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(71) Applicant: **OTIS ELEVATOR COMPANY** [US/US]; One Carrier Place, Farmington, CT 06032 (US).

(72) Inventor; and

(71) Applicant *(for US only)*: **BLANCHARD, Antoine Adrian** [FR/FR]; Avenue des Montoires, F-45500 Gien (FR).

(74) Agents: **COLOMBET, Alain** et al.; Lavoix, 62, rue de Bonnel, F-69003 Lyon (FR).

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(54) Title: ELEVATOR VIBRATION DAMPING DEVICE

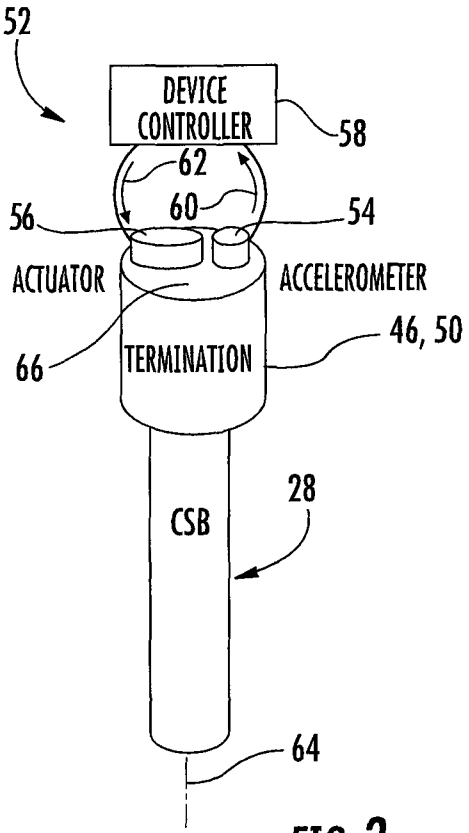


FIG. 3

(57) Abstract: An elevator system includes a stationary structure, a first sheave rotationally supported by the structure, a rope supported by the first sheave, and an elevator car supported by the rope. A vibration damping device of the elevator system is positioned at a first termination of the rope, and is configured to reduce vibration waves in the rope, thereby reducing noise in the elevator car.

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ELEVATOR VIBRATION DAMPING DEVICE

BACKGROUND

[0001] The present disclosure relates to an elevator, and more particularly, to a vibration damping device of the elevator.

[0002] One of the most popular elevator designs is known as a roped elevator. In such designs the elevator car of the elevator is raised and lowered by steel ropes, elevator cables or belts rather than (for example) pushed hydraulically from below. The ropes are typically looped around a sheave (e.g., pulley) connected to an electric motor. When the motor turns in one rotational direction, the elevator car rises; and, when the motor turns in an opposite rotational direction, the elevator car lowers. The elevator may be gearless with the motor connected directly to the sheave or may include gears generally positioned between the motor and the sheave. Traditionally, the sheave, motor and related electric control systems are housed in a machine room positioned above an elevator shaft that the elevator car moves within; however, the need for such rooms are becoming less common.

[0003] Secured to the top of the elevator car may be a second pulley. The rope may extend from the first sheave and down to the second pulley where the rope loops through the pulley and extends upward to the top of the shaft where an end of the rope is rigidly secured. An opposite end of the rope (or a second rope) may be secured to a counterweight of the elevator that may generally hang from the other side of the first sheave. Typically, the counterweight weighs about the same as the elevator car when filled to about fifty percent capacity. Use of the counterweight conserves energy and reduces the work output of the motor required to raise the elevator car.

[0004] Many other features are included as part of the elevator that contribute toward a smooth, quiet and comfortable ride. For example, the elevator shaft may generally include a series of rails that keep the elevator car and counterweight from swaying back and forth. However, further noise reduction and/or vibration damping is still desirable to contribute further to ride comfort.

SUMMARY

[0005] An elevator vibration damping device constructed and arranged to mount to a termination of a rope according to one, non-limiting, embodiment of the present disclosure includes an electronic controller; an accelerometer configured to sense vibration waves and send a vibration signal to the electronic controller; and an actuator configured to receive a damping command from the electronic controller and transmit energy into the termination.

[0006] Additionally to the foregoing embodiment, the vibration waves include longitudinal vibration waves and the actuator is constructed and arranged to reduce longitudinal vibration waves in the rope.

[0007] In the alternative or additionally thereto, in the foregoing embodiment, the vibration waves include lateral vibration waves and the actuator is constructed and arranged to reduce lateral vibration waves in the rope.

[0008] In the alternative or additionally thereto, in the foregoing embodiment, the controller, the accelerometer and the actuator are packaged as one unit.

[0009] An elevator system according to another, non-limiting, embodiment includes a stationary structure; a first sheave rotationally supported by the structure; a rope supported by the first sheave and including a first termination; an elevator car supported by the rope; and a first vibration damping device configured to inject energy into the rope for reducing vibration waves.

[0010] Additionally to the foregoing embodiment, the first vibration damping device is positioned at the first termination which is load bearing.

[0011] In the alternative or additionally thereto, in the foregoing embodiment, the system includes a drive system including the first sheave constructed and arranged to controllably drive the rope, and wherein the vibration damping device is integrated into the drive system for injecting energy into the rope through the first sheave to reduce longitudinal vibration.

[0012] In the alternative or additionally thereto, in the foregoing embodiment, the rope is a coated steel belt.

[0013] In the alternative or additionally thereto, in the foregoing embodiment, the first termination is at the stationary structure and the vibration wave is a longitudinal vibration wave with respect to the rope.

[0014] In the alternative or additionally thereto, in the foregoing embodiment, the elevator system includes a second sheave rotationally supported by the elevator car, wherein the rope extends substantially downward from the first sheave to the second sheave and substantially upward from the second sheave and to the first termination supported by the structure.

[0015] In the alternative or additionally thereto, in the foregoing embodiment, the elevator system includes a counterweight supported by a first portion of the rope; and a third sheave rotationally supported by the counterweight, and wherein the first portion of the rope substantially extends downward from the first sheave and through the third sheave and substantially upward to the first termination supported by the structure.

[0016] In the alternative or additionally thereto, in the foregoing embodiment, the elevator system includes a second sheave rotationally supported by the elevator car, wherein a second portion of the rope extends substantially downward from the first sheave to the second sheave and substantially upward from the second sheave and to a second termination supported by the structure; and a second vibration damping device positioned at the second termination configured to reduce longitudinal vibration waves in the second portion.

[0017] In the alternative or additionally thereto, in the foregoing embodiment, the elevator system includes a counterweight supported by a first portion of the rope extending at least in-part downward from the first sheave, and wherein a second portion of the rope extends at least in-part downward from the first sheave to the elevator car.

[0018] In the alternative or additionally thereto, in the foregoing embodiment, the first termination is disposed at the elevator car the vibration waves include longitudinal vibration waves with respect to the second portion.

[0019] In the alternative or additionally thereto, in the foregoing embodiment, the first termination is disposed at the elevator car and the vibration waves include lateral vibration waves with respect to the second portion.

[0020] In the alternative or additionally thereto, in the foregoing embodiment, the first termination is disposed at the counterweight and the vibration waves include longitudinal vibration waves with respect to the first portion.

[0021] In the alternative or additionally thereto, in the foregoing embodiment, the first termination is disposed at the counterweight, and the vibration waves include lateral vibration waves with respect to the first portion.

[0022] In the alternative or additionally thereto, in the foregoing embodiment, the vibration damping device includes an electronic controller, an accelerometer configured to sense the vibration waves and send a vibration signal to the electronic controller, and an actuator configured to receive a damping command from the electronic controller and transmit energy into the first termination.

[0023] A method of reducing noise in an elevator car of an elevator system according to another, non-limiting, embodiment includes sensing vibration waves at a termination of an elevator rope by an accelerometer; and injecting energy into the termination by an actuator to cancel out at least a portion of the sensed vibration waves.

[0024] Additionally to the foregoing embodiment, the method includes transmitting a signal indicative of sensed vibration waves from the accelerometer and to an electronic controller; processing the signal by the controller; and sending a signal command to the actuator indicative of energy to be transmitted to the termination.

[0025] The foregoing features and elements may be combined in various combinations without exclusivity, unless expressly indicated otherwise. These features and elements as well as the operation thereof will become more apparent in light of the following description and the accompanying drawings. However, it should be understood that the following description and drawings are intended to be exemplary in nature and non-limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Various features will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiments. The drawings that accompany the detailed description can be briefly described as follows:

[0027] FIG. 1 is a perspective view of an elevator system with parts broken away to show internal detail as one, non-limiting, exemplary embodiment of the present disclosure;

[0028] FIG. 2 is a block diagram of the elevator system;

[0029] FIG. 3 is a schematic of a vibration damping device of the elevator system;

[0030] FIG. 4 is a perspective view of an actuator and an accelerometer of the device and secured to a rope termination; and

[0031] FIG. 5 is a block diagram of a second embodiment of an elevator system utilizing the vibration damping device.

DETAILED DESCRIPTION

[0032] Referring to FIG. 1, an elevator system 20 of the present disclosure is illustrated. The elevator system 20 may include an elevator car 22, a counterweight 24, a drive system 26, and a rope 28. The elevator car 22 may carry passengers or other objects and is constructed to move substantially vertically in a hoistway 30 of the elevator system 20. Boundaries of the hoistway 30 may be defined by a stationary structure or building 32 that may utilize and house the elevator system 20. The drive system 26 may be housed in a machine room 34 of the building 32 located generally above the hoistway 30, and may include an electric motor 36 that rotates a sheave 38. The rope 28 is wrapped about the sheave 38 and extends between the elevator car 22 and the counterweight 24 such that when the drive system 26 receives a command signal to raise the elevator car 22, the

sheave is rotated in a first direction that lowers the counterweight 24 as the elevator car 22 rises, and vice-versa. The counterweight 24 generally weighs about the same as the elevator car 22 when at about fifty percent capacity, and thus reduces the work output requirements of the drive system 26.

[0033] Referring to FIGS. 1 and 2, the elevator system 20 may further include at least one sheave or pulley 40 (i.e., two illustrated) rotationally mounted to the elevator car 22, and a sheave or pulley 42 rotationally mounted to the counterweight 24. From the sheave 38 of the drive system 26, a car portion 44 of the rope 28 may generally extend in a downward direction, then wrap about the sheave 40, and extend back upward to a termination 46 of the rope 28. Similarly and from an opposite side of the sheave 38 of the drive system 26, a counterweight portion 48 of the rope 28 may generally extend in a downward direction, wrap about the sheave 42, and extend back upward to a termination 50 of the rope 28. Both terminations 46, 50 of the rope 28 may be load bearing and may be secured to and supported by the structure 32.

[0034] The rope 28 may be any variety of flexible and elongated members and includes braided elevator cables that may be steel, and belts. The belts may include a series of small elevator cables or straps coated with any variety of materials (e.g., polyurethane) and referred to as coated steel belts (CSB). It is further contemplated and understood that the rope 28 may include a series of ropes aligned side-by-side with each rope wrapped about the sheaves 38, 40, 42 in respective grooves. It is further understood that the car and counterweight portions 44, 48 of the rope 28 may generally be separated at the sheave 38 of the drive system 26 with the car portion 44 wrapping about the sheave 38 in a first rotational direction, and the counterweight portion 48 wrapping about the sheave 38 in an opposite rotational direction. It is further understood that the portion 44, 48 may be other than car and counterweight portions and is dependent upon any number of non-limiting examples of sheave arrangements. For example, an elevator system may not have a counterweight, yet may still have two rope portions on either side of a motor driven sheave.

[0035] Referring to FIGS. 2 and 3, the terminations 46, 50 may be dead end hitches as is generally known in the art. Associated with at least one of the terminations 46, 50 is a

vibration damping device 52 configured to reduce longitudinal vibration waves (see arrow 53 in FIG. 2) in the rope 28 that may otherwise be transmitted to the elevator car 22 and contribute toward noise. The vibration damping device 52 may include an accelerometer 54, an actuator 56 and an electronic controller 58. The accelerometer 54 and the actuator 56 may be mounted directly to the terminations 46, 50, and the electronic controller 58 may receive data signals (see arrow 60 in FIG. 3) from the accelerometer and issue command signals (see arrow 62) to the actuator 56 over wired and/or wireless paths. The electronic controller 58 may be remotely located or may be packaged together with the accelerometer 54 and actuator 56 producing one compact module for easy installation. Moreover the device 52 may be retrofitted onto existing elevator systems without modifying pre-installed structures or components. It is further understood that if the rope 28 actually includes a plurality of ropes typically aligned side-by-side, each rope is associated with a respective vibration damping device 52 for damping longitudinal vibration waves.

[0036] It is further contemplated that the actuator 56 of the vibration damping device 52 may be integrated into the drive system 26. The drive system 26 may inject energy by controlling the system's acyclisms via current sheave rotation commands. The energy is thus injected through the sheave 38 and into the rope 28 thus damping longitudinal vibration waves in the rope.

[0037] In operation, the elevator system 20 may produce longitudinal vibrations along the length of the rope 28. More specifically, elevator operation may produce longitudinal displacement of the rope 28 along a rope centerline 64 having a vibration frequency and longitudinal amplitude that may contribute toward noise within the elevator car 22. The vibration damping device 52 facilitates the substantial cancellation of the longitudinal vibration waves by adding energy to rope 28 at the terminations 46, 50. Each termination 46, 50 may include a surface 66 that is substantially normal to the centerline 64 proximate to the terminations, and that faces in an opposite direction than the projecting direction of the rope 28. The accelerometer 54 and the actuator 56 may be rigidly mounted to the surface 66. The surface 66 may further be the end of a threaded bolt utilized as part of the termination 46, 50 to secure the rope 28 to the structure 32 (see FIG. 4).

[0038] In operation and as the elevator car 22 travels up and down, longitudinal vibration waves may be transmitted through the rope 28. The accelerometer 54 senses the longitudinal vibration waves and transmits the data to the controller 58 that electronically processes the data and issues the command signal 62 to the actuator 56. The actuator 56 may then transmit appropriate degrees of energy into the rope 28 to cancel-out the longitudinal vibration waves. It is further contemplated and understood that the vibration damping device 52 may not completely cancel all longitudinal vibration but may transmit enough energy and at appropriate frequencies into the rope 28 to prevent resonating vibrations.

[0039] Referring to FIG. 5, a second embodiment of an elevator system is illustrated wherein like elements to the first embodiment have like identifying numerals except with the addition of a prime symbol suffix. The elevator system 20' may include a car portion 44' having a termination 46' at an elevator car 22'. Similarly, the counterweight portion 48' may have a termination 50' at a counterweight 24'. Vibration damping devices 52' may be mounted to each termination 46', 50'.

[0040] The counterweight 24' and/or the elevator car 22' may experience noise attributable from lateral vibration waves (see arrow 68) and/or longitudinal vibration waves 53'. The vibration damping device 52' of elevator system 20' may be configured to both the lateral and longitudinal vibration waves 68, 53'.

[0041] While the present disclosure is described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the spirit and scope of the present disclosure. In addition, various modifications may be applied to adapt the teachings of the present disclosure to particular situations, applications, and/or materials, without departing from the essential scope thereof. The present disclosure is thus not limited to the particular examples disclosed herein, but includes all embodiments falling within the scope of the appended claims.

CLAIMS

What is claimed is:

1. An elevator vibration damping device constructed and arranged to mount to a termination of a rope, the device comprising:

an electronic controller;

an accelerometer configured to sense vibration waves and send a vibration signal to the electronic controller; and

an actuator configured to receive a damping command from the electronic controller and transmit energy into the termination.

2. The elevator vibration damping device set forth in claim 1, wherein the vibration waves include longitudinal vibration waves and the actuator is constructed and arranged to reduce longitudinal vibration waves in the rope.

3. The elevator vibration damping device set forth in any preceding claim, wherein the vibration waves include lateral vibration waves and the actuator is constructed and arranged to reduce lateral vibration waves in the rope.

4. The elevator vibration damping device set forth in any preceding claim, wherein the controller, the accelerometer and the actuator are packaged as one unit.

5. An elevator system comprising:

a stationary structure;

a first sheave rotationally supported by the structure;

a rope supported by the first sheave and including a first termination;

an elevator car supported by the rope; and

a first vibration damping device configured to inject energy into the rope for reducing vibration waves.

6. The elevator system set forth in claim 5, wherein the first vibration damping device is positioned at the first termination which is load bearing.

7. The elevator system set forth in claim 5 further comprising:

a drive system including the first sheave constructed and arranged to controllably drive the rope, and wherein the vibration damping device is integrated into the drive system for injecting energy into the rope through the first sheave to reduce longitudinal vibration.

8. The elevator system set forth in any preceding claim, wherein the rope is a coated steel belt.

9. The elevator system set forth in any of claims 6 and 8, wherein the first termination is at the stationary structure and the vibration wave is a longitudinal vibration wave with respect to the rope.

10. The elevator system set forth in any of claims 6, 8 and 9 further comprising:

a second sheave rotationally supported by the elevator car, wherein the rope extends substantially downward from the first sheave to the second sheave and substantially upward from the second sheave and to the first termination supported by the structure.

11. The elevator system set forth in any of claims 6, and 8-9 further comprising:

a counterweight supported by a first portion of the rope; and

a third sheave rotationally supported by the counterweight, and wherein the first portion of the rope substantially extends downward from the first sheave and through the third sheave and substantially upward to the first termination supported by the structure.

12. The elevator system set forth in claim 11 further comprising:

a second sheave rotationally supported by the elevator car, wherein a second portion of the rope extends substantially downward from the first sheave to the second

sheave and substantially upward from the second sheave and to a second termination supported by the structure; and

a second vibration damping device positioned at the second termination configured to reduce longitudinal vibration waves in the second portion.

13. The elevator system set forth in any of claims 6, and 8-12 further comprising:

a counterweight supported by a first portion of the rope extending at least in-part downward from the first sheave, and wherein a second portion of the rope extends at least in-part downward from the first sheave to the elevator car.

14. The elevator system set forth in claim 13, wherein the first termination is disposed at the elevator car, and the vibration waves include longitudinal vibration waves with respect to the second portion.

15. The elevator system set forth in claim any of claims 13 and 14, wherein the first termination is disposed at the elevator car the vibration waves include lateral vibration waves with respect to the second portion.

16. The elevator system set forth in claim 13, wherein the first termination is disposed at the counterweight and the vibration waves include longitudinal vibration waves with respect to the first portion.

17. The elevator system set forth in claim 13 or 16, wherein the first termination is disposed at the counterweight and the vibration waves include lateral vibration waves with respect to the first portion.

18. The elevator system set forth in any preceding claim, wherein the vibration damping device includes an electronic controller, an accelerometer configured to sense the vibration waves and send a vibration signal to the electronic controller, and an actuator configured to receive a damping command from the electronic controller and transmit energy into the first termination.

19. A method of reducing noise in an elevator car of an elevator system comprising:

sensing vibration waves at a termination of an elevator rope by an accelerometer; and

injecting energy into the termination by an actuator to cancel out at least a portion of the sensed vibration waves.

20. The method set forth in claim 19 further comprising:

transmitting a signal indicative of sensed vibration waves from the accelerometer and to an electronic controller;

processing the signal by the controller; and

sending a signal command to the actuator indicative of energy to be transmitted to the termination.

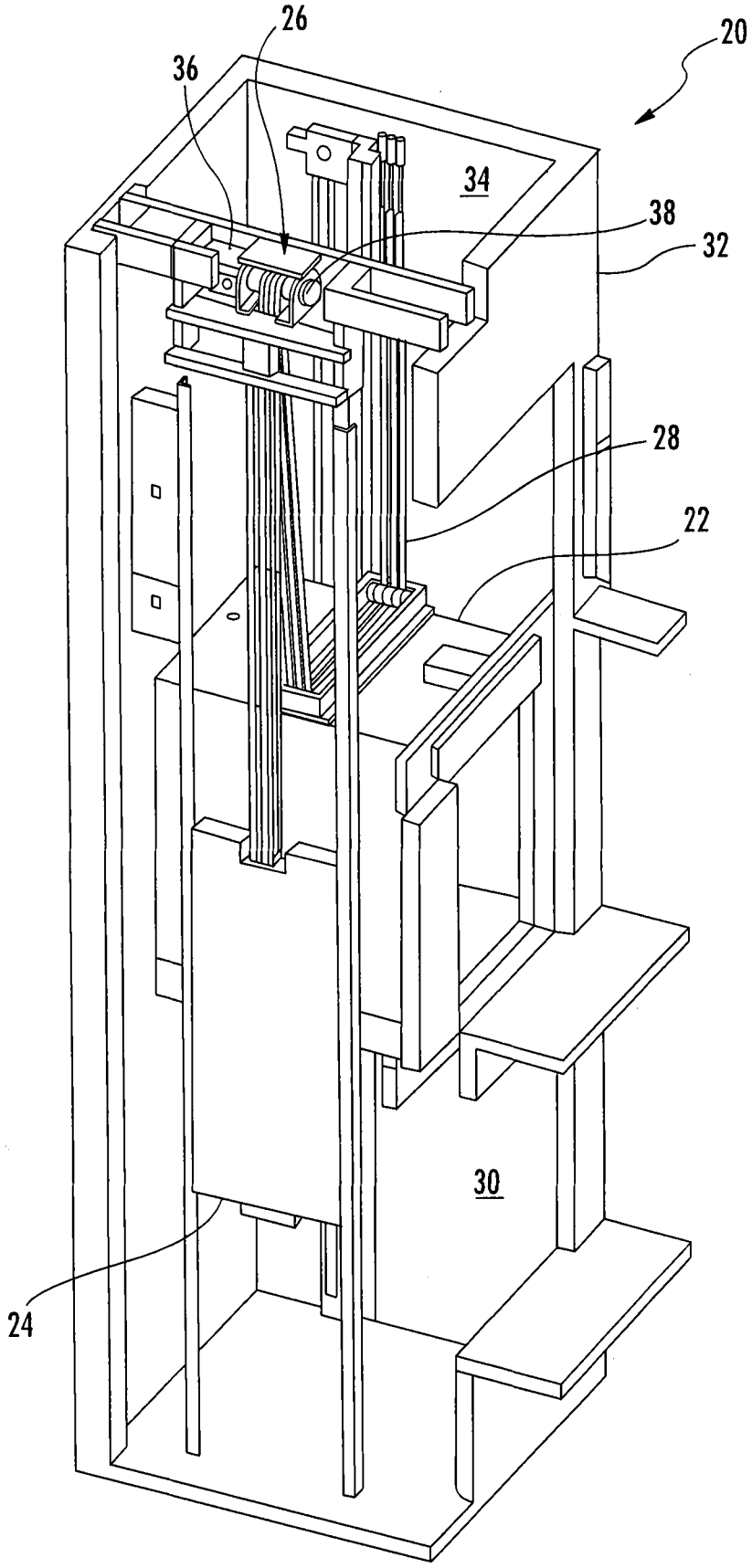


FIG. 1

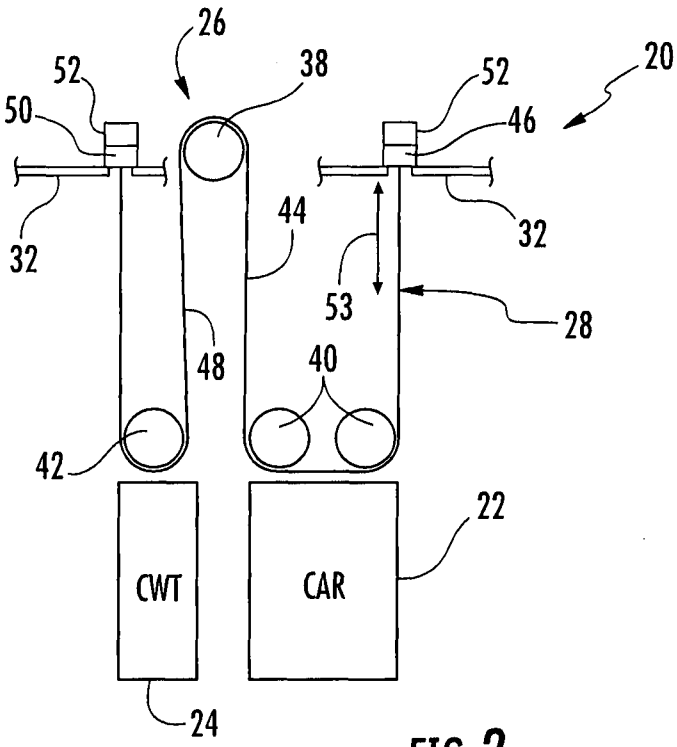

26
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32
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44
53
28
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40
42
22
CWT
CAR
24

FIG. 2

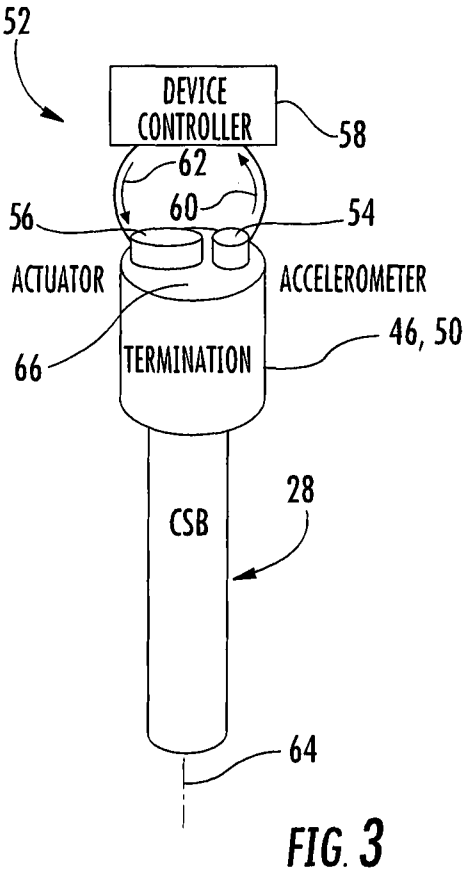

52
DEVICE CONTROLLER
58
62
60
56
54
ACTUATOR
ACCELEROMETER
66
TERMINATION
46, 50
CSB
28
64

FIG. 3

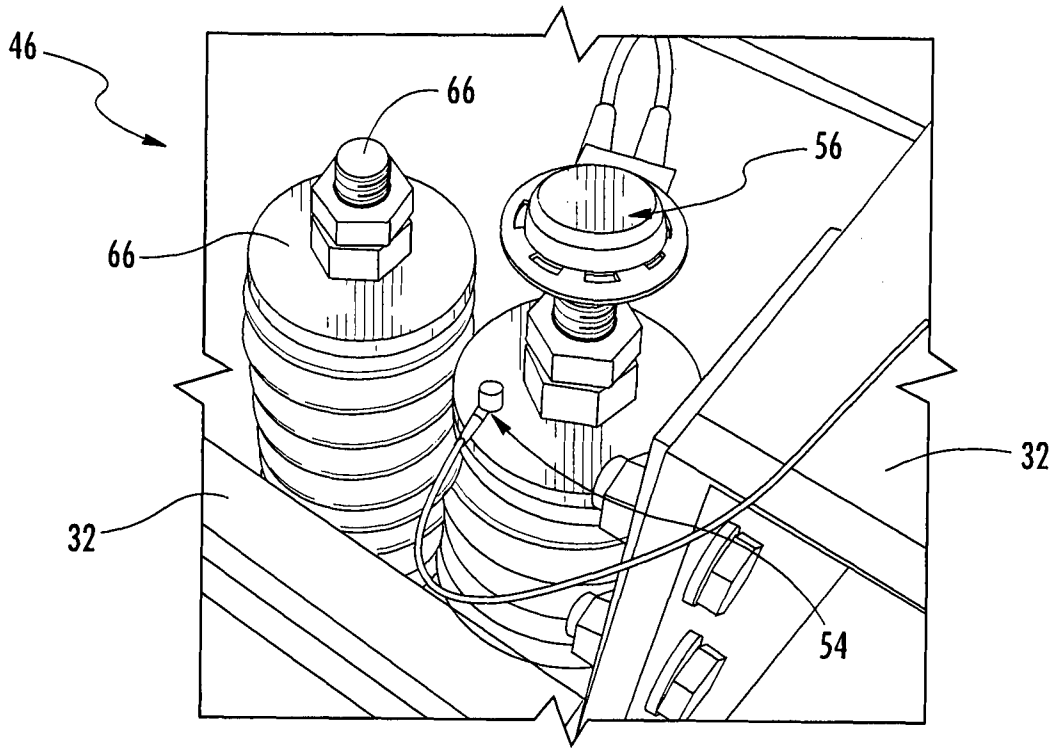

46
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66
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32
32
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FIG. 4

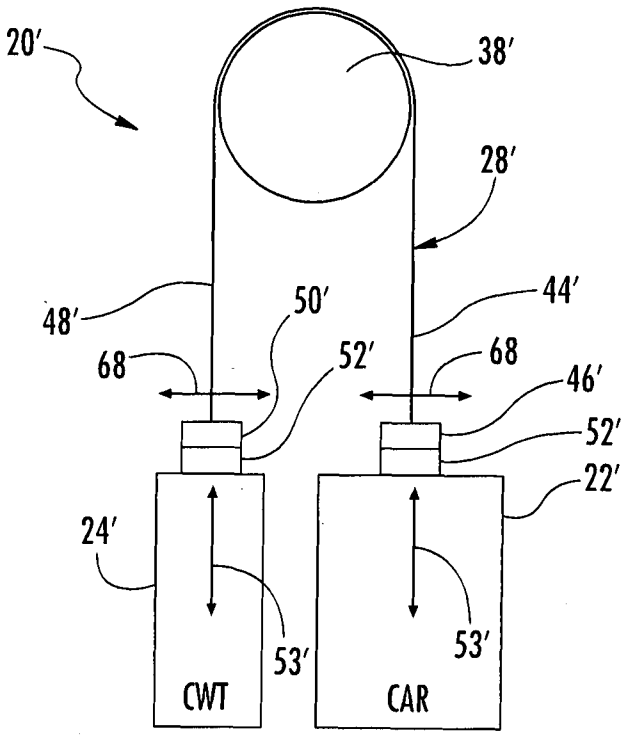

20'
38'
28'
48'
50'
44'
68
52'
68
46'
52'
22'
24'
53'
53'
CWT
CAR

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/001254

A. CLASSIFICATION OF SUBJECT MATTER
INV. B66B7/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B66B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2003 192242 A (MITSUBISHI ELECTRIC CORP) 9 July 2003 (2003-07-09) paragraphs [0020], [0022], [0045]; figures 1-6	1-3,5-7, 9-20 4,8
X	JP 2014 159328 A (TOSHIBA ELEVATOR CO LTD) 4 September 2014 (2014-09-04) abstract; figures 1-5	1-3,5,6, 13-20
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Y	WO 2013/158073 A1 (OTIS ELEVATOR CO [US]; BLANC ARTHUR [US]; POLAK DAVID R [US]; HOMMA KE) 24 October 2013 (2013-10-24) abstract; figure 3	4,8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 March 2016	23/03/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Janssens, Gerd

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2015/001254

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