

## **AN ELEVATOR**

### **Field of the invention**

The invention relates to an elevator. The elevator is particularly meant for transporting passengers and/or goods.

### **5 Background of the invention**

An elevator typically comprises a hoistway, and an elevator car and a counterweight movable in the hoistway. The elevator further comprises a rotatable traction member, such as a traction wheel, engaging ropes connected to the car. The ropes pass around the rotatable traction member  
10 and suspend at least the elevator car and the counterweight. For controlling rotation of the rotatable traction member, the elevator comprises a drive machinery, which typically comprises a motor for rotating the rotatable traction member, a control unit for controlling the motor, as well as a brake for braking rotation of said rotatable traction member. Force for moving the car and  
15 counterweight is transmitted from the motor to the car via the rotatable traction member and the roping, whereby car movement can be controlled by controlling rotation of the rotatable traction member. The elevator comprises plurality of landings at which the elevator car is arranged to stop during use of the elevator for loading and/or unloading of the car.

20 In an elevator having traditional steel ropes, the ropes pass inside grooves of the rotatable traction member. In this kind of elevator the rope shape keep the tensioned ropes in their grooves. There are, however, elevators where the ropes cannot be reliably and gently guided by such grooves. This kind of challenges are mostly faced with belt like ropes. Particularly, "groove" type  
25 guidance, which includes considerable edges, cannot be used with ropes having sensitive surface structure and/or internal structure.

Running of a rope outside its intended course is potential to cause different dangerous problems such as damaging the rope itself or other components of the elevator. Thus, there is a need to prevent the rope from running outside its

intended course, or in some other way prevent the situation from developing this far. This is challenging especially with solutions where the guidance by the rotatable traction member is not strong, such as with solutions where belt-like ropes are guided by cambered circumference of the rotatable traction member.

- 5 In solutions utilizing cambered (cambered shape also later referred to as crowning shape) traction member, it may happen that the rope reaches the shallow edge area between adjacent crowning shapes meant to guide adjacent ropes. Crowning acts as guidance of the rope and generally the total width of the crowning is the area where rope can move sideways. The  
10 intended placement of the rope is in the middle of the cambered area; but normally the rope is allowed to move sideways a little bit. Once a rope meets the shallow edge area it will try to climb along the cambered shape meant for the rope next to this rope. This is dangerous, firstly because the edge area will potentially damage the individual rope, but also because the rope configuration  
15 has changed away from how it is meant to be, which could cause dramatic system level problems.

A drawback of the known elevators has been that running of a rope outside its intended course, and further development of the problem into even more hazardous state have not been prevented in an adequately reliable manner.

- 20 This has been a problem especially with elevators where mechanical shape-locking of the rope into its groove has been unreliable or impossible due to specific configuration of the ropes and the traction member.

### **Brief description of the invention**

- The object of the invention is, inter alia, to solve previously described  
25 drawbacks of known solutions and problems discussed later in the description of the invention. The object of the invention is to introduce a new elevator wherein running of a rope of an elevator outside its intended course is reacted to quickly and effectively. Embodiments are presented, inter alia, in which further development of the problem into even more hazardous state can be  
30 prevented in a reliable manner. Embodiments are presented, inter alia, in

which said object is realized with simple and reliable configuration. Embodiments are presented, inter alia, where this object is achieved gently without damaging the ropes.

It is brought forward a new elevator, which comprises a hoistway, an elevator  
 5 car vertically movable in the hoistway, a plurality of ropes connected to the car, a rotatable traction member, preferably located in or in proximity of the upper end of the hoistway, the rotatable traction member comprising a circumferential traction surface area for each of the several ropes, each rope being arranged to pass around the rotatable traction member resting against a circumferential  
 10 traction surface area of the traction member. The elevator further comprises a drive machinery for controlling rotation of the rotatable traction member. The elevator further comprises means for detecting displacement of each of the ropes over a first limit position (defined for the rope in question) in the first axial direction of the rotatable traction member, and over a second limit position  
 15 (defined for the rope in question) in the second axial direction of the traction member, in particular for detecting displacement of each of the ropes away from between a first limit position and a second limit position, which first and second limit positions are apart from each other in axial direction of the rotatable traction member. Displacement of one or more of said ropes in axial  
 20 direction of the rotatable traction member over the first or second limit position (defined for the rope in question) is arranged to trigger the drive machinery to stop the rotation of the rotatable traction member, preferably to brake rotation of the rotatable drive member with mechanical brake(s) of the elevator and/or to stop the motor from rotating the rotatable traction member. Said limits thus  
 25 define the allowed range of movement of the rope in question in direction of said axis. Thus, drifting of the rope away from its intended course, particularly from its circumferential traction surface area can be reacted to by bringing the elevator into a swift stop.

In a preferred embodiment, the ropes are in the form of belts. Belt-shaped  
 30 ropes are prone to wandering in axial direction of the rotatable traction member, because they are difficult to control without damaging the rope and

without complicated arrangements. The solution presented is particularly preferable in case each circumferential traction surface area of the rotatable traction member has a crowning shape.

- In a preferred embodiment, the elevator comprises a safety circuit breaking of which is arranged to cause the drive machinery to brake rotation of the traction member and/or to stop rotating the rotatable traction member, and displacement of one or more of said ropes in axial direction of the traction member over the first or second limit position is arranged to trigger said stopping i.e. the drive machinery to brake rotation of the rotatable traction member and/or to stop rotating the rotatable traction member by triggering a series of one or more actions including at least breaking of the safety circuit. In this way, the reaction to displacement of the rope(s) is swift and safe. Preferably said means for detecting displacement of each of the ropes preferably comprise a relay operating a safety switch of the safety circuit.
- In a preferred embodiment, said means for detecting displacement of each of said ropes comprise on opposite sides of each of said ropes in said axial direction of the traction member a first and a second sensing member, the first sensing member being positioned at the first limit position defined for the rope in question, particularly such that a contact face thereof is positioned at the point of the limit position, and the second sensing member being positioned at the second limit position defined for the rope in question, particularly such that a contact face thereof is positioned at the point of the limit position, each sensing member being displaceable, in particular by the rope, preferably pushed by it, which rope has displaced in said axial direction to collide into contact with the sensing member, displacement of each sensing member being arranged to trigger said stopping i.e. the drive machinery stop the rotation of the traction member.

- In a preferred embodiment, each of said sensing members is displaceable at least in the longitudinal direction of the rope, whereby the rope, when it moves in its longitudinal direction during elevator use and is displaced in said axial

direction to collide into contact with the sensing member, is arranged to engage the sensing member, preferably frictionally, and push, and thereby displace it at least in the longitudinal direction of the rope. Thus, when the rope has engaged with a sensing member next to it, the rope can displace the  
5 sensing member in question by its movement. The sensing member in question moves then along with the rope after said engagement, whereby chafing between the rope and the sensing member engaging it, is not extensive enough to cause damage to the rope.

In a preferred embodiment, each of said sensing members is mounted pivotally  
10 displaceably around an axis parallel with the axial direction of the traction member, pivoting displacement of each sensing member being arranged to trigger said stopping i.e. the drive machinery to stop the rotation of the traction member. The displacement in the longitudinal direction of the rope mentioned in the previous paragraph is preferably arranged to displace the sensing  
15 member by pivoting around said axis.

In a preferred embodiment, said sensing members are mounted displaceably via a common displaceable carrier body. The sensing members together with the body preferably form a rake-like structure. The sensing members are thus simple to position relative to ropes in such a way there are for each rope on  
20 opposite sides of the rope in said axial direction of the traction member a first and a second sensing member.

In a preferred embodiment, said means for detecting displacement of each of said ropes comprise at least one electrical sensor arranged to sense position of the displaceable carrier body. Displacement of the carrier body, in particular  
25 pivoting thereof, is arranged to trigger said stopping i.e. the drive machinery to stop the rotation of the traction member. Thus, displacement of each sensing member is arranged to cause displacement of the carrier body, the displacement of which is arranged to trigger said stopping i.e. the drive machinery stop the rotation of the traction member. Thus displacement of each  
30 sensing member is arranged to trigger said stopping via said carrier body.

In a preferred embodiment, said circumferential traction surface areas have each a surface roughness or a surface texture substantially different from the roughness or a surface texture, respectively, of the circumferential surface areas of the traction member next to it in said axial direction of the traction member, whereby drifting of the rope away from its circumferential traction surface area to rest against the surface area next to it changes sound and/or vibration produced in the contact area during use, and said means for detecting displacement of one or more of said ropes comprise a sensing arrangement comprising one or more sensors for sensing sound and/or a vibration, which sensing arrangement is arranged to trigger said stopping i.e. the drive machinery to stop the rotation of the traction member if the sound and/or vibration sensed by the sensing arrangement meet predetermined criteria, such as reaches a predetermined limit or changes in a predetermined way. Thus, the displacement of rope(s) can be reacted to effectively with a simple and reliable configuration. Also, this can be carried out gently without damaging the ropes. Preferably, said circumferential traction surface areas are each smoother, such as have a surface roughness lower, or a more even surface texture, than the circumferential surface areas of the traction member next to it in said axial direction of the traction member. In this case, said circumferential surface areas of the traction member next to said circumferential traction surface areas preferably have each a serrated texture. Said circumferential traction surface areas are then preferably unserrated.

In a preferred embodiment, said means for detecting displacement of one or more of said ropes comprise one or more sensing devices for receiving ultrasonic sound or electromagnetic radiation from said limit positions and a monitoring unit connected to the one or more sensing devices and arranged to trigger said stopping i.e. the drive machinery to stop the rotation of the traction member, if ultrasonic sound or electromagnetic radiation received from one or more of said limit positions meets predetermined criteria, such as reaches a predetermined limit or changes in a predetermined way. Thus, the displacement of rope(s) can be reacted to effectively with a simple and reliable

configuration. Also, this can be carried out gently without damaging the ropes. Preferably, each of said one or more sensing devices comprise a receiver for receiving ultrasonic sound, or electromagnetic radiation from the limit position(s) it is associated with. Also preferably, said means for detecting  
 5 displacement of each of said ropes comprise one or more senders for sending towards said limit positions. Then, it is preferable that each of the one or more sensing devices comprises a sender for sending ultrasonic sound or electromagnetic radiation towards the limit position(s) it is associated with.

The one or more sensing devices mentioned in previous paragraphs can  
 10 comprise one or more photocells, one or more laser beam sensors, one or more ultrasonic sensing devices, one or more optical cameras, one or more scanners, one or more machine vision devices, or one or more pattern recognition devices.

In a preferred embodiment, the ropes pass around the rotatable traction  
 15 member adjacent each other in axial direction of the rotatable traction member as well as adjacent each other in the width-direction of the ropes, the wide sides of the ropes against the traction member.

In a preferred embodiment, the rotatable traction member is a traction wheel.

In a preferred embodiment, each circumferential traction surface area of the  
 20 rotatable traction member has an individual crowning shape.

In a preferred embodiment, the drive machinery for controlling rotation of the rotatable traction member comprises a motor for rotating the rotatable traction member, and a control unit for controlling the motor, and/or a brake for braking rotation of said rotatable traction member.

25 In a preferred embodiment, displacement of one or more of said ropes in axial direction of the traction member over the first or second limit position is arranged to trigger said stopping i.e. drive machinery to stop the rotation of the traction member including braking rotation of the rotatable drive member with

mechanical brake(s) of the elevator and/or stopping the motor from rotating the rotatable traction member. Said braking rotation of the rotatable drive member includes preferably at least activating the mechanical brake(s). In addition to said stopping the motor from rotating the rotatable traction member the motor  
5 can be additionally electrically controlled to decelerate the rotation of the rotatable traction member.

In a preferred embodiment, when the rope is completely between the first and second limit thereof, its rope surface area placed against the traction member and the circumferential traction surface area (meant for the rope in question) at  
10 least substantially coincide.

In a preferred embodiment, the ropes are in the form of belts having width/thickness ratio at least 2. The in the form of belts preferably have an elastic coating embedding load bearing members of the rope, which load bearing members are positioned on the same plane adjacent each other in  
15 width direction of the rope, and isolated by said coating. The elastic coating increases friction between the rotatable traction member and the rope, but also protects the load bearing members. The load bearing members are preferably metallic, such as steel wires, or non-metallic members, such as members made of fiber-reinforced composite material, extending throughout the length  
20 of the rope.

In a preferred embodiment, said means for detecting displacement of each of the ropes are arranged to detect displacement of a rope section of each rope, which rope section is positioned against the traction wheel, or which rope section is positioned in the proximity of the traction wheel, preferably less than  
25 2 meters from the traction wheel.

The elevator as described referred to above is preferably, but not necessarily, installed inside a building. The car of the elevator is preferably arranged to serve two or more landings. It preferably responds to calls from landing(s) and/or destination commands from inside the car so as to serve persons on

the landing(s) and/or inside the elevator car. Preferably, the car has an interior space suitable for receiving a passenger or passengers.

### **Brief description of the drawings**

In the following, the present invention will be described in more detail by way of  
 5 example and with reference to the attached drawings, in which

Figure 1a illustrates schematically an elevator according to an embodiment of the invention.

Figures 1b and 1c illustrate details for the elevator of Figure 1a.

10 Figure 2 illustrates a preferred arrangement for triggering the drive machinery of the elevator of Figure 1a to stop the rotation of the rotatable traction member.

Figure 3 illustrates a first preferred embodiment for the means for detecting displacement of the ropes of the elevator in axial direction of the rotatable  
 15 traction member.

Figure 4 illustrates a partial and enlarged view of Figure 3.

Figure 5 illustrates a second preferred embodiment for the means for detecting displacement of the ropes of the elevator in axial direction of the rotatable traction member.

20 Figure 6 illustrates a partial and enlarged view of Figure 5.

Figure 7 illustrates the means for detecting displacement of the ropes of Figure 5 as viewed in said axial direction.

Figure 7 illustrates the three-dimensionally the means for detecting displacement of the ropes of Figure 5.

25 Figure 9a illustrates a third preferred embodiment for the means for detecting displacement of the ropes of the elevator in axial direction of the rotatable traction member.

Figure 9b illustrates a preferred structure for a sensing device of Figure 9a.

### Detailed description

Figure 1a illustrates an elevator according to a preferred embodiment. The elevator comprises a hoistway H, an elevator car 1 and a counterweight 2 vertically movable in the hoistway H. The elevator further comprises a rotatable traction member 6, in particular a traction wheel located in or at least in proximity of the upper end of the hoistway H. The rotatable traction member 6 engages an elevator roping R, comprising several ropes, which are connected to the car 1 and pass adjacent each other around the rotatable traction member 6. The roping R suspends the elevator car 1, and in this case, also a counterweight 2. The elevator comprises a drive machinery M for controlling rotation of the rotatable traction member 6, which drive machinery M comprises a motor 7 for rotating the rotatable traction member 6, and a control unit 100 for controlling the motor 7 and a brake b for braking rotation of said rotatable traction member 6. Force for moving the car 1 and counterweight 2 is transmitted from the motor 7 to the car 1 via the rotatable traction member 6 and the roping R, whereby car movement can be controlled by controlling rotation of the rotatable traction member 6. The elevator comprises plurality of landings  $L_0$  to  $L_n$ , at which the elevator car 1 is arranged to stop during use of the elevator.

The rotatable traction member 6 has a circumferential traction surface area 11a,11b,11c for each of the several ropes 3a, 3b, 3c, i.e. a specific area individually for each rope against which the rope in question is intended to pass. As illustrated in Figure 1c, each of said ropes 3a,3b,3c is arranged to pass around the rotatable traction member 6 resting against the circumferential traction surface area 11a,11b,11c of the traction member 6 provided for it.

The elevator comprises means (10,12a-13c ; 30 ; 50) for detecting displacement of each of the ropes 3a,3b,3c in axial direction of the rotatable traction member (6). Said means are provided for detecting displacement of each of the ropes 3a,3b,3c away from between a first limit  $L_{1a}, L_{1b}, L_{1c}$  position and a second limit position  $L_{2a}, L_{2b}, L_{2c}$ , which first and second limit

positions L1a, L2a ; L1b, L2b ; L1c,L2c are apart from each other in axial direction of the traction member 6. More specifically, said means (10,12a-13c ; 30 ; 50) are provided for detecting displacement of each of the ropes 3a,3b,3c over a first limit position L1a,L1b,L1c defined for the rope in question in the first axial direction X<sub>1</sub> of the rotatable traction member 6, and over a second limit position L2a,L2b,L2c defined for the rope in question in the opposite direction, i.e. the second axial direction X<sub>2</sub> of the traction member 6, which limit positions are on opposite sides of the rope 3a,3b,3c in question in axial direction of the rotatable traction member 6. Displacement of one or more of said ropes 3a,3b,3c away from between the first limit position L1a,L1b,L1c and the second limit position L2a,L2b,L2c in the axial direction of the traction member 6, i.e. in the first or second axial direction over the first or the second limit position L1a, L2a ; L1b, L2b ; L1c,L2c respectively is arranged to trigger said stopping, i.e. said drive machinery M to stop the rotation of the traction member 6, preferably to brake rotation of the rotatable traction member 6 by activating mechanical brakes b and/or to stop the motor from rotating the rotatable traction member 6. Thereby said limit positions define the allowed range of movement of the rope 3a,3b,3c in question in direction of said axis. Upon displacement of a rope 3a,3b,3c away from its range of movement, stopping of the rotation of the traction member is triggered. The limits positions L1a, L2a ; L1b, L2b ; L1c,L2c are preferably such that when the rope 3a,3b,3c in question is completely between the first and second limit position L1a, L2a ; L1b, L2b ; L1c,L2c thereof, its rope surface area placed against the traction member 6 and the circumferential traction surface area 11a,11b,11c meant for the rope in question at least substantially coincide. Drifting of the rope 3a,3b,3c away from its circumferential traction surface area 11a,11b,11c is thus reacted to by bringing the elevator into a swift stop.

The ropes are in the illustrated embodiments in the form of belts as illustrated in Figure 1c, for instance. Belt-shaped ropes are prone to wandering in axial direction of the rotatable traction member 6, because they are difficult to control without damaging the rope and without complicated arrangements. The

solution presented is particularly preferable in case each circumferential traction surface area 11a,11b,11c of the rotatable traction member 6 has an individual crowning shape for preventing movement of the rope placed to pass against it from moving away from its circumferential traction surface area  
 5 11a,11b,11c in axial direction of the rotatable traction member 6.

Figure 2 shows a preferred arrangement for triggering of said stopping i.e. the triggering of the drive machinery M to stop the rotation of the rotatable traction member 6 in a swift and reliable manner. In this case, the elevator comprises a safety circuit 9 (also referred to as a safety chain) breaking of which is  
 10 arranged to cause the drive machinery M to brake rotation of the traction member 6 (with brake(s) b of the elevator) and to stop the motor from rotating the rotatable traction member 6, and displacement of one or more of said rope 3a,3b,3c in axial direction of the traction member 6 over the first or second limit position is arranged to trigger said stopping i.e. the drive machinery M to brake  
 15 rotation of the rotatable traction member 6 and to stop rotating the rotatable traction member 6 by triggering a series of one or more actions including at least breaking of said safety circuit 9.

It is preferable, that the breaking of the safety circuit 9 causes that power supply 60 to the frequency converter 100a is broken (the power supply 60  
 20 being thereby also a power supply of the motor 7) and/or that the power supply 61 of the actuator(s) of the brake(s) b is broken, which actuator(s) keep(s) the brake(s) b normally in released state when powered. For this purpose the safety circuit 9 is connected to a contactor 62, which may be in the form of a relay, controlling switches of the power supply lines 60 and 61, as illustrated in  
 25 the Figure 2. Preferably, the safety circuit 9 is under voltage and the breaking thereof is arranged to cause the contactor 62 to release said switches to opened state and thereby to break the power supply of these power lines 60,61. For the purpose of breaking the safety circuit 9 in context of said triggering, said means (10,12a-13c ; 30 ; 50) preferably comprise a relay r  
 30 operating a safety switch s of the safety circuit 9. The relay r is preferably a normally closed –type relay (NC), for instance relay in the form of a SPSTNC –

type relay. The safety circuit 9 may be seen to form part of the drive machinery M.

As mentioned, the drive machinery comprises an elevator control unit 100, This elevator control unit 100 preferably comprises a frequency converter 100a  
 5 and a monitoring unit 100b. The control unit 100 is preferably connected with electrical connections 61,63 to the brake(s) b and the motor 7 via which connections it can control the brake(s) b and the motor 7. Thus, in context of said triggering the actions can be realized via these connections. Said electrical connection 63 is preferably electrical power supply for the motor 7  
 10 and said electrical connection 61 is preferably electrical power supply for the brake(s) b. The brake(s) are preferably mechanical brake(s). The brake(s) is/are preferably arranged to act on the drive member 6 during the braking by frictional engagement either directly or via a component connected to rotate with the drive member 6. The brake(s) is/are preferably so called machine  
 15 brake(s). The brake b and the motor 7 are preferably both operable by said control unit 100.

Figure 3 illustrates a preferred first embodiment for the means 10,12a-13c for detecting the above mentioned displacement of each of the ropes 3a,3b,3c in axial direction of the rotatable traction member 6. As mentioned, the rotatable  
 20 traction member 6 comprises a circumferential traction surface area for each of the several ropes 3a, 3b, 3c and each rope 3a,3b,3c is arranged to pass around the rotatable traction member 6 resting against a circumferential traction surface area 11a,11b,11c of the traction member 6. In the preferred embodiment these circumferential traction surface areas 11a,11b,11c have  
 25 each a surface roughness or a surface texture substantially different than the circumferential surface areas 12a,13a;12b,13b,12c,13c of the traction member 6 next to it in said axial direction of the traction member 6, whereby drifting of the rope 3a,3b,3c away from its circumferential traction surface area 11a,11b,11c to rest against the surface area 12a,13a;12b,13b,12c,13c next to  
 30 it changes sound and/or vibration produced in the contact area during passage of the ropes against the rotatable traction member 6. Said means 10,12a-13c

for detecting displacement of one or more of said ropes 3a,3b,3c comprise a sensing arrangement 14,15 comprising one or more sensors 14 for sensing sound and/or a vibration, which sensing arrangement 14,15 is arranged to trigger said stopping i.e. to trigger the drive machinery M to stop the rotation of the traction member 6, if the sound and/or vibration sensed by the sensing arrangement 14,15 meet(s) predetermined criteria, such as reaches a predetermined limit or changes in a predetermined way. For determining whether the sound and/or vibration sensed by the sensing arrangement 14,15 meet(s) predetermined criteria the sensing arrangement 14,15 preferably comprises a processing unit 15 arranged to carry out said determination and said triggering to stop the rotation of the rotatable traction member 6 if the predetermined criteria is/are met.

In this embodiment the position of each of the limit position L1a, L2a ; L1b, L2b ; L1c, L2c is defined by said criteria, in particular such that each limit position is in the position that the rope has reached when the criteria are met. The criteria are preset such that the sound and/or vibration meet(s) the predetermined criteria, such as reaches a predetermined limit or changes in a predetermined way, when the rope has drifted axially to be positioned to a certain amount against the circumferential surface 12a,13a;12b,13b,12c,13c of the traction member 6 having different surface roughness than the circumferential traction surface area 11a,11b,11c of the rope in question. In practice, the criteria are preset such that for each rope the first limit position L1a, L1b, L1c is located within the axial length of the circumferential surface 12a;12b,12c of the traction member next to the circumferential traction surface area 11a,11b,11c on the first axial side thereof, and that for each rope 3a,3b,3c the second limit position L2a, L2b, L2c is located within the axial length of the circumferential surface 13a;13b,13c of the traction member 6 next to the circumferential traction surface area 11a,11b,11c on the second axial side thereof.

In the preferred embodiment, the circumferential traction surface areas 11a,11b,11c are each smoother, such as have a surface roughness lower or more even surface texture, than the circumferential surface areas

12a,13a;12b,13b,12c,13c of the rotatable traction member 6 next to it in said axial direction of the traction member 6, whereby drifting of the rope 3a,3b,3c away from its circumferential traction surface area 11a,11b,11c to rest against the circumferential surface area 12a,13a;12b,13b,12c,13c of the traction member 6 next to it on either axial side thereof, increases sound and/or vibration produced in the contact area during passage of the rope against the rotatable traction member 6.

As mentioned, the circumferential traction surface areas 11a,11b,11c can each be smoother than the circumferential surface areas 12a,13a;12b,13b,12c,13c of the rotatable traction member 6 next to it in said axial direction of the traction member 6 by having a more even surface texture than the latter. For this purpose, said circumferential surface areas of the traction member next to said circumferential traction surface areas preferably have each an uneven texture, such as a pattern machined into the surface of the traction member 6. Said uneven texture is preferably a serrated texture machined into the surface of the traction member 6. Said circumferential traction surface areas are then preferably unserrated.

Figure 5 illustrates a preferred second embodiment for the means for detecting the above mentioned displacement of each of the ropes 3a,3b,3c in axial direction of the rotatable traction member 6. Said means 30 comprise for each rope on opposite sides of the rope 3a,3b,3c in said axial direction of the traction member 6 a first and a second sensing member 31,32 ; 32, 33; 33,34. In the embodiment as illustrated, there are several ropes whereby there are sensing members which extend between the ropes next to each other. Each sensing member comprises a contact face which the rope next to it can contact when the rope in question is displaced in said axial direction. Each first sensing member 31,32,33 is positioned at the first limit position L1a,L1b,L1c of the rope in question, such that a contact face c thereof is positioned at the point of the limit position L1a,L1b,L1c. Each second sensing member 32,33,34 is positioned correspondingly at the second limit position L2a,L2b,L2c of the rope in question such that a contact face c thereof is positioned at the point of the

limit position, and each sensing member 31,32 ; 32, 33; 33,34 is arranged to be displaceable pushed by the rope, which is displaced in said axial direction such that it collides into contact with the sensing member in question. Displacement of each sensing member 31,32,33,34 is arranged to trigger said

5 stopping i.e. to trigger the drive machinery M to stop the rotation of the traction member 6. Figure 6 illustrates a partial and enlarged view of Figure 5. For the sake of clarity, only a small number of the sensing members are marked with reference numbers and illustrated in Figure 6. The rest of the sensing members visible in Figure 5 works similarly as the ones discussed here.

10 Each of said sensing members 31,32,33,34 is displaceable at least in the longitudinal direction of the rope 3a,3b,3c, whereby the rope 3a,3b,3c, when it moves in its longitudinal direction during elevator use, in particular during car movement, and is displaced in said axial direction to collide into contact with the sensing member 31,32,33,34, is arranged to engage the sensing member

15 31,32,33,34 next to it and push it at least in the longitudinal direction of the rope 3a,3b,3c. Thus, when the rope 3a,3b,3c has engaged with a sensing member 31,32,33 or 34 next to it, the rope 3a,3b,3c can displace the sensing member 31,32,33,34 in question by its movement. The sensing member 31,32,33 or 34 in question moves then along with the rope 3a,3b,3c after said

20 engagement, whereby chafing between the rope 3a,3b,3c and the sensing member 31,32,33 or 34 engaging it, is not extensive enough to cause damage to the rope 3a,3b,3c. Said engagement is preferably frictional. The contact surface c of each sensing member 31,32,33,34 is preferably elastically displaceable in said axial direction so as to ensure gentle contact. For this

25 purpose the contact surface c is made of elastic material and/or the sensing member is elastically bendable in said axial direction. The elastic material is preferably elastomer, such as rubber, silicon or polyurethane, for instance. The elasticity of the contact surface c also facilitates firm frictional engagement between the rope 3a,3b,3c and the sensing member 31,32,33,34. In this

30 embodiment, displacement of each sensing member 31,32,33,34 at least in the longitudinal direction of the rope 3a,3b,3c is arranged to trigger said stopping.

So as to provide for the sensing members said displaceability at least in the longitudinal direction of the rope 3a,3b,3c, preferably each of said sensing members 31,32,33,34 is mounted pivotally displaceably around an axis a, which axis is parallel with the axial direction  $X_1$ ,  $X_2$  of the traction member 6.

5 Pivoting displacement of each sensing member 31,32,33,34 is arranged to trigger said stopping i.e. to trigger the drive machinery M to stop the rotation of the traction member 6. In the preferred embodiment, the sensing members 31,32,33,34 are mounted displaceably in the above defined way via a common pivotally displaceable carrier body 35. Thus, the displaceability need not be  
10 provided for them individually. Thus, the structure has small amount of moving parts, whereby it is reliable, simple, and easy to manufacture. The carrier body 35 is preferably mounted pivotally on a frame 37 mounted stationary.

In the preferred embodiment, each of said sensing members 31,32,33,34 is mounted pivotally displaceably towards either turning direction around said  
15 axis a. Thus, the sensing members 31,32,33,34 can be engaged by the rope 3a,3b,3c and be displaced pushed by the rope at least in the longitudinal direction of the rope 3a,3b,3c independently of the movement direction of the rope.

In the preferred embodiment, said means 30 for detecting displacement  
20 comprise at least one electrical sensor 36, arranged to sense position of the displaceable carrier body 35. The sensor is preferably in the form of a switch having a sensing nose 40 sensing the position of the carrier body 35. In the preferred embodiment, the sensing nose 40 extends into an opening 42 formed in one of two flanges 41 of the carrier body 35, via which flanges 41 the  
25 carrier body 35 is pivotally mounted on a stationary mounted frame 37, in particular on flanges 38 thereof. The means 30 preferably also comprise means 39 for resisting said displacement of the carrier body 35. Said means 30 are in the embodiment illustrated in Figure 8 in the form of one or more spring 39 arranged to resist pivoting of the carrier body 35. The spring(s) is  
30 preferably also used for keeping the sensing members positioned such that the sensing members can pivot towards either direction around axis a. The

spring(s) is preferably a helical spring mounted coaxially along the axis a between the carrier body 35 and the frame 37. For achieving the triggering of the drive machinery M to stop the rotation of the rotatable traction member 6 said sensor 36 can either include or be connected to a relay r (as described  
 5 referring to Figure 2) operating a safety switch s of the safety circuit 9, for instance.

Figure 9a illustrates a preferred third embodiment for the means 50 for detecting the above mentioned displacement of each of the ropes 3a,3b,3c in axial direction of the rotatable traction member 6. Said means 50 comprise  
 10 sensing devices 52-55 for receiving electromagnetic radiation or ultrasonic sound from said limit positions L1a,L2a;L1b,L2b;L1c,L2c and a monitoring unit 51, connected to the sensing devices and arranged to trigger said drive machinery M to stop the rotation of the traction member 6 if electromagnetic radiation or ultrasonic sound received from one or more of said limit positions  
 15 L1a,L2a;L1b,L2b;L1c,L2c meet(s) predetermined criteria, such as reaches a predetermined limit or changes in a predetermined way. Each sensing device 52-55 may be in the form of a photocell, infrared, microwave or laser beam sensor, ultrasonic sound sensor for instance. Said sensing devices 52-55 each comprise a receiver for receiving electromagnetic radiation or ultrasonic  
 20 sound from a limit position L1a,L2a;L1b,L2b;L1c,L2c it is associated with. Figure 9b illustrates a preferred structure for a sensing device of 52,53,54,55. Preferably, in addition to a receiver 56 each sensing device 52-55 additionally comprises a sender 57 for sending electromagnetic radiation or ultrasonic sound (if the receiver is a receiver for receiving ultrasonic sound) towards the  
 25 limit position L1a,L2a;L1b,L2b;L1c,L2c it is associated with, whereby the electromagnetic radiation or ultrasonic sound sent by the sender towards the limit position L1a,L2a;L1b,L2b;L1c,L2c is reflected from a rope displaced over the limit position in question. Electromagnetic radiation or ultrasonic sound received by the receiver associated with the limit position  
 30 L1a,L2a;L1b,L2b;L1c,L2c in question is arranged to be monitored by the monitoring unit 51, and if the electromagnetic radiation or ultrasonic sound

received from one or more of said limit positions L1a,L2a;L1b,L2b;L1c,L2c meet(s) predetermined criteria, the monitoring unit 51 is arranged to trigger said drive machinery M to stop the rotation of the traction member 6, e.g. in the elsewhere defined way. For achieving the triggering of the drive machinery M to stop the rotation of the rotatable traction member 6 said monitoring unit is connected to a relay r (as described referring to Figure 2) operating a safety switch s of the safety circuit 9, for instance. In Figure 9, the positions whereto the sensing devices 52-55 are arranged to send said electromagnetic radiation or ultrasonic sound, and wherefrom the sensing devices 52-55 are arranged to receive said electromagnetic radiation or ultrasonic sound from are illustrated as beams drawn in dashed line. In case the means 50 are provided without senders, the ambient light conditions and sound conditions provide electromagnetic radiation and ultrasonic sound to such a degree that displacement of the rope over the limit position changes the observation of the receiving device to a detectable amount whereby it is possible to implement the device without a sender.

Alternative to the multiple sensing devices for receiving electromagnetic radiation or ultrasonic sound from said limit positions L1a,L2a;L1b,L2b;L1c,L2c described, said means 50 may comprise only one of said sensing devices for receiving ultrasonic sound or electromagnetic radiation from limit positions L1a,L2a;L1b,L2b;L1c,L2c, i.e. one sensing device for receiving ultrasonic sound or electromagnetic radiation from several limit positions, and a monitoring unit connected to the one sensing device and arranged to trigger said drive machinery M to stop the rotation of the traction member 6 if the ultrasonic sound or electromagnetic radiation received from one or more of said limit positions L1a,L2a;L1b,L2b;L1c,L2c meet(s) predetermined criteria, such as reaches a predetermined limit or changes in a predetermined way. In this case, the one or more sensing devices can be in the form of an ultrasonic sensing device, optical camera, scanner, a machine vision device or a pattern recognition device. In these cases, the sensing device can comprise one or

more senders for sending ultrasonic sound or electromagnetic radiation towards said limit positions L1a,L2a;L1b,L2b;L1c,L2c.

The elevator illustrated is an elevator provided with a counterweight; however the elevator may be alternatively configured to be without a counterweight. The  
5 means for detecting displacement of the ropes can be adapted to work independent of whether the elevator comprises a counterweight or not. In the above, said triggering is carried out via the safety circuit 9, which is preferable as the safety circuit is a part normally present in any elevator, but this kind of implementation is not necessary, because said triggering could be carried out  
10 in many alternative ways.

The ropes 3a,3b,3c next to each other have both a limit position defined for it between them. For each of the ropes 3a,3b,3c two limit positions L1a, L2a ; L1b, L2b ; L1c,L2c are defined. However, it is possible that for each, rope limit positions in addition to said first and second are defined, and displacement of  
15 the rope over this additional limit can trigger an action different from the action described in the above, such as a warning signal in case the additional limit is within the first and second limit positions.

It is to be understood that the above description and the accompanying Figures are only intended to illustrate the present invention. It will be apparent  
20 to a person skilled in the art that the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

## CLAIMS

1. An elevator comprising
  - a hoistway;
  - 5 an elevator car vertically movable in the hoistway;
  - a plurality of ropes connected to the car;
  - a rotatable traction member comprising a circumferential traction surface area for each of the several ropes;
  - each rope being arranged to pass around the rotatable traction member resting against a circumferential traction surface area of the traction member;
  - 10 a drive machinery for controlling rotation of the rotatable traction member;
  - characterized** in that the elevator comprises means for detecting displacement of each of the ropes over a first limit position in the first axial direction of the rotatable traction member, and over a second limit position in the second axial direction of the traction member; and in that displacement of one or more of said ropes in axial direction of the rotatable traction member over the first or second limit position is arranged to trigger the drive machinery to stop the rotation of the rotatable traction member.
  - 15 20
2. An elevator according to claim 1, **wherein** the ropes are in the form of belts.
- 25 3. An elevator according to any of the preceding claims, **wherein** said stopping of the rotation of the rotatable traction member includes braking rotation of the rotatable drive member with mechanical brake(s) of the elevator and/or stopping the motor from rotating the rotatable traction member.
- 30

4. An elevator according to any of the preceding claims, **wherein** the elevator comprises a safety circuit breaking of which is arranged to cause the drive machinery to brake rotation of the traction member with mechanical brake(s) of the elevator and/or to stop the motor from rotating the rotatable traction member, and displacement of one or more of said ropes in axial direction of the traction member over the first or second limit position is arranged to trigger the drive machinery to brake rotation of the rotatable traction member with mechanical brake(s) of the elevator and/or to stop the motor from rotating the rotatable traction member by triggering a series of one or more actions including at least breaking of the safety circuit.
5. An elevator according to any of the preceding claims, **wherein** said means for detecting displacement of each of said ropes comprise on opposite sides of each of said ropes in said axial direction of the traction member a first and a second sensing member, the first sensing member being positioned at the first limit position of the rope in question and the second sensing member being positioned at the second limit position of the rope in question, each sensing member being displaceable by the rope, which is displaced in said axial direction to collide into contact with the sensing member, and displacement of each sensing member being arranged to trigger the drive machinery stop the rotation of the traction member.
6. An elevator according to claim 5, **wherein** each of said sensing members is displaceable at least in the longitudinal direction of the rope, whereby the rope, when it moves in its longitudinal direction during elevator use and is displaced in said axial direction to collide into contact with the sensing member, is arranged to engage the sensing member and push and displace it at least in the longitudinal direction of the rope.

- 5 7. An elevator according to claim 5 or 6, **wherein** each of said sensing members is mounted pivotally displaceably around an axis parallel with the axial direction of the traction member, pivoting displacement of each sensing member being arranged to trigger the drive machinery to stop the rotation of the traction member.
- 10 8. An elevator according to any of claims 5 to 7, **wherein** said sensing members are mounted displaceably via a common displaceable carrier body.
- 15 9. An elevator according to claim 8, **wherein** said means for detecting displacement of each of said ropes comprise at least one electrical sensor arranged to sense position of the displaceable carrier body, and displacement of the carrier body, in particular pivoting thereof, is arranged to trigger the drive machinery to stop the rotation of the traction member.
- 20 10. An elevator according to any of the preceding claims, **wherein** said circumferential traction surface areas have each a surface roughness or a surface texture substantially different from the surface roughness or the surface texture of the circumferential surface areas of the traction member next to it in said axial direction of the traction member, and said means for detecting displacement of each of said ropes comprise a sensing arrangement comprising one or more sensors for sensing sound and/or a vibration, which sensing arrangement is arranged to trigger the drive machinery to stop the rotation of the traction member if the sound and/or vibration sensed by the sensing arrangement meet predetermined criteria, such as reaches a predetermined limit or changes in a predetermined way.
- 25 30 11. An elevator according to any of the preceding claims, **wherein** said means for detecting displacement of each of said ropes comprise one or

more sensing devices for receiving ultrasonic sound or electromagnetic radiation from said limit positions, and a monitoring unit connected to the one or more sensing devices and arranged to trigger the drive machinery to stop the rotation of the traction member if ultrasonic sound or electromagnetic radiation received from one or more of said limit positions meets predetermined criteria.

5

12. An elevator according to claim 11, **wherein** each of the one or more sensing devices comprises a receiver for receiving ultrasonic sound or electromagnetic radiation from the limit position(s) it is associated with.

10

13. An elevator according to any of the preceding claims, **wherein** the ropes pass around the rotatable traction member adjacent each other in axial direction of the rotatable traction member as well as in the width-direction of the ropes, the wide sides of the ropes against the traction member.

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14. An elevator according to any of the preceding claims, **wherein** the rotatable traction member is a traction wheel.

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15. An elevator according to any of the preceding claims, **wherein** each circumferential traction surface area of the rotatable traction member has an individual crowning shape.

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16. An elevator according to any of the preceding claims, **wherein** the drive machinery for controlling rotation of the rotatable traction member comprises a motor for rotating the rotatable traction member, and a control unit for controlling the motor, and/or a mechanical brake for braking rotation of said rotatable traction member.

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