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(54) **ELEVATOR DOOR COMPONENT MONITORING SYSTEMS AND METHODS**

(57) Elevator door air cord monitoring systems and methods are provided. The elevator door air cord monitoring systems include a door air cord (702) having a first end (706) and a second end (708) and an air cord monitoring system (714) connected to the door air cord (702). The air cord monitoring system (714) includes a power source electrically coupled to the door air cord (702) and configured to transmit a current through the door air cord and a controller arranged to monitor a resistivity signal associated with the current passed through the door air cord (702), wherein the controller is configured to generate a first maintenance signal if the monitored resistivity signal exceeds a threshold value.

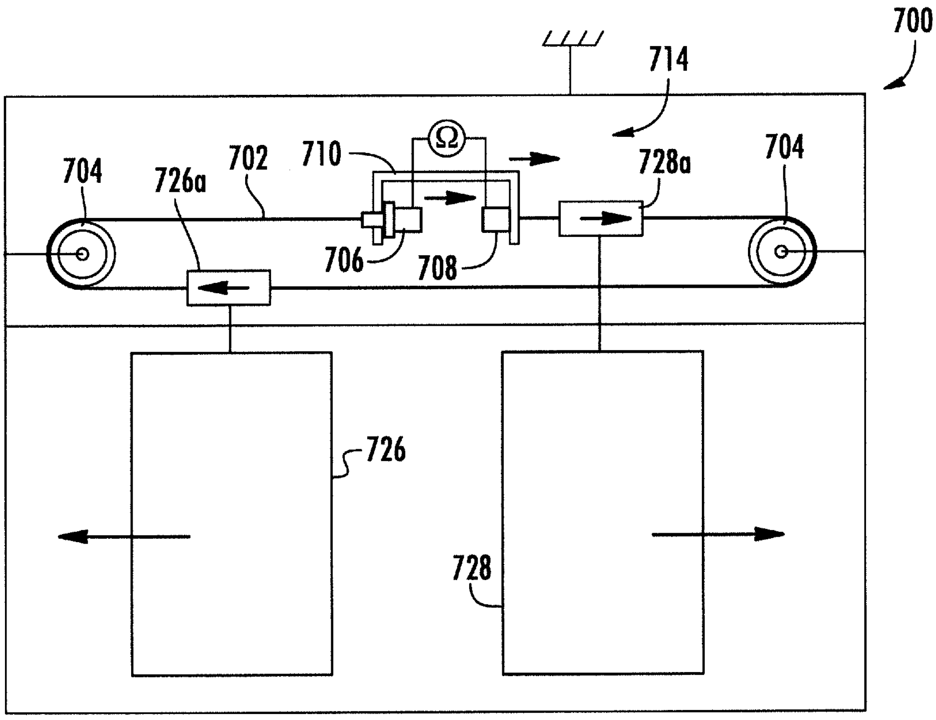

FIG. 7

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Description

BACKGROUND

[0001] The subject matter disclosed herein generally relates to elevator systems and, more particularly, to monitoring systems, devices, and processes for monitoring the health of elevator door components and systems.

[0002] Elevator door systems typically include one or more car doors and one or more landing doors that operate in concert to enable ingress to and egress from an elevator car. In such systems, linkages between car doors and landing doors are used to open and close the elevator doors, such that the landing doors and elevator car doors open in tandem or simultaneously. Different elevator door system operations exist. For example, central opening doors typically have two doors that open/close at a central location in a landing opening and the doors move apart or away from each other, with the doors moving along a door air cord. Telescopic opening doors typically open/close from one side of a landing opening. In such arrangements, one door panel is configured to move faster than another door panel such that a telescoping motion is achieved. Due to the arrangement of the linkages relative to the door operating unit and each door, in such telescopic opening systems, it is known that one door panel will move at a varying speed relative to another door panel.

[0003] As noted, the elevator system doors are typically fixedly connected by a cord (known in the art as an air cord) disposed about a pair of pulleys. For example, as a first landing door opens or closes, a second (associated) landing door also opens or closes due to its connection via the air cord, in both central opening and telescopic systems. In telescopic arrangements, because the doors are connected via the air cord, the doors will travel at the same speed, thus providing a smooth opening or closing operation. In telescopic arrangements, as noted above, the air cord system enables one door panel to move faster (typically twice as fast) than another door panel of the door. The increased speed of one panel as compared to the other enables a smooth opening/closing operation of the door.

[0004] The air cord may wear over time, requiring maintenance, such as inspection, repair, and/or replacement. Accordingly, it may be advantageous to provide improved inspection techniques associated with elevator system door air cords.

SUMMARY

[0005] According to some embodiments, elevator door component monitoring systems are provided. The elevator door component monitoring systems include a door air cord having a first end and a second end and an air cord monitoring system connected to the door air cord. The air cord monitoring system includes a power source electrically coupled to the door air cord and configured to transmit a current through the door air cord and a controller arranged to monitor a resistivity signal associated with the current passed through the door air cord, wherein the controller is configured to generate a first maintenance signal if the monitored resistivity signal exceeds a threshold value.

[0006] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator door component monitoring systems may include that the threshold value represents a predetermined amount of wear on the door air cord.

[0007] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator door component monitoring systems may include that the threshold value is a first threshold value, wherein the first threshold value is a predetermined amount of wear on the door air cord, and the controller is further configured to generate a second maintenance signal if the monitored resistivity signal exceeds a second threshold value.

[0008] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator door component monitoring systems may include that the second threshold value represents a failure of the door air cord.

[0009] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator door component monitoring systems may include a bracket, wherein the first end and the second end of the door air cord are each connected to the bracket and an air cord insulator arranged between the first end of the door air cord and the bracket to electrically isolate the first end of the door air cord.

[0010] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator door component monitoring systems may include that the power source is at least one of an ohmmeter, a voltmeter, an ammeter, and a multimeter.

[0011] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator door component monitoring systems may include that the power source and the controller are a single unit.

[0012] According to some embodiments, elevator systems including elevator door air cord monitoring systems of any described embodiment are provided.

[0013] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator systems may include a landing door having a landing door lintel, wherein the door air cord is a door air cord of the landing door and the door air cord is located within the landing door lintel.

[0014] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator systems may include an elevator car door having an elevator car door lintel, wherein the door air cord is a door air cord of the elevator car door and the door air cord is located within the elevator car door lintel.

[0015] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator systems may include a telescopic elevator door having one or more door panels operably connected to the door air cord.

[0016] In addition to one or more of the features described above, or as an alternative, further embodiments of the elevator systems may include a central opening elevator door having one or more door panels operably connected to the door air cord.

[0017] According to some embodiments, methods of monitoring the structural health of door air cords of elevator systems are provided. The methods include passing an electrical current through an elevator system door air cord, monitoring an electrical resistivity of the door air cord by monitoring the electrical current in the elevator system door air cord, and when a monitored resistivity signal exceeds a threshold value, generating a maintenance signal.

[0018] In addition to one or more of the features described above, or as an alternative, further embodiments of the methods may include that the threshold value is a first threshold value and the generated maintenance signal is a first maintenance signal, the method further comprising, when a monitored resistivity signal exceeds a second threshold value, generating a second maintenance signal.

[0019] In addition to one or more of the features described above, or as an alternative, further embodiments of the methods may include calibrating an initial resistance value associated with the elevator system door air cord.

[0020] The foregoing features and elements may be combined in various combinations without exclusivity, unless expressly indicated otherwise. These features and elements as well as the operation thereof will become more apparent in light of the following description and the accompanying drawings. It should be understood, however, that the following description and drawings are intended to be illustrative and explanatory in nature and non-limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The subject matter is particularly pointed out and distinctly claimed at the conclusion of the specification. The foregoing and other features, and advantages of the present disclosure are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic illustration of an elevator system that may employ various embodiments of the present disclosure;

FIG. 2 is a schematic illustration of a landing floor of an elevator system with a hall call panel that may employ various embodiments of the present disclosure;

FIG. 3 is a schematic illustration of an example of an elevator system door air cord system that can employ embodiments of the present disclosure;

FIG. 4 is a schematic illustration of an air cord monitoring system in accordance with an embodiment of the present disclosure;

FIG. 5 is a schematic plot of a resistivity signal as monitored in accordance with an embodiment of the present disclosure;

FIG. 6 is a flow process for structural health monitoring of an elevator system door air cord in accordance with an embodiment of the present disclosure;

FIG. 7 is a schematic illustration of an air cord monitoring system in accordance with an embodiment of the present disclosure for a central opening door system;

FIG. 8A is a schematic illustration of an air cord monitoring system in accordance with an embodiment of the present disclosure for a telescopic opening door system, illustrating a first state of operation; and

FIG. 8B is a schematic illustration of an air cord monitoring system in accordance with an embodiment of the present disclosure for a telescopic opening door system, illustrating a second state of operation.

DETAILED DESCRIPTION

[0022] FIG. 1 is a perspective view of an elevator system 101 including an elevator car 103, a counterweight 105, a roping 107, a guide rail 109, a machine 111, a position encoder 113, and an elevator controller 115. The elevator car 103 and counterweight 105 are connected to each other by the roping 107. The roping 107 may include or be configured as, for example, ropes, steel cables, and/or coated-steel belts. The counterweight 105 is configured to balance a load of the elevator car 103 and is configured to facilitate movement of the elevator car 103 concurrently and in an opposite direction with respect to the counterweight 105 within an elevator shaft 117 and along the guide rail 109.

[0023] The roping 107 engages the machine 111, which, in this illustrative embodiment, is part of an overhead structure of the elevator system 101, although other arrangements are possible without departing from the scope of the present disclosure. The machine 111 is configured to control movement between the elevator car 103 and the counterweight 105. The position encoder 113 may be mounted on an upper sheave of a speed-governor system 119 and may be configured to provide position signals related to a position of the elevator car

103 within the elevator shaft 117. In other embodiments, the position encoder 113 may be directly mounted to a moving component of the machine 111, or may be located in other positions and/or configurations as known in the art.

[0024] The elevator controller 115 is located, as shown in the illustrative arrangement, in a controller room 121 of the elevator shaft 117 and is configured to control the operation of the elevator system 101, and particularly the elevator car 103. In other embodiments the controller 115 can be located in other locations, including, but not limited to, fixed to a landing or landing door or located in a cabinet at a landing. The elevator controller 115 may provide drive signals to the machine 111 to control the acceleration, deceleration, leveling, stopping, etc. of the elevator car 103. The elevator controller 115 may also be configured to receive position signals from the position encoder 113. When moving up or down within the elevator shaft 117 along guide rail 109, the elevator car 103 may stop at one or more landings 125 as controlled by the elevator controller 115.

[0025] The machine 111 may include a motor or similar driving mechanism. In accordance with embodiments of the disclosure, the machine 111 is configured to include an electrically driven motor. The power supply for the motor may be any power source, including a power grid, which, in combination with other components, is supplied to the motor. Although shown and described with a roping system, elevator systems that employ other methods and mechanisms of moving an elevator car within an elevator shaft may employ embodiments of the present disclosure. FIG. 1 is merely a non-limiting example presented for illustrative and explanatory purposes.

[0026] FIG. 2 is a schematic illustration of an elevator system 201 that may incorporate embodiments disclosed herein. As shown in FIG. 2, an elevator car 203 is located at a landing 225. The elevator car 203 may be called to the landing 225 by a passenger or mechanic 227 that desires to travel to another floor within a building or perform maintenance on a portion of the elevator system 201. The elevator car 203 includes car doors 231 and the landing 225 includes landing doors 233. When the elevator car 203 is located at the landing 225, an opening operation can be performed wherein a component of the car doors 231 will engage with a component of the landing doors 233 to open both sets of doors 231, 233 and then enable ingress and egress between the elevator car 203 and the landing 225.

[0027] A landing door lintel 229 of the elevator system 201 (which may be located at one or more landings 225) can house various of the components of the doors to enable operation thereof. For example, an elevator door air cord can be contained within the landing door lintel 229.

[0028] As shown in FIG. 3, an illustration of an elevator door system 300 is schematically shown. The elevator door system 300 includes a continuous door air cord 302 having an upper run 304 and a lower run 306, a pair of pulleys 308 about which the door air cord 302 is disposed, a door lock (shown schematically) 310, a coupling 312 for attaching a first landing door 314 to the upper run 304 of the door air cord 302, a stop 316 fixedly attached to a second landing door 318, and a clamp 320 attached to the lower run 306 of the door air cord 302. The door lock 310, in this embodiment, includes of a latch 322 and a catch 324. The elevator door system 300 illustratively shown in FIG. 3 is representative of a central-opening landing door arrangement, where landings doors 314, 318 open by moving away from each other. However, those of skill in the art will appreciate that other door operations are possible without departing from the scope of the present disclosure. For example, embodiments of the present disclosure may be applicable to telescopic or side opening/closing doors.

[0029] As will be appreciated by those of skill in the art, both the landing doors and the elevator car doors can include door air cords. The door air cords may be wired or metal cords that are used for operation of the elevator system doors. Over time, the door air cords may suffer wear, fatigue, failure, etc. and thus maintenance may be required thereon. If a door air cord fails, one or more of the elevator system doors may not operate, which can lead to down-time, lack of operation, etc. for the elevator system while maintenance is performed. Because the door air cords are located within the lintel of the system, visual inspection is difficult or impossible, and thus it may be difficult to determine when wear has occurred, and preventative maintenance is difficult to perform.

[0030] Accordingly, embodiments provided herein are directed to monitoring systems for elevator system door air cords. Because the door air cords are metal wires, electrical current can be passed through the door air cords, and electrical monitoring can be used to determine a health state of the door air cord.

[0031] For example, turning to FIG. 4, a schematic illustration of an elevator door system 400 in accordance with an embodiment of the present disclosure is shown. The illustration of FIG. 4 omits the elevator doors for simplicity, but those of skill in the art will appreciate that one or more elevator doors may be operably connected to the elevator door system 400. The elevator door system 400 includes a door air cord 402 disposed on a pair of pulleys 404. The elevator door system 400 may be a schematic representation of a telescopic door operation, as will be appreciated by those of skill in the art. The door air cord 402 is a metallic wire, roping, cord, etc. having a first end 406 and a second end 408. As shown, both the first end 406 and the second end 408 of the door air cord 402 are secured to a bracket 410. The bracket 410 is a metallic bracket that is mounted to (or part of) a structural lintel 412 (e.g., landing door lintel, elevator car door lintel) or other framing, structure, support, etc. of an elevator system, as will be appreciated by those of skill in the art. In some arrangements, the bracket may be fixedly mounted or attached to the lintel, and in other arrangements, the bracket may be movably mounted to the lintel, depending on the door operation mechanism, as will be appreciated by those of skill in the art.

[0032] An air cord monitoring system 414 is shown electrically coupled to the door air cord 402. The air cord monitoring system 414 includes a controller 416, an electrical source 420, a ground 422, and an air cord insulator 424. The controller 416 can be a computer system, electrical control circuit, processor, or other type of control system and may, in some embodiments, include memory or digital storage, busses, processors, integrated circuits, etc., as will be appreciated by those of skill in the art. Further, in some embodiments, the controller 416 and the electrical source 420 can be integrated into a single unit.

[0033] In some embodiments, the controller 416 and/or the electrical source 420 may be or include an ohmmeter that can supply a current into the door air cord 402 with a complete circuit to the ground 422. In other arrangements, the controller 416 and/or the electrical source 420 can by any type of system arranged to measure (directly or indirectly), monitor, and/or determine a resistivity of an electrical system (e.g., a resistivity of the door air cord 402). For example, voltmeters, ammeter, multimeter, etc. can be used or incorporated into the systems described herein without departing from the scope of the present disclosure.

[0034] The controller 416 and/or the electrical source 420 are arranged to determine an electrical resistivity signal that passes through the door air cord 402. For example, as illustratively shown, the arrows along the door air cord 402 illustrate a direction of current through a monitored circuit of the air cord monitoring system 414. Current will pass from the electrical source 420 into the first end 406 of the door air cord 402. The air cord insulator 424 prevents the circuit from shorting out as the door air cord 402 passes through the bracket 410 at the first end 406. The current will then flow through the door air cord 402 toward the second end 408 where the electrical current will flow into and through the bracket 410 and the structural lintel 412 to the ground 422. As such, the air cord monitoring system 414 can monitor the current that passes through the door air cord 402. Advantageously, because the door air cord 402 is a metal wire, cord, or roping, the state of health of the door air cord 402 may be monitored through monitoring an electrical resistivity of the system.

[0035] For example, when the door air cord 402 is in normal or healthy condition, the electrical resistivity may be low, as wear occurs, the electrical resistivity will increase, and at some point, if the door air cord 402 breaks, the effective resistivity would be infinite (no current passing through the door air cord 402).

[0036] Turning to FIG. 5, a schematic plot 500 of an electrical resistivity signal 502 in accordance with a monitoring process of the present disclosure is shown. In plot 500, the horizontal axis is time and the vertical axis is resistivity. The time axis is divided into three separate periods, a first period T_1, a second period T_2, and a third period T_3. An air cord monitoring system, similar to that shown and described with respect to FIG. 4, can be used to monitor a structural health of a door air cord by monitoring a resistivity signal passed through the door air cord. The first period T_1 is a period representative of normal operation and structural health of the door air cord, and thus an initial resistance value R_0 is present. That is, a base line, or initial resistivity signal value may be determined to indicate the resistivity of the signal when the door air cord is new, non-worn, and/or undamaged.

[0037] As the door air cord is used, structural wear will occur to the door air cord, which will in turn impact a resistance of the system. As the door air cord is used, the second period T_2 will be present, wherein the resistivity is greater than the initial resistance value R_0, but is not infinite (which is present in the third period T_3). One or more intermediate determined resistivity values R_1, R_2, can be determined throughout the life of the door air cord. The determined resistivity values R_1, R_2 will be compared against the initial resistance value R_0 and/or compared to one or more threshold or predetermined values. If the determined resistivity values R_1, R_2 exceed a predetermined value or threshold, an alarm or other type of notification can be generated by a controller of the air cord monitoring system to indicate that inspection, maintenance, and/or repair may be required.

[0038] The third period T_3 is a period wherein the door air cord is broken and the resistivity signal is at a maximum value R_3. The maximum value R_3 in some embodiments may be infinite, in that no signal is detected by the air cord monitoring system. Such may occur if the door air cord breaks and a complete electrical circuit cannot be achieved.

[0039] In some embodiments, the monitoring may be continuous, and in other embodiments, the current passed through the door air cord may be generated at set intervals, on demand, or based on a schedule.

[0040] Turning now to FIG. 6, a flow process 600 for monitoring a structural health of an elevator system door air cord in accordance with an embodiment of the present disclosure is shown. The flow process 600 may be performed using an air cord monitoring system as shown and described above, and may be applied to landing door air cords and/or elevator car door air cords.

[0041] At block 602, a calibration step is performed wherein an initial resistivity value is determined. The initial resistivity value may be indicative of a healthy or normally operational (e.g., undamaged, non-worn) door air cord. In some embodiments, the calibration may be set to "zero-out" the base value. In other embodiments, an absolute (actual) resistivity determination or measurement may be obtained and changes therefrom may be monitored. As will be appreciated by those of skill in the art, the initial calibration of block 602 may be performed in any number of ways, without departing from the scope of the present disclosure. It is noted that at block 602, electrical current is passed through the door air cord to obtain the initial resistivity value, as would be readily appreciated by those of skill in the art.

[0042] At block 604, a power source (e.g., electrical power source, such as an ohmmeter, a voltmeter, an ammeter, or a multimeter) is used to pass electrical current through the door air cord.

[0043] At block 606, a controller or other monitoring device (e.g., the electrical power source) monitors a resistivity signal passing through the door air cord.

[0044] At block 608, if the monitored resistivity signal exceeds a first threshold, the system is arranged to generate a first maintenance signal. The first threshold may be a predetermined value or range of values for the resistivity signal. In some embodiments, the first threshold may be based on the initial resistivity value, and may be an absolute or percentage change relative to the initial resistivity value. Through modeling, simulation, testing, historical data, etc., the first threshold can be set for the specific or particular door air cord, with the threshold representing a specific or range of wear or degradation of structural health of the door air cord. For example, in some embodiments, the first threshold may be representative of an amount of wear or damage having occurred to the door air cord, but prior to complete failure. The first maintenance signal can be used to indicate that inspection or other preventative maintenance operation is required (or recommended) to be performed on the door air cord. In some embodiments, the first maintenance signal may be a light indicator in the elevator car, at the landing, or at some other location that is part of the elevator system. In some embodiments, the first maintenance signal may be an automatically generated message or signal that is transmitted or displayed on a computer or other display that is associated with the elevator system.

[0045] At block 610, if the monitored resistivity signal exceeds a second threshold, the system is arranged to generate a second maintenance signal. The second threshold may be a predetermined value or range of values for the resistivity signal. In some embodiments, the second threshold may be based on the initial resistivity value, and may be an absolute or percentage change relative to the initial resistivity value. Through modeling, simulation, testing, historical data, etc., the second threshold can be set for the specific or particular door air cord, with the threshold representing a specific or range of wear or degradation of structural health of the door air cord. For example, in some embodiments, the second threshold may be representative of a complete failure of the door air cord. The second maintenance signal can be used to indicate that a maintenance operation is required to be performed on the door air cord, such as complete replacement of the door air cord, or a portion thereof. In some embodiments, the second maintenance signal may be a light indicator in the elevator car, at the landing, or at some other location that is part of the elevator system. In some embodiments, the second maintenance signal may be an automatically generated message or signal that is transmitted or displayed on a computer or other display that is associated with the elevator system.

[0046] In some embodiments, multiple first thresholds may be employed. That is, in some embodiments, multiple intermediate threshold values of the resistivity signal may be set to trigger different maintenance signals (e.g., warnings). For example, one first threshold value may be set to prompt an inspection, and another first threshold value may be set when inspection or repair may be required. The different threshold values may be set with increasing resistivity values such that the lowest value is normal operation, with increasing values indicating wear on the door air cord. As such, in the above example, the first threshold is a greater resistivity value than the initial value and the second threshold is a greater resistivity value than the first threshold value.

[0047] Turning now to FIG. 7, a schematic illustration of an elevator door system 700 in accordance with an embodiment of the present disclosure is shown. The elevator door system 700 shown in FIG. 7 is a central opening elevator system, where a first elevator door panel 726 is connected to a door air cord 702 by a first connector 726a and a second elevator door panel 728 is connected to the door air cord 702 by a second connector 728a. The door air cord 702 is fixedly connected to a bracket 710 that is movably mounted to a lintel, contrary to a telescoping door opening system, as will be appreciated by those of skill in the art. Further, the door air cord 702 is connected about a pair of pulleys 704 that, in contrast to a telescoping arrangement, are fixedly connected to the lintel. During operation, when the elevator door panels 726, 728 are opened, the bracket 710 moves to the right (in the illustration), thus moving the door air cord 702 about the pulleys 704.

[0048] As shown, the second connector 728a, fixedly connected to the door air cord 702, will travel to the right in the illustration, and thus the connected second elevator door panel 728 will travel to the right. Simultaneously, the first connector 726a will travel to the left as the door air cord 702 moves about the pulleys 704 and, thus, the second elevator door panel 726 will move to the left. In such arrangements, the elevator door panels 726, 728 will travel at the same speed during the elevator operation. Accordingly, the elevator door panels 726, 728 move away from each other to allow access to an elevator car or landing. The door air cord 702 has a first end 706 and a second end 708, with the elevator door panels 726, 728 suspended thereon by the connectors 726a, 728a. As shown, both the first end 706 and the second end 708 of the door air cord 702 are secured to the bracket 710, as described above. An air cord monitoring system 714, having structure and operation similar to that described above, is shown electrically coupled to the door air cord 702.

[0049] Turning now to FIGS. 8A-8B, schematic illustrations of an elevator door system 800 in accordance with an embodiment of the present disclosure is shown. The elevator door system 800, shown in FIGS. 8A-8B, is a telescopic opening elevator system, with FIG. 8A illustrating a first state of closing and FIG. 8B illustrating a second state of closing. In this arrangement, a first elevator door panel 830 is connected to a pair of pulleys 804 about which a door air cord 802 is connected, with the pulleys 804 being movably connected to a lintel, as will be appreciated by those of skill in the art. A second elevator door panel 832 is connected to the door air cord 802 and is able to travel at a different speed than the first elevator door panel 830. In operation, the first elevator door panel 830 and the second elevator door panel 832 move in the same direction (e.g., to the right) to open or close. The door air cord 802 has a first end 806 and a second end 808, with the second elevator door panel 832 suspended on the door air cord 802, and the first elevator door panel 830 connected to the movable pulleys 804. As shown, both the first end 806 and the second end 808 of the door air cord 802 are secured to a bracket 810 that is fixed to the lintel. An air cord monitoring system 814, having structure and operation similar to that described above, is shown electrically coupled to the door air cord 802. In operation, the first elevator door panel 830 will travel at a first speed and the second elevator door panel 832 will travel at a second speed, typically twice the first speed, to provide a smooth door opening operation.

[0050] In the above embodiments, the air cord monitoring systems 714, 814 may be substantially similar. However, in some embodiments, for example as schematically shown, the ground of the air cord monitoring system 814 of FIGS. 8A-8B may be rivets or other metallic elements that ground into metal of the elevator system. Further, although two types of elevator door operation are shown and described herein, those of skill in the art will appreciate that other types of operation and/or arrangement/attachment of components, parts, and/or elements can be employed without departing from the scope of the present disclosure. That is, embodiments of the present disclosure are directed to air cord monitoring systems for elevators, regardless of the specific elevator door operation and mechanism.

[0051] Advantageously, embodiments provided herein enable monitoring of the structural health of an elevator system door air cord. In some embodiments, such monitoring may be passive and/or continuous, thus eliminating the need for down-time of elevator operation and/or costs associated with scheduled inspection maintenance operations. Further, advantageously, embodiments provided herein enable preventative maintenance to be performed on an elevator system door air cord, prior to failure of the door air cord. Thus, down-time and costs associated with elevator systems can be reduced.

[0052] As used herein, the use of the terms "a," "an," "the," and similar references in the context of description (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or specifically contradicted by context. The modifier "about" used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (e.g., it includes the degree of error associated with measurement of the particular quantity).

[0053] While the present disclosure has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the present disclosure is not limited to such disclosed embodiments. Rather, the present disclosure can be modified to incorporate any number of variations, alterations, substitutions, combinations, sub-combinations, or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the present disclosure. Additionally, while various embodiments of the present disclosure have been described, it is to be understood that aspects of the present disclosure may include only some of the described embodiments.

[0054] Accordingly, the present disclosure is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. An elevator door component monitoring system comprising:

    a door air cord having a first end and a second end; and
    an air cord monitoring system connected to the door air cord, the air cord monitoring system comprising:

        a power source electrically coupled to the door air cord and configured to transmit a current through the door air cord; and
        a controller arranged to monitor a resistivity signal associated with the current passed through the door air cord, wherein the controller is configured to generate a first maintenance signal if the monitored resistivity signal exceeds a threshold value.

2. The elevator door component monitoring system of claim 1, wherein the threshold value represents a predetermined amount of wear on the door air cord.

3. The elevator door component monitoring system of any preceding claim, wherein the threshold value is a first threshold value, wherein the first threshold value is a predetermined amount of wear on the door air cord, and the controller is further configured to generate a second maintenance signal if the monitored resistivity signal exceeds a second threshold value.

4. The elevator door component monitoring system of claim 3, wherein the second threshold value represents a failure of the door air cord.

5. The elevator door component monitoring system of any preceding claim, further comprising:

a bracket, wherein the first end and the second end of the door air cord are each connected to the bracket; and
an air cord insulator arranged between the first end of the door air cord and the bracket to electrically isolate the first end of the door air cord.

6. The elevator door component monitoring system of any preceding claim, wherein the power source is at least one of an ohmmeter, a voltmeter, an ammeter, and a multimeter.

7. The elevator door component monitoring system of any preceding claim, wherein the power source and the controller are a single unit.

8. An elevator system including the elevator door component monitoring system of any preceding claim.

9. The elevator system of claim 8, further comprising:

a landing door having a landing door lintel, wherein the door air cord is a door air cord of the landing door and the door air cord is located within the landing door lintel.

10. The elevator system of claim 8 or 9, further comprising:

an elevator car door having an elevator car door lintel, wherein the door air cord is a door air cord of the elevator car door and the door air cord is located within the elevator car door lintel.

11. The elevator system of any of claims 8 to 10, further comprising a telescopic elevator door having one or more door panels operably connected to the door air cord.

12. The elevator system of any of claims 8 to 11, further comprising a central opening elevator door having one or more door panels operably connected to the door air cord.

13. A method of monitoring the structural health of a door air cord of an elevator system, the method comprising:

passing an electrical current through an elevator system door air cord;
monitoring an electrical resistivity of the door air cord by monitoring the electrical current in the elevator system door air cord; and
when a monitored resistivity signal exceeds a threshold value, generating a maintenance signal.

14. The method of claim 13, wherein the threshold value is a first threshold value and the generated maintenance signal is a first maintenance signal, the method further comprising, when a monitored resistivity signal exceeds a second threshold value, generating a second maintenance signal.

15. The method of any of claims 13-14, further comprising calibrating an initial resistance value associated with the elevator system door air cord.

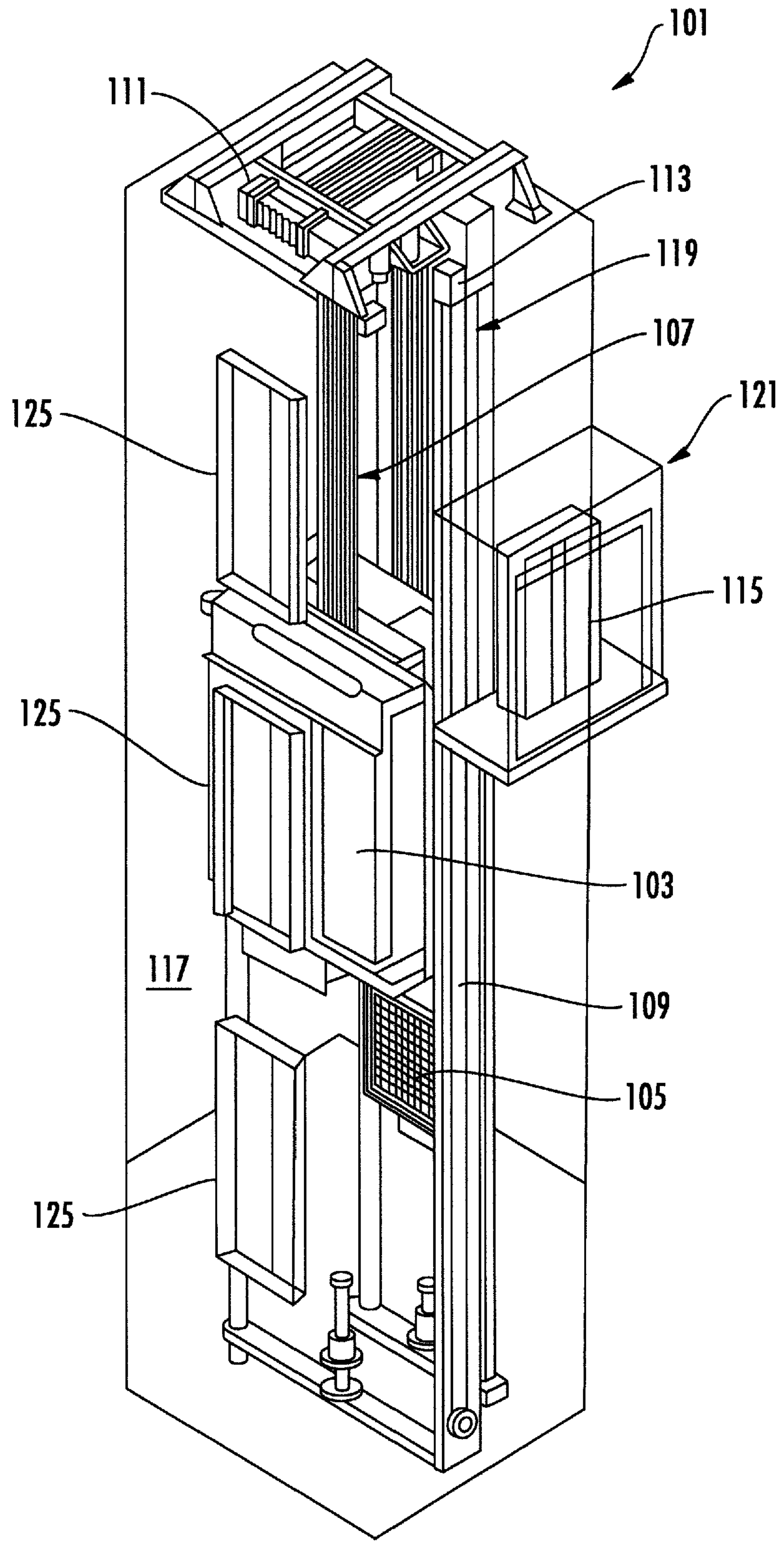


FIG. 1

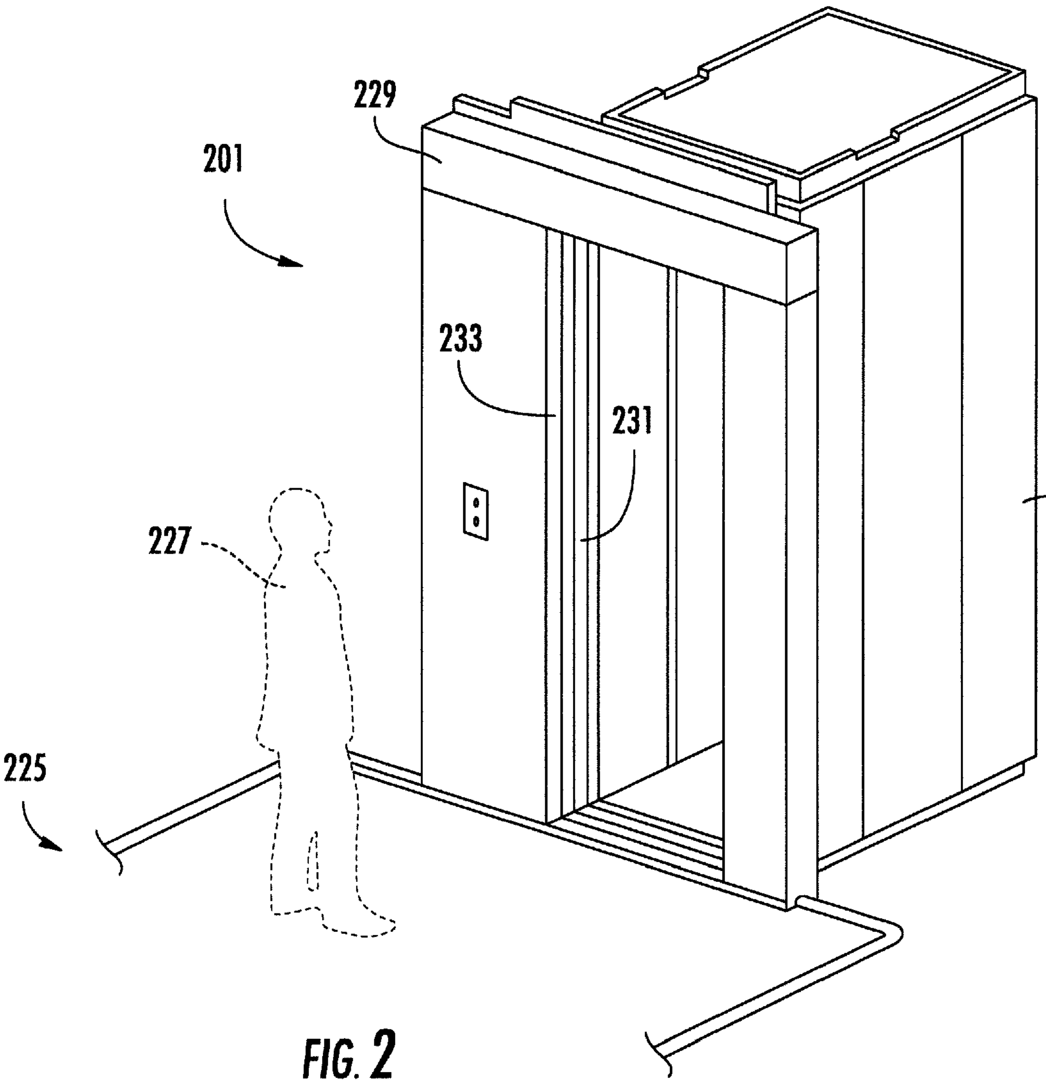
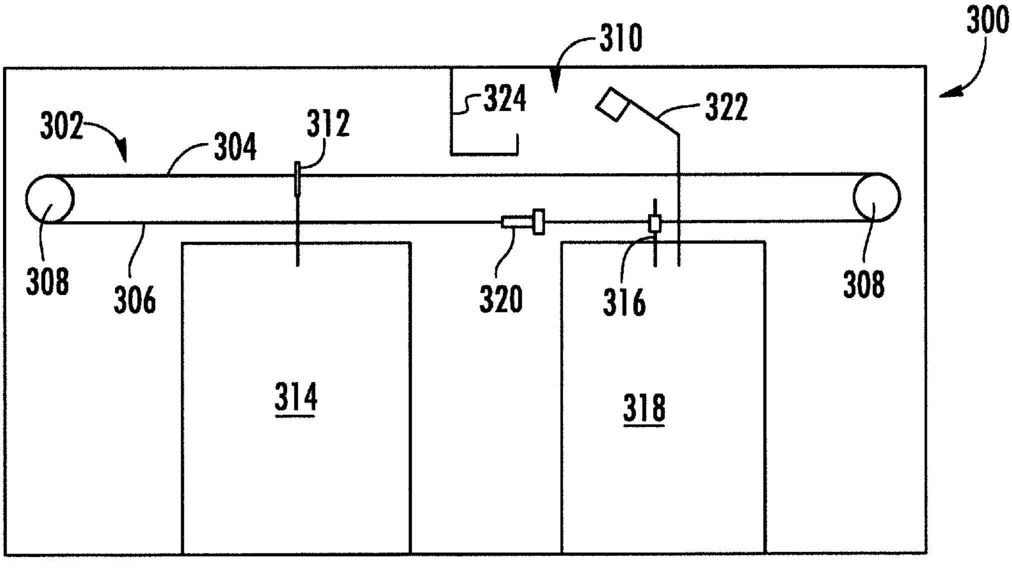

229
201
233
231
203
227
225

FIG. 2


300
310
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320
316
308
314
318

FIG. 3

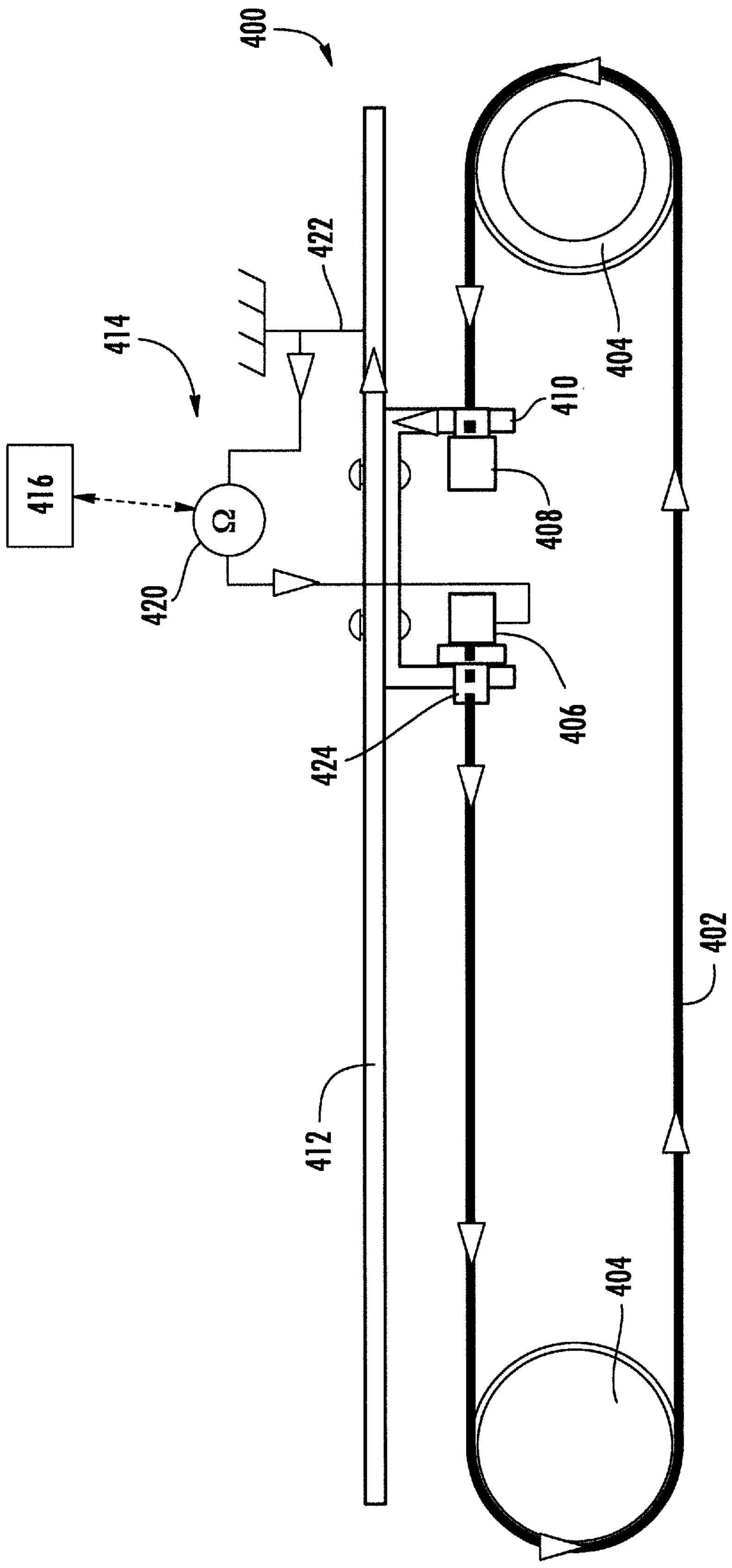


FIG. 4

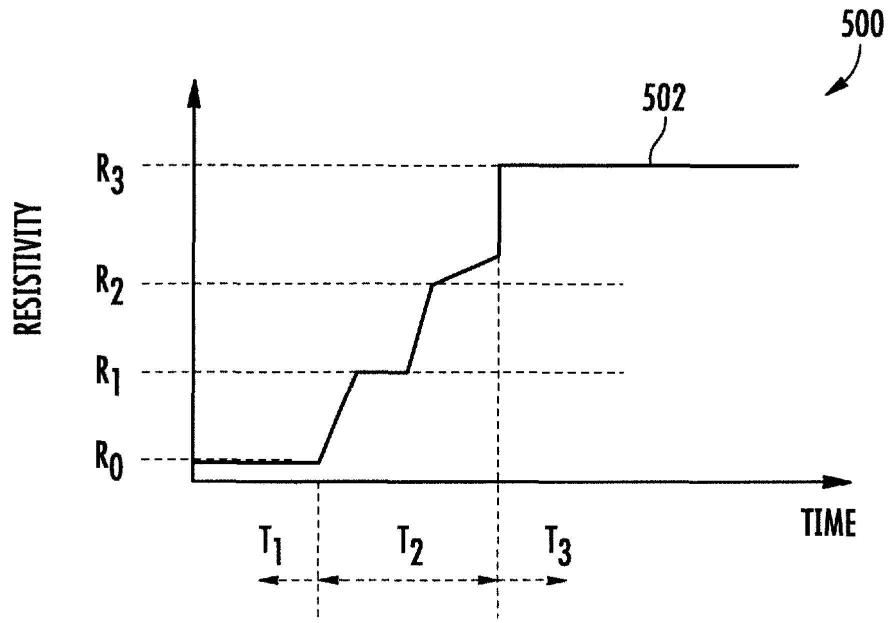

500
502
RESISTIVITY
R3
R2
R1
R0
TIME
T1
T2
T3

FIG. 5

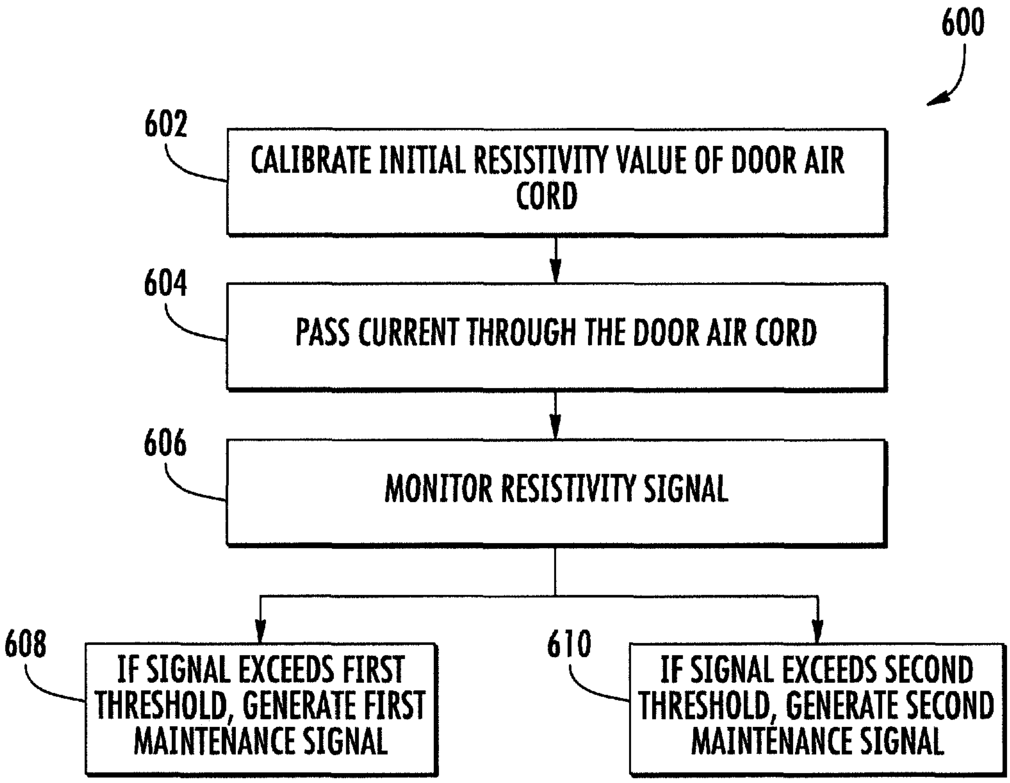

600
602
CALIBRATE INITIAL RESISTIVITY VALUE OF DOOR AIR CORD
604
PASS CURRENT THROUGH THE DOOR AIR CORD
606
MONITOR RESISTIVITY SIGNAL
608
IF SIGNAL EXCEEDS FIRST THRESHOLD, GENERATE FIRST MAINTENANCE SIGNAL
610
IF SIGNAL EXCEEDS SECOND THRESHOLD, GENERATE SECOND MAINTENANCE SIGNAL

FIG. 6

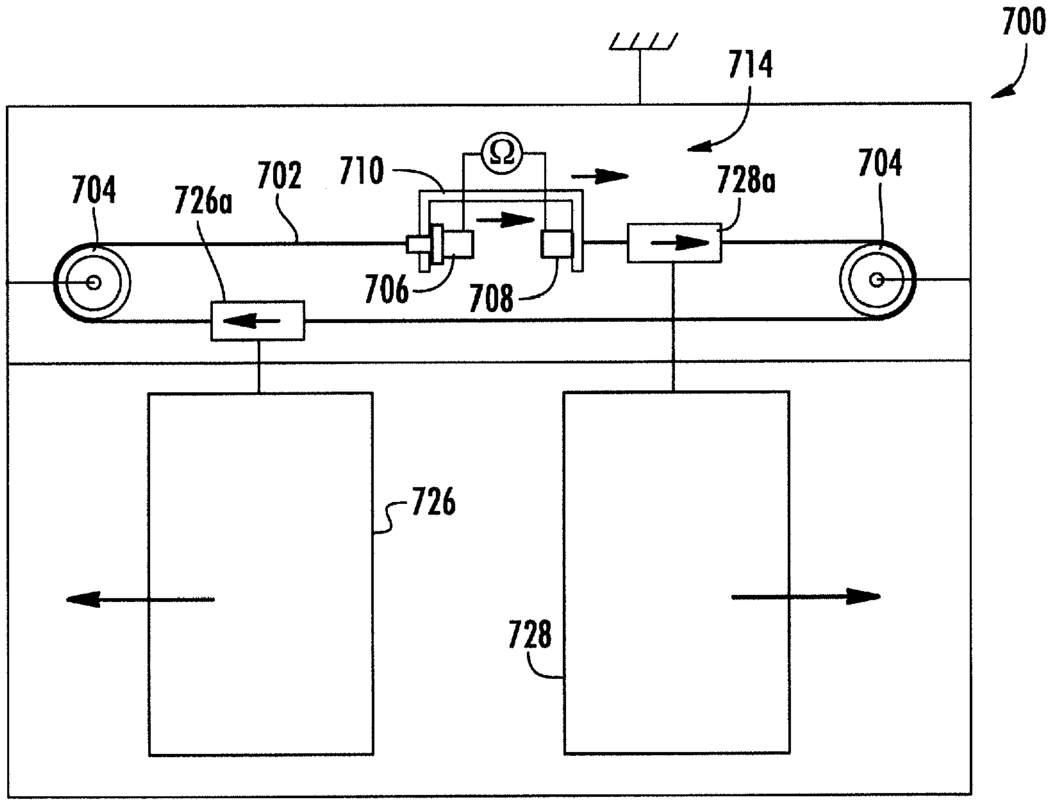


FIG. 7

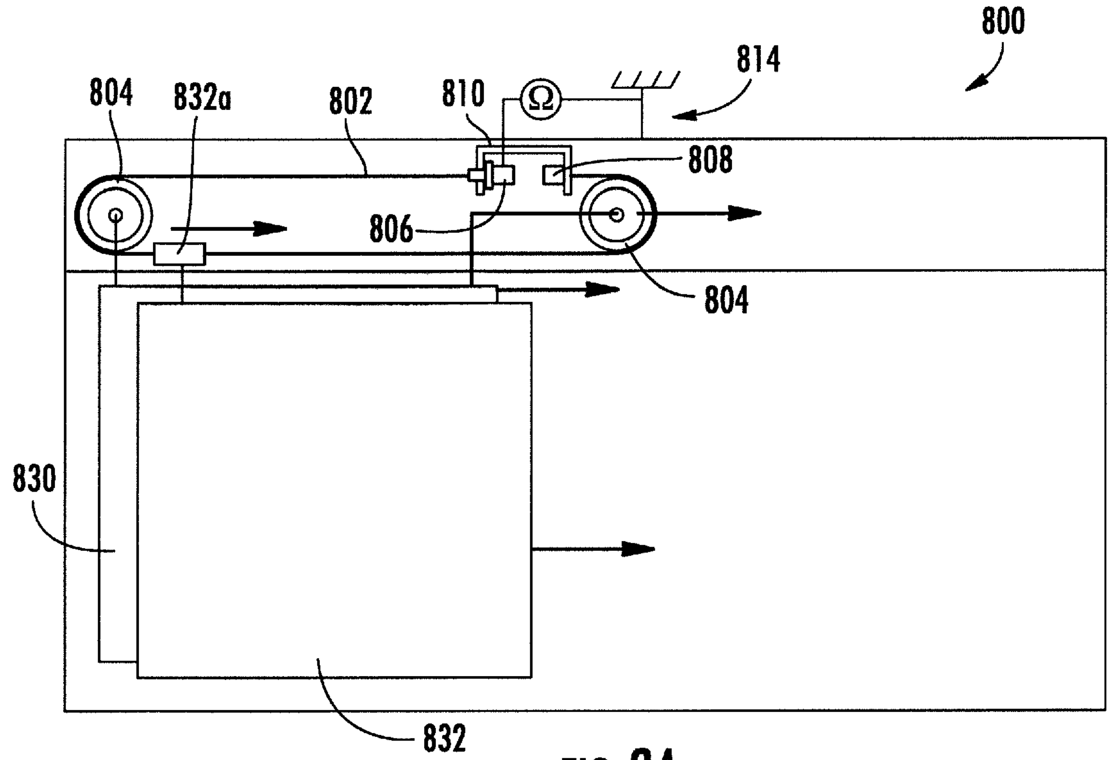
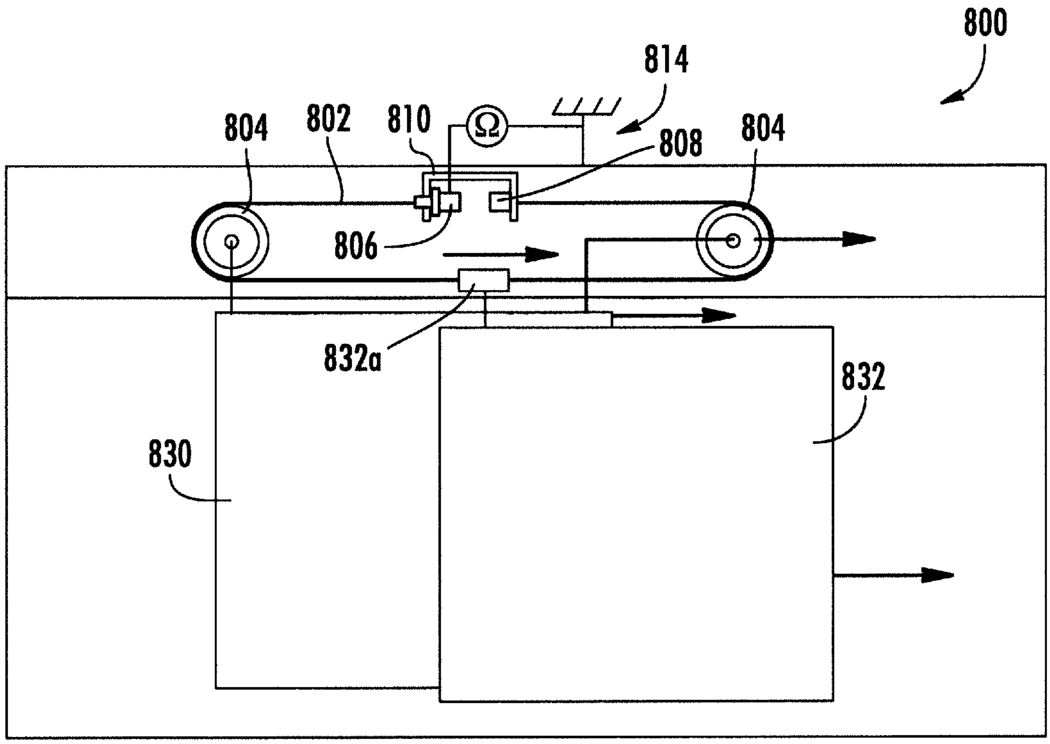

800
814
804
832a
802
810
Ω
808
806
804
830
832

FIG. 8A


800
814
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810
Ω
808
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806
832a
832
830

FIG. 8B

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EUROPEAN SEARCH REPORT

Application Number
EP 18 30 5172

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	JP 2010 100409 A (MITSUBISHI ELECTRIC CORP; MITSUBISHI ELEC BUILDING TECHN) 6 May 2010 (2010-05-06) * abstract; figures 1-6 * -----	1-15	INV. B66B5/00 B66B7/12 B66B13/08 B66B13/14
A	EP 1 556 303 A1 (WITTUR SPA [IT]) 27 July 2005 (2005-07-27) * paragraphs [0011] - [0022] * * claims 1, 3, 13 * -----	1-15	
A	CN 205 381 840 U (ZHOUSHAN NANWEI TONGLI ELEVATOR ENG CO LTD) 13 July 2016 (2016-07-13) * abstract; figure 1 * * paragraphs [0031], [0032] * -----	1-15	
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B66B
E05F

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	5 October 2018	Bleys, Philip

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05-10-2018

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