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(54) **ELEVATOR DOOR SYSTEM**

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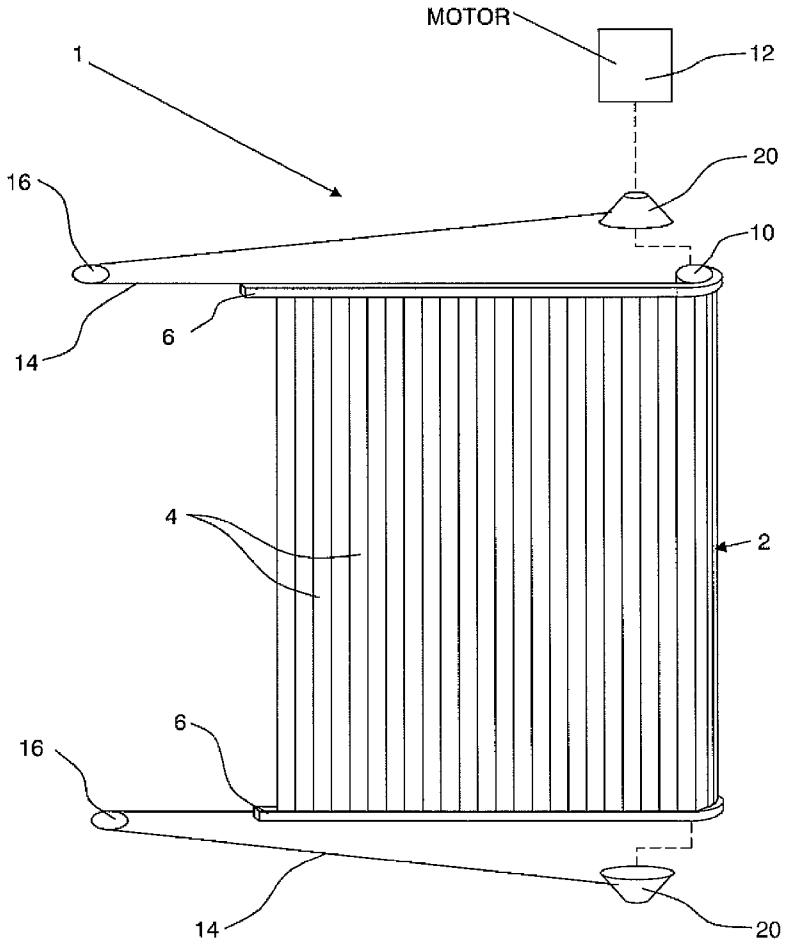
(57) **ABSTRACT**

An elevator door system includes a motor, a vertical reel, and a door attached at a first end to the vertical reel for winding and unwinding thereupon. A force transmission device interconnects a second end of the door and a compensation device whereby the motor simultaneously drives the vertical reel and the compensation device having a variable diameter. In use, as the door is unwound from the vertical reel, the force transmission device is simultaneously wound upon the compensation device. Hence, not only is a thrust exerted on the door by the vertical reel, but a drag is exerted thereupon by the force transmission device. Furthermore, the compensation device has a variable diameter to compensate for, amongst other things, the changes in the diameter the door wound on the vertical reel. Hence, the tension in the force transmission device and the door can be kept substantially constant during operation.



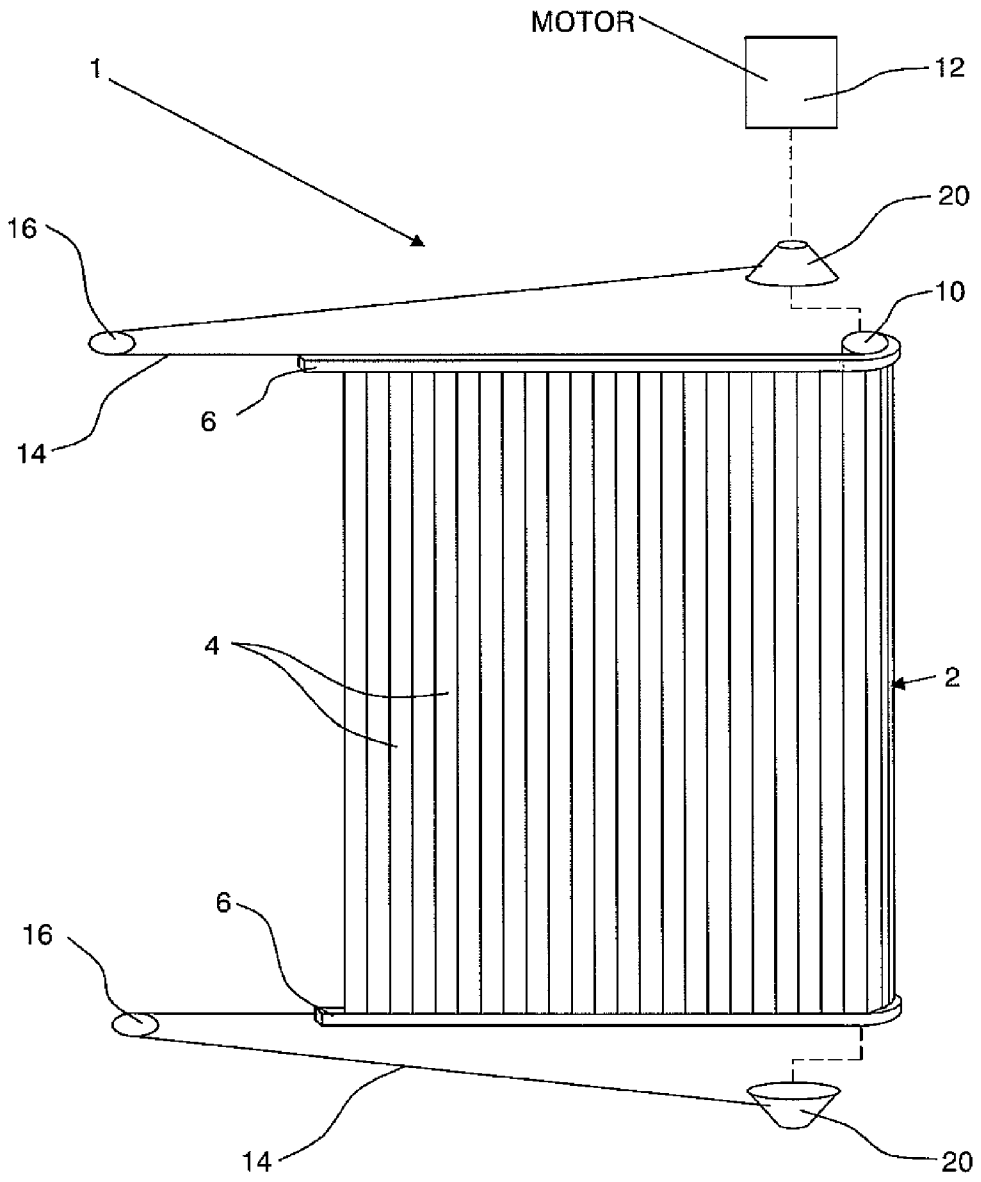


FIG. 1

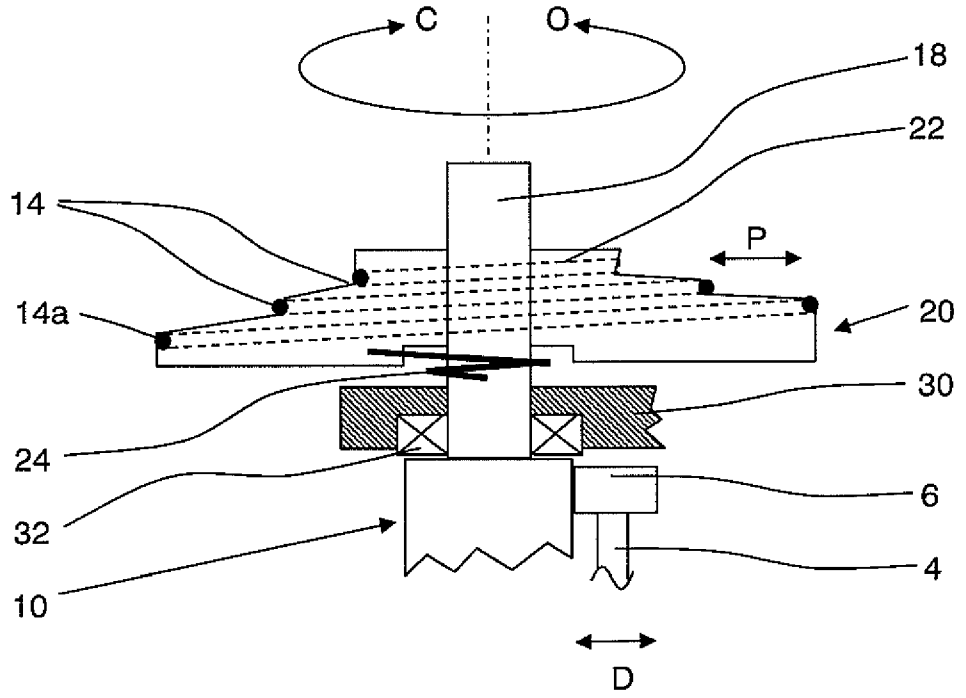


FIG. 2

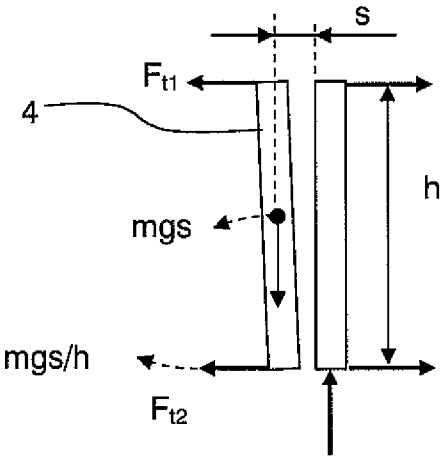


FIG. 3

ELEVATOR DOOR SYSTEM

BACKGROUND OF THE INVENTION

[0001] The present invention relates to elevator doors systems and, in particular, to an elevator door system comprising a door that is wound upon a vertical axis during an opening operation.

[0002] Such elevator door systems are well known from the prior art and are described, for example, in WO-A2-2005/070807 and WO-A2-2005/070808. Each elevator door is generally formed from a stainless steel sheet or interconnected vertical rigid panels, typically manufactured from a metal. In operation, as the elevator door is opened and closed, the plurality of panels or sheet is wound onto and unwound from a vertical axis in the form of a motorized reel whereby the driving force from the motor is transmitted through the reel and onto the door to provide lateral movement thereof. Normally, the door is biased to its closed position by a weight or a spring. Accordingly, to open the door, the motor must develop a force which must overcome the inherent friction and also the counteracting biasing force of the weight or spring to provide the necessary acceleration.

SUMMARY OF THE INVENTION

[0003] An objective of the present invention is to make more efficient use of the motor, thereby enabling savings in both cost and space requirement.

[0004] This objective is achieved by an elevator door system comprising a motor, a vertical axis reel, and a door attached at a first end to the reel for winding and unwinding thereupon. The door system further comprises a force transmission means interconnecting a second end of the door and a compensation means whereby the motor simultaneously drives the vertical reel and the compensation means and wherein the compensation means has a variable diameter.

[0005] In use, as the door is unwound from the vertical reel, the force transmission means is simultaneously wound upon the compensation means. Hence, not only is a thrust exerted on the door by the vertical reel, but a drag is exerted thereupon by the force transmission means. Furthermore, the compensation means has a variable diameter to compensate for, amongst other things, the changes in the diameter of the door wound on the vertical reel. Hence, the tension in the force transmission means and the door can be kept substantially constant during operation.

[0006] Preferably, the compensation means is a cone whereby the force transmission means is attached to a large diameter portion thereof and, in use, is wound successively in decreasing diameter thereupon. Advantageously, at any time during operation, the current diameter at which the force transmission means is being wound around the cone corresponds with the diameter that the outermost layer of the door is wound around the vertical reel. Hence, as a given length of the door is unwound from the vertical reel, the same length of force transmission means is taken up on the cone. Therefore, the tension in the force transmission means and the door is kept relatively constant during operation.

[0007] Preferably, the pitch between successive windings of the force transmission means on the cone is substantially equal to the depth of the door. Accordingly, the tension in the force transmission means and the door can be kept relatively constant during operation even though the depth dimension of the force transmission means is considerably smaller than that of the door. In this instance, a wire, a rope or a cable is suitable for use as the force transmission means.

[0008] In one embodiment, the compensation means is mounted on the vertical reel. Accordingly, the motor need only drive one of the compensation means and the vertical reel to ensure simultaneous rotation of the other. Preferably, resilient means interconnects the cone and the vertical reel. It is beneficial to provide some resilience in the system to absorb energy therefrom if, for example, the door engages with an obstruction during a closing operation.

[0009] To make most efficient use of the available space, preferably the vertical reel and the compensation means are disposed on one side of the doorway and the force transmission means is deflected by a pulley disposed on an opposite side of the doorway.

[0010] The door system according to the present invention causes the tension in the force transmission means to be greater than or equal to a combination of the acceleration and friction forces acting on the door. Accordingly, the force transmission means will never go slack during operation of the door system.

[0011] Preferably, a first force transmission means is provided at an upper part of the door and coupled to a first compensation means, and a second force transmission means is provided at a lower part of the door and coupled to a second compensation means. To counteract the door's tendency to tilt, the tension of the second force transmission means should be at least "mgs/h" greater than the tension of the first force transmission where "m" is the mass of the door panel, "g" is the gravitational force, "s" is the horizontal displacement of the upper end of the panel relative to the lower end of the panel and "h" is the height of the panel.

DESCRIPTION OF THE DRAWINGS

[0012] The above, as well as other, advantages of the present invention will become readily apparent to those skilled in the art from the following detailed description of a preferred embodiment when considered in the light of the accompanying drawings in which:

[0013] FIG. **1** is an exploded perspective view an elevator door system according to the present invention;

[0014] FIG. **2** is a partial cross-section showing in greater detail the compensation means and vertical reel of the embodiment of FIG. **1**; and

[0015] FIG. **3** is a schematic illustration of the forces acting on the leading panel of the door shown in FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0016] FIG. **1** is a general perspective view of an elevator door system **1** according to the present invention incorporating a car door **2** which, in use, is used to control access to an elevator car (not shown) through a doorway from a landing within a building. The door **2** is composed of a plurality of vertically aligned panels **4** each of which is preferably extruded from aluminium for its superior strength to weight ratio. The panels **4** are bound at their upper and lower extremities by flexible belts **6** and guided in upper and

lower guide channels (not shown). The belts **6** are attached at one end to a vertical reel **10** mounted at one side of the doorway, rotation of which is controlled by a motor **12** to open and close the door **2**. The opposing ends of the belts **6** are attached to cables **14** which are deflected by diverting pulleys **16** mounted at the other side of the doorway and connected to a compensation means or device in the form of conical spools **20** which are also rotated by the motor **12**. In a closing operation, the door **2** is unwound or paid-out from the reel **10** whereas the cables **14** are simultaneously wound or drawn upon the conical spools **20**. Conversely, in an opening operation, the door **2** is wound onto the reel **10** while the cables **14** are unwound from the conical spools **20**.

[**0017**] FIG. **2** is a cross-section through an upper portion of the reel **10** of FIG. **1**. It will be readily appreciated that the lower portion of the reel **10** corresponds. The reel **10** is provided with a central axle **18** which, in use, is driven by the motor **12**. The reel **10** and the central axle **18** are rotatably supported by bearings **32** on a fixation bracket **30** which is securely mounted to the elevator car. The conical spool **20** is rotatably mounted on the central axle **18** and is connected thereto by a helical spring **24**.

[**0018**] The cable **14** is attached to the conical spool **20** at a point **14***a* on the widest diameter of the spool **20**. In the drawing, both the cable **14** and the door **2** extend from the plane of the page.

[**0019**] In the fully open position, the door **2** is completely wound in layers on the reel **10** while the cable **14** is completely unwound from the conical spool **20** and attached thereto only at the point **14***a*. Preferably the diameter of the spool **20** at the point **14***a* corresponds to the diameter of the outer layer of the door **2** on the reel **10**. In a closing operation, indicated by an arrow C in FIG. **2**, the door **2** is sequentially unwound from the reel **10**, whereas the cable **14** is sequentially wound onto a spiral groove **22** on the conical spool **20**. The spiral groove **22** has decreasing diameter and preferably its pitch P corresponds to a depth D of the door **2**. With this arrangement, for every rotation of the central axle **18**, the same amount of door **2** is unwound from the reel **10** as the amount of the cable **14** wound onto the conical spool **20**. Hence, the tension in the door **2** and the cable **14** can be kept relatively constant during operation. In the specific situation shown in FIG. **2**, the door **2** has almost been completely unwound from the reel **10** while the cable **14** has almost been completely wound onto the conical spool **20**.

[**0020**] Although in the preferred embodiment, the instantaneous diameter of the cable **14** on the conical spool **20** is substantially the same as the diameter of the outer layer door **2** on the reel **10** and the pitch P of the spiral groove **22** corresponds to the depth D of the door **2**, it will be readily understood that the same effect of constant tension can be achieved using differing diameters and pitches.

[**0021**] FIG. **3** shows an analysis of the tensioning forces required in the door system **1**. Due to the inherent nature of the panels **4** which make up the door **2**, there is a tendency for the panels **4** to tilt under the force of gravity. To counteract this tendency, a tension F_{t2} in the lower cable **14** is "mgs/h" greater than a tension F_{t1} in the upper cable **14**; where "m" is the mass of the door panel **4**, "g" is the gravitational force, "s" is the horizontal displacement of the upper end of the panel **4** relative to the lower end of the panel **4** due to tilt and "h" is the height of the panel **4**.

[**0022**] Furthermore, to ensure that the cables **14** are always tensioned during operation of the door system **1**, a tension F_t in both of the cables **14** should be at least equal to the acceleration and friction forces acting on the door **2**: $F_t \geqq m\,(a+\mu g)$, where "μ" is the coefficient of friction.

[**0023**] Although the invention has been described with specific reference to the door **2** comprising a plurality of the vertically aligned panels **4**, it will be appreciated that the invention is equally applicable for any door which is capable of being wound upon and unwound from the reel **10**. In particular, the door can be in the form of sheet material as disclosed in WO-A2-2005/070807.

[**0024**] In accordance with the provisions of the patent statutes, the present invention has been described in what is considered to represent its preferred embodiment. However, it should be noted that the invention can be practiced otherwise than as specifically illustrated and described without departing from its spirit or scope.

What is claimed is:

1. An elevator door system including a motor rotating a vertical reel and a door attached at a first end to the vertical reel for winding and unwinding thereupon comprising:

a compensation means having a variable diameter; and

a force transmission means interconnecting a second end of the door and said compensation means whereby the motor simultaneously drives the vertical reel and said compensation means.

2. The door system according to claim 1 wherein said compensation means is a cone and said force transmission means is attached to a larger diameter portion of said cone.

3. The door system according to claim 2 whereby said cone is configured to provide a pitch between successive windings of said force transmission means on said cone substantially equal to a depth of the door.

4. The door system according to claim 2 wherein said cone is mounted on the vertical reel.

5. The door system according to claim 4 including resilient means interconnecting said cone and the vertical reel.

6. The door system according to claim 1 wherein the door includes a plurality of vertically aligned panels mounted to a belt, a first end of said belt being fixed to the vertical reel and a second end of said belt fixed to said force transmission means.

7. The door system according to claim 1 wherein a tension in said force transmission means is greater than or equal to a combination of an acceleration force and a friction force acting on the door during operation of the door.

8. The door system according to claim 1 including a first one of said force transmission means provided at an upper part of the door and being coupled to a first one of said compensation means, and a second one of said force transmission means provided at a lower part of the door and being coupled to a second one of said compensation means.

9. The door system according to claim 8 wherein a tension in said second force transmission means is greater than a tension in said first force transmission means.

10. The door system according to claim 9 wherein said tension in said second force transmission means is mgs/h greater than said tension in said first force transmission and where "m" is a mass of a panel of the door, "g" is gravita-

tional force, "s" is a horizontal displacement of an upper end of said panel relative to a lower end of said panel and "h" is a height of said panel.

11. An elevator door system comprising:

a vertical reel;

a motor rotating said vertical reel;

a door attached at a first end to said vertical reel for winding and unwinding thereupon by operation of said motor;

a compensation means having a varied diameter; and

a force transmission means interconnecting a second end of said door and said compensation means whereby said motor simultaneously drives said vertical reel and said compensation means.

12. The door system according to claim 11 wherein said compensation means is a cone and said force transmission means is attached to a larger diameter portion of said cone.

13. The door system according to claim 12 wherein said cone is configured to provide a pitch between successive windings of said force transmission means on said cone substantially equal to a depth of said door.

14. The door system according to claim 12 wherein said cone is mounted on said vertical reel.

15. The door system according to claim 14 including resilient means interconnecting said cone and said vertical reel.

16. The door system according to claim 11 wherein said door includes a plurality of vertically aligned panels mounted to a belt, a first end of said belt being fixed to said vertical reel and a second end of said belt fixed to said force transmission means.

17. The door system according to claim 11 wherein a tension in said force transmission means is greater than or equal to a combination of an acceleration force and a friction force acting on said door during operation of said door.

18. The door system according to claim 1 including a first one of said force transmission means provided at an upper part of the door and being coupled to a first one of said compensation means, and a second one of said force transmission means provided at a lower part of the door and being coupled to a second one of said compensation means.

19. The door system according to claim 18 wherein a tension in said second force transmission means is greater than a tension in said first force transmission means during operation of said door.

20. The door system according to claim 19 wherein said tension in said second force transmission means is mgs/h greater than said tension in said first force transmission and where "m" is a mass of a panel of said door, "g" is gravitational force, "s" is a horizontal displacement of an upper end of said panel relative to a lower end of said panel and "h" is a height of said panel.

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