism 140 is in a first, preloaded state and the protective switching device 100 in a closed contact state, a first event characterized by an excess current causing an overload or a short-circuit on the circuit controlled by the protective switching device 100 may safely occur 840.

[0103] In response to such a first event, the trigger mechanism 140 of the protective switching device 100 is tripped, and the trigger mechanism transits 850 from the first, preloaded state to a second, tripped state. Transiting 850 from the first, preloaded state to the second, tripped state goes along with the contact 110 of the protective switching device 100 being opened 860 and thus interrupting the circuit in order to protect a controlled device. For opening 860 the contact 110 of the protective switching device 100, which thus enters an open contact state, the mechanical energy previously stored in the spring 230 is used and the spring 230 is decompressed. At the same time, the handle 130 is automatically turned back 870 from the on-position to a tripped position, when the trigger mechanism 140 is tripped.

[0104] The following steps of the method according to the present invention are governed by whether or not a second event occurs 880. Figure 8B describes the proceeding of the method of the present invention in response to the occurrence of such a second event 900, while Figure 8C discloses how the method of the present invention continues in the case of absence of said second event 1000.

[0105] Referring now first to Figure 8B, it is assumed that said second event occurs 900. Said second event is related to an electrical reset signal indicating re-establishment of a safe condition of the circuit controlled by the protective switching device 100. Said second event is performed by a controller, which generates said electrical reset signal in response to analyzing information about the state of the controlled circuit obtained from a plurality of sensors or based on receiving a signal from an operator pushing a button at the protective switching device 100 or on a remote control.

[0106] In response to the occurring of the second event 900, the trigger mechanism 140 is electrically reset 910. As a result of this electrical reset, manually moving the 920 handle 130 from the tripped position, either directly or via the off-position, to the on-position enables transitioning 930 of the trigger mechanism 140 from the second, tripped state to the first, preloaded state. When the trigger mechanism 140 is again reset into the first, preloaded state, the contact 110 of the protective switching device 100 is re-closed 940 and the closed contact state of the protective switching device 100 is again achieved. Hence, the protective switching device 100 is again set back into its initial state and ready to interrupt the electric circuit in order to protect a controlled device such as a motor from any potential damage caused by an excess current.

[0107] Figure 8C, on the other hand, illustrates the process of the method of the present invention as long as the second event has not yet occurred 1000 and the trigger mechanism 140 has thus not been electrically reset by means of an electric signal.

[0108] If the user in this situation manually moves 1010 the handle 130 from the tripped position to the on-position, the transition of the trigger mechanism 140 from the second, tripped state to the first, preloaded state is inhibited 1020. Hence, despite manually moving 1010 the handle 130, the contact 110 of the protective switching device 100 remains 1030 in the open contact state and the re-closing of the contact 110 of the protective switching device 100 is inhibited as long as the controlled device is still deemed to be in an unsafe state.

[0109] From the forgoing and further it will be appreciated that, although specific embodiments have been described herein for purposes of illustration, various modifications may be made without deviating from the scope of the present disclosure. For example, as the skilled person will note, the lock and generally the trigger mechanism described in the present invention can be designed in many different ways and is not limited to the example embodiment disclosed in the present invention.

LIST OF FURTHER PREFERRED EXAMPLES OF THE INVENTION

[0110]

Example 1. A method for inhibiting manual re-closing of a contact of a protective switching device as long as an electrical reset has not yet occurred, comprising:

> preloading a trigger mechanism into a first, preloaded state by moving a handle from an off-position to an on-position resulting in a closed contact state of the protective switching device;
>
> tripping the trigger mechanism by a first event, in response to which the trigger mechanism transits from the first, preloaded state to a second, tripped state resulting in an open contact state of the protective switching device;
>
> inhibiting transition of the trigger mechanism from the second, tripped state to the first, preloaded state despite moving the handle from a tripped position to the on-position as long as a second event has not occurred;
>
> in response to the occurring of the second event, electrically resetting the trigger mechanism, so that moving the handle from the tripped position to the on-position results in transitioning of the trigger mechanism from the second, tripped state to the first, preloaded state resulting in a re-closing of the contact of the protective switching device to achieve the closed contact state of the protective switching device, wherein
>
> said first event is related to an excess current from an overload or a short circuit or another external trigger input and the second event is related to an electrical reset signal indicating re-establishment of a safe condition.

Example 2. The method of example 1, wherein the trigger mechanism is achieved by a trip actuator and a lock comprising a latch, a lever and a spring.

Example 3. The method of example 2, wherein preloading the trigger mechanism into the first, preloaded state comprises preloading the lock, wherein the spring is compressed and the lever engages with the latch being in an initial latch state.

Example 4. The method of example 3, wherein tripping the trigger mechanism by the first event includes the trip actuator interacting with the latch by moving from an initial state into a displaced state and thus shifting the latch from the initial latch state into a blocked state.

Example 5. The method of example 4, wherein electrically resetting the trigger mechanism comprises moving the trip actuator back to the initial state in response to the electrical reset signal, wherein the latch is reset to move back from the blocked state to the initial latch state.

Example 6. The method of example 4, wherein the trip actuator comprises a linearly movable plunger in an electromagnetic coil attached to a spring and surrounded by a permanent magnet, wherein a magnetic field of the permanent magnet keeps the plunger in an initial state against a force of the spring, and wherein the trip actuator is linearly displaced into the displaced state by the magnetic field of the permanent magnet being weakened in response to the excess current of the first event and the force of the spring thus pushing the plunger.

Example 7. The method of examples 4 to 6, wherein linearly displacing the trip actuator and thus tripping the latch makes the lock transit from the first, preloaded state into a relaxed state, wherein the contact of the protective switching device is opened.

Example 8. The method of example 5, wherein electrically resetting the trigger mechanism is performed by applying a voltage of a changed polarity to the trip actuator.

Example 9. The method of example 8, wherein the applied voltage for electrically resetting the trigger mechanism is significantly higher than a voltage acting on the trip actuator when the trigger mechanism is tripped.

Example 10. The method of examples 8 and 9, wherein applying the voltage signal of the changed polarity to the trip actuator results in again strengthening the magnetic field of the permanent magnet and thus moving the linearly movable plunger of the trip actuator back to the initial state against the force of the spring and thus resetting the latch to move back from the blocked state to the initial latch state.

Example 11. The method of examples 8 to 10, wherein the electrical energy needed for applying the voltage of the changed polarity to the trip actuator is taken from an externally charged energy storage.

Example 12. The method of example 5, wherein electrically resetting the trigger mechanism is performed by a reset actuator, the reset actuator moving the linearly movable plunger of the trip actuator back to the initial state and thus resetting the latch to move back from the blocked state to the initial latch state.

Example 13. The method of example 5, wherein electrically resetting the trigger mechanism is performed by employing an electric motor moving a spindle on a propeller shaft, wherein the spindle pushes the linearly movable plunger of the trip actuator back to the initial state and thus resets the latch to move back from the blocked state to the initial latch state.

Example 14. The method of example 5, wherein tripping the trigger mechanism causes releasing a small finger locking the lock and causing a blocked state of the latch.

Example 15. The method of example 14, wherein electrically resetting the trigger mechanism comprises retracting said previously released small finger by applying an electric signal to a locking finger reset actuator, wherein the latch is reset to move back from the blocked state to the initial latch state.

Example 16. The method of any of examples 1 to 15, wherein the first event and the second event are monitored by a plurality of sensors.

Example 17. The method of any of examples 1 to 16, wherein electrically resetting the trigger mechanism is performed by a controller including evaluation electronics analyzing information from the plurality of sensors and subsequently providing an electrical signal. Example 18. The method of any of examples 2 to 17, wherein preloading the trigger mechanism into the first, preloaded state by moving the handle from the off-position to the on-position comprises inputting mechanical energy, said mechanical energy being stored in the spring.

Example 19. The method of any of examples 2 to 18, wherein tripping the trigger mechanism by the first event comprises using the stored mechanical energy of the spring for opening the contact of the protective switching device.

Example 20. The method of any of examples 2 to 19, wherein inhibiting transition of the trigger mechanism from the second, tripped state to the first, preloaded state despite moving the handle from the tripped position to the on-position as long as a second event has not occurred comprises the lever not engaging with the latch being in the blocked state.

Example 21. A protective switching device inhibiting manual re-closing of a contact as long as an electrical reset has not yet occurred, comprising:

at least one trip actuator;
a lock containing a latch, a lever, a spring and an actuating part;
a contact connected to the actuating part;
a controller connected to a plurality of sensors; and
a movable handle,
characterized in that
the lock is configured to be preloaded into a first, preloaded state, in which the spring is compressed and the lever engages with the latch in an initial latch state, by moving the handle from an off-position to an on-position resulting in a closed contact state of the protective switching device;
the latch is configured to be tripped by a first event moving the trip actuator from an initial state into a displaced state and thus shifting the latch from the initial latch state into a blocked state, wherein said first event is related to an excess current from an overload or a short circuit or another external trigger input, and, in response to which the spring is decompressed and the lock thus is configured to transit from the first, preloaded state to a relaxed state resulting in an open contact state of the protective switching device;
the lock is further configured to be inhibited to transit from the second, tripped state to the first, preloaded state despite moving the handle from the tripped position to the on-position, due to the lever not engaging with the latch being in the blocked state as long as a second event has not occurred on the trip actuator;
the latch is further configured to be electrically reset to move back from the blocked state to the initial latch state in response to the occurring of the second event, wherein the second event is performed by the controller analyzing information from the plurality of sensors and comprises an electrical reset signal indicating re-establishment of a safe condition and moving the trip actuator back to the initial state, so that moving the handle from the tripped position to the on-position results in the lock configured to transit from the relaxed state to the first, preloaded state resulting in a re-closing of the contact of the protective switching device to achieve the closed contact state of the protective switching device.

Example 22. The protective switching device of example 21, the trip actuator comprising a linearly movable plunger in an electromagnetic coil attached to a spring and surrounded by a permanent magnet, wherein a magnetic field of the permanent magnet keeps the plunger in an initial state against a force of the spring, and wherein the trip actuator is linearly displaced into the displaced state by the magnetic field of the permanent magnet being weakened in response to the excess current of the first event and the force of the spring thus pushing the plunger.

Example 23. The protective switching device of example 22, wherein the latch is configured to be electrically reset by applying a voltage of a changed polarity to the trip actuator.

Example 24. The protective switching device of examples 22 and 23, wherein the applied voltage for electrically resetting the latch is significantly higher than a voltage acting on the trip actuator when the latch is tripped.

Example 25. The protective switching device of examples 22 to 24, wherein applying the voltage signal of the changed polarity to the trip actuator results in again strengthening the magnetic field of the permanent magnet and thus moving the linearly movable plunger of the trip actuator back to the initial state against the force of the spring and thus resetting the latch to move back from the blocked state to the initial latch state.

Example 26. The protective switching device of examples 22 to 25, wherein the electrical energy needed for applying the voltage of the changed polarity to the trip actuator is taken from an externally charged energy storage.

Example 27. The protective switching device of example 22, further comprising a reset actuator configured to electrically reset the latch by moving the linearly movable plunger of the trip actuator back to the initial state and thus resetting the latch to move back from the blocked state to the initial latch state.

Example 28. The protective switching device of example 22, further comprising an electric motor including a spindle movable attached to a propeller shaft configured to electrically reset the latch by the spindle pushing the linearly movable plunger of the trip actuator back to the initial state and thus resetting the latch to move back from the blocked state to the initial latch state.

Example 29. The protective switching device of example 21, further comprising a small finger configured to be released in order to lock the lock and to cause a blocked state of the latch.

Example 30. The protective switching device of example 29, further comprising a locking finger reset actuator, wherein the previously released small finger is further configured to be retracted by applying an electric signal to the locking finger reset actuator, wherein the latch is configured to be reset to move back from the blocked state to the initial latch state.

Example 31. The protective switching device of any of examples 21 to 30, further comprising a second trip actuator, wherein the second trip actuator is a bimetal element configured to be thermally expanded by the excess current of the first event and thus acting as a temperature sensor interrupting a controlled circuit if temperatures exceed a certain limit.

Example 32. The protective switching device of any of examples 21 to 31, wherein the protective switching device is one of a circuit breaker or a motor protective switching device, MPSD.

Example 33. A safety motor starter, comprising:

a contactor; and
a protective switching device according to any of examples 22 to 32 allowing manually switching a motor on and off and being connected in series to the contactor.

Example 34. The safety motor starter of example 33, further being connected to an emergency stop switch, which is configured to open the contactor in response to being pressed.

Example 35. The safety motor starter of example 33 or 34, wherein a main contact of the contactor is welded in response to an overload and wherein the latch of the protective switching device is configured to be tripped and the lock thus is configured to transit from the first, preloaded state to a relaxed state resulting in an open contact state of the protective switching device.

Example 36. The safety motor starter of example 35, wherein the contactor comprising the welded main contact is configured to be replaced by a new contactor and wherein the latch is further configured to be electrically reset to move back from the blocked state to the initial latch state in response to the controller detecting a changed state of an auxiliary contact of the contactor.

Claims

1. A method for inhibiting manual re-closing of a contact of a protective switching device as long as an electrical reset has not yet occurred, comprising:

preloading a trigger mechanism into a first, preloaded state by moving a handle from an off-position to an on-position resulting in a closed contact state of the protective switching device;
tripping the trigger mechanism by a first event, in response to which the trigger mechanism transits from the first, preloaded state to a second, tripped state resulting in an open contact state of the protective switching device;
inhibiting transition of the trigger mechanism from the second, tripped state to the first, preloaded state despite moving the handle from a tripped position to the on-position as long as a second event has not occurred;
in response to the occurring of the second event, electrically resetting the trigger mechanism, so that moving the handle from the tripped position to the on-position results in transitioning of the trigger mechanism from the second, tripped state to the first, preloaded state resulting in a re-closing of the contact of the protective switching device to achieve the closed contact state of the protective switching device, wherein said first event is related to an excess current from an overload or a short circuit or another external trigger input and the second event is related to an electrical reset signal indicating re-establishment of a safe condition.

2. The method of claim 1, wherein the trigger mechanism is achieved by a trip actuator and a lock comprising a latch, a lever and a spring, and
wherein preloading the trigger mechanism into the first, preloaded state comprises preloading the lock, wherein the spring is compressed and the lever engages with the latch being in an initial latch state, and/or
wherein tripping the trigger mechanism by the first event includes the trip actuator interacting with the latch by moving from an initial state into a displaced state and thus shifting the latch from the initial latch state into a blocked state, and/or
wherein displacing the trip actuator and thus tripping the latch makes the lock transit from the first, preloaded state into a relaxed state, wherein the contact of the protective switching device is opened, and/or
wherein electrically resetting the trigger mechanism comprises moving the trip actuator back to the initial state in response to the electrical reset signal, wherein the latch is reset to move back from the blocked state to the initial latch state.

3. A protective switching device inhibiting manual re-closing of a contact as long as an electrical reset has not yet occurred, comprising:

at least one trip actuator;
a lock containing a latch, a lever, a spring and an actuating part;
a contact connected to the actuating part;
a controller connected to a plurality of sensors; and
a movable handle,
characterized in that
the lock is configured to be preloaded into a first, preloaded state, in which the spring is compressed and the lever engages with the latch in an initial latch state,
by moving the handle from an off-position to an on-position resulting in a closed contact state of the protective switching device;
the latch is configured to be tripped by a first event moving the trip actuator from an initial state into a displaced state and thus shifting the latch from the initial latch state into a blocked state, wherein said first event is related to an excess current from an overload or a short circuit or another external trigger input, and, in response to which the spring is decompressed and the lock thus is configured to transit from the first, preloaded state to a relaxed state resulting in an open contact state of the protective switching device;
the lock is further configured to be inhibited to transit from the second, tripped state to the first, preloaded state despite moving the handle from the tripped position to the on-position, due to the lever not engaging with the latch being in the blocked state as long as a second event has not occurred on the trip actuator;
the latch is further configured to be electrically reset to move back from the blocked state to the initial latch state in response to the occurring of the second event, wherein the second event is performed by the controller analyzing information from the plurality of sensors and comprises an electrical reset signal indicating re-establishment of a safe condition and moving the trip actuator back to the initial state, so that moving the handle from the tripped position to the on-position results in the lock configured to transit from the relaxed state to the first, preloaded state resulting in a re-closing of the contact of the protective switching device to achieve the closed contact state of the protective switching device.

4. The method of claim 2 or the protective switching device of claim 3, wherein the trip actuator comprises a linearly movable plunger in an electromagnetic coil attached to a spring and surrounded by a permanent magnet, wherein a magnetic field of the permanent magnet keeps the plunger in an initial state against a force of the spring, and wherein the trip actuator is linearly displaced into the displaced state by the magnetic field of the permanent magnet being weakened in response to the excess current of the first

event and the force of the spring thus pushing the plunger.

5. The method of claims 2 and 4 or the protective switching device of claims 3 and 4, wherein electrically resetting the latch is performed by applying a voltage of a changed polarity to the trip actuator, and wherein the applied voltage for electrically resetting the latch is significantly higher than a voltage acting on the trip actuator when the latch is tripped, and wherein applying the voltage of the changed polarity to the trip actuator results in again strengthening the magnetic field of the permanent magnet and thus moving the linearly movable plunger of the trip actuator back to the initial state against the force of the spring and thus resetting the latch to move back from the blocked state to the initial latch state, and wherein an electrical energy needed for applying the voltage of the changed polarity to the trip actuator is taken from an externally charged energy storage.

6. The method of claims 2 and 4 or the protective switching device of claims 3 and 4, wherein electrically resetting the latch is performed by a reset actuator, the reset actuator moving the linearly movable plunger of the trip actuator back to the initial state and thus resetting the latch to move back from the blocked state to the initial latch state, or wherein electrically resetting the latch is performed by employing an electric motor moving a spindle on a propeller shaft, wherein the spindle pushes the linearly movable plunger of the trip actuator back to the initial state and thus resets the latch to move back from the blocked state to the initial latch state.

7. The method of claims 2 and 4 or the protective switching device of claims 3 and 4, wherein tripping the latch causes releasing a small finger locking the lock and causing a blocked state of the latch, and wherein electrically resetting the latch comprises retracting said previously released small finger by applying an electric signal to a locking finger reset actuator, wherein the latch is reset to move back from the blocked state to the initial latch state.

8. The method of any of claims 1 to 7 or the protective switching device of any of claims 3 to 7, wherein the first event and the second event are monitored by a plurality of sensors.

9. The method of any of claims 2 to 8 or the protective switching device of any of claims 3 to 8, wherein electrically resetting the latch is performed by a controller including evaluation electronics analyzing information from the plurality of sensors and subsequently providing an electrical signal.

10. The method of any of claims 2 to 9 or the protective switching device of any of claims 3 to 9, wherein preloading the lock into the first, preloaded state by moving the handle from the off-position to the on-position comprises inputting mechanical energy, said mechanical energy being stored in the spring, and/or wherein tripping the trigger mechanism by the first event comprises using the stored mechanical energy of the spring for opening the contact of the protective switching device.

11. The method of any of claims 2 to 10 or the protective switching device of any of claims 3 to 10, wherein inhibiting transition of the lock from the second, tripped state to the first, preloaded state despite moving the handle from the tripped position to the on-position as long as a second event has not occurred comprises the lever not engaging with the latch being in the blocked state.

12. The method of any of claims 2 to 11 or the protective switching device of any of claims 3 to 11, further comprising a second trip actuator, wherein the second trip actuator is a bimetal element configured to be thermally expanded by the excess current of the first event and thus acting as a temperature sensor interrupting a controlled circuit if temperatures exceed a certain limit.

13. The method of any of claims 1 to 12 or the protective switching device of any of claims 3 to 12, wherein the protective switching device is one of a circuit breaker or a motor protective switching device, MPSD.

14. A safety motor starter, comprising:

    a contactor; and
    a protective switching device according to any of claims 3 to 13 allowing manually switching a motor on and off and being connected in series to the contactor.

15. The safety motor starter of claim 14, further being connected to an emergency stop switch, which is configured to open the contactor in response to being pressed, and/or wherein a main contact of the contactor is welded in response to an overload and wherein the latch of the protective switching device is configured to be tripped and the lock thus is configured to transit from the first, preloaded state to a relaxed state resulting in an open contact state of the protective switching device, and wherein the contactor comprising the welded main contact is configured to be replaced by a new contactor and wherein the latch is further configured to be electrically reset to move back from the blocked

state to the initial latch state in response to the controller detecting a changed state of an auxiliary contact of the contactor.

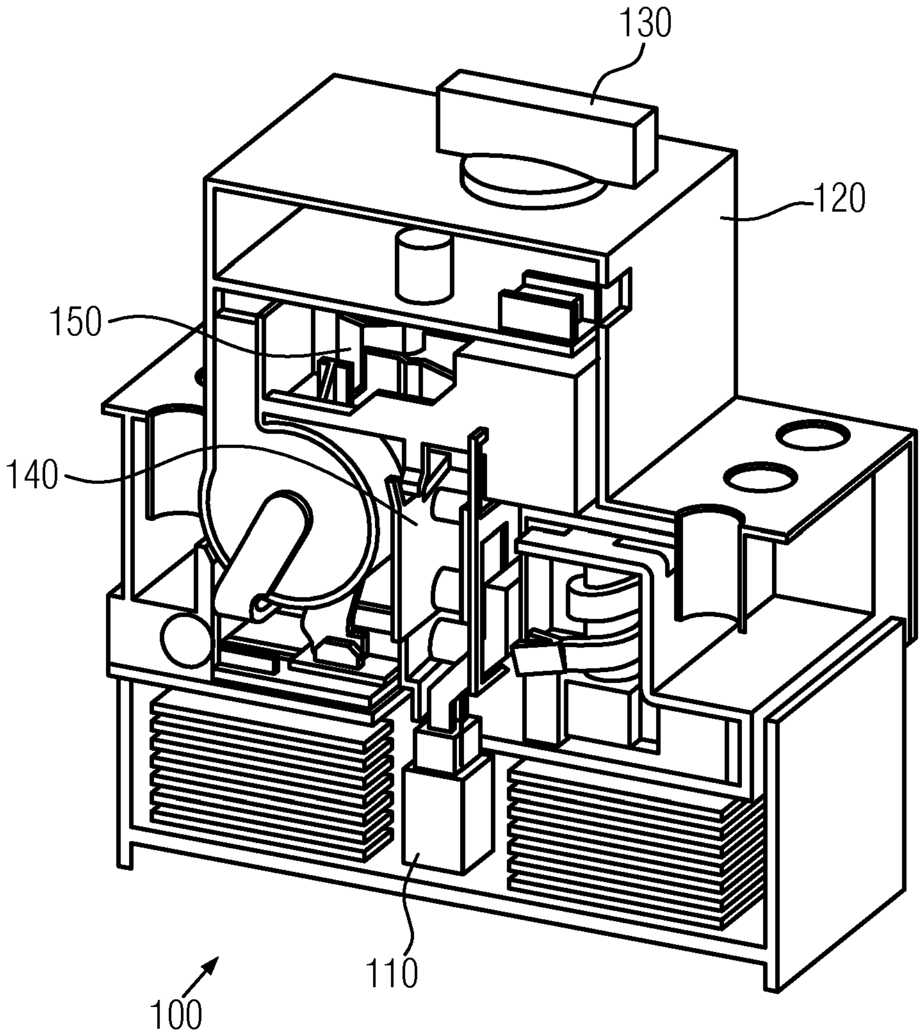

FIG. 1

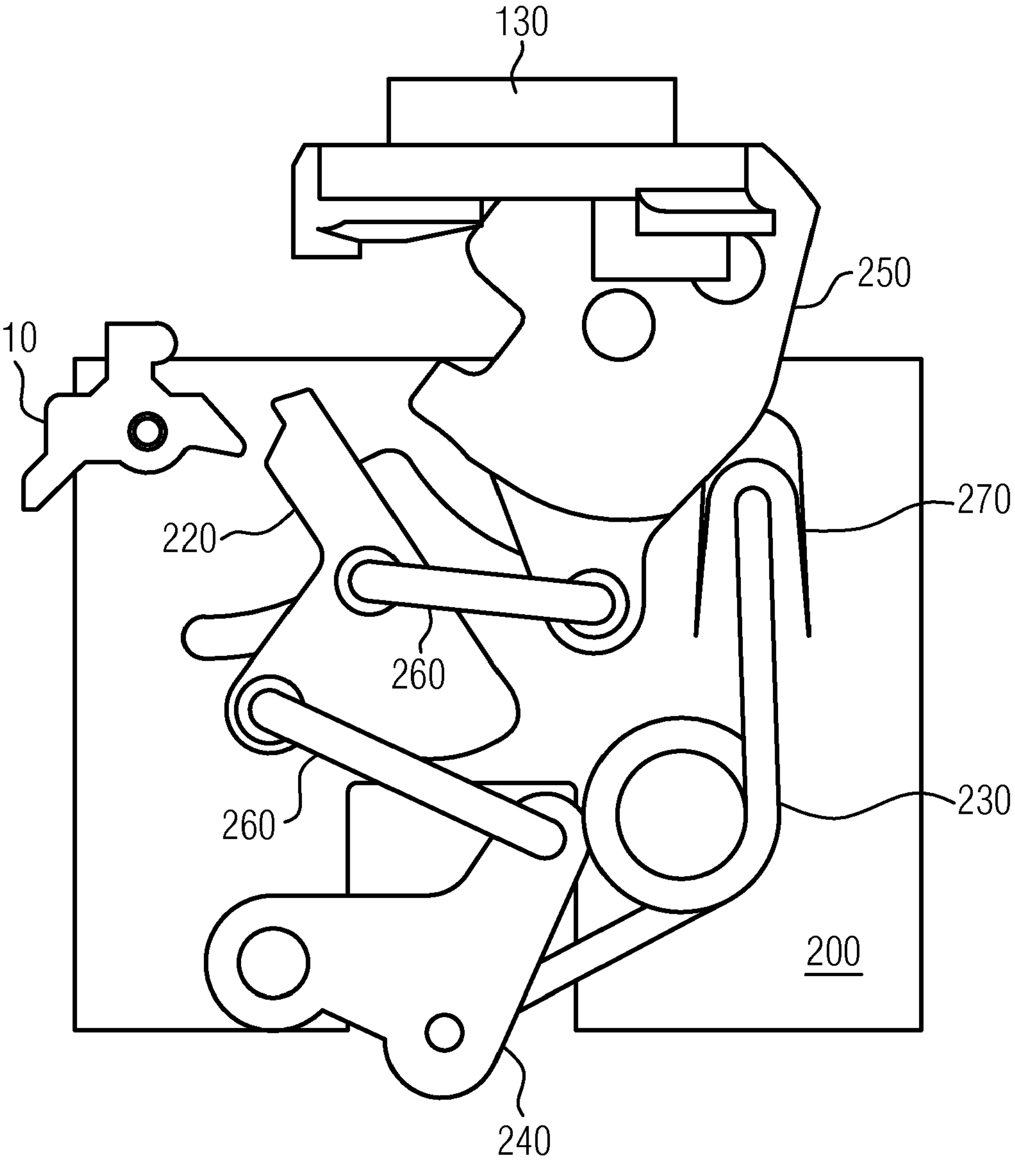

FIG. 2A

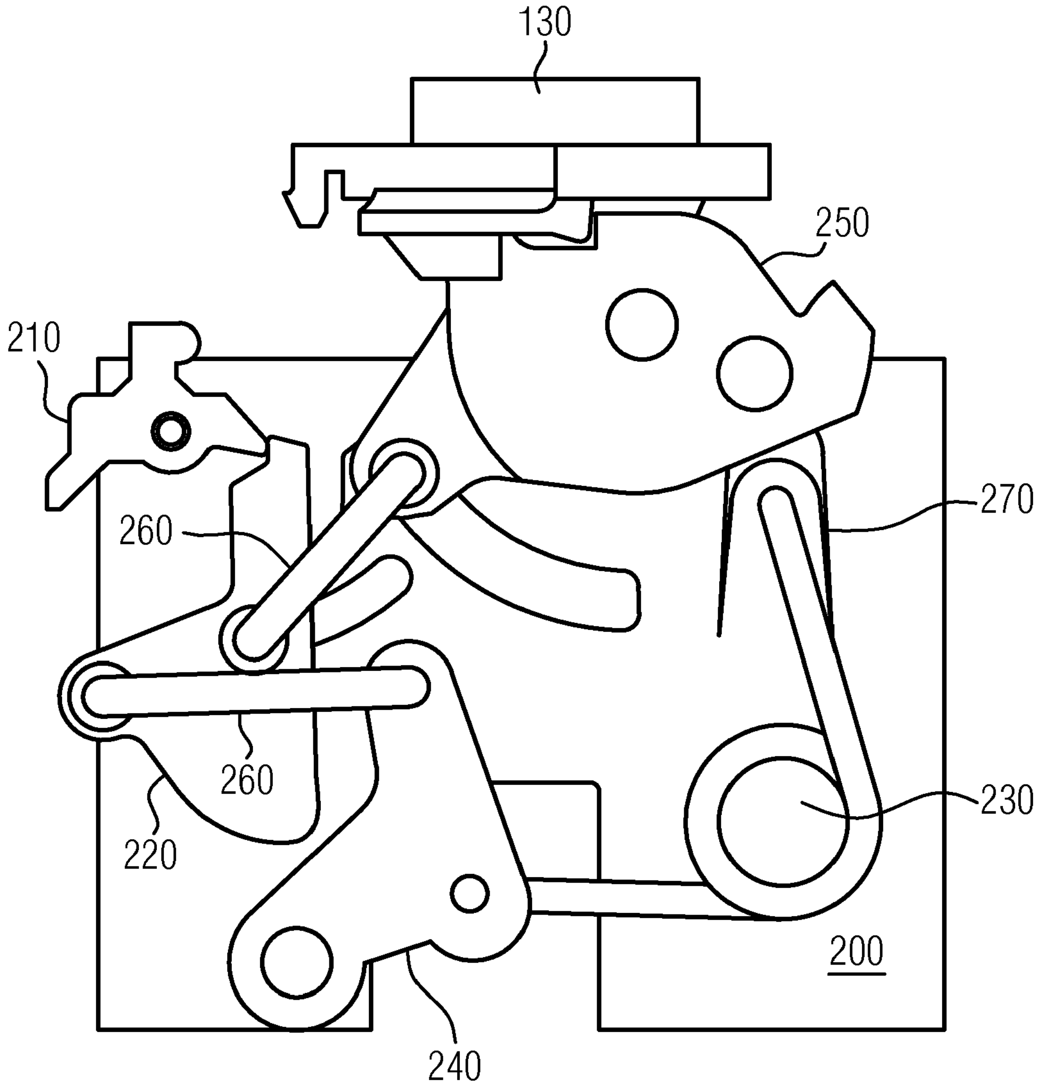

FIG. 2B

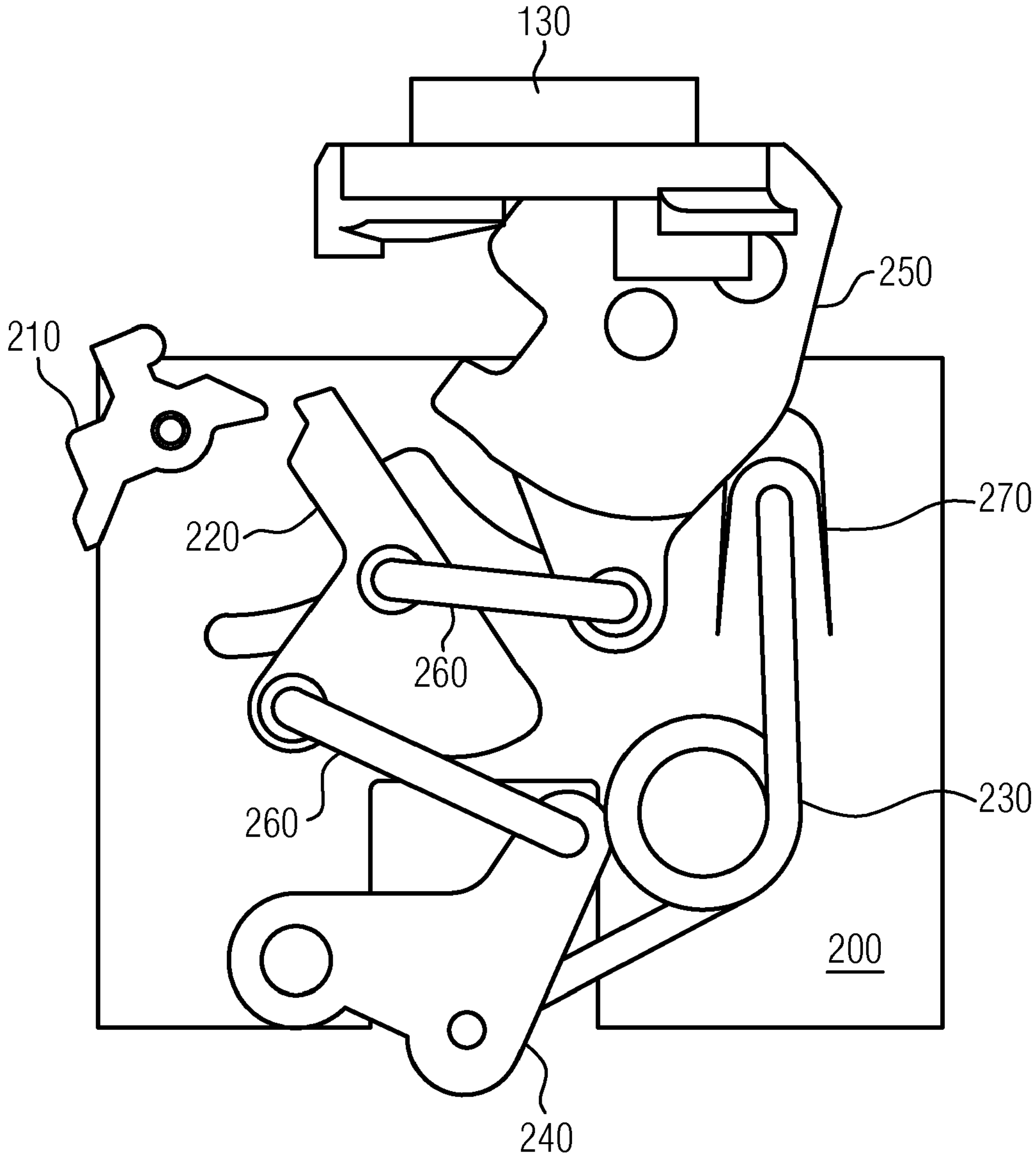

FIG. 2C

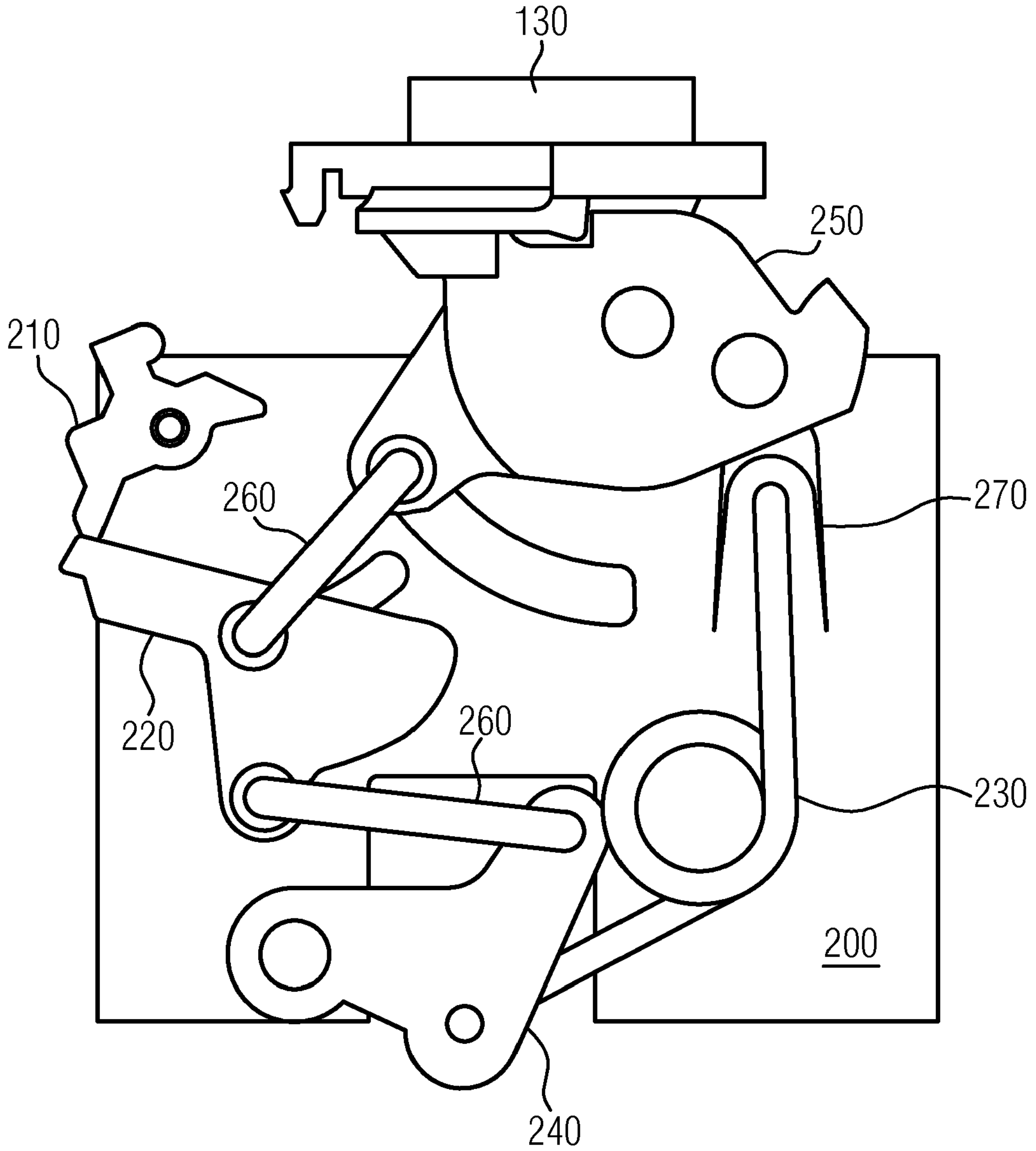

FIG. 2D

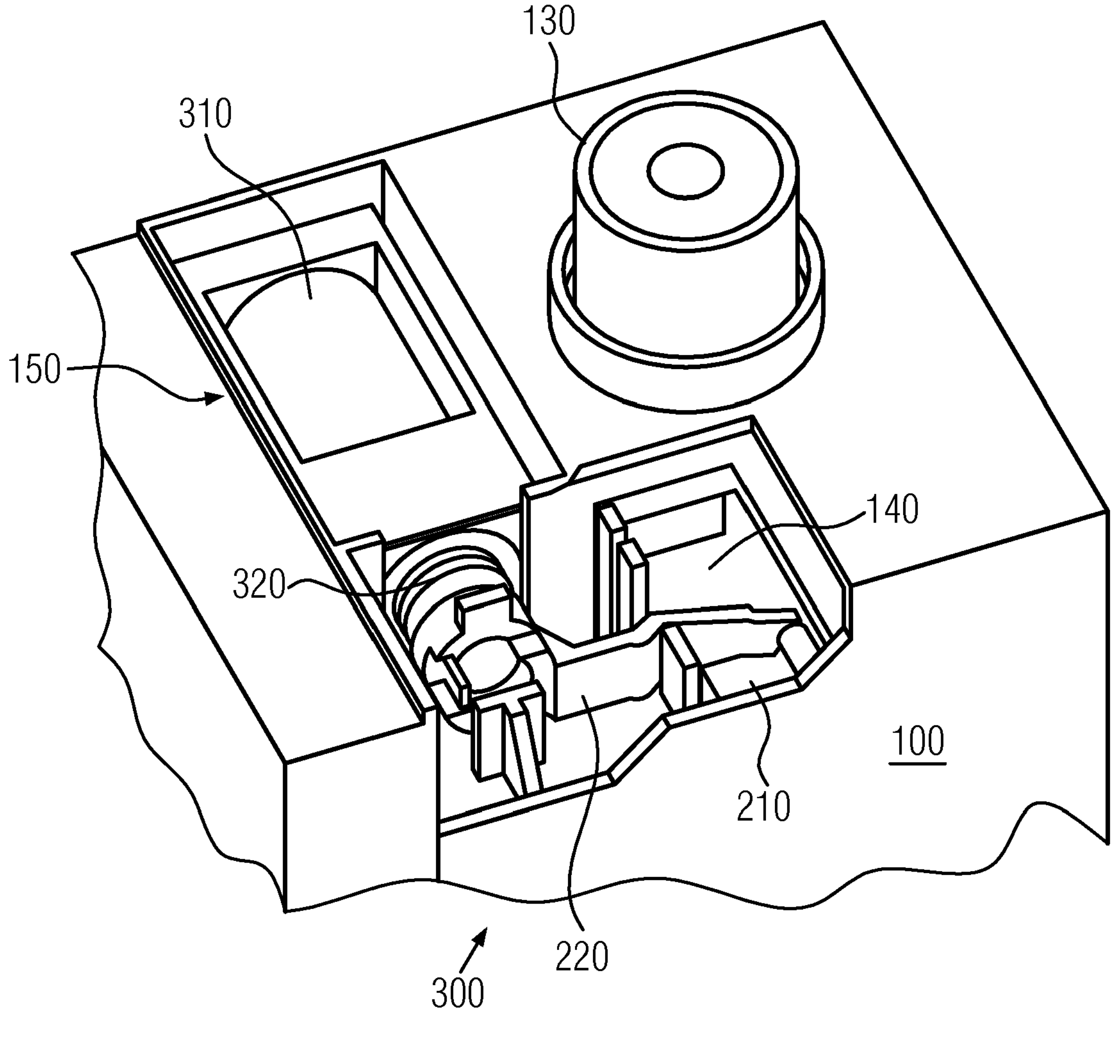

FIG. 3

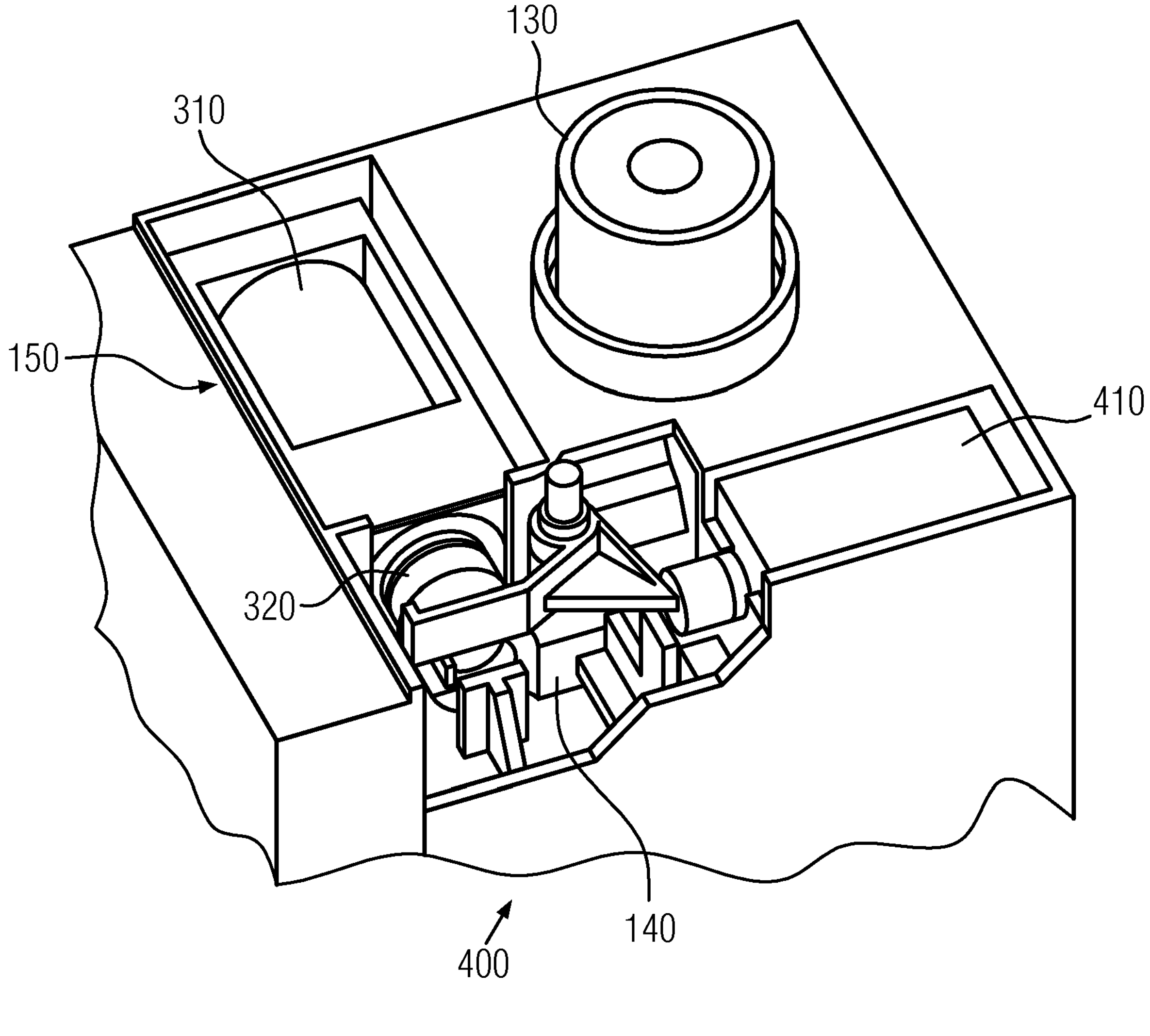

FIG. 4

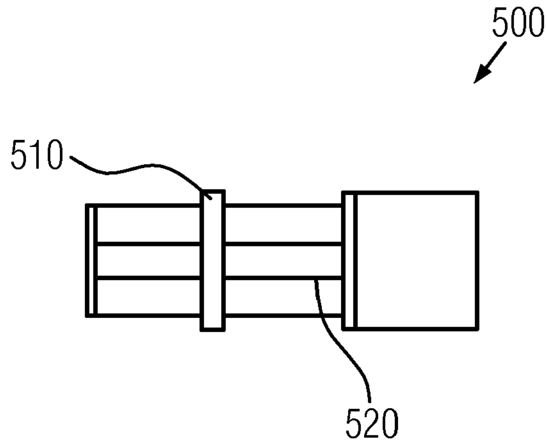

FIG. 5

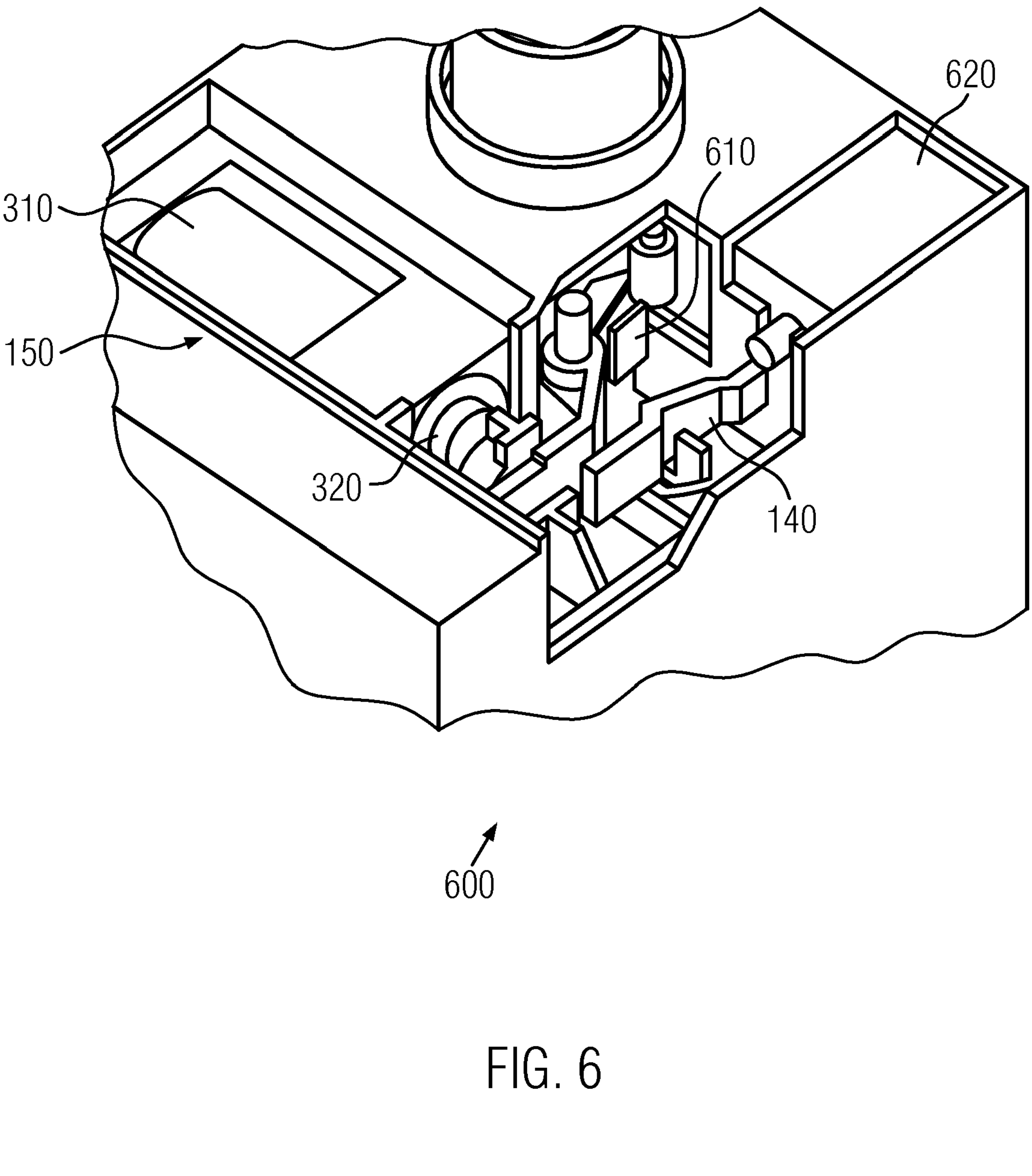

FIG. 6

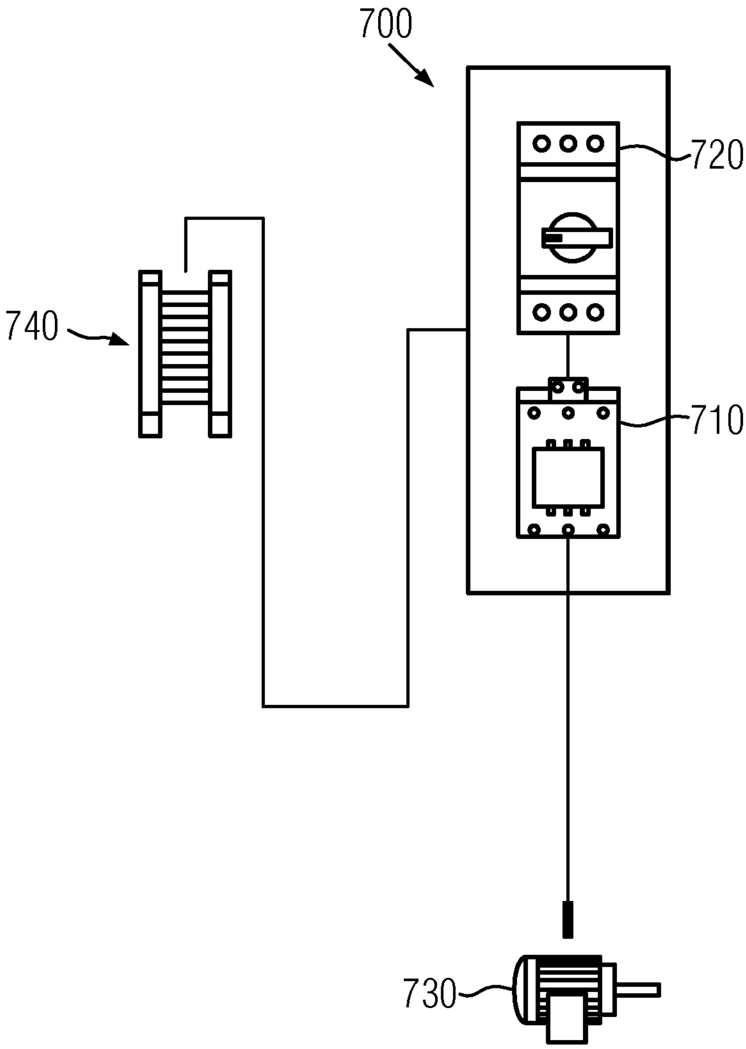

FIG. 7

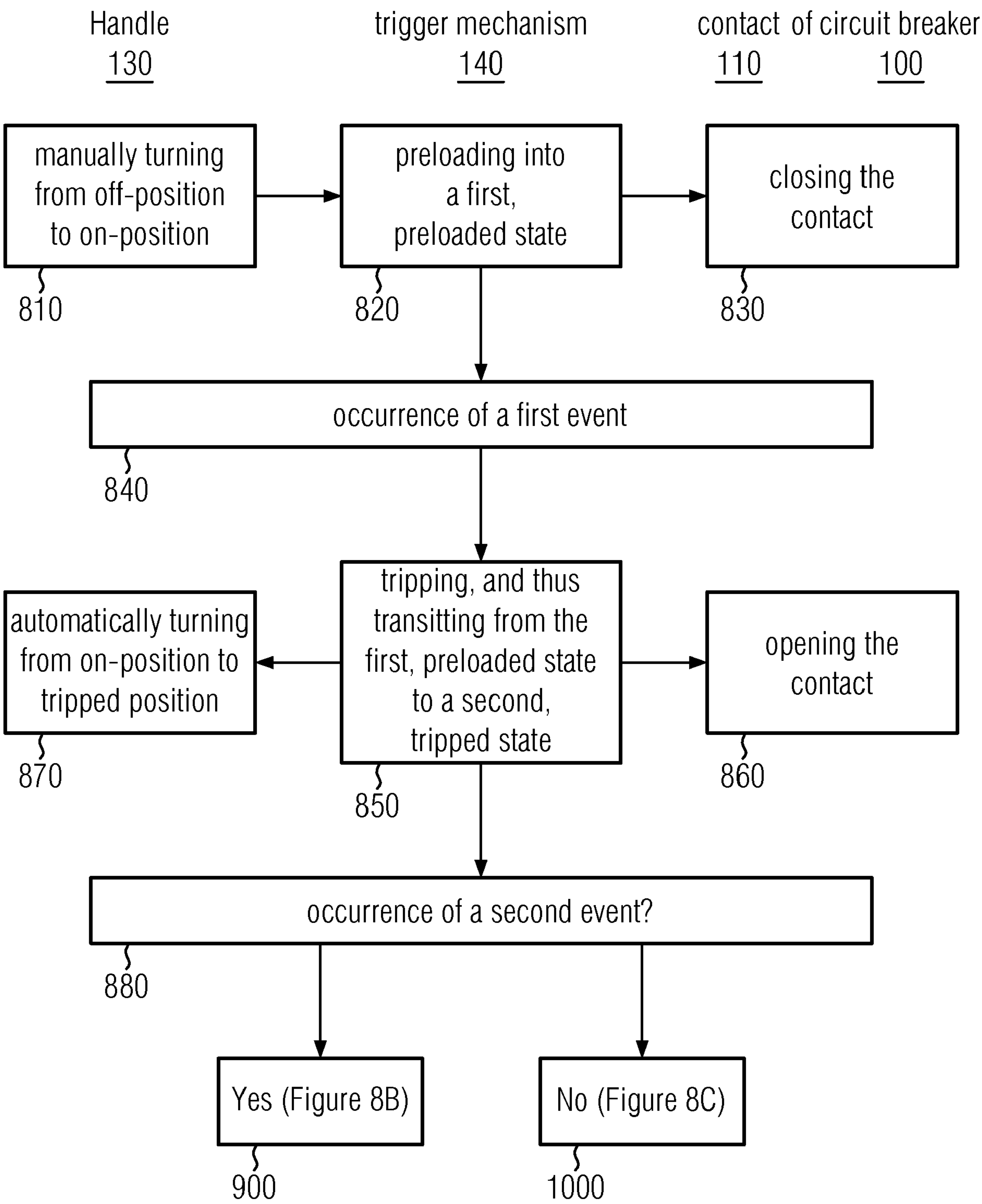
Handle
130
trigger mechanism
140
contact of circuit breaker
110
100
manually turning from off-position to on-position
810
preloading into a first, preloaded state
820
closing the contact
830
occurrence of a first event
840
automatically turning from on-position to tripped position
870
tripping, and thus transitting from the first, preloaded state to a second, tripped state
850
opening the contact
860
occurrence of a second event?
880
Yes (Figure 8B)
900
No (Figure 8C)
1000

FIG. 8A

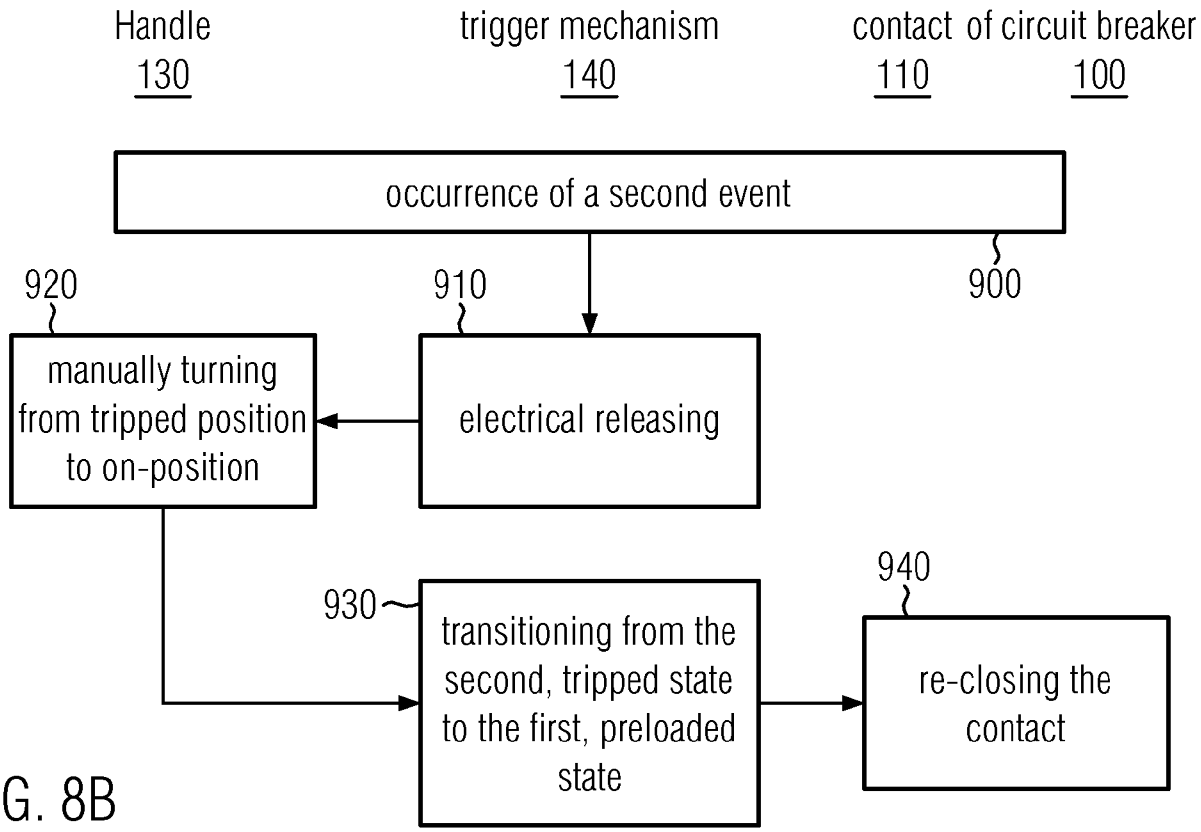
Handle
130
trigger mechanism
140
contact of circuit breaker
110
100
occurrence of a second event
900
920
910
manually turning from tripped position to on-position
electrical releasing
930
transitioning from the second, tripped state to the first, preloaded state
940
re-closing the contact

FIG. 8B

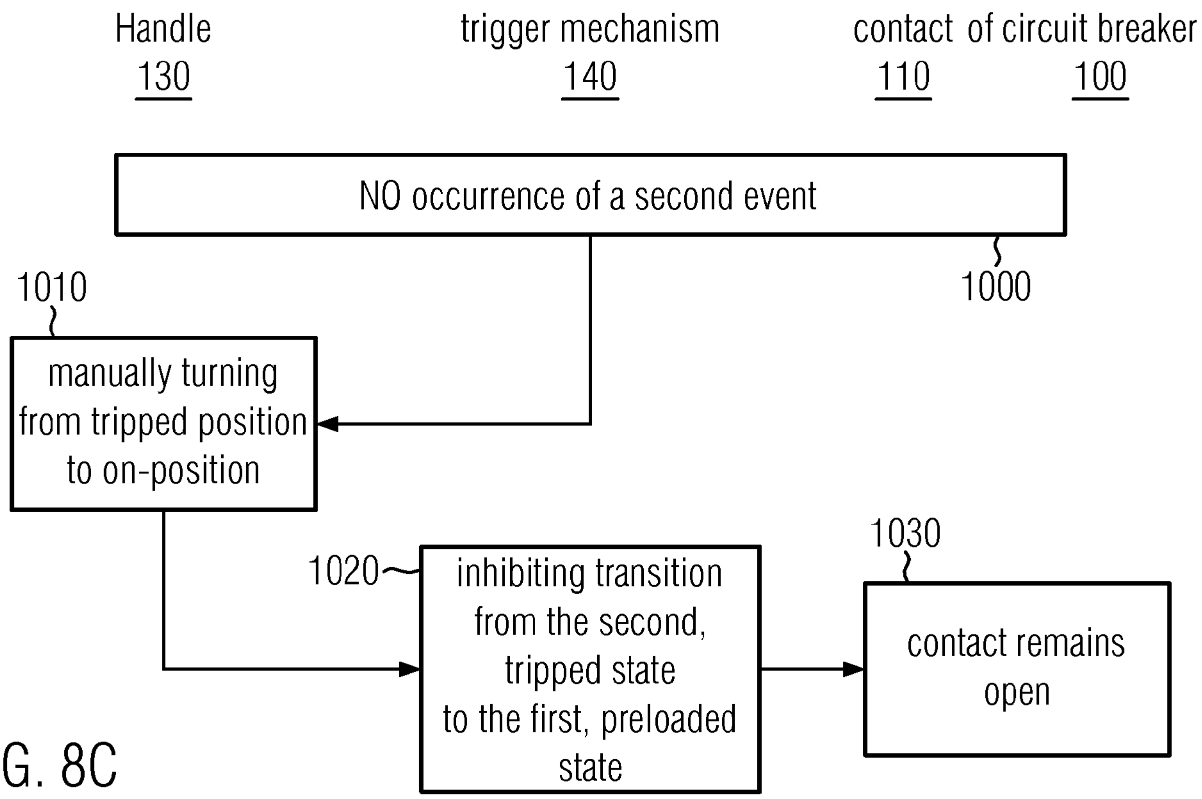
Handle
130
trigger mechanism
140
contact of circuit breaker
110
100
NO occurrence of a second event
1000
1010
manually turning from tripped position to on-position
1020
inhibiting transition from the second, tripped state to the first, preloaded state
1030
contact remains open

FIG. 8C

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EUROPEAN SEARCH REPORT

Application Number
EP 19 15 5058

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/085627 A1 (YANG GUANG [US]) 12 April 2012 (2012-04-12) * paragraph [0024] - paragraph [0041]; figures 1-4 * -----	1-15	INV. H01H71/62 H01H71/64
X	US 9 799 476 B2 (FASANO MICHAEL [US]; CARLING TECH INC [US]) 24 October 2017 (2017-10-24) * column 4, line 6 - column 6, line 54; figures 1-4 * -----	1-15	
A	EP 0 330 421 A2 (DELTA ACC & DOMESTIC SWITCH [GB]) 30 August 1989 (1989-08-30) * column 2, line 61 - column 4, line 23; figures 1-3 * -----	1-15	

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H01H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 July 2019	Dobbs, Harvey

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

& : member of the same patent family, corresponding document

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