(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 023 236 B2

(12) NEW EUROPEAN PATENT SPECIFICATION
After opposition procedure

(45) Date of publication and mention of the opposition decision:
**04.02.2009 Bulletin 2009/06**

(45) Mention of the grant of the patent:
**04.02.2004 Bulletin 2004/06**

(21) Application number: **99936066.2**

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

(51) Int Cl.:
***B66B 7/06*** (2006.01) ***D07B 1/22*** (2006.01)

(86) International application number:
**PCT/US1999/003643**

(87) International publication number:
**WO 1999/043590 (02.09.1999 Gazette 1999/35)**

(54) **TRACTION ELEVATOR SYSTEM USING A FLEXIBLE, FLAT ROPE AND A PERMANENT MAGNET MACHINE**

TREIBSCHEIBENAUFZUGSYSTEM MIT FLEXIBLEM FLACHSEIL UND PERMANENTMAGNET-ANTRIEB

SYSTEME D'ASCENSEUR A TRACTION DANS LEQUEL UN CABLE PLAT ET SOUPLE AINSI QU'UNE MACHINERIE A AIMANTS PERMANENTS SONT UTILISES

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

(30) Priority: **26.02.1998 US 31108**
**09.10.1998 US 169415**
**22.12.1998 US 218990**

(43) Date of publication of application:
**02.08.2000 Bulletin 2000/31**

(60) Divisional application:
**03024661.5 / 1 391 413**

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## Description

**[0001]** The present invention relates to elevator systems, and more particularly to elevator systems that use machines with rotors having permanent magnets.

**[0002]** A typical traction elevator system includes a car and a counterweight disposed in a hoistway, a plurality of ropes that interconnect the car and counterweight, and a machine having a traction sheave engaged with the ropes. The ropes, and thereby the car and counterweight, are driven by rotation of the traction sheave. The machine, and its associated electronic equipment, along with peripheral elevator components, such as a governor, are housed in a machineroom located above the hoistway.

**[0003]** A recent trend in the elevator industry is to eliminate the machineroom and locate the various elevator equipment and components in the hoistway. An example is JP 4-50297, which discloses the use of a machine located between the car travel space and a wall of the hoistway. Another example is US Patent 5, 429,211, which discloses the use of a machine located in the same position but having a motor with a disc-type rotor. This configuration makes use of the flatness of such a machine to minimize the space needed for the machine in the hoistway. This machine disclosed also makes use of permanent magnets in the rotor in order to improve the efficiency of the machine. These types of machines, however, are limited to relatively low duties and low speeds.

**[0004]** One possible solution to apply such machines to higher duty load elevator systems or higher speed systems is to increase the diameter of the rotor. This solution is not practical, however, due to the space constraints of the hoistway. Another solution, disclosed in PCT Application PCT/FI98/00056 (WO98/32685) is to use a machine with two motors and a traction sheave sandwiched between the two motors. This solution, however, also exceeds the space limitations of the hoistway and requires the provision of a separate machineroom above the hoistway to house the machine.

**[0005]** WO-A-9943602, which forms prior art under Art. 54(3) EPC, discloses a belt climbing elevator.

**[0006]** Another elevator system is also known from EP-A- 0 688 735.

**[0007]** "Hannover Messe : Neue Idee von Contitech-Hubgurte für Aufzüge", Contitech, Pages 14-16, 04.98 discloses a lifting belt system for elevators wherein a plurality of steel cables are arranged in parallel and surrounded with rubber to form a lifting belt having an aspect ratio greater than one.

**[0008]** JP-A-7117957 discloses an elevator device comprising a hoist constituted of an outer rotor motor provided of the top section of a hoistway. In particular it discloses an elevator system having a car and a counterweight disposed within a hoistway defined by hoistway walls, the elevator system including:

a rope engaged with the car and the counterweight so as to suspend the car and counterweight; and
a machine arranged within the hoistway and including a traction sheave and a motor having a rotor and a stator and further including an air gap between the rotor and stator the traction sheave being directly connected with the rotor for concurrent rotation and engaged with the rope to drive the rope through traction between the rope and traction sheave, and thereby drive the car through the hoistway, wherein the rotor is formed in part from permanent magnets.

**[0009]** The above art notwithstanding, scientists and engineers under the direction of the Applicant are working to develop elevator systems that efficiently utilize the available space and meet the duty load and speed requirements over a broad range of elevator applications.

**[0010]** According to the present invention, there is provided an elevator system as claimed in claim 1.

**[0011]** Thus an elevator system in accordance with one aspect of the invention includes a machine having a rotor including permanent magnets and a flat rope engaged with the machine.

**[0012]** Flat rope, as used herein, is defined to include ropes having an aspect ratio, defined as the ratio of width w relative to thickness t, greater than one. A more detailed description of an example of such ropes is included in commonly owned co-pending US Patent Application Serial Number 09/031,108, entitled "Tension Member for an Elevator", filed February 2, 1998, issued as US 6,401,871).

**[0013]** An advantage of the present invention is the size of the machine required to meet duty load and speed requirements. The combination of the improved efficiency of the machine and the torque reduction provided by the flat rope result in a very compact machine that can be fit within the space constraints of a hoistway without adversely affecting the performance of the elevator system. This permits the machine to be located in positions that were previously impractical.

**[0014]** Another advantage is a reduction in the energy consumption of the elevator system using the present invention. The flat rope results in an engagement surface, defined by the width dimension, that is optimized to distribute the rope pressure. Therefore, the maximum pressure is minimized within the rope. In addition, by increasing the aspect ratio relative to a round rope, which has an aspect ratio substantially equal to one, the thickness of the rope may be reduced while maintaining a constant cross-sectional area of the rope. Minimizing the thickness of the rope results in a smaller diameter traction sheave, which in turn reduces the torque on the machine decreases the size of the motor and may eliminate the need for gearing. In addition, the smaller diameter of the sheave results in an increased rotational speed of the motor, which further increases the efficiency of the machine.

**[0015]** In a particular embodiment, the permanent magnet machine is combined with a flat rope that includes a plurality of load-carrying members and a sheath that surrounds the load-carrying members and is formed from polyurethane. The load-carrying members are steel cords formed from very thin wires, with the wires having diameter of .25 mm or less. The use of a sheath formed from polyurethane permits the outer surface of the rope to be optimized for traction.

**[0016]** An advantage of this particular embodiment is the minimal risk of heat damage to the sheath and the load-carrying members of the rope due to use of a machine having a rotor with permanent magnets. In a conventional induction motor, much of the heat losses are in the rotor. This heat loss is conducted directly to the ropes through the sheave. For ropes formed from materials other than steel, which are more temperature sensitive, exposure to such a heat source may lead to degradation of the rope. By using a machine having a rotor with permanent magnets, however, the principle source of heat loss is through the stator and not through the rotor. Therefore, since there is no direct path between the stator and the ropes, the ropes are not exposed to the primary source of heat and the risk of heat related degradation of the materials of the rope is minimized. In addition, the increased efficiency of the permanent magnet machine reduces the total heat generated and therefore further reduces the heating of the ropes.

**[0017]** The foregoing and other features and advantages of the present invention become more apparent in light of the following detailed description of the exemplary embodiments thereof, as illustrated in the accompanying drawings, in which:

Figure 1 is a perspective view of an elevator system according to the present invention.

Figure 2 is a perspective view of an alternate embodiment of the present invention.

Figure 3 is a sectioned side view of a machine and ropes used in the embodiments of Figures 1 and 2.

**[0018]** Illustrated in Figure 1 is an elevator system 10 according to the present invention. The elevator system 10 includes a car 12, a pair of car guide rails 14, a counterweight 16, a pair of counterweight guide rails 18, a plurality of ropes 20 interconnecting the car 12 and counterweight, and a traction machine 22 engaged with the ropes 20. The car 12 and counterweight 16 are interconnected to move concurrently and in opposite directions within a hoistway 23.

**[0019]** The car 12 includes a frame 24 and a pair of diverter sheaves 26 (only one of which is shown in Figure 1) disposed on opposite sides of the underside of the car frame 24. The diverter sheaves 26 define an engagement means between the car 12 and ropes 20 and permit the ropes 20 to pass underneath the car 12 such that the car 12 is underslung.

**[0020]** The counterweight 16 includes a diverter sheave 28 disposed on the top of the counterweight 16. This diverter sheave 28 defines an engagement means between the counterweight 16 and ropes 20. As a result of the roping arrangement shown in Figure 1, both the car 12 and counterweight 16 are roped in a 2:1 arrangement relative to the machine 22.

**[0021]** The machine 22 is located between the travel path of the car 12 and a wall 30 of the hoistway 23. The machine 22 is illustrated in more detail in Figure 3. The machine 22 includes a motor 32 having a shaft 34 and a traction sheave 36. The motor 32 includes a frame 38, bearings 40, a stator 42 and a rotor 44. The traction sheave 36 is disposed on the end of the shaft 34 and defines an engagement surface 46 for the ropes 20. The rotor 44 is disposed in a fixed relationship to the shaft 34 and includes a plurality of permanent magnets 48 disposed radially inward of the stator 42 such that a radial air gap 50 is defined between the rotor 44 and stator 42. The use of permanent magnets 48 increases the efficiency and minimizes the size of the motor 32.

**[0022]** The ropes 20 interconnecting the car 12 and counterweight 16 are flexible flat ropes. As shown in Figure 3, there are three separate flat ropes 20 engaged with the machine 22. Each flat rope 20 includes a plurality of load-carrying members 52 encompassed by a sheath 54. The plurality of load-carrying members 52 support the tension loads in the ropes 20. The sheath 54 provides a retention layer for the load-carrying members 52 while also defining an engagement surface 56 for the flat rope 20. Traction between the flat rope 20 and the machine 22 is the result of the interaction between the engagement surface 56 of the ropes 20 and the complementary engagement surface 46 of the machine 22. Although shown in Figure 3 as having three flat ropes 20, each having four load-carrying members 52, it should be noted that different numbers of flat ropes and different numbers of load-carrying members within each rope may be used, such as an embodiment having a single flat rope or a flat rope having a single load-carrying member.

**[0023]** The load-carrying member are formed from steel cord. In order to provide sufficient flexibility in the rope, the cord is formed from steel wires having diameters of 0.25 mm or less.

**[0024]** A suggested material for the sheath is polyurethane. Polyurethane provides the durability required while also enhancing the traction between the flat rope and the machine. Although this material is suggested, other materials may also be used. For instance, a sheath formed from neoprene or rubber may be used.

**[0025]** The use of flexible, flat ropes 20 minimizes the size of the traction sheave 36 and thereby minimizes the torque on the motor 32 and increases the rotational speed of the motor 32. By combining these characteristics of the flat ropes 20 with the characteristics of the permanent magnet machine 22, the motor 32 size is further reduced and the machine 22 can be fit within the space available between the car 12 and hoistway wall 30. Another advantage is that the higher rotational speeds further increases the efficiency of the motor 32 and may eliminate the need for a gear box.

**[0026]** The use of a rotor 44 having permanent magnets 48 also reduces the amount of heat loss through the rotor 44 as compared to conventional induction motors. As shown in Figure 3, the rotor 44, traction sheave 36 and ropes 20 are in direct contact. This direct contact results in heat generated in the rotor 44 being conducted to the ropes 20. For conventional induction motors, the rotor accounts for approximately one-third of the heat loss. However, for rotors using permanent magnets, the heat loss through the rotor is minimal and the primary source of heat loss in such motors is through the stator. As shown in Figure 3, in embodiments according to the present invention there is no direct path between the stator 42 and the ropes 20. Therefore, the effects on the ropes 20 of the heat loss of the motor 22 is minimized. This is especially significant for ropes having a sheath formed from non-metallic materials, such as polyurethane, that are more susceptible to heat degradation than steel.

**[0027]** The elevator system 10 illustrated in Figure 1 includes an underslung car 12. Figure 2 illustrates another embodiment. In this embodiment, a car 57 includes a pair of diverter sheaves 58 located on the top of the car 57 in a manner known as overslung. In conventional elevator systems, overslung roping arrangements are less desirable in some applications due to the need to provide additional overhead space for the elevator system. In the configuration shown in Figure 2, however, the effects of an overslung car 57 are minimized as a result of the small machine and small sheaves that may be used with the present invention. Therefore, an overslung car 57 using Applicants' invention requires less overhead space and is more practical.

**[0028]** In another alternative (not shown), the car may be directly roped to the machine such that no sheaves are required on the car. In addition, although it is not illustrated, the machine may be located above the car travel path. Although in this particular embodiment an allowance will have to be made for the space required in the overhead for the machine, the combination of a permanent magnet machine and flexible flat ropes will minimize this space allowance.

**[0029]** The embodiments illustrated in Figures 1-3 were all elevator systems having gearless machines. Although the invention is particularly advantageous in that it extends the range of usefulness of gearless machines, it should be noted that the invention may also be used with geared machines in particular applications.

**[0030]** Although the invention has been shown and described with respect to exemplary embodiments thereof, it should be understood by those skilled in the art that various changes, omissions, and additions may be made thereto, without departing from the scope of the invention as defined in the claims.

## Claims

1. An elevator system (10) having a car (12) and a counterweight (16) disposed within a hoistway (23) defined by hoistway walls (30), the elevator system including:

   a rope (20) engaged with the car (12) and the counterweight (16) so as to suspend the car and counterweight, the rope including one or more load-carrying members (52), wherein the load-carrying members (52) are formed from steel wires having a diameter of 0.25 mm or less, and a sheath (54), wherein the sheath is formed from a non-metallic material; and

   a machine (22) arranged within the hoistway and including a traction sheave (36) and a motor (44) and a stator (42), wherein the rotor (44) is spaced radially inward of the stator (42), and further including an air gap (50) between the rotor (44) and stator (42), the traction sheave (36) being directly connected with the rotor (44) for concurrent rotation and engaged with the rope (20) to drive the rope through traction between the rope and traction sheave, and thereby drive the car (12) through the hoistway (23), wherein the rotor (44) is formed in part from permanent magnets (48);

   wherein the rope (20) has a width w, a thickness t measured in the bending direction, and an aspect ratio, defined as the ratio of width w relative to thickness t, greater than one.

2. The elevator system according to claim 1, wherein the sheath (54) is formed from a polyurethane material.

3. The elevator system according to claim 1 or 2, wherein the machine (22;78) is gearless.

4. The elevator system according to any preceding claim, wherein the machine (22) is disposed between the travel space of the car (12) and a wall (30) of the hoistway (23).

5. The elevator system according to any preceding claim, wherein the rope (20) is engaged with a pair of sheaves (26) disposed on the car (12) such that the rope (20) passes underneath the car.

6. The elevator system according to any of claims 1 to 4, wherein the rope (20) is engaged with a sheave (58) disposed on the top of the car.

7. The elevator system according to any preceding claim, wherein the load-carrying members (52) are encased within a sheath (54) and wherein the sheath (54) defines the engagement surface for engaging the traction sheave (36).

## Patentansprüche

1. Aufzugsystem (10) mit einer Kabine (12) und einem Gegengewicht (16), die in einem Aufzugschacht (23) angeordnet sind, der durch Schachtwände (30) gebildet ist, wobei das Aufzugsystem aufweist:

ein Seil (20), das mit der Kabine (12) und dem Gegengewicht (16) derart zusammenwirkt, dass die Kabine und das Gegengewicht aufgehängt sind,
wobei das Seil ein oder mehrere Last tragende Elemente (52) aufweist, wobei die Last tragenden Elemente (52) aus Stahldrähten mit einem Durchmesser von 0,25 mm oder weniger gebildet sind, sowie eine Ummantelung (54) aufweist, wobei die Ummantelung aus einem nichtmetallischen Material gebildet ist; und
eine Maschine (22), die in dem Aufzugschacht angeordnet ist und die eine Treibscheibe (36) und einen Motor mit einem Rotor (44) und einem Stator (42) aufweist, wobei der Rotor (44) von dem Stator (42) radial nach innen beabstandet ist, sowie ferner einen Luftspalt (50) zwischen dem Rotor (44) und dem Stator (42) aufweist, wobei die Treibscheibe (36) für eine gleichlaufende Rotation direkt mit dem Rotor (44) verbunden ist und mit dem Seil (20) zusammenwirkt, um das Seil durch Traktion zwischen dem Seil und der Treibscheibe anzutreiben und so die Kabine (12) im Aufzugschacht (23) zu verfahren, wobei der Rotor (44) teilweise aus Permanentmagneten (48) gebildet ist;
wobei das Seil (20) eine Breite w, eine in der Biegerichtung gemessene Dicke t und ein Seitenverhältnis, das als das Verhältnis der Breite w relativ zu der Dicke t definiert ist, größer als 1 aufweist.

2. Aufzugsystem nach Anspruch 1, wobei die Ummantelung (54) aus einem Polyurethanmaterial gebildet ist.

3. Aufzugsystem nach Anspruch 1 oder 2, wobei die Maschine (22; 78) getriebelos ist.

4. Aufzugsystem nach einem der vorangehenden Ansprüche, wobei die Maschine (22) zwischen dem Verfahrbereich der Kabine (12) und einer Wand (30) des Aufzugschachts (30) angeordnet ist.

5. Aufzugsystem nach einem der vorangehenden Ansprüche, wobei das Seil (20) mit einem Paar von Seilscheiben (26) zusammenwirkt, die an der Kabine (12) derart angeordnet sind, dass das Seil (20) unter der Kabine verläuft.

6. Aufzugsystem nach einem der Ansprüche 1 bis 4, wobei das Seil (20) mit einer Seilscheibe (58) zusammenwirkt, die oben auf der Kabine angeordnet ist.

7. Aufzugsystem nach einem der vorangehenden Ansprüche, wobei die Last tragenden Elemente (52) in die Ummantelung (54) eingebettet sind und wobei die Ummantelung die Kontaktfläche zum Zusammenwirken mit der Treibscheibe (36) bildet.

## Revendications

1. Système d'ascenseur (10) possédant une cabine (12) et un contrepoids (16) disposé à l'intérieur d'une cage d'ascenseur (23) définie par des parois de cage d'ascenseur (30), le système d'ascenseur comprenant :

un câble (20) engagé avec la cabine (12) et le contrepoids (16) afin de suspendre la cabine et le contrepoids, le câble comprenant un ou plusieurs éléments porteurs de charge (52), dans lequel les éléments porteurs de charge (52) sont formés de fils métalliques possédant un diamètre de 0,25 mm ou moins, et une gaine (54), dans lequel la gaine est formée d'un matériau non métallique ; et
une machinerie (22) agencée à l'intérieur de la cage d'ascenseur et comprenant une poulie de traction (36) et un moteur possédant un rotor (44) et un stator (42), dans lequel le rotor (44) est espacé de façon radiale vers l'intérieur du stator (42), et comprenant en outre un espace d'air (50) entre le rotor (44) et le stator (42), la poulie de traction (36) étant directement connectée au rotor (44) pour une rotation concourante et engagée avec le câble (20) pour entraîner le câble par traction entre le câble et la poulie de traction, et ainsi entraîner la cabine (12) à travers la cage d'ascenseur (23), dans lequel le rotor (44) est formé en partie d'aimants permanents (48) ;
dans lequel le câble (20) possède une largeur w, une épaisseur t mesurée dans la direction de déformation, et un rapport d'aspect défini comme le rapport de la largeur w par rapport à l'épaisseur t, supérieur à un.

2. Système d'ascenseur selon la revendication 1, dans lequel la gaine (54) est formée à partir d'un matériau de polyuréthanne.

3. Système d'ascenseur selon la revendication 1 ou 2, dans lequel la machinerie (22 ; 78) est sans engrenage.

4. Système d'ascenseur selon l'une quelconque des

revendications précédentes, dans lequel la machinerie (22) est disposée entre l'espace de course de la cabine (12) et une paroi (30) de la cage d'ascenseur (23).

**5.** Système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel le câble (20) est engagé avec une paire de poulies (26) disposées sur la cabine (12) de sorte que le câble (20) passe en dessous de la cabine.

**6.** Système d'ascenseur selon l'une quelconque des revendications 1 à 4, dans lequel le câble (20) est engagé avec une poulie (58) disposée au-dessus de la cabine.

**7.** Système d'ascenseur selon l'une quelconque des revendications précédentes, dans lequel les éléments porteurs de charge (52) sont enfermés à l'intérieur de la gaine (54) et dans lequel la gaine (54) définit la surface d'engagement pour engager la poulie de traction (36).

FIG.1

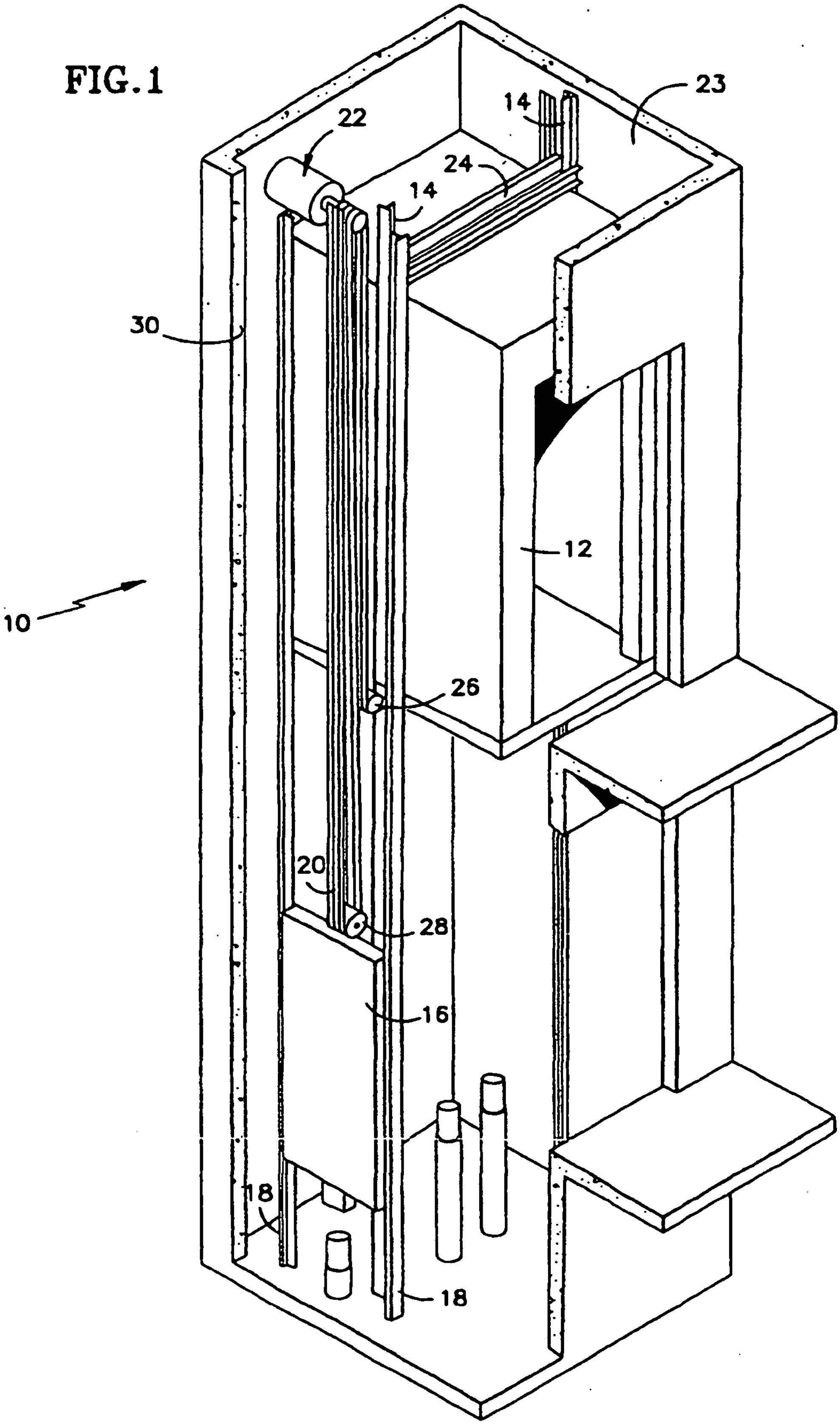
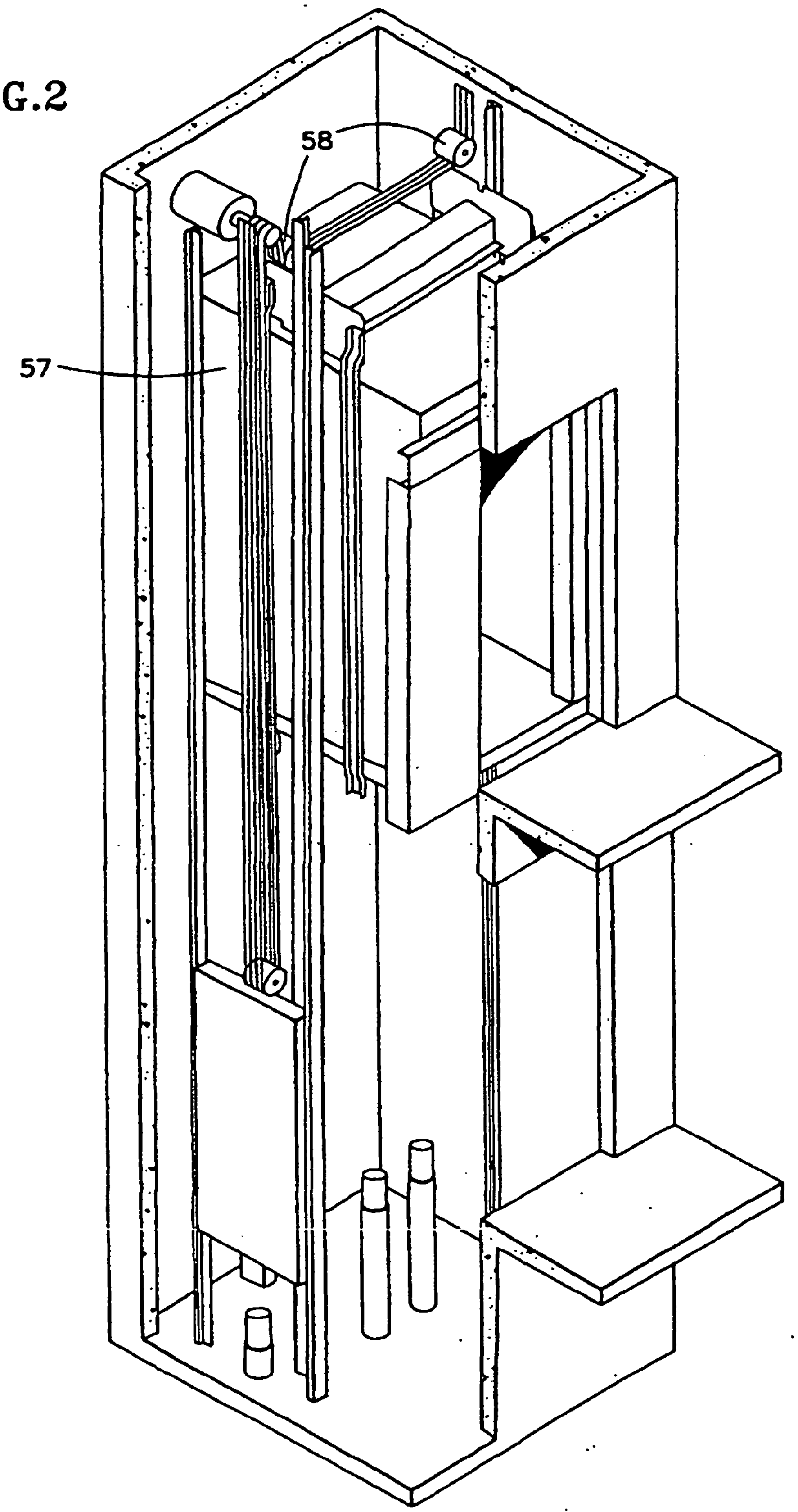


FIG.2



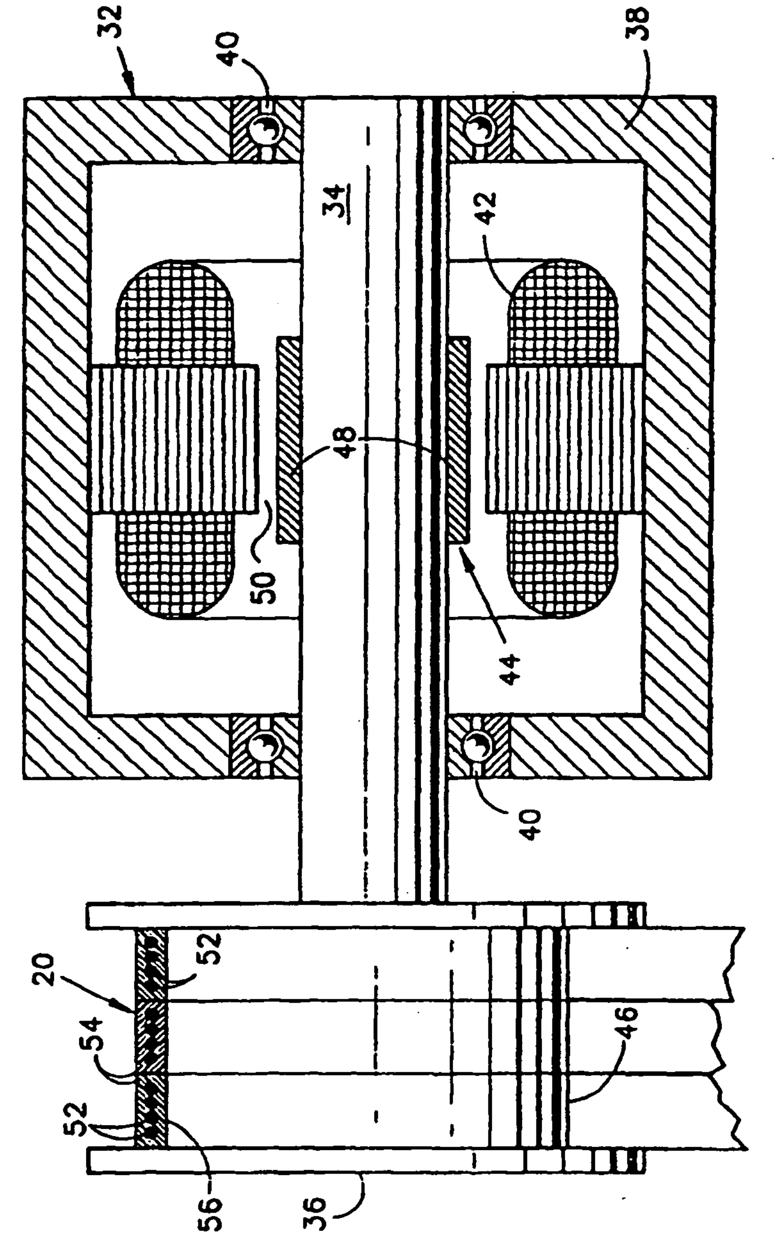



FIG.3

## REFERENCES CITED IN THE DESCRIPTION

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