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(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

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(54) **Title**: PULLEY FOR ELEVATORS

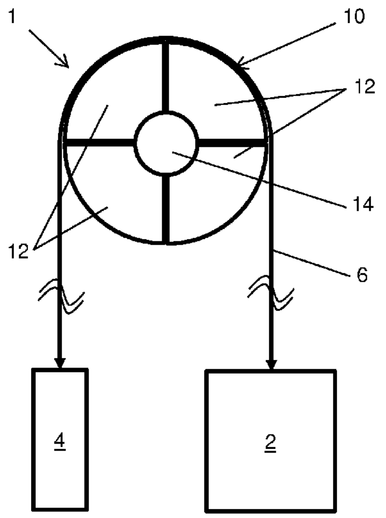

FIG. 1A

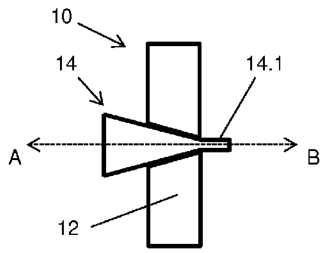

FIG. 1B

(57) **Abstract**: Enhancement of a traction elevator (1) so as to enable more self-regulation with respect to power consumption, speed regulation, torque regulation and/or general performance by providing an elevator pulley (10;50), an elevator comprising the pulley and a method of operating the elevator. The elevator pulley (10;50) comprises a core (16) aligned along an axis (A-B) of the pulley (10;50) and a plurality of pulley segments (12) arranged circumferentially around the core (14) wherein the core (14) is selectively movable along the pulley axis (A-B) and wherein the segments (12) are radially displaceable by axial movement of the core (14).

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Pulley for Elevators

Description

The present disclosure relates to elevators and particularly to a method and mechanism for improving both elevator performance and energy efficiency within such installations.

Conventional traction driven elevator systems typically consist of an elevator car and counterweight interconnected by and supported on a rope. The rope is wrapped around a traction sheave, which is coupled to an electrical motor, so that when the motor is driven the car and counterweight are moved in opposing directions along an elevator hoistway. The traction sheave may have a smooth circumferential surface for engagement with the rope or can be provided, as in US 4,013,142, with a plurality of fixed segments with grooves therebetween.

The counterweight compensates not only for the weight of the empty elevator car but also for a preset percentage of the rated load. Typically this balance factor is 40-50% of the rated load. In operation, however, the elevator system is rarely ever balanced and the electric motor must compensate for any imbalance between the car and counterweight sides of the traction sheave thus leading to considerable power consumption.

Instead of the conventional traction driven elevator described above, WO-A1-2006/057510 discloses an positively driven elevator which has an improved structure such that a counterweight offsets the weight of a car, its passengers and cargo according to changes in weight of the passengers and cargo, thus reducing power consumption. The elevator car is attached to a rope which is fixed to and wound upon a first drum or winch which is positively driven by a motor. Similarly, the counterweight is attached to a rope mounted to and wound upon a second drum or winch. The first and second drums are selectively coupled to each other by an electronic control transmission, typically in the form of a continuously variable transmission to selectively transmit power therebetween. The gear ratio of the transmission is adjusted in consideration of the number of passengers or the weight of cargo, so that power consumption required for operating the elevator is reduced. A similar positively driven system is described in US-A1-2005/0006181.

It is an objective of the present invention to obtain at least some of the advantages taught with respect to the positively driven systems described in both WO-A1-2006/057510 and US-A1-2005/0006181 for a conventional traction driven elevator.

In particular, it is an objective of the present invention to enhance the traction elevator so as to enable more self-regulation with respect to power consumption, speed regulation, torque regulation and/or general performance by providing an elevator pulley, an elevator comprising the pulley and a method of operating the elevator according to the independent claims.

The elevator pulley comprises a core aligned along an axis of the pulley and a plurality of pulley segments arranged circumferentially around the core wherein the core is selectively movable along the pulley axis and wherein the segments are radially displaceable by axial movement of the core.

Accordingly, in use, axial movement of the tapered core in one direction along the pulley axis results in the projection of the segments radially outwards from the pulley axis thereby effectively enlarging the diameter of the pulley. Conversely, movement of the core in the opposite direction results in the withdrawal of the segments radially inwards towards the pulley axis.

The axial core can have one of a number of different tapered profiles. It can be conical. Alternatively, the core can have a plurality of tapered projections around a cylindrical centre. In a further example, the core may be in the form of a pyramid. Preferably, the number of sides of the pyramid engaging with the segments correspond to the number of segments.

The segments can be axially keyed to the core and thereby provide guidance as the core is selectively moved along the pulley axis.

In one example the pulley further comprises a base plate. The segments can be radially keyed to the base plate to provide guidance and also to ensure that the segments are retained at the same axial position as the core is selectively moved along the pulley axis.

Preferably, the pulley further comprises one or more spring elements to bias each of the segments radially inward towards the pulley axis. Preferably, the spring element is a retention spring encircling the segments. The retention spring ensures that all segments move radially in unison and to the same extent when the core is moved axially.

Advantageously, sides of neighbouring segments of the pulley have complementary profiles. In a particular example, the sides of the segments have a generally S-shaped profile. An advantage of this arrangement is that at the transition from one segment to the neighbouring segment, any traction means engaging with the pulley is always at least partially supported along its cross-section on one of the segments.

The pulley may further comprise an actuator to selectively move the core along the pulley axis.

The invention also provides an elevator comprising an elevator car and counterweight interconnected by and supported on traction means, wherein the traction means engages with the elevator pulley described above.

Within the elevator, the pulley can be coupled directly or indirectly to an electrical motor so that when the motor is driven, the pulley rotates and engages with the traction means to move the car and counterweight in opposing directions along an elevator hoistway. This arrangement permits continuous variable transmission, whereby the torque and speed at which the pulley engages with the belt can be varied with respect to the torque and speed of the motor driving the pulley.

Additionally, the invention provides a method for operating an elevator comprising the steps of providing a pulley for engagement with traction means, and selectively expanding and contracting the pulley.

The invention is herein described by way of specific examples with reference to the accompanying drawings of which:

FIGS. 1A and 1B are schematics depicting plan and side views, respectively, of an exemplary embodiment of an elevator incorporating a traction sheave according to the present invention;

FIGS. 2A and 2B correspond to the arrangements illustrated in FIGS. 1A and 1B wherein the traction sheave of an exemplary embodiment is placed into a different operating condition;

FIG. 3 is illustrates an exemplary embodiment of a typical combination of the traction sheave of FIGS. 1 and 2 together with a drive within a traction elevator;

FIG. 4 is a signal diagram depicting an example of the flow of information and command signals within the elevator of FIG. 3;

FIG. 5 is an exploded perspective view of an exemplary embodiment showing the interrelationship between the sheave segments and base plate from FIG. 3;

FIGS. 6A and 6B are schematics depicting plan and side views, respectively, of an exemplary embodiment of a traction sheave according to the present invention;

FIGS. 7A and 7B are schematics depicting plan and side views, respectively, of an exemplary embodiment of a traction sheave according to the present invention;

FIGS. 8A and 8B are plan side views illustrating, in an exemplary embodiment, the interaction between neighbouring segments of a traction sheave in retracted and expanded positions, respectively; and

FIG. 9 is a schematic of an elevator of an exemplary embodiment incorporating a deflection pulley according to the present invention.

FIGS. 1A and 1B are schematics depicting plan and side views, respectively, of an exemplary embodiment of an elevator 1 incorporating a traction sheave 10 according to the present invention. As in a conventional traction driven elevator system, an elevator car 2 and a counterweight 4 are interconnected by and supported on a traction means 6. In the arrangement illustrated, a 1:1 roping ratio is shown where the opposing terminations of the traction means 6 are directly fastened to car 2 and counterweight 4, respectively. However, it will be appreciated that other roping ratios can also be used. Typically, the traction means 6 maybe a cable, rope or belt. The traction means 6 is wrapped over the traction sheave 10, which is coupled to an electrical motor 36 so that when the motor 36 is driven the car 2 and counterweight 4 are moved in opposing directions along an elevator hoistway. In this particular example, the traction means 6 engages with the traction sheave 10 over a wrap angle of 180° but other wrap angles are also possible.

The elevator traction sheave 10 has a central core 14 aligned along an axis A-B of the traction sheave 10. A plurality of sheave segments 12 are arranged circumferentially around the core 14. The core 14 has a tapered profile such that it extends radially outward more so at one axial end (to the left in FIG. 1B) than it does at the opposing axial end (to the right of FIG. 1B). In this example, the core 14 is in the form of a cone that tapers inwards towards one end 14.1. The core 14 is selectively movable along the pulley axis A-B so that the sheave segments 12 can be extended radially outwards and retracted radially inwards from the pulley axis A-B, respectively.

With the core 14 axially positioned to the left as shown in FIG. 1B, the traction sheave segments 12 are in their fully retracted position. As the core 14 moves axially to the right, as shown in FIG. 2B, the segments 12 extend progressively outwards from axis A-B and consequently the travel path of the traction means 6 over the traction sheave 10 is lengthened, as shown in FIG. 2A. Conversely, movement in the opposite direction results in the retraction of the segments 12 radially inwards towards the pulley axis A-B and subsequent reduction in the travel path of the traction means 6 over the traction sheave 10. These gradual and continual variations in the length of the travel path of the traction means 6 over the traction sheave 10 during operation permits continuous variable transmission whereby the torque and speed at which the traction sheave 10 engages with the traction means 6 can be varied with respect to the torque and speed of the motor 36 driving the traction sheave 10.

FIG. 3 is illustrates an exemplary embodiment of a typical combination of the traction sheave 10 of FIGS. 1 and 2 together with a drive 30 within a traction elevator 1. In addition to the segments 12 and core 14 as previously described, the traction sheave 10 additionally includes a base plate 16, which retains the segments 12 at a preset axial position and, in this particular example, an actuator 18 to move the core 14 axially. As all components of the sheave 10 rotate in unison, power and control signals are fed to the actuator 18 from a sheave control 20 via brushes 22, which engage with corresponding rings mounted on the surface of the actuator 18.

Alternately, the actuator 18 can be provided with its own power source. Such a power source in disclosed in European Patent Application No. 14198949.1 wherein the traction sheave comprises a piezoelectric layer positioned such that any force imparted to the sheave during engagement with the tension member compresses the piezoelectric layer which in turn generates electrical energy which can be harvested and thereby stored in a power storage unit which can be integral with the traction sheave. In this instance, the control signals can be communicated wirelessly from the sheave control 20.

Preferably the actuator 18 is a stepper motor engaging with a screw thread provided on the associated end 14.1 of the core 14 to progressively move the core 14 in the opposing axial directions A and B.

Instead of incorporating the actuator 18 into the sheave 10, it is equally feasible to provide the actuator 18 independently so that it acts on the opposing, exposed end of the core 14 (to the left in FIG. 3).

The traction sheave 10 is directly or indirectly connected to a drive shaft 34 of the drive 30. The drive shaft 34 is rotated by an electric motor 36 and can be halted by one or more brakes 32. Typically the traction sheave 10 and/or drive shaft 34 will be rotatably supported by one or more bearings (not shown).

In order to determine the best travel profile to adopt for the elevator 1 in a particular situation, the elevator controller 40 must discern the prevailing conditions. Accordingly, as shown in FIG. 4, multiple sensors are arranged in the elevator 1 to communicate information to the controller 40 such as sensors 42 to inform the elevator controller 40 of the car's instantaneous position within the hoistway, a load sensor 44 to determine the load within the car 2 and standard call input devices 46 to transmit passengers' travel requests to the controller 40. From the information gathered, the elevator controller 40 generates the required command signals to the drive 30 to perform the necessary travel but additionally it can also determine whether it is beneficial to expand or contract the traction sheave 10 during travel and instruct the sheave control 20 accordingly. Although, shown as a separate component, the sheave control 20 can be incorporated into the drive 30 or into the elevator controller 40.

FIG. 5 is an exploded, perspective view of an exemplary embodiment showing in more detail the interrelationship between the sheave segments 12 and base plate 16 from the previously described examples. Each of the segments 12 is provided with a dovetail key 24 which is slotted into corresponding radial grooves 26 formed in the base plate 16. A constant force retention spring 28 encircles the keys 24 after insertion into base plate 16 to bias each of the segments 12 radially inward towards the pulley axis A-B. Additionally, the retention spring 28 ensures that all segments 12 move radially in unison and to the same extent when the core 14 is axially inserted and withdrawn by the actuator 18.

Although not shown, it will be appreciated that the sheave segments 12 can alternatively or additionally be axially keyed to the core 14 to provide guidance as the core 14 inserted and withdrawn by the actuator 18.

FIGS. 6 and 7 correspond to the schematics outlined in FIG. 2, but illustrate the use of axial cores 16 having different tapered profiles. In particular, FIG. 6 shows a core 14 having a plurality of discrete tapered projections 14.2 arranged around a cylindrical centre 14.2. FIG. 7 illustrates the use of a core 14 having the form of a pyramid.

FIGS. 8A and 8B are views from above a traction sheave illustrating the arrangement of neighbouring segments in a retracted position and in an expanded position, respectively. The sides 14.1 of neighbouring segments 14 have complementary profiles. In this particular example the sides 14.1 of the segments have a generally S-shaped profile. An advantage of this arrangement is that at the transition of the belt 6 from one segment 14 to the neighbouring segment 14 it is always at least partially supported along its cross-section on one of the segments 14. Looking at the cross-section of the belt 6 directly above the pulley axis A-B, it is evident from the drawing that the left section is always supported on the upper segment 14, while the section to the right is support on the lower segment 14.

Although described above in relation to a traction sheave, it is easily conceivable that the invention can be applied similarly to other elevator pulleys. For example, FIG. 9 illustrates such an application with a conventional traction sheave 10 and a segmented deflection pulley 50. The elevator car 2 and counterweight 4 are interconnected by and supported on a traction means 6. The traction means 6 extends from the car 2 over a wrap angle α on the conventional traction sheave 10, across to the segmented deflection pulley 50 and down to the counterweight 4. As in the previously described examples, the segments 12 of the deflection pulley 50 can be extended radially outwards and retracted radially inwards, respectively. The effect of selectively varying the effective diameter of the deflection pulley 10 in this manner will be that the wrap angle α of the tension member 6 on the traction sheave 10 can be altered and thereby the drive characteristic of the elevator 1 can be altered.

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 pulley (10;50), comprising a core (16) aligned along an axis (A-B) of the pulley (10;50), and a plurality of pulley segments (12) arranged circumferentially around the core (14) characterised in that the core (14) is selectively movable along the pulley axis (A-B) and wherein the segments (12) are radially displaceable by axial movement of the core (14).

2. An elevator pulley according to claim 1 wherein the core (14) is tapered.

3. An elevator pulley according to claim 1 or claim 2 wherein the segments (12) are axially keyed to the core (14).

4. An elevator pulley according to any preceding claim, further comprising a base plate (16).

5. An elevator pulley according to claim 4 wherein the segments (12) are radially keyed to the base plate (16).

6. An elevator pulley according to any preceding claim, further comprising one or more spring elements to bias the segments radially inward towards the pulley axis.

7. An elevator pulley according to claim 6, wherein the spring element is a retention spring (28) encircling the segments (12).

8. An elevator pulley according to any preceding claim wherein sides (12.1) of neighbouring segments (12) have complementary surfaces.

9. An elevator pulley according any preceding claim, further comprising an actuator (18) to selectively move the core (16) along the pulley axis (A-B).

10. An elevator (1) comprising an elevator car (2) and counterweight (4) interconnected by and supported on traction means (6) wherein the traction means engages with a pulley according to any of claims 1 to 8.

11. An elevator according to claim 10, further comprising an actuator (18) to selectively move the core (16) along the pulley axis (A-B).

12. An elevator (1) comprising an elevator car (2) and counterweight (4) interconnected by and supported on traction means (6) wherein the traction means engages with a pulley according to claim 9.

13. An elevator according to any of claims 10 to 12 wherein the pulley is coupled to an electrical motor so that when the motor is driven, the pulley rotates and engages with the traction means to move the car and counterweight in opposing directions along an elevator hoistway.

14. A method for operating an elevator (1) comprising the steps of providing a plurality of pulley segments (12) for engagement with traction means (6), and selectively radially expanding and contracting the pulley segments from a pulley axis (A-B).

15. A method according to claim 14 further comprising the steps of arranging the pulley segments (12) circumferentially around a tapered core (14) and selectively moving the core along the pulley axis (A-B).

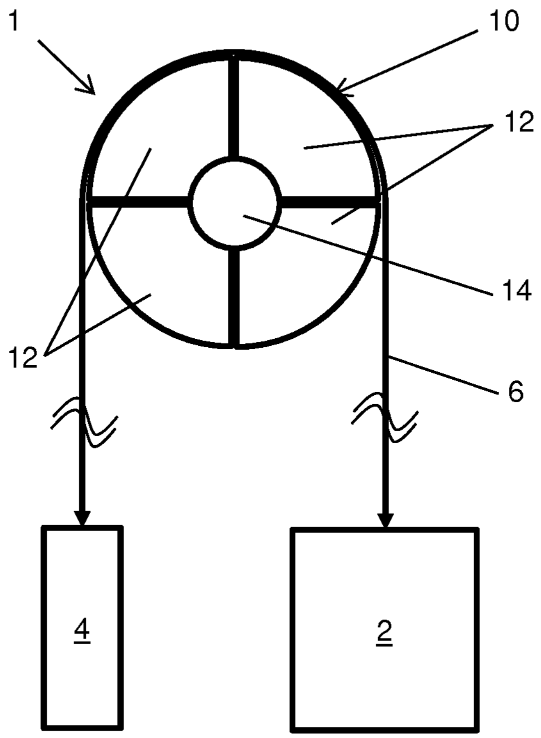

FIG. 1A

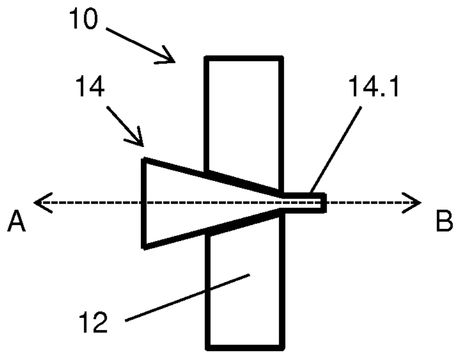

FIG. 1B

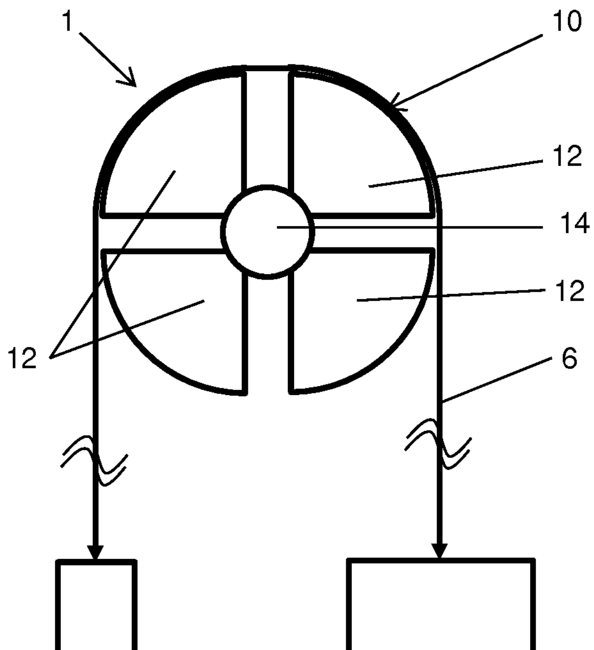

FIG. 2A

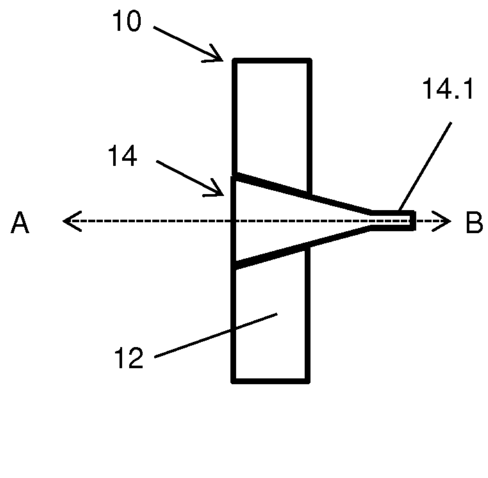

FIG. 2B

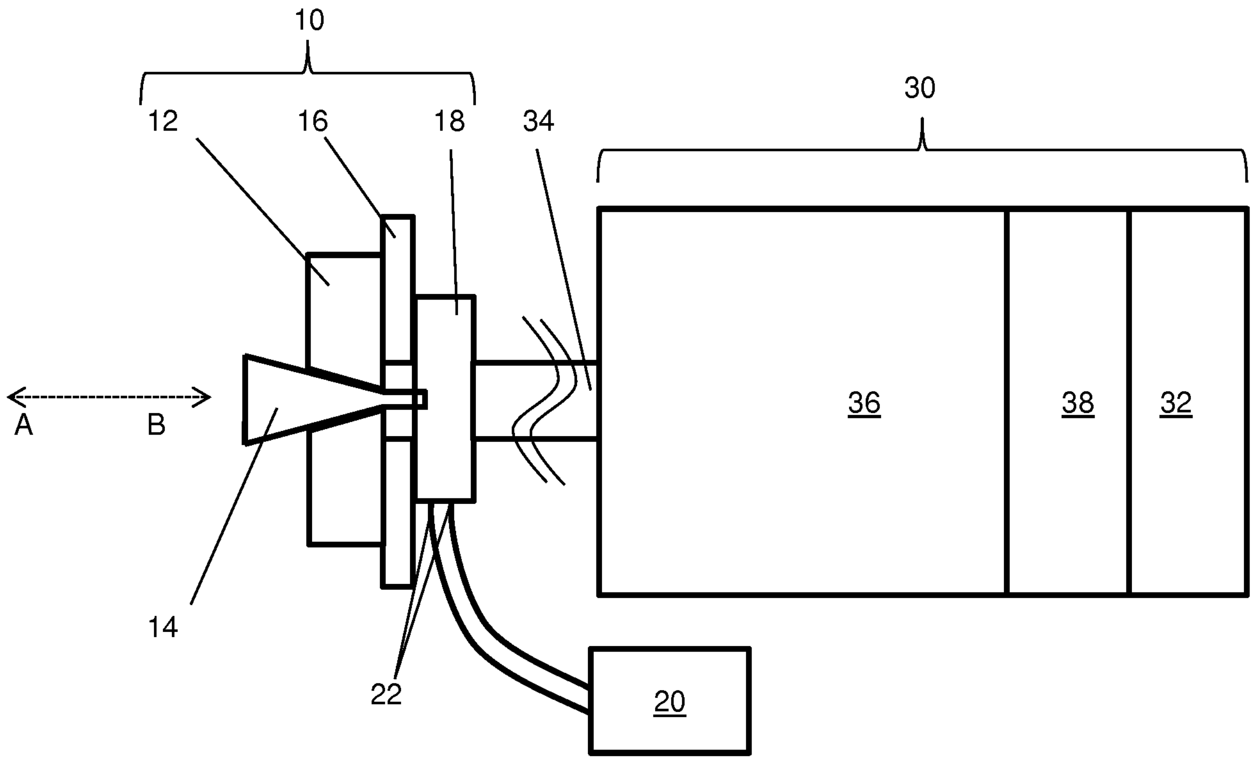
10
12
16
18
34
30
A
B
36
38
32
14
22
20

FIG. 3

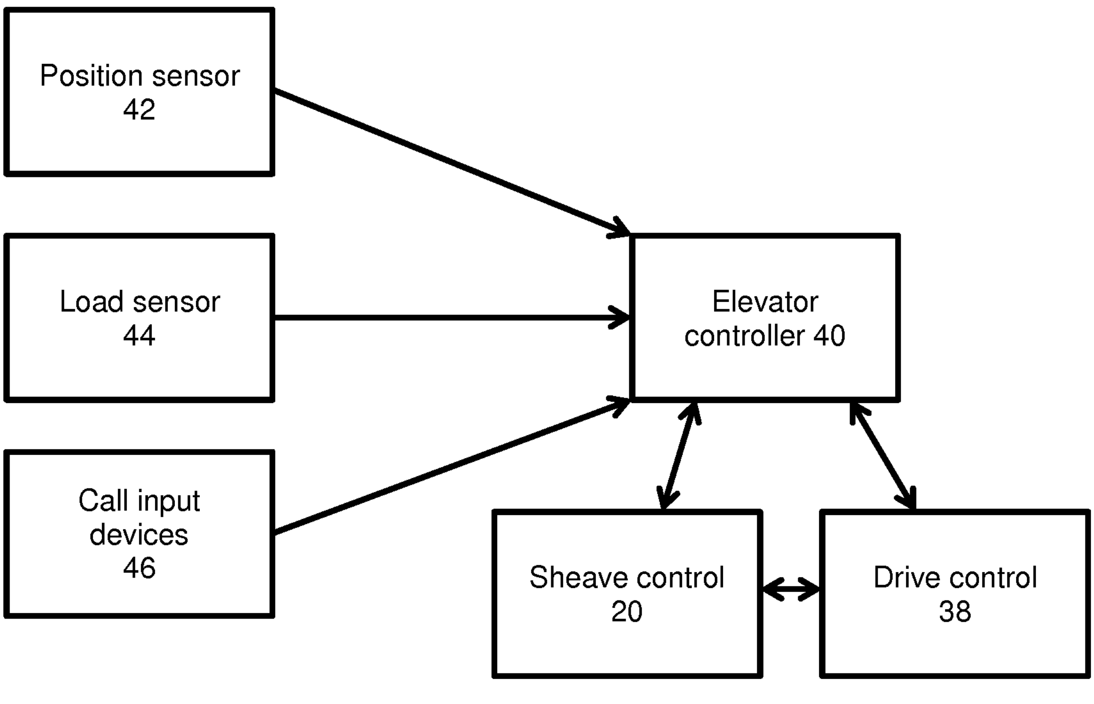
Position sensor
42
Load sensor
44
Call input
devices
46
Elevator
controller 40
Sheave control
20
Drive control
38

FIG. 4

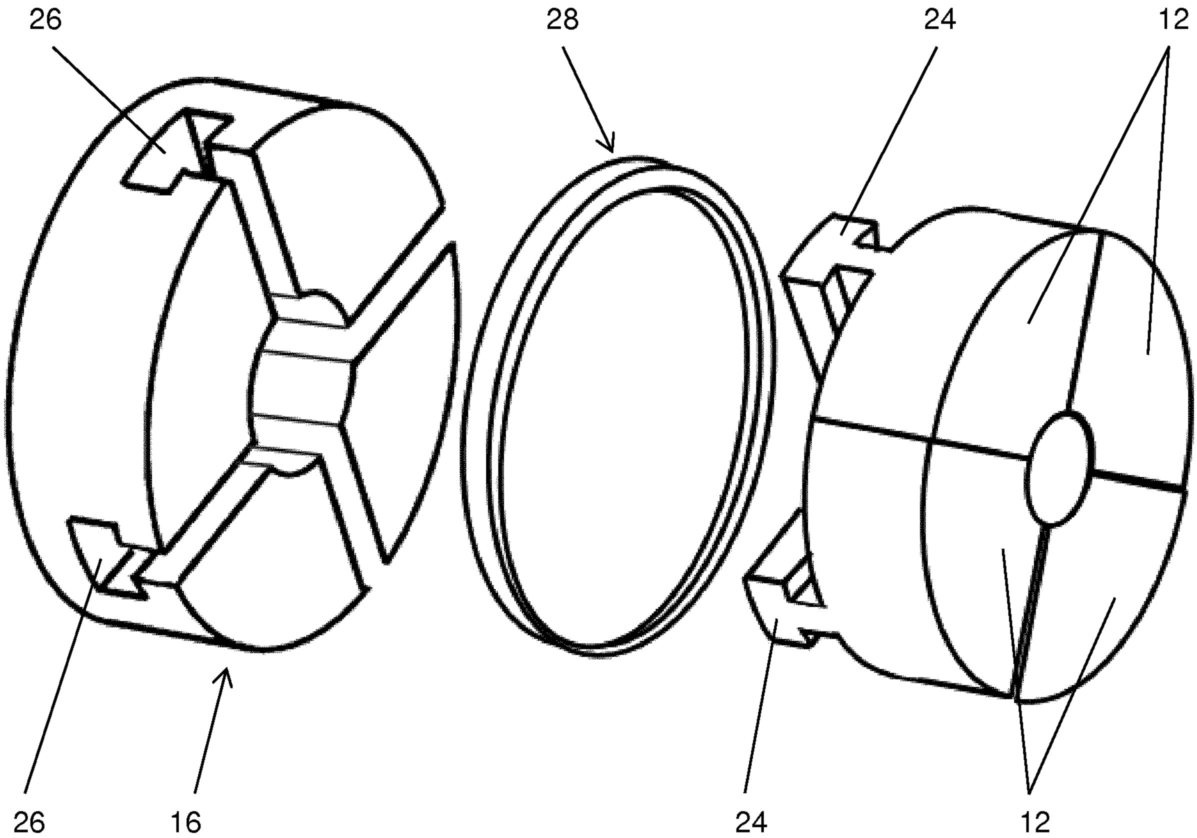

FIG. 5

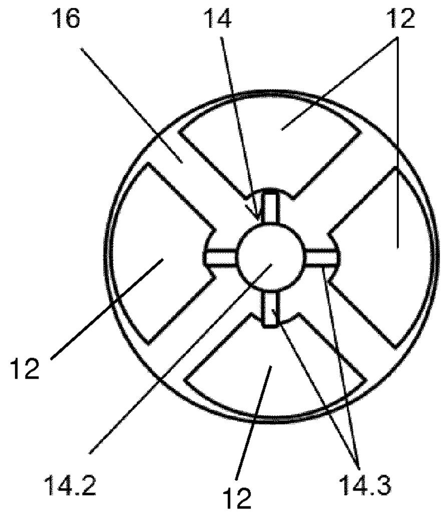

FIG. 6A

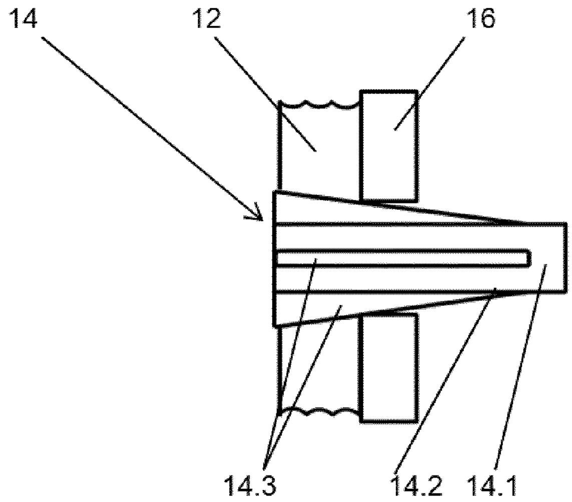

FIG. 6B

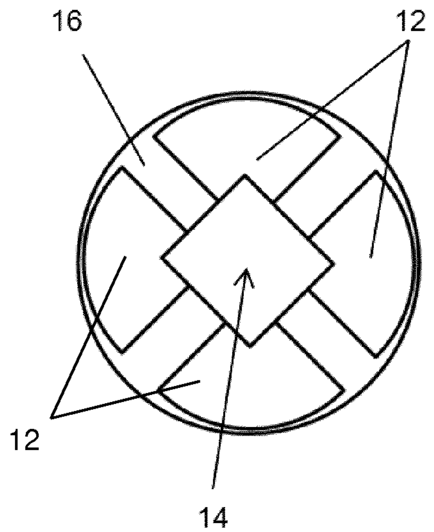

FIG. 7A

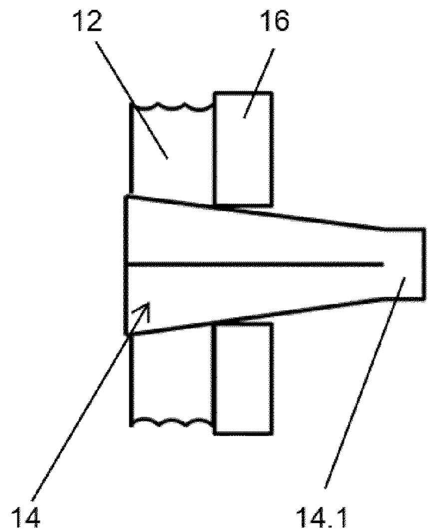

FIG. 7B

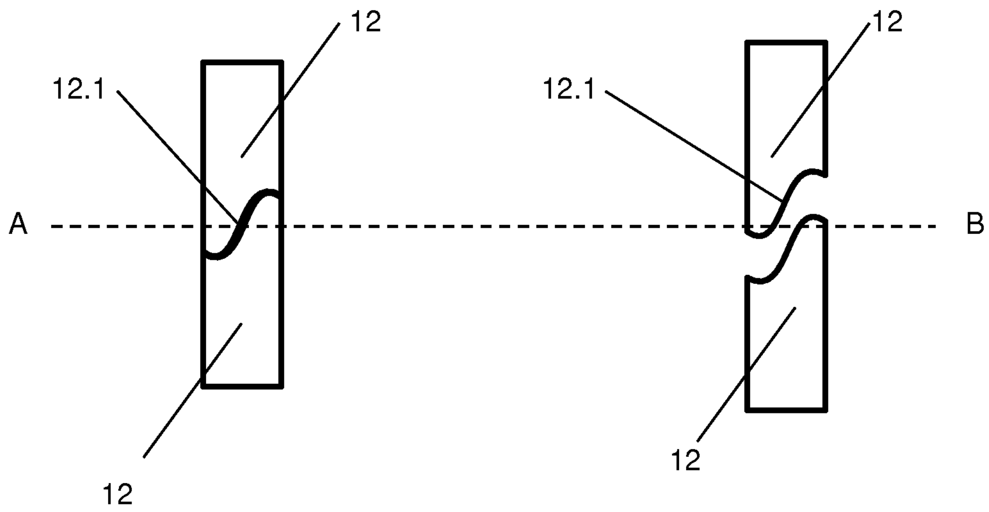

FIG. 8A FIG. 8B

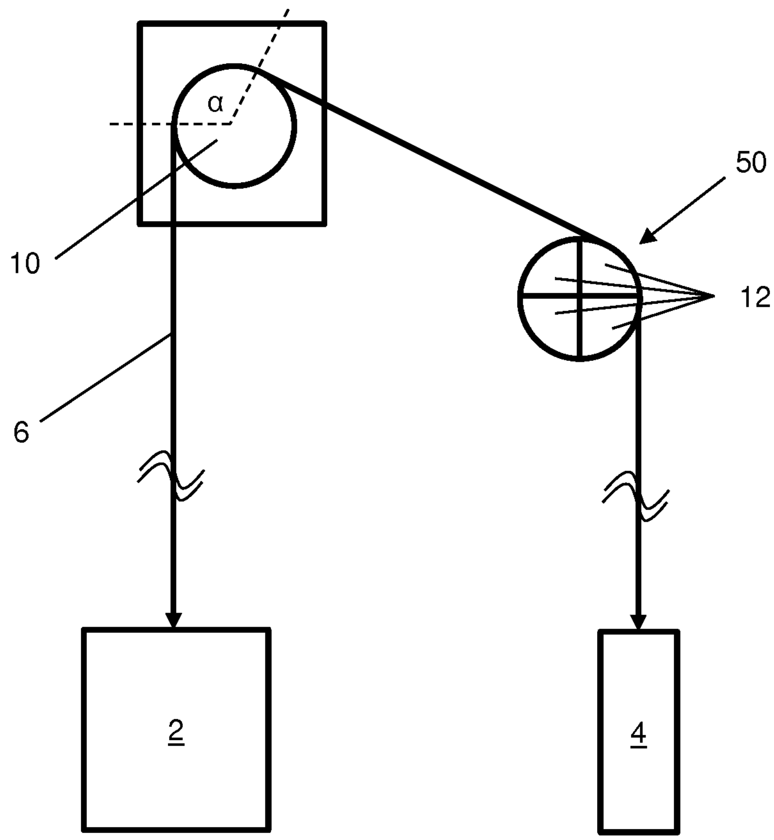

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/079593

A. CLASSIFICATION OF SUBJECT MATTER
INV. B66B15/04 F16H55/56
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 F16H

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.
A	US 4 013 142 A (HAGG ARTHUR C) 22 March 1977 (1977-03-22) abstract; figure 3	1-15
A	GB 149 723 A (HENRY BARCLAY ALLAN) 26 August 1920 (1920-08-26) figures 1-3	1-15
A	US 2005/006181 A1 (LEE KWAN-CHUL [US]) 13 January 2005 (2005-01-13) cited in the application abstract	1-15

☐ 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 March 2016	16/03/2016

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	Lenoir, Xavier

3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/079593

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4013142	A	22-03-1977	AU	512111	B2	25-09-1980
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