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

(11) EP 1 777 191 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.04.2007 Bulletin 2007/17

(21) Application number: **06121962.2**

(22) Date of filing: **09.10.2006**

(51) Int Cl.:
B66B 13/08 *(2006.01)* ***E06B 9/68*** *(2006.01)*
E06B 9/58 *(2006.01)*

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **21.10.2005 EP 05109847**

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(54) **Elevator door system**

(57) The present invention provides an elevator door system (1) comprising, a motor (12), a vertical axis (10), a door (2) attached at a first end to the vertical axis for winding and unwinding thereupon. Force transmission means (14) interconnect a second end of the door (2) and compensation means (20) whereby the motor (12) simultaneously drives the vertical axis (10) and the compensation means (20) and wherein the compensation means (20) has variable diameter.

In use, as the door (2) is unwound from the vertical axis (10), the force transmission means (14) is simultaneously wound upon the compensation means (20). Hence, not only is a thrust exerted on the door (2) by the vertical axis (10) but a drag is exerted thereupon by the force transmission means (14). Furthermore, the compensation means (20) has a variable diameter to compensate for, amongst other things, the changes in the diameter the door (2) wound on the vertical axis (10). Hence, the tension in the force transmission means (14) and the door (2) can be kept substantially constant during operation.

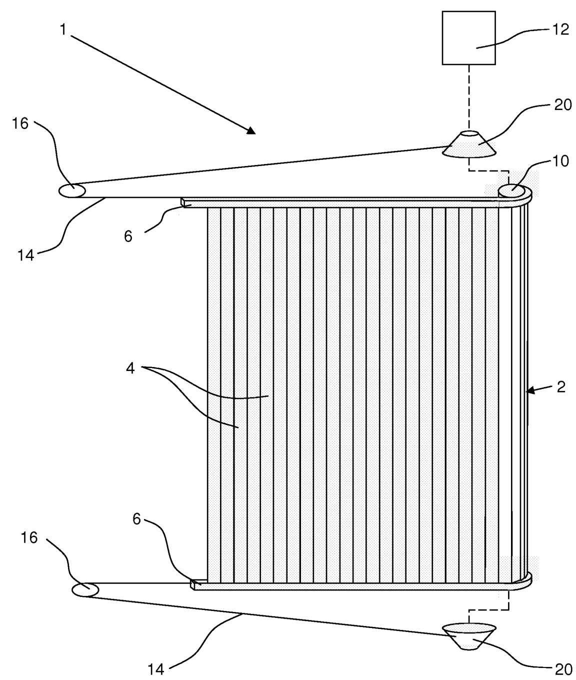

FIG. 1

EP 1 777 191 A1

Description

[0001] The 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 motorised 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 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.

[0003] The 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, a door attached at a first end to the vertical axis for winding and unwinding thereupon CHARACTERISED IN further comprising force transmission means interconnecting a second end of the door and compensation means whereby the motor simultaneously drives the vertical axis and the compensation means and wherein the compensation means has a variable diameter.

[0005] In use, as the door is unwound from the vertical axis, the force transmission means is simultaneously wound upon the compensation means. Hence, not only is a thrust exerted on the door by the vertical axis 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 the door wound on the vertical axis. 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 axis. Hence, as a given length of the door is unwound from the vertical axis, 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 axis. According, the motor need only drive one of the compensation means and the vertical axis to ensure simultaneous rotation of the other. Preferably, resilient means interconnects the cone and the vertical axis. 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 axis 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] A door system according to any preceding claim wherein the tension in the force transmission means is 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 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.

[0012] The present invention is hereinafter described by way of a specific example with reference to the accompanying drawings in which:

Figure 1 is an exploded perspective view an elevator door system according to the present invention;
Figure 2 is a partial cross-section showing in greater detail the compensation means and vertical axis of the embodiment of Fig. 1; and
Figure 3 is an illustration of the forces acting on the leading panel of the door.

[0013] 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 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 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.

[0014] 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 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 connected thereto by a helical spring 24.

[0015] The cable 14 is attached to the conical spool 20 at a point 14a on the widest diameter of the spool 20. In the diagram, both the cable 14 and the door 2 extend from the plane of the page.

[0016] 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 point 14a. Preferably the diameter of the spool 20 at point 14a corresponds to the diameter the outer layer of the door 2 makes on the reel 10. In a closing operation, indicated by 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 the 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 cable 14 wound onto the conical spool 20. Hence, the tension in the door 2 and 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.

[0017] Although in the preferred embodiment, the instantaneous diameter the cable 14 makes 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.

[0018] 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, the tension F_{t2} in the lower cable 14 is mgs/h greater than the 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 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.

[0019] Furthermore, to ensure that the cables 14 are always tensioned during operation of the door system 1, the 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: $F_t \geq m(a + \mu g)$, where μ is the coefficient of friction.

[0020] Although the invention has been described with specific reference to a door 2 comprising a plurality of 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.

Claims

1. An elevator door system (1) comprising, a motor (12), a vertical axis (10), a door (2) attached at a first end to the vertical axis for winding and unwinding thereupon
   CHARACTERISED IN further comprising
   force transmission means (14) interconnecting a second end of the door (2) and compensation means (20) whereby the motor (12) simultaneously drives the vertical axis (10) and the compensation means (20) and wherein the compensation means (20) has variable diameter.

2. A door system (1) according to claim 1, wherein the compensation means is a cone (20) whereby the force transmission means (14) is attached to a large diameter portion thereof.

3. A door system (1) according to claim 2, whereby the pitch (P) between successive windings of the force transmission means (14) on the cone (20) is substantially equal to the depth (D) of the door (2).

4. A door system (1) according to claim 2 or claim 3, wherein the cone (20) is mounted on the vertical axis (10).

5. A door system (1) according to claim 4 further comprising resilient means (24) interconnecting the cone and the vertical axis.

6. A door system (1) according to any preceding claim, wherein the door (2) comprised a plurality of vertically aligned panels (4) mounted to a belt (6), a first end of the belt (6) is fixed to the vertical axis (10) and a second end of the belt (6) fixed to the force transmission means (14).

7. A door system (1) according to any preceding claim, wherein the tension (F_t) in the force transmission means (14) is greater than or equal to a combination of the acceleration force (ma) and the friction force ($m\mu g$) acting on the door (2).

8. A door system (1) according to any preceding claim, wherein a first force transmission means (14) is provided at an upper part of the door (2) and coupled to a first compensation means (20), and a second force transmission means (14) is provided at a lower part of the door (2) and coupled to a second compensation means (20).

9. A door system (1) according to claim 8, wherein the tension (F_{t2}) of the second force transmission means is greater than the tension (F_{t1}) of the first force transmission means.

10. A door system (1) according to claim 9, wherein the tension (F_{t2}) of the second force transmission means is mgs/h greater than the tension (F_{t1}) of the first force transmission where m is the mass of the door panel (4), g is the gravitational force, s is horizontal displacement of the upper end of the panel (4) relative to the lower end of the panel (4) and h is the height of the panel (4).

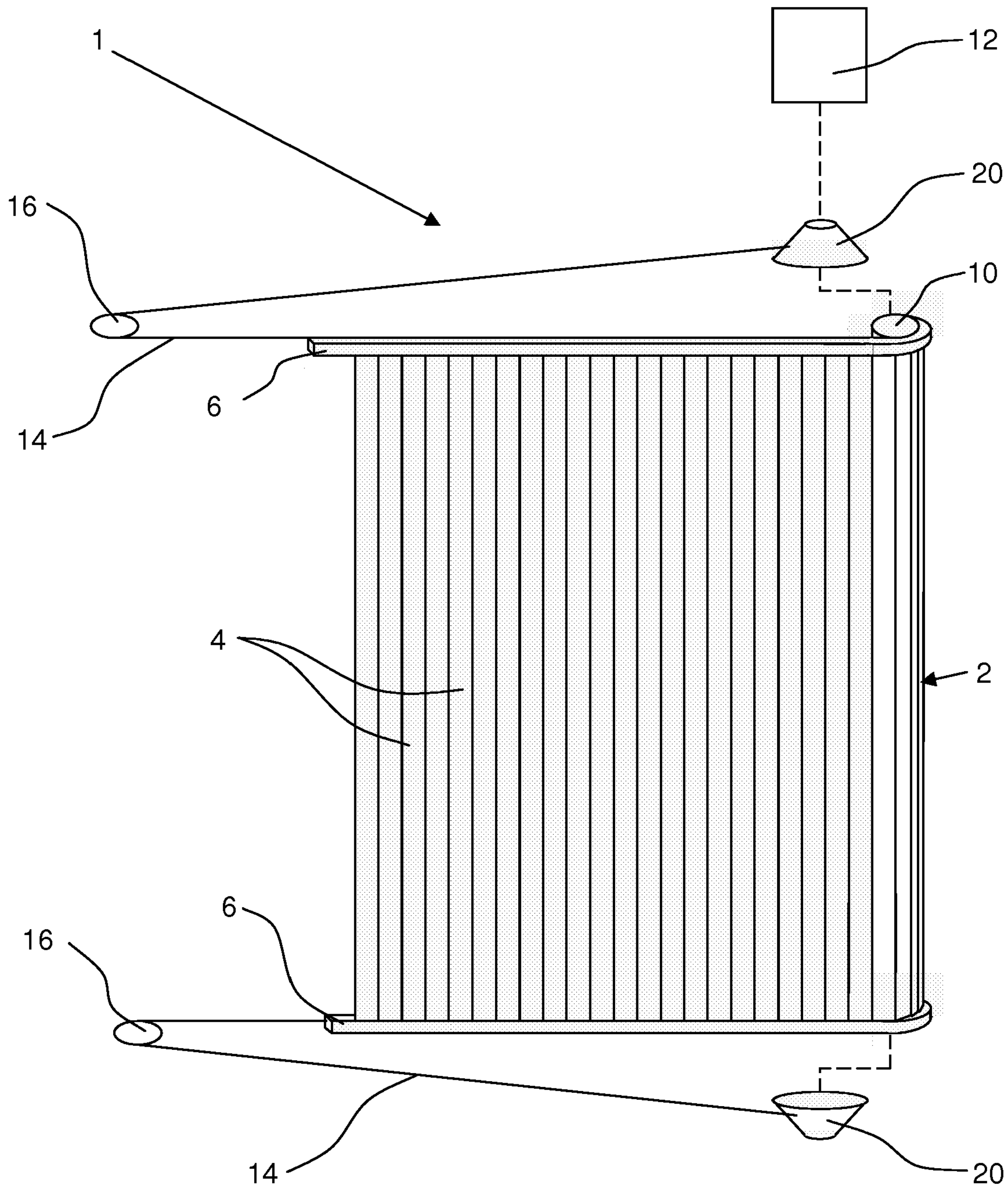

FIG. 1

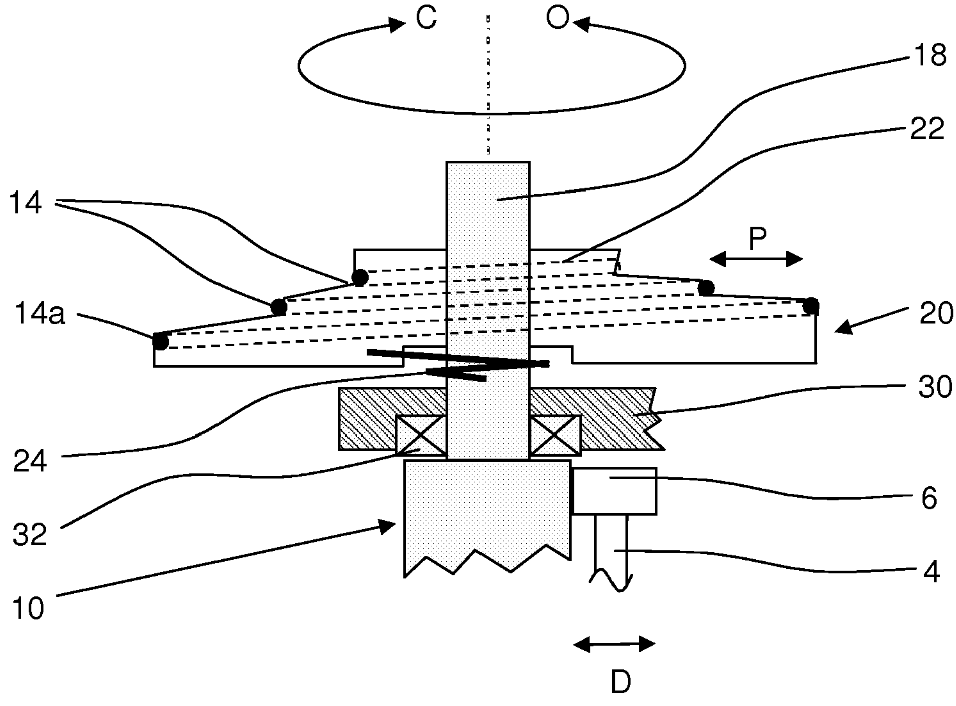

FIG. 2

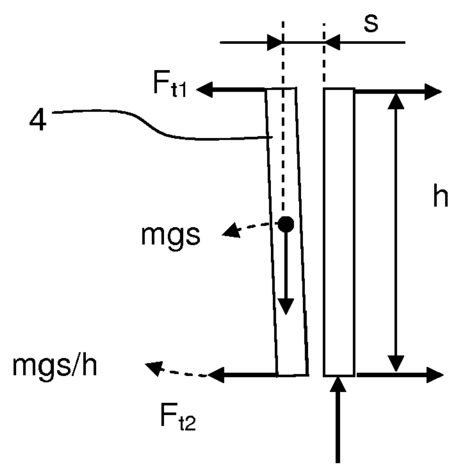

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 06 12 1962

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	US 2004/206462 A1 (FITZGERALD ROBERT M ET AL) 21 October 2004 (2004-10-21) * paragraphs [0150] - [0156] * * paragraphs [0162] - [0176] *	6	

TECHNICAL FIELDS SEARCHED (IPC)

B66B
E06B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 February 2007	ECKENSCHWILLER, A

4

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 12 1962

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

REFERENCES CITED IN THE DESCRIPTION

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