

Lift system

The invention relates to a lift system according to the introductory part of claim 1.

Lift systems of this kind are known, for example from EP-1 329 412 A1. The lift system described there comprises two lift cages in a common lift shaft, each with a respective drive and with only a common counterweight.

It is disadvantageous with this known system, inter alia, that the drive or the traction for the two lift cages is not uniform. This can have the consequence that, for example, the support means are non-uniformly loaded, which is not desirable.

It is now the object of the invention to propose a lift system of the kind stated in the introduction by which the disadvantages of the state of the art are avoided.

According to the invention this object is fulfilled for the lift system of the kind stated in the introduction by the features of the independent claim 1.

Preferred developments and details of the lift system according to the invention are defined by the dependent claims.

Further details and advantages of the invention are described in the following by way of examples and with reference to the drawing, in which:

Fig. 1A shows a first example of embodiment of the invention, from the side;

Fig. 1B shows the example of embodiment of the invention illustrated in Fig. 1A, seen from A-A' in Fig. 1A;

Fig. 1C shows the example of embodiment of the invention illustrated in Fig. 1A, in a section along the line B-B' in Fig. 1A;

Fig. 1D shows the lower lift cage illustrated in Fig. 1A, but with fastening regions for the support means strands in the upper cage region;

Fig. 2 shows a second example of embodiment of the invention, with additional tensioning means, in the same illustration as Fig. 1A; and

Fig. 3 shows Fig. 1B with further details, in enlarged illustration.

The following generally applies to the drawing and the further description:

- The figures are not to be regarded as true to scale.
- The same or similar constructional elements, or constructional elements with the same or similar function, are provided in all figures with the same reference numerals.
- Statements such as right, left, above, below refer to the respective arrangement in the figures.
- Deflecting rollers and deflecting auxiliary rollers are illustrated in sections generally perpendicular to their axes of rotation as black circles.
- Drive pulleys are illustrated generally in sections perpendicular to their axes of rotation as circular lines.
- Those parts or runs of support means strands or tensioning means strands, which are disposed between one of the lift cages and an upper counterweight deflecting roller, are illustrated by lines different from those parts of the support means strands or tensioning means strands which are disposed between the other lift cage K2 and the upper counterweight deflecting roller.
- It is additionally indicated for each run by a usual diameter signature and with one of the numerals 1 and 2 whether there is concerned at the corresponding locations in each instance one or two support means strands or tensioning means strands; moreover, it is indicated which support means strands or tensioning means strands are concerned.

Figs. 1A, 1B and 1C show a first example of embodiment of a lift system 10 according to the invention. These are strongly schematic side views or sections, on the basis of which the basic elements of the invention are explained.

A lower lift cage K1 and an upper lift cage K2 of the new lift system 10 are disposed one above the other in a common lift shaft 11. A common counterweight 12 is also disposed in the lift shaft 11. The counterweight 12 is suspended at an upper counterweight deflecting

roller arrangement 12.1 in a so-termed 2:1 suspension. A roller arrangement with more than one roller is also to be understood by the term "counterweight deflecting roller". A speed of the lower lift cage K1 is indicated by v_1 , a speed of the upper lift cage K2 by v_2 and a speed of the counterweight 12 by v_3 .

Drive means for driving the two lift cages are disposed in the upper region or above the actual lift shaft 11. The drive means comprise a first arrangement for the lower lift cage K1 and a second drive arrangement for the upper lift cage K2.

The first drive arrangement, which is associated with the lower lift cage K1, comprises a first motor M.A1 and a second motor M.B1. The motors M.A1 and M.B1 are synchronised (for example electrically or electronically). The first motor M.A1 is coupled with a first drive pulley 13.A1. The second motor M.B1 is coupled with a second drive pulley 13.B1.

The second drive arrangement, which is associated with the upper lift cage K2, comprises a third drive motor M.AB2. The third motor M.AB2 is coupled by way of a common shaft with a third drive pulley 13.A2 and a fourth drive pulley 13.B2, i.e. in this preferred form of embodiment a common motor M.AB2 for driving two drive pulleys 13.A2 and 13.B2 is provided. However, two separate motors can also be used here.

The new lift system 10 further comprises a flexible support means TA, TB, which consists substantially of a first support means strand TA and a second support means strand TB. The support means strands TA and TB each have a first end and a second end. Advantageously, each of the support means strands TA and TB is formed by two or more parallel support means elements, such as, for example, by two belts or two cables. Each support means strand TA and TB can, however, also comprise only one belt or cable. The load-bearing structure of these support means strands TA and TB is advantageously made of steel, aramide or Vectran.

In the present example of embodiment the first drive pulley 13.A1 and the second drive pulley 13.A2 are associated with the first support means strand TA, whilst the third drive pulley 13.B1 and the fourth drive pulley 13.B2 are associated with the second support means strand TB.

The motor M.A1 and the drive pulley 13.A1 for the lower lift cage K1 are arranged at a first

height. The motor M.B1 and the drive pulley 13.B1, similarly for the lower lift cage K1, are arranged at a second height. The motor M.AB2 and the drive pulleys 13.A2 and 13.B2 for the upper lift cage K2 are similarly arranged at the second height. The second height lies below the first height. This arrangement is advantageous, but not essential.

The lift system 10 can also comprise four motors, wherein then an own motor is associated with each drive pulley or each end of the support means strands. However, it is essential for the desired uniform traction that an own drive pulley is associated with each end of the support means strands in order to thus be able to introduce the drive forces uniformly into the support means strands TA, TB.

Moreover, the new lift system 10 comprises several deflecting rollers, in the present example a first deflecting roller 14.A1, a second deflecting roller 14.A2 for the first support means strand TA, a third deflecting roller 14.B1 for the second support means strand TB and a fourth deflecting roller 14.A3, 14.B2 for the two support means strands TA and TB.

The lower lift cage K1 has in its lower cage region B1 a first fastening region 15.1 and a second fastening region 15.11, which are arranged laterally at mutually opposite sides of the lift cage K1.

The upper lift cage K2 has in its upper cage region a third fastening region 15.2 and a fourth fastening region 15.22, which are arranged at least approximately centrally and which in the present example of embodiment virtually coincide at 15.2/15.22. For reasons of clarity of the drawing they are shown in Fig. 1A without horizontal spacing.

The support means strands TA, TB are fixed at the lateral fastening regions 15.1, 15.11 of the lower lift cage K1 and at the central fastening point 15.2/15.22 of the upper lift cage K2 in such a manner that each of the lift cages K1 and K2 is suspended at both support means strands TA and TB. The lift cages K1 and K2 are suspended in a so-termed 1:1 suspension at the support means strands TA and TB, as is described in detail further below. The first support means strand TA runs from the first fastening region 15.1 to the lower lift cage K1, where it is fastened by its first end, upwardly and directly to the first drive pulley 13.A1. From the latter, the first support means strand TA runs, for example via the first deflecting roller 14.A1 and the second deflecting roller 14.A2, downwardly to the upper counterweight deflecting roller 12.1. From the latter, the first drive means strand

TA runs upwardly, via the deflecting roller 14.A3, further to the third drive pulley 13.A2 and from this directly to the central fastening region 15.2/15.22 at the upper lift cage K2, where it is fastened by its second end.

The second support means strand TB runs upwardly from the second fastening region 15.11 to the lower lift cage K1 and directly to the second drive pulley 13.B1. From the latter, the second support means strand TA runs downwardly via the fourth deflecting roller 14.B1 to the upper counterweight deflecting roller 12.1. From the latter, the second drive means strand TA runs upwardly, via the deflecting roller 14.B2, further to the fourth drive pulley 13.B2 and from this directly to the central fastening point 15.2/15.22 at the upper lift cage K2.

The two support means strands TA and TB respectively run parallel directly to the upper counterweight deflecting roller 12.1 and away from this.

Fig. 1C shows how the introduction of force through the support means strands TA and TB for the lift cage K1 takes place. Fig. 1D shows an alternative with respect thereto.

Figs. 1A, 2 and 3 show an advantageous arrangement of the drive pulleys 13.A1, 13.B1, 13.A2, 13.B2 in the uppermost region of the lift shaft 11. The drive pulleys 13. A1, 13.B1, 13.A2, 13.B2 are arranged vertically, i.e. with horizontal axes, as apparent from Fig. 3. A guide device for the vertical guidance of the cages K1 and K2 in the lift shaft 11 comprises two stationary guide rails 19.1 and 19.11, which extend vertically along opposite sides of the lift shaft 11 and are fastened thereto in a manner which is not illustrated. The guide device additionally comprises guide bodies, which are not illustrated. Two guide bodies, which co-operate with the respective guide rails 19.1 and 19.11, are preferably mounted in vertically aligned arrangement on both sides at each of the cages K1 and K2. The guide bodies at a side of the cages K1, K2 are advantageously mounted at the largest possible spacing in height. The guide rails 19.1 and 19.11 are arranged diagonally with respect to the counterweight 12.

A further guide device with two guide rails 19.2, 19.22 is arranged in the region of the narrow sides of the counterweight 12 and serves for guidance of the counterweight 12.

The first support means strand TA, going out from the first fastening point 15.1 at the lower

lift cage K1, runs along the same side of the lift shaft 11 as the guide rail 19.1. The second support means strand TB, going out from the second fastening point 15.11 at the lower lift cage K1, runs along the same side of the lift shaft 11 as the guide rail 19.11.

Fig. 1C shows the same lower lift cage K1, but with the fastening points 15.1 and 15.11 in the upper cage region.

Fig. 2 shows a second example of embodiment of the invention. This comprises all constructional elements described with respect to Figs. 1A, 1B and 1C as well as an additional device in order to better tighten the support means strands TA and TB and to better guide the lift cages K1 and K2 as well as the counterweight 12.

The lift system 10 according to Fig. 2 comprises for this purpose a lower counterweight deflecting roller 12.2 which is suspended at the counterweight 12. Centrally disposed at the lower region B1 of the lower lift cage K1 are a fifth fastening region 15.3 and a sixth fastening region 15.33, which virtually coincide at 15.3/15.33.

A seventh fastening point 15.4 and an eighth fastening point 15.44 are disposed laterally at the lower region B2 of the upper lift cage K2 at opposite sides of the lift cage K2. The seventh fastening point 15.4 and the eighth fastening point 15.44 are, in the present example of embodiment, disposed near those sides of the lift shaft 11 at which the guide rails 19.1, 19.11 run.

Alternatively, the seventh and eighth fastening points 15.4, 15.44 are disposed in the upper region of the lift cage K2.

A flexible tensioning means SA, SB substantially consists of a first tensioning means strand SA and a second tensioning means strand SB. Each of the tensioning means strands SA and SB has a first end and a second end. Advantageously, each of the tensioning means strands SA, SB is formed by two or more parallel tensioning means elements, such as, for example, by two belts or two cables. Each tensioning means strand SA, SB can, however, also comprise only one belt or cable. The load-bearing structure of the tensioning means strands SA, SB is advantageously made of steel, aramide or Vectran.

The first and second fastening regions 15.1, 15.11 as well as the fifth and sixth fastening regions 15.3, 15.33 are located in common in the lower region B1 of the cage K1 or each on a lower region B1 or upper region of the cage K1. If the first and second fastening regions 15.1, 15.11 are located in the upper region of the cage K1, the advantage resides in the use of shorter support means strands TA, TB. If the first and second fastening regions 15.1, 15.11 are located in common with the fifth and sixth fastening regions 15.3, 15.33 in the lower region B1 of the cage K1 the advantage resides in the simple construction of the cage K1. The force-introducing structure then consists substantially of a simple beam.

Analogous arguments also apply to the third, fourth, seventh and eighth fastening regions 15.2, 15.22, 15.4, 15.44, which are located either in common in the upper region of the cage K2 or respectively in an upper region or lower region B2 of the cage K2. If the seventh and eighth fastening regions 15.4, 15.44 are located in the lower region B2 of the cage K2, the advantage resides in the use of shorter tensioning means strands SA, SB. If the seventh and eighth fastening regions 15.4, 15.44 are located in common with the third and fourth fastening regions 15.2, 15.22 in the upper region of the cage K2 the advantage resides in the simple construction of the cage K1. The force-introducing structure then substantially consists of a simple beam.

Moreover, several deflecting rollers are arranged in the lower region of the lift shaft 11. Two tensioning rollers 16.A1, 16.A2 for the first tensioning means strand TA and two tensioning rollers 16.B1, 16.B2 for the second tensioning means strand TB are provided. Moreover, two auxiliary rollers 17.A1 and 17.A2 for the first tensioning means strand TA as well as two auxiliary rollers 17.B1, 17.B2 for the second tensioning means strand TB are provided. In addition, a pre-tensioning arrangement 16 is provided.

The first tensioning means strand SA is fastened by its first end to the central fastening region 15.3/15.33 of the lower lift cage K1 and runs from there around the tensioning rollers 16.A1 and 16.A2 to the lower counterweight deflecting roller 12.2. From the lower counterweight deflecting roller 12.2. the first tensioning means strand SA runs via the deflecting rollers 17.A1 and 17.A2 to the seventh fastening region 15.4 at the upper lift cage K2, where it is fastened by its second end.

The second tensioning means strand SB is fastened by its first end at the central fastening

region 15.3/15.33 of the lower lift cage K1 and runs from there around the tensioning rollers 16.B1 and 16.B2 to the lower counterweight deflecting roller 12.2. From the lower counterweight deflecting roller 12.2 the second tensioning means strand SB runs via the deflecting roller 17.B1 and 17.B2 to the eighth fastening region 15.44 at the upper lift cage K2, where it is fastened by its second end.

Fig. 3 is an enlarged illustration of Fig. 1B, in which details are shown which are not apparent or not clearly apparent in Fig. 1C. Illustrated are, in particular, a first vertical centre plane E1, a second vertical centre plane E2, a first vertical diagonal plane D1 and a second vertical diagonal plane D2.

The first fastening region 15.1 and the second fastening region 15.11 lie in the lower cage region on opposite sides of the lower lift cage K1, on opposite sides of the first vertical centre plane E1 and on opposite sides of the second vertical centre plane E2, in order to ensure a substantially centrally symmetrical, i.e. balanced, force introduction into the lift cage K1 (not recognisable in Fig. 3). This balanced force introduction has the advantage that less friction and wear occur at the guide rails. Moreover, the occurrence of audible or detectable knocks during travel is significantly reduced.

The fastening region 15.2/15.22 lies centrally at the upper cage region of the upper lift cage K1, so that here, too, a central force introduction takes place (not recognisable in Fig. 3).

Fig. 3 additionally shows that at least three motors M.AB2, M.A1, M.B1 are provided for driving the four drive pulleys 13.A, 13.A2, 13.B1, 13.B2. In an alternative arrangement, which is not shown here, the lift system 10 additionally has a fourth motor which drives the drive pulley 13.B2. Thus, in this alternative arrangement a motor is associated with each drive pulley 13.A, 13.A2, 13.B1, 13.B2. By comparison with conventional lift systems in which a motor is associated with each lift cage, up to two motors M.AB2, M.A1, M.B1 are allocated to each cage K1, K2 in the illustrated example. Correspondingly, the individual motor must generate up to half the amount of torque and can thus be designed to be significantly smaller. The advantage of such an arrangement is an extremely flexible and space-saving positioning of the motors in M.AB2, M.A1, M.B1 in the upper region of the lift shaft 11.

By means of the deflecting rollers 14.A1, 14.A2, 14.A3, 14.B1, 14.B2 the support means strands TA, TB are guided respectively by the drive pulleys 13.A, 13.A2, 13.B1, 13.B2 above the lift cage K2 to the rear side of the lift shaft 11 and from there deflected laterally past the lift cages K1, K2 in the direction of the counterweight 12. These additional deflecting rollers enable use of smaller drive pulleys 13.A, 13.A2, 13.B1, 13.B2. Small drive pulleys have the advantage that smaller drive torques are needed for operating the lift system 10. Accordingly, even smaller motors can be used. An even more flexible space-saving positioning of the motors, drive pulleys and deflecting rollers in the upper region of the lift shaft 11 results therefrom.

Thanks to the small dimensions of the drive pulleys 13.A, 13.A2, 13.B1, 13.B2 these drive pulleys can, in addition, be arranged at an inclination with respect to the centre plane E2. In the illustrated example the drive pulleys 13.A1, 13.B1 are disposed at an inclination relative to one another and enable, in co-operation with the associated deflecting rollers 14.A1, 14.A2, 14.B1, a correspondingly inclined guidance of the support means strands TA, TB above the lift cage K2 towards the projection of the upper counterweight deflecting roller 12.1. The advantage of this guidance running together at an inclination is the use of smaller upper counterweight deflecting rollers 12.1.

Due to the fact that both cages K1, K2 are connected by way of common support means TA, TB with only one counterweight 12 and due to the special form of 1:1 suspension of the cages K1, K2 and the 2:1 suspension of the counterweight 12, different speeds v_1 , v_2 and v_3 result depending on the respective travel situation. If the cage K1 moves upwardly at the speed v_1 while the cage K2 is stationary then the counterweight 12 moves downwardly at $v_3 = v_1/2$. If the cage K2 moves downwardly at the speed v_2 while the cage K1 is stationary then the counterweight 12 moves upwardly at $v_3 = v_2/2$. If the cages K1, K2 move at the same speed $v_1 = v_2$ towards one another then v_3 is zero. If the cage K1 and the cage K2 move downwardly at the same speed $v_1 = v_2$ then the counterweight 12 moves upwardly at $v_3 = v_1 = v_2$.

What is claimed is:

1. An elevator system comprising a lower elevator car, an upper elevator car, a common counterweight, a support means for supporting the lower and upper elevator cars, a drive means for driving the lower and upper elevator cars with the support means, which drive means are arranged in an elevator shaft for moving the upper elevator car and the lower elevator car vertically independently of one another, further comprising:

- a first support means strand of the support means with a first end and a second end;
 - a second support means strand of the support means with a first end and a second end;
 - a first drive pulley and a fourth drive pulley of the drive means associated with said first support means strand; and
 - a second drive pulley and a third drive pulley of the drive means associated with said second support means strand,
- said drive pulleys associated with one of said support means strands rotating in vertical planes being inclined relative to one another, wherein the inclination of one of the vertical planes is about a vertical axis orthogonal to an axis of rotation of one of the drive pulleys.

2. The elevator system according to claim 1 wherein the lower elevator car is suspended in a balanced state at two separate mutually opposite fastening regions, wherein said first end of said first support means strand is fixed to a first one of said fastening regions and wherein a first end of said second support means strand is fixed to a second one of said fastening regions.

3. The elevator system according to claim 2 wherein the upper elevator car is suspended in a common central upper fastening region at said second end of said first support means strand and said second end of said second support means strand.

4. The elevator system according to claim 3 wherein said mutually opposite fastening regions are disposed in a lower car region of the lower elevator car.

5. The elevator system according to claim 3 wherein said mutually opposite fastening regions are disposed in an upper car region of the lower elevator car.

6. The elevator system according to claim 3 wherein said central fastening region is disposed in an upper car region of the upper elevator car.

7. The elevator system according to claim 1 wherein the drive means includes four motors, each of said motors driving an associated one of said first through fourth drive pulleys.

8. The elevator system according to claim 1 wherein the drive means includes a first motor for driving said first drive pulley, a second motor for driving said second drive pulley, and a third motor for driving by a common shaft said third drive pulley and said fourth drive pulley.

9. The elevator system according to claim 1 including tensioning means for exerting downwardly directed tension forces on the lower elevator car and on the upper elevator car and are connected with the counterweight by at least one counterweight deflecting roller.

10. The elevator system according to claim 9 wherein said tensioning means includes a biasing means with two tensioning rollers for a first tensioning means strand and with two other tensioning rollers for a second tensioning means strand.

11. The elevator system according to claim 10 wherein said tensioning means strands are formed from cables or belts.

12. The elevator system according to claim 1 wherein said first and second support means strands are formed from cables or belts.

13. An elevator system comprising a lower elevator car, an upper elevator car, a common counterweight, a support means for supporting the lower and upper elevator cars, a drive means for driving the lower and upper elevator cars with the support means, which drive means are arranged in an elevator shaft for moving the upper elevator car and the lower elevator car vertically independently of one another, further comprising:

- a first support means strand of the support means with a first end and a second end;
- a second support means strand of the support means with a first end and a second end;

- a first drive pulley and a fourth drive pulley of the drive means associated with said first support means strand, said first and fourth drive pulleys rotating in vertical planes being inclined relative to one another, wherein the inclination of one of the vertical planes is about a vertical axis orthogonal to an axis of rotation of one of the first and fourth drive pulleys; and
- a second drive pulley and a third drive pulley of the drive means associated with said second support means strand, said second and third drive pulleys rotating in vertical planes being inclined relative to one another, wherein the inclination of one of the vertical planes is about a vertical axis orthogonal to an axis of rotation of one of the second and third drive pulleys.

14. An elevator system comprising a lower elevator car, an upper elevator car, a common counterweight, a support means for supporting the lower and upper elevator cars, a drive means for driving the lower and upper elevator cars with the support means, which drive means are arranged in an elevator shaft for moving the upper elevator car and the lower elevator car vertically independently of one another, further comprising:

- a first support means strand of the support means with a first end and a second end;
- a second support means strand of the support means with a first end and a second end;
- a first drive pulley and a fourth drive pulley of the drive means associated with said first support means strand, said first and fourth drive pulleys rotating in vertical planes being inclined relative to one another, wherein the inclination of one of the vertical planes is about a vertical axis orthogonal to an axis of rotation of one of the first and fourth drive pulleys; and
- a second drive pulley and a third drive pulley of the drive means associated with said second support means strand, said second and third drive pulleys rotating in vertical planes, being inclined relative to one another and said vertical planes associated with said third and fourth drive pulleys extending parallel to one another, wherein the inclination of one of the vertical planes is about a vertical axis orthogonal to an axis of rotation of one of the second and third drive pulleys.