

Moving a heavy, overload with an Elevator

5 The present invention relates to an elevator and a method of temporarily operating the elevator outside of normal, nominal operating conditions so as to enable the transportation of a heavy, overload from one floor to another.

In order to maximise installation efficiency while maintaining cost-effectiveness, elevators are conventionally designed and commissioned to operate within predetermined nominal operating conditions, such as rated load and speed, to satisfy the specified transport requirements for a specific installation.

10 There are, however, temporary and infrequent occasions when it would be useful for the building owner to be able to operate the elevator outside of the nominal operating conditions e.g. for transporting a heavy article, such as an electrical transformer, that would otherwise overload the elevator.

15 Conventionally, a solution has been used whereby the mass of the counterweight is increased in proportion to the intended overload of the car so as to maintain the balancing factor between the car and counterweight. After the overload has been transported to the desired location, the additional mass is removed from the counterweight and the elevator can be returned to normal operation.

20 An alternative solution has been described in WO-A1-2011/039405 wherein an additional hoist is attached to the elevator car to supplement the existing elevator drive and thereby compensate for the overload. As with the previous example, after the overload has been transported to the desired location, the additional hoist can be detached from the car and the elevator can be returned to normal operation.

25 In both the methods described above the technician is required to attach additional equipment to an elevator component which is designed to move substantial distances within the hoistway, such as affixing a substantial additional mass to the counterweight or attaching an additional hoist to the elevator car. Not only are these procedures time-consuming and cumbersome but they can also be inherently dangerous. Furthermore, in the first procedure described above, the additional mass is generally added to the counterweight from the pit of the elevator installation. The resultant severely
30 overbalanced elevator is then moved by the drive so that the overload, e.g. transformer,

can be loaded into the empty car from the ground floor. This severely unbalanced trip requires the drive to produce and the motor to consume substantially larger electrical currents than during normal operation which can greatly reduce the lifespan of both electrical components.

5 The above issues are, in at least some cases, addressed through the technologies described in the claims.

An objective of the present invention is to enable the temporary transportation of an overload within an elevator installation having a car and a counterweight interconnected by one or more suspension ropes engaging a traction sheave which is driven by a motor.
10 Instead of adding an additional hoist to the car or additional mass to the counterweight, the traction between the suspension ropes and the traction sheave is enhanced independently of the counterweight. Instead of adding additional mass to the counterweight as in the prior art previously discussed, the enhanced traction between the suspension ropes and the traction sheave according to the present invention facilitates the
15 temporary operation the elevator outside of normal, nominal operating conditions so as to enable the transportation of a heavy, overload from one floor to another.

Preferably, enhanced traction is achieved by increasing the tension on a compensation rope suspended between the car and counterweight. An actuator can be provided for selectively applying force to the compensation rope.

20 Alternatively, the traction can be enhanced by squeezing the ropes in grooves on the traction sheave. In such a case, the traction sheave may be provided with an undercut to improve traction between the suspension ropes and the traction sheave or V-grooves can be provided on the traction sheave. In another example a liner is introduced between the traction sheave and the suspension ropes to enhance traction.

25 In an alternative arrangement, a device may be installed to exert pressure on the suspension ropes as they engage with the traction sheave over a wrap angle. The pressure exertion device may comprise a tensioned, closed-loop belt entrained over one or more rollers.

Traction may be enhanced by increasing the wrap angle over which the suspension ropes
30 engage the traction sheave. If the suspension ropes between the car and the counterweight follow a path over the traction sheave and a deflection pulley, the deflection pulley can be

displaced to change the wrap angle. Alternatively, an additional pulley can be introduced between the sheave and the deflection pulley to change the wrap angle.

Preferably, the motor is switchable between parallel and series configuration.

5 During intended overload operation, the speed and acceleration of the elevator can be reduced, forced cooling can be introduced through the drive and the motor, the travel path to transport the overload can be broken up with intermediate stops and/or the number of starts the elevator can make in an hour can be restricted.

10 Other objectives, features and advantages of the present invention will be apparent from the following detailed description of preferred embodiments thereof taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an exemplary schematic showing an arrangement of components within an elevator installation according to the present invention;

FIG. 2A is a view of the compensation rope tensioning device according to an embodiment of the present invention for use in the installation of FIG. 1;

15 FIG. 2B corresponds to FIG. 2A but shows the compensation rope tensioning device displaced to a different vertical position to increase the force imparted by the tensioning device on the compensation rope;

FIG. 3A is an exploded view of the traction sheave and deflection pulley of FIG. 1;

20 FIG. 3B corresponds to FIG. 3A but illustrates a displaceable deflection pulley in accordance with an embodiment of the present invention;

FIG. 3C corresponds to FIG. 3A but illustrates the use of an additional pulley in accordance with an embodiment of the present invention;

FIG. 4 corresponds to FIG. 3A but illustrates the suspension ropes arrangement in a double wrap over the traction sheave and deflection pulley

25 FIG. 5 is an exploded view of the traction sheave and deflection pulley of FIG. 1 incorporating a pressure exertion device in accordance with an embodiment of the present invention;

FIG. 6 is an exploded view of the traction sheave and deflection pulley of FIG. 1 incorporating a traction sheave liner in accordance with an embodiment of the present invention;

FIG. 7A is an axial cross-section through the top of the traction sheave shown in FIG. 1;

5 FIG. 7B is an axial cross-section of a traction sheave having an alternative groove arrangement;

FIG. 7C is an axial cross-section of a traction sheave having a further alternative groove arrangement;

10 FIG. 8A is an axial cross-section of a traction sheave having a further alternative groove configuration depicting the suspension ropes arranged for normal operation;

FIG. 8B corresponds to FIG. 7A depicting the suspension ropes arranged for overload operation;

FIG. 9 depicts typical drive arrangement for the elevator installation of FIG. 1;

FIG. 10A and 10B show alternative winding configuration for the motor of FIG. 9; and

15 FIG. 11 is a flowchart to illustrate an example of a procedure to temporarily operate the elevator 1 outside of normal, nominal operating conditions so as to enable the transportation of a heavy, overload from one floor to another.

20 FIG. 1 illustrates an exemplary embodiment of an arrangement of components within a typical high-rise elevator installation 1. An elevator drive 8, a deflection pulley 14 and an elevator controller 16 are arranged in a machine room above a hoistway 3. Within the hoistway 3, an elevator car 2 and a counterweight 4 are supported on suspension ropes 6. In this example, the suspension ropes 6 have a 1:1 roping ratio whereby they extend from an end connection fixed to the car 2 up the hoistway 3 for engagement through a wrap angle α with a traction sheave 12 which is rotated by a motor 10 of the elevator drive 8, subsequently over the deflection pulley 14 and back down the hoistway 3 to a further end connection fixed to the counterweight 4. Naturally, the skilled person will easily appreciate other roping arrangements, such as 2:1, 4:1 or x:1 roping ratios, are equally possible and the invention can also be implemented with elevators using belts instead of conventional suspension ropes.

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Preferably, the counterweight 4 is designed so that its total mass is equal to the sum of the mass of the empty elevator car 2 plus 50% of the nominal rated load.

5 In high-rise applications particularly, not only must the imbalance between the car 2 and counterweight 4 be considered, but also the imbalance caused by the weight of the suspension ropes 6 is appreciable. For example, if the car 2 is at the lowest landing within the hoistway 3 and thereby the counterweight 4 is at high level within the hoistway 3, the majority of the length of the suspension ropes 6 is located on the car side of the traction sheave 12 rather than on the counterweight side of the sheave 12. To offset this imbalance due to the suspension ropes 6 it is conventional practise to install one or more
10 compensation chains or ropes 18 suspended between the car 2 and the counterweight 4. For convenience only one compensation rope 18 is illustrated in the drawing, but it will be appreciated that more than one compensation rope can be installed. The compensation rope 18 is guided under pulleys 22 in a weighted pulley box 20 located in a pit of the hoistway 3.

15 Accordingly, the suspension ropes 6, the car 2, the counterweight 4 and the compensation rope 18 form a closed-loop system where the length of the suspension ropes 6 and compensation rope 18 on the car side of the traction sheave 12 is substantially equal to that on the counterweight side of the traction sheave 12.

20 In normal operation, the elevator controller 16 receives signals from conventional landing operating panels and car operating panels (not shown) to determine the travel path that the elevator 1 must undertake in order to satisfy passengers' travel requests. Once the travel path has been determined, the controller 16 outputs signals to the drive 8 so that the traction sheave 12 can be rotated by the motor 10 in the appropriate direction. The traction sheave 12 engages with the suspension ropes 6 to vertically move the car 2 and counterweight 4 in opposing directions along guiderails (not shown) within the hoistway 3. Additionally, from signals generated by a load measurement device 19 mounted to the elevator car 2, the controller 16 can monitor load within the car 2, and particularly, can
25 determine whether the car 2 is overloaded while stationary at any landing. In this case an overload alarm can be issued within the car 2 to allow some passengers to disembark from the car 2.
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If the overload alarm is overridden in the elevator controller 16, and a heavy overload, such as a transformer, is subsequently introduced into the elevator car 2 from a landing,

the substantial imbalance between the overloaded car 2 and counterweight 4 will ultimately cause the suspension ropes 6 to slip in the traction sheave 12 resulting in unintended if not uncontrollable car movement. In such an overload condition, the elevator 1 can be severely underbalanced since the mass of the counterweight 4 with the
5 50% balancing factor as discussed previously is no longer capable of balancing the overloaded elevator car 2.

A solution to this problem is provided for with a compensation rope tensioning device according to the invention as illustrated in FIGS. 2A and 2B. In this embodiment, the compensation rope pulley box 20 is attached through a damper or spring 26 to an actuator
10 24 mounted to the pit floor 3.1 of the hoistway 3. In normal operation when the elevator 1 is operating under nominal, rated load conditions, as shown in FIG. 2A, the actuator 24 and spring 24 impose a downward force F_{c1} on the pulley box 20. This force F_{c1} is ultimately transmitted through the compensation rope 18, the car 2 and counterweight 4, to act as tension within the suspension ropes 6.

If however, the elevator installation 1 is to be used for the temporary transportation of an overload within the car 2, the actuator 24 draws the spring 26 and the pulley box 20 downwards imparting a greater downward force F_{c2} on the pulley box 20 resulting in
15 greater tension the suspension ropes 6. This greater tension in the suspension ropes 6 about the traction sheave 12 improves or enhances the traction therebetween reducing the likelihood of slippage when an overload is introduced into the car 2.
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The actuator 24 may be hydraulic, pneumatic, electromechanical or purely mechanical and can be automatically operated via command signals from the elevator controller 16 or it can be manually operated from the pit 3.1 of the hoistway.

Although, in the illustrated embodiment, the actuator 24 is used for both normal and
25 overload conditions, it will be appreciated that the weight of the pulley box 20 may be used exclusively to impose the required tension to the compensation rope 18 during normal operation, as in FIG. 1, and the actuator 24 may be temporarily installed to the pit floor 3.1 to increase the downward force F_c on the pulley box 20 for intended overload operation only.

30 Naturally, the person skilled in the art will also appreciate that instead of the actuator 24, additional weights can be added to the pulley box 20 to increase the downward force F_c .

acting on the compensation rope pulley box 20 for intended overload operation. Alternatively, additional compensation chains or ropes 18 can be installed to increase the tension in the suspension ropes 6 about the traction sheave 12 resulting in enhanced traction therebetween.

5 FIG. 3A is a plan view of the drive 8 and deflection pulley 14 arrangement from FIG. 1. As previously described, in normal operation, the suspension ropes 6 extend from the car 4 for engagement through a wrap angle α over the traction sheave 12 which is rotated by a motor 10, subsequently over the deflection pulley 14 and back down the hoistway 3 to the counterweight 4.

10 For overload operation, the arrangement can be modified as illustrated in FIGS. 3B or 3C to enhance traction between the traction sheave 12 and the suspension ropes 6. In the example of FIG. 3B, the deflection pulley 14 is vertically displaceable, so that for intended overload operation the pulley 14 is displaced downwards as shown which results in the suspension ropes 6 having a greater wrap angle α_1 about the traction sheave 12.
15 Naturally, the deflection pulley 14 could be horizontally displaceable to achieve the required change in the wrap angle α .

In the alternative shown in FIG. 3C, the deflection pulley 14 remains in the same position as in FIG. 3A but an additional pulley 30 is introduced between the sheave 12 and the deflection pulley 14 to engage with the suspension ropes 6 and thereby again increase the
20 wrap angle α_2 .

It will be apparent to the skilled person that other arrangements are possible in order to increase the wrap angle to enhance the traction between the suspension ropes 6 and the traction sheave 12. For example, instead of having a single wrap arrangement as shown in FIGS. 3A-3C, the suspension ropes 6 may be double wrapped, as shown in FIG. 4, or
25 even triple wrapped around the traction sheave 12 and the deflection pulley 14.

FIG. 4 is an exploded view of the machine 10 and deflection pulley 14 of FIG. 1. If an overload operation is intended, a pressure exertion device 40 is provided to exert a pressure (shown by the arrows) on the suspension ropes 6 as they engage the traction sheave over the wrap angle α . The device 40 comprises a tensioned, closed-loop belt 42
30 entrained over two rollers 44. Accordingly, the traction between the ropes 6 and the sheave 12 is enhanced by the additional pressure exerted on the ropes 6 by the closed-

loop belt 42 of the device 40.

In most conventional high-rise elevator installations 1, as depicted in FIG. 1, the suspension ropes 6 are manufactured from steel and engage with a steel surface on the traction sheave 12. The coefficient of friction of steel-to-steel is relatively low. In such a situation, in order to accommodate overload operation, the arrangement illustrated in FIG. 6 can be implemented wherein a traction sheave liner 48 is introduced between the traction sheave 12 and the suspension ropes 6. The liner 48 is preferably made of a plastics material which enhances the coefficient of friction and thereby the traction of the system.

FIG. 7A is an axial cross-section through the top of the traction sheave 12 shown in FIG. 1. The suspension ropes 6 are accommodated in and engage with half-rounded grooves 50 provided around the circumference of the traction sheave 12. In order to enhance the contact and thereby the traction between the suspension ropes 6 and the traction sheave 12 it is possible to provide undercuts 52 as shown in FIG. 7B. Alternatively, V-shaped grooves 54 as shown in FIG. 7C can be implemented to improve contact between the suspension ropes 6 and the traction sheave 12. The person skilled in the art will readily recognise that other groove arrangements on the traction sheave 12 which squeeze the ropes 6 as they engage the traction sheave 12 can be employed to improve contact and thereby traction between the sheave 12 and the ropes 6.

FIGS. 8A and 8B illustrate a traction sheave 12 having an alternate sequence of half-rounded grooves 50 and V-shaped grooves 54 in the axial direction. In FIG. 8A the ropes 6 are accommodated in the half-rounded grooves 50 for normal operation. If overload operation is intended, the ropes 6 can be transferred into the neighbouring V-shaped grooves 54 as shown in FIG. 8B to enhance contact and traction between the suspension ropes 6 and the traction sheave 12.

Although each of the previous embodiments of the invention have been described separately, it will be appreciated that features of the individual embodiments can be combined to enhance traction between the traction sheave 12 and the suspension ropes 6.

In addition to any of the techniques described above to enhance traction between the traction sheave 12 and the suspension ropes 6, it is also beneficial to increase the torque transmitted from the motor 10 to the traction sheave 12 when operating the elevator 1 in

overload conditions. A typical drive 8 for the elevator installation 1 is depicted in FIG. 9. Electrical power is drawn from a three phase AC mains power supply, passed through an AC-DC power converter 62 which supplies DC in a DC bus or link 64, inverted by a DC-AC power inverter 68 and fed in three phases U, V and W onto the three phase AC motor 10.

Within the three phase AC motor 10, the armature windings are arranged in double star configuration with the winding pairs of each phase U, V, W arranged in parallel, as shown in FIG. 10A. In order to increase the motor torque for operation in overload conditions, the drive 8 should deliver more current, which could exceed the maximum allowable value or overheat the drive's semiconductors. A commutation from parallel to series connection of the motor windings as shown in FIG. 10B decreases the needed current for the required torque. This commutation from parallel to series connection can be conducted manually by a certified technician by appropriate re-wiring of the terminal box of the motor. More preferably, however, the commutation can be achieved by means of an electrical switch attached to the terminal box. The electrical switch can be actuated manually by a technician or can be activated automatically by the elevator controller 16.

By reconfiguring the armature windings as discussed above for intended overload operation, the operating voltage will inherently rise. In order to mitigate against the deleterious effects of over-voltage on the drive 8, the speed and/or the acceleration of the elevator 1 can be reduced, enhanced forced cooling can be implemented through the drive 8 and motor 10 and the travel path to transport the overload can be broken up with intermediate stops. Preferably, during intended overload operation, the number of starts that the elevator 1 can make in an hour is restricted.

An example of a procedure to temporarily operate the elevator 1 outside of normal, nominal operating conditions so as to enable the transportation of a heavy, overload from one floor to another is explained with reference to the flowchart illustrated in FIG. 11. The process commences at step S1 when the elevator car 2 in response to a call arrives at a landing of the building and the doors are subsequently opened. At this point, the elevator controller 16 can monitor the load within the car from signals generated by the load measurement device 19. If no overload is detected by the controller 16 at stage S2, the doors can close and the elevator 1 can commence a normal trip at stage S3 in response to conventional elevator calls.

On the contrary, if an overload is detected at S2, the procedure progresses to step S4 where a determination is made as to whether the controller 16 has been switched or enabled for an overload trip. If at stage S4 the controller 16 has not been enabled for an overload trip, then the car 2 remains stationary at the landing with its doors open and an overload alarm can be issued at step S5 within the car 2 to allow some passengers to disembark from the car 2.

If an overload trip has been enabled within the controller 16 at stage S4, then traction between the ropes 6 and the traction sheave 12 is enhanced at stage S6 in accordance with the examples illustrated in and described previously with respect to FIGS. 2 – 8.

Furthermore, at stage S7 internal parameters of the drive 8 can be switched by software or keyswitch so as to protect the drive 8 and motor 10 during the intended overload travel. For example the speed and/or the acceleration of the elevator 1 can be reduced, enhanced forced cooling can be implemented through the drive 8 and motor 10 and the travel path to transport the overload can be broken up with intermediate stops. Preferably, during intended overload operation, the number of starts that the elevator 1 can make in an hour is restricted.

In stage S8, the armature windings can be commutated from parallel to series connection as shown in FIG. 10.

For safety reasons, it is preferable that no person travels in the elevator car 2 with the overload during the overload trip. In step S9, the controller 16 can receive signals from a conventional person detector such as an infrared sensor to determine whether any personnel are present in the car 4. If anyone is detected in the car 4, then the car 2 remains stationary at the landing with its doors open and an alarm can be issued at step S10 within the car 2 to allow the detected personnel to disembark from the car 2.

When nobody has been detected in the car 4 at stage S9, the doors can close and the elevator 1 can commence an overload trip at stage S11.

The procedural steps outlined above can be carried out automatically by the elevator controller 16, manually by a trained technician or there can be a combination with some of the steps manually implemented and others automatically implemented.

Having illustrated and described the principles of the disclosed technologies, it will be apparent to those skilled in the art that the disclosed embodiments can be modified in arrangement and detail without departing from such principles. In view of the many possible embodiments to which the principles of the disclosed technologies can be applied, it should be recognized that the illustrated embodiments are only examples of the technologies and should not be taken as limiting the scope of the invention. Rather, the scope of the invention is defined by the following claims and their equivalents.

Claims

1. An elevator installation (1) comprising a car (2) and a counterweight (4) interconnected by one or more suspension ropes (6) engaging a traction sheave (12) which is driven by a motor (10), and configured to enhance traction between the suspension ropes (6) and the traction sheave (12) independently of the counterweight (4) for temporary transportation of an overload, wherein the motor (10) windings are switchable from parallel to series configuration.
2. An elevator installation (1) according to claim 1, further comprising an actuator (24) applying force (F_c) to a compensation rope (6) suspended between the car (2) and the counterweight (4).
3. An elevator installation (1) according to claim 1 wherein the suspension ropes (6) between the car (2) and the counterweight (4) follow a path over the traction sheave (12) and a deflection pulley (14) whereby the deflection pulley (14) is displaceable.
4. An elevator installation (1) according to claim 1 wherein the suspension ropes (6) between the car (2) and the counterweight (4) follow a path over the traction sheave (12) and a deflection pulley (14) further comprising an additional pulley (30) between the sheave (12) and the deflection pulley (14).
5. An elevator installation (1) according to claim 1, further comprising a pressure exertion device (40) to exert a pressure on the suspension ropes (6) as they engage the traction sheave (12) over a wrap angle (α).
6. An elevator installation (1) according to claim 5 wherein the pressure exertion device (40) comprises a tensioned, closed-loop belt (42) entrained over one or more rollers (44).
7. An elevator installation (1) according to claim 1, further comprising a traction sheave liner (48) between the traction sheave (12) and the suspension ropes (6).
8. An elevator installation (1) according to claim 1 wherein the counterweight (4) is

designed so that its total mass is equal to or greater than the sum of the mass of the empty elevator car (2) plus 50% of the nominal rated load so that during temporary transportation of the overload the elevator is underbalanced.