

Lift installation with a linear drive system and linear drive system for such a lift installation

The subject of the invention relates to a lift installation with a linear drive system according to the introductory part of claim 1 and a linear drive system for a lift installation according to the introductory part of claim 14.

Different lift configurations with linear motor drive systems are known. However, in lift configurations of that kind the most diverse problems arise, which previously could be solved only in part. This is due to the fact, inter alia, that the problems are in part diametrically opposed and the isolated solution of one of the problems is frequently accompanied by problems in other areas.

This conflict is explained in the following by way of an example. Linear motor drive systems, particularly those operating with permanent magnets, have very high attraction forces between a primary - or stationary - part and a secondary - or movable - part. If use is now made of such a permanent magnet linear motor not only as a direct drive system, but also as support means of the lift cage then a precise and secure guidance of the lift cage has to be guaranteed. With respect thereto Figures 1A, 1B and 2A, 2B show different basic configurations of lift installations with permanent magnet linear drive systems.

A configuration is shown in Figures 1A and 1B in which a lift cage 13 is moved by means of a permanent magnet linear drive system 10, 11 along a lift shaft in y direction. Such a permanent magnet linear drive system typically comprises a stationary part 10, which is fastened in the shaft, and a movable part 11, which is fastened to the lift cage 13. It can be seen from the plan view in Fig. 1B that no guidance in the y-z plane is effected in such a configuration, so that additional guide shoes have to be provided at the lift cage 13 to guide the lift cage 13 along guide rails 12 arranged on the right and the left near the lift cage 13. A comparable lift installation can be inferred from the patent application EP 0 785 162 A1.

Another basic configuration is shown in Figures 2A and 2B. As can be seen in the plan view in Fig. 2B, the permanent magnet linear drive system comprises a stationary part 10 and two movable parts 12. Guidance in the y-z plane is thereby achieved. However, in order to avoid tipping in the x-y plane guide rails are similarly necessary or the lift cage 13

was carried by further support means such as a cable 12' mounted centrally at the lift cage.

The previously known approaches are therefore technically complicated, require much material and space in the lift shaft and are thus cost-intensive.

In addition, the known solutions are not suitable or are only conditionally suitable for lift installations in rucksack configuration, which for constructional or aesthetic reasons require only one wall of the lift shaft for drive, support means and guidance.

The object is therefore set of proposing a lift installation which, with use of a linear motor drive system, demands little space in the lift shaft.

It is to be regarded as a further object to provide a linear motor drive system for a lift installation in rucksack configuration.

These objects are fulfilled, for the lift installation, by the characterising features of claim 1 and, for a linear drive system, by the characterising features of claim 14.

Particularly advantageous features can be inferred from the dependent claims.

The invention is described in more detail in the following by way of examples of embodiment and with reference to the drawings, in which:

- Fig. 1A shows a schematic side view of a part of a first lift installation with a linear drive system;
- Fig. 1B shows a schematic plan view of the first lift installation according to Fig. 1A;
- Fig. 2A shows a schematic side view of a part of a second lift installation with a linear drive system;
- Fig. 2B shows a schematic plan view of the second lift installation according to Fig. 2A;

- Fig. 3 shows a schematic side view of a part of a third lift installation with a linear drive system, wherein a lift installation in rucksack configuration is concerned;
- Fig. 4A shows a schematic perspective view of a part of a first lift installation according to the invention with two movable parts;
- Fig. 4B shows a schematic plan view of the first lift installation according to the invention, in accordance with Fig. 4A;
- Fig. 5A shows a schematic plan view of a part of a second lift installation according to the invention;
- Fig. 5B shows a schematic plan view of a part of a third lift installation according to the invention;
- Fig. 6A shows a further example of a stationary part of a linear drive system according to the invention in schematic sectional illustration;
- Fig. 6B shows a further example of a stationary part of a linear drive system according to the invention in schematic sectional illustration;
- Fig. 7A shows a schematic plan view of a part of a fourth lift installation according to the invention with four movable parts;
- Fig. 7B shows a schematic plan view of a part of a fifth lift installation according to the invention with auxiliary guide; and
- Fig. 8 shows a part view of a sixth lift installation according to the invention with emergency guide.

A configuration of a lift installation is known in which the technical/mechanical components are typically mounted only at one shaft wall. Such a configuration is also termed rucksack configuration, since the lift cage sits, like a rucksack, symmetrically on a cage frame which, provided with support means, is suspended and guided in the lift shaft at one side.

Due to the fact that only one shaft wall is occupied, the three further walls of the lift cage are freely selectable as accesses and accordingly can have up to three cage doors. The at least one cage door can adjoin the rear wall provided for the technical/mechanical components, in which case one speaks of a side rucksack configuration, or it can be mounted at the front wall of the lift cage disposed opposite this rear wall, which is termed normal rucksack configuration. The expert has with respect thereto numerous possibilities of realisation.

The rucksack principle is now transferred to a lift installation with permanent magnet linear drive system in Fig. 3, this being a strongly schematic illustration. As indicated in Fig. 3, the lift cage 14 is seated on an L-shaped cage frame, to the upright limb of which the movable part 11 of the permanent magnet linear drive system is fastened. The stationary part 10 of the drive is fastened perpendicularly in the lift shaft (analogously to the arrangement shown in Fig. 1A). Between the movable part 11 and the stationary part 10 there are strong attraction forces which are oriented in the normal direction and denoted by F_N . If the drive system is controlled in drive in suitable mode and manner the lift cage 14 can be moved upwardly or downwardly as illustrated by the force vectors F_{auf} and F_{ab} . In the case of a rucksack configuration of the illustrated format there is now added a torque D which is caused by the weight F_K of the laden or unladen lift cage 14 and which acts on the permanent magnet linear drive system, as indicated by a double arrow.

Special measures are obviously necessary in order to ensure for this rucksack configuration a precise and secure guidance of the lift cage 14. However, such guides would oblige, if the known approaches are followed, further mechanical guide elements near the lift cage 14 (for example, the lateral guide rails 12 such as in Fig. 1B) and/or above the lift cage 14 (for example, a guide cable 12' as in Fig. 2A).

According to the invention a completely different route is followed as is described in the following with reference to the schematic Figures 4A and 4B.

In Fig. 4A a schematic perspective view of a part of a shaft rear wall 26 with the parts 20, 21 of the permanent magnet linear drive system serving as a direct drive is shown. The stationary part 20 (also termed support column) of the drive system is fastened to the shaft rear wall 26 and has a longitudinal axis L_y extending parallel to the y direction. In departure from the previously known stationary parts, at least two interaction surfaces a_1 ,

a2 arranged at an inclination relative to one another are provided at the stationary part 20. Moreover, the drive system comprises at least two movable parts 21 (also termed units), wherein each of the movable parts 21 is associated with a respective one of the interaction surfaces a1 and a2. An interaction length b oriented in y direction is associated with each interaction surface a1, a2. The interaction length b is the length between a guide point at the end and the centre of a movable part 21. Whereas repelling forces arise at the end guide point, attractive forces are effected in the centre point of the movable part 21. The interaction length b is thus the effective length preventing tipping movement of the lift cage 24 in the x-y plane. The interaction length b extends over a part region of the lift cage 24, it being smaller than the height of the lift cage 24. If the drive system is controlled in drive in suitable mode and manner then the lift 24 can be moved upwardly or downwardly as illustrated by the force vectors F_{auf} and F_{ab} . The ratio of attraction force F_N divided by force vectors F_{auf} and F_{ab} is termed force ratio K. A force ratio K typically lies in the range of 2 to 20, preferably in the range of 3 to 10.

In Fig. 4B it can be seen by way of suggestion that the lift cage 24 is arranged in a rucksack configuration. In order to be able to characterise the lift cage 24, the rotational axes D_x , D_y and D_z acting at the cage centre of gravity are illustrated in Fig. 4B. Between the movable parts 21 and the interaction surfaces a1, a2 of the stationary part 20 there are strong attraction forces which are oriented in normal direction and again denoted by F_N . The spacing between the cage centre of gravity of the interaction surfaces a1, a2 is denoted as line of action L_x . According to Fig. 4B the centre connecting line, which extends in z direction, of the interaction surfaces a1, a2 is used as reference for determination of spacing. The line of action L_x is accordingly the shortest distance between the cage centre of gravity and this centre connecting line. For optimisation of the efficiency of the permanent magnet linear drive system the parts 20, 21 are spaced apart by a smallest possible air gap. The air gap is, for example, 1 millimetre wide. In constructional terms the air gap has the advantage that it enables a contactless guidance of each of the movable parts 21 on the corresponding stationary part 20. The vertical movement of the lift cage 24 is thus contactlessly guided on the stationary part by way of the permanent magnet linear drive system via the movable parts 21.

By virtue of the inclined orientation of the interaction surfaces a1, a2 relative to one another there results, according to the invention, a spatial, i.e. 3-dimensionally acting, guidance. Thus, rotation or tipping of the lift cage 24 about the axes D_x , D_y and D_z of

rotation is prevented. Through this novel combination, in particular, the torques (torque D in Fig. 3) caused by the rucksack combination are absorbed. Stated in other words, compensation for the disadvantage of eccentric suspension of the lift cages 24 is provided by the special design of the permanent magnet linear drive system. The ratio of line of action L_x divided by the interaction length b is termed eccentricity L_x/b . The eccentricity is typically 0.1 to 1.6, preferably 0.2 to 0.8.

The expression permanent magnet linear drive system is used in the present context in order to denote a direct drive system comprising a synchronous linear motor excited by permanent magnets. The corresponding surfaces of the stationary part of the permanent magnet linear drive system are termed interaction surfaces, since an interaction takes place between the surfaces and the movable units of the drive system.

Instead of a linear drive system which comprises at least one permanent magnet it is also possible to use a linear drive system which comprises at least one layer structure with at least one coil. The movable part can be conceived as a layered structure produced by application of different layers on the substrate.

The layers can be applied in succession and optionally suitably structured. In this manner three-dimensional structures of materials with different characteristics can be applied to the substrate. Individual layers can consist of an electrically insulating material or comprise regions of an electrically insulating material. The conductor track can be composed of conductor track sections respectively formed in different layers of the layer structure. Individual sections of the conductor track can cross over, for example, in different planes and be separated in the crossover region by an electrically insulating layer. Moreover, the possibility exists of arranging individual sections of the conductor track in different layers separated by an intermediate layer and providing in the intermediate layer an electrically conductive region which produces an electrical connection between these sections of the conductor track.

Layers of the stated kind can also be applied on both sides of the substrate and optionally structured. It is provided, for example, that a first part of the conductor track is formed at a first surface of the substrate and a second part of the conductor track at a second surface of the substrate, wherein an electrical connection is produced between the first and the

second part. This makes it possible to impart a particularly complex geometric structure to the conductor track.

In a variant of the movable part at least one section of the conductor track can have, for example, the form of a coil, wherein each coil comprises one or more windings. The coil can be arranged on one side of a substrate, but it can also be composed of different sections of the conductor track which are arranged on different sides of the substrate and electrically connected together.

In a further variant of the movable part several serially arranged sections of the conductor track can each have the form of a coil, wherein the coils are constructed in such a manner that, in the case of a current flow through the conductor track, adjacent coils produce respective magnetic fields with different polarity. The conductor track can be arranged in such a manner that, for example, in the case of supply of the conductor track with a direct current there is produced at a surface of the movable part a static magnetic field, the polarity of which has a periodic polarity reversal along the direction in which the movable part is movable relative to the stationary part. In this manner a movable part for provision of a large number of magnetic poles can be constructed. With a suitable arrangement of the conductor track the area available on the substrate can be efficiently utilised. This is relevant for optimisation of the efficiency of the linear drive system and the accuracy with which the movement of the movable part relative to the stationary part can be controlled during operation of the linear drive system.

Further details of the invention are explained in the following.

The two inclined interaction surfaces a_1 , a_2 extend parallel to the longitudinal axis L_y and lie in planes including an angle W greater than 0° and smaller than 180° (i.e., $0^\circ < W < 180^\circ$). The surface normals of the interaction surfaces a_1 , a_2 are inclined towards the lift cage 24.

The size of the angle W is a function of the force ratio K and the eccentricity L_x/b . With consideration of the arbitrarily selected safety condition that only 20% of the attraction force shall suffice to stabilise the eccentrically loaded rucksack lift the following dependence results: $\sin W/2 = 5 \cdot (L_x/b)/K$. The angle W preferably lies between 20% and

160°. For example, the angle W is around 120° for an eccentricity of 0.7 and a force ratio K of 4.

The movable part comprises at least two units 21, which are so arranged in common on a rear side 27 of the lift cage 24 and mechanically positively connected with the lift cage 24 that in the case of drive control each of the two units 21 produces an upward or downward movement along one of the interaction surfaces a_1 , a_2 . The lift cage 24 can thereby be moved upwardly or downwardly.

Due to the inclined arrangement of the two interaction surfaces a_1 and a_2 the attraction forces F_N of the drive system at least partly provide mutual compensation. This assists with avoidance of the disadvantage of the very high attraction forces and friction losses, which are connected with therewith, of previous drive systems with permanent magnet linear drive.

Moreover, it can be recognised in Fig. 4B that the lift cage 24 has at the rear side 27 a cage frame 25 or equivalent means at which on the one hand the two units 21 are mechanically positively mounted and which on the other hand is designed for eccentric support of the lift cage 24.

In the illustrated example of embodiment the lift installation is disposed in a lift shaft, wherein according to the invention only a form of shaft rear wall 26 is required in order to accept the mechanical/technical elements of the lift installation.

Two plan views of parts of two further examples of embodiment of lift installations 1 according to the invention are shown in Figs. 5A and 5B. A rearward shaft wall 26 is shown. The stationary part 20 of the drive system is arranged at or in front of this shaft wall 26. The stationary part 20 has at least two inclined interaction surfaces a_1 and a_2 . Whereas the interaction surfaces a_1 and a_2 in the example of embodiment according to Fig. 5A are inclined away from one another, in the example of embodiment according to Fig. 5B they are inclined towards one another. The angle W is approximately 120°.

The attraction forces F_N of the drive system can be resolved into the force components F_Q (transverse forces) and F_H (holding forces). The two transverse forces of the two units 21 provide mutual compensation, since they are both oriented parallel to the z direction, but

have mutually opposite directions. In effect, the lift cage 25 is supported by the holding forces F_H . Due to this partial compensation of the forces the otherwise existing friction between the stationary part 20 and the movable parts 21 is significantly reduced.

According to the invention the stationary part 20 is preferably polygonal in cross-section perpendicular to the longitudinal axis L_y and the surface normals of the two interaction surfaces a_1 , a_2 are inclined towards or away from one another. In both instances they face towards the lift cage 24.

By virtue of the inclined arrangement of the interaction surfaces a_1 , a_2 compensation is provided, in particular, for torques D_z which result from the eccentric suspension, caused by the rucksack configuration, of the lift cage 24.

Through the corresponding attraction forces F_N of the unit 21 opposite the respective interaction surface a_1 , a_2 there are produced not only a rotational stabilisation of the lift cage 24 about the rotational axis D_x extending perpendicularly to the longitudinal axis L_y and perpendicularly to the rear side of the lift cage 24, but also a rotational stabilisation of the lift cage 24 about a rotational axis D_z extending perpendicularly to the longitudinal axis L_y and parallel to the rear side of the lift cage 24. A rotation about the y rotational axis D_y is also prevented by the lateral spacing of the units 21.

According to the invention the attraction forces of the permanent magnets of the permanent magnet linear drive system thus serve for stabilisation of the eccentrically arranged lift cage 24 and for three-dimensional stabilisation as well as guidance. Due to the eccentrically acting weight force F_K the reaction forces for support of the guide of the drive system are reduced and thereby the friction forces diminished.

Compensation for the transverse forces F_Q and stabilisation in the rotational axis D_z can be fixed by a variation of the angle W in the design of a lift installation or a corresponding permanent magnet linear drive system. The stationary part 20 of the permanent magnet linear drive system is thus used for three-dimensional guidance of the rucksack lift cage 24.

The stationary part 20 has a niche or rest a_3 in an upper region. As shown in Figs. 4A as well as 7A and 7B, the rest a_3 is located on the upper end of the stationary part 20. It is at

least partly enclosed by the interaction surfaces a1, a2 and can be used for the mounting of shaft components. Thus, shaft components such as a position transmitter, a brake partner of a holding brake or also a mechanically positive holding lock can be mounted here.

Forms of embodiment in which the movable parts 21 of the drive system are fastened in the upper region of the cage rear side 27 are particularly advantageous.

The forms of embodiment can be realised with or without further support means for supporting the lift cage 24. Such support means are, for example, steel or aramide cables or belts which connect the lift cage 24 with a counterweight.

Further advantageous forms of embodiment are shown in Figs. 7A and 7B. Fig. 7A shows a lift installation 1 with in each instance two movable parts 21, which are arranged one above the other in y direction, per interaction surface a, b. Accordingly, the interaction length b extends from the end guidance point of a first movable part 21 to the centre of the second movable part 21 of the same interaction surface a1, a2. Fig. 7B shows a lift installation 1 with a main guidance in movable parts 21 and an auxiliary guidance in at least one guide shoe 22. Whereas each of the movable parts 21 is guided on one of the two interaction surfaces a, b obliquely inclined relative to one another, the guide shoe 22 is guided laterally adjacent to the stationary part 20 on a guide rail. According to Fig. 7B a respective guide shoe 22 is illustrated on the left and the right of the stationary part 20 per interaction surface a, b. Accordingly, the interaction length b extends from the end guidance point in the guide shoe 22 up to the centre of the movable part 21 of an interaction surface a1, a2.

According to the invention the primary part of the drive system can be integrated either in the stationary part 20 or in the movable part 21. The secondary part of the drive system is then disposed in the respective other part.

Preferably, the coils S of the electromagnets (such as can be seen in, for example, Fig. 8) of the primary part of the drive system are seated in the stationary part 20, whilst the permanent magnets of the secondary parts 21 are in the movable part of the drive system. However, the converse arrangement can also be selected.

However, drive systems can also be used in which the primary part comprises not only coils, but also permanent magnets.

Further examples of stationary parts 20 of a permanent magnet linear drive system according to the invention are shown in sectional illustration in Figures 6A and 6B.

An emergency guide 29 according to the invention, which in the illustrated example is seated at the top at the cage frame 25, is shown in Fig. 8.

The emergency guide 29 engages at least partly around or behind the stationary part 20 in order to prevent tipping away (about the D_z rotational axis) of the lift system 24 if the permanent magnet linear drive system should fail (for example in the case of a current failure) or if the attraction forces produced by the permanent magnet linear drive system should drop away. The emergency guide 29 is so constructed that in normal operation it runs in contact-free manner along the stationary part 20. It comes into mechanical engagement only in the case of emergency. Preferably, emergency guides 29 are provided at the two upper corners of the lift cages 24.

It is regarded as an advantage of the illustrated rucksack arrangement with drive system at the cage frame 25 that the actual lift cage 24 can be (sound) insulated relative to the frame 25.

The permanent linear drive system according to the invention and the corresponding lift installations are space-saving in projection of the shaft.

It is of further advantage that compensation for the motor attraction forces is in part provided by the torque produced by the cage weight F_K and that due to the contact-free guidance via the air gap no friction losses arise as in the case of conventional arrangements.

It is also advantageous that through the use of at least two movable parts 21 a redundancy is given in the drive.

The individual elements and aspects of the different forms of embodiment can be combined with one another as desired.

Patent Claims

1. Lift installation (1) with a lift cage (24) and a linear drive system with a stationary part (20), the longitudinal axis (L_y) of which is arranged in vertically along a shaft wall (26) of the lift installation (1), and with a movable part which moves along the stationary part (20) when the linear drive system is controlled in drive, characterised in that
 - the lift cage (24) is arranged in a rucksack configuration and is movable by the linear drive system along the stationary part (20),
 - the stationary part (20) has at least two inclined interaction surfaces (a1, a2) which extend parallel to the longitudinal axis (L_y) and which lie in a plane, which includes an angle (W) between 0° and 180° and the surface normals of which are oriented towards the lift cage (24), and
 - the movable part comprises at least two units (21) which are so arranged in common on a rear side (27) of the lift cage (24) and mechanically positively connected with the lift cage (24) that when drive control is carried out each of the two units (21) produces a movement along one of the interaction surfaces (a1, a2) in order to thereby move the lift cage (24).
2. Lift installation (1) according to claim 1, characterised in that the stationary part (20) is polygonal in cross-section perpendicular to the longitudinal axis (L_y) and the surface normals of the two interaction surfaces (a1, a2) are inclined away from or towards one another.
3. Lift installation (1) according to claim 1 or 2, characterised in that between a first one (a1) of the two interaction surfaces and a first one of the two units (21) there is a first traction force (F_N) substantially parallel to the surface normal of this interaction surface (a1) and that between the second one (a2) of the two interaction surfaces and the second one of the two units (21) there is a second attraction force (F_N) substantially parallel to the surface normal of this interaction surface (a2).
4. Lift installation (1) according to claim 3, characterised in that the first and the second attraction force (F_N) act at least partly opposite one another and the effective

holding forces (F_H) acting between each of the units (21) and the associated interaction surface (a1, a2) therefore reduce.

5. Lift installation (1) according to claim 1 or 2, characterised in that the inclined arrangement of the interaction surfaces (a1, a2) compensate for torques (D_x , D_y , D_z) resulting from the eccentric suspension of the lift cage (24) due to the rucksack configuration.

6. Lift installation (1) according to claim 1 or 2, characterised in that the two units (21) are arranged at the same height, but at a spacing from one another, on the rear side (27) of the lift cage (24) so as to produce a rotational stabilisation of the lift cage (24) about an axis (D_y) extending parallel to the longitudinal axis (L_y).

7. Lift installation (1) according to claim 1 or 2, characterised in that due to the inclined arrangement of the interaction surfaces (a1, a2) and the corresponding attraction forces of the unit (21) opposite the respective interaction surface (a1, a2) there is produced not only a rotational stabilisation of the lift cage (24) about an axis (D_x) extending perpendicularly to the longitudinal axis (L_y) and perpendicularly to the rear side of the lift cage (24), but also a rotational stabilisation of the lift cage (24) about an axis (D_z) extending perpendicularly to the longitudinal axis (L_y) and parallel to the rear side of the lift cage (24).

8. Lift installation (1) according to one of the preceding claims, characterised in that due to the inclined arrangement of the interaction surfaces (a1, a2) the stationary part (20) serves as a three-dimensional guide element for a vertical movement of the lift cage (24) along the shaft wall (26).

9. Lift installation (1) according to one of the preceding claims, characterised in that the units (21) are separated from the stationary part (20) by way of an air gap and contactlessly guide the vertical movement of the lift cage (24) along the shaft wall (26).

10. Lift installation (1) according to one of the preceding claims, characterised in that a guide shoe (22) guides the vertical movement of the lift cage (24) on a guide rail.

11. Lift installation (1) according to one of the preceding claims, characterised in that provided in an upper region of the lift cage (24) is an emergency guide (29) which engages at least partly around or behind the stationary part (20) in order to prevent tipping away of the lift cage (24) in case the linear drive system should fail or the attraction forces produced by the linear drive system should drop away.

12. Lift installation (1) according to one of the preceding claims, characterised in that an upper region of the stationary part (20) has a rest (a3) which can be used for mounting shaft components such as a position transmitter and/or a brake partner of a holding brake and/or a mechanically positively acting holding lock.

13. Lift installation (1) according to one of the preceding claims, characterised in that the linear drive system comprises at least one permanent magnet or at least one layer structure with at least one coil.

14. Linear drive system for use in a lift installation (1) with a stationary part (20), the longitudinal axis (L_y) of which is arranged vertically along a shaft wall (26) of the lift installation (1), and with a movable part (21), which moves along the stationary part (20) when the linear drive system is controlled in drive, characterised in that

- the stationary part (20) has at least two inclined interaction surfaces (a1, a2), which extend parallel to the longitudinal axis (L_y) and lie in a plane including an angle (α) between 0° and 180° ,
- the stationary part (20) is designed for mounting in front of or at a rear wall (26) of a lift shaft or a building wall and
- the movable part comprises at least two units (21) able to be mechanically positively mounted in common on a rear side of the lift cage (24) at a cage frame (25),

wherein the linear drive system is designed for the purpose of moving the lift cage (24) by the units (21), which are movable along the stationary part (20), when the linear drive system is controlled in drive.

15. Linear drive system according to claim 14, characterised in that the linear drive system comprises at least one permanent magnet or at least one layer structure with at least one coil.