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

(11) **EP 3 742 462 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.11.2020 Bulletin 2020/48

(51) Int Cl.:
H01H 13/70 *(2006.01)* ***A61G 13/02*** *(2006.01)*
H01H 3/14 *(2006.01)*

(21) Application number: **19175340.9**

(22) Date of filing: **20.05.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **TRUMPF Medizin Systeme GmbH + Co. KG**
07318 Saalfeld (DE)

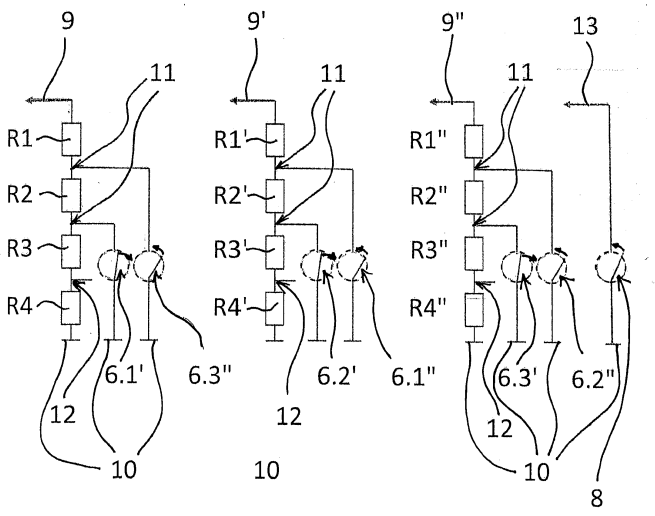
(72) Inventor: **WILDT, Marcus**
Batesville, IN 47006 (US)

(74) Representative: **Prüfer & Partner mbB**
Patentanwälte · Rechtsanwälte
Sohnckestraße 12
81479 München (DE)

(54) SWITCHING DEVICE, MEDICAL APPARATUS COMPRISING THE SWITCHING DEVICE, AND METHOD FOR OPERATING THE SWITCHING DEVICE

(57) A switching device (2) comprises at least two actuators (5.1, 5.2, 5.3) for actuating an action of a medical apparatus (1), several switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3"), and several output channels (9, 9', 9") configured to transmit an output signal. A first switch unit (6.1', 6.2', 6.3') and a second switch unit (6.1", 6.2", 6.3") are respectively assigned to one of the actuators (5.1, 5.2, 5.3), and the actuators (5.1, 5.2, 5.3) are configured to actuate the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") upon one actuating motion. The switching device (2) is configured such that the first and second switch unit (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") assigned to one of the actuators (5.1, 5.2, 5.3) are connected to different output channels (9, 9', 9"), and the output signal of the output channel (9, 9', 9") is defined by switching states of the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") connected to the output channel (9, 9', 9").

Fig. 2



EP 3 742 462 A1

Description

[0001] The invention relates to a switching device, a medical apparatus comprising the switching device, and a method for operating the switching device, in particular to a switching device, a medical apparatus comprising the switching device, and a method for operating the switching device proving a single fault condition safety.

[0002] In medical applications, there are certain "essential performances" of medical apparatuses which are to be provided even upon appearance of a single fault condition. In case that the medical apparatus is an operating table, these "essential performances" mostly relate to movements of the operating table. In particular, the movements of the operating table must not be possible without any intention of a user. Therefore, actuating of predefined actions of the operating table can be performed by means of a switching device by switching several redundant switches actuated by operating one actuator and by evaluating signals of the several switches. However, such a configuration requires one output channel for each switch so that, due to an increase of actuated functions, a cable transmitting the signals to an evaluation unit of the operating table has to have additional lines which, on the one hand, increases the manufacturing costs and, on the other hand, renders a compatibility with existing connection devices impossible.

[0003] In order to avoid the increase of the number of the lines, electronics provided in the switching device and providing serial signals can be used. However, this requires electronics, e.g., using a microcontroller, which in turn also increases the manufacturing costs and renders a compatibility with existing connection devices impossible.

[0004] Therefore, the object underlying the invention is to remedy the above-mentioned disadvantages and to provide a switching device for a medical apparatus, the switching device including a simple equipment and avoiding an increase of the number of output channels for a safe operation even in case of a single fault.

[0005] The object is achieved by a switching device according to claim 1, a medical apparatus according to claim 12, and a method according to claim 13. Advantageous further developments are included in the dependent claims.

[0006] According to an aspect of the invention, a switching device for a medical apparatus comprises at least two actuators configured to actuate a respectively predefined action of the medical apparatus, several output channels configured to transmit a respective output signal to the medical apparatus for actuating the respectively predefined action, and several switch units respectively connected to one of the several output channels, wherein a first switch unit and a second switch unit of the switch units are assigned to one of the at least two actuators, the at least two actuators are configured to actuate the first and second switch units assigned to a respective actuator of the two actuators to change their switching state upon one actuating motion of the respective actuator, and the first and second switch units assigned to one of the at least two actuators are connected to different output channels. The switching device is configured such that the output signal of a predefined output channel of the output channels is determined by the switching states of the switch units assigned to different actuators of the two actuators and being connected to the predefined output channel.

[0007] By this configuration, output signals at two different output channels are changed by operating one of the actuators. Therefore, in an evaluation unit of the medical apparatus downstream of the switching device, an operation of a respective one of the two actuators can be determined redundantly by the switching state of two switch units which can assist in determining a single fault condition.

[0008] Moreover, due to the definition of the output signal by the switching states of the switch units assigned to different actuators, i.e., the switch units assigned to different actuators are connected to one output channel, even though merely two output channels are used, switching states of four switch units can be detected so that a safe operation by avoiding an increase of the number of output channels can be achieved.

[0009] In an advantageous implementation of the switch device, the at least two actuators with respectively assigned first and second switch units are provided in a predetermined number larger than two, and the output channels are provided in the predetermined number.

[0010] The provision of more than two actuators with respectively assigned switch units enables performing a larger number of predefined actions of the medical apparatus.

[0011] In a further advantageous implementation of the switch device, the switching device comprises an input channel, the output channels are configured as analog channels, and the switch units connected to one of the output channels, depending on their switching states, provide different electric potentials with respect to an input channel as the output signal at the one of the output channels.

[0012] By the analog output channel providing different electric potentials, a simple configuration of the switching device without an own controller is possible which reduces manufacturing costs and provides a flexibility of the use of the switching device. Namely, an accordingly adapted evaluation unit of different medical apparatuses for actuating predefined actions of different kinds of medical apparatuses can be used collaborating with the same switch device.

[0013] In a further advantageous implementation of the switching device, the switching device is respectively provided with several serially connected resistors as potential dividers between the input channel and each of the output channels, wherein respectively two of the resistors have a junction therebetween, and the switch units are respectively connected to the input channel and to one

of the junctions.

[0014] This configuration is a simple option for providing the different electric potentials without the need of a controller or costly components.

[0015] In a yet further advantageous implementation of the switch device, the switching device comprises a separation equipment configured to separate the switch units from each other.

[0016] By the separation equipment, a failure of several switch units due to a root failure can be avoided so that the safety is improved.

[0017] In another advantageous implementation of the switching device, the separation equipment comprises a barrier, and the first switch unit and the second switch unit assigned to one of the actuators are arranged such that the barrier is located between the first switch unit and the second switch unit respectively assigned to the one of the actuators.

[0018] By the separation equipment comprising the barrier, a failure of several switch units due to the root failure impairing the function, e.g., upon an ingress of liquid, can be avoided since, e.g., the intruded liquid can be hindered to reach several of the switch units. Also, e.g., a mechanical damage of the switching device does not imperatively lead to a failure of more of the switch units due to a mechanical protection of the switch units by an appropriately formed separation barrier so that the safety is improved.

[0019] In a further advantageous implementation of the switching device, the first and second switch units assigned to one of the actuators are based on different switching principles.

[0020] Due to the different switching principles of the first and second switch units assigned to one actuator, e.g., on the one hand, mechanical contacts operated by a button and, on the other hand, e.g., reed switches, the failure of both switch units assigned to one actuator due to one root failure is unlikely so that the safety is improved.

[0021] In a further advantageous implementation of the switching device, one of the first and second switch units assigned to one of the actuators is configured as a normally open switch and the other one is configured as a normally closed switch.

[0022] This configuration enables a simple option for distinguishing a proper function of the switch units in case of several failures, e.g. sticking of contacts, which improves safety.

[0023] In a further advantageous implementation of the switching device, upon operation of one of the actuators, the first switch unit assigned to the one of the actuators is configured to increase an electric potential at one of the first output channels and the second switch unit assigned to the one of the actuators is configured to decrease the electric potential at another one of the output channels.

[0024] By this principle, a failure due to common mode interference can be prevented in order to improve safety.

[0025] In a further advantageous implementation of the switching device, the output channels are provided with a respective additional connection point for providing an additional different signal at a respective output channel.

[0026] Due to the additional connection point, alternative functions switched by the switching device can be added and distinguished.

[0027] A further advantageous implementation of the switching device comprises a function-changing switch configured to provide a function-changing signal at a separate function-changing output channel to the medical apparatus.

[0028] By this configuration, the number of the predefined actions of the medical apparatus actuated by the switching devices can be doubled by providing merely one additional output channel.

[0029] According to a further aspect of the invention, a medical apparatus comprises the switching device and an evaluation unit configured to interpret the output signals of the output channels in order to actuate the respectively defined action of the medical apparatus.

[0030] By such a medical apparatus, performing additional predefined actions thereof is possible without a necessity of providing additional output channels of the switching device. Furthermore, the safety against the single fault condition is enhanced.

[0031] According to a further aspect of the invention, a method is provided, the method comprising the steps: operating a predefined one of the actuators of the switching device, thereby, respectively switching one of the first switch units and one of the second switch units respectively assigned to the predefined one of the actuators to change the switching states of the switch units, and outputting, in a redundant manner by the switching device at different defined output channels, the output signals respectively determined by the switching states of the first switch unit and the second switch unit assigned to the predefined one of the actuators and by the switching states of further switch units assigned to another actuator and being connected to the defined output channels.

[0032] By performing these steps, in an evaluation unit of the medical apparatus downstream of the switching device, an operation of a respective one of the actuators can be determined redundantly by the switching states of two switch units. This can assist in determining the single fault condition. Moreover, by this method, even though merely a reduced number of output channels are used, switching states of at least twice as much as switch units can be detected so that a safe operation by using a reduced number of output channels can be achieved.

[0033] In an advantageous implementation of the method, depending on the switching state of the switch units, the output signals at one of the output channels respectively differ in an electric potential with respect to an input channel.

[0034] By the provision of the different electric potentials, the operated actuator and, therefore, the actuated predefined function of the medial apparatus can be determined by the evaluation unit in an easy and reliable

manner.

[0035] In a further advantageous implementation of the method, it comprises the step: operating a function-changing switch, thereby providing a function-changing signal at a separate function-changing output channel.

[0036] By performing this step, the number of the predefined actions of the medical apparatus actuated by the switching devices can be doubled by providing merely one additional output channel.

[0037] In the following, the invention is elucidated by means of embodiments referring to the attached drawings.

[0038] In particular,

Fig. 1 shows a medical apparatus and a switching device according to the invention;

Fig. 2 shows a switching principle of the switching device of Fig. 1; and

Fig. 3 shows a flowchart of a method according to the invention for operating the switching device of Fig 1.

[0039] **Fig. 1** shows a medical apparatus 1 comprising a switching device 2 according to the invention connected to the medical apparatus by a cable 3. In the shown embodiment, the medical apparatus 1 is configured as an operating table and the switching device 2 is configured as a foot switch. In alternative embodiments, the medical apparatus 1 is configured as another kind of medical apparatus, such as an operating lamp, and the switching device is configured as, e.g., a remote control operated by hand connected to the medical device 1 by the cable.

[0040] The medical apparatus 1 further comprises an evaluation unit 4 configured to interpret output signals of output channels of the switching device 2 in order to actuate a respectively defined action of the medical apparatus 1.

[0041] The switching device 2 comprises three actuators 5.1, 5.2, 5.3 for actuating a respectively predefined action of the medical apparatus 1. Alternatively, the switching device 2 comprises merely two, or more than three actuators 5.1, 5.2, 5.3. The actuators 5.1, 5.2, 5.3 respectively actuate a Trendelenburg motion, a tilting motion around a longitudinal axis of a tabletop of the operating table, and a lifting motion for a height-adjustment of the tabletop. Alternatively, the actuators 5 do not actuate all of these three motions but alternative or additional motions by means of a respective appropriate number of actuators 5.1, 5.2, 5.3.

[0042] Furthermore, the switching device 2 comprises several switch units 6.1', 6.1", 6.2', 6.2", 6.3', 6.3". A first switch unit 6.1', 6.2', 6.3' and a second switch unit 6.1", 6.2", 6.3" of the several switch units 6.1', 6.1", 6.2', 6.2", 6.3', 6.3" are respectively assigned to one of the three actuators 5.1, 5.2, 5.3 and the three actuators 5.1, 5.2, 5.3 are configured to actuate the assigned first and second switch units 6.1', 6.1", 6.2', 6.2", 6.3', 6.3" upon one actuating motion of a respective actuator 5,1, 5.2, 5.3 of the three actuators 5.1, 5.2, 5.3 to change a switching state of the switch units 6.1', 6.1", 6.2', 6.2", 6.3', 6.3". The first switch unit 6.1' and the second switch unit 6.1" are assigned to the actuator 5.1, the first switch unit 6.2' and the second switch unit 6.2" are assigned to the actuator 5.2, and the first switch unit 6.3' and the second switch unit 6.3" are assigned to the actuator 5.3.

[0043] The first switch unit 6.1', 6.2', 6.3' and the second switch unit 6.1", 6.2", 6.3" assigned to one of the actuators 5.1, 5.2, 5.3 are based on different switching principles. The switching principles are, on the one hand, e.g., represented by a switching principle of a mechanical switch, the contacts of which can be connected and disconnected by pressing and releasing a button acting to one of the contacts and, on the other hand, by a reed switch, the contacts of which are connected and disconnected by means of a magnet moved towards the reed switch and attracting one of the reeds of the reed switch. Other switching principles, e.g., inductive, capacitive, optical, are alternatively possible.

[0044] The first switch unit 6.1', 6.2', 6.3' is configured as a normally open switch and the second switch unit 6.1", 6.2", 6.3" is configured as a normally closed switch.

[0045] Alternatively, the first switch unit 6.1', 6.2', 6.3' is configured as a normally closed switch and the second switch unit 6.1", 6.2", 6.3" is configured as a normally open switch.

[0046] The switching device 2 further comprises a function-changing switch 8 configured to actuate a change of the motions of the medical apparatus 1.

[0047] Moreover, the switching device 2 is provided with a separation equipment configured to respectively separate the first switch units 6.1', 6.2', 6.3' and the second switch units 6.1", 6.2", 6.3" assigned to one of the actuators 5.1, 5.2, 5.3 from each other. The separation equipment comprises barriers 7 respectively being located between the first switch units 6.1', 6.2', 6.3' and the second switch units 6.1", 6.2", 6.3" respectively assigned to one of the actuators 5.1, 5.2, 5.3.

[0048] **Fig. 2** shows a switching principle of the switching device 1 of Fig. 1. The switching device 1 comprises three output channels 9, 9', 9", configured to transmit a respective output signal to the medical apparatus 1 for actuating the respectively predefined action. The first switch unit 6.1' assigned to the actuator 5.1 (Fig. 1) and the second switch unit 6.3" assigned to the actuator 5.3 (Fig. 1) provide output signals at the output channel 9, the first switch unit 6.2' assigned to the actuator 5.2 (Fig. 1) and the second switch unit 6.1" assigned to the actuator 5.1 (Fig. 1) provide output signals at the output channel 9', and the first switch unit 6.3' assigned to the actuator 5.3 (Fig. 1) and the second switch unit 6.2" assigned to the actuator 5.2 (fig. 1) provide output signals at the output channel 9". This configuration results in that the switching device 1 is configured such that the output signal of a predefined output channel 9, 9', 9" of the output

channels 9, 9', 9" is determined by the switching states of the switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" assigned to different actuators 5.1, 5.2, 5.3 and being connected to the predefined output channel 9, 9', 9".

[0049] The output channels 9, 9', 9" are provided in the same number as the number of the actuators 5.1, 5.2, 5.3. Alternatively, another quantity of output channels can be provided. In this case, either merely one switch unit provides an output signal at anyone or several of the output channels. However, this would require a larger number of output channels. Or more than two switch units respectively provide an output signal at any one or several of the output channels. However, this could result in a reduction of the reliability of the switching device since more different output signals have to be provided at one output channel.

[0050] The output channels 9, 9', 9" are configured as analog channels, and the switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" connected to one of the output channels 9, 9', 9", depending on their switching states, provide different electric potentials with respect to an input channel 10 as the output signal at the one of the output channels 9, 9', 9".

[0051] In order to provide the different electric potentials, the switching device 1 is respectively provided with several serially connected resistors R1, R2, R3, R4, R1', R2', R3', R4', R1", R2", R3", R4" as potential dividers between the input channel 10 and each of the output channels 9, 9', 9" of the switching device 1, wherein two of the potential dividers R1, R2, R3, R1', R2', R3', R1", R2", R3" respectively have a junction therebetween. The switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" are respectively connected to the input channel 10 and to one of the junctions 11. Alternatively, the resistors R1, R2, R3, R4, R1', R2', R3', R4', R1", R2", R3", R4" as the potential dividers are not respectively serially connected between the input channel 10 and each of the output channels 9, 9', 9" but the switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" are respectively connected to the input channel 10 via one of the resistors R1, R2, R3, R4, R1', R2', R3', R4', R1", R2", R3", R4". Therefore, the output signal of each output channel 9, 9', 9" is an electric potential resulting from the switching states of all of the switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" connected to the respective output channel 9, 9', 9".

[0052] The first switch units 6.1', 6.2', 6.3' and the second switch units, 6.1", 6.2", 6.3" assigned to one of the actuators 5.1, 5.2, 5.3 respectively have two states. In a non-operated state and in an operated state of the actuators 5.1, 5.2, 5.3, the respectively assigned first and second switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" have predefined switching states, which, in case of the switching device 1 comprising the potential dividers, result in a predefined electric potential at each output channel 9, 9', 9". Each electric potential, which is not an exact value but a voltage range, provided by the output channels 9, 9', 9" is determined by a combination of switching states of the switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" connected to one of the output channels 9, 9', 9". By combining the electric potential of the output signal of several output channels 9, 9', 9", for each switch unit 6.1', 6.2', 6.3', 6.1", 6.2", 6.3", the current switching state can be determined. By current switching states of each of the switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3", the operated actuator 5.1, 5.2, 5.3 and, therefore, a desired function of the medical apparatus 1 can be determined. If the electric potential provided by one of the output channels 9, 9', 9" is not defined in the evaluation unit 4 or a change of the electric potential of several output channels 9, 9', 9" is not defined in the evaluation unit 4, a failure of the switching device 1 can be determined.

[0053] The resistance value of the respective resistors R1, R2, R3, R4, R1', R2', R3', R4', R1", R2", R3", R4" is to be set such that the voltage ranges caused by the different resistors R1, R2, R3, R4 at the output channel 9,and by the resistors R1', R2', R3', R4' at the output channel 9', and by the resistors R1", R2", R3", R4" at the output channel 9" do not overlap. Therefore, tolerances of the resistors R1, R2, R3, R4, R1', R2', R3', R4', R1", R2", R3", R4", contact tolerances of the electric contacts, and supply voltage tolerances have to be considered.

[0054] Due to the provision of the first switch units 6.1', 6.2', 6.3' as normally closed switch and the second switch units 6.1", 6.2", 6.3" as normally open switch at one of the output channels 9, 9', 9" and due to the assignment of one of the first switch units 6.1', 6.2', 6.3' and one of the second switch units 6.1", 6.2", 6.3" to one of the actuators 5.1, 5.2, 5.3, in this embodiment, upon operation of one of the actuators 5.1, 5.2, 5.3, the assigned first switch unit 6.1', 6.2', 6.3' increases an electric potential at one of the output channels 9, 9', 9" and the second switch unit 6.1", 6.2", 6.3" decreases an electric potential at the other one of the output channels 9, 9', 9". Alternatively, depending on the kind of the switch unit, upon operation of one of the actuators 5.1, 5.2, 5.3, the assigned first switch unit 6.1', 6.2', 6.3' decreases an electric potential at one of the output channels 9, 9', 9" and the second switch unit 6.1", 6.2", 6.3" increases an electric potential at the other one of the output channels 9, 9', 9", or both of the first and second switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" can either increase or decrease the electric potential at the output channel 9, 9', 9".

[0055] Alternatively, the switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" do not provide different electric potentials at the respective output channel 9, 9', 9" but other output signals having different characteristics, e.g., a different frequency.

[0056] The output channels 9, 9', 9" are provided with a respective connection point 12 for providing an additional different signal at the respective output channel 9, 9', 9". Alternatively, no connection point 12 for providing an additional different signal at the respective output channel 9, 9', 9" is provided.

[0057] The function-changing switch 8 is configured to provide the function-changing signal at a separate function-changing output channel 13. Alternatively, no function-changing signal is provided but a changed function

of the operating table is performed using the switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3".

[0058] **Fig. 3** shows a flowchart of a method according to the invention for operating the switching device 2.

[0059] During operation, in an optional step S1, the function-changing switch 8 is operated, thereby providing a function-changing signal at a separate function-changing output channel 13.

[0060] In a second step S2, one of the actuators 5.1, 5.2, 5.3 of the switching device 1 is operated and, thereby, one of the first switch units 6.1', 6.2', 6.3' and one of the second switch units 6.1", 6.2", 6.3" assigned to the one of the actuators 5.1, 5.2, 5.3 are switched to change their switching states and, in a redundant manner by the switching device at different defined output channels 9, 9', 9", the output signals determined by the switching states of the first switch unit 6.1', 6.2', 6.3' and the second switch unit 6.1", 6.2", 6.3" assigned to the actuator 5.1, 5.2, 5.3 and by the switching states of further switch units 6.1', 6.2', 6.3', 6.1", 6.2", 6.3" assigned to another actuator 5.1, 5.2, 5.3 and being connected to the defined output channels 9, 9', 9" are output.

[0061] Depending on the switching state of the switch units, the output signals at one of the first and second output channels 9, 9', 9" respectively differ in an electric potential with respect to the input channel 10. Alternatively, output signals having, e.g., a different frequency are output.

[0062] Although the present invention has been described with reference to specific features and embodiments thereof, it is evident that various modifications and combinations can be made thereto without departing from the spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded simply as an illustration of the invention as defined by the appended claims, and are contemplated to cover any and all modifications, variations combinations or equivalents that fall within the scope of the present invention.

Claims

1. A switching device (2) for a medical apparatus (1), the switching device (2) comprising
   at least two actuators (5.1, 5.2, 5.3) configured to actuate a respectively predefined action of the medical apparatus (1),
   several output channels (9, 9', 9") configured to transmit a respective output signal to the medical apparatus (1) for actuating the respectively predefined action, and
   several switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") respectively connected to one of the several output channels (9, 9', 9"),
   wherein
   a first switch unit (6.1', 6.2', 6.3') and a second switch unit (6.1", 6.2", 6.3") of the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") are assigned to one of the at least two actuators (5.1, 5.2, 5.3), and the at least two actuators (5.1, 5.2, 5.3) are configured to actuate the first and second switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") assigned to a respective actuator (5.1, 5.2, 5.3) of the two actuators (5.1, 5.2, 5.3) to change their switching state upon one actuating motion of the respective actuator (5.1, 5.2, 5.3),
   the first and second switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") assigned to one of the at least two actuators (5.1, 5.2, 5.3) are connected to different output channels (9, 9', 9"), and
   the switching device (2) is configured such that the output signal of a predefined output channel (9, 9', 9") of the output channels (9, 9', 9") is determined by the switching states of the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") assigned to different actuators (5.1, 5.2, 5.3) of the two actuators (5.1, 5.2, 5.3) and being connected to the predefined output channel (9, 9', 9").

2. The switching device (2) of claim 1, wherein
   the at least two actuators (5.1, 5.2, 5.3) with respectively assigned first and second switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") are provided in a predetermined number larger than two, and
   the output channels (9, 9', 9") are provided in the predetermined number.

3. The switching device (2) of claim 1 or 2, wherein
   the switching device comprises an input channel (10),
   the output channels (9, 9', 9") are configured as analog channels, and
   the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") connected to one of the output channels (9, 9', 9"), depending on their switching states, provide different electric potentials with respect to an input channel (10) as the output signal at the one of the output channels (9, 9', 9").

4. The switching device (2) of claim 3, wherein
   the switching device (2) is respectively provided with several serially connected resistors (R1, R2, R3, R4, R1', R2', R3', R4', R1", R2", R3", R4") as potential dividers between the input channel (10) and each of the output channels (9, 9', 9"), wherein respectively two of the resistors (R1, R2, R3, R4, R1', R2', R3', R4', R1", R2", R3", R4") have a junction (11) therebetween, and
   the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") are respectively connected to the input channel (10) and to one of the junctions (11).

5. The switching device (2) of claim 3 or 4, wherein
   the switching device (2) comprises a separation equipment configured to separate the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") from each other.

6. The switching device (2) of claim 5, wherein the separation equipment comprises a barrier (7), and
the first switch unit (6.1', 6.2', 6.3') and the second switch unit (6.1", 6.2", 6.3") assigned to one of the actuators (5.1, 5.2, 5.3) are arranged such that the barrier (7) is located between the first switch unit (6.1', 6.2', 6.3') and the second switch unit (6.1", 6.2", 6.3") respectively assigned to the one of the actuators (5.1, 5.2, 5.3).

7. The switching device (2) of any preceding claim, wherein
the first and second switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") assigned to one of the actuators (5.1, 5.2, 5.3) are based on different switching principles.

8. The switching device (2) of any preceding claim, wherein
one of the first and second switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") assigned to one of the actuators (5.1, 5.2, 5.3) is configured as a normally open switch and the other one is configured as a normally closed switch.

9. The switching device (2) of claim 8, wherein
upon operation of one of the actuators (5.1, 5.2, 5.3), the first switch unit (6.1', 6.2', 6.3') assigned to the one of the actuators (5.1, 5.2, 5.3) is configured to increase an electric potential at one of the output channels (9, 9', 9") and the second switch unit (6.1", 6.2", 6.3") assigned to the one of the actuators (5.1, 5.2, 5.3) is configured to decrease the electric potential at another one of the output channels (9, 9', 9").

10. The switching device (2) of any preceding claim, wherein
the output channels (9, 9', 9") are provided with a respective connection point (12) for providing an additional different signal at a respective output channel (9, 9', 9").

11. The switching device (2) of any preceding claim, further comprising
a function-changing switch (8) configured to provide a function-changing signal at a separate function-changing output channel (13) to the medical apparatus (1).

12. A medical apparatus (1) comprising
a switching device (2) of one of the preceding claims, and
an evaluation unit (4) configured to interpret the output signals of the output channels (9, 9', 9") in order to actuate the respectively defined action of the medical apparatus (1).

13. A method for actuating a predefined action of a medical apparatus (1) according to claim 12, the method comprising the steps:

operating a predefined one of the actuators (5.1, 5.2, 5.3) of the switching device (2), thereby, respectively switching one of the first switch units (6.1', 6.2', 6.3') and one of the second switch units (6.1", 6.2", 6.3") respectively assigned to the predefined one of the actuators (5.1, 5.2, 5.3) to change the switching states of the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3"); and
outputting, in a redundant manner by the switching device (2) at defined different output channels (9, 9', 9"), the output signals respectively defined by the switching states of the first switch unit (6.1', 6.2', 6.3') and the second switch unit (6.1", 6.2", 6.3") assigned to the predefined one of the actuators (5.1, 5.2, 5.3) and by the switching states of further switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3") assigned to another actuator (5.1, 5.2, 5.3) and being connected to the defined output channel (9, 9', 9").

14. The method according to claim 13, wherein,
depending on the switching state of the switch units (6.1', 6.2', 6.3', 6.1", 6.2", 6.3"), the output signals at one of the output channels (9, 9', 9") respectively differ in an electric potential with respect to an input channel (10).

15. The method according to claim 13 or 14, further comprising the step:
operating a function-changing switch (8), thereby providing a function-changing signal at a separate function-changing output channel (13).

Fig. 1

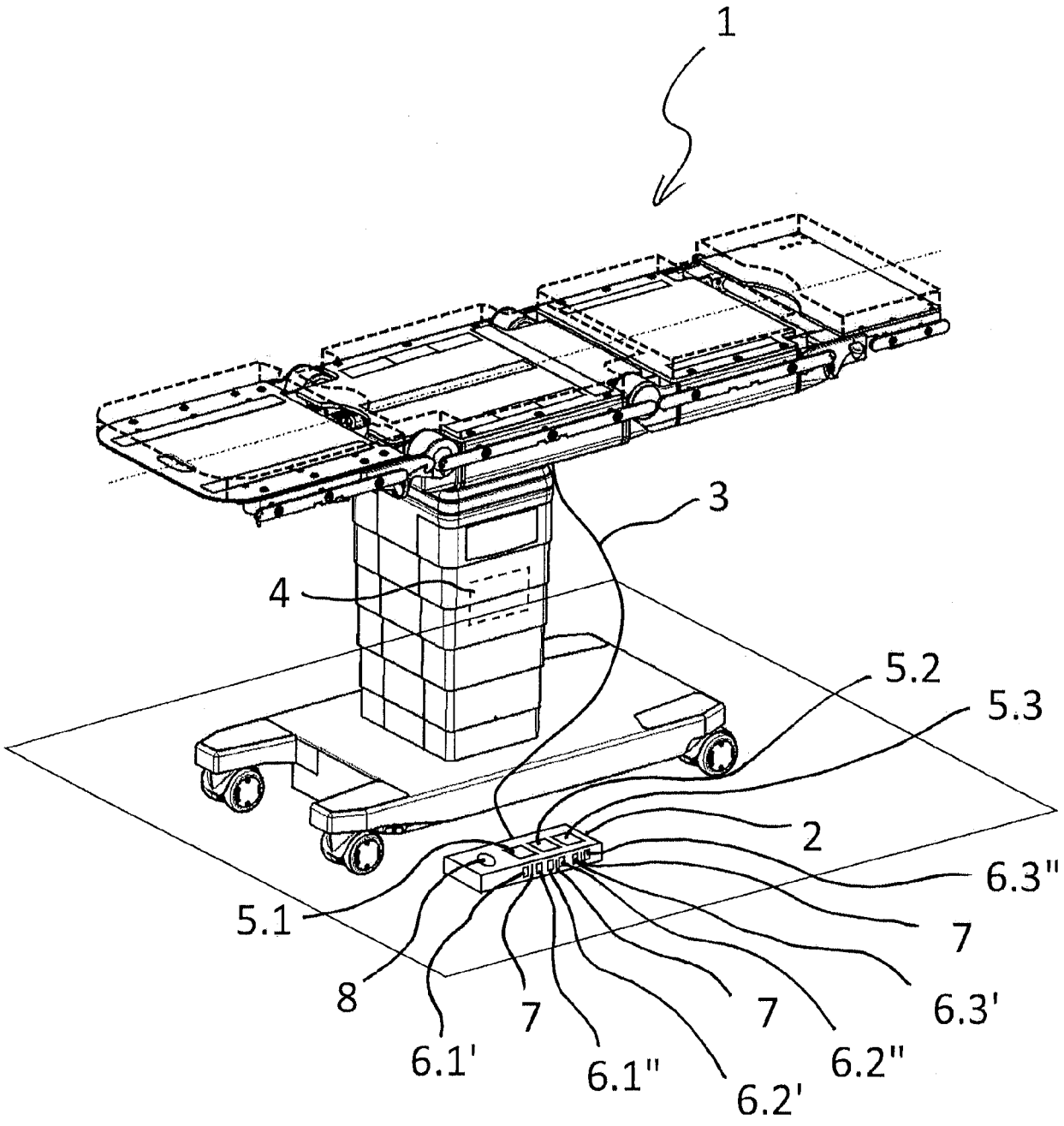


Fig. 2

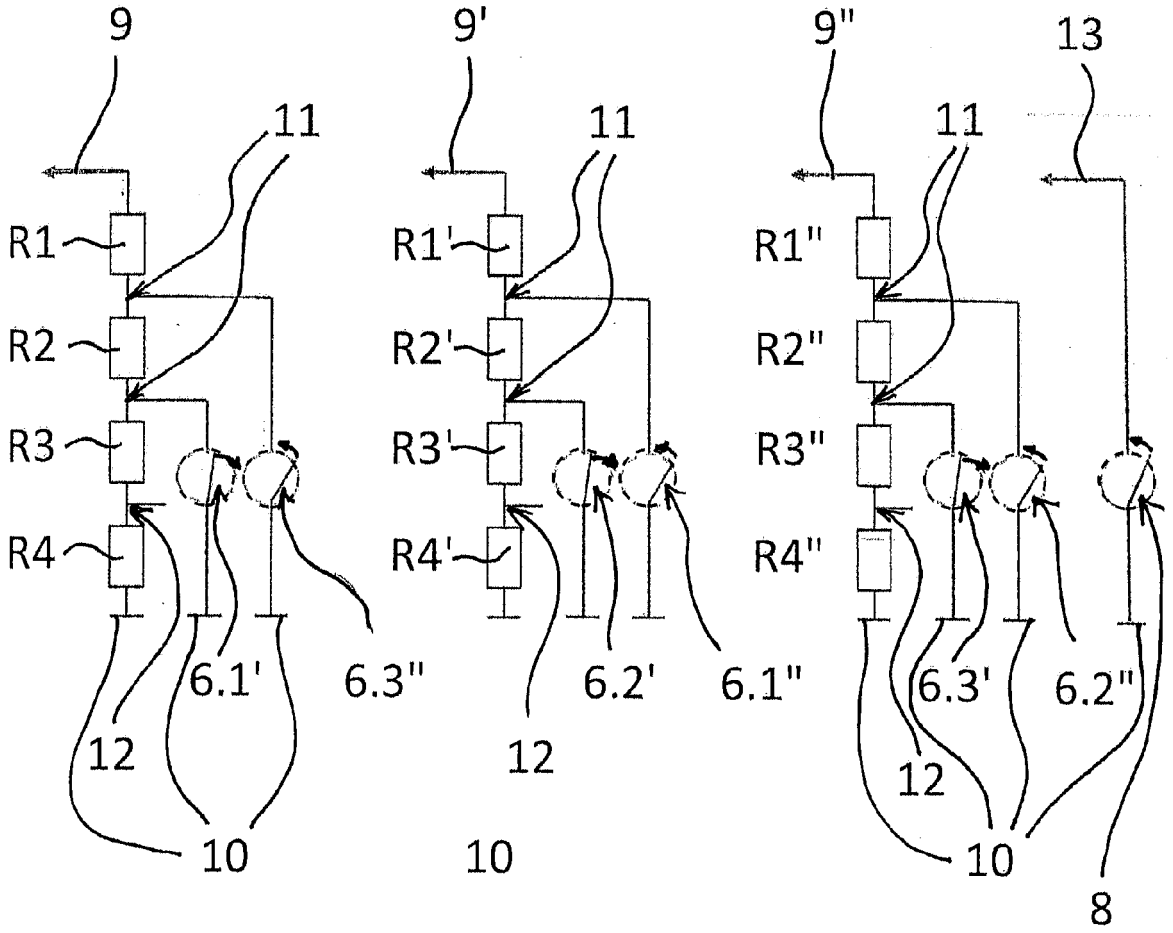
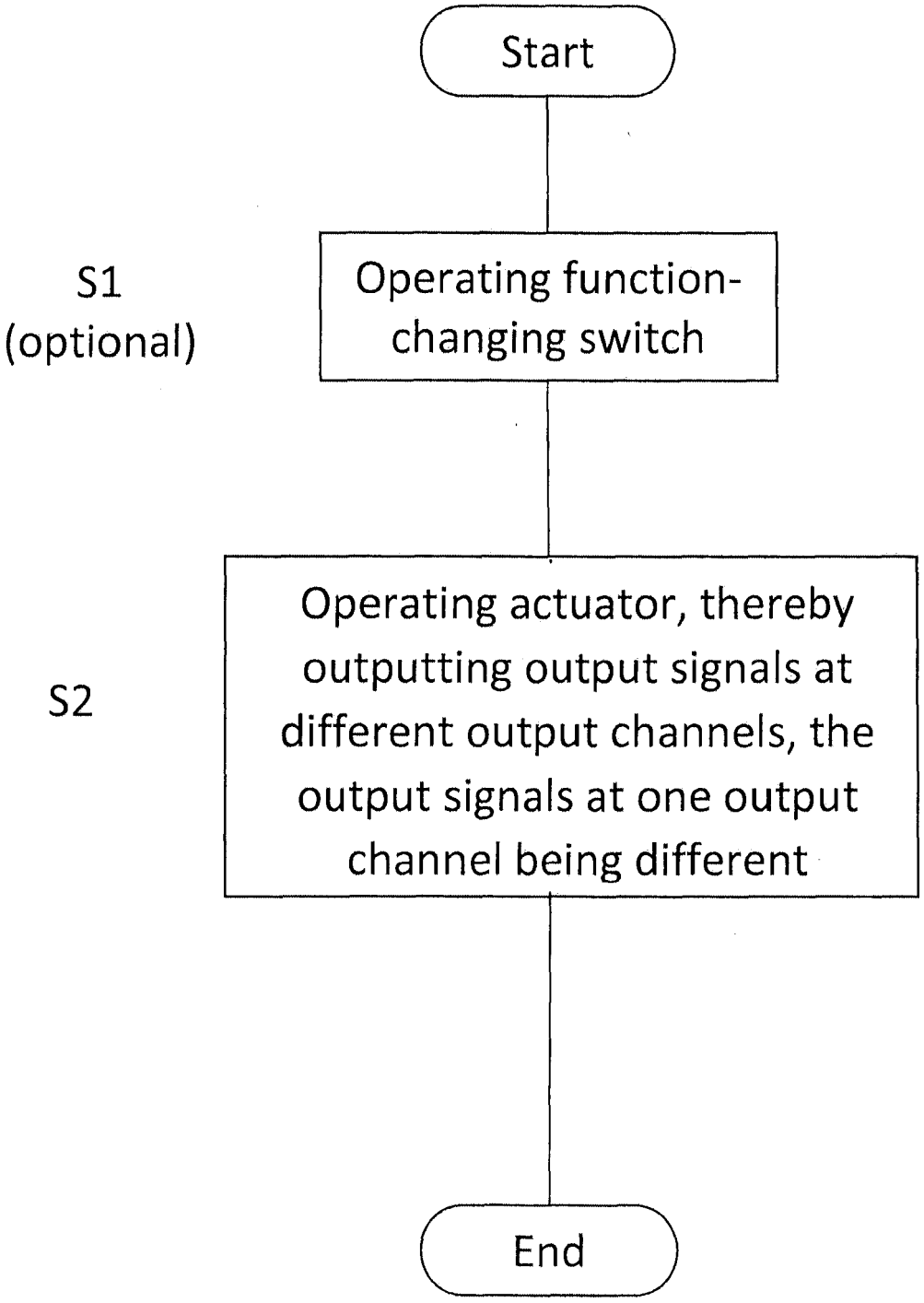

9
11
R1
R2
R3
R4
6.1'
6.3"
12
10
9'
11
R1'
R2'
R3'
R4'
6.2'
6.1"
12
10
9"
13
11
R1"
R2"
R3"
R4"
6.3'
6.2"
12
10
8

Fig.3


Start
S1
(optional)
Operating function-changing switch
S2
Operating actuator, thereby outputting output signals at different output channels, the output signals at one output channel being different
End

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 17 5340

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	US 2009/090610 A1 (GRIMM MATTHIAS [DE] ET AL) 9 April 2009 (2009-04-09)	1-3, 5-11, 13-15	INV. H01H13/70 A61G13/02
Y	* paragraphs [0006] - [0009], [0016] -	12	
A	[0043], [0048] - [0052] *	4	ADD. H01H3/14
	* figures 1,2,3,5 *		

Y	US 5 214 360 A (GONSER DONALD I [US] ET AL) 25 May 1993 (1993-05-25)	12	
	* column 6, line 1 - column 7, line 25 *		
	* column 3, line 24 - column 4, line 58 *		
	* figures 1,2,4-7 *		

TECHNICAL FIELDS SEARCHED (IPC)

H03K
H01H
A61G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 December 2019	Ledoux, Serge

CATEGORY OF CITED DOCUMENTS

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

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

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 17 5340

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.

04-12-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009090610 A1	09-04-2009	AT 517793 T	15-08-2011
		BR PI0620684 A2	22-11-2011
		CN 101346265 A	14-01-2009
		DE 102005060810 A1	12-07-2007
		EP 1966016 A1	10-09-2008
		PL 1966016 T3	30-11-2011
		US 2009090610 A1	09-04-2009
		WO 2007071299 A1	28-06-2007
US 5214360 A	25-05-1993	CA 2131833 A1	16-09-1993
		EP 0631698 A1	04-01-1995
		US 5214360 A	25-05-1993
		US 5324900 A	28-06-1994
		WO 9318575 A1	16-09-1993

EPO FORM P0459

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