

Lift installation and use of such a lift installation for high-speed lifts

The invention relates to a lift installation according to the introductory part of independent patent claim 1 and to use of the same.

In lift installations having a lift cage connected with a counterweight by way of support means the counterweight moves in opposite direction to the lift cage. The lift cage and the counterweight are in that case respectively guided in own substantially rectilinear guide tracks. A pressure shock in the lift shaft, which can cause vibrations and noise, can occur when the counterweight passes the lift cage particularly in single lift shafts and with fast-moving lift cages. Moreover, the sudden pressure change, which is connected therewith, in the lift cage can be unpleasant for the passengers or the vibrations can be sensed as disturbing. The lift installation then has deficient travel comfort. Disruptive noises can also arise in buildings in which the lift installation is located.

These problems occur particularly with present-day lift installations, since there is increasing effort to reduce the enclosed space as much as possible and to accommodate components of the lift installation in the smallest possible space.

This problem of crossing of the counterweight and the lift cage in the lift shaft has been known for a long time. However, previously only one solution of interest to deal with disadvantages arising during crossing of two lift cages was offered. This solution is of recent date and is evident from the Japanese patent application of the company Toshiba Corp., with the publication number 2002003090 A. This patent application is concerned with lift installations in multiple lift shafts with several lift cages which move past one another. It is proposed to reduce the speed of the cages, before meeting in the lift shaft, by means of a control so as to prevent creation of noises and vibrations. Passengers can, however, perceive this reduction in speed as unpleasant. In addition, the conveying capacity of the overall installation is reduced, because a longer travel time results due to the reduction in speed.

In addition, there are numerous solutions concerned with improvement of aerodynamics, i.e. the air resistance, of lift cages, but intrinsically say nothing about the problem of pressure shock and possible solutions.

The object therefore arises of providing a lift installation which on the one hand reduces the problems arising due to the pressure shock when the counterweight and the lift cage pass and correspondingly improves travel comfort and on the other hand does not create excessive mechanical or control complication.

Moreover, solutions are to be offered which enable good space utilisation of the building and are particularly suitable for use in high-speed lifts.

According to the invention these objects are fulfilled by provision of a specially designed lift shaft having a local cross-sectional enlargement in the region where the lift cage and the oppositely running counterweight meet in the lift shaft. Due to such a local cross-sectional enlargement the pressure shock, which appears to be the principal cause for vibrations and noises, can be significantly reduced without the space enclosed by the lift shaft having to be significantly increased.

Movement of the counterweight past the lift cage can take place almost free of vibration and noise through a corresponding constructional measure in creation of the lift shaft.

Further advantageous forms of embodiment can be inferred from the dependent claims.

Further details of the invention and the various advantages thereof are explained in more detail in the following part of the description.

The invention is described in detail in the following by way of examples and with reference to the schematic drawings, which are not true to scale and in which:

- Fig. 1 shows a first lift installation according to the invention in strongly simplified illustration, from the side;
- Fig. 2 shows a strongly simplified section through a conventional lift shaft with lift cage and counterweight;
- Fig. 3A shows a strongly simplified section through the lift shaft of a first lift installation according to the invention in accordance with Fig. 1;

- Fig. 3B shows a strongly simplified section through the lift shaft of a second lift installation according to the invention;
- Fig. 3C shows a strongly simplified section through the lift shaft of a third lift installation according to the invention; and
- Fig. 4 shows a schematic detail of a fourth lift installation according to the invention in strongly simplified illustration, from the side.

Components which are the same and function similarly or identically are provided in all figures with the same reference numerals.

Fig. 1 shows a lift installation 1. The lift installation 1 comprises a lift shaft 10 which in the illustrated example is bounded by a floor 10.1, side walls 10.2, 10.3 and a (intermediate) roof 10.4. Disposed in the lift shaft 10 is at least one lift cage 11 and counterweight 12, which are arranged to be movable along vertical rectilinear guide tracks 14, 15. The lift cage 11 is connected by way of support means (not illustrated) with the counterweight 12 so that during movement of the lift cage 11 the counterweight 12 executes an opposite movement, as indicated by the arrows above the lift cage 11 and below the counterweight 12. At the illustrated instant the lift cage 11 moves upwardly and the counterweight 12 downwardly. A single cage is shown in the example according to Fig. 1. A multi-deck cage, for example a double-deck cage, could obviously also be used. In the case of a multi-deck cage several cages are arranged one behind the other and move as a coherent cage transport unit in the lift shaft.

The lift cage 11 and the counterweight 12 move past one another in a proximity region A. The length LA of this proximity region A (schematically indicated in Fig. 1 by a brace) depends on the length of the lift cage LK and the length of the counterweight LG. The length LA of the proximity region A can be determined according to the following formula:

$$LA = LK + LG + \frac{|LK - LG|}{2}.$$

If the counterweight LG and the cage LK are of the same length, the length LA of the proximity region A is thus:

$$LA = 2 * LK \text{ or } 2 * LG.$$

The proximity region A is located at that place of the lift shaft 10 where lift cage 11 and counterweight 12 meet. In the case of a multi-deck cage the length LK contains the length of the entire cage transport unit.

According to the invention an enlargement E of the cross-section Q of the lift shaft 10 is provided in the proximity region A in order to reduce the pressure shock which builds up in the proximity region A when the lift cage 11 moves past the counterweight 12.

The mentioned pressure shock arises due to the fact that the movement of the counterweight past the lift cage produces a transient change in the flow resistance of the cage, since the air flow near the lift cage is influenced. The counterweight 12 already influences the air flow shortly prior to passing of the counterweight 12 and lift cage 11 and the air can hardly flow past the cage 11 in the remaining shaft cross-section $QV = Q - (QA + QG)$ of a conventional lift shaft. In the stated formula QA is the cross-section of the lift cage 11 and QG the cross-section of the counterweight 12. This situation is schematically illustrated in Fig. 2 in a section through a conventional lift shaft. The remaining shaft cross-section QV is hatched in this illustration.

Different forms of embodiment of the invention are now shown by way of Figures 3A, 3B and 3C. The local cross-sectional increase QE resulting due to the enlargement E provided at the lift shaft E is indicated in these figures by a hatching different from the rest of the shaft cross-section.

Fig. 3A now shows a section C-C in the region of the enlargement E through the lift shaft 10 shown in Fig. 1. The solution shown in Figures 1 and 3A is a first possible form of embodiment of the invention. In this first form of embodiment the enlargement E is seated at the rearward shaft wall 10.3.

A further form of embodiment, by way of example, of the invention is shown in Fig. 3B. In the form of embodiment shown in this figure the enlargement E is located at the rearward shaft wall 10.3 and extends over the entire width of this rearward shaft wall. This form of embodiment has the advantage that in constructional terms it can be realised more simply than the variant shown in Fig. 3A.

Yet a further form of embodiment, by way of example, of the invention is shown in Fig. 3C. In the form of embodiment shown in this figure the enlargement E extends not only along the rearward shaft wall 10.3, but also along at least a part of the side walls. It is obviously conceivable to extend this enlargement over the entire depth of the side walls.

The effective cross-sectional enlargement (termed QE) is of approximately the same size in all three examples shown in Figures 3A, 3B and 3C. However, this dimensioning was only selected so as to be able to make a better comparison of the forms of embodiment with one another. The example shown in Figs. 3A to 3C are obviously also usable on arrangements in which the counterweight is arranged laterally. In that case the arrangement of the cross-sectional enlargement QE is advantageously selected in correspondence with the arrangement of the counterweight.

Through this special form of construction of the lift shaft 10 with a local enlargement E the pressure build-up or pressure shock cannot even build up at the outset or it is at least reduced so substantially that disturbing vibrations or noises no longer arise. Thus, with relative consideration of the cage, a cross-section QV' remaining substantially constant over the entire travel path is present.

The enlargement E can be provided in the form of one or more local widenings of the lift shaft 10, wherein the effective cross-section QW of the lift shaft 10 is larger in the region of the enlargement E than in the remaining region of the lift shaft 10. In that case the enlargement E, which locally increases the effective cross-section QW of the lift shaft 10, can result from a widening within the lift shaft 10 in that, as shown in Figs. 1A and 3A, the wall thickness d of a wall of the lift shaft 10 (for example the rear wall 10.3) or several side walls (see, for example, Fig. 3C) of the lift shaft 10 is or are reduced in the proximity region A. In this case no additional space of the otherwise building utilisation is removed outside the lift shaft 10. The disadvantage of this variant is that due to the local reduction in the wall thickness d a possible weakening of the building statics arises in the proximity region A of the lift shaft 10. In addition, disadvantages with respect to acoustic, thermal or fire insulation of the lift shaft 10 by comparison with the remaining parts of the building can result from a reduced wall thickness of the side walls of the lift shaft 10.

However, a wall constructed with local thinning can be statically reinforced by

constructional measures and fire authority regulations can also be maintained by, for example, application of suitable insulating means.

Another variant for local enlargement of the effective cross-section QW of the lift shaft 10 is the attachment of a widening to the lift shaft 10 in the proximity region A. In this variant the wall thickness of the lift shaft 10 is not reduced in the proximity region A, but an enlargement E is provided in rucksack-manner at a side (or at several sides) of the lift shaft 10. A disadvantage of this variant is that, however, additional space of the otherwise building utilisation is removed.

Accordingly, a combination of the two above-described variants is also conceivable. In that case not only the wall thickness of the lift shaft 10 is reduced, but also attachment of a widening to the lift shaft 10 in the proximity region A is provided. The advantages and disadvantages of the two variants can thereby be optimised.

Investigations have shown that the enlargement E considered in terms of cross-section (i.e. QE) should preferably have an extent approximately corresponding with the cross-section QG of the counterweight 12 so as to offer, to the air compressed by the counterweight 12, an escape possibility when the lift cage 11 moves past the counterweight 12. It is thus sufficient to provide a cross-sectional enlargement which is significantly smaller than the cross-section QA of the lift cage 11. This result is of interest and was not previously taken into consideration. If the lift shaft 10 were to be locally enlarged by the cross-section QA of the lift cage 11, then this would be too large and lead to quite complicated constructional measures and the realisation would not be economically feasible.

Calculations and evaluations of experimental tests have given the result that the cross-section QE should preferably correspond with 0.5 to 3 times the cross-section QG of the counterweight 12.

$$0.5 * QG < QE < 3 * QG.$$

A cross-section QE in the boundary area of $0.5 * QG$ in this connection requires a very small amount of constructional space in the building and a cross-section QE in the boundary area of $3 * QG$ produces a substantial reduction in the pressure shock.

Forms of embodiment are particularly preferred in which:

$$1 \cdot QG < QE < 2 \cdot QG.$$

This design rule makes it possible to achieve good travel comfort with a small space requirement.

In addition, it was ascertained that the length LE of the enlargement E also plays a role. The enlargement E should have, considered in the vertical direction of the lift shaft 10, a length LE larger than the length LA of the proximity region A. Since the first contact of the built-up pressure in front of the counterweight 12 and the built-up pressure in front of the lift cage 11 occurs before passing of the cage 11 and counterweight 12 takes place the dimensioning of the length LE of the enlargement E should preferably proceed from the following formula:

$$1.2 \cdot LA \leq LE \leq 1.5 \cdot LA.$$

The same considerations as for the cross-sectional enlargement QE also apply here in analogous manner. A small length extent LE needs less constructional space and a large length extent LE promotes travel comfort. A length LE comprising a 25% addition to the length LA is particularly suitable, i.e.:

$$LE \approx 1.25 \cdot LA.$$

Advantageously, the length LE can be adapted to the arrangement of building intermediate ceilings so that the length LE extends over a number of floors, for example over two floors. This can be realised in simple manner in the building.

In the stated dimensional examples for the length LE it was also already taken into consideration that the support cables stretch in the course of time. Due to this stretching a slight displacement of the crossing point in the lift shaft can result. If the length LE were to be selected to be too short, it consequently could be possible after some time for the proximity region to displace, in correspondence with the cable stretching, to outside the enlargement E, whereby pressure shocks would arise again.

The cross-section Q of the lift shaft 10 should preferably slowly widen in the enlargement region E to the effective cross-section QW. An abrupt enlargement of the effective cross-section QW by an edge can lead to additional pressure shocks or disturbances. Attention should accordingly be given to the enlargement E, considered in cross-section, having a gentle cross-sectional enlargement from the normal shaft cross-section Q to the enlarged cross-section $Q + QE$ in the region of the enlargement E. This transition is readily apparent in Fig. 4. An angle W of the transition of less than 10 degrees is ideal, wherein an angle W of less than 7° has proved particularly advantageous (see Fig. 4).

It has proved that the enlargement of the cross-section QE should be located as close as possible to the point of the cross-section Q of the lift shaft 10 at which the ram pressure regions of the lift cage 11 and the counterweight 12 impinge on one another.

The escape behaviour of the air masses can additionally be favourably influenced by an aerodynamic cladding 13 of the lift cage 11 and/or the counterweight 12. Thus, for example, the aerodynamic cladding of the counterweight 12, as shown in Fig. 4 can be designed in the manner that the air masses are urged away from the lift cage 10 into the cross-sectional enlargement QE. An aerodynamic cladding of the counterweight 12 additionally has the advantage that the counterweight 12 produces less air resistance in its travel through the lift shaft 10. Due to the shape of the aerodynamic cladding 12, fewer disturbances arise. When the lift cage 11 and the counterweight 12 pass the air masses are selectively removed into the enlargement region E.

In a currently preferred form of embodiment of the lift installation of the invention the enlargement E is disposed, considered in the vertical direction of the lift shaft 10, approximately in the centre of the region of the lift shaft 10 travelled over by the lift cage 11. Meeting of the lift cage 10 and the counterweight 12 occurs in this region.

The invention has proved itself particularly in lift installations designed as high-speed lift installations for conveying at speeds of at least 4 m/sec, but use of this invention is also feasible in the case of lower speeds when for the purpose of reduction of the space surrounding the lift installation the remaining shaft cross-section QV is reduced.

Reference Numerals

1	lift installation
10	lift shaft
10.1	floor of 10
10.2, 10.3	side walls of 10
10.4	ceiling of 10
11	lift cage
12	counterweight
13	aerodynamic cladding of the counterweight 12
14	guide track, counterweight
15	guide track, lift cage
A	proximity region
E	enlargement
Q	cross-section
QW	effective cross-section
QV	remaining cross-section
QE	enlargement of the cross-section
QG	cross-section of the counterweight
QA	cross-section of the lift cage
LA	length of the proximity region
LB	length of the completely enlarged region
LE	length of the enlargement E
LG	length of the counterweight 12
LK	length of the lift cage 10
W	angle

Patent Claims

1. Lift installation (1) with a lift shaft (10), a counterweight (12) and a lift cage (11), the counterweight (12) and lift cage (11) being arranged to be movable along substantially rectilinear guide tracks (14, 15) and the lift cage (11) being connected by way of support means with the counterweight (12) so that on movement of the lift cage (11) the counterweight (12) executes an opposite movement and the lift cage (11) moves past the counterweight (12) in a proximity region (A) in the lift shaft (10), characterised in that in the proximity region (A) an enlargement (E) of the cross-section (Q) of the lift shaft (10) is provided in order to reduce a pressure shock which builds up in the proximity region (A) when the lift cage (11) moves past the counterweight (12).
2. Lift installation (1) according to claim 1, characterised in that the enlargement (E) is provided in a form of one or more local widenings at the lift shaft (10) and the cross-section (Q) of the lift shaft (10) is greater in the region of the enlargement (E) than in the remaining region of the lift shaft (10).
3. Lift installation (1) according to claim 2, characterised in that the enlargement (E) considered in cross-section (QE) has an extent which approximately corresponds with the cross-section (QG) of the counterweight (12) so as to offer a possibility of escape to the air, which is displaced by the counterweight (12), when the lift cage (11) moves past the counterweight (12), wherein the cross-section (QE) of the enlargement (E) preferably corresponds with between 0.5 to 3 times the cross-section (QG) of the counterweight (12).
4. Lift installation (1) according to claim 2 or 3, characterised in that the enlargement (E) considered in cross-section has a gentle cross-sectional enlargement from the normal shaft cross-section (Q) to the enlarged cross-section (Q + QE) in the region of the enlargement (E) and the corresponding angle (W) is preferably smaller than 10 degrees.
5. Lift installation (1) according to claim 2, 3 or 4, characterised in that the enlargement (E) considered in the vertical direction of the lift shaft (10) has a length (LE) which is oriented to the proximity region (A, LA) and is preferably determined according to the following formula:

$$1.2 \cdot LA \leq LE \leq 1.5 \cdot LA.$$

6. Lift installation (1) according to any one of the preceding claims, characterised in that the enlargement (E) is disposed at one of the side walls (10.2; 10.3) bounding the lift shaft (10) or at several of these side walls (10.2; 10.3).
7. Lift installation (1) according to any one of the preceding claims, characterised in that the enlargement (E) is disposed at one of the side walls (10.2; 10.3) which is at the same time the side wall (10.3) closest to the counterweight (12).
8. Lift installation (1) according to any one of the preceding claims, characterised in that the enlargement (E) considered in the vertical direction of the lift shaft (10), is disposed approximately in the middle of the region of the lift shaft (10) able to be travelled over by the lift cage (11).
9. Use of the lift installation (1) according to any one of the preceding claims as a high-speed lift installation for transporting at speeds of at least 4 m/sec.