

(19)



(11)

**EP 1 056 676 B1**

(12)

**EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:  
**22.10.2008 Bulletin 2008/43**

(51) Int Cl.:  
**B66B 9/02 (2006.01) B66B 17/12 (2006.01)**

(21) Application number: **99908277.9**

(86) International application number:  
**PCT/US1999/003641**

(22) Date of filing: **19.02.1999**

(87) International publication number:  
**WO 1999/043592 (02.09.1999 Gazette 1999/35)**

(54) **BELT-CLIMBING ELEVATOR HAVING DRIVE IN COUNTERWEIGHT**

RIEMENKLETTERNDER AUFZUG MIT ANTRIEB IM GEGENGEWICHT

ASCENCEUR A MONTEE SUR COURROIE DOTE D'UN CONTREPOIDS A ENTRAINEMENT INTEGRE

(84) Designated Contracting States:  
**DE ES FR IT PT**

(30) Priority: **26.02.1998 US 31108**  
**30.09.1998 US 163584**  
**22.12.1998 US 218990**

(43) Date of publication of application:  
**06.12.2000 Bulletin 2000/49**

(60) Divisional application:  
**07008069.2 / 1 808 399**

(73) Proprietor: **Otis Elevator Company**  
**Farmington, CT 06032 (US)**

(72) Inventors:  
• **ERICSON, Richard, J.**  
**Southington, CT 06489 (US)**  
• **SCHRÖDER-BRUMLOOP, Helmut, L.**  
**D-13467 Berlin (DE)**

- **FERRARAY, Jean-Marc**  
**F-75017 Paris (FR)**
- **SERVI, Armando**  
**Madrid (ES)**
- **REBILLARD, Pascal**  
**F-45500 Gien (FR)**

(74) Representative: **Leckey, David Herbert**  
**Frank B. Dehn & Co.**  
**St Bride's House**  
**10 Salisbury Square**  
**London**  
**EC4Y 8JD (GB)**

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**EP 1 056 676 B1**

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## Description

**[0001]** The present invention relates to elevator systems and, more particularly, to an elevator guide system requiring less installation and operation space than conventional elevator systems by utilizing combined function structures so that an elevator counterweight houses a drive system.

**[0002]** The drive system drives a drive rope or member by traction. British Standard BS 5655 Part I 1986 defines a traction drive lift as a lift whose ropes are driven by friction.

**[0003]** Known elevator systems typically confine all elevator components to the hoistway or the machine room. The hoistway is an elongated, vertical shaft having a rectangular base in which the elevator car translates. The hoistway houses, among other things, the car guide rails which are usually a pair of generally parallel rails, fixed to opposite walls near the center of each wall, and running the approximate length of the hoistway. A counterweight having a pair of guide rails is positioned adjacent to a third wall. The hoistway houses additional components including terminal landing switches, ropes and sheave arrangements, and buffers for the counterweight and the car.

**[0004]** It is essential that the elevator components are located and oriented with precision prior to and during operation. The interior walls of the hoistway must be properly dimensioned and aligned, and the physical interface between the hoistway walls and the elevator components must be capable of withstanding varying load during use. It is particularly essential that the guide rails on which the car rides are properly positioned and solidly maintained. For quality of ride and safety, the guide rails need to be precisely plumb, square and spaced to avoid car sway, vibration and knocking. Guide rails are typically steel, T-shaped sections in sixteen foot lengths. The position of guide rails within the hoistway affects the position of the hoisting machine, governor and overhead (machine room) equipment. The machine room is typically located directly above the hoistway. The machine room houses the hoist machine and governor, the car controller, a positioning device, a motor generator set, and a service disconnect switch.

**[0005]** Because the various components of the hoistway and machine room require precise positioning and they produce varying and substantial loads, it is costly and complicated to assemble a typical traction elevator system.

**[0006]** EP-A-0 565 516 discloses a traction drive elevator system having the features of the preamble of claim 1.

**[0007]** It is an object of the present invention to provide an improved elevator system that optimizes use of space by providing a multi-function component that functions as a counterweight and a support for the drive machine and system, so that the need for a machine room and other space-consuming components is eliminated. It is

a further object to provide an improved elevator system that achieves optimum efficiency in construction and materials by various means including, for example, providing a counterweight apparatus that stores potential energy as an integral part of the lift arrangement and that reduces the required torque for movement of the elevator car.

**[0008]** The present invention provides an elevator system as claimed in claim 1. In one embodiment, a counterweight-drive assembly includes a motor and drive pulley sized to maintain a narrow profile and to be suspended and to move in coordination with an elevator car. The counterweight-drive assembly is connected to an elevator car by one or more suspension ropes or belts. A traction belt is adapted to engage the drive pulley and is fixed vertically in the hoistway to form the counterweight-drive assembly path. A flat rope or belt is used. As used herein, the terms "flat belt" and "flat rope" mean a belt or rope having an aspect ratio of greater than one, where the aspect ratio is the ratio of the belt or rope width to the thickness. When torque is applied through the drive pulley, the counterweight-drive assembly is caused to move up or down the hoistway. Additional deflection rollers guide the traction belt around the drive pulley to attain sufficient surface contact area and resultant traction. Because a flat belt is used, sufficient traction is achieved with a small diameter drive pulley, thus conserving space.

**[0009]** In another embodiment of the present invention, a counterweight-drive assembly includes a modular motor arrangement of four drive motors mounted to a counterweight body. Each motor has a sheave that cooperates with one of two fixed ropes attached at a hoistway ceiling and tensioned at the other end by a spring or tensioning weight. The motors and sheaves are preferably positioned at the four corners of the counterweight body. The motors and sheaves are proportioned and arranged to minimize thickness of the assembly and, thus, spaced required for mounting and operation. The path of the ropes around the upper and lower sheaves provides 360 degree effective wrap around for high traction. The use of multiple drive sheaves enables a large collective traction area with small diameter sheaves and small motors, thereby conserving space. Another advantage of using multiple drive sheaves and corresponding motors is that, in the event of failure of one motor, the others can continue the operation of the elevator system provided that they are sufficiently powered.

**[0010]** By having suspension belts separate from a traction belt, each can be respectively optimized for its particular function without concern for other performance characteristics. For example, the suspension ropes can be optimized for tension failure since they are not required to provide a traction medium. Further, the traction rope can be optimized for traction with only limited concern for tension failure, as the maximum tension it is subjected to results from the mass difference between the car and the counterweight. Additionally, the use of traction belts enables a reduction in motor size where, for example, cylindrical motors can be implemented instead

of flat motors.

Fig. 1 is an orthogonal, schematic view of an elevator assembly which does not fall within the scope of the present invention but which is provided for reference purposes.

Fig. 2 is a perspective, schematic view of the elevator assembly as shown in Fig. 1.

Fig. 3 is a schematic, side view of a component of the elevator assembly of Fig. 1.

Fig. 4 is a schematic, front view of component of Fig. 3.

Fig. 5 is a schematic, front view of an embodiment of the present invention elevator assembly.

Fig. 6 is a schematic, side view of the elevator assembly of Fig. 5.

Fig. 7 is a sectional, side view of a traction sheave and a plurality of flat ropes, each having a plurality of cords.

Fig. 8 is a sectional view of one of the flat ropes.

**[0011]** An elevator assembly which does not form part of the present invention is illustrated in Figs. 1-4 for illustrative purposes only. An elevator assembly (10) includes an elevator car (12) and a guide rail assembly (14). The guide rail assembly (14) comprises an elongated, vertical member (18) having at least two faces for fixing, respectively, a first elevator car guide rail (20) and a first counterweight guide rail (22). The vertical member (18) may be attached to a stationary structure such as a wall of the hoistway (not shown). A second elevator car guide rail (16) is positioned opposite of and facing the first elevator car guide rail (20). The two elevator car guide rails (20, 16) are adapted to slidably receive the elevator car (12) in a conventional manner through the use of conventional guide shoes (not shown) or the like. A second counterweight guide rail (24) is positioned opposite of and facing the first counterweight guide rail (22) in such a way that the two counterweight guide rails (22, 24) lay in a plane that is generally orthogonal to the plane in which the elevator car guide rails (16, 20) lay.

**[0012]** The counterweight-drive assembly (26) comprises a body (28) housing a drive assembly (30), a motor (32), and weights (34), as shown in Fig. 4. Components of the drive assembly (30) are shown schematically in Fig. 3 and include a toothed drive pulley (36) adapted to provide torque from the motor (32), and first and second deflection pulleys (38, 40) for effecting surface contact of the toothed belt (42) along a predetermined surface area of the drive pulley (36) for predetermined traction. A system using a toothed belt is not within the scope of the present invention. Also shown schematically in Fig. 3 are tension varying devices (44, 46) which may be of a conventional type such as springs (not shown). A belt-tensioning device (48) is shown schematically and it may also be of a conventional type such as a spring (not shown). The motor (32) can be an electric motor and can be supplied power and control signals via a power and

control cable (50) as shown, whereby the cable (50) is adapted to move with the counterweight-drive assembly (26).

**[0013]** A rope, group of ropes or suspension belt (52), as shown, suspends both the elevator car (12) and the counterweight-drive assembly (26). A first end (54) of the suspension belt (52) is fixed to a stationary object overhead, such as a beam (56) of the ceiling of the hoistway (not shown). A first idler pulley (58) fixed to the counterweight-drive assembly (26) engages the suspension belt (52). A second idler pulley (60) fixed to the overhead beam (56) engages the suspension belt (52). Third and fourth idler pulleys (62, 64) are fixed to the bottom of the elevator car (12) and also engage the belt (52). The third and fourth idler pulleys (62, 64) need not necessarily be positioned under the elevator car (12) and may be, for example, replaced by one or more idler pulleys positioned above the car. The second end (64) of the suspension belt (52) is fixed relative to the hoistway (not shown) at a height sufficient to enable desired vertical movement of the elevator car (12) and counterweight-drive assembly (26) as will be described below.

**[0014]** In operation, when the motor (26) is energized, torque is transferred through the toothed drive pulley (32) to the toothed belt (42) such that the counterweight-drive assembly (26) will move along and relative to the toothed belt (42). The counterweight-drive assembly (26) will selectively move up or down depending on the direction of rotation of the toothed drive pulley (36). When the counterweight-drive assembly (26) is caused to move downward along the toothed belt (42) the first idler pulley (58) moves downward with it thereby lengthening the amount of belt (52) between the first and second idler pulleys (60). As a result, the length of available belt (52) extending past the second idler pulley (60) is proportionally shortened and the elevator car (12) is caused to be lifted upward on the third and fourth idler pulleys (62, 64). In a similar manner, the elevator car (12) is lowered as the counterweight-drive assembly (26) is driven upward.

**[0015]** Referring now to Figs. 5-6, an embodiment of the present invention is directed to a self-climbing counterweight-drive assembly (100). The counterweight-drive assembly (100) can be adapted to be used with a suspension belt (52) and idler (58, 60, 62, 64) arrangement in accordance with Figs. 1-4 or in a similar fashion to couple the assembly (100) with an elevator car (12). As is the case of the illustrative arrangement in accordance with Figs. 1-4, movement of the elevator car (12) will be dependent upon movement of the counterweight-drive assembly (100).

**[0016]** The counter-weight drive assembly (100) of the this embodiment includes a body (102) having fixed thereon a group of four electric motors (104, 106, 108, 110). Each motor (104-110) is equipped with a corresponding drive sheave (112, 114, 116, 118). A pair of fixed ropes (120, 122) are attached to an overhead structure (not shown) in the hoistway (not shown) and are either fixed or tensioned by conventional means (not shown) at the

bottom. As shown specifically in Fig. 6 with respect to the second rope (122), each rope (120, 122) extends downwardly to engage and wrap under a lower drive sheave (118), extends upwardly to engage and wrap over an upper drive sheave (114), and extends downward again to be tensioned or fixed.

**[0017]** The traction between the ropes (120, 122) and sheaves (112-118) is controlled by adjusting the tension in each respective rope (120, 122). In accordance with the invention the ropes (120, 122) are flat ropes because they are capable of wrapping around small diameter sheaves while supplying sufficient traction. It is then possible to minimize profile thickness of the assembly (100).

**[0018]** As is the case in the arrangement in accordance with Figs. 1-4, traction is not dependent upon weight and, therefore a light weight elevator car (12) can be implemented. In the above-described embodiment, each drive sheave (112-118) is engaged by one of the ropes (120, 122) about 180 degrees and, thus, the total effective wrap angle is about 360 degrees on each side. The total wrap angle is determinative of the total traction.

**[0019]** It is conceivable to vary the above embodiment by powering only two of the four motors, or by providing one motor with transmission components to drive all four sheaves. It is further conceivable to provide only one rope instead of two.

**[0020]** As can be realized from the foregoing description of the above embodiment, mounting motors on a counterweight-drive assembly (100) will remove vibration and noise from the car (12). The positioning of the drive sheaves (112-118) makes sheave mounting and servicing convenient. The ability to use small motors (104-110) provides costs savings.

**[0021]** A principal feature of the present invention is the flatness of the ropes used in the above described elevator system. The increase in aspect ratio results in a rope that has an engagement surface, defined by the width dimension "w", that is optimized to distribute the rope pressure. Therefore, the maximum rope pressure is minimized within the rope. In addition, by increasing the aspect ratio relative to a round rope, which has an aspect ratio equal to one, the thickness "t1" of the flat rope (see Fig. 8) may be reduced while maintaining a constant cross-sectional area of the portions of the rope supporting the tension load in the rope.

**[0022]** As shown in Fig. 7 and 8, the flat ropes 722 include a plurality of individual load carrying cords 726 encased within a common layer of coating 728. The coating layer 728 separates the individual cords 726 and defines an engagement surface 730 for engaging the traction sheave 724. The load carrying cords 726 may be formed from a high-strength, lightweight non-metallic material, such as aramid fibers, or may be formed from a metallic material, such as thin, high-carbon steel fibers. It is desirable to maintain the thickness "d" of the cords 726 as small as possible in order to maximize the flexibility and minimize the stress in the cords 726. In addition, for cords formed from steel fibers, the fiber diameters

should be less than .25 millimeters in diameter and preferably in the range of about .10 millimeters to .20 millimeters in diameter. Steel fibers having such diameter improve the flexibility of the cords and the rope. By incorporating cords having the weight, strength, durability and, in particular, the flexibility characteristics of such materials into the flat ropes, the traction sheave diameter "D" may be reduced while maintaining the maximum rope pressure within acceptable limits.

**[0023]** The engagement surface 730 is in contact with a corresponding surface 750 of the traction sheave 724. The coating layer 728 is formed from a polyurethane material, preferably a thermoplastic urethane, that is extruded onto and through the plurality of cords 726 in such a manner that each of the individual cords 726 is restrained against longitudinal movement relative to the other cords 726. Other materials may also be used for the coating layer if they are sufficient to meet the required functions of the coating layer: traction, wear, transmission of traction loads to the cords and resistance to environmental factors. It should be understood that although other materials may be used for the coating layer, if they do not meet or exceed the mechanical properties of a thermoplastic urethane, then the benefits resulting from the use of flat ropes may be reduced. With the thermoplastic urethane mechanical properties the traction sheave 724 diameter is reducible to 100 millimeters or less.

**[0024]** As a result of the configuration of the flat rope 722, the rope pressure may be distributed more uniformly throughout the rope 722. Because of the incorporation of a plurality of small cords 726 into the flat rope elastomer coating layer 728, the pressure on each cord 726 is significantly diminished over prior art ropes. Cord pressure is decreased at least as  $n^{-1/2}$ , with n being the number of parallel cords in the flat rope, for a given load and wire cross section. Therefore, the maximum rope pressure in the flat rope is significantly reduced as compared to a conventionally roped elevator having a similar load carrying capacity. Furthermore, the effective rope diameter 'd' (measured in the bending direction) is reduced for the equivalent load bearing capacity and smaller values for the sheave diameter 'D' may be attained without a reduction in the D/d ratio. In addition, minimizing the diameter D of the sheave permits the use of less costly, more compact, high speed motors as the drive machine.

**[0025]** A traction sheave 724 having a traction surface 750 configured to receive the flat rope 722 is also shown in Fig. 7. The engagement surface 750 is complementarily shaped to provide traction and to guide the engagement between the flat ropes 722 and the sheave 724. The traction sheave 724 includes a pair of rims 744 disposed on opposite sides of the sheave 724 and one or more dividers 745 disposed between adjacent flat ropes. The traction sheave 724 also includes liners 742 received within the spaces between the rims 744 and dividers 745. The liners 742 define the engagement surface 750 such that there are lateral gaps 754 between the sides of the flat ropes 722 and the liners 742. The pair of rims 744

and dividers, in conjunction with the liners, perform the function of guiding the flat ropes 722 to prevent gross alignment problems in the event of slack rope conditions, etc. Although shown as including liners, it should be noted that a traction sheave without liners may be used.

**[0026]** While the preferred embodiments have been herein described, it is acknowledged that variations to these embodiments can be made without departing from the scope of what is claimed.

## Claims

### 1. An elevator system comprising:

a suspension member (52);  
 a drive member (120,122;722) fixed within an elevator hoistway;  
 a counterweight-drive assembly (100) suspended by the suspension member and having drive means for drivingly engaging said drive member (120,122;722) in traction for driving said counterweight-drive assembly (100) relative thereto; and  
 an elevator car (12) suspended by the suspension member (52) for concurrent movement of the car (12) and counterweight-drive assembly (100);

whereby said elevator car (12) is moved in response to movement of said counterweight-drive assembly (100) relative to the drive member (120,122;722);  
**characterised in that:**

said drive member (120,122;722) is a flat rope.

### 2. An elevator system according to claim 1, wherein said suspension member (52) comprises a series of idler pulleys, including a first idler (58) pulley fixed to said counterweight-drive means (100), a second idler pulley (60) fixed relative to the hoistway, and at least one idler pulley (62,64) fixed to said elevator car (12).

### 3. An elevator system as claimed in claim 1 or 2, wherein said counterweight-drive assembly (100) comprises a counterweight body (102) and said drive means is mounted on said body (102), said drive means including at least one drive sheave (112,114,116,118) adapted to drivingly engage in traction said flat rope (120,122;722), and including motor means (104,106,108,110) for supplying torque to said at least one drive sheave (112,114,116,118) to effect movement of the counterweight body (102) relative to said flat rope (120,122;722).

### 4. An elevator system according to claim 3, wherein

said drive means comprise a plurality of electric motors (104,106,108,110) and corresponding drive sheaves (112,114,116,118) mounted on said body (102).

## Patentansprüche

### 1. Aufzugssystem, aufweisend:

ein Aufhängungselement (52);  
 ein Antriebselement (120, 122; 722), das in einem Aufzugschacht festgelegt ist;  
 eine Gegengewicht-Antriebsanordnung (100), die durch das Aufhängungselement aufgehängt ist und eine Antriebseinrichtung für den antriebsmäßigen Eingriff mit dem Antriebselement (120, 122; 722) in Traktion aufweist, um die Gegengewicht-Antriebsanordnung (100) relativ dazu antriebsmäßig zu bewegen; und  
 einen Aufzugfahrkorb (12), der durch das Aufhängungselement (52) für eine gleichlaufende Bewegung des Fahrkorbs (12) und der Gegengewicht-Antriebsanordnung (100) aufgehängt ist;

wobei der Aufzugfahrkorb (12) in Abhängigkeit von einer Bewegung der Gegengewicht-Antriebsanordnung (100) relativ zu dem Antriebselement (120, 122; 722) bewegt wird;

**dadurch gekennzeichnet, dass** es sich bei dem Antriebselement (120, 122; 722) um ein Flachseil handelt.

### 2. Aufzugssystem nach Anspruch 1, wobei das Aufhängungselement (52) eine Reihe von antriebslosen Scheiben aufweist, die eine erste antriebslose Scheibe (58), die an der Gegengewicht-Antriebseinrichtung (100) angebracht ist, eine zweite antriebslose Scheibe (60), die relativ zu dem Aufzugschacht festgelegt ist, sowie mindestens eine antriebslose Scheibe (62, 64), die an dem Aufzugfahrkorb (12) angebracht ist, umfassen.

### 3. Aufzugssystem nach Anspruch 1 oder 2, wobei die Gegengewicht-Antriebsanordnung (100) einen Gegengewichtkörper (102) aufweist und die Antriebseinrichtung an dem Körper (102) angebracht ist, wobei die Antriebseinrichtung mindestens eine Antriebs scheibe (112, 114, 116, 118) aufweist, die dazu ausgebildet ist, mit dem Flachseil (120, 122; 722) traktionsmäßig in Antriebseingriff zu treten, sowie eine Motoreinrichtung (104, 106, 108, 110) aufweist, zum Zuführen von Drehmoment zu der mindestens einen Antriebs scheibe (112, 114, 116, 118), um eine Bewegung des Gegengewichtkörpers (102) relativ zu dem Flachseil (120, 122; 722) zu bewerkstelligen.

4. Aufzugssystem nach Anspruch 3, wobei die Antriebseinrichtung eine Mehrzahl von Elektromotoren (104, 106, 108, 110) und entsprechenden Antriebs scheiben (112, 114, 116, 118), die an dem Körper (102) angebracht sind, aufweist.

de contrepoids (102) par rapport audit câble plat (120, 122 ; 722).

4. Système d'ascenseur selon la revendication 3, dans lequel lesdits moyens d'entraînement comprennent une pluralité de moteurs électriques (104, 106, 108, 110) et des poulies à gorge d'entraînement (112, 114, 116, 118) correspondantes montées sur ledit corps (102).

## Revendications

1. Système d'ascenseur comprenant :

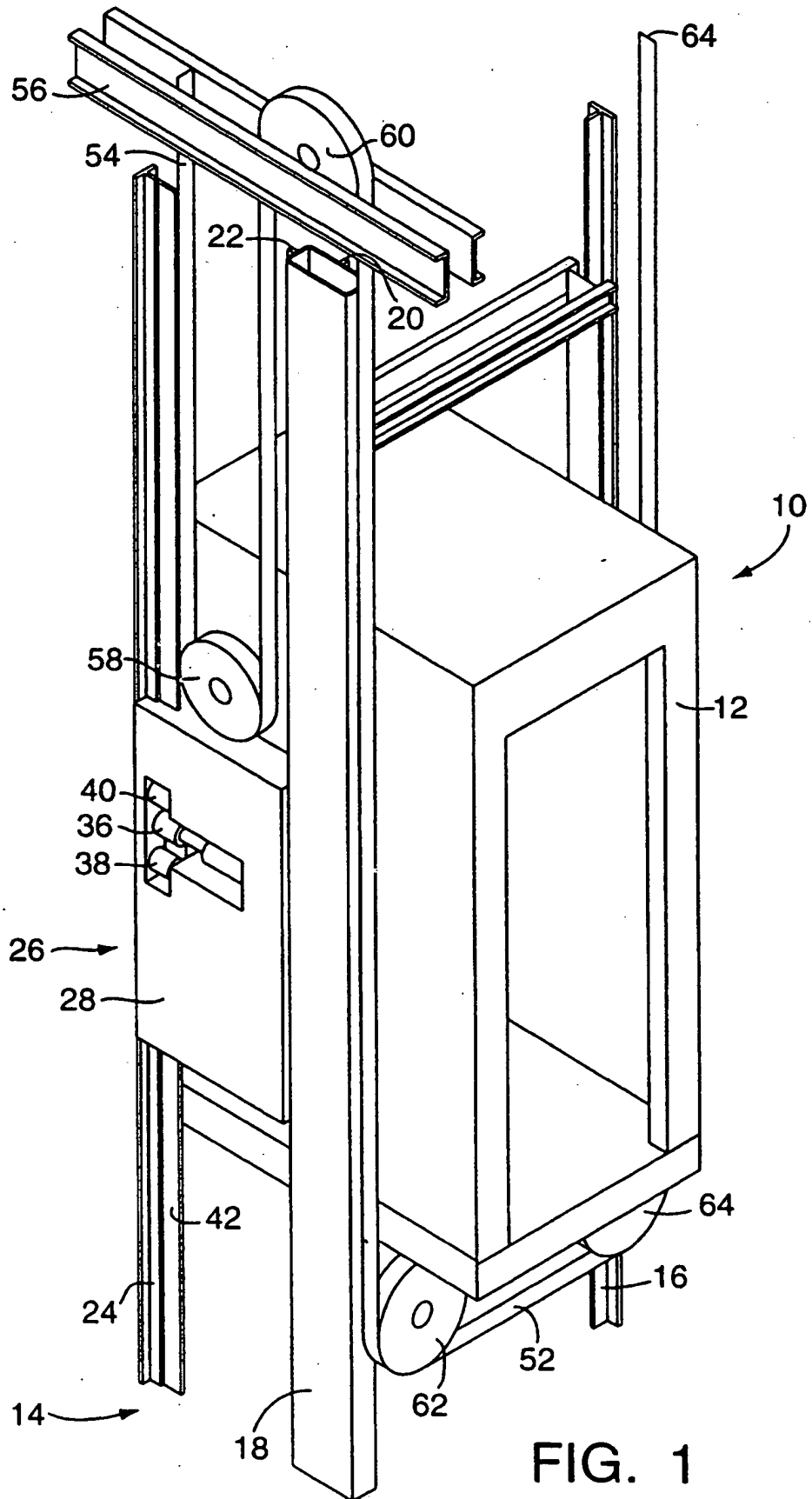
un élément de suspension (52) ;  
 un élément d'entraînement (120, 122 ; 722) fixé à l'intérieur d'une cage d'ascenseur ;  
 un ensemble d'entraînement par contrepoids (100) suspendu par l'élément de suspension et ayant des moyens d'entraînement pour mettre en prise par entraînement ledit élément d'entraînement (120, 122 ; 722) en traction pour entraîner ledit ensemble d'entraînement par contrepoids (100) par rapport à celui-ci ; et  
 une cabine d'ascenseur (12) suspendu par l'élément de suspension (52) pour le mouvement simultané de la cabine (12) et de l'ensemble d'entraînement par contrepoids (100) ;  
 moyennant quoi ladite cabine d'ascenseur (12) est déplacée en réponse au mouvement dudit ensemble d'entraînement par contrepoids (100) par rapport à l'élément d'entraînement (120, 122 ; 722) ;

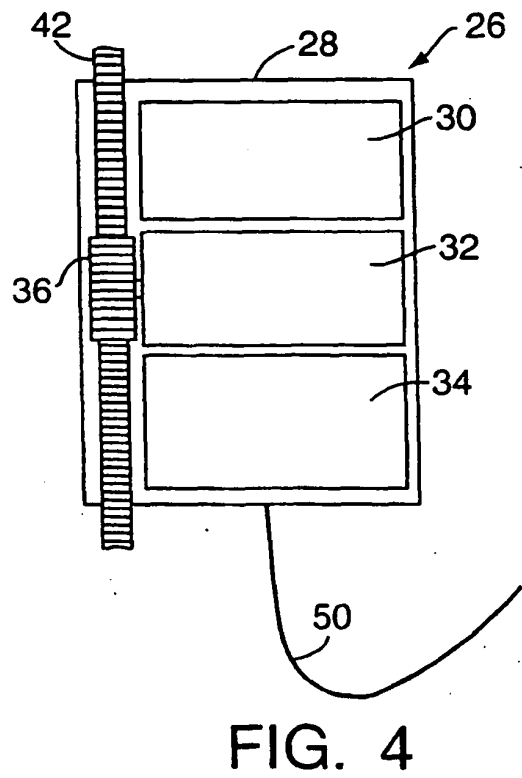
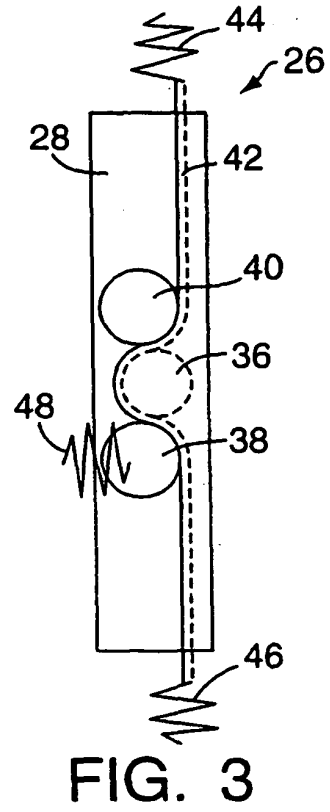
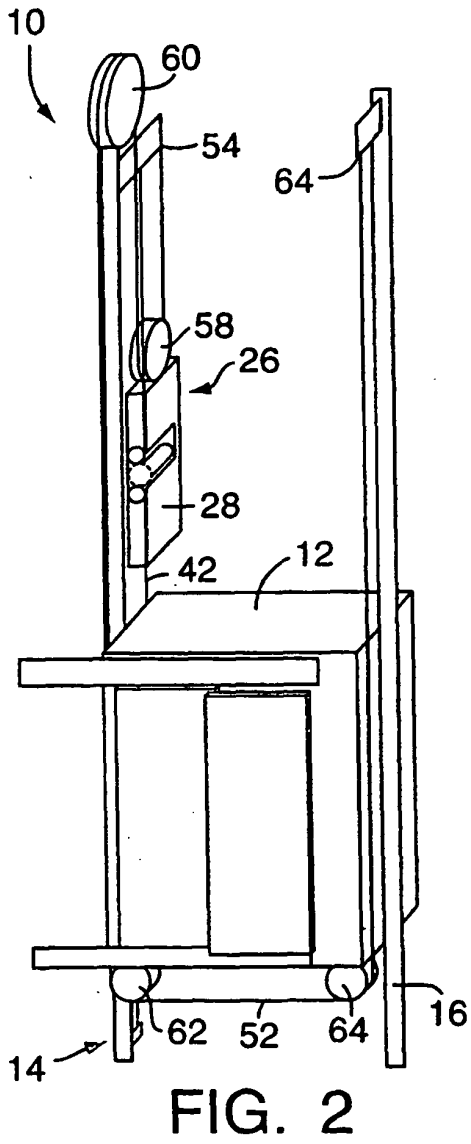
### caractérisé en ce que :

ledit élément d'entraînement (120, 122 ; 722) est un câble plat.

2. Système d'ascenseur selon la revendication 1, dans lequel ledit élément de suspension (52) comprend une série de poulies de renvoi, comprenant une première poulie de renvoi (58) fixée auxdits moyens d'entraînement par contrepoids (100), une seconde poulie de renvoi (60) fixée par rapport à la cage, et au moins une poulie de renvoi (62, 64) fixée sur ladite cabine d'ascenseur (12).

3. Système d'ascenseur selon la revendication 1 ou 2, dans lequel ledit ensemble d'entraînement par contrepoids (100) comprend un corps de contrepoids (102), et lesdits moyens d'entraînement sont montés sur ledit corps (102), lesdits moyens d'entraînement comprenant au moins une poulie à gorge d'entraînement (112, 114, 116, 118) adaptée pour mettre en prise par entraînement, en traction, ledit câble plat (120, 122 ; 722) et comprenant des moyens de moteur (104, 106, 108, 110) pour alimenter un couple à ladite au moins une poulie à gorge d'entraînement (112, 114, 116, 118) pour effectuer le mouvement du corps





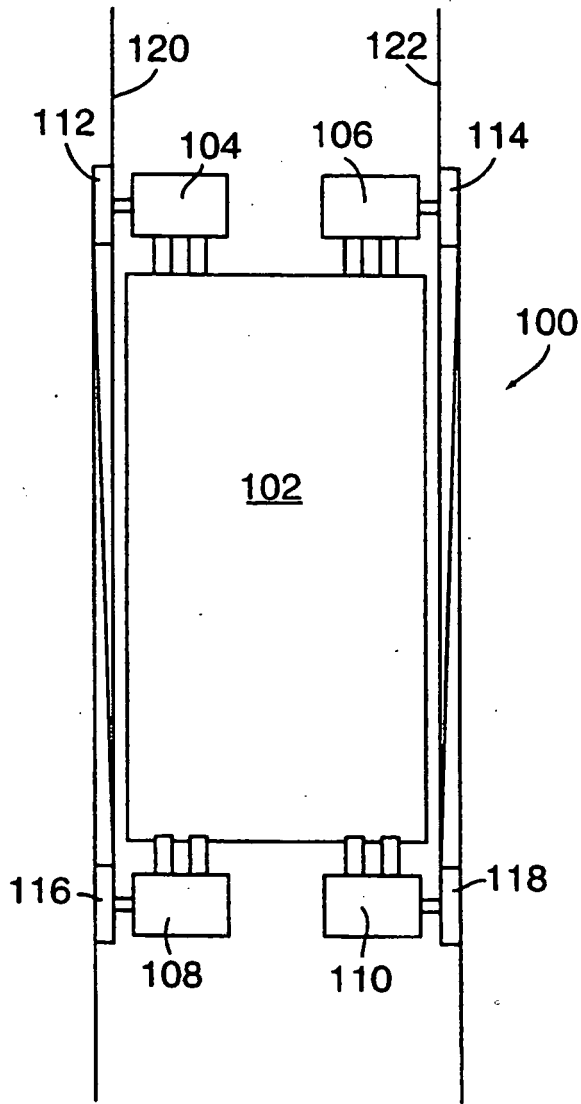


FIG. 5

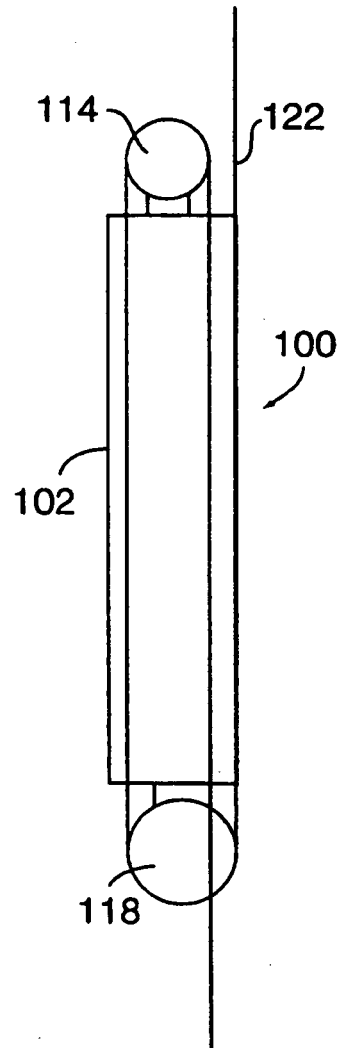


FIG. 6



**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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