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(71) Applicant: **Kone Corporation**
00330 Helsinki (FI)

(72) Inventor: **Kattainen, Ari**
05830 Hyvinkää (FI)

(74) Representative: **Papula Oy**
P.O. Box 981
00101 Helsinki (FI)

(54) **A safety controller for a hoisting machine**

(57) The invention relates to a safety apparatus for an elevator. The safety apparatus comprises a message bus, sensor interfaces for elevator related sensors and at least one processor connected to the first message bus. The at least one processor is configured to receive sensor signals from the sensor interface and to determine a safe direction state based on the sensor signal, the safe direction state indicating which directions are safe for moving an elevator car of the elevator, to transmit a downward direction power supply control signal in response to the safe direction state indicating that downward direction is safe, to transmit an upward direction power supply control signal in response to the safe direction state indicating that upward direction is safe. At least one power supply control element is configured to control the state of at least two power supply connections based on the downward direction power supply control signal and the upward direction power supply control signal.

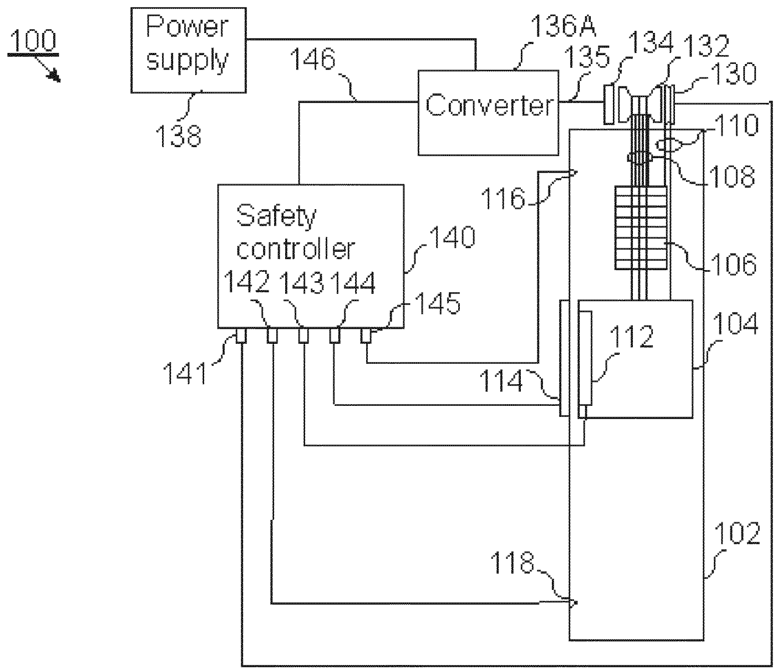

FIG. 1A

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Description

BACKGROUND OF THE INVENTION

Field of the invention:

[0001] The invention relates to hoisting machines, and hoisting machine safety. Particularly, the invention relates to a safety controller for a hoisting machine.

Description of the Related Art:

[0002] Modern elevators are equipped with safety circuits. The safety circuits supervise elevator car and hoistway safety through a plurality of sensors installed in the elevator car and the hoistway. In the elevator car the sensors supervise, for example, elevator doors and a stop button. In the hoistway, the sensors supervise, for example, doors leading to the hoistway in each floor. Sensors also supervise elevator car movement in the hoistway. There may be limit detector sensors which detect when an elevator car has moved beyond a lower or a higher limit set for the normal movement of the elevator car. The limits may be exceeded, for example, in case of elevator car overloading. In the case of brake failure an elevator car may fall downwards with rapid acceleration, if the elevator car has a load, which together with the weight of the elevator car, exceeds the weight of the counterweight. If the load together with the weight of the elevator car is significantly lighter than the counterweight, the elevator car may start rising upwards with rapid acceleration. The balance also depends on the weight of traction ropes and possible compensation ropes. Uncontrolled acceleration of an elevator car is limited by an overspeed governor, which consists of an overspeed governor wheel and at least one governor rope hung over the governor wheel and connected to the elevator car on one end and to the counterweight on the other end. In case the speed of the governor wheel exceeds a predefined threshold speed, the centrifugal force causes a mechanical device to stop the governor wheel rotation which causes a pull of the governor rope thereby engaging elevator car brakes. To provide further safety the stopping of the governor wheel may also cause a braking of the traction sheave or traction means of the elevator car. The overspeed governor may also be equipped with electronic or electrical sensors connected to the safety circuit.

[0003] There are also hydraulic elevators where the elevator car is hoisted using a hydraulic cylinder mounted below the elevator car in the hoistway. The hydraulic elevators may be used in cases where there is not enough room above the highest floor in the hoistway for an elevator engine room wherein a traction sheave and a traction motor are placed. A hydraulic cylinder may also be used to raise a traction sheave connected to an elevator car. The hydraulic elevators differ from traction lift elevators in the sense that the use of the hydraulic cylinder renders it impossible for the elevator car to move above a height in the hoistway. The hydraulic cylinder cannot extend its maximum length. Hydraulic elevators are equipped with pawl devices which prevent the elevator car from falling down in case hydraulic pressure is lost in the hydraulic cylinder. The pawl devices do not prevent the moving of the elevator car upwards. The pawl devices may be installed on every floor.

[0004] The current safety circuits are designed to stop the elevator in error situations involving a fault indication from many different sensors such as the limit detectors or the overspeed governor. Depending on the severity of the fault indicator, for example, from the limit detectors or the overspeed governor it would be possible to recover from the error situation by moving the elevator car to a nearest floor. Therefore, it would be beneficial if there were capabilities in the safety circuit to control the elevator car in special circumstances in a restricted way that does not jeopardize the security further.

SUMMARY OF THE INVENTION:

[0005] According to an aspect of the invention, the invention is a safety apparatus for an elevator, the safety apparatus comprising: a safety controller further comprising a first message bus, at least one sensor interface connected to the first message bus and at least one sensor in the elevator, at least one processor connected to the first message bus, the at least one processor being configured to receive a sensor signal from the at least one sensor interface, to determine a safe direction state based on the sensor signal, the safe direction state indicating which directions are safe for moving an elevator car of the elevator, to transmit a downward direction power supply control signal in response to the safe direction state indicating that downward direction is safe, to transmit an upward direction power supply control signal in response to the safe direction state indicating that upward direction is safe; and at least one power supply control element configured to control the state of at least two power supply connections based on the downward direction power supply control signal and the upward direction power supply control signal.

[0006] According to a further aspect of the invention, the invention is a method comprising: receiving, by a safety controller of an elevator safety apparatus, a sensor signal from at least one sensor interface; determining a safe direction state for the elevator based on the sensor signal, the safe direction state indicating which directions are safe for moving an elevator car of the elevator; transmitting a downward direction power supply control signal in response to the safe direction state indicating that downward direction is safe; transmitting an upward direction power supply control signal in response to the safe direction state indicating that downward direction is safe; and controlling the state of at least two power supply connections based on the downward direction power supply control signal and the upward direction power supply control signal.

[0007] According to a further aspect of the invention, the invention is a computer program comprising code adapted to cause the following when executed on a data-processing system: receiving, by a safety controller of an elevator safety apparatus, a sensor signal from at least one sensor interface; determining a safe direction state for the elevator based on the sensor signal, the safe direction state indicating which directions are safe for moving an elevator car of the elevator; transmitting a downward direction power supply control signal in response to the safe direction state indicating that downward direction is safe; and transmitting an upward direction power supply control signal in response to the safe direction state indicating that downward direction is safe.

[0008] According to a further aspect of the invention, the invention is a computer program product comprising the computer program.

[0009] According to a further aspect of the invention, the invention is a safety apparatus for an elevator. The safety apparatus comprises a safety controller and at least one power supply control element. The safety controller further comprises a first message bus, at least one sensor interface connected to the first message bus and at least one sensor in the elevator, at least one processor connected to the first message bus, the at least one processor being configured to receive a sensor signal from the at least one sensor interface, to determine a safe direction state based on the sensor signal, the safe direction state indicating which directions are safe for moving an elevator car of the elevator, to transmit a downward direction power supply control signal in response to the safe direction state indicating that downward direction is safe, to transmit an upward direction power supply control signal in response to the safe direction state indicating that upward direction is safe. The at least one power supply control element is configured to control the state of at least two power supply connections based on the downward direction power supply control signal and the upward direction power supply control signal.

[0010] In one embodiment of the invention, the safety controller may be communicatively connected to the at least one power supply control element. The safety controller may transmit the upward direction power supply control signal and the downward direction power supply control signal to the at least one power supply control element via the first message bus and at least one power supply control element interface. The safety controller may transmit the upward direction power supply control signal and the downward direction power supply control signal to the at least one power supply control element via at least one power supply control element interface, each power supply control element interface being connected to a respective power supply control element.

[0011] In one embodiment of the invention, the at least one power supply control element may be connected to the safety controller.

[0012] In one embodiment of the invention, a safety controller may be referred to as a computer unit or a computer. The computer unit or the computer may execute an application for elevator safety, which responds to elevator safety related sensor signals.

[0013] In one embodiment of the invention, a safety controller comprises a computer unit or a computer configured to control a number of mechanical switch contacts and relay contacts which may be in series. The at least one sensor may comprise at least one of final limit sensors, an emergency stop button sensor, an overspeed governor based overspeed sensor, an elevator car door open and closed position sensor. A signal from any of these sensors may constitute a possible hazardous operation of the elevator. The sensors may send signals to the application for elevator safety.

[0014] In one embodiment of the invention, the at least one sensor interface is installed in the elevator hoistway and the at least one processor are comprised in the elevator car.

[0015] In one embodiment of the invention, the safe direction state is stored in a memory of the elevator safety controller.

[0016] In one embodiment of the invention, the downward direction power supply signal is a power supply enabling signal used to determine whether power may be supplied for moving the elevator car in downward direction. The presence of the signal indicates that power may be supplied.

[0017] In one embodiment of the invention, the upward direction power supply signal is a power supply enabling signal used to determine whether power may be supplied for moving the elevator car in upward direction. The presence of the signal indicates that power may be supplied.

[0018] In one embodiment of the invention, one of the at least two power supply connection is for power supply to a valve controlling flow of hydraulic fluid from a hydraulic cylinder supporting the elevator car.

[0019] In one embodiment of the invention, the at least one power supply control element comprises a downward direction contactor and the downward direction power supply control signal is a direct current voltage transmitted to a control circuit of the downward direction contactor.

[0020] In one embodiment of the invention, one of the at least two power supply connections is for power supply to a pump for pumping hydraulic fluid to a hydraulic cylinder supporting the elevator car.

[0021] In one embodiment of the invention, the at least one power supply control element comprises an upward direction contactor and the upward direction power supply control signal is a direct current voltage transmitted to a contactor control circuit of the upward direction contactor.

[0022] In one embodiment of the invention, the at least one power supply control element comprises an electrical power converter and the apparatus comprises a second message bus connected to the electrical power converter and the safety controller, the electrical power converter further comprising a controller.

[0023] In one embodiment of the invention, the downward direction power supply control signal and the upward direction power supply control signal are transmitted over the second message bus to the controller of the electrical power converter.

[0024] In one embodiment of the invention, the electrical power converter further comprises a converter matrix and the controller of the electrical power converter is configured to control connections in the converter matrix based on the downward direction power supply control signal and the upward direction power supply control signal.

[0025] In one embodiment of the invention, the electrical power converter further comprises an inverter and a rectifier supplying power to the inverter and the controller of the electrical power converter is configured to control inverter output based on the downward direction power supply control signal and the upward direction power supply control signal.

[0026] In one embodiment of the invention, the electrical power converter supplies three phase alternating current to an electrical motor rotating a traction sheave of the elevator.

[0027] In one embodiment of the invention, the electrical power converter supplies electrical current to a valve controlling flow of hydraulic fluid from hydraulic cylinder.

[0028] In one embodiment of the invention, the electrical power converter supplies electrical current to a pump for pumping hydraulic fluid to a hydraulic cylinder supporting the elevator car.

[0029] In one embodiment of the invention, the at least one sensor in the elevator comprise a limit sensor for detecting a vertical limit for the movement of the elevator car. There may be an upper limit which corresponds to the highest point where the roof of the elevator car may be hoisted when the elevator car is hoisted or moved. There may be a lower limit which corresponds to the lowest point where the floor of the elevator car may be lowered when the elevator car is lowered or moved. A limit sensor for detecting a vertical limit for the movement of the elevator car may be located in the elevator car or in the elevator hoistway. In response to a movement of the elevator car beyond a vertical limit, a limit sensor for the vertical limit may indicate the sensor signal to the safety controller. The safety controller may be configured to determine a safe direction state for the elevator based on the sensor signal, the safe direction state indicating that a direction opposite to the exceeded limit is safe for moving an elevator car of the elevator.

[0030] In one embodiment of the invention, the at least one sensor in the elevator comprise an overspeed detection sensor configured to transmit a signal in response to an overspeed governor indicating overspeed.

[0031] In one embodiment of the invention, the at least one sensor in the elevator comprise a sensor configured to detect a retracted or extended position of a pawl device. In response to the sensor indicating to the safety controller that the pawl is extended, the safety controller may be configured to determine that upward direction is safe.

[0032] In one embodiment of the invention, the at least one sensor in the elevator comprise a door sensor configured to determine whether a floor landing door is closed. In response to the door sensor sending a signal to the safety controller indicating that the door is open, the safety controller may be configured to determine a safe direction state for the elevator based on the sensor signal. The safe direction state may be determined so that moving the elevator car further away from the open door is safe.

[0033] In one embodiment of the invention, the elevator car may also be referred to as elevator cage. The elevator car may be elevator cage.

[0034] In one embodiment of the invention, the computer program is stored on a non-transitory computer readable medium. The non-transitory computer readable medium may be, but is not limited to, a removable memory card, a removable memory module, a magnetic disk, an optical disk, a holographic memory or a magnetic tape. A removable memory module may be, for example, a USB memory stick, a PCMCIA card or a smart memory card.

[0035] In one embodiment of the invention, an apparatus comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform a method according to any of the method steps.

[0036] The embodiments of the invention described hereinbefore may be used in any combination with each other. At least two of the embodiments may be combined together to form a further embodiment of the invention. A method, a safety apparatus, a computer program or a computer program product to which the invention is related may comprise at least one of the embodiments of the invention described hereinbefore.

[0037] It is to be understood that any of the above embodiments or modifications can be applied singly or in combination to the respective aspects to which they refer, unless they are explicitly stated as excluding alternatives.

[0038] The benefits of the invention are related to increased safety of elevators and possibility of controlling the elevator better in fault situations, for example, by moving the elevator car to a floor so that passengers may exit the elevator car.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0039] The accompanying drawings, which are included to provide a further understanding of the invention and constitute a part of this specification, illustrate embodiments of the invention and together with the description help to explain the principles of the invention. In the drawings:

Fig. 1A illustrates a traction elevator system comprising a hoistway, an elevator car, traction means and a safety controller in one embodiment of the invention;

Fig. 1B illustrates a hydraulic elevator system comprising a hoistway, an elevator car, a hydraulic cylinder and a safety controller in one embodiment of the invention;

Fig. 2A illustrates an elevator safety controller controlling a matrix converter using safe direction signals via a message bus in one embodiment of the invention;

Fig. 2B illustrates an elevator safety controller controlling a converter comprising a rectifier and an inverter using safe direction signals via a message bus in one embodiment of the invention;

Fig. 3 illustrates an elevator safety controller controlling power supply to elevator hoisting and lowering apparatus with separate direction specific contactors; and

Fig. 4 illustrates a method for safe elevator direction control in one embodiment of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS:

[0040] Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

[0041] Figure 1A illustrates a traction elevator system 100 comprising a hoistway, an elevator car, traction means and a safety controller in one embodiment of the invention.

[0042] In Figure 1A there is illustrated a traction elevator system 100. Elevator system 100 comprises a hoistway 102 in which an elevator car 104 is moved. In hoistway 102 there is also a counterweight 106 and traction means 108 looped over traction sheave 132 and connected to elevator car 104 on one end and to counterweight 106 on the other end. Traction means 108 may comprise a plurality of traction ropes or a traction belt. To elevator car 104 on one end and to counterweight 106 on the other end may also be connected at least one governor rope 110. The at least one governor rope 110 may be looped over an overspeed governor wheel 130. There may also be another governor wheel (not shown) at the bottom of hoistway 102 under which another governor rope also connected to elevator car 104 and counterweight 106 is looped. Traction sheave 132 is rotated by an electrical motor 134 to which power is fed by a converter 136A via a power supply cable 135. Converter 136A may supply, for example, a tree-phase electrical current to electrical motor 134. Electrical current may be supplied to converter 136A from a further power supply 138, for example, an electrical grid. Converter 136A is controlled in Figure 1A by a safety controller 140 via a controlling connection 146. Safety controller 140 comprises interfaces 141 - 145 for receiving signals from a plurality of sensors. The number of interfaces in Figure 1A is just for illustrative purposes and may vary from embodiment to embodiment. Interface 141 may be connected to a sensor (not shown) associated with overspeed governor wheel 130. The sensor may be used to detect overspeed of overspeed governor wheel 130. Interface 142 may be connected to a lower limit sensor 118, which detects if elevator car 104 is lowered below a lower limit in hoistway 102. The lower limit may be supervised so that a floor of elevator car 104 must not be moved below the lower limit. Interface 145 may be connected to an upper limit sensor 116, which detects if elevator car 104 is hoisted above an upper limit. The upper limit may be supervised so that a roof of elevator car 104 must not be moved above the upper limit in hoistway 102. Interface 144 may be connected to a floor door 114 leading to elevator car 104 when elevator car 104 is in that floor. Interface 143 may be connected to an elevator car door 112 within elevator car 104.

[0043] Safety controller 140 may maintain information on a safe direction state in a memory (not shown). The possible safe direction state values comprise "both directions safe", "upwards safe" and "downward safe". In normal conditions the safe direction state indicates that both directions are safe. Based on the safe direction state, safety controller 140 may provide regularly a safe direction signal to converter 136A via controlling connection 146. In response to a signal from at least one of interfaces 141 - 145 the safe direction state of safety controller 140 may be changed from the state "both directions safe" to either "upwards safe" or "downwards safe". For example, if upper limit sensor 116 transmits a signal that elevator car 104 has moved beyond the upper limit, the safe direction state of safety controller 140 may be changed to "downwards safe". Similarly, if lower limit sensor 118 transmits a signal that elevator car 104 has moved beyond the lower limit, the safe direction state of safety controller 140 may be changed to "upward safe". Further, if overspeed governor wheel 130 associated sensor transmits a signal that elevator car 104 has exceeded a speed limit in downwards direction, safe direction state of safety controller 140 may be changed to "downwards safe", which may enable that elevator car 104 is lowered with a lower speed to nearest floor in the downwards direction. Depending on the safe direction signal to converter 136A, converter 136A supplies electrical power to electrical motor 134 for rotating traction sheave 132 only in directions that correspond to the safe direction state of safety controller 140.

[0044] Figure 1B illustrates a hydraulic elevator system 150 comprising hoistway 102, elevator car 104, a hydraulic cylinder 126 and safety controller 140 in one embodiment of the invention. In Figure 1B elevator car 104 is hoisted by hydraulic cylinder 126 in hoistway 102. Hydraulic fluid is pumped to hydraulic cylinder 126 by means of a pump 125 to raise elevator car 104. Hydraulic fluid is allowed to exit via a valve 124 to a reservoir 126 of hydraulic fluid so that elevator car 104 is lowered. The dropping of elevator car 104 in case of loss of hydraulic pressure in hydraulic cylinder 126 is prevented with at least pawl devices 120 and 122. Pawl device 120 engages a first support 121 in hoistway 102, whereas pawl device 122 engages a second support 123 in hoistway 102. In Figure 1B interface 145 of safety controller 140 is connected to a sensor (not shown) in pawl device 120, whereas interface 142 of safety controller 140 is connected to a sensor (not shown) in pawl device 122.

[0045] In a manner similar to Figure 1A, safety controller 140 may maintain information on a safe direction state in a memory (not shown). The possible safe direction state values comprise "both directions safe", "upwards safe" and "downward safe". In normal conditions the safe direction state indicates that both directions are safe. Based on the safe direction state, safety controller 140 may provide regularly a safe direction signal to converter 136A via controlling connection 146. In response to a signal from at least one of interfaces 142 - 145 a safe direction state of safety controller 140 may be changed from "both directions safe" state to either the "upwards safe" state or the "downwards safe" state. If the safe direction state of safety controller 140 is "both directions safe", safety controller 140 transmits a signal to converter 136B via controlling connection 146 which allows converter 136B to supply electrical power to pump 125 via electrical power cable 135A and to valve 124 via electrical power cable 135B. If the safe direction state of safety controller 140 is "downwards safe", safety controller 140 transmits a signal to converter 136B via controlling connection 146 which allows converter 136B to supply electrical power to valve 124 via electrical power cable 135B, but does not allow converter 136B to supply electrical power to pump 125. Similarly, if the safe direction state of safety controller 140 is "upwards safe", safety controller 140 transmits a signal to converter 136B to supply electrical power to pump 125, but does not allow converter 136B to supply electrical power to valve 124. Sensors associated with pawl devices 120 and 122 may transmit signals to respective interfaces 145 and 142 regarding the current states of pawl devices 120 and 122. If at least one of pawl devices 120 and 122 is in the extended position not allowing elevator car 104 to be lowered by hydraulic cylinder 126, the safe direction state of safety controller 140 is set to "upward safe". If pawl devices 120 and 122 are in the retracted position, sensors associated pawl devices 120 and 122 transmit signals regarding the retracted state to safety controller 140 via respective interfaces 145 and 142. This causes the setting of safe direction state of safety controller 140 to "both directions safe", which enables elevator car 104 to be hoisted or lowered.

[0046] Figure 2A illustrates an elevator safety controller controlling a matrix converter using safe direction signals via a message bus in one embodiment of the invention.

[0047] In Figure 2A there is an elevator safety apparatus 200. Apparatus 200 comprises a safety controller 210. The safety controller may 210 comprise a memory 226, a first processor 224 and a second processor 222. Memory 226, first processor 224 and second processor 222 may be comprised in a chipset 220. First processor 224 and second processor 222 provide redundancy, for example, so that second processor 222 acts as a hot standby processor for first processor 224. Memory 226, first processor 224 and second processor 222 may be communicatively connected to an input-output controller 230, for example, via chipset 220. Input-output controller comprises interfaces 232, 233 and 234. Interfaces 232, 233 and 234 may be connected to a number of electrical or electronic sensors associated with an elevator hoistway and an elevator car (not shown), for example, such as illustrated in Figures 1A and 1B. Memory 228 stores a safe direction state variable 228. Safe direction state variable may have values comprising "both directions safe", "upwards safe" and "downwards safe". Safety controller 210 is connected to a converter 240 via a first message bus 236 and a second message bus 238. First message bus 236 and second message bus 238 provide redundancy and fault tolerance for the case of message bus failure. Converter 240 comprises a controller 242 and a matrix 244. Controller 242 comprises a first processor 248 and a second processor 246. First processor 224 and second processor 222 within safety controller 210 are configured to transmit a signal comprising a current value of safe direction state variable 228 on first message bus 236 and on second message bus 238. The signal is transmitted to controller 242. Based on the signal controller 242 is configured to control connections in matrix 244. Matrix 244 switches incoming power supply lines of three phases U1, V1 and W1 to outgoing power supply lines of three phases U2, V2 and W2. Outgoing power supply lines are connected to electrical motor 202, which may be, for example, an induction motor. Based on the signal controller 242 ensures that no connections are made in matrix 244 that contradict the safe directions indicated by the signal.

[0048] Figure 2B illustrates an elevator safety apparatus 250. Elevator safety apparatus 250 comprises safety controller 210 controlling a converter 240 comprising a rectifier 254 and an inverter 252 using safe direction signals via a message bus in one embodiment of the invention. In Figure 2B controller 242 controls inverter 252 to which Direct Current (DC) power supply from an Alternating Current (AC) rectifier 254 is connected. To rectifier 254 are connected three-phase lines U1, V1 and W1 of AC power supply. Inverter 252 is controlled based on the signal comprising the current value of the safe direction state variable 228. Based on the signal controller 242 ensures that outgoing three phase lines U2, V2 and W2 are not supplied power by inverter 252 in a manner which contradicts the safe directions indicated by the signal.

[0049] The embodiments of the invention described hereinbefore in association with Figures 1A, 1B, 2A and 2B may be used in any combination with each other. Several of the embodiments may be combined together to form a further embodiment of the invention.

[0050] Figure 3 illustrates an elevator safety apparatus 300. Elevator safety apparatus 300 comprises safety controller 210. The difference in Figure 3 is that safety controller 210 comprises a first contactor 312 and a second contactor 322. First contactor 312 comprises a first control circuit 310. Second contactor 322 comprises a second control circuit 320. First contactor 312 and second contactor 322 are switched using circuit control signals from safety controller 210. The circuit control signals to control circuits 310 and 320 are determined in safety controller 210 based on a current state of safe direction state variable 228. A switched on state of contactor 312 may correspond to "upwards safe" state of safe direction state variable 228, whereas a switched on state of contactor 322 may correspond to "downwards safe" state of safe direction state variable 228. Contactors 312 and 322 may be normally open type of contactors. Thus, "upwards safe" or "both directions safe" state of safe direction state variable 228 may be indicated by supplying from control circuit 210 a DC voltage signal to control circuit 310 which causes contactor 312 to close. Similarly, "downwards safe" or "both directions safe" state of safe direction state variable 228 may be indicated by supplying from control circuit 210 a DC voltage signal to control circuit 320 which causes contactor 322 to close. Contactor 312 may be used to supply electrical power for a hydraulic cylinder pump or an electrical motor coupled with a traction sheave. An electrical motor converter may be used to ensure that power supply via contactor 312 allows only rotating electrical motor in a direction corresponding to upward movement of an elevator car. Contactor 322 may be used to supply electrical power for a hydraulic cylinder valve or the electrical motor coupled with the traction sheave. The electrical motor converter may be used to ensure that power supply via contactor 322 allows only rotating electrical motor in a direction corresponding to downward movement of an elevator car.

[0051] Figure 4 is a flow chart illustrating a method for safe elevator direction control in one embodiment of the invention.

[0052] At step 400 a sensor signal is received from a sensor in the elevator. The sensor signal may be received from a sensor in a hoistway of the elevator or a sensor in the elevator car.

[0053] At step 402 a safe direction state is determined based on the sensor signal.

[0054] In one embodiment of the invention, the safe direction state is stored in a memory of an elevator safety controller.

[0055] At step 404 a downward direction power supply signal is transmitted in response to the safe direction state indicating that downward direction is safe.

[0056] In one embodiment of the invention, the downward direction power supply signal is a power supply enabling signal used to determine whether power may be supplied for moving the elevator car in downward direction. The presence of the signal indicates that power may be supplied.

[0057] At step 406 an upward direction power supply signal is transmitted in response to the safe direction state indicating that upward direction is safe.

[0058] In one embodiment of the invention, the upward direction power supply signal is a power supply enabling signal used to determine whether power may be supplied for moving the elevator car in upward direction. The presence of the signal indicates that power may be supplied.

[0059] At step 408 the state of at least two power supply connections is controlled based on the downward direction power supply control signal and the upward direction power supply control signal.

[0060] In one embodiment of the invention, the steps may be performed in the order of numbering.

[0061] It is to be understood that the exemplary embodiments are for exemplary purposes, as many variations of the specific hardware used to implement the exemplary embodiments are possible, as will be appreciated by those skilled in the hardware art(s). For example, the functionality of one or more of the components of the exemplary embodiments can be implemented via one or more hardware devices, or one or more software entities such as modules.

[0062] The exemplary embodiments can store information relating to various processes described herein. This information can be stored in one or more memories, such as a hard disk, optical disk, magneto-optical disk, RAM, and the like. One or more databases can store the information regarding cyclic prefixes used and the delay spreads measured. The databases can be organized using data structures (e.g., records, tables, arrays, fields, graphs, trees, lists, and the like) included in one or more memories or storage devices listed herein. The processes described with respect to the exemplary embodiments can include appropriate data structures for storing data collected and/or generated by the processes of the devices and subsystems of the exemplary embodiments in one or more databases.

[0063] All or a portion of the exemplary embodiments can be implemented by the preparation of one or more application-specific integrated circuits or by interconnecting an appropriate network of conventional component circuits, as will be appreciated by those skilled in the electrical art(s).

[0064] As stated above, the components of the exemplary embodiments can include computer readable medium or memories according to the teachings of the present inventions and for holding data structures, tables, records, and/or other data described herein. Computer readable medium can include any suitable medium that participates in providing instructions to a processor for execution. Such a medium can take many forms, including but not limited to, non-volatile media, volatile media, transmission media, and the like. Non-volatile media can include, for example, optical or magnetic disks, magneto-optical disks, and the like. Volatile media can include dynamic memories, and the like. Transmission media can include coaxial cables, copper wire, fiber optics, and the like. Transmission media also can take the form of acoustic, optical, electromagnetic waves, and the like, such as those generated during radio frequency (RF) communications, infrared (IR) data communications, and the like. Common forms of computer-readable media can include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other suitable magnetic medium, a CD-ROM, CDRW, DVD, any other suitable optical medium, punch cards, paper tape, optical mark sheets, any other suitable physical medium with patterns of holes or other optically recognizable indicia, a RAM, a PROM, an EPROM, a FLASH-EPROM, any other suitable memory chip or cartridge, a carrier wave or any other suitable medium from which a computer can read.

[0065] While the present inventions have been described in connection with a number of exemplary embodiments, and implementations, the present inventions are not so limited, but rather cover various modifications, and equivalent arrangements, which fall within the purview of prospective claims.

[0066] The embodiments of the invention described hereinbefore in association with the figures presented and the summary of the invention may be used in any combination with each other. At least two of the embodiments may be combined together to form a further embodiment of the invention.

[0067] A method, a safety apparatus, a computer program or a computer program product to which the invention is related may comprise at least one of the embodiments of the invention described hereinbefore.

[0068] It is obvious to a person skilled in the art that with the advancement of technology, the basic idea of the invention may be implemented in various ways. The invention and its embodiments are thus not limited to the examples described above; instead they may vary within the scope of the claims.

Claims

1. A safety apparatus for an elevator, the safety apparatus comprising:

   a safety controller further comprising
   a first message bus,
   at least one sensor interface connected to the first message bus and at least one sensor in the elevator,
   at least one processor connected to the first message bus, the at least one processor being configured to receive a sensor signal from the at least one sensor interface, to determine a safe direction state based on the sensor signal, the safe direction state indicating which directions are safe for moving an elevator car of the elevator, to transmit a downward direction power supply control signal in response to the safe direction state indicating that downward direction is safe, to transmit an upward direction power supply control signal in response to the safe direction state indicating that upward direction is safe; and
   at least one power supply control element configured to control the state of at least two power supply connections based on the downward direction power supply control signal and the upward direction power supply control signal.

2. The safety apparatus according to claim 1, wherein one of the at least two power supply connections is for power supply to a valve controlling flow of hydraulic fluid from a hydraulic cylinder supporting the elevator car.

3. The safety apparatus according to claim 2, wherein the at least one power supply control element comprises a downward direction contactor and the downward direction power supply control signal is a direct current voltage transmitted to a control circuit of the downward direction contactor.

4. The safety apparatus according to claim 1 or 2, wherein one of the at least two power supply connections is for power supply to a pump for pumping hydraulic fluid to a hydraulic cylinder supporting the elevator car.

5. The safety apparatus according to claim 4, wherein the at least one power supply control element comprises an upward direction contactor and the upward direction power supply control signal is a direct current voltage transmitted to a contactor control circuit of the upward direction contactor.

6. The safety apparatus according to claim 1, wherein the at least one power supply control element comprises an electrical power converter and the apparatus comprises a second message bus connected to the electrical power converter and the safety controller, the electrical power converter further comprising a controller.

7. The safety apparatus according to claim 6, wherein the downward direction power supply control signal and the upward direction power supply control signal are transmitted over the second message bus to the controller of the electrical power converter.

8. The safety apparatus according to claim 6, wherein the electrical power converter further comprises a converter matrix and the controller of the electrical power converter is configured to control connections in the converter matrix based on the downward direction power supply control signal and the upward direction power supply control signal.

9. The safety apparatus according to claim 6, wherein the electrical power converter further comprises an inverter and a rectifier supplying power to the inverter and the controller of the electrical power converter is configured to control inverter output based on the downward direction power supply control signal and the upward direction power supply control signal.

10. The safety apparatus according to claim 6, wherein the electrical power converter supplies three phase alternating current to an electrical motor rotating a traction sheave of the elevator.

11. The safety apparatus according to claim 6, wherein the electrical power converter supplies electrical current to a valve controlling flow of hydraulic fluid from hydraulic cylinder.

12. The safety apparatus according to claim 6, wherein the electrical power converter supplies electrical current to a pump for pumping hydraulic fluid to a hydraulic cylinder supporting the elevator car.

13. The safety apparatus according to any of the claims 1 - 12, wherein the at least one sensor comprises a limit sensor for detecting a vertical limit for the movement of the elevator car.

14. The safety apparatus according to any of the claims 1 - 13, wherein the at least one sensor comprises an overspeed detection sensor configured to transmit a signal in response to an overspeed governor indicating overspeed of the elevator car.

15. The safety apparatus according to any of the claims 1 - 14, wherein the at least one sensor comprises a sensor configured to detect a retracted or extended position of a pawl device.

16. The safety apparatus according to any of the claim 1 - 15, wherein the at least one sensor comprise a door sensor configured to determine whether a landing door of the elevator is closed.

17. A method, comprising:

receiving, by a safety controller of an elevator safety apparatus, a sensor signal from at least one sensor interface;
determining a safe direction state for the elevator based on the sensor signal, the safe direction state indicating which directions are safe for moving an elevator car of the elevator;
transmitting a downward direction power supply control signal in response to the safe direction state indicating that downward direction is safe;
transmitting an upward direction power supply control signal in response to the safe direction state indicating that downward direction is safe; and
controlling the state of at least two power supply connections based on the downward direction power supply control signal and the upward direction power supply control signal.

18. A computer program comprising code adapted to cause the following when executed on a data-processing system:

receiving, by a safety controller of an elevator safety apparatus, a sensor signal from at least one sensor interface;
determining a safe direction state for the elevator based on the sensor signal, the safe direction state indicating which directions are safe for moving an elevator car of the elevator;
transmitting a downward direction power supply control signal in response to the safe direction state indicating that downward direction is safe; and
transmitting an upward direction power supply control signal in response to the safe direction state indicating that downward direction is safe.

19. The computer program according to claim 18, wherein said computer program is stored on a non-transitory computer readable medium.

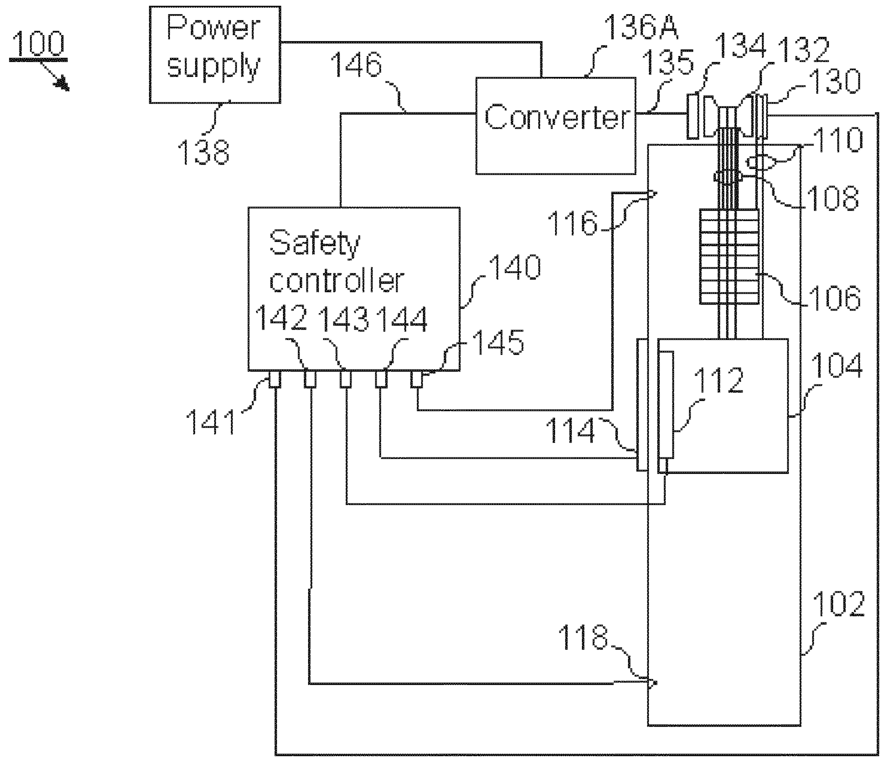
100
Power supply
138
146
136A
Converter
135
134
132
130
110
108
116
Safety controller
140
142 143 144
145
106
104
112
141
114
102
118

FIG. 1A

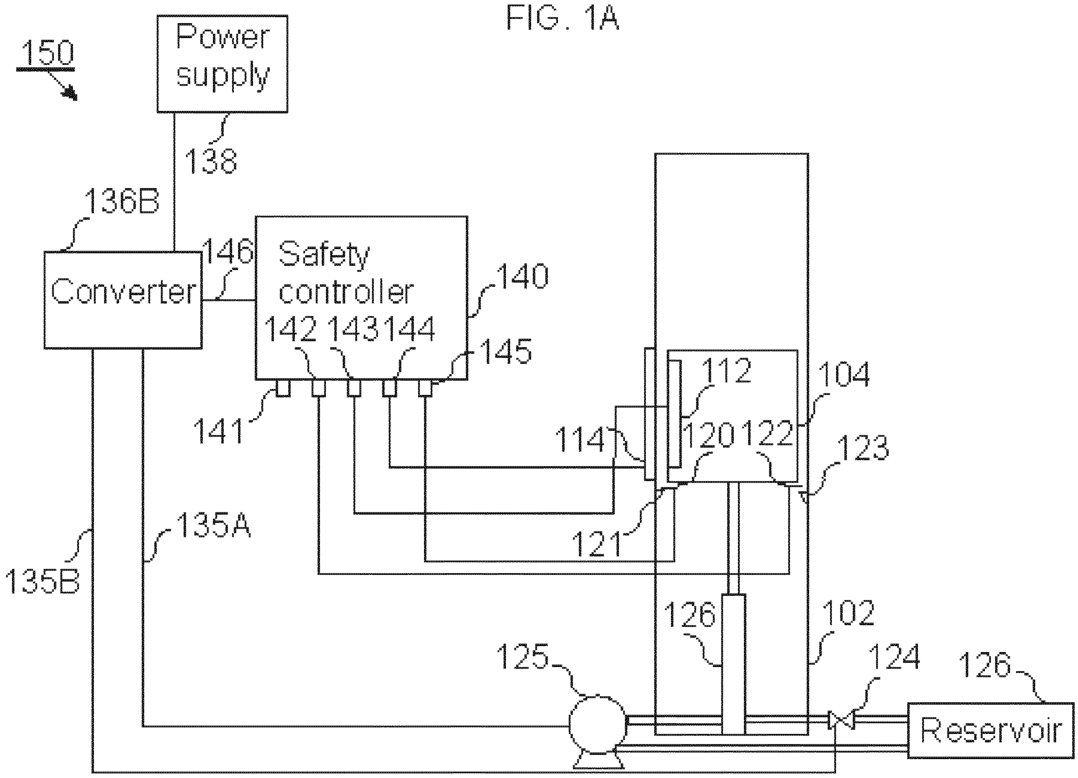
150
Power supply
138
136B
Converter
146
Safety controller
140
142 143 144
145
141
112
104
114
120 122
123
121
135A
135B
126
102
125
124
126
Reservoir

FIG. 1B

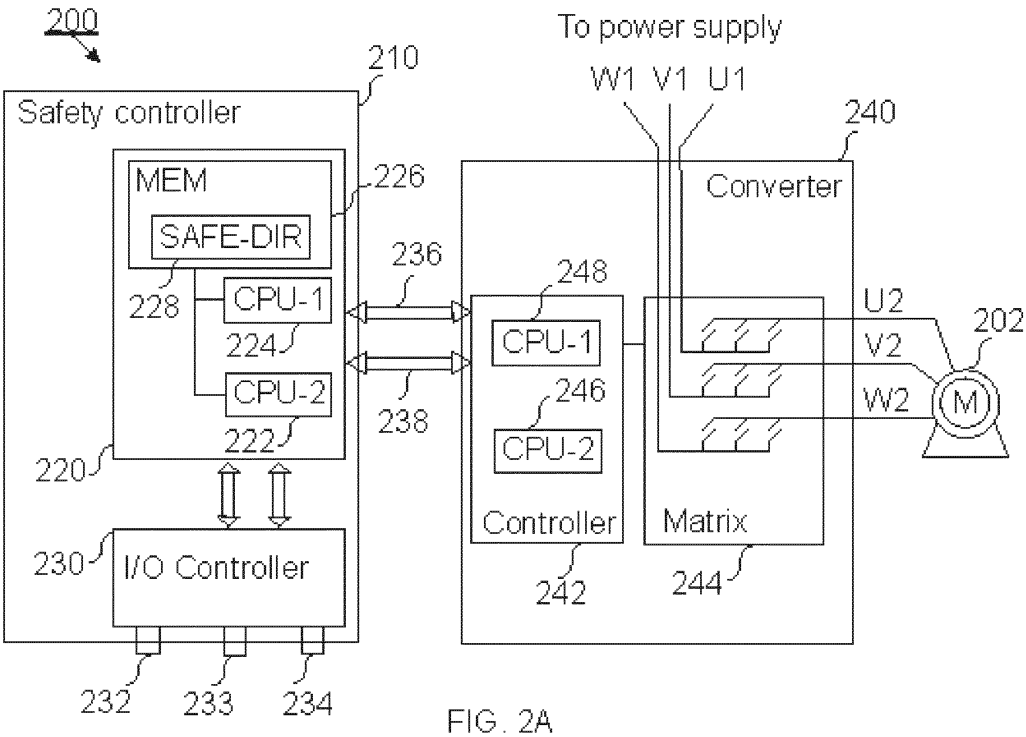
200
To power supply
W1 V1 U1
210
240
Safety controller
MEM
SAFE-DIR
226
Converter
236
248
228
CPU-1
U2
202
CPU-1
224
V2
246
238
CPU-2
W2
M
CPU-2
222
220
Controller
Matrix
230
I/O Controller
242
244
232
233
234

FIG. 2A

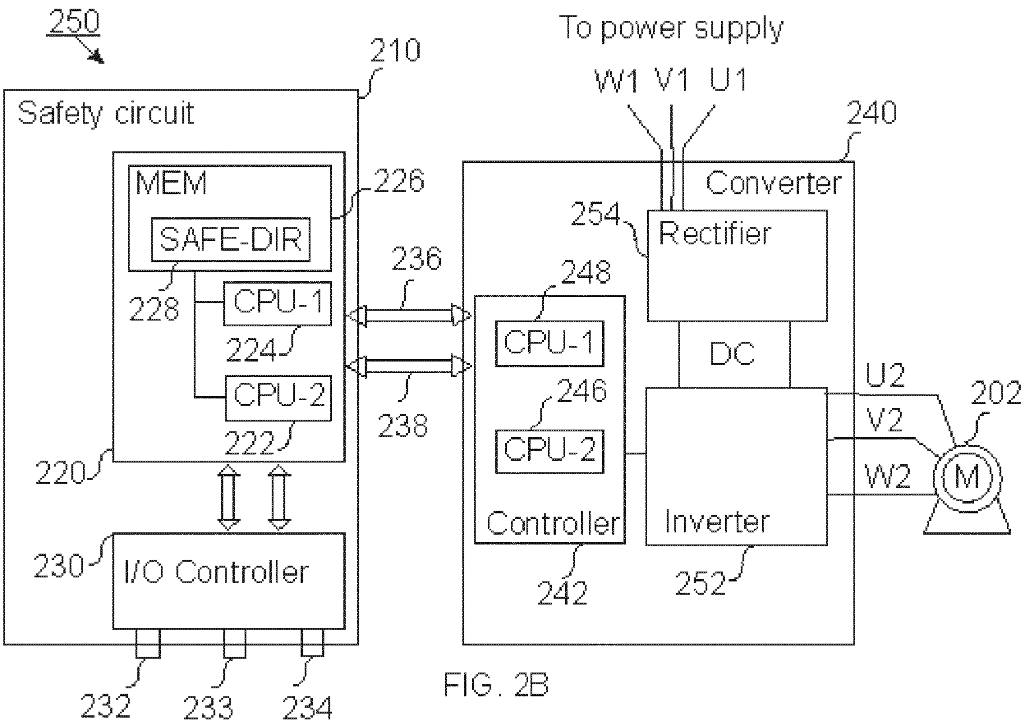
250
To power supply
210
W1 V1 U1
240
Safety circuit
MEM
226
Converter
254
Rectifier
SAFE-DIR
236
248
228
CPU-1
CPU-1
224
DC
U2
CPU-2
246
202
V2
222
238
CPU-2
220
W2
M
Controller
Inverter
230
I/O Controller
242
252
232
233
234

FIG. 2B

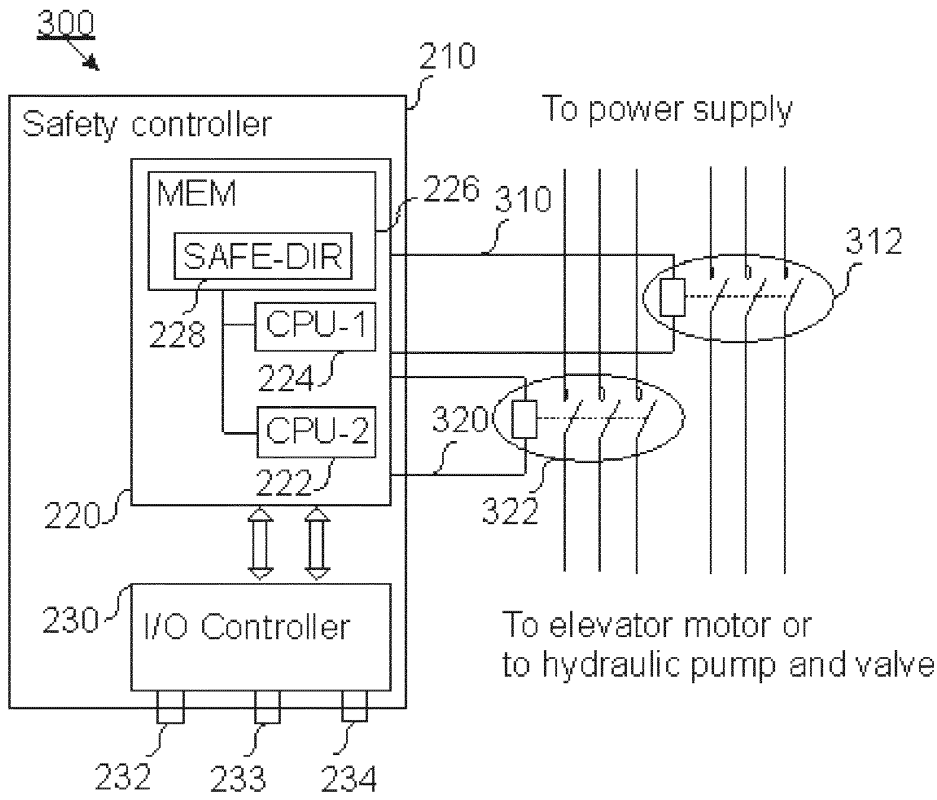
300
210
Safety controller
To power supply
MEM
226
310
312
SAFE-DIR
228
CPU-1
224
320
CPU-2
222
322
220
230
I/O Controller
To elevator motor or
to hydraulic pump and valve
232
233
234

FIG. 3

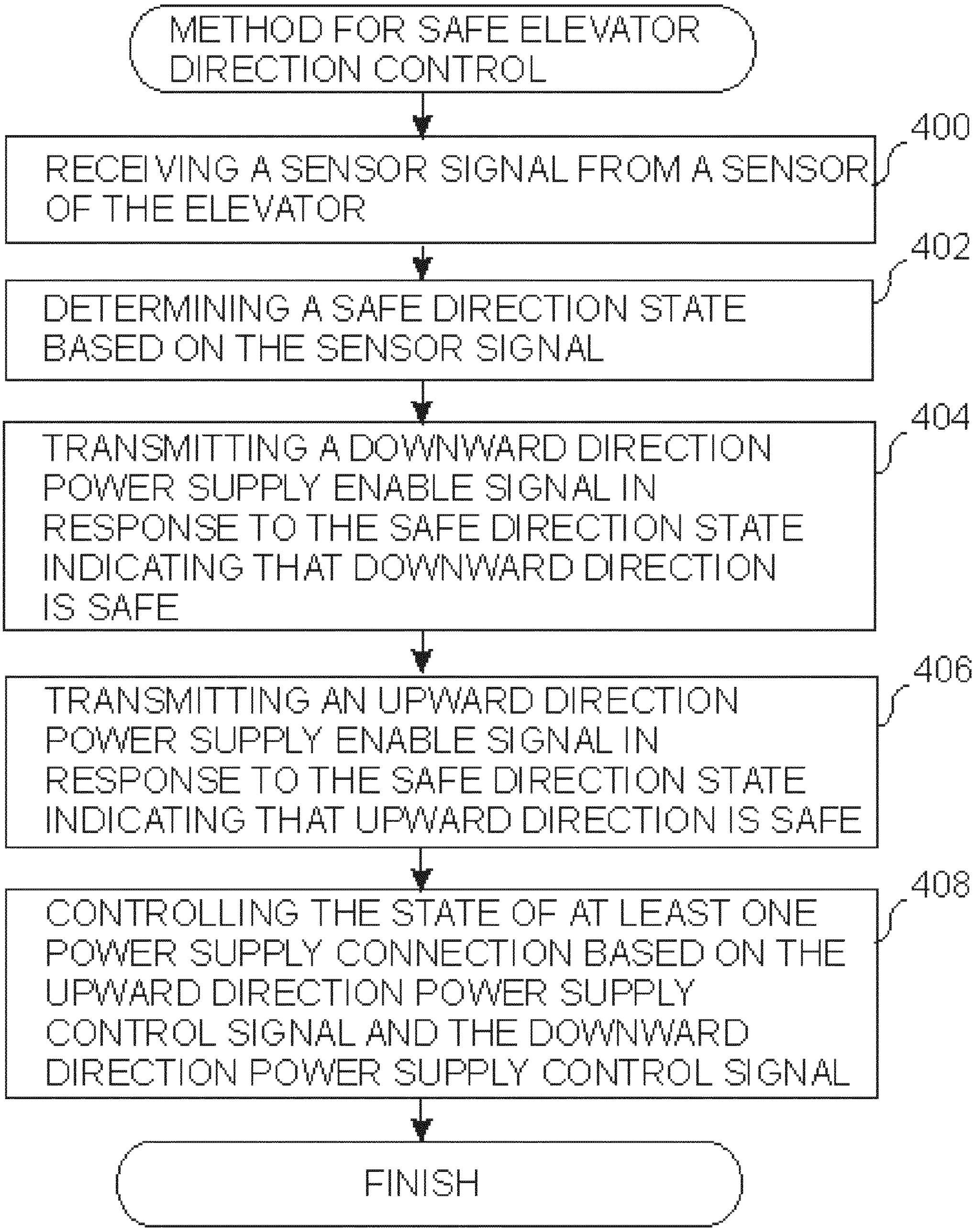
METHOD FOR SAFE ELEVATOR DIRECTION CONTROL
400
RECEIVING A SENSOR SIGNAL FROM A SENSOR OF THE ELEVATOR
402
DETERMINING A SAFE DIRECTION STATE BASED ON THE SENSOR SIGNAL
404
TRANSMITTING A DOWNWARD DIRECTION POWER SUPPLY ENABLE SIGNAL IN RESPONSE TO THE SAFE DIRECTION STATE INDICATING THAT DOWNWARD DIRECTION IS SAFE
406
TRANSMITTING AN UPWARD DIRECTION POWER SUPPLY ENABLE SIGNAL IN RESPONSE TO THE SAFE DIRECTION STATE INDICATING THAT UPWARD DIRECTION IS SAFE
408
CONTROLLING THE STATE OF AT LEAST ONE POWER SUPPLY CONNECTION BASED ON THE UPWARD DIRECTION POWER SUPPLY CONTROL SIGNAL AND THE DOWNWARD DIRECTION POWER SUPPLY CONTROL SIGNAL
FINISH

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 2026

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 Y	US 2009/255762 A1 (KETONEN ARI [FI] ET AL) 15 October 2009 (2009-10-15) * abstract * * paragraphs [0014] - [0039], [0114] - [0122] * * figure 1 *	1,6-10, 13-18 2-7,11, 12,19	INV. B66B5/00
X Y	US 3 815 710 A (SHRUM W) 11 June 1974 (1974-06-11) * abstract * * column 2, line 29 - column 6, line 2 * * figure 1 *	1,17,18 2-5,19	
X Y	US 4 785 915 A (SHAH DENIS D [US] ET AL) 22 November 1988 (1988-11-22) * abstract * * column 3, line 60 - column 6, line 57 * * figures 1, 2 *	1-5,17, 18 6,7,11, 12,19	
Y	US 3 570 243 A (COMER DONALD T ET AL) 16 March 1971 (1971-03-16) * column 3, lines 5-28 * * figure 1 *	2-5	TECHNICAL FIELDS SEARCHED (IPC) B66B
Y	US 2011/181212 A1 (KANGAS JANI [FI] ET AL) 28 July 2011 (2011-07-28) * paragraph [0019] *	19	
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Y	EP 2 022 742 A1 (THYSSENKRUPP ELEVATOR AG [DE]) 11 February 2009 (2009-02-11) * abstract * * paragraphs [0023], [0024], [0051] - [0053] * * figures 2-4 *	6,7	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 March 2014	Oosterom, Marcel

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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
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Application Number
EP 13 17 2026

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

- [ ] Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

- [ ] No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- [X] All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

- [ ] As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

- [ ] Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

- [ ] None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

- [ ] The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 13 17 2026

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-5, 17-19

   Hydraulic elevator drive.

   ---

2. claims: 1, 6-16

   Safety apparatus for an elevator.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 17 2026

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-03-2014

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EP 2022742 A1	11-02-2009	CN 101687606 A	31-03-2010
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		WO 2009018886 A1	12-02-2009

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