

Lift, particularly for transporting persons

The invention relates to a lift, particularly for transporting persons, which comprises a lift shaft, a lift cage guided in the lift shaft and a drive motor directly driving the lift cage. The drive motor is provided with an active primary part arranged at the lift cage and a passive secondary part arranged in stationary position in the lift shaft and spaced from the primary part by an air gap.

The lift cage of conventional lifts is usually moved up and down in the lift shaft by means of wire cables which run over a drive pulley driven by an electric motor. This indirect drive of the lift cage is connected with the disadvantage of an additional space requirement for the drive pulley and the electric motor.

In addition, lifts which are provided with a direct drive of the lift cage are known in the state of the art. Thus, EP 0 785 162 A1 describes a lift in which the lift cage is driven directly by a linear motor. The linear motor comprises a primary part arranged at the lift cage and a secondary part fastened to the wall of the lift shaft and provided with permanent magnets. The primary part is provided with windings to which a three-phase current is supplied. In this manner there is created a magnetic travelling field forming electromagnetic forces which linearly move the primary part and thus the lift cage relative to the secondary part.

A linear motor directly driving the lift cage is additionally known from EP 0 858 965 A1. With respect to low transverse forces, this linear motor has a secondary part which is arranged at the lift cage and which is formed from two rows of mutually opposite permanent magnets. The primary part, thereagainst, consists of windings which are arranged between the permanent magnets of the secondary part.

The provision of a linear motor for direct drive of the lift cage does indeed have the advantage, in distinction from lifts with an indirect drive by means of wire cables, that no additional space requirement for an electric motor and a drive pulley is needed. Moreover, the provision of a linear motor makes a counterweight connected with the lift cage redundant. An insufficient power capability and a manufacturing outlay which is comparatively high in the economic respect have proved to be a disadvantage of the known linear motors particularly in the case of relatively high lift shafts. With respect to manufacturing outlay it is possibly required to provide the entire wall of the lift shaft with

either the secondary part or the primary part. Since the primary part comprises several windings and the secondary part is equipped with permanent magnets, comparatively high costs thus result.

The invention is based on the object of developing a lift of the kind stated in the introduction in the respect that a comparatively high power capability of the drive motor directly driving the lift cage can be achieved with comparatively favourable production costs.

According to the invention for fulfilment of this object it is provided in correspondence with claim 1, in the case of a lift with the above-mentioned features, that the drive motor is formed as a transverse flux motor which moves the primary part linearly relative to the secondary part under the influence of an electromagnetic propulsive force, wherein the secondary part comprises at least one rail which is made of a soft magnetic material and which is subdivided into a plurality of segments of predetermined length and wherein the segments are fastened to a wall of the lift shaft by means of intermediate elements.

A lift of that kind makes use of the knowledge that a comparatively high force density results in the case of a transverse flux machine. This is because by contrast to linear motors operating in accordance with the longitudinal flux principle, the magnetic flux in the case of transverse flux motors is guided perpendicularly to the direction of movement with the consequence that relatively small pole pitches, which lead to a large force density, can be realised.

The construction of the secondary part as a rail made from a soft magnetic material ensures a comparatively economic production and enables simple mounting in the lift shaft. Since the magnets and windings, which are required for producing the magnetic flux, are arranged in the moved primary part it is sufficient to make the passive secondary part out of a soft magnetic material more favourable in economic respect. By soft magnetic material in the sense of the present invention there is understood a material which can be readily magnetised and demagnetised, such as, for example, iron or ferrite. The rail can additionally be made of a solid material or be laminated with the soft magnetic material.

For producing a magnetic flux running transversely to the direction of movement of the lift cage the primary part advantageously comprises an excitation module which is provided with at least one collector, which is composed of alternately arranged magnets and soft magnetic intermediate elements, as well as with at least one excitation winding extending in the direction of movement of the lift cage, wherein the magnets are arranged in the collector for formation of a predetermined pole pitch with alternating polarity.

The provision of the excitation module enables a modular construction of the primary part. Thus, for example, depending on the respectively required performance capability several excitation modules can be arranged adjacent to one another and/or one after the other. The spacing of the magnets in the collector corresponds with the pole pitch, wherein the magnetic flux produced by the magnets is transmitted by way of the soft magnetic intermediate elements to the secondary part. The magnets are usefully constructed as permanent magnets and for this purpose consist of, for example, a rare earth metal, such as, for example, neodymium.

In order to prevent, in the case of presence of several excitation modules, an unfavourable magnetic coupling of the magnetic fields produced by the excitation modules from arising, the rail is subdivided into a plurality of segments spaced apart in the direction of movement of the lift cage. If the spacing between the excitation modules is selected to be at least the length of the longest segment, then it is excluded that two excitation modules arranged one behind the other co-operate with one and the same segment. This is because the air gap, which results through the spaced arrangement of the segments, between the individual segments represents a resistance for the magnetic flux, which counteracts dispersion of the magnetic flux. The segmentation in accordance with the invention of the rail thus contributes to the magnetic field lines running predominantly in transverse direction, i.e. perpendicularly to the direction of movement of the lift cage. Due to the arrangement of the segments on the intermediate elements a simple mounting and precise alignment of the segments is, in addition, taken into account.

The subjects of the dependent claims represent advantageous embodiments of the lift according to the invention.

Thus, in the constructional respect it is of advantage to arrange the intermediate elements on support elements fastened to the wall of the lift shaft. It is of further advantage to make

the intermediate elements and the support elements of a non-magnetic material, preferably aluminium, in order to avoid a disturbing influence on the magnetic flux. The intermediate elements and the support elements are preferably made from the same material so that they have the same thermal coefficient of expansion. Thermally induced stresses between the intermediate elements and the support elements are thus prevented.

The segments can advantageously be connected together and the intermediate elements spaced apart in the direction of movement of the lift cage. In the case of such an embodiment the force flow predominantly runs through the segments. In a particularly preferred embodiment of the lift according to the invention the segments are spaced apart, however, in the direction of the movement of the lift cage and the intermediate elements connected together so that the force flow is taken up principally by the intermediate elements. The support elements receiving in both cases only still kinking forces can be spaced apart in the direction of movement of the lift cage in order to make possible a thermally induced length expansion. Depending on the respective case of use it is also possible to omit the support elements. Alternatively, the segments and the intermediate elements can be spaced apart in the direction of movement of the lift cage and the support elements connected together so that the force flow is conducted predominantly through the support elements.

In correspondence with a preferred development of the lift according to the invention the intermediate elements are provided with a guide surface for guidance of the primary part in a transverse direction, which is perpendicular to the movement direction, of the lift cage. Alternatively or additionally the intermediate elements can be provided with a guide surface for guidance of the primary part in a normal direction, which is perpendicular to the movement direction and the transverse direction, of the lift cage.

The segments are preferably provided with a fastening part which is connected with the intermediate elements in force-locking manner and/or shape-locking manner and/or material-locking manner. Such an embodiment enables a simple mounting and reliable fastening of the segments on the intermediate elements. In order to ensure a simple and precise alignment of the segments on the intermediate elements the fastening part is provided with projections and is inserted in shape-locking manner in a correspondingly formed groove of the intermediate element.

With respect to economic production it is advantageous to provide the segments with the same length. In order to avoid vibrations of the lift cage and guarantee a low-noise movement of the primary part on the rails, the ends of the intermediate end elements are advantageously chamfered.

Finally, in an advantageous development of the lift according to the invention the rail is provided with equidistantly arranged teeth on at least one side, wherein a tooth pitch, which is formed by the teeth, of the rail is an integral multiple of the pole pitch of the collector. Through the provision of the rail with teeth there results a high magnetic flux density between primary part and secondary part and thus a comparatively large force density. If the secondary part is formed by several rails arranged, for example, adjacent to one another, it is advantageous to arrange the rails in such a manner that the tooth pitches of the rails are arranged to be displaced relative to one another. This is because in this way transverse forces which arise can be minimised.

Details and further advantages of the lift according to the invention are evident from the following description of preferred examples of embodiment. In the associated drawings, which illustrate the examples of embodiment merely schematically, there are shown in detail:

- Fig. 1 a perspective view of a lift;
- Fig. 2a a perspective view of an excitation module in a first form of embodiment;
- Fig. 2b a front view of the excitation module according to Fig. 2a;
- Fig. 3a a perspective view of an excitation module in a second form of embodiment;
- Fig. 3b a front view of the excitation module according to Fig. 3a;
- Fig. 4a a perspective view of an excitation module in a third form of embodiment;

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- Fig. 4b a front view of the excitation module according to Fig. 4a;
- Fig. 5a an illustration of the size relationships of excitation modules and segments of a rail;
- Fig. 5b an illustration according to Fig. 5a;
- Fig. 5c an illustration according to Fig. 5a;
- Fig. 6a an illustration of the course of magnetic field lines in the case of two excitation modules arranged one after the other and a continuous rail;
- Fig. 6b an illustration of the course of magnetic field lines in the case of two excitation modules arranged one after the other and a segmented rail;
- Fig. 7 a perspective view from below of an excitation module provided with a slide shoe;
- Fig. 8 an end view of rails fastened to an intermediate element;
- Fig. 9a an illustration of the force flow in the case of interconnected segments of the secondary part;
- Fig. 9b an illustration according to Fig. 9a in the case of interconnected support elements of the secondary part;
- Fig. 9c an illustration according to Fig. 9a in the case of interconnected intermediate elements of the secondary part;
- Fig. 10 a perspective view of the secondary part;
- Fig. 11 an end view of the primary part guided on the secondary part;

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- Fig. 12a a perspective view of a rail of the secondary part;
- Fig. 12b an enlarged illustration of the region characterised in Fig. 12 by XIIb;
- Fig. 12c an end view of the rail arranged on a support element by means of a fastening part;
- Fig. 13 a perspective view of a further form of embodiment of the fastening part;
- Fig. 14a an end view of the excitation module according to Fig. 2b with illustrated orientation of propulsive force and transverse force;
- Fig. 14b a plan view of the excitation module according to Fig. 14a with illustrated orientation of propulsive force and transverse force;
- Fig. 15a a front view of the excitation module according to Fig. 3b with illustrated orientation of propulsive force and transverse force;
- Fig. 15b a plan view of the excitation module according to Fig. 15a with illustrated orientation of propulsive force and transverse force;
- Fig. 16a a front view of the excitation module according to Fig. 4b with illustrated orientation of propulsive force and transverse force;
- Fig. 16b a plan view of the excitation module according to Fig. 16a with illustrated orientation of propulsive force and transverse force;
- Figs. 17a to 17l different arrangements of excitation modules of a drive motor;
- Fig. 18a an illustration of the quantitative course of the propulsive force in the case of unregulated current strength;
- Fig. 18b an illustration of the quantitative course of the current strength in the case of unregulated current strength;

- Fig. 19a an illustration of the quantitative course of the propulsive force in the case of regulated current strength;
- Fig. 19b an illustration of the quantitative course of the current strength in the case of regulated current strength; and
- Fig. 20 an illustration of the regulation of the current strength supplied to the excitation module.

In the case of the lift illustrated in Fig. 1 a lift cage 20 is arranged to be movable in a lift shaft 10 extending over several storeys 11. The lift cage 20 is provided with several guide rollers 20 which move the lift cage 20 along guides 21 arranged in the lift shaft 10.

The lift cage 20 is directly driven by a drive motor 30. For this purpose the drive motor 30, which is designed as a transverse flux motor, comprises an active primary part 40 and a passive secondary part 50. The primary part 40 is arranged at the lift cage 20, whereagainst the secondary part 50 is fastened to a wall 12 of the lift shaft 10 and is spaced from the primary part 40 by an air gap. The primary part 40 is linearly movable relative to the secondary part 50 under the influence of an electromagnetically generated propulsive force F_v .

As can be seen particularly in Figs. 2a to 4b, the primary part 40 comprises an excitation module 41 for producing a magnetic flux running transversely to the direction x of movement of the lift cage 20. The excitation module 41 is provided with at least one collector 44a to 44e as well as with at least one excitation winding 48 extending in the direction x of movement of the lift cage 20. The collector 44a to 44e is composed of several permanents 42 arranged in alternation and of intermediate elements 43 made from a soft magnetic material. The permanent magnets 42 are arranged with alternating polarity in the collector 44a to 44e and form a pole pitch.

The form of embodiment, which is shown in Figs. 2a and 2b, of the excitation module 41 comprises two collectors 44c, 44d which are constructed to be substantially I-shaped and arranged parallel to one another in the direction x of movement of the lift cage 20 and are each provided with a respective excitation winding 48. With respect to a material-saving

design, the feedback of the excitation winding 48, which usually consists of copper, in the case of arrangement of several excitation modules 41 can be utilised in order to excite an adjacent collector.

Thereagainst, the form of embodiment, which is shown in Figs. 3a and 3b, of the excitation module 41 comprises a yoke 47 which surrounds the collector 44e at three sides and which is composed of a base plate 47a, which is provided with the excitation winding 48, and two limbs 47b. The limbs 47b are each spaced from the collector 44e by a respective intermediate space 45b and extend along two opposite sides of the collector 44e. The secondary part 50, which is constructed as a rail 51 subdivided into segments 52, is arranged in the intermediate space 45b. The yoke 47 serves the purpose of ensuring a magnetic return flux from the segments 52 of the rail 51 to the primary part 40. In an alternative embodiment, the excitation module 41 can comprise two or more of the collectors 44e. The yoke 47 has a further limb 47b for each additional collector 44e in order to ensure the magnetic return flux. If several excitation modules 41 are arranged adjacent to one another, then the yoke 47 and the excitation winding 48 can be designed in such a manner that the yoke 47 and/or the excitation winding 48 of several collectors 44c are used at the same time. A lightweight and material-saving mode of construction is thus guaranteed.

In the case of the form of embodiment, which is shown in Figs. 4a and 4b, of the excitation module 41 there are provided two collectors 44a, 44b which are constructed to be substantially U-shaped and face one another by their open sides and which are arranged to be spaced apart by an intermediate space 45a. The collectors 44a, 44b have limbs 46 which are respectively provided with the excitation windings 48 extending in the direction x of movement of the lift cage 20. The segments 52 of the rail 51 are arranged in the intermediate space 45a.

As apparent from Fig. 4a, on supply of a three-phase current to the excitation winding 48 a magnetic flux M, which flows through the secondary part 50 and runs transversely to the direction x of movement of the lift cage 20, results. A magnet flux M of that kind also arises in the case of the forms of embodiment of the excitation module 41 according to Figs. 2a to 3b. The form of embodiment shown in Figs. 2a and 2b differs from the remaining forms of embodiment of the excitation module 41 in that, however, the segments 52 of the rail 51 are not arranged between two collectors, but the collectors 44c,

44d extend between the segments 52. For producing a magnetic flux M running transversely to the direction x of movement of the lift cage 20 this reversal of the arrangement of collectors 44c, 44d and segments 52 is without significance.

Figs. 5a to 5c allow recognition that the rail 51 formed from a soft magnetic material, such as, for example, iron or ferrite, is composed of a plurality of segments 52 of equal length l spaced apart in the direction x of movement of the lift cage 20. The rail 51 is further provided with a plurality of teeth 53, as apparent from Figs. 6a and 6b. Regardless of the segmentation of the rail 51 into individual segments 52, the teeth 53 are equidistantly arranged. The tooth pitch, which is formed in this manner, of the rail 51 corresponds with an integral multiple of the pole pitch of the collectors 44a to 44e, for example twice the pole pitch. The teeth 53 can be arranged on one side or on two sides of the rail 51 and extend in transverse direction. As further apparent from Figs. 6a and 6b, the secondary part can consist of several rails 51. The teeth 53 are in this case arranged in such a manner that the tooth pitches of the rails 51 are arranged to be displaced relative to one another.

Several excitation modules 41a, 41b are arranged one after the other in the direction x of movement of the lift cage 20 in such a manner that the spacing d between two excitation modules 41a, 41b amounts to at least the length l of the longest segment 52, as Figs. 5a to 5c show. In this manner it is ensured that independently of the length of the segments 52 two excitation modules 41a, 41b do not co-operate at the same time with one and the same segment 52. A dispersion of the magnetic flux M due to a coupling of the magnetic fields produced by excitation modules 41a, 41b, as shown in Fig. 6a on the basis of continuous rails 51, can thus be largely avoided, as is apparent from Fig. 6b.

The intermediate elements 43 of the collectors 44a to 44e, the yoke 47 of the excitation module 41 shown in Figs. 3a and 3b and the rails 51 represent passive components, i.e. components that are merely field-conducting. In order to achieve a targeted field conductance, these passive components can be constructed as a plate stack, which is composed of electrically mutually insulated plates of, for example, soft iron. Such a plate stack can advantageously be made by cementing. In this case the individual plates are provided at one side or both sides with a glue layer and after stacking one on the other are glued together by the action of pressure and heat. Cementing has, by contrast to other production methods such as, for example, welding, punch-stacking or riveting, the

advantage that a short circuit, which prejudices conduction of the magnetic flux M , between two or more plates is avoided.

The excitation module 41 can be provided with guide rollers or a slide shoe 60 in order to ensure reliable guidance on the rails 51. As shown in Fig. 7 on the basis of an excitation module 41 similar to the form of embodiment shown in Figs. 3a and 3b, the slide shoe 60 is arranged at the underside of the collector 44e. The collector 44e clamped in place in this manner between the slide shoe 40 and the yoke 47 thus experiences a reliable fastening. The slide shoe 60 is provided with a sliding guide surface 61 for guidance in a transverse direction y , which is perpendicular to the direction x of movement, of the lift cage 20. Beyond that the slide shoe 60 has a sliding guide surface 62 for guidance in a normal direction z , which is perpendicular to the movement direction x and the transverse direction y , of the lift cage 20. In order to ensure a low-vibration introduction of the segments 52 of the guide rail 51 into the intermediate space 45b the sliding guide surface 61 is provided with chamfers 63 for guidance in transverse direction y . Further contribution to a low-vibration and thus low-noise guidance of the excitation module 41 on the rails 51 is made by the provision in the slide shoe 60 of slot-like recesses 65, 66 which extend parallel to the sliding guide surfaces 61, 62. By reason of the recesses 65, 66, the sliding guide surfaces 61, 62 are designed to be resilient. This resilient design ensures that the air gap required between primary part 40 and secondary part 50 for a relative movement remains constant during movement of the excitation module 41.

A secondary part 50 designed in correspondence with the excitation module 41 shown in Fig. 7 is illustrated in Fig. 8. The secondary part 50 comprises three rails 51 which engage in the intermediate spaces 45b of the excitation module 41. The rails 51 are arranged on an intermediate element 71, which is fastened to the wall 12 of the lift shaft 10, by means of a fastening part 54a engaging in a groove 56. The intermediate element 71 is provided with guide surfaces 72, 73 which co-operate with the straight guide surfaces 61, 62 of the slide shoe 60 for reliable guidance of the excitation module 41.

As apparent from, in particular, Fig. 1, the lift cage 20 is directly driven by a drive motor 30. A wire cable, as in the case of indirectly driven conventional lifts, is not required. In order to reduce the propulsive force F_v required for movement of the lift cage 20, a counterweight connected with the lift cage 20 can, nevertheless, be provided. In this case it is possible to arrange a further primary part 40 of the drive motor 30 at the

counterweight. Alternatively, it is also possible to provide only one primary part 40 which is fastened to the counterweight.

As can be recognised in Figs. 9a to 9c, support elements 70, on which the intermediate elements 71 carrying the segments 52 are arranged, are fastened to the wall 12 of the lift shaft 10. The support elements 70 and the intermediate elements 71 are made of a non-magnetic material, such as, for example, aluminium. Figs. 9a to 9c clarify the course of the force flow K, which is conducted into the secondary part 50, in the case of different arrangements of the segments 52, the intermediate elements 71 and the support elements 70. In the case of the embodiment shown in Fig. 9a only the segments 52 are connected together. The force flow K in this case runs predominantly through the segments 52. In Fig. 9b, thereagainst, only the support elements 70 are connected together. The force flow K therefore runs from the segments 52 to the support elements 70 by way of the intermediate elements 71. In the case of embodiment shown in Fig. 9c only the intermediate elements 71 are connected together, so that the force flow K is conducted from the segments 52 to the intermediate elements 71. The embodiment shown in Fig. 9c has proved particularly advantageous. The segments 52 in this case are spaced apart from one another so that a magnetic coupling of two excitation modules 41a, 41b arranged one after the other can be avoided, as shown in Fig. 6b. In addition, the interconnected intermediate elements 71 enable a precise arrangement and alignment of the segments 52 and a reliable guidance of the excitation module 41. The intermediate elements 71 and support elements 70 made of the same material have the same coefficients of thermal expansion so that thermally induced changes in length do not produce any stresses, which impair the force flow K, between the support elements 70 and the intermediate elements 71. Since the force flow K is derived by way of the intermediate elements 71, the support elements 70 take up merely kinking forces. Depending on the respective case of use it can therefore be sufficient to omit the support element 70 and to fasten the intermediate elements 71 directly to the wall 12 of the lift shaft 10.

An accurate alignment of the segments 52 is required for a low-vibration and low-noise guidance of the excitation module 41 on the rails 51. As can be recognised in Fig. 10, the segments 52 arranged on the intermediate elements 71 can be aligned in the transverse direction y by the intermediate elements 71. For this purpose the intermediate elements 71 are fastened on the support elements 70 by means of screws 74. Aligning plates 76,

which by means of thumbscrews adjust several segments 52 arranged in succession, can be used for alignment in the movement direction x.

Fig. 10 further allows recognition of guide surfaces 72 which ensure guidance of the excitation module 41 in transverse direction y. The guide surface 72 can co-operate with the sliding guide surfaces 61, which is shown in Fig. 7, of the slide shoe 60 or with guide rollers 64 shown in Fig. 11. Provision of the slide shoe 60 or the guide rollers 64 depends on the respective case of use.

Figs. 12a to 12c allow recognition that the rail 51 is fastened to the intermediate element 71 by means of a fastening part 54a. The fastening part 54a is arranged on a side of the rail 51 which is not provided with the teeth 53. The fastening part 54 can be an integral constituent of the rail 51 or a separate component connected with the rail 51. The fastening part 54a engages in a groove 56 of the intermediate element 71 and is connected with the intermediate element 71 in at least force-locking and shape-locking manner. For this purpose the fastening part 54a is provided with projections 55 and arranged by means of a press seat in the correspondingly designed groove 56. Alternatively or additionally, the intermediate element 71 and the fastening part 54a can be connected by means of a screw connection which engages in a bore 57 of the fastening part 54a. Depending on the respective case of use it can, in addition, be advantageous to weld the fastening part 54a and the intermediate element 71 together.

The shape-locking fastening of the fastening element 54a and thus the rail 51 to the intermediate element 71 offers the advantage of a simple alignment of the rail 51 or the segments 52 on the intermediate element 71 during mounting. Beyond that, the fastening part 54a contributes to an effective transmission of the force flow K to the intermediate element 71.

If the segments 52 or the teeth 53 are constructed as a plate stack, then it is advantageous to provide a fastening part 54b which is connected with the intermediate element 71 by material couple, for example by ultrasound welding, and to hold the plate stack in the manner of a clamp. Such a fastening part 54b is illustrated in Fig. 13. The fastening part 54b is, with respect to economic production, made from a preferably thermoplastic synthetic material.

Apart from the propulsive force F_v required for the movement of the lift cage 20, the excitation module 41 generates an unavoidable transverse force F_q . The orientation of the propulsive force F_v and the transverse force F_q in the case of the different forms of embodiment of the excitation module 41 according to Figs. 2a to 4b is shown in Figs. 14a to 16b. The propulsive force F_v and the transverse force F_q are not constant, but are subject to periodic fluctuations. In order to obtain an approximately constant propulsive force F_v , it is advantageous to arrange several excitation modules 41a to 41d one after the other, the supply voltages of which are displaced by a predetermined phase angle. Through a suitable selection of the phase angle the propulsive forces respectively generated by the excitation modules 41a to 41b can be superimposed to form a resultant propulsive force F_{vR} which is substantially constant with respect to time. Beyond that, it is possible in this manner to provide compensation for or at least minimise the respective transverse forces F_q .

Different arrangements of several excitation modules 41a to 41d are shown in Figs. 17a to 17l. In Fig. 17a there is illustrated a two-phase drive motor 30 which is composed of, in total, four excitation modules 41a, 41b, wherein the supply voltage of the excitation module 41a is displaced relative to the supply voltage of the excitation module 41b by a phase angle of 90° . The drive motor 30 illustrated in Fig. 17b differs from the drive motor 30 according to Fig. 17a in that only three excitation modules 41a, 41b, are provided, wherein the excitation module 41b has twice the length of the excitation module 41a. The design, which is shown in Fig. 17c, of the drive motor 30 has, in total, five excitation modules 41a, 41b, arranged in alternation, wherein the middle excitation modules 41a, 41b have over twice the length of the excitation modules 41a at the ends. In this manner a higher power capability of the drive motor 30 results.

Drive motors 30 which have two excitation modules 41a, 41b arranged adjacent to one another are shown in Figs. 17d and 17e. The drive motor according to Fig. 17d comprises, in total, eight excitation modules 41a, 41b, whereagainst the drive motor 30 according to Fig. 17e manages, for the same power capability, with six excitation modules 41a, 41b, since the middle excitation modules 41a, 41b have a greater length. In order to provide compensation for transverse forces F_q which arise, excitation modules 41a, 41b of which the supply voltages are displaced in phase are arranged adjacent to one another.

Fig. 17f and 17g each show a three-phase drive motor 30. The drive motor 30 according to Fig. 17f is composed of, in total, six excitation modules 41a to 41c, whereagainst the drive motor 30 according to Fig. 17g has, in total, five excitation modules 41a to 41c. The supply voltages of the excitation modules 41a to 41c are displaced by a phase angle in each instance of 120° .

A four-phase drive motor 30 is shown in Figs. 17h and 17i. The drive motor 30 according to Fig. 17h is composed of, in total, eight excitation modules 41a to 41d, which are arranged one after the other in movement direction x and the supply voltages of which are displaced by a phase angle of in each instance 90° . The drive motor 30 according to Fig. 17i differs from the drive motor 30 according to Fig. 17h in that two excitation modules of the same phase are combined to form the centre excitation module 41a. In Fig. 17j there is shown a four-phase drive motor 30 which is composed of two rows of excitation modules 41a to 41d. The excitation modules 41a to 41d are arranged anew in such a manner that mutually opposite excitation modules 41a, 41b; 41c, 41d are of unequal phase.

A four-phase drive motor 30 in which the excitation modules 41a, 41b; 41c, 41d are arranged in two groups G_1 and G_2 are illustrated in Figs. 17k and 17l. The supply voltages of the excitation modules 41a, 41b, 41c, 41d within a group G_1 , G_2 , are displaced each time by a phase angle of 90° , wherein the supply voltages of the excitation modules 41a, 41b of the first group G_1 are displaced relative to the supply voltages of the excitation modules 41c, 41d of the second group G_2 by a phase angle of 45° . This has the consequence that four phases each displaced by a phase angle of 45° are present, which generate the propulsive force F_v . By virtue of the grouped arrangement of the excitation modules 41a to 41d there can be achieved a guidance of the excitation modules 41a to 41d on the rails 51 which is simple with respect to construction. The reason for that is that due to the subdivision of the excitation modules 41a to 41d into groups G_1 and G_2 the guiding surface of the drive motor 30 is shortened.

In the case of presence of several excitation modules 41a, 41b the propulsive force F_{vR} driving the lift cage 20 is yielded as a resultant of the propulsive forces F_{va} , F_{vb} generated by the individual excitation modules 41a, 41b, as can be recognised in Fig. 18a. The course of the individual propulsive forces F_{va} , F_{vb} corresponds, in the case of a conventional supply voltage with an approximately trapezium-shaped current course, as

shown in Fig. 18b, only approximately with the square form of a sinusoidal oscillation. The resultant propulsive force F_{vR} is therefore subject to undesired fluctuations. In order to achieve a constant propulsive force F_{vR} , it is therefore necessary for the individual propulsive forces F_{va} , F_{vb} of the excitation modules 41a, 41b to correspond exactly with the square form of a sinusoidal oscillation, as can be recognised in Fig. 19a. A course of that kind of the propulsive forces F_{va} , F_{vb} of the individual excitation modules 41a, 41b results when the current strengths I_a , I_b supplied to the excitation modules 41a, 41b are regulated. Fig. 19b shows the course of the current strengths I_a , I_b which are regulated in such a manner that the course of the propulsive forces F_{va} , F_{vb} produced by the excitation modules 41a, 41b each have the square form of a sinusoidal oscillation.

In Fig. 20 there is illustrated a regulating circuit which clarifies the regulation of the current strength I . Apart from the excitation module 41, there are present in the regulating circuit a current regulator R_i , a target value transmitter S , a position or speed regulator R_v and a table T . On the basis of the table T , the target value of the current I can be predetermined in dependence on the required propulsive force F_v and the speed as well as the position of the lift cage 20. The target value of the current I is additionally influenced by the speed regulator R_v . The current regulator R_i then regulates the current strength I , which is to be fed to the excitation module 41, in correspondence with the predetermined target value.

The afore-described lift is distinguished by a comparatively high power capability of the drive motor 30, which drives the lift cage 20, with comparatively low production costs. The reason for that is primarily the design of the drive motor 30 as a transverse flux motor with the primary part 40 and the secondary part 50. Through the construction of the secondary part 50 as a rail 51 divided into segments 52, an effective magnetic flux M in transverse direction can be achieved. Not least, through the above-described arrangements of several excitation modules 41a to 41d and the regulation of the current strength I , which is to be supplied to the excitation module 41, a constant propulsive force F_v can be ensured.

Patent Claims

1. Lift, particularly for transporting persons, with a lift shaft (10), a lift cage (20) guided in the lift shaft (10) and a drive motor (30) directly driving the lift cage (20), wherein the drive motor (30) comprises an active primary part (40) arranged at the lift cage (20) and a passive secondary part (50) arranged in stationary position in the lift shaft (10) and spaced from the primary part (40) by an air gap, characterised in that the drive motor (30) is formed as a transverse flux motor with permanent magnets (42) in the primary part, which primary part (40) moves linearly relative to the secondary part (50) under the influence of an electromagnetic propulsive force (F_v), wherein the secondary part (50) comprises at least one rail (51) which is made of a soft magnetic material and which is subdivided into a plurality of segments (52) of predetermined length (l).
2. Lift according to claim 1, characterised in that the segments (52) are fastened to a wall (12) of the lift shaft (10) by means of intermediate elements (71).
3. Lift according to claim 2, characterised in that the intermediate elements (71) are arranged on support elements (70) fastened to the wall (12) of the lift shaft (10) and/or that the intermediate elements (71) are provided with a guide surface (72) for guidance of the primary part (40) in a transverse direction (y), which is perpendicular to the movement direction (x), of the lift cage (20) and/or that the intermediate elements (71) are provided with a guide surface (73) for guidance of the primary part (40) in a normal direction (z), which is perpendicular to the movement direction (x) and the transverse direction (y), of the lift cage (20) and/or that the segments (52) are provided with a fastening part (54a, 54b) which is connected with the intermediate elements (71) in force-locking and/or shape-locking and/or material-locking manner and/or that the ends of the intermediate elements (71) are chamfered.
4. Lift according to claim 3, characterised in that the intermediate elements (71) and the support elements (70) are made from the same material and/or that the intermediate elements (71) and the support elements (70) are made from a non-magnetic material, preferably aluminium.
5. Lift according to one of claims 2 to 4, characterised in that the segments (52) are connected together and the intermediate elements (71) are spaced apart in the direction

(x) of movement of the lift cage (20) or that the segments (52) are spaced apart in the direction (x) of movement of the lift cage (20) and the intermediate elements (71) are connected together.

6. Lift according to claim 3, characterised in that the support elements (70) are spaced apart in the direction (x) of movement of the lift cage (20) or that the segments (52) and the intermediate elements (71) are spaced apart in the direction (x) of movement of the lift cage (20) and the support elements (70) are connected together.

7. Lift according to claim 3, characterised in that the fastening part (54a) is provided with projections (55) and inserted in shape-locking manner into a correspondingly formed groove (56) of the intermediate element (71).

8. Lift according to one of claims 1 to 7, characterised in that the segments (52) have the same length (l) and/or that the rail (51) is provided on at least one side with equidistantly arranged teeth (53), wherein a tooth pitch, which is formed by the teeth (53), of the rail (51) is an integral multiple of a pole pitch of the primary part (40) and/or that several rails (51) are arranged to be offset relative to one another by way of the tooth pitch formed by the teeth (53).

9. Lift according to claim 1, characterised in that for producing a magnetic flux running transversely to the direction (x) of movement of the lift cage (20) the primary part (40) comprises an excitation module (41) which is provided with at least one collector (44a, 44b; 44c, 44d; 44e), which is composed of magnets (42) and soft magnetic intermediate elements (43) arranged in alternation, as well as with at least one excitation winding (48) extending in the direction (x) of movement of the lift cage (20), wherein the magnets (42) are arranged in the collector (44a, 44b; 44c, 44d; 44e) for formation of a predetermined pole pitch with alternating polarity.

10. Lift according to claim 9, characterised by two collectors (44a, 44b) which are formed to be substantially U-shaped and face one another by their open sides and which are arranged to be spaced apart by an intermediate space (45a), wherein the collectors (44a, 44b) have limbs (46) which are provided with the excitation winding (48) and wherein the secondary part (50) is arranged in the intermediate space (45a) or by two collectors (44c, 44d) which are formed to be substantially I-shaped and are arranged to extend

parallel to one another in the direction (x) of movement of the lift cage (20) and which are each provided with the excitation winding (48) or by a yoke (47), which at least partially surrounds the collector (44e), for a magnetic return flux from the secondary part (50) to the primary part (40), wherein the yoke (47) comprises a base plate (47a), which is provided with the excitation winding (48), and at least two limbs (47b), wherein the limbs (47b) extend through an intermediate space (45b) at a spacing from the collector (44e) along two opposite sides of the collector (44d) and wherein the secondary part (50) is arranged in the intermediate space (45b).

11. Lift according to one of claims 9 and 10, characterised by at least two single-phase excitation modules (41a, 41b), the supply voltages of which are displaced by a predetermined phase angle and which are arranged at a predetermined spacing (d) one after the other or one adjacent to the other in the direction (x) of movement of the lift cage (20).

12. Lift according to claim 7, characterised in that the rail (51) is subdivided into a plurality of segments (52) of predetermined length (l) spaced apart in the direction (x) of movement of the lift cage (20), wherein the spacing (d) between the excitation modules (41a, 41b) amounts to at least the length (l) of the longest segment (52).

13. Lift according to one of claims 10 to 12, characterised in that the intermediate elements (43) of the primary part (40) and/or the yoke (47) and/or the rail (51) is or are constructed as a plate stack, wherein the plate stack is composed of mutually electrically insulated plates consisting of soft iron.

14. Lift according to claim 13, characterised in that the plate stack is produced by cementing.

15. Lift according to one of claims 9 to 14, characterised in that the excitation module (41) is provided with guide rollers (64) or with a slide shoe (60), wherein the slide shoe (60) has at least one sliding guide surface (61) for guidance in a transverse direction (y), which is perpendicular to the movement direction (x), of the lift cage (20) and/or at least one sliding guide surface (62) for guidance in a normal direction (z), which is perpendicular to the movement direction (x) and the transverse direction (y), of the lift cage (20).

16. Lift according to claim 15, characterised in that the sliding guide surfaces (61, 62) are formed to be resilient and/or that the sliding guide surface (61) for guidance in transverse direction (y) is provided with chamfers (63) for introducing the rail (50) into the excitation module (41).

17. Lift according to one of claims 1 to 16, characterised in that the lift cage (20) is connected with a counterweight moved in the lift shaft (10) in opposite sense to the lift cage (20), wherein the primary part (40) of the drive motor (30) is arranged at the counterweight in addition to or instead of at the lift cage (20) and/or guide means (21, 22) for guidance of the lift cage (20) in the lift shaft (10) are provided.

18. Lift according to one of claims 1 to 17, characterised in that to obtain an approximately constant propulsive force (F_v) the primary part (40) comprises at least two single-phase excitation modules (41, 41b, 41c, 41d) which are arranged adjacent to one another or one after the other in the direction (x) of movement of the lift cage (20) and produce a magnetic flux (M) running transversely to the direction (x) of movement of the lift cage (20) and the supply voltages of which are displaced by a predetermined phase angle.

19. Lift according to claim 18, characterised in that three excitation modules (41a, 41b, 41c) are arranged one after the other in the direction (x) of movement of the lift cage (20), the supply voltages of the modules being displaced by a phase angle of in each instance 120° , or that four excitation modules (41a, 41b, 41c, 41d) are arranged one after the other in the direction (x) of movement of the lift cage (20), the supply voltages of the modules being displaced by a phase angle of in each instance 90° .

20. Lift according to one of claims 18 and 19, characterised in that the excitation modules (41, 41b, 41c, 41d) are arranged in at least two groups (G_1 , G_2), wherein the supply voltages of the excitation modules (41a, 41b, 41c, 41d) within a group (G_1 , G_2) are displaced each time by a phase angle of at least 90° and wherein the supply voltages of the excitation modules (41a, 41b) of the first group (G_1) are displaced relative to the supply voltages of the excitation modules (41c, 41d) of the second group (G_2) by a phase angle of 45° .

21. Lift according to one of claims 18 to 20, characterised in that excitation modules (41a, 41a; 41b, 41b; 41d, 41d) of like phase are arranged in a centre section of the drive

motor (30) one after the other in the direction (x) of movement of the lift cage (20) and/or that excitation modules (41a, 41b) of unequal phase are arranged adjacent to one another in a transverse direction (y), which is perpendicular to the movement direction (x), of the lift cage (20).

22. Lift according to one of claims 18 to 21, characterised in that excitation modules (41a, 41a; 41b, 41b; 41d, 41d) of like phase are combined into a unit which corresponds with twice or a multiple of the length of other excitation modules (41b, 41a; 41c) of the drive motor (30) and/or that a regulation of the current strength (I_a , I_b) supplied to the excitation modules (41a, 41b) is carried out, wherein the current strength (I_a , I_b) of the excitation modules (41a, 41b) is regulated in such a manner that the course of the propulsive force (F_{va} , F_{vb}) produced by the excitation modules (41a, 41b) has each time the square shape of a sinusoidal oscillation.