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(54) **ELEVATOR SAFETY SYSTEM, ELEVATOR, AND METHOD FOR PERFORMING A SAFETY SHUTDOWN OF AN ELEVATOR**

(57) An elevator safety system (50) comprising an elevator safety chain comprising safety contacts and a safety output (1001), a converter unit (30) connected to and configured to operate an elevator motor (20), wherein the converter unit (30) comprises a safety input (31) to prevent generation of torque in the motor (20). The safety system (50) also comprises a brake contactor or relay (40) comprising at least one auxiliary contact (C2_AUX, C3_AUX) configured to operate together with a primary contact (C2, C3) of the brake contactor or relay (40) which is in connection with the safety output (1001) and configured to operate based on the status thereof. Furthermore, the auxiliary contact (C2 AUX, C3_AUX) of the brake contactor or relay (40) is configured to control the operation of the safety input (31) of the converter unit (30) so that the generation of torque is prevented during a safety shutdown.

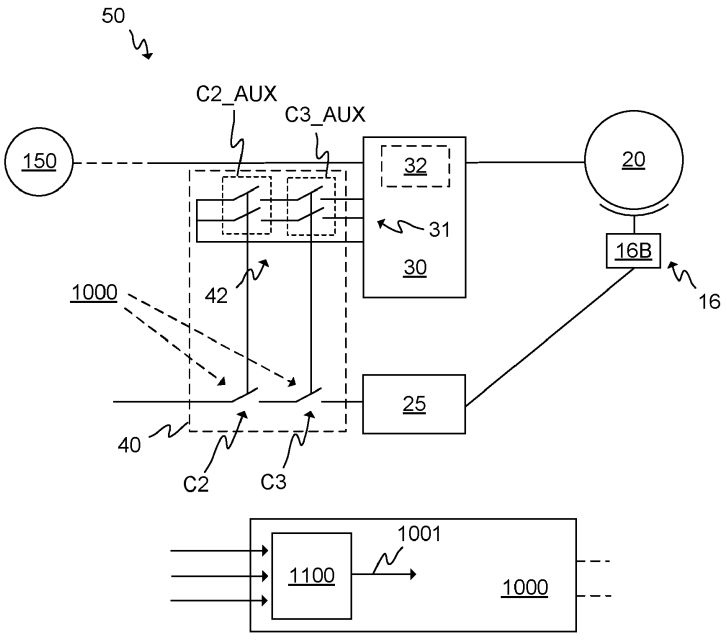

FIG. 2

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Description

FIELD OF THE INVENTION

[0001] The present invention relates in general to elevators. In particular, however not exclusively, the present invention concerns elevator safety systems for performing a safety shutdown of the elevator.

BACKGROUND

[0002] Elevators are equipped with electrical drives. Elevator service is provided, that is, the normal operation of the elevator is conducted by driving elevator car between different landings of the building, for instance, by utilizing the electrical drive.

[0003] Typical electrical drives comprise a frequency converter and hoisting machinery of the elevator. With the frequency converter, electrical power is supplied to elevator motor of the hoisting machinery to generate driving torque.

[0004] Normally, the hoisting machinery includes two hoisting machinery brakes. During standstill and in emergency situations, the brakes will be engaged against a traction sheave or a rotating axis of the elevator hoisting machinery to stop, keep in place, and decelerate the elevator car. A safety shutdown is performed responsive to determining an emergency situation.

[0005] In known solutions, the safety shutdown has been carried out by separating both the elevator motor and the hoisting machinery brakes from mains power supply by means of safety contactors.

SUMMARY

[0006] An objective of the present invention is to provide an elevator safety system for an elevator, an elevator, and a method for performing a safety shutdown of an elevator. Another objective of the present invention is that the elevator safety system, the elevator, and the method provide a reliable and simple solution for performing the safety shutdown.

[0007] The objectives of the invention are reached by an elevator safety system, an elevator, and a method as defined by the respective independent claims. According to a first aspect, an elevator safety system is provided. The elevator safety system comprises an elevator safety chain comprising safety contacts and a safety output, wherein a status of the safety output is arranged to depend on statuses of the safety contacts. The elevator safety chain is configured to perform, or at least to initiate, a safety shutdown depending on the status of the safety output. The elevator safety system further comprises a converter unit connected to and configured to operate an elevator motor for providing hoisting function of the elevator, wherein the converter unit comprises a safety input, such as for performing a Safe Torque Off (STO) function, and wherein the converter unit is configured to prevent generation of torque in the elevator motor based on operation of the safety input. The converter unit may be a frequency converter, for instance. Still further, the elevator safety system comprises a brake contactor or relay configured to selectively supply or interrupt electrical power to at least one hoisting machinery brake by closing or opening at least one primary contact of the brake contactor or relay. Furthermore, the brake contactor or relay comprises an auxiliary contact or contacts configured to operate together with, or in tandem with or along with, or in response to operation of, the at least one primary contact, wherein the brake contactor or relay is in connection with the safety output and configured to operate based on the status of the safety output. Furthermore, the auxiliary contact or contacts of the brake contactor or relay is configured to control the operation of the safety input of the converter unit so that the generation of driving torque is prevented during the safety shutdown.

[0008] The safety input refers herein to means or arrangement for preventing generation of torque in the electrical motor so that the movement of the rotor is at least not continued to be supported. This may be performed by preventing the power semiconductor switches of the converter unit responsible for the torque control, such as switches of the output power stage of the frequency converter or of the inverter, to operate.

[0009] The converter unit may be configured to prevent the generation of driving torque by blocking control pulses from at least some of the power switches of an output power stage of the converter unit.

[0010] In various embodiments, the elevator, and optionally the elevator safety system, may comprise an input contactor or relay configured to selectively supply or interrupt electrical power to the converter unit by at least one main contact of the input contactor or relay. Furthermore, the input contactor or relay may comprise at least one auxiliary contact configured to supply or interrupt electrical power to at least one hoisting machinery brake together with, or in response to the operation of, the at least one main contact. The input contactor or relay may be controlled by the converter unit independently of the status of the safety output.

[0011] In some embodiments, the input contactor or relay may be arranged to be closed during an idle time between elevator starts when the measured or forecasted idle time is below a given time threshold, and the input contactor or relay may be arranged to be opened when the measured or forecasted idle time meets or exceeds the given time threshold.

[0012] In various embodiments, the safety output of the elevator safety chain may be connected to a control coil of the brake contactor or relay. Thus, the control coil may operate the brake contactor or relay in response to the change of status of the safety output or, in general, based on said status.

[0013] Furthermore, the brake contactor or relay may comprise normally open (NO) contact(s) as the primary contact(s). The normally open contact(s) may be ar-

ranged to open when the voltage supply to the control coil of the brake contactor or relay is interrupted. In various embodiments, electrical power may be supplied to the at least one hoisting machinery brake through the normally open contacts).

[0014] In various embodiments, the auxiliary contact(s) of the brake contactor or relay may comprise the auxiliary contacts integrated to the brake contactor or relay, thereby operating together with or in response to the operation or synchronized with the primary contact(s).

[0015] In addition, a further contactor or relay may be arranged to connect input phases of the elevator motor to each other. The further contactor may substantially provide a short-circuit condition between the input phases. The further contactor may, preferably, be in connection with the safety output and is configured to operate depending on the status of the safety output.

[0016] According to a second aspect, an elevator is provided. The elevator comprises an elevator car arranged to be moved in an elevator shaft of the elevator, an elevator motor arranged to provide hoisting function of the elevator, at least one hoisting machinery brake configured for resisting the movement of the motor, and a converter unit connected to and configured to control the operation of the motor. Furthermore, the elevator comprises the elevator safety system in accordance with the first aspect.

[0017] According to a third aspect, a method for performing a safety shutdown of an elevator is provided. The elevator comprises an elevator car arranged to be moved in an elevator shaft of the elevator, an elevator motor arranged to provide hoisting function of the elevator, at least one hoisting machinery brake, a converter unit connected to and configured to control the operation of the motor, and comprising a safety input, such as for performing a Safe Torque Off function. Furthermore, the converter unit is configured to prevent generation of torque in the elevator motor based on operation of the safety input. The elevator further comprises an elevator safety chain comprising safety contacts and a safety output, wherein a status of the safety output is arranged to depend on statuses of the safety contacts. The elevator safety chain is configured to perform a safety shutdown depending on the status of the safety output. The elevator further comprises a brake contactor or relay configured to selectively supply or interrupt electrical power to the at least one hoisting machinery brake by closing or opening at least one primary contact of the brake contactor or relay, wherein the brake contactor or relay comprises at least one auxiliary contact configured to operate together with, or along with or in response to operation of, the at least one primary contact, and wherein the brake contactor or relay is in connection with the safety output and configured to operate based on the status of the safety output.

[0018] The method comprises monitoring the status of the safety output, initiating the safety shutdown based on the status of the safety output, interrupting supply of electrical power to the at least one hoisting machinery brake by opening the at least one primary contact of the brake contactor or relay, and operating the safety input of the converter unit by the auxiliary contact(s) to prevent the generation of driving torque in the elevator motor, wherein the auxiliary contact(s) of the brake contactor or relay is/are configured to control the operation of the safety input of the converter unit.

[0019] The present invention provides an elevator safety system for an elevator, an elevator, and a method for performing a safety shutdown of an elevator. The present invention provides advantages over known solutions in that the brake contactor or relay is substantially the only mechanical switch, or set of switches, needed for the safety shutdown function of the elevator. This means that a reliable and simply solution for elevator safety shutdown is provided. As brake current is normally also much smaller than motor current of an elevator hoisting machinery, only a very small contactor or relay is needed for elevator safety shutdown.

[0020] Various other advantages will become clear to a skilled person based on the following detailed description.

[0021] The terms "first", "second" and "third" are herein used to distinguish one element from other element, and not to specially prioritize or order them, if not otherwise explicitly stated.

[0022] The exemplary embodiments of the present invention presented herein are not to be interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" is used herein as an open limitation that does not exclude the existence of also unrecited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated.

[0023] The novel features which are considered as characteristic of the present invention are set forth in particular in the appended claims. The present invention itself, however, both as to its construction and its method of operation, together with additional objectives and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF FIGURES

[0024] Some embodiments of the invention are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings.

Figure 1 illustrates schematically an elevator according to an embodiment of the present invention.

Figure 2 illustrates schematically an elevator safety system according to an embodiment of the present invention.

Figure 3 illustrates schematically a converter unit according to an embodiment of the present invention.

Figure 4 illustrates schematically an elevator safety system according to an embodiment of the present invention.

Figure 5 shows a flow diagram of a method according to an embodiment of the present invention.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0025] Figure 1 illustrates schematically an elevator 100 according to an embodiment of the present invention. The elevator 100 may comprise an elevator car 10 arranged to be moved in an elevator shaft 12. The moving of the elevator car 10 may be implemented, preferably, by a hoisting rope or belt 13 in connection with a traction sheave 14 or the like. Furthermore, the elevator 100 comprises an elevator motor 20 arranged to operate, such as rotate by the rotor thereof, the traction sheave 14 for moving the elevator car 10, if not essentially directly coupled to the hoisting rope 13. The traction sheave 14 may be connected, via a mechanical connection 22, directly or indirectly via a gear to a shaft of the motor 20. The elevator 100 may comprise a machine room or be machine roomless, such as have the motor 20 in the elevator shaft 12.

[0026] The elevator 100 may preferably comprise at least one, or at least two, hoisting machinery brake(s) 16 configured for resisting or, preferably, preventing the movement of the motor 20, that is the rotor thereof, directly or via the traction sheave 14 or components thereof and/or therebetween. Furthermore, the elevator 100 may comprise a brake controller 25 configured to operate at least one of the at least one hoisting machinery brake 16. The brake controller 25 may further be in connection with other elements of the elevator 100, such as an elevator control unit and/or a safety control system 1000. The brake controller 25 may comprise an actuator (not shown) for operating the brake 16 or at least be in connection with such an actuating device.

[0027] There may additionally be, at least in some embodiments, a counterweight 18 arranged in connection with the elevator car 10 such as is known to a person skilled in the art of elevators. Still further, the elevator 100 may additionally comprise a guide rail 17 or rails 17 arranged into the elevator shaft 12 for guiding the movement of the elevator car 10.

[0028] The elevator 100 of Fig. 1 further comprises a converter unit 30. The converter unit 30 may comprise, or substantially be, an inverter or a frequency converter, for connecting to, and controlling the operation of, the motor 20, and a controller in connection with the converter unit 30, wherein the controller is configured to operate the converter unit 30 to provide electrical power (signals), such as having variable voltage and variable frequency, to the windings of the motor 20. The controller may be a separate controller device or be comprised in the converter unit 30, for instance.

[0029] Still further, the converter unit 30 may be arranged to be fed by an electrical power source 150, such as of the elevator 100, for example from an external electrical power grid or mains power supply, or another power source, for example, a battery system. Additionally, the electrical power source 150 may intake electrical power from the converter unit 50.

[0030] The elevator 100 preferably comprises landings 19 or landing floors 19 and, for example, landing floor doors and/or openings, between which the elevator car 10 is arranged to be moved during the normal operation of the elevator 100, such as to move persons and/or items between said floors 19.

[0031] Furthermore, the elevator 100 may comprise the safety control system 1000 for performing safety functions of the elevator 100. The safety control system 1000 may, for example, comprise at least part of a safety chain of the elevator 1000.

[0032] The elevator safety chain may comprise plurality safety contacts, such as landing door safety contacts, car door safety contacts, overspeed governor safety contact, pit buffer safety contacts, etc. They may be connected in series and/or in parallel. The statuses of the safety contacts are configured to be monitored. The safety chain has, such as in a safety logic unit thereof, at least one safety output which provides a safety signal following the combined status of the safety contacts. Safety signal may be, for example, a digital one-bit signal or an output of a safety relay. In an embodiment, the status of the safety output changes from "1" to "0" when one or several of the safety contacts open(s).

[0033] In various embodiments, such as in the one shown in Fig. 1, the elevator 100 preferably comprises an elevator safety system 50, preferably at least in connection with the safety control system 1000.

[0034] Figure 2 illustrates schematically an elevator safety system 50 according to an embodiment of the present invention. The elevator safety system 50 may comprise an elevator safety chain comprising safety contacts and a safety output 1001, wherein a status of the safety output 1001 is, preferably, arranged to depend on statuses, such as on a combination thereof, of the safety contacts as is known to a skilled person in the art of elevators. The elevator safety chain may be configured to perform or at least initiate a safety shutdown depending on the status of the safety output 1001.

[0035] The statuses of the safety contacts may be received, and preferably monitored, by a safety chain logic unit 1100. The safety chain logic unit 1100 may then determine the status of the safety output 1001 based on the combined status of the safety contacts. The information about the status of the safety output 1001 may then be provided to an elevator control unit and/or safety control system 1000, and/or utilized directly in determining the operating condition, such as an emergency condition, of the elevator 100.

[0036] It should be noted that the safety chain, as well as monitoring thereof, and the logic of determining of the status of the safety output 1001 may be implemented in various ways as is known to a skilled person, such as including utilization of analog electrical circuits and switches, and/or digital devices and communication channels, computing units, such as microprocessors, microcontrollers, distributed processing elements, and/or different kinds of sensors, etc.

[0037] The elevator safety system 50 may further comprise the converter unit 30 connected to and configured to operate an elevator motor 20 for providing hoisting function of the elevator 100, such as moving the elevator car 10 in the elevator shaft 12.

[0038] Still further, the converter unit 30 may comprise a safety input 31, such as for performing a Safe Torque Off (STO) function. The converter unit 30 may be configured to prevent generation of torque in the elevator motor 20 based on operation of the safety input 31, such as when the status of the safety input 31 changes from inactive state to an active state.

[0039] In general, the STO is an electronic signal used in motor controllers for safety reasons. The STO, once in operation, ensures that no torque-generating energy can continue to act upon the motor. The STO can be used where power removal is required to prevent an unexpected start. The function disables the signals that control the power semiconductors, that is switching thereof, of the output power stage of the converter unit, thus preventing the frequency converter or the inverter from generating the voltage and/or required to rotate, or at least support the rotation of, of the rotor of the motor. In an active state of the STO, control pulses may be blocked from power switches, such as transistors, of the output power stage. In accordance with various embodiments of the present invention, this means that power supply from frequency converter to the elevator motor is interrupted in a safe way, however, not requiring separation of the elevator motor from the mains power supply.

[0040] The elevator safety system 50 may also comprise a brake contactor or relay 40, such as comprising one or contacts C2, C3, configured to selectively supply or interrupt electrical power to at least one hoisting machinery brake 16, or at least to or via the brake controller 25 thereof, by closing or opening at least one primary contact C2, C3 of the brake contactor or relay 40. As can be seen, the one hoisting machinery brake 16 preferably comprises an actuating device 16B. Furthermore, the brake contactor or relay 40 may comprise, as shown at 42, at least one auxiliary contact C2_AUX, C3_AUX, such as normally open (NO) contacts, configured to operate together with, in tandem with, or in response to operation of the at least one primary contact C2, C3.

[0041] The brake contactor or relay 40 may preferably be in connection with the safety output 1001 and configured to operate based on the status of the safety output 1001. Still further, the auxiliary contacts C2_AUX, C3_AUX of the brake contactor or relay 40 may be configured to control the operation of the safety input 31 of the converter unit 30 so that the generation of torque is prevented during the safety shutdown. In various embodiments, at least the primary contact or contacts C2 and C3 may be NO type of contacts, thereby closing only if control signal, such as in a suitable form and having sufficient amount of electrical power, is applied to the control device, such as the control coil, of the brake contactor or relay 40. The auxiliary contacts may also be NO type of contacts.

[0042] In various embodiments, the auxiliary contact(s) may be arranged integrated, optionally removable, to the brake contactor or relay 40. Thus, the auxiliary contacts) may be arranged to close based on the control signal to the control coil of the brake contactor or relay 40.

[0043] Even though the electrical power source 150 is shown to be directly connected to the converter unit 30, it is to be noted that there may be one or several devices arranged therebetween, such as input filter(s), circuit breaker(s), and/or contactor(s) or relay(s), and/or a device for charging the energy storage element(s) of the converter unit 30.

[0044] Figure 3 illustrates schematically a converter unit 30 according to an embodiment of the present invention. The converter unit 30 may be a frequency converter or an inverter. The controllable switches, such as power semiconductor switches, of the output power stage 38 of the converter unit 30 are shown. The switches may be controlled by the controller 32, such as having drivers for the switches and a modulation unit, for instance, among other components, such as processing units and memory devices. Furthermore, the converter unit 30 may comprise, preferably being integrated into the converter unit 30, the safety input 31. The safety input 31 may also comprise a circuitry for monitoring the status of the safety input 31. Further, the safety input 31 may be in connection with the controller 32 for preventing the generation of torque in the elevator motor 20 based on operation of the safety input 31, or the operation of the safety input 31 may be utilized in more direct manner to block the control signal to the switches. As can be seen in Fig. 3, the safety input 31 may comprise one or several inputs. The converter unit 30 may also comprise an input power stage 36, such as a rectifier.

[0045] In various embodiments, the output power stage 38 may comprise, such as also shown in Fig. 3, high-side switches connected to the first potential of the intermediate circuit, such as to the positive potential of the direct current (DC) link, and low-side switches connected to the second potential of the intermediate circuit, such as to the negative potential of the DC link. Thus, the prevention of driving torque may be performed by blocking only the control pulses of the high-side switches or, alternatively, the low-side switches. Naturally, it is possible to block control pulses of all of the switches.

[0046] In various embodiments, the operation and structure of the converter unit 30, such as with respect to number of phases, phase legs, levels, and/or number

and types of switches, control units, methods of control, filters in connection thereto, topology of the converter/rectifier/inverter, etc., may substantially be of any suitable type known for the skilled person.

[0047] Figure 4 illustrates schematically an elevator safety system 50 according to an embodiment of the present invention. The elevator safety system 50 may comprise an elevator safety chain comprising safety contacts and a safety output 1001, wherein a status of the safety output 1001 is, preferably, arranged to depend on statuses, such as on a combination thereof, of the safety contacts as is known to a skilled person in the art of elevators. The elevator safety chain may be configured to perform or at least initiate a safety shutdown depending on the status of the safety output 1001.

[0048] The statuses of the safety contacts may be received, and preferably monitored, by a safety chain logic unit 1100. The safety chain logic unit 1100 may then determine the status of the safety output 1001 based on the combined status of the safety contacts. The information about the status of the safety output 1001 may then be provided to an elevator control unit and/or safety control system 1000, and/or utilized directly in determining the operating condition, such as an emergency condition, of the elevator 100.

[0049] The elevator safety system 50 may further comprise the converter unit 30 connected to and configured to operate an elevator motor 20 for providing hoisting function of the elevator 100, such as moving the elevator car 10 in the elevator shaft 12.

[0050] Still further, the converter unit 30 may comprise a safety input 31, such as for performing a Safe Torque Off (STO) function. The converter unit 30 may be configured to prevent generation of torque in the elevator motor 20 based on operation of the safety input 31, such as when the status of the safety input 31 changes from inactive state to an active state.

[0051] The elevator safety system 50 may also comprise a brake contactor or relay 40, such as comprising one or contacts C2, C3, configured to selectively supply or interrupt electrical power to at least one hoisting machinery brake 16, or at least to or via the brake controller 25 thereof, by closing or opening at least one primary contact C2, C3 of the brake contactor or relay 40. As can be seen, the one hoisting machinery brake 16 preferably comprises an actuating device 16B. Furthermore, the brake contactor or relay 40 may comprise, as shown at 42, auxiliary contacts C2_AUX, C3_AUX, such as normally open (NO) contacts, configured to operate together with or in response to operation of the at least one primary contact C2, C3.

[0052] The brake contactor or relay 40 may preferably be in connection with the safety output 1001 and configured to operate based on the status of the safety output 1001. Still further, the auxiliary contact(s) C2_AUX, C3_AUX of the brake contactor or relay 40 may be configured to control the operation of the safety input 31 of the converter unit 30 so that the generation of torque is prevented during the safety shutdown. In various embodiments, at least the primary contact or contacts C2 and C3 may be NO type of contacts, thereby closing only if control signal, such as in a suitable form and having sufficient amount of electrical power, is applied to the control device, such as the control coil, of the brake contactor or relay 40. The auxiliary contact(s) may also be NO type of contacts.

[0053] In various embodiments, the auxiliary contact(s) may be arranged integrated, optionally removable, to the brake contactor or relay 40. Thus, the auxiliary contacts may be arranged to close based on the control signal to the control coil of the brake contactor or relay 40.

[0054] Even though the electrical power source 150 is shown to be directly connected to the converter unit 30, it is to be noted that there may be one or several devices arranged therebetween, such as input filter(s), circuit breaker(s), and/or contactors) or relay(s), and/or a device for charging the energy storage element(s) of the converter unit 30.

[0055] Furthermore, the elevator safety system 50 may comprise an input contactor or relay 44 configured to selectively supply or interrupt electrical power to the converter unit 30 by at least one main contact C1 of the input contactor or relay 44. The input contactor or relay 44 may, optionally, comprise at least one auxiliary contact C1_AUX, such as integrated thereto, configured to supply or interrupt electrical power to at least one hoisting machinery brake 16, or at least to or via the brake controller 25, together with or in response to the operation of the at least one main contact C1.

[0056] Furthermore, there may also be several other situations in which the input contactor or relay 44 may be configured to be opened. For example, when the elevator operation is interrupted because of an error, such as opening of a safety contact comprised or not in the safety chain, the input contactor or relay 44 may be opened. In the normal operation of the elevator 100, when elevator has stopped at a landing floor 19, the input contactor or relay 44 may be opened provided that a longer than usual idle time is measured or expected (such as forecasted) to save energy (for example, when low traffic conditions are being detected). In various other conditions, however, such as when electrical power is required to drive the motor 20, it may be kept closed.

[0057] In various embodiment, the input contactor or relay 44 may be controlled by the converter unit 30 independently of the status of the safety output 1001. Thus, the input contactor or relay may be provided between the electrical power supply 150, such as mains power supply, and the motor 20 but this contactor is not needed for the safety shutdown. Therefore, it does not have to be controlled by the safety output 1001 but may instead be controlled by any microcontroller or corresponding associated with normal elevator operations. Consequently, opening frequency of the input contactor or relay 44 may be lowered which will improve elevator noise characteristics and lifetime of the input contactor or relay 44.

[0058] Therefore, during the safety shutdown, the input contactor or relay 44 may be arranged to be closed and the safety input 31 may be operated to prevent supply of electrical power from the converter unit 30 to the elevator motor 20 or at least to prevent the generation of torque in the elevator motor 20.

[0059] Alternatively or in addition, the elevator safety system 50 may comprise a further contactor 48 arranged to connect input phases of the elevator motor 20 to each other, thereby providing a short-circuit condition thereto or at least a low resistance path for the current in the circuit thereof, thereby providing dynamic braking of the motor 20. Furthermore, the further contactor 48 may optionally be in connection with the safety output 1001 and may be configured to operate depending on the status of the safety output 1001.

[0060] Figure 5 shows a flow diagram of a method according to an embodiment of the present invention. Step 500 refers to a start-up phase of the method. Suitable equipment and components are obtained and systems assembled and configured for operation.

[0061] Step 510 refers to monitoring the status of the safety output 1001. This may be performed by the safety control unit 1000, for instance.

[0062] Step 520 refers to determining and initiating the safety shutdown based on the status of the safety output 1001.

[0063] Step 530 refers to interrupting supply of electrical power to the at least one hoisting machinery brake 16 by opening the at least one primary contact C2, C3 of the brake contactor or relay 40.

[0064] Step 540 refers to operating the safety input 31 of the converter unit 30 by the at least one auxiliary contact C2_AUX, C3_AUX, to prevent the generation of driving torque in the elevator motor 20, wherein the auxiliary contact(s) C2_AUX, C3_AUX of the brake contactor or relay 40 may be configured to control the operation of the safety input 31 of the converter unit 30.

[0065] Method execution may be stopped at step 599. The safety shutdown has been performed and the hoisting machine brake 16 is controlled to be resisting the movement of the rotor of the elevator motor 20 and/or the traction sheave 14. In preferable embodiments, the input contactor or relay 44, regardless of the safety shutdown, may be configured to supply electrical power to the converter unit 30. The input contactor or relay 44 may be configured to be controlled by the converter unit 30.

[0066] With respect to various embodiments of the method, the similar features may be utilized as described hereinabove with respect to and in Figs. 1-4.

Claims

1. An elevator safety system (50) for an elevator (100), comprising:

an elevator safety chain comprising safety contacts and a safety output (1001), wherein a status of the safety output (1001) is arranged to depend on statuses of the safety contacts, and wherein the elevator safety chain is configured to perform a safety shutdown depending on the status of the safety output (1001);

a converter unit (30) connected to and configured to operate an elevator motor (20) for providing hoisting function of the elevator (100), **characterized in that**

the converter unit (30) comprises a safety input (31), such as for performing a Safe Torque Off function, wherein the converter unit (30) is configured to prevent generation of driving torque in the elevator motor (20) based on operation of the safety input (31);

a brake contactor or relay (40) configured to selectively supply or interrupt electrical power to at least one hoisting machinery brake (16) by closing or opening at least one primary contact (C2, C3) of the brake contactor or relay (40), wherein the brake contactor or relay (40) comprises at least one auxiliary contact (C2_AUX, C3_AUX) configured to operate together or in tandem with the at least one primary contact (C2, C3), and wherein the brake contactor or relay (40) is in connection with the safety output (1001) and configured to operate based on the status of the safety output (1001); and

the auxiliary contact (C2_AUX, C3_AUX) of the brake contactor or relay (40) is configured to control the operation of the safety input (31) of the converter unit (30) so that the generation of torque is prevented during the safety shutdown.

2. The elevator safety system (50) of claim 1, wherein the converter unit (30) is configured to prevent the generation of torque by blocking control pulses from at least some of the power switches of an output power stage (38) of the converter unit (30).

3. The elevator safety system (50) of claim 1 or 2, comprising an input contactor or relay (44) configured to selectively supply or interrupt electrical power to the converter unit (30) by at least one main contact (C1) of the input contactor or relay (44).

4. The elevator safety system (50) of claim 3, wherein the input contactor or relay (44) comprises at least one auxiliary contact (C1_AUX) configured to supply or interrupt electrical power to at least one hoisting machinery brake (16) together with or in response to the operation of the at least one main contact (C1).

5. The elevator safety system (50) of claim 3 or 4, wherein the input contactor or relay (44) is controlled by the converter unit (30) independently of the status of the safety output (1001).

6. The elevator safety system (50) of any one of claims 3-5, wherein the input contactor or relay (44) is arranged to be closed during an idle time between elevator starts, when a measured or forecasted idle time is below a given time threshold and the input contactor or relay (44) is arranged to be opened when the measured or forecasted idle time meets or exceeds the given time threshold.

7. The elevator safety system (50) of any one of claims 1-6, wherein the safety output (1001) is connected to a control coil of the brake contactor or relay (40).

8. The elevator safety system (50) of any one of claims 1-7, wherein the brake contactor or relay (40) comprises normally open contacts.

9. The elevator safety system (50) of claim 8, wherein the normally open contacts are arranged to open when voltage supply to a control coil of the brake contactor or relay (30) is interrupted.

10. The elevator safety system (50) of claim 9, wherein electrical power is supplied to the at least one hoisting machinery brake (16) through the normally open contacts.

11. The elevator safety system (50) of any one of claims 1-10, wherein the auxiliary contacts (C2_AUX, C3_AUX) are integrated to the brake contactor or relay (40).

12. The elevator safety system of any one of claims 1-11, comprising a further contactor (48) arranged to connect input phases of the elevator motor (20) to each other.

13. The elevator safety system (50) of claim 12, wherein the further contactor (48) is in connection with the safety output (1001) and is configured to operate depending on the status of the safety output (1001).

14. An elevator (100) comprising:

an elevator car (10) arranged to be moved in an elevator shaft (12) of the elevator (100);
an elevator motor (20) arranged to provide hoisting function of the elevator (100);
at least one hoisting machinery brake (16) configured for resisting the movement of the motor (20), such as rotation of a rotor of the motor (20),
a converter unit (30) connected to and configured to control the operation of the motor (20);
characterized in that
the elevator (100) comprises the elevator safety system (50) of any one of claims 1-13.

15. A method for performing a safety shutdown of an elevator (100), wherein the elevator (100) comprises:

- an elevator car (10) arranged to be moved in an elevator shaft (12) of the elevator (100),
- an elevator motor (20) arranged to provide hoisting function of the elevator (100),
- at least one hoisting machinery brake (16),
- a converter unit (30) connected to and configured to control the operation of the motor (20), and comprising a safety input (31), such as for performing a Safe Torque Off function, wherein the converter unit (30) is configured to prevent generation of torque in the elevator motor (20) based on operation of the safety input (31),
- an elevator safety chain comprising safety contacts and a safety output (1001), wherein a status of the safety output (1001) is arranged to depend on statuses of the safety contacts, and wherein the elevator safety chain is configured to perform a safety shutdown depending on the status of the safety output (1001), and
- a brake contactor or relay (40) configured to selectively supply or interrupt electrical power to the at least one hoisting machinery brake (16) by closing or opening at least one primary contact (C2, C3) of the brake contactor or relay (40), wherein the brake contactor or relay (40) comprises at least one auxiliary contact (C2_AUX, C3_AUX) configured to operate together or in tandem with the at least one primary contact (C2, C3), and wherein the brake contactor or relay (40) is in connection with the safety output (1001) and configured to operate based on the status of the safety output (1001);

characterized in that the method comprises:

monitoring (510) the status of the safety output;
initiating (520) the safety shutdown based on the status of the safety output (1001);
interrupting (530) supply of electrical power to the at least one hoisting machinery brake (16) by opening the at least one primary contact (C2, C3) of the brake contactor or relay (40), and
operating (540) the safety input (31) of the converter unit (30) by the auxiliary contact (C2_AUX, C3_AUX) to prevent the generation of driving torque in the elevator motor (20), wherein the auxiliary contact (C2_AUX, C3_AUX) of the brake contactor or relay (40) is configured to control the operation of the safety input (31) of the converter unit (30).

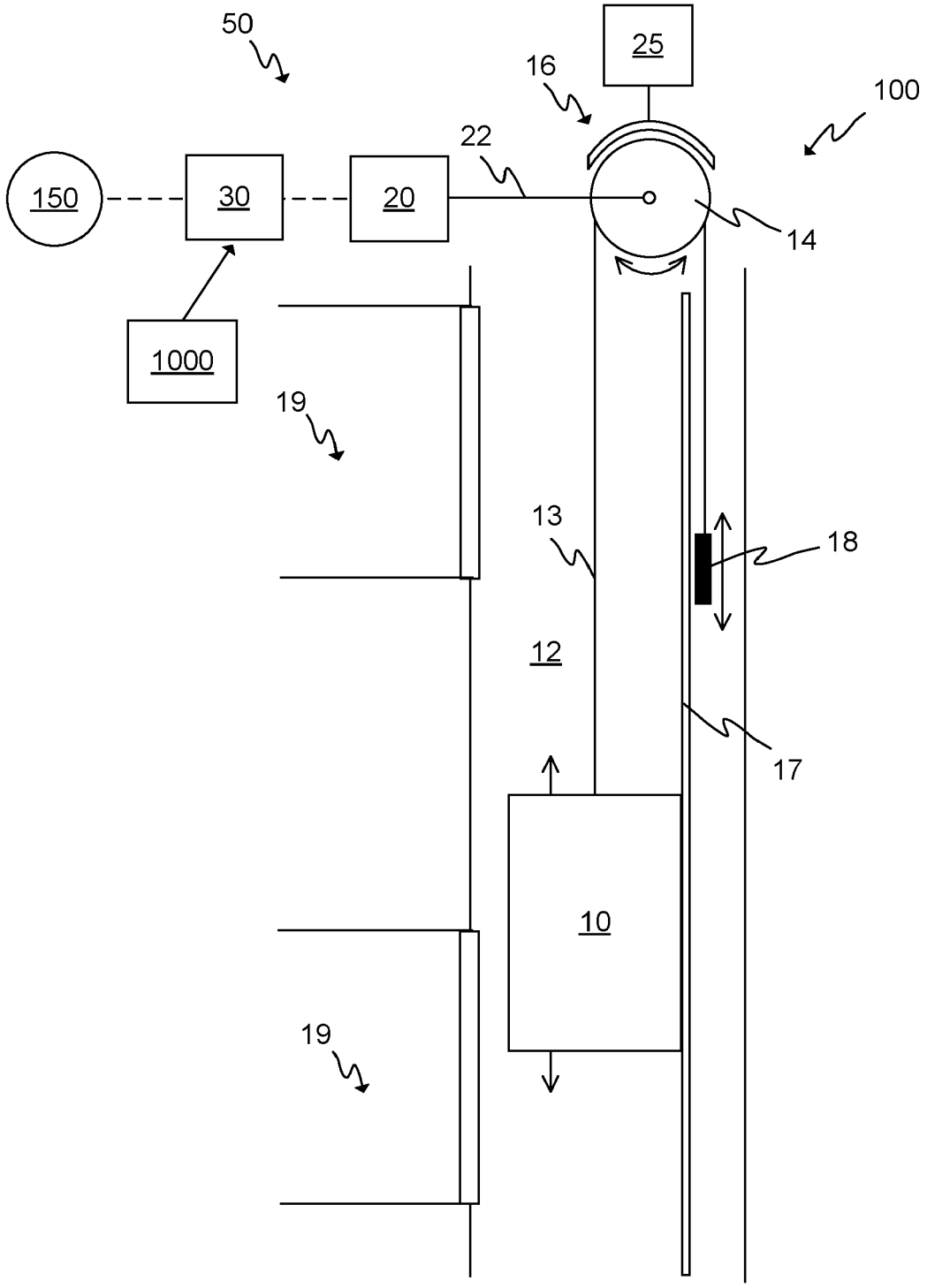

FIG. 1

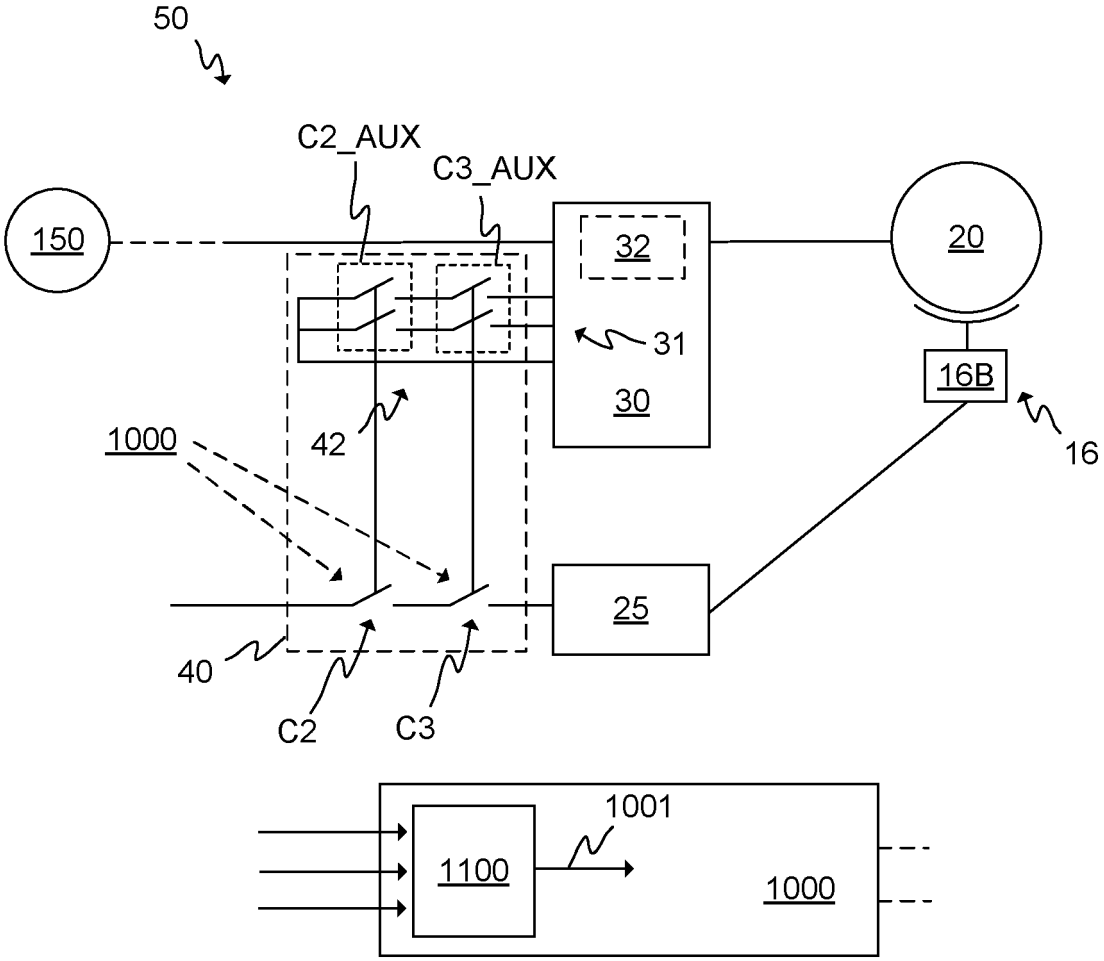
50
C2_AUX
C3_AUX
150
32
20
31
30
16B
16
1000
42
25
40
C2
C3
1001
1100
1000

FIG. 2

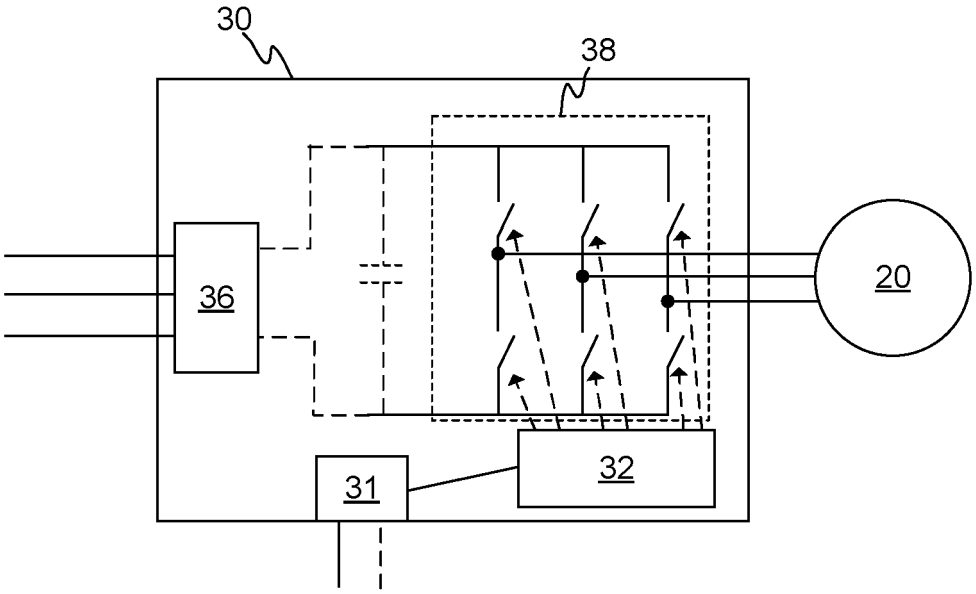
30
38
36
20
31
32

FIG. 3

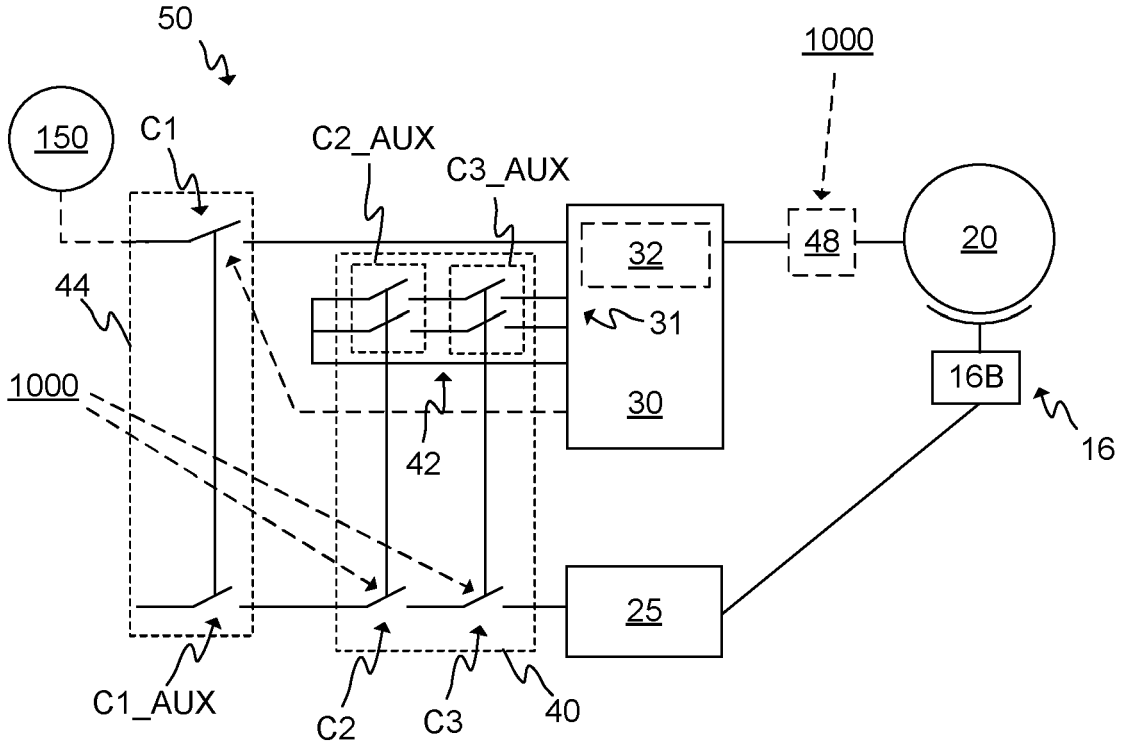
50
1000
150
C1
C2_AUX
C3_AUX
32
48
20
44
31
1000
30
16B
16
42
25
C1_AUX
C2
C3
40

FIG. 4

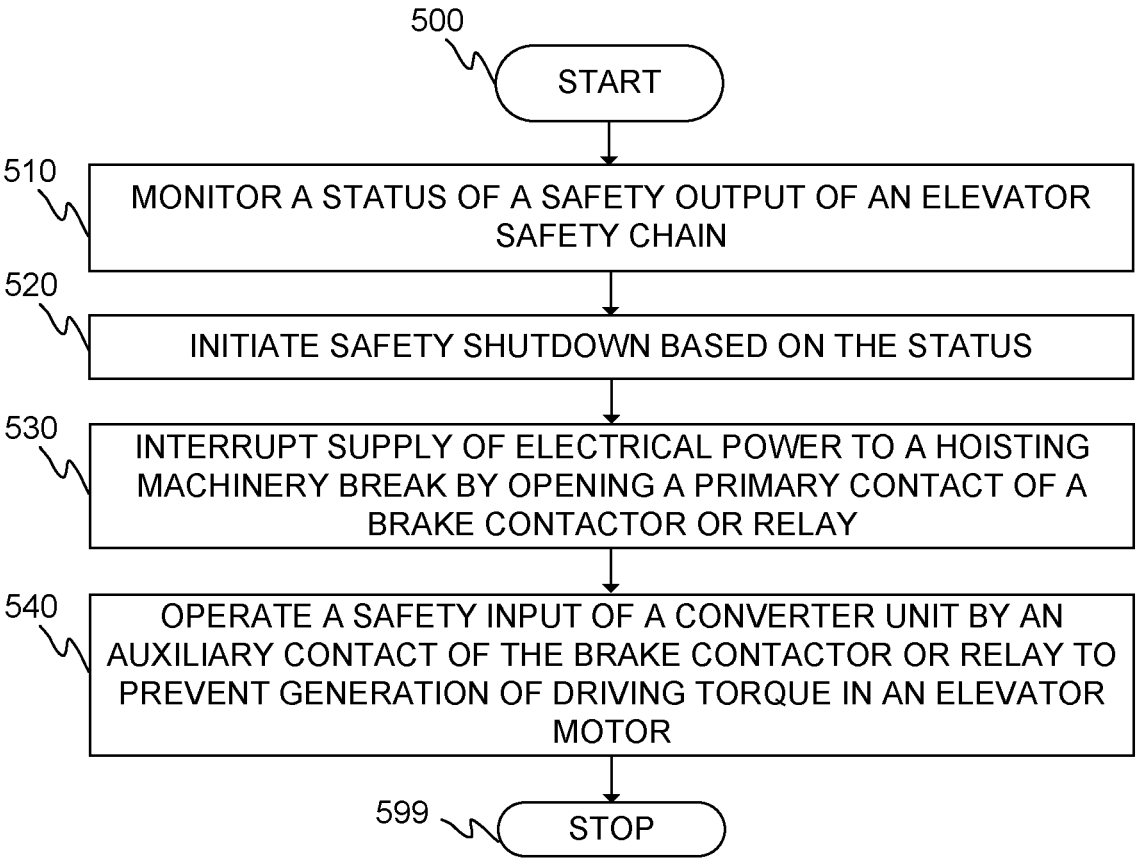
500
START
510
MONITOR A STATUS OF A SAFETY OUTPUT OF AN ELEVATOR SAFETY CHAIN
520
INITIATE SAFETY SHUTDOWN BASED ON THE STATUS
530
INTERRUPT SUPPLY OF ELECTRICAL POWER TO A HOISTING MACHINERY BREAK BY OPENING A PRIMARY CONTACT OF A BRAKE CONTACTOR OR RELAY
540
OPERATE A SAFETY INPUT OF A CONVERTER UNIT BY AN AUXILIARY CONTACT OF THE BRAKE CONTACTOR OR RELAY TO PREVENT GENERATION OF DRIVING TORQUE IN AN ELEVATOR MOTOR
599
STOP

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 20 17 0826

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	WO 2014/126562 A1 (OTIS ELEVATOR CO [US]) 21 August 2014 (2014-08-21) * paragraph [0009] - paragraph [0017] * * figures 1, 2 *	1,3,11, 12,14,15 2,4-10, 13	INV. B66B1/32 B66B1/30
A	WO 2015/093217 A1 (HITACHI LTD [JP]) 25 June 2015 (2015-06-25) * figures 1-5 *	1-15	
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B66B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	2 October 2020	Szován, Levente

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02-10-2020

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