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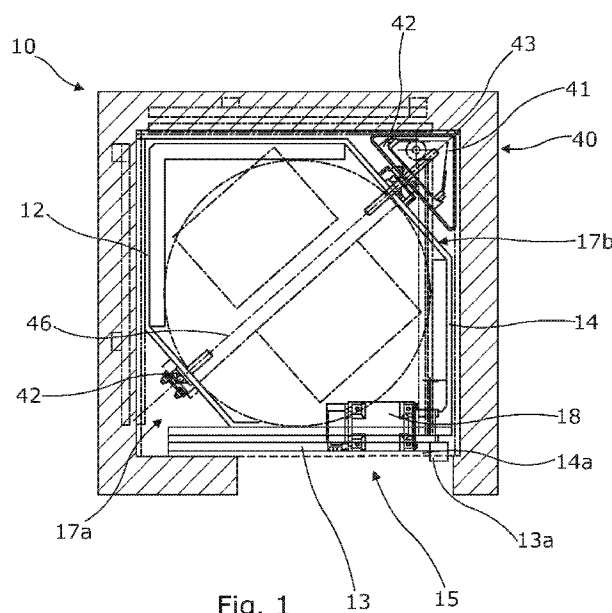


Fig. 1

(57) Abstract: The present invention describes an elevator system comprising an elevator car (12, 112, 212), wherein the lateral cross-section of the elevator car is substantially square in shape with at least one corner cut off (16a, 16b). The elevator system further comprises a lift mechanism configured to raise and lower the elevator car (12, 112, 212); and a counterweight mechanism (40) comprising an elongate counterweight (41). The counterweight (41) is located adjacent to the at least one cut-off corner (16a, 16b) of the elevator car (12, 112, 212). The counterweight (41) has a substantially triangular cross-sectional shape, and is configured to be accommodated within a space defined by one of the at least one cut-off corners (16a, 16b) of the elevator car (12, 112, 212).

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Elevator System

FIELD OF THE INVENTION

This invention relates to a lift/elevator system, in particular an elevator system with a counterweight for moving a lift car between two or more distinct positions.

BACKGROUND OF THE INVENTION

Conventional lift or elevator systems are driven by lifting mechanisms comprising either cables or a hydraulic piston. In both cases, the systems comprise a lift car mounted on a platform within a shaft. The lifting mechanism is also present within the shaft, alongside guide rails that prevent the car from rocking or deviating from its vertical path.

In the case of cable systems or traction lifts, a series of metal cables and pulleys connect the lift car to a motor that hoists the car up or down. Most traction lift systems have a control room above the shaft in which the motor and pulleys are housed, although in some smaller designs, they are located at the top of the shaft itself. The ropes are attached to the lift car and looped around a sheave or pulley, which is driven by the motor. The weight of the car is balanced by a counterweight located within the shaft and is guided by additional guide rails. The counterweight, along with various gears, helps to reduce the load on the motor. The lift car itself is

very heavy and despite the gears and counterweight, a large powerful motor is still required to move the lift car.

These types of lift systems also comprise safety mechanisms in the form of governors and/or electromechanical brakes. Governors ensure the lift car does not move too quickly by attaching an additional cable or rope that runs over a flywheel and attaches to the governor. If the safety rope moves too quickly, and/or there is a rapid change in acceleration (i.e. the car falling), pins in the mechanism fly outwards from the change in motion to engage a surrounding ratchet arrangement to stop the rope and therefore lift car from moving. Electromagnetic brakes prevent motion past certain predetermined locations, or brake the system if there is a loss of power.

Hydraulic lifts comprise a fluid reservoir and a piston or cylinder, powered by a pump. The pump is connected to a motor to raise and lower the car from below. The pump, motor and fluid reservoir are large systems and are placed in a space below the car at the base of the lift shaft. This type of lift is only used for short distances of travel (for example fewer than six stories) as the cylinder size is relative to the distance of travel, so high shafts would require a large piston. These systems are also fairly inefficient when compared to traction lifts as a large amount of energy is required to pump the cylinder full of fluid from the fluid reservoir when raising the car. Safety mechanisms in hydraulic lifts are normally rupture valves and a manual slack/broken cable which can be attached to a switch to prevent operation of the lift.

In both types of systems, the presence of the guide rails (and ropes/counterweights where needed) in the lift shaft limits the cross-sectional area of the lift car compared to that of the shaft. The presence of control rooms for the driving mechanisms means that the shaft must be made taller or have an additional space in order to accommodate them at either the top or bottom of the shaft (dependent on the type of lifting mechanism).

Thus, it would be desirable to provide a lift apparatus and system which addresses at least some of these issues.

SUMMARY OF THE INVENTION

Accordingly, in a first aspect, this invention provides an elevator system comprising:

- an elevator car; wherein the lateral cross-section of the elevator car is substantially square in shape with at least one corner cut off;

- a lift mechanism configured to raise and lower the elevator car; and,

- a counterweight mechanism comprising an elongate counterweight, the counterweight located adjacent to the at least one cut-off corner of the elevator car;

- wherein the counterweight has a substantially triangular cross-sectional shape, and is configured to be accommodated within a space defined by one of the at least one cut-off corners of the elevator car.

The space defined can be between one of the at least one cut-off corners of the elevator car and a corner of a shaft accommodating the elevator car. However, a shaft is not necessarily required.

Guide shoes, rails and rollers are typically required to support the counterweight. The counterweight mechanism can comprise a hoop having a triangular cross-section, and is configured to attach to a guide rail bracket to support movement of the counterweight. A guide rail bracket can be located adjacent to each cut-off corner of the elevator car. Opposing guide rail brackets can be aligned along the cross-sectional centre line of the elevator car.

The lateral cross-section of the elevator car can be substantially quadrilateral in shape, such as square or rectangular in shape, with at least one corner cut off. The elevator car can be substantially square in shape with a first and a second corner cut off.

The lift mechanism can be located adjacent to the at least one cut-off corner of the elevator car. The lift mechanism can be located adjacent to one of the first or second cut-off corner of the elevator car. The counterweight can be located adjacent to the other of the first or second cut-off corner of the elevator car.

The at least one corner can be cut-off at a substantially 30 – 45 degree angle. The elevator car can comprise a plurality of wall panels. Adjacent wall panels can be at an

angle of from 135 to 150 degrees to each other, forming the at least one cut-off corner.

Each wall panel can be removable and/or interchangeable. The elevator car can also comprise a removable and/or interchangeable floor (or bottom) panel and/or ceiling (or top) panel.

At least one of the plurality of wall panels of the elevator car can be removable to form an opening and be selectively closed by a door, thus providing an access point into the elevator car.

The elevator car can be formed of a frame defining the shape of the elevator car. The frame can comprise beading attached along each vertical and/or horizontal part of the frame. The plurality of wall panels can be removably and/or interchangeably attached to the beading, such as by clipping the panels into the beading.

Each of the plurality of panels can be formed of a composite material, such as an aluminium honeycomb material.

The present invention is designed to be used with many types of lift mechanism, for example those found on traction elevators. The lift mechanism can be configured to raise and lower the elevator car. The lift mechanism can comprise the traditional

traction methods of steel ropes or flat belts, for raising and lowering the elevator car. With such lift mechanisms, the elevator car can be supported centrally. The lift mechanism can comprise a drive mechanism comprising a flexible drive member coupled to the elevator car, and drive means configured to drive the drive member to raise and lower the elevator car.

As described in the Applicant's published patent application WO2018073612, the lift mechanism can specifically comprise:

- an elongate support member located adjacent to the elevator car and having a substantially vertical longitudinal axis;

- a drive mechanism comprising a flexible drive member maintained longitudinally around the support member and drive means configured to drive the drive member relative to the support member about an axis substantially orthogonal to the longitudinal axis.

The lift mechanism and support member can be located adjacent to a cut-off corner of the elevator car, such as in the space defined between one cut-off corner and a corner of a lift shaft. In such embodiments, the elevator car can be supported from one side such that the elevator car is cantilevered.

The drive mechanism can be a positive-drive mechanism. The drive mechanism can be a push-drive mechanism. Additionally or alternatively, the drive mechanism can

comprise a pull-drive mechanism. This can result in a push-pull drive mechanism. The push-drive mechanism can further comprise at least one pulley coupled to the drive member and the drive means.

The drive means can be a motor, such as a geared or gearless motor. Operation of the drive means in a first direction can cause upward vertical movement of the elevator car. Operation of the drive means in a second, opposite direction can cause downward vertical movement of the elevator car. That is, operation of the drive means in a first direction can cause upward vertical movement of the elevator car relative to the support member and, operation of the drive means in a second, opposite direction can then cause downward relative movement of the elevator car relative to the support member.

The motor can be located within a recess at a lower end of a lift shaft or other space accommodating the system. Alternatively, where there is a shallow, or even no, pit beneath the elevator car, the motor can be located above the elevator car, such as adjacent to the doors (where one or more panels have been replaced with doors), or at the top of the lift shaft (if there is one). Where the motor is located above the lift car and not in the pit, there is no need for operators to go into the pit for maintenance purposes, thus there is less safety risk to personnel.

The drive member can comprise one of steel coated ropes, a chain, and a belt, such as

a toothed v-shaped belt or flat belt. The drive member can comprise a continuous loop.

The elevator system can comprise a single drive member. The counterweight can be attached to the single drive member by any suitable means. Alternatively, the elevator system can comprise multiple drive members. The total weight of the counterweight can be split equally between each drive member, such as by attaching an individual (smaller) counterweight to each drive member.

A lifting member can be connected to the base or side of the elevator car. The lifting member is coupled to the drive means such that operation of the push-drive mechanism causes substantially vertical movement of the elevator car relative to the support member. The lifting member can be configured to push the elevator car upwards from below in response to the drive means driving the drive member in the first direction. Similarly, the lifting member can be configured to guide the elevator downwards in response to the drive means driving the drive member in the second direction.

Where the drive member is a chain system, the lifting member can comprise a plate connected to the base or side of the elevator car. The lifting member or plate can comprise a security fork for providing a connection between the drive means and the elevator car. The lifting member or plate can also include one or more load cells for

generating an electrical signal representative of a weight and/or force associated with the elevator car.

The lifting member or plate can comprise a layer of anti-vibration material adjacent to the base of the elevator car. Furthermore, each of the panels can comprise an anti-vibration material, such as rubber, to minimise the vibrations and noise within the elevator car.

The support member can comprise a plurality of substantially parallel vertical beams. The support member can comprise two pairs of vertical beams, and the drive member can extend lengthways between the first pair of beams, and lengthways between the second pair of beams. Each beam can comprise fixing points located at intervals along the length of the beam, and wherein brackets attach to the fixing points to separate the beams into pairs. The pairs of beams can be attached to each other by connecting members located at intervals along the length of each beam. At least one beam can be attached to a wall of a lift shaft (or other space accommodating the elevator system) via a fixing bracket.

The system can further comprise a plurality of sliding shoes or rollers attached to the base of the elevator car and a plurality of corresponding sliding shoes or rollers attached to the uppermost surface of the elevator car.

The lift mechanism can comprise a safety mechanism to control the movement of the elevator car. The safety mechanism can be attached to one of the panels, such as a wall panel located at one of the cut-off corners of the elevator car.

Also described herein is an elevator system comprising:

- an elevator car; wherein the lateral cross-section of the elevator car is substantially square in shape with at least one corner cut-off; and

- a lift mechanism configured to raise and lower the elevator car;

- wherein the elevator car comprises a plurality of removable and/or interchangeable wall panels.

The lateral cross-section of the elevator car can be substantially quadrilateral in shape, such as square or rectangular in shape, with at least one corner cut off. The elevator car can be formed of a frame, such as an extruded aluminium frame. The frame can be finished by water transfer film printing or an electro-coated polymer. The frame can define the shape of the elevator car. Beading can be attached along each vertical and/or horizontal part of the frame, such as on an inner and/or an outer surface of each vertical and/or horizontal part of the frame. The plurality of wall panels can be removably attachable to the beading. Each wall panel can be attached to the beading by clipping (or “snapping-in”) each wall panel into the beading. Each wall panel can also be removed from the beading by unclipping each wall panel from the beading.

The frame of the elevator car can be designed to have more than one different type (or shape, such as cross-sectional shape) of extrusion, such that the extrusions, along with the beading, provide different angles between adjacent wall panels. For example 90 degrees or 135 degrees between adjacent wall panels. When the angle between adjacent wall panels is more than 90 degrees, such as 135 degrees, this can provide the cut-off corner of the elevator car.

The frame is a structural feature of the elevator car. The elevator car can also comprise a removable and/or interchangeable floor (or bottom) panel and/or ceiling (or top) panel. The top and bottom panels can also be structural. The wall panels are not structural, hence they can be removed and replaced.

Any one of the plurality of wall panels of the elevator car can be replaceable. At least one panel can be removed to form an opening, thus providing an access point into the elevator car. Advantageously, such an opening can be on at least one side of the elevator car. Each opening can be selectively closed by a door. The panel can be removed and replaced with a door stop. One or more of the panels can be replaced with different panels, such that the interior of the elevator car can be easily redesigned, such as to change the interior colour of the panels.

The lift mechanism can be located adjacent to the at least one cut-off corner of the elevator car.

The at least one corner can be cut-off at a substantially 30 – 45 degree angle (providing a 135 – 150 degree angle between adjacent panels). The lateral cross-section of the elevator car is substantially quadrilateral in shape, such as square or rectangular in shape, with two corners cut-off. For example a first cut-off corner and a second cut-off corner. The lift mechanism can be located adjacent to either the first or the second cut-off corner of the elevator car.

The system can further comprise a counterweight mechanism. The counterweight mechanism can be located adjacent to either the first or second cut-off corner of the elevator car. The counterweight mechanism can comprise a counterweight. The counterweight can be any shape. The counterweight can be elongate and have a triangular cross-sectional shape. A triangular cross-sectional shape can allow the counterweight to be accommodated in a space defined by one of the cut-off corners of the elevator car. The space defined can be between the at least one cut-off corner and a corner of the surrounding lift shaft. However, it will be appreciated that a lift shaft is not necessarily required.

Guide shoes, rails and rollers are typically required to support the counterweight. The counterweight bracket required to support the counterweight obstructs at least one of the wall panels, meaning it/they cannot be removed and replaced with doors.

The elevator car can be formed of a composite material. For example, one or more of

the plurality of panels can be formed of a composite material. One or more of the plurality of panels can be formed of an aluminium honeycomb material. Advantageously, the honeycomb structure of the material can help to minimise the amount of material used, and thus helps to minimize the weight, and also the cost, of the elevator car.

One or more of the plurality of panels can comprise an emissive electroluminescent layer, such as that found in organic light-emitting diodes (OLEDs), which can be produced through organic vapour generating printing or inkjet printing. Alternatively, the panel can comprise an electro-coated polymer. Such a layer can be on the inner surface or the outer surface of one or more of the panels. Advantageously, this can allow one or more of the panels to act as a digital display to display images (for example, advertising) on the inside and/or the outside of the elevator car.

Whilst the invention has been described above, it extends to any inventive combination of the features set out above in the first or second aspects of the invention, or in the following description or drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention can be performed in various ways, and an embodiment thereof will now be described by way of example only, with reference being made to the accompanying drawings, in which:

Fig. 1 is a top view of a lift shaft with an elevator car;

Fig. 2 is a top view of the Fig. 1 elevator car;

Fig. 3 is a side view of a lift shaft with an elevator car and counterweight mechanism;

Fig. 4 is a side view of the counterweight mechanism only;

Fig. 5 is a top view of a lift shaft with an elevator car and lift mechanism; and,

Fig. 6 is a three-dimensional view of an elevator car.

DETAILED DESCRIPTION OF THE DRAWINGS

The term 'upward' as used herein will be understood to refer to extension or movement from a lower position to a relatively higher position. Whereas the term 'downward' as used herein will be understood to refer to extension or movement from a higher position to a relatively lower position.

Although the following example comprises a lift shaft within which the lift car is located, it is envisaged that such a standalone lift shaft is not essential, and the invention can operate without the presence of a lift shaft.

Figs. 1 and 2 show a lift shaft 10 and a lift car 12. The cross-section of the lift car 12 is square in shape with two corners cut-off at a substantially 45 degree angle: a first cut-off corner 17a and a second cut-off corner 17b. The cross-sectional area of the lift car 12 fully complies with at least the European standards outlined in the Disability

Discrimination Act 1995, which stresses the importance of having sufficient space available for wheelchair manoeuvring. A benefit of an increased cross-sectional area can be a greater manoeuvring area for wheelchair users, as demonstrated by the turning circles outlined in the lift car shown in Figs. 1 and 2. For example, the turning circles can have a 1400mm diameter, and the doors can be 900mm in width, thus giving a wheelchair user sufficient space to enter/exit the lift, and the turn around as required.

Advantageously, the cross-sectional area of the lift car 12 is significantly greater than the cross-sectional area of known lift cars, in respect of a comparably sized shaft. A greater cross-sectional area can increase, such as double, the capacity of the lift car.

The lift car 12 comprises a plurality of removable and/or interchangeable wall panels 14. Fig. 1 shows that one of the wall panels 14a of the lift car 12 has been removed to reveal an opening 15 into the lift car 12. The removed wall panel 14a has been replaced with doors 13 and door stops 13a. The opening 15 is selectively closed by the doors 13, thus providing an access point into the car 12. Fig. 1 also shows the outline of other positions in which the doors could be located, such as opposite the current door position or adjacent the current door position on one of the side panels.

The lift shaft 10 also comprises a counterweight mechanism 40, which will be discussed in more detail later. The counterweight mechanism 40 obstructs one of the

sides of the lift car 12, meaning that the either the rear or right-hand wall panels 14 cannot be removed and replaced with doors.

The lift car 12 comprises a plurality of vertical and horizontal extruded aluminium posts (not shown) which create a frame defining the shape of the lift car 12. These posts are structural, and provide support for the lift car 12. The floor and ceiling panels of the lift car (not shown) are interchangeable/replaceable, and they are also structural.

Beading (not shown) is attached to each of the vertical and/or horizontal posts. Typically there is a gap of around 12 mm between the inside and the outside of the frame of the elevator car which can accommodate the panels. The wall panels 14 clip or snap into the beading. The structural features of the lift car 12 (the frame and the top/bottom panels) provide the necessary structure to allow any of the panels, particularly the wall panels, to be removable and interchangeable.

The frame and beading together are designed to provide a predefined angle between the adjacent wall panels. For example, an extrusion with beading can be designed to fit panels together at a 90 degree angle (shown as 16a in Fig. 2). In another example, an extrusion with beading is designed to fit panels together at a 135 – 150 degree angle, to provide the 30 – 45 degree angle cut-off corner (shown as 16b in Fig. 2). The angles are defined to be wide enough to minimise any twisting of the elevator car

structure.

The lift car 12 is made of a composite material, such as fibre glass or carbon fibre or similar composite components. Alternatively, it could be formed of a honeycomb core sandwiched between sheets of aluminium or the like. For example, the floor, ceiling and wall panels 14 are made of an aluminium honeycomb material. The doors 13 are also made from a composite material, which reduces the weight from, for example, 100kg (for steel doors) to around 10 – 15kg (for composite doors).

Advantageously, composite materials are typically stronger (for example, around 10 times stronger), for the same mass of known materials such as steel. This would allow the lift car to be lighter while still retaining a similar strength. For example, taking the average person to weigh 75kg, a known lift car with 10 people will weigh around 1500kg, whereas a lift car made of composite material with 10 people will weigh around 900kg.

The elevator car of the present invention can be integrated with a traditional car sling. Advantageously, embodiments of the present invention comprising a structural frame and lightweight composite panels, negates the need for a car sling. Such an arrangement can help to reduce the depth at the bottom of the elevator car, and thus can help to minimise the distance which the elevator car extends into the pit at the bottom of a lift shaft. As such, traditional buffers, such as point buffers, may no

longer be required. It is envisioned that a simple cushioning mechanism will be sufficient, such as a displaced load pad. Furthermore, since the height of the elevator car is reduced, there is no need for a traditionally deep pit. As such, the present invention can reduce the depth of the pit to around 150mm or less (depending on the thickness of the panels), thus saving space and ultimately saving cost. Moreover, such a shallow pit will not normally need to be waterproofed, unlike known pits, because it will not lie beneath the water table.

Advantageously, the lift car of the present invention requires less skilled labour to make and install, thus saving costs whilst maintaining a high standard of quality and safety. Firstly, the extruded posts and beading need to be assembled to define the shape of the lift car. Then the honeycomb panels simply need to be cut to the correct shape and size using known cutting tools, such as a circular saw, and then clipped into the beading. Anti-vibration material, such as rubber, is also installed on the panels to minimise noise and vibrations within the lift shaft. Holes then need to be drilled in the top panel (which is permanently attached to the frame) so pulley systems can be installed (if required), and safety gear must also be mounted to one of the panels and adjacent guide rails. The lift car is then ready to install in a lift shaft.

The lift shaft 10 also comprises a counterweight mechanism 40, as shown in Fig. 1 (top view), Fig. 3 (front view), and Fig. 4 (side view of counterweight mechanism without lift car). The counterweight mechanism 40 comprises an elongate counterweight 41

with a triangular cross-sectional shape. The shape of the counterweight 41 can be clearly seen in Figs. 1 and 4(A). The counterweight 41 is located within the space defined between the lift shaft 10 and the second cut-off corner 17b. The counterweight 41 has a triangular cross-sectional shape, such that the counterweight 41 can be accommodated by the second cut-off corner 17b and make efficient use of the space available.

The counterweight mechanism 40 comprises a hoop 43 which is triangular in cross-section. A guide rail bracket 42 is attached to the hoop 43, and supports the upwards and downwards movement of the counterweight 41. Such a hoop/bracket mitigates the need for skilled labour to install specific counterweight rails, as is typical in this field.

As can be seen in Fig. 1, the guide rails 42 are located adjacent the cut-off corners of the elevator car, and are aligned along the cross-sectional centre line 46 of the lift car 12. Advantageously, aligning the counterweight guide rails in this way allows the lift car to be easily scaled upwards and downwards in cross-sectional size. Therefore, if a car is required for a smaller lift shaft, then it is easy to produce a scaled down version of the lift car without needing to reposition any components to maintain lift car stability.

The counterweight 41 can be attached to a single drive member 44. Alternatively if

there are multiple drive members, the weight can be split equally between each drive member, such that a counterweight is attached to each drive member. The weight and dimensions of the counterweight are dependent on the material used to make the counterweight.

The two cut-off corners 17a, 17b typically serve different purposes. The first cut-off corner 17a typically accommodates any electrical components of the elevator system, such as the safety mechanism and any magnetic read tape (which is used to detect the absolute position of the lift car). The second cut-off corner 17b typically accommodates any mechanical components of the elevator system, such as the counterweight.

The lift shaft 10 also comprises a lift mechanism, comprising a motor 18. It is envisaged that the lift mechanism could be a known lift mechanism, such as a traction lift having steel ropes. Alternatively, the lift mechanism could be the same or similar to that described in the Applicant's published patent application WO2018073612. Regardless of the type of lift mechanism used, the lift mechanism comprises drive means in the form of a geared or gearless motor, and a flexible drive member coupled to the lift car. The drive member can comprise one of steel ropes, a chain, and a belt, such as a flat or toothed v-shaped belt. In use, the motor drives the drive member to raise and lower the lift car within the lift shaft.

Fig. 3 shows a lift mechanism and counterweight. The lift mechanism comprises a motor 18 (geared or gearless), and a drive member 44 that allows traction to be separated from suspension, such that traction is 1:1 and attached though pulleys to the counterweight as shown in Fig. 4. The suspension is coupled to various pulleys 47a – d, such that the lift has 2:1 roping, reducing the car speed to half that of the rope speed.

Fig. 4 shows a positive drive lift mechanism and a counterweight 41. The lift mechanism comprises a geared or gearless motor 18, and a drive member 44. The counterweight 41 has a triangular cross-section, as described above. The drive member 44 is directly connected to the motor 18, thus providing a 1:1 traction system. However, the lift car (not shown) is suspended by ropes in a 2:1 configuration, thus the lift car will move at half the speed of the ropes. This is a novel system, and allows the lift car to be moved by moving the counterweight.

Fig. 5 shows an embodiment from WO2018073612 whereby a lift mechanism 120 is located in the space defined between a lift shaft 110 and a cut-off corner 117a, and the lift car 112 is cantilevered. Features in common with Figs. 1 – 4 will be referred to here by the same reference numeral, except preceded by a “1”. These features will not be described in detail again.

As described in in more detail below, and also in WO2018073612, the lift mechanism

120 is a push-drive mechanism (a type of positive drive). In this embodiment, the lift mechanism 120 is located in the space defined between a corner of the lift shaft 110 and the cut-off corner of the lift car 112. The lift mechanism 120 comprises drive means in the form of a geared motor 130. A flexible drive member 144 is also coupled to the lift car 112, such that in use, the motor 130 drives the drive member 144 to raise and lower the lift car 112 within the lift shaft 110. Operation of the motor 130 in a first direction causes upward vertical movement of the lift car 112, whereas operation of the motor 130 in a second, opposite direction causes downward relative movement of the lift car 112.

Alternatively, embodiments of the lift mechanism can be a pull-drive mechanism.

As shown in Figure 5, embodiments of the lift mechanism 120 comprise two pairs of vertical beams 145, and a continuous drive member 144, such as a chain, extends lengthways between the pairs of beams 145, such that the drive member 144 rotates in use around both pairs of beams 145.

A geared motor 130 drives the drive member 144 via a drive pulley (not shown) around the pairs of beams 145. The motor 130 moves in a first, or forward, direction, and a second, or backwards, direction. The motor 130 is located beneath the lift car 112 at the bottom of the lift shaft 110 within a pit, or recess. Alternatively it can be located above the lift car at the top of the lift shaft 110.

The pit depth depends on the maximum speed of the lift car 112, and it is envisioned that the system of the present invention can travel around $0.15 \text{ ms}^{-1} - 1.6 \text{ ms}^{-1}$, and have a pit as shallow as 50mm, as discussed above. Advantageously, such a shallow pit can help to save time on pit construction and waterproofing of the pit area (since the pit is normally below ground, it requires a waterproof construction).

Since the lift car 112 is much lighter than a known lift car, the motor does not need to provide as much power to drive the drive member 144 to move the lift car 112 upwards and downwards. It is envisaged that the lift car can be powered using a single phase or a three phase power supply. For example, a single phase power supply would be typically used with lift cars installed in a residential environment, whereas three-phase power supplies are typically used in commercial environments.

Attached to the drive member 144 is a lifting plate 122. The lifting plate 122 is located underneath, and is attached to, the base of the lift car 112. Fig. 5 also shows sliding shoes 124, 126 located at the top and bottom of the lift car 112. The lifting plate 122 and sliding shoes 124 support the lift car 112 as it moves upwards and downwards within the lift shaft 110. The sliding shoes 124, 126 advantageously help to minimise any lateral or rotational movement of the lift car 112. The lifting plate 122 itself does not prevent the side-to-side movement of the lift car 112, therefore it is beneficial to provide sliding shoes 124, 126 to prevent, or at least minimise, such movement.

The lift car 112 is picked up, and supported, from one side by the lifting plate 122, and sliding shoes 124, 126. In other words, the lift car 112 is cantilevered within the lift shaft 110. The lift car 112 is guided up and down the lift shaft 110 due to the walls of the lift car 112 being adjacent to the walls of the lift shaft 110. This is in direct contrast to known lift systems where the lift car is supported along its central axis from above by a system of ropes, pulleys and counterweights, and is guided up and down the lift shaft by additional guide rails. For example, known lifts typically have counterweights which are around 1.5 times the maximum weight limit for that particular lift car. Sufficient space must be left between the walls of the lift car and the walls of the lift shaft to accommodate the ropes, pulleys, counterweights and guide rails, which means that the cross-sectional area of the lift car is smaller and its capacity is therefore reduced. Alternatively, the lift car can be centrally hung.

In use, to move the lift car 112 from a lower height to a greater height, the motor 130 activates and turns in a forward direction. The activation of the motor 130 causes the drive pulley to rotate, which in turn causes the drive member 144 to rotate in a first direction around the beams 145. Since the motor 130 is geared, the power output from the motor 130 is the same as the power input to the drive pulley. Therefore, based on such a 1:1 ratio, the initial speed of the drive member 144 can be around 1.6 meters per second (ms^{-1}). The lifting plate 122, which is attached to drive member 144, is subsequently caused to move in an upwards direction at an initial speed of 1.6

ms^{-1} . The lift car 112 accelerates upwards at a rate of 0.6 meters per second squared (ms^{-2}). There is no limit on how fast the lift car 112 can move nor how high it can travel, but it is typically capped at a speed of around 2.5 ms^{-1} and a height of around 20 floors. The upwards movement of the lifting plate 122 pushes the attached lift car 112 from below to move the lift car 112 in an upwards direction from the lower height to the greater height. The motion of the lift car 112 is stabilised by the sliding shoes 124, 126, so that the lift car 112 does not rotate as it is pushed upwards. As the lift car 112 moves upwards, the counterweight moves downwards. The downwards motion of the counterweight helps to pull the lift car 112 upwards. Therefore the lift car 112 is pushed upwards, or in some embodiments both pushed and pulled upwards, from the lower height to the greater height.

Furthermore, to move the lift car 112 from a greater height to a lower height, the motor 130 firstly stops, and then begins turning in a backwards direction. Drive pulley also stops and rotates in the opposite direction, which in turn rotates the drive member 144 in an opposite, or clockwise, direction around the beams 145. The lifting plate 122 is subsequently caused to move in a downwards direction at an initial speed of 1.6 ms^{-1} . The lift car 112 accelerates downwards at a rate of 0.6 ms^{-2} . The downward movement of the lifting plate 122 guides the attached lift car 112 from below to move the lift car 112 in a downwards direction from the greater height to the lower height. Again, the motion of the lift car 112 is stabilised by the sliding shoes 124, 126, so that the lift car 112 does not rotate as it is guided downwards. As the lift

car 112 moves downwards, the counterweight moves upwards. The downward force acting on the counterweight due to gravity helps to slow the speed of the downwards motion of the lift car 112. The motion of the lift car 112 (in both an upwards and downwards direction) is guided by the walls of the lift shaft 110.

The lift mechanism 120 described herein is suitable for use with small lift cars, for example with an 8 person capacity, to much larger lift cars, such as a 26 tonne goods lift.

Fig. 6 shows a three-dimensional view of the lift car 212 which has a single cut-off corner, and removable/interchangeable wall panels. As can be seen, some of the default panels made of composite materials (such as an aluminium honeycomb material), have been removed and replaced with glass, or other transparent material.

Similar to the embodiment shown in Fig. 1, the lift car 212 can be operated with any appropriate lift mechanism, such as a traction mechanism, or the Applicant's own push-drive mechanism as described in WO2018073612.

It will be appreciated that the lift car could have any cross-sectional shape, as long as at least one corner of the lift car is sufficiently cut away to accommodate the lift mechanism and/or counterweight.

For the avoidance of doubt, the terms 'lift' and 'elevator' are utilised interchangeably herein to refer to a platform or compartment housed in a shaft for raising and lowering people or things to different levels.

Although the invention has been described above with reference to an exemplary embodiment, it will be appreciated that various changes or modifications can be made without departing from the scope of the invention as defined in the appended claims.

Claims

1. An elevator system comprising:
 - an elevator car; wherein the lateral cross-section of the elevator car is substantially square in shape with at least one corner cut off;
 - a lift mechanism configured to raise and lower the elevator car;
 - a counterweight mechanism comprising an elongate counterweight, the counterweight located adjacent to the at least one cut-off corner of the elevator car;
 - wherein the counterweight has a substantially triangular cross-sectional shape, and is configured to be accommodated within a space defined by one of the at least one cut-off corners of the elevator car.
2. An elevator system as claimed in claim 1, wherein the counterweight is configured to be accommodated within a space defined between one of the at least one cut-off corners of the elevator car and a corner of a shaft accommodating the elevator car.
3. An elevator system as claimed in either claim 1 or 2, wherein the elevator car is supported centrally.
4. An elevator system as claimed in any preceding claim, wherein the

counterweight mechanism comprises a hoop having a triangular cross-section, and wherein the hoop is configured to attach to a guide rail bracket to support movement of the counterweight.

5. An elevator system as claimed in claim 4, wherein a guide rail bracket is located adjacent to each cut-off corner of the elevator car, and wherein opposing guide rail brackets are aligned along the cross-sectional centre line of the elevator car.

6. An elevator system as claimed in any preceding claim, wherein the elevator car is substantially square in shape with a first and a second corner cut off.

7. An elevator system as claimed in claim 6, wherein the lift mechanism is located adjacent to the first or second cut-off corner of the elevator car and is configured to raise and lower the elevator car.

8. An elevator system as claimed in either claim 6 or 7, wherein the counterweight is located adjacent to the first or second cut-off corner of the elevator car.

9. An elevator system as claimed in any preceding claim, wherein the at least one corner is cut-off at a substantially 30 – 45 degree angle.

10. An elevator system as claimed in any preceding claim, wherein the elevator car comprises of a plurality of wall panels, and wherein adjacent wall panels can be arranged at an angle of from 135 to 150 degrees to each other, forming the at least one cut-off corner.

11. An elevator system as claimed in claim 10, wherein each wall panel is removable and/or interchangeable.

12. An elevator system as claimed in claim 11, wherein at least one of the plurality of wall panels of the elevator car is removable to form an opening and be selectively closed by a door, thus providing an access point into the elevator car.

13. An elevator system as claimed in either claim 11 or 12, wherein the elevator car also comprises a removable and/or interchangeable floor panel and/or ceiling panel.

14. An elevator system as claimed in any of claims 11 to 13, wherein the elevator car is formed of a frame defining the shape of the elevator car; the frame comprising beading attached along each vertical and/or horizontal part of the frame.

15. An elevator system as claimed in claim 14, wherein the plurality of wall panels are removably and/or interchangeably attached to the beading, such as by clipping

the panels into the beading.

16. An elevator system as claimed in any of claims 11 to 15, wherein each of the plurality of panels is formed of a composite material, such as an aluminium honeycomb material.

17. An elevator system as claimed in any previous claim, wherein the lift mechanism comprises a drive mechanism comprising a flexible drive member coupled to the elevator car, and drive means configured to drive the drive member to raise and lower the elevator car.

18. An elevator system as claimed in claim 17, wherein the drive member can comprise one of coated steel ropes, a chain, and a belt, such as a flat or toothed v-shaped belt.

19. An elevator system as claimed in either claim 17 or 18, further comprising a single drive member; and, wherein the counterweight is attached to the single drive member.

20. An elevator system as claimed in either claim 17 or 18, further comprising multiple drive members; and, wherein the weight of the counterweight can be split equally between each drive member, such as by attaching a counterweight to each

drive member.

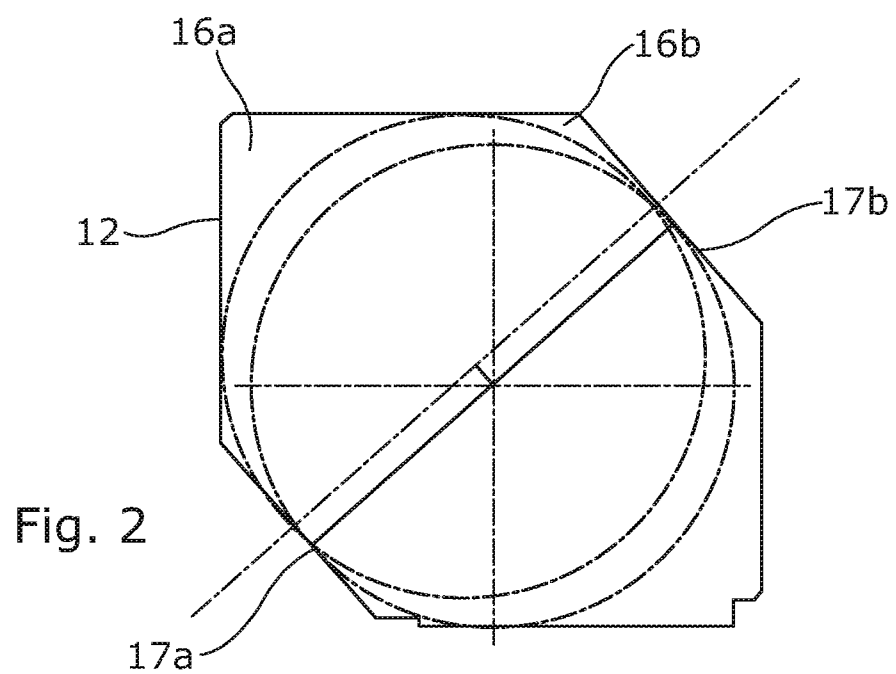
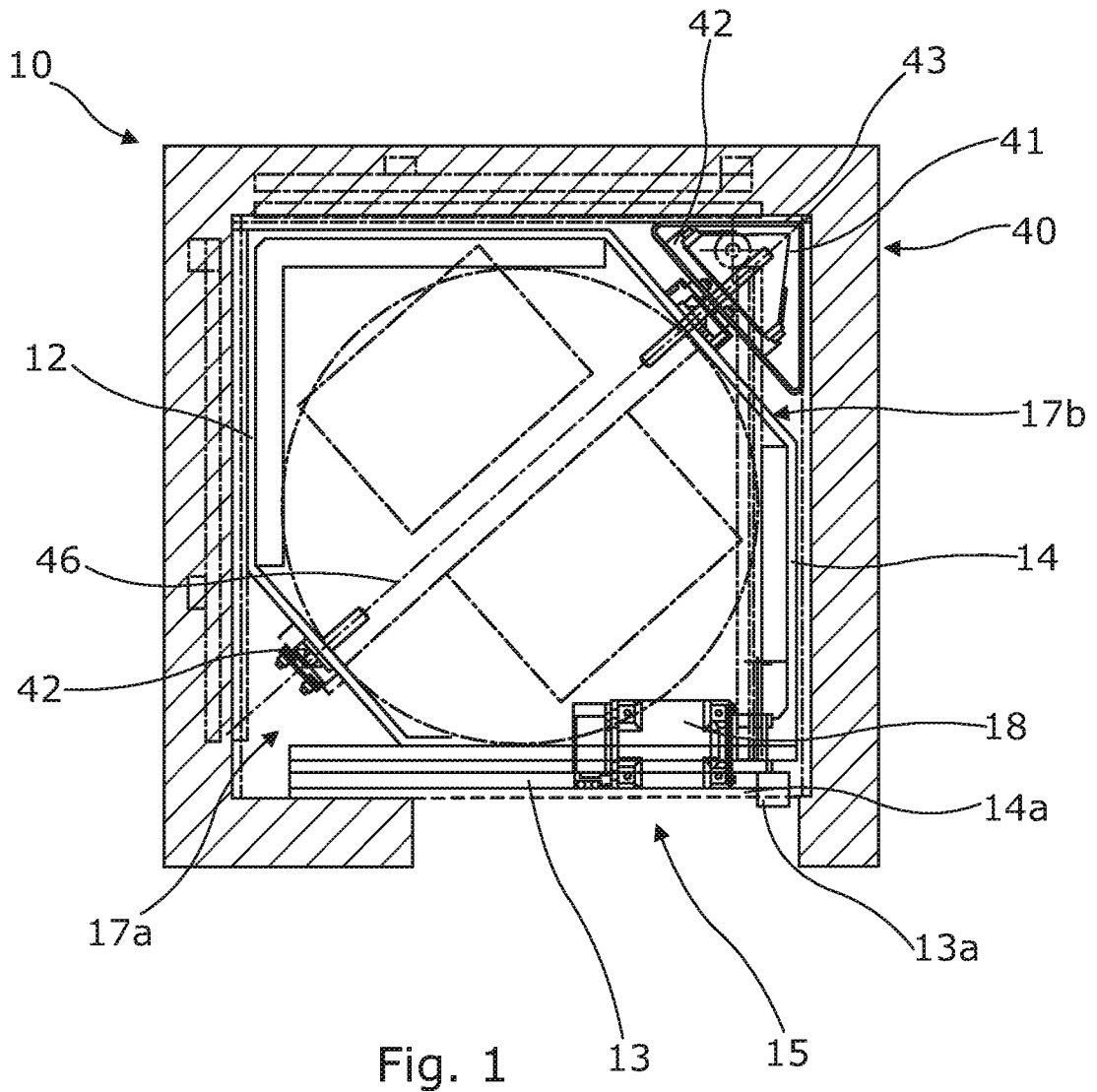
21. An elevator system as claimed in any of claim 17 to 20, wherein the drive means is a motor, such as a geared or gearless motor.

22. An elevator system as claimed in any one of claim 17 to claim 21, wherein operation of the drive means in a first direction causes upward vertical movement of the elevator car and, operation of the drive means in a second, opposite direction causes downward vertical movement of the elevator car.

23. An elevator system as claimed in any of claim 17 to claim 22, wherein the drive mechanism is a positive-drive mechanism.

24. An elevator system as claimed in any of claim 17 to claim 23, wherein the drive mechanism is a push-drive mechanism.

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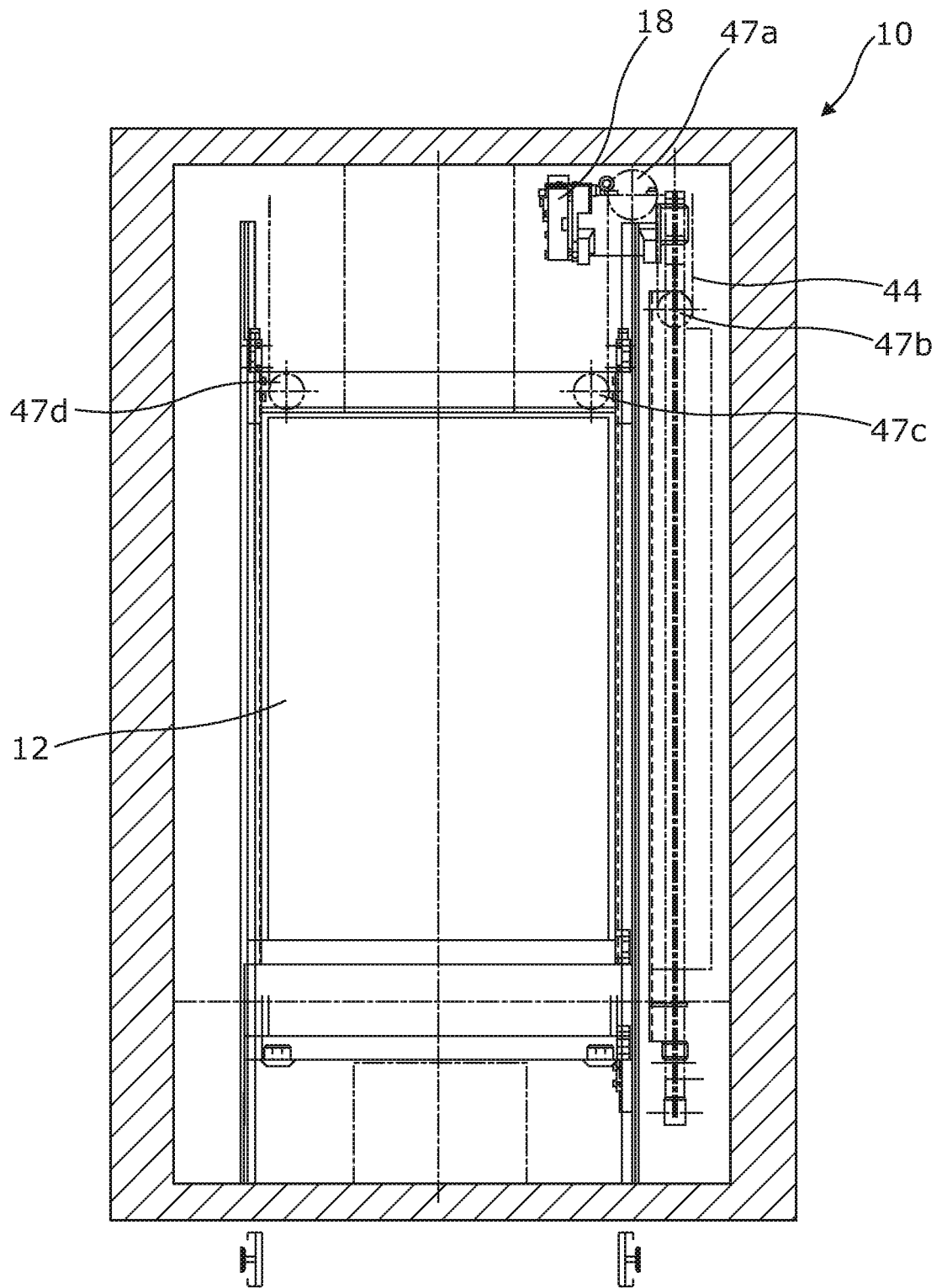


Fig. 3

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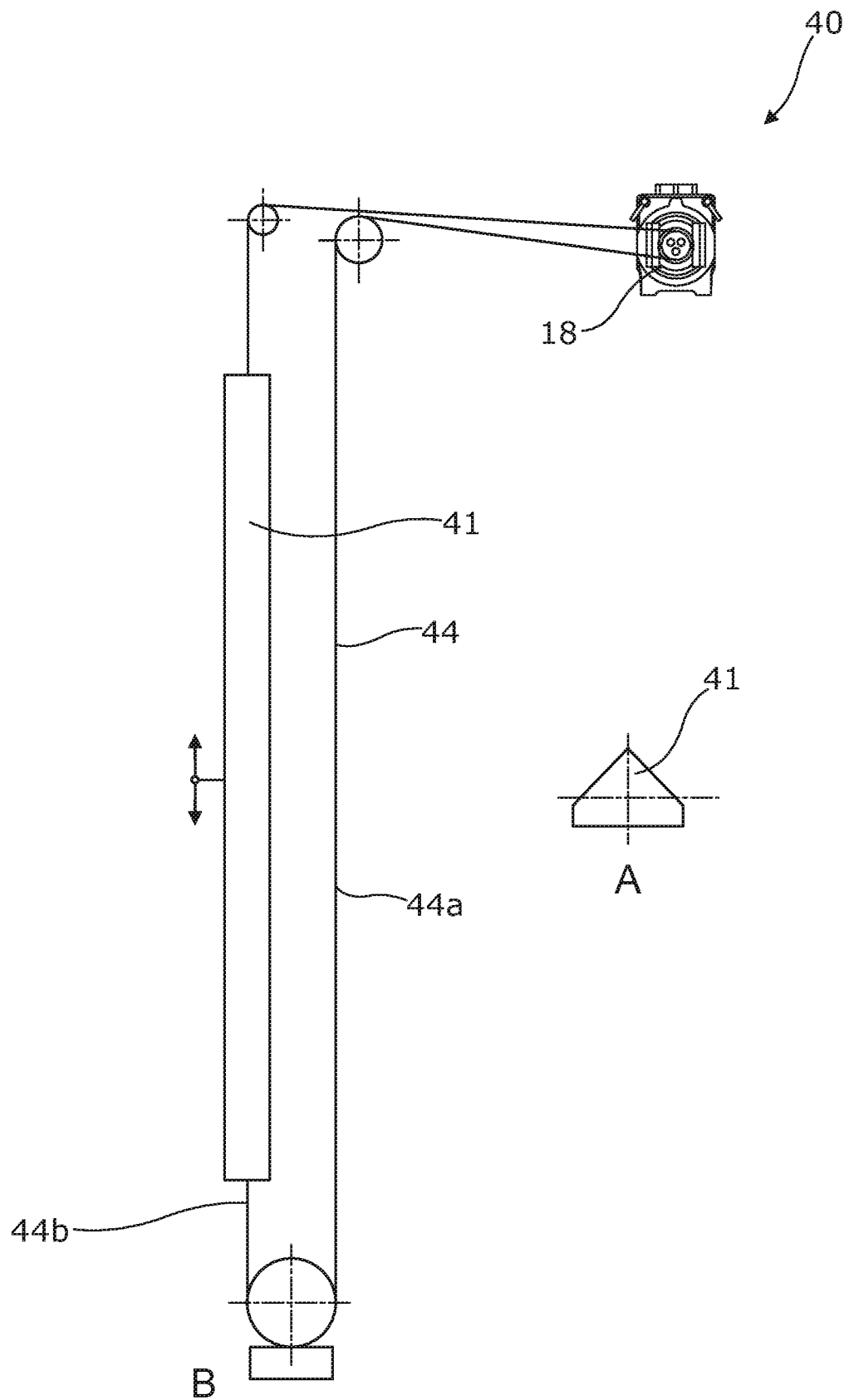
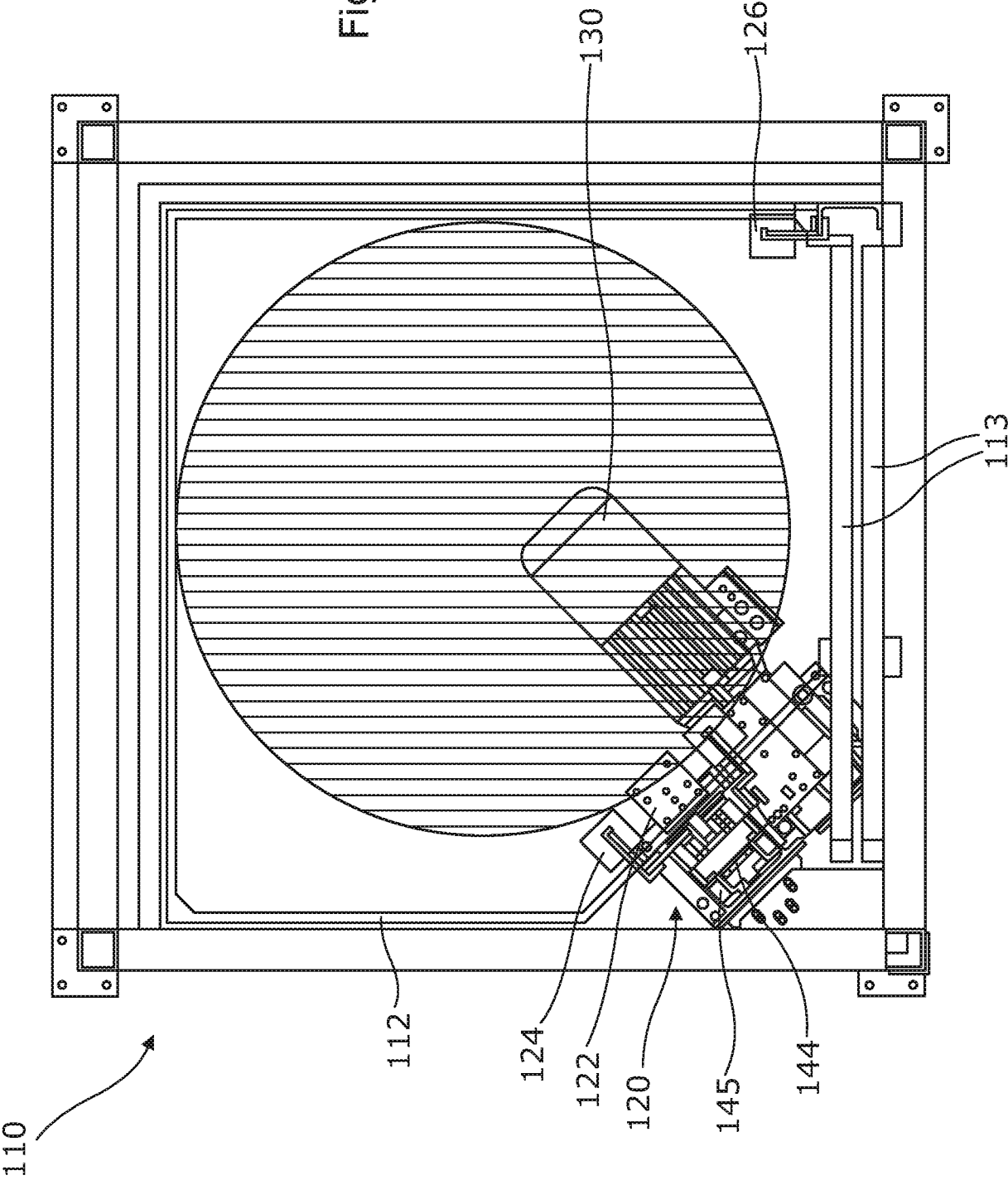


Fig. 4

Fig. 5



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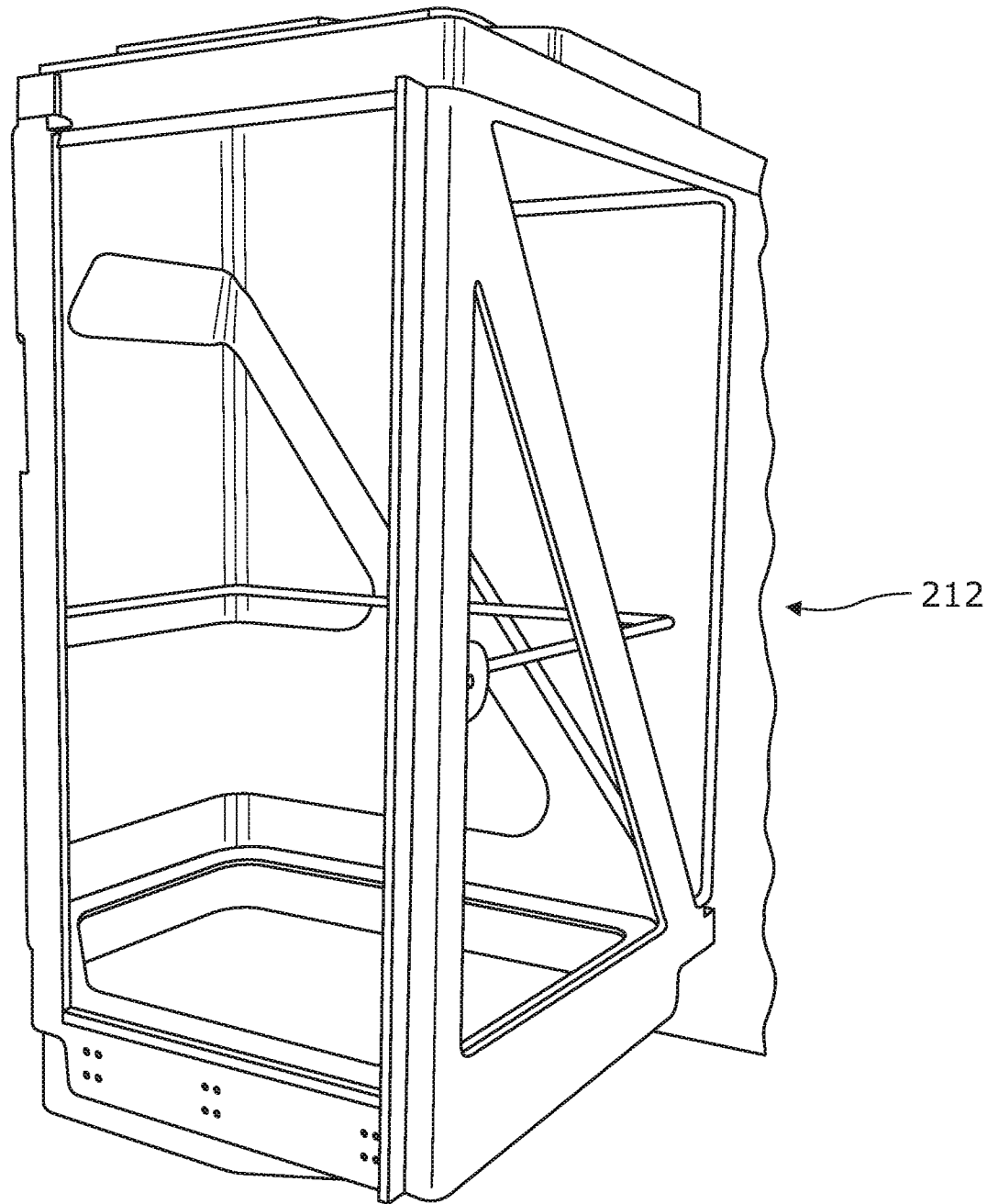


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2019/051659

A. CLASSIFICATION OF SUBJECT MATTER
INV. B66B17/12
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	EP 1 741 660 A1 (MITSUBISHI ELECTRIC CORP [JP]) 10 January 2007 (2007-01-10)	1-3,6, 8-10, 17-24
Y	paragraphs [0033], [0077] - [0085]	7,11-16
A	figures 14-16	4,5

X	JP H04 89787 A (MITSUBISHI ELECTRIC CORP) 23 March 1992 (1992-03-23)	1-6, 8-10, 17-24
A	figures 1-3 & DATABASE WPI Week 199218 Thomson Scientific, London, GB; AN 1992-147663 & JP H04 89787 A (MITSUBISHI DENKI KK) 23 March 1992 (1992-03-23) abstract	7,11-16
	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

26 August 2019

Date of mailing of the international search report

02/09/2019

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2019/051659

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2018/073612 A1 (SINGAPORE LIFT COMPANY PTE LTD [SG]) 26 April 2018 (2018-04-26) cited in the application abstract page 7, line 9 - page 15, line 6 figures 1-6 -----	7
Y	WO 2006/136643 A1 (KONE CORP [FI]; CALVARESI GIANLUCA [IT] ET AL.) 28 December 2006 (2006-12-28) abstract page 11, line 13 - page 17, line 29 figures 1-13 -----	11-16
A	WO 2009/034068 A1 (INVENTIO AG [CH]; LINDBERG BJARNE [CH]; SILBERHORN GERT [CH]) 19 March 2009 (2009-03-19) abstract page 10, line 24 - page 16, line 6 figures 1-6 -----	1-10, 17-24
A	EP 1 333 000 A1 (MONITOR S P A [IT]) 6 August 2003 (2003-08-06) paragraph [0025] - paragraph [0032] figures 9A-10B -----	1-24

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2019/051659

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1741660	A1	10-01-2007	CN 1812926 A 02-08-2006
			EP 1741660 A1 10-01-2007
			JP W02005105652 A1 13-12-2007
			US 2007045053 A1 01-03-2007
			WO 2005105652 A1 10-11-2005

JP H0489787	A	23-03-1992	NONE

WO 2018073612	A1	26-04-2018	NONE

WO 2006136643	A1	28-12-2006	EP 1901987 A1 26-03-2008
			WO 2006136643 A1 28-12-2006

WO 2009034068	A1	19-03-2009	NONE

EP 1333000	A1	06-08-2003	CN 1436714 A 20-08-2003
			EP 1333000 A1 06-08-2003
			IT MI20020511 A1 12-09-2003
