

DEVICE FOR CHECKING A SAFETY CHAIN OF AN ELEVATOR

DESCRIPTION

An elevator apparatus with a safety circuit is known from specification EP 1 090 870 A1, wherein the safety circuit comprises a series circuit of contacts, a safety relay, a voltage converter and a monitor, the signal from the safety relay being communicated to an elevator control. A voltage to be regulated across the safety relay is applied to a network of the elevator apparatus that is connected with the voltage converter. The voltage converter, the series circuit and the network form a regulating system that checks the voltage across the safety relay and holds it constant when all contacts of the series circuit are closed. When doing so, the safety circuit acts independently of an output voltage of a voltage source that is subject to voltage fluctuations.

The object of the invention is particularly to provide a device by means of which a reliable functioning of a hardware component, in particular of the safety circuit of an elevator, is realisable with little outlay.

According to the invention the object is fulfilled by a testing device with the features of patent claim 1, by an elevator device with the features of claim 9 and by a hardware monitoring method with the features of claim 14. Further refinements and developments of the invention can be inferred from the subclaims.

A testing device is proposed that serves the purpose of monitoring an elevator apparatus, or a component of an elevator, in particular a composite resistor of an elevator apparatus. This testing device comprises at least one hardware monitoring unit which is provided for the purpose of monitoring at least one functionally relevant composite resistor. "Hardware" shall be particularly understood as at least one material component, for example a sensor. "Hardware monitoring unit" is particularly to be understood as a unit that in at least one operating mode performs a checking and/or analysis of at least one characteristic of at least one component and/or a sensing of at least one physical parameter and/or, particularly preferably, has a processing unit, a memory unit, and contained in the memory unit an operating program for a monitoring. "Provided" shall be particularly understood as specially equipped and/or designed and/or programmed. A resistor shall be understood to be a material element that presents to an electric current flowing through this element a resistance which is hereinafter referred to a resistance value. A "functionally relevant resistor" shall be particularly understood as a resistor

element whose condition, particularly its resistance value, is significant for at least one function of a device that contains the resistor. A "composite resistor" shall be particularly understood to be a resistor that results from connecting together at least two individual resistor elements. Such a composite resistor can, for example, consist of all the individual switching elements of a safety circuit of an elevator that form individual resistors. The individual resistors arranged in such a safety circuit are, in particular, formed by output switching elements of sensors, which sensors detect states, in particular positions, of elevator components important for safety of the elevator operation. Such output switching elements of sensors are preferably present in the form of electronic or mechanical switches, in particular in the form of output switching contacts. With "monitoring" by the hardware monitoring unit of a resistor shall be particularly understood that the hardware monitoring unit, in particular at various points in time, quantitatively and/or qualitatively evaluates at least one characteristic of the resistor. With an embodiment according to the invention, a device for achieving reliable functioning of the safety circuit can be realised. In particular, a testing device with a unit for recognition of functionally hazardous changes in the condition of interacting hardware components and, in particular, a series of electrically interconnected individual resistors, can be realised. In particular, the detection of a functionally hazardous increase in on-state resistance values of electric output switching elements of sensors of a safety circuit of an elevator can be realised.

Preferably, the hardware monitoring unit of the testing device comprises at least one sensing unit with at least one current measuring unit and/or at least one voltage measuring unit and/or at least one resistance measuring unit. By this means, a constructively simple embodiment of the hardware monitoring unit can be realised.

It is further proposed that the sensing unit be provided for the purpose of continuously, or at certain time intervals, sensing at least one resistance characteristic variable that serves to determine functionally hazardous changes in condition of the resistor. Such a resistance characteristic variable shall particularly be understood to be a physical magnitude that can be used to calculate a resistance value or that gives the resistance value of the resistor directly. Examples of such resistance characteristic variables are an electric voltage applied to the resistor and an electric current present in the resistor. In this manner, a reliable monitoring of the condition of the functionally relevant resistor can be realised.

Advantageously, the current measuring unit is embodied as an induction current measuring unit. In this manner, a contactless measuring of the current strength in a conductor that carries the electric current can be realised. In particular, the introduction of a measuring resistance into this conductor, for example into the safety circuit of an elevator, can be avoided.

In a preferred variant embodiment of the invention, the hardware monitoring unit, or the sensing unit present in the monitoring unit, has a comparison unit that is provided for the purpose of comparing a resistance characteristic variable with at least one reference value. By this means, a simple quantitative monitoring can be realised.

Preferably, the hardware monitoring unit or sensing unit contains at least one calibrating unit provided for the purpose of generating, preferably automatically, the reference value for the resistance characteristic variable. In this manner, a simple commissioning of the testing device can be realised. In particular, a determination of the reference value by an installation technician can be avoided.

Advantageously, the hardware monitoring unit or sensing unit has at least one output unit which is provided for the purpose of emitting at least one signal when an inadmissibly large change in the condition of the monitored hardware component, for example an inadmissibly large increase in a resistance characteristic variable or the resistance value of a functionally relevant composite resistor, is detected. In particular, by this means, the functional safety of the device that contains the composite resistor, for example of an elevator that is monitored by a safety circuit, can be realised. In particular, a need for maintenance of the composite resistor, for example of a safety circuit, can be signalled and preventive maintenance initiated. In particular, an operational incapability of the hardware components, for example of the functionally relevant resistor, can be prevented. In particular, the signal from the output unit can also be transmitted wirelessly, as for example by radio, and in particular also by SMS and/or e-mail.

Furthermore, an elevator apparatus is proposed that comprises at least one safety circuit, which is in operative connection with an elevator control, and at least one testing device. "Safety circuit" shall be particularly understood to mean, in particular, at least two serially connecting output switching elements of sensors, which sensors each sense an operating state of an apparatus of an elevator. The testing device has at least one hardware

monitoring device which in at least one operating mode monitors at least one functionally relevant condition of at least one hardware component of the safety circuit. A "functionally relevant" property of a hardware component shall be understood to be a characteristic of the hardware component that affects at least one function of a device containing this hardware component. In particular, a "condition" of a hardware component shall be particularly understood to be a characteristic of the hardware component which the latter possesses or obtains as a result of the action thereon of environmental influences and/or chemical and/or physical processes. In particular, that the hardware monitoring unit "monitors" a condition of a hardware component shall be understood to mean that, in particular at various points in time, the hardware monitoring unit quantitatively and/or qualitatively checks at least one characteristic or feature of the condition of the hardware component. With an embodiment of the elevator apparatus according to the invention, the recognition of functionally hazardous changes in the condition of interacting hardware components, in particular of interconnected resistors, can be realised. In particular, the elevator apparatus can signal the need for preventive maintenance of a safety circuit, so that, by means of preventive maintenance a reliable functioning of a safety circuit, for example of the safety circuit of an elevator, can be ensured.

Preferably, the hardware monitoring unit belonging to the testing device of the elevator apparatus contains at least one sensing device, which in the at least one operating mode senses at least one resistance characteristic variable that serves to determine the resistance value of the safety circuit, or indicates its resistance value directly. By this means, a constructionally simple monitoring of the condition of the safety circuit is realised.

Advantageously, the resistance characteristic variable sensed by the sensing unit is the resistance value of the entire safety circuit. In this manner, an inexpensive construction can be realised. In particular, an elaborate monitoring of individual resistors can be obviated.

Preferably, the sensing unit comprises at least one current measuring unit and/or at least one voltage measuring unit and/or at least one resistance measuring unit. By this means, a constructive simple embodiment of the sensing unit can be realised.

It is further proposed that the current measuring unit be embodied as an induction current

measuring unit. In this manner, a contactless measurement of the current strength can be realised. In particular, an introduction of a measurement resistance into a conductor unit carrying the electric current can be avoided.

Advantageously, in the at least one operating mode, the sensing unit continuously or at certain time intervals senses at least one resistance characteristic variable. By this means, a reliable monitoring of the condition of the hardware components, for example of the output switching elements of the sensors of the safety circuit, can be realised.

It is further proposed that the hardware monitoring unit belonging to the testing device of the elevator apparatus comprises at least one comparison unit, which, in the at least one operating mode, compares the resistance characteristic variable with at least one reference variable. By this means, simple quantitative monitoring of the condition of the hardware components, in particular of the output switching elements of the sensors of the safety circuit, can be realised.

In a preferred variant embodiment, the hardware monitoring unit belonging to the testing device of the elevator apparatus comprises at least one calibrating unit, which in the at least one operating mode generates the reference value. In this manner, a simple commissioning of the testing device can be realised. In particular, determination of the reference value by an installation technician can be avoided.

During operation of the elevator, a safety circuit voltage that is preferably taken from the elevator control is transmitted by way of the safety circuit and an interruption of this safety circuit voltage, for example by an output switching element of one of the sensors of the safety circuit, is detected by a control unit belonging to the elevator apparatus. In such a case, this control unit causes the elevator control to stop operation of the elevator. It is therefore preferably integrated into the elevator control or arranged in its proximity and can deliver a safety circuit voltage that originates from the elevator control, or contain a voltage source of its own for the safety circuit voltage. For at least one major part of the total operating time, the safety circuit voltage energises the safety circuit and causes in the safety circuit a current flow when all output switching elements of the sensors of the safety circuit are conductive.

In one possible embodiment of the invention, the current flow that occurs when the safety

circuit is uninterrupted is used for monitoring the condition of the hardware components, in particular for monitoring the resistance value of the series-connected output switching element of sensors. Then, from the voltage across the conducting output switching elements of the sensors, for example across a series of closed output switching contacts, and from the current strength that is sensed, at least the total resistance value of the entire safety circuit is determined. With suitable sensing devices, additional characteristics of the transmitted voltage and/or of the current flow that arises can be registered and evaluated.

In a particularly preferred embodiment of the invention, the hardware monitoring unit belonging to the testing device of the elevator apparatus has at least one separate monitoring voltage source. From this separate monitoring voltage source, for the purpose of monitoring the condition of the hardware components of the safety circuit, in particular for monitoring the total resistance value of the serially connected output switching elements of sensors of the safety circuit, a measurement voltage is applied to the safety circuit. In normal elevator operation, the separate monitoring voltage source of the safety circuit is decoupled from the safety circuit while the monitoring voltage described further above that is taken from the elevator control is applied to the safety circuit. To perform a measurement operation for monitoring the condition of the hardware components of the safety circuit, the separate monitoring voltage source is preferably connected with the safety circuit at a point in time when all output elements of the sensors of the safety circuit are conductive. Such a measurement operation advantageously takes place during a stationary period of the elevator and lasts less than 10 seconds, preferably less than one second. During the measurement operation, the said monitoring voltage, which in normal operation is applied via the safety circuit, is decoupled from the safety circuit and preferably prevents any movement of the elevator by the elevator control.

In this manner, in the at least one operating mode a separate monitoring voltage source can be coupled to the safety circuit, which is more suitable for monitoring the condition of the hardware components than the voltage source connected with the safety circuit when the safety circuit is in operation. By this means, a usability of an adapted voltage, and in particular an improved quality of the evaluation of the measurement operation for monitoring the condition of the hardware components, can be realised.

Preferably, the hardware monitoring unit comprises at least one output unit which, upon a

detected change of the condition of the hardware components, in particular a change in the resistance value of the series-connected output switching elements of the sensors of the safety circuit, generates a signal. This signal serves to inform the elevator maintenance personnel of a need for maintenance of the safety circuit. By this means, a preventive maintenance of the safety circuit can be ensured. In particular, the risk of an interruption in the operation of the elevator apparatus, and in particular of an elevator in which the elevator apparatus is installed, can be reduced. The signal can also be transmitted wirelessly, as for example by radio, and in particular also by SMS and/or e-mail to a maintenance organisation.

It is further proposed that the elevator apparatus has at least one triggering unit that activates the hardware monitoring unit. This triggering unit is preferably integrated into the hardware monitoring unit belonging to the testing unit of the elevator apparatus. Since the hardware monitoring can only be performed when all output switching elements contained in the safety circuit are conductive, the activation preferably takes place at a defined time of day at which usually only little elevator traffic occurs or when the safety circuit has not been interrupted for a long period of time. By this means it can be realised that the short interruption of operation of the elevator that is necessary for the hardware monitoring is not perceptible as a disturbance.

Preferably, at least one of the sensors of the safety circuit is embodied as a mechanical limit switch by way of which a press element actuates an electric output switching contact. By this means, a simple construction of the sensor can be realised. The sensors can, however, also be embodied as, for example, inductive or capacitive switches, magnetic switches (reed switches), light sensors or light barriers, pressure switches, etc.

Further proposed is a monitoring method, in particular for monitoring at least part of an elevator apparatus. In this monitoring method, in at least one operating mode at least one functionally relevant condition of at least one hardware component of a safety circuit is monitored. In particular, the said hardware component comprises at least two serially connected output switching elements of sensors of the safety circuit. By means of the monitoring method, a particularly reliable functioning of the safety circuit and therefore of the elevator can be realised.

Furthermore, a hardware monitoring method, in particular with a testing device, is

proposed, in which a functionally relevant composite resistor is monitored by means of a continuous or periodically occurring measurement of the total resistance value. Through initiation of a preventive maintenance upon sensing of an inadmissibly increased total resistance value, a particularly reliable functioning of the safety circuit of an elevator and hence of the elevator itself can be realised.

Further advantages are evident from the following written description. Shown in the drawing are exemplifying embodiments of the invention. The drawing, the description and the claims contain numerous features in combination. The expert will expediently also consider the features individually and combine them into advantageous further combinations.

There:

- Fig. 1 shows a schematic representation of an elevator apparatus;
- Fig. 2 shows an elevator with the elevator apparatus;
- Fig. 3 shows a schematic representation of a comparison of a resistance characteristic variable with a reference variable;
- Fig. 4 shows a time-ray that represents an operating time of the elevator apparatus;
- Fig. 5 shows a schematic representation of an alternative exemplifying embodiment of an elevator apparatus with a separate monitoring voltage source; and
- Fig. 6 shows a further schematic representation of an alternative exemplifying embodiment with an induction current measuring unit.

Fig. 1 shows a schematic representation of an elevator apparatus 1 according to the invention, which comprises a safety circuit 10 with three series-connected output switching elements (output switching contacts) 12.1, 14.1, 15.1 of sensors 12, 14, 15, and a testing device 11 with a control unit 44 and a hardware monitoring unit 16. A sensing

unit 20 of the hardware monitoring unit 16 comprises a resistance measuring unit 34 which is composed of a current measuring unit 30 and a voltage measuring unit 32.

In installed state, the elevator apparatus 1 is a part of an elevator. Fig. 2 shows such an elevator with the elevator apparatus. The elevator has elevator hoistway doors 48, 50 and a car door 52. Closable by the car door 52 is a car 54 of the elevator which is provided for the purpose of transporting goods and persons. The sensors 12, 14, 15 are each assigned to one of the door locking elements 86, 88, 90 of the elevator hoistway doors 48, 50 or of the car door 52. If one of the elevator hoistway doors 48, 50 or the car door 52 is closed and locked, the electrical output switching contact 12.1, 14.1, 15.1 (not shown in Fig. 2) of the sensor 12, 14, 15 assigned to this door is also closed. If one of the elevator hoistway doors 48, 50 or the car door 52 is at least partly open and/or unlocked, the electrical output switching contact 12.1, 14.1, 15.1 of the sensor 12, 14, 15 assigned to this door is open. Only in a state in which the output switching contacts 12.1, 14.1, 15.1 of all sensors of the safety circuit 10 are closed and capable of functioning and the safety circuit is thus conducting current can an elevator control 45 recognise the state of the elevator as safe and release operation of the elevator, i.e. a movement of the car 54 relative to the elevator hoistway doors 48, 50. For the purpose of detecting whether this safe state is present, in normal operation of the elevator a voltage lies at the safety circuit of the elevator apparatus 1. This voltage causes a current flow when the output switching contacts 12.1, 14.1, 15.1 of all sensors 12, 14, 15 of the safety circuit 10 are closed. When the current flow is detected by the control unit 44, this signals to the elevator control 45 that a movement of the car 54 is allowed. In this embodiment, the control unit 44 is integrated in the elevator control 45 represented by means of chain-dotted lines.

In at least one operating mode, the hardware monitoring unit 16 monitors at least one functionally relevant condition of the hardware components 18 formed by the sensors 12, 14, 15. In principle, the safety circuit 10 conducts electric current when the output switching elements of all sensors 12, 14, 15 of the safety circuit 10 are conductive, i.e. when the output switching contacts 12.1, 14.1, 15.1 of the sensors 12, 14, 15, illustrated in Figs. 1 and 2 are closed. So that in a safe state of the elevator current can actually flow through the safety circuit 10, the output switching elements or the output switching contacts 12.1, 14.1, 15.1 of the sensors 12, 14, 15 must be capable of functioning. This means that in each sensor of the safety circuit the electrical resistance value of its output switching element or of its output switching contact must not exceed an admissible value

when the sensor detects the safe state of the elevator component (e.g. a door locking element) monitored by it. By this means it is ensured that the series-connected output switching elements or output switching contacts allow a current flow through the safety circuit 10 that is unequivocally detectable by the control unit 44. For this purpose, the output switching elements of the sensors 12, 14, 15, which are embodied as output switching contacts 12.1, 14.1, 15.1, must, for example, be free of significant contamination and free of significantly oxidised contact points, so that in the conductive state they do not form excessively high contact resistances in the safety circuit.

For the purpose of monitoring the functionally relevant on-state resistances of the output switching contacts 12.1, 14.1, 15.1 of the sensors 12, 14, 15, which together form a resistor 17, in the at least one operating mode the sensing unit 20 senses a resistance characteristic variable which can be, for example, the total resistance value 22 of the safety circuit 10. The total resistance value of the safety circuit 10 is that resistance value which the series connection of the output switching contacts 12.1, 14.1, 15.1 of the sensor 12, 14, 15 of the safety circuit 10 has in total when all output switching contacts of the sensors are in a closed state.

The current measuring unit 30 has an output 46 which is connected to an input 58 of the control unit 44. Further, an input 60 of the current measuring unit 30 is connected with an end 76 of the safety circuit 10, i.e. the sensor 12. An output 56 of the control unit 44 is conductively connected with an end 78 of the safety circuit 10, i.e. with the sensor 15. Furthermore, an input 62 of the voltage measuring unit 32 is conductively connected with the output 56. An output 64 of the voltage measuring unit 32 is connected with the input 58 of the control unit 44. The voltage measuring unit 32 measures a voltage present between the output 56 and the input 58 of the control unit 44 in the state in which the safety circuit 10 in principle conducts electric current. Furthermore, the current measuring device 30 measures the current strength of the electric current that flows through the safety circuit 20 when the safety circuit 10 is in the state in which it in principle conducts electric current, and, by means of the control 44, a voltage is applied to the input 58 and to the output 56. Should at least the output switching contact 12.1, 14.1, 15.1 of one of the sensors 12, 14, 15 be too heavily contaminated and/or oxidised, then in this situation the safety circuit 10 carries only a current of reduced current strength or no current at all. From the measured current strength and the measured voltage, the hardware monitoring unit 16 determines the total resistance value 22 of the safety circuit 10.

The hardware monitoring unit 16 of the testing device 11 comprises a comparison unit 24 which in the at least one operating mode compares the resistance characteristic variable, in the present case the measured total resistance value 22, with a reference value 26 (Fig. 3). The reference value 26 is identical to the total resistance value that the safety circuit 10 has with uncontaminated and unoxidised output switching contacts 12.1, 14.1, 15.1 of the sensors 12, 14, 15, in particular immediately after first commissioning of the elevator apparatus. In the at least one operating mode, in particular immediately after the first commissioning of the elevator apparatus, the reference value 26 is measured by the hardware monitoring unit 16, which comprises a calibrating unit 28, and stored in a memory unit 66 of the comparison unit 24. After a sensing of the total resistance value 22, which is performed after the measurement of the reference value 26, the comparison unit 24 compares the measured total resistance value 22 of the safety circuit with the reference value 26 and signals to an output unit 40 integrated in the hardware monitoring unit 16 a need for maintenance of the sensors 12, 14, 15 when the total resistance value 22 deviates by more than a certain percentage value from the reference value 26. After a receipt of the need-for-maintenance signal, the output unit 40 notifies an elevator maintenance organisation or a maintenance person by means of a telephone or radio connection. The maintenance person can then remove a possible contamination and/or oxidation and/or other impairment of the output switching contacts of the sensors 12, 14, 15 before a further rise in the total resistance value of the safety circuit 10 causes an interruption of the elevator operation.

In the embodiment of the testing device according to Fig. 1, the sensing unit 20 senses the resistance characteristic variable and/or the total resistance value 22 during all phases of the operating time in which all output switching contacts of the sensors of the safety circuit are closed, i.e. in all phases in which the current measuring unit detects a current flow. Fig. 4 shows a time-ray which begins with completion of first commissioning of the elevator apparatus. Immediately after the first commissioning, the reference value 26 is measured at a time instant 68. For example, during the aforesaid phase 69 of the operating time 67 after the time instant 68, the resistance characteristic variable or total resistance value 22 is measured and compared with the reference value 26.

The hardware monitoring unit 16 of the testing device 11 comprises a processing unit, a memory unit and an operating program, which is stored in the memory unit.

In principle, the safety circuit 10 can have further electrical contacts which, for example, serve to monitor a brake of the elevator. The elevator apparatus 1 can also be retrofitted in an already existing elevator or in existing elevator systems.

Illustrated in Figs. 5 and 6 are two alternative exemplifying embodiments of an elevator apparatus. Components, characteristics and functions that remain essentially the same are in principle indicated by the same reference numbers. However, to differentiate the exemplifying embodiments, in Figs. 5 and 6 the reference numbers are suffixed with the letters "a" and "b", respectively. The following description is essentially limited to the differences relative to the exemplifying embodiment in Figs. 1 to 4, while for components, characteristics and functions that remain the same, reference should be made to the description of the exemplifying embodiment in Figs. 1 to 4.

The elevator apparatus 1a illustrated in Fig. 5 comprises a testing device 11a with a control unit 44a and a safety circuit 10a, wherein the control unit and the safety circuit preferably form a part of the elevator control 45a of an elevator. Furthermore, the testing device 11a comprises a hardware monitoring unit 16a with a sensing unit 20a and a switching relay 70a with two switching contacts 70.1a, 70.2a. During operation of the elevator, a safety circuit voltage is applied to the safety circuit 10a via the control unit 44a of the elevator control 45a. In a state in which the output switching elements of the sensors 12a, 14a, 15a, which are embodied as electronic contacts, are closed, a current flows through the safety circuit 10a which, for example, activates a safety relay 48a of the control unit 44a, which signals to the elevator control 45a that transportation of persons and/or goods by the elevator is possible without danger. The control unit 44a has a time measuring unit 74 which measures a period of time during which the current flows uninterruptedly through the safety circuit 10a. Should this period of time exceed a certain value, a triggering unit 42a of the control unit 44a activates the hardware monitoring unit 16a and the switching relay 70a with the switching contacts 70.1a, 70.2a. The switching contacts 70.1a, 70.2a thereupon decouple the safety circuit 10a from the control unit 44a and connect one end 76a of the safety circuit 10a with one input 80a of the hardware monitoring unit 16a, and another end 78a of the safety circuit 10a with an output 82a of the hardware monitoring unit 16a. By this means, a voltage generated by a monitoring voltage source 84a in the hardware monitoring unit 16a is applied to the safety circuit 10a. A current measuring unit 30a and a voltage measuring unit 32a of the sensing unit 20a

form a resistance measuring unit 34a which determines a total resistance value of the safety circuit 10a. This takes place by means of the current measuring unit 30a measuring the current flow that is generated by the voltage source 84a, the resistance measuring unit 34a measuring the monitoring voltage that is present on the safety circuit during the measuring operation, and the sensing unit determining from the measured current strength and the measured monitoring voltage the instantaneous total resistance value of the safety circuit. As described above in connection with Fig. 1, the total resistance that is determined in a comparison unit 24a is compared with a stored reference value, whereupon if applicable the comparison unit of an output unit 40a signals an inadmissibly high total resistance value. After the preferably less than 10-seconds-long sensing of the total resistance value, the switching relay decouples the safety circuit 10a from the sensing unit 20a and applies again to the safety circuit the safety circuit voltage that originates from the control unit 44a of the elevator control 45a. If the hardware monitoring unit 16a is activated on the basis of the time period during which the safety circuit is not interrupted, a measurement of the total resistance value takes place preferably at night, because in this time period use of the elevator is rare. In principle, it is also conceivable that the control unit 44a recognises in another manner that the elevator is not in use and thereupon causes a decoupling of the safety circuit 10a from the safety circuit voltage and a coupling to the monitoring voltage source of the hardware monitoring unit 16a. It is further conceivable that the sensing of the total resistance value 22 is limited to a fixed number of measurements per unit of time, for example to one measurement per day at a time in which, according to experience, the elevator is hardly used.

Fig. 6 shows a further exemplifying embodiment of an elevator apparatus 1b with a control unit 44b, a safety circuit 10b, and a hardware monitoring unit 16b with a sensing unit 20b. The manner of functioning of the elevator apparatus 1b is substantially the same as the manner of functioning of the elevator apparatus described in connection with the elevator apparatus described with Figs. 1 and 2. Here, the sensing unit 20b has a current measuring unit 30b which is embodied as an induction current measuring unit. When a current flows through the safety circuit 10b, a current is induced in the current measuring unit 30b, by means of which the current measuring unit 30b calculates the current strength of the electric current that flows through the safety circuit 10b. Ends 76b, 78b of the safety circuit 10b are directly conductively connected with the control unit 44b.

CLAIMS

1. Testing device (11; 11a; 11b) for checking an elevator apparatus (1; 1a; 1b) of an elevator, wherein the testing device comprises at least one hardware monitoring unit (16; 16a; 16b) which is provided for the purpose of monitoring at least one functionally relevant composite resistor (17; 17a; 17b), wherein the hardware monitoring unit (16; 16a; 16b) contains at least one sensing unit (20; 20a; 20b) which comprises at least one current measuring unit (30; 30a; 30b) and/or at least one voltage measuring unit (32; 32a; 32b) and/or at least one resistance measuring unit (34; 34a; 34b), characterised in that the testing device (11; 11a; 11b) is provided for the purpose of recognising a functionally hazardous increase in the on-state resistance values of electrical output switching elements (12.1, 14.1, 15.1; 12.1a, 14.1a, 15.1a; 12.1b, 14.1b, 15.1b) of sensors (12, 14, 15; 12a, 14a, 15a; 12b, 14b, 15b) of a safety circuit of an elevator.
2. Testing device according to claim 1, characterised in that the hardware monitoring unit (16; 16a; 16b) comprises an output unit (40; 40a; 40b) which is provided for the purpose of emitting at least one signal when an impermissibly strong increase of the resistance value of the functionally relevant composite resistor is detected.
3. Testing device according to one of claims 1 and 2, characterised in that the hardware monitoring unit (16; 16a; 16b) comprises at least one comparison unit (24; 24a; 24b) which is provided for the purpose of comparing a resistance characteristic variable (22) with at least one reference variable (26).
4. Testing device according to any one of claims 1 to 3, characterised in that the current measuring unit (30; 30a; 30b) is constructed as an induction current measuring unit.
5. Testing device according to one of claims 3 and 4, characterised by at least one calibrating unit (28; 28a; 28b) which is provided for the purpose of generating the reference variable (26).
6. Elevator apparatus (1; 1a; 1b) with a testing device (11; 11a; 11b) according to any one of claims 1 to 5, and at least one safety circuit (10; 10a; 10b) having at least two serially connected output switching elements (12.1, 14.1, 15.1; 12.1a, 14.1a, 15.1a; 12.1b,

14.1b, 15.1b) of sensors (12, 14, 15; 12a, 14a, 15a; 12b, 14b, 15b), wherein the testing device (11; 11a; 11b) comprises at least one hardware monitoring unit (16; 16a; 16b) which in at least one operating mode monitors at least one functionally relevant condition of at least one hardware component (18; 18a; 18b) of the safety circuit (10; 10a; 10b) and the hardware monitoring unit (16; 16a; 16b) comprises at least one sensing unit (20; 20a; 20b) which in the at least one operating mode senses at least one resistance characteristic variable (22) which serves for ascertaining the total resistance value of the safety circuit (10; 10a; 10b) or indicates the total resistance value thereof, characterised in that the testing device is provided for the purpose of recognising a functionally hazardous increase in the on-state resistance values of electrical output switching elements of sensors of a safety circuit of an elevator.

7. Elevator apparatus (1; 1a; 1b) according to claim 6, characterised by a monitoring voltage source (84a).

8. Elevator apparatus (1; 1a; 1b) according to one of claims 6 and 7, characterised by at least one triggering unit (42b) which, in at least one operating process, after a specific time period of uninterrupted current flow in the safety circuit (10b) activates the hardware monitoring unit (16b).

9. Elevator apparatus (1; 1a; 1b) according to any one of claims 6 to 8, characterised in that at least one of the sensors (12, 14, 15; 12a, 14a, 15a; 12b, 14b, 15b) comprises an output switching element which is constructed as an electrical output switching contact (12.1, 14.1, 15.1; 12.1a, 14.1a, 15.1a; 12.1b, 14.1b, 15.1b).

10. Hardware monitoring method, particularly with a testing device (11; 11a; 11b) according to any one of claims 1 to 5, in which a functionally relevant composite resistor (17; 17a; 17b) of a safety circuit (10; 10a; 10b) of an elevator control (45; 45a) is monitored in order to recognise a functionally hazardous increase in the on-state resistance values of electrical output switching elements of sensors at a safety circuit of an elevator.