

Lift installation with a braking device and method for braking and holding a lift installation

The present invention relates to a lift installation with braking equipment and to a method for braking and arresting a lift installation, according to the definition of the independent patent claims.

A lift installation comprises a lift cage which moves in vertical direction within guide tracks or guide rails. The lift cage is in the case of need braked or held at standstill by braking equipment. For holding or braking the lift cage a braking force is required. The braking equipment for that purpose usually utilises at least two brake units which when required press at least one brake lining against a counter-surface. This pressing is effected by means of a normal force. The braking force of a brake lining is determined by the normal force together with the coefficient of friction defined by the brake lining, the counter-surface and any intermediate layers. The counter-force is usually defined by a surface of the guide track or the guide rail.

DE 3934492 shows braking equipment for a lift cage which in the case of braking engages the guide rail, wherein the braking force is regulated by means of an acceleration sensor. The braking force in that case is applied by a spring, wherein in the case of a too-high deceleration value the braking force can be reduced or, in the case of too-low deceleration, amplified by a regulable magnet.

A disadvantage of this equipment resides in the fact that the brake equipment is not designed for holding a lift cage in a stopped position, such as, for example, at a regular stop at a floor. In addition, the braking equipment is set to a fixed value which is predetermined by the spring and which in the working case is either moved towards as quickly as possible, which leads to a significant transient process, or which in the working case is moved towards slowly, controlled by the counter-force of the stroke magnets, whereby the speed in the case of a fully laden cage disadvantageously increases. Moreover, the regulable magnet is expensive and heavy, it additionally absorbs a large amount of power, and monitoring of the operational readiness of the equipment can be difficult to carry out. The power requirement is high because the maximum possible braking force to be applied by the braking equipment is oriented towards a freely falling, fully laden cage. However, as a rule, for example in the case of braking from excess

speed, a cage which is unladen or laden only to a small extent is braked. In this connection, only small braking forces are required.

Example:

A typical stroke magnet produces, in the case of a power requirement (PM) of up to 4000 W, a stroke force / thrust force (FM) of approximately 1500 N. With the assumption of a lever translation (i) of 3 and a coefficient of friction (μ) of 0.2 there results according to

$$\text{FBR} = \text{FM} \times i \times \mu \times 2$$

a braking force regulating range (FBR) of +/- 1800 N per brake housing, or in the case of two brake housings a regulating range (FBR2) of +/- 3600 N results. The weight of a corresponding stroke/thrust magnet amounts to up to 50 kg or for two magnets up to 100 kg. With consideration of an additional spring per brake housing, which produces a braking force in each instance of 5000 N, a total braking force of 10,000 N with a braking force regulating range of +/- 3600 N thus results in the case of two brake housings. A braking installation with low braking forces of that kind is merely sufficient for safety braking of a cage with a total weight of about 1000 kg (useful load 480 kg and cage mass 520 kg). The weight of this lift cage is in that case increased by approximately 10% and the necessary electrical regulating power is up to 2 x 4 kW.

US 5 323 878 discloses a further braking equipment with two brake units. The brake units are arranged in the region of a drive engine. The braking forces are transmitted by way of support elements from the drive engine to the cage. The braking force of each brake unit is determined by a brake control unit with consideration of the cage speed or cage load. In the mentioned example, the braking force is produced by means of a spring, wherein a hydraulic piston force counteracts this spring. This embodiment corresponds with a currently usual, safer mode of construction, since in the case of failure of the hydraulic system the springs brake with their maximum possible force. The requisite hydraulic piston force of each brake is calculated by a brake control unit with consideration of the cage speed or cage load and hydraulically controlled. The hydraulic piston force must in that case be established with consideration of brake-specific characteristics, such as piston diameter, spring force or installation geometry of each brake unit.

A disadvantage of this equipment resides in the fact that relevant influencing factors, which influence the braking force, are not recognised and not taken into consideration. A defect of a spring, wear of a brake lining or jamming of brake levers can lead to a relevant influencing of the braking force, which is not recognised. Moreover, the brake control unit must take into consideration brake-specific characteristics, such as piston diameter, spring force or installation geometry, of each brake unit, since the brake control unit presets the hydraulic piston force for each individual brake unit. These disadvantages potentially increase the susceptibility to fault in the case of installation and in the case of replacement as well as in operation; hence the brake-specific characteristics of each brake unit have to be input at the brake control unit.

The object of the present invention is accordingly to provide regulable braking equipment and a method for braking and holding a lift cage, which enables retardation or holding in correspondence with the operational state of the lift installation and responds quickly and in gentle manner. The braking equipment must, in addition, fulfil high safety demands and it shall be able to be operated with lower power and have little additional weight. The susceptibility of the braking equipment to fault shall, moreover, be low.

This object is fulfilled by the invention as illustrated in the independent claims.

According to the invention each brake unit comprises a normal force regulation which regulates an effective normal force in correspondence with a target normal force value determined by a brake control unit and/or each brake unit comprises a locking device which can lock the brake unit in a set braking position corresponding with a set effective normal force.

The solution according to the invention has the advantageous effect that each brake unit has an own normal force regulation, which regulates an effective normal force in correspondence with a target normal force, so that an own target normal force can be associated with each brake unit. The brake unit itself can thus quickly and accurately set a normal force and thus independently correct deviations in the region of the brake unit, such as geometric deviations (for example, wear of a brake plate or different dimensions of brake rails), by a regulating process. Susceptibility of the overall braking equipment to fault is thereby significantly reduced. Replacement of a brake unit is possible in simple manner, since the brake-specific characteristics, such as piston diameter, spring force,

installation geometry or other constructionally determined data, of the brake unit are taken into consideration in the brake unit itself and thus complicated inputs, which are susceptible to error, of these brake-specific characteristics at the brake central unit are eliminated.

Depending on the braking force requirement an energy-saving and secure normal force distribution or a presetting of the target normal force per brake unit is selected by the brake control unit. The braking force requirement results from an operational state of the lift installation such as, for example, a loading, a travel speed, a location in the lift shaft, an acceleration value or other state magnitudes of the lift cage or the lift installation. This allows a particularly gentle braking of the lift installation.

According to the invention, in the case of holding or braking a set braking position can be locked. In that case a set effective normal force is locked. This enables holding or braking of the lift cage without further feed of energy.

The illustrated solutions enable braking or holding of the lift cage in correspondence with the operational state of the lift installation and the equipment can be rapidly, but nevertheless gently, brought into engagement. The solutions fulfil high safety demands and need little power. The susceptibility of the braking equipment to fault is low.

Further refinements and advantages of the invention follow from the dependent subclaims.

Embodiments of braking equipment according to the invention are illustrated by way of example in the following figures.

Fig. 1 a lift installation with braking equipment.

Fig. 2 a schematic illustration of the braking equipment.

Fig. 3 a brake unit with normal force regulation.

Fig. 4 a brake unit with locking device.

Fig. 5 a brake unit with a different locking device.

Fig. 6 a brake unit fastened by means of slide pins and bracket.

Fig. 7 a brake unit fastened by means of resilient element and bracket.

A lift installation 1 consists at least of a lift cage 2 and a lift drive 10. As illustrated in Fig. 1, a lift installation 1 by way of example further requires support means 11 and a counterweight 12, wherein the lift drive 10 drives the support means 11 and thus moves the lift cage 2 and the counterweight 12 in diametrical opposition. The lift installation 1 requires at least one braking equipment 13. The braking equipment 13 holds a stationary lift cage 2 - for example, during the loading time at a floor 6 - or it brakes the lift cage 2 in an emergency situation - for example, in the case of unexpected opening of the floor access - or it effects safety braking - for example, in the case of failure of a support means 11 - of a lift cage 2 which is too fast. These different load cases require different braking or holding forces F_B .

Fig. 2 shows a variant of a braking equipment 13, which consists of a brake control unit 15 with energy supply 43 and - in the illustrated example - four functionally identical brake units 14. Functionally identical means that the brake units have the same functional structure, but can be completely different in correspondence with their geometric dimensions. Each brake unit 14 has a brake force measuring means 36, 37. The energy supply 43 supplies the brake control unit 15 and the brake units 14 with a secure voltage U_B . Lift control 5 and measuring sensors 20, 21, 22 and 23 deliver required lift signals to the brake control unit 15. The brake control unit 15 supplies individual brake units 14 with individual target presets $S_{B1} \dots i$. In Fig. 2, 1 to i stands for the individual brake units 14. A target presetting S_{Bi} is, for example, a target normal force F_{N-soll} or a target air gap 30. These presets S_{Bi} are transmitted to the associated brake unit. The brake unit 14 processes this target preset in own regulating blocks 16, 28 F_N , S_N , which operate with known regulating technologies. The brake units 14 supply effective state magnitudes $Z_{B1} \dots i$ back to the brake control unit 15. Effective state magnitudes $Z_{B1} \dots i$ can in turn be an effective normal force F_{N-eff} or an effective air gap 30. In the illustrated example each brake unit 14 has a brake force measuring means 36, 37, which establishes an effective braking force $F_{B1} \dots i$ and communicates this value to the brake control unit 15. The brake control unit 15 has in the illustrated example additionally a safety module 44.

The braking equipment 13 according to the invention is provided for the afore-mentioned different load cases. The braking equipment 13 consists, as illustrated in Fig. 1 and Fig. 2, of at least two brake units 14 and each brake unit 14 comprises a normal force regulation 16, wherein this normal force regulation 16 regulates an effective normal force F_{N-eff} in the brake unit 14 in correspondence with a target preset S_{Bi} of the target normal force F_{N-soll} , which is predetermined by a brake control unit 15.

The advantage of this normal force regulation 16 is that the brake unit itself can rapidly and accurately set a desired normal force and deviations in the region of the brake unit 14, such as, for example, wear or dimensional differences of the brake unit or a brake rail 9, can be rapidly and directly, i.e. within the brake unit itself, corrected. The susceptibility of the braking equipment to fault is significantly reduced, since compensation for dimensional influences such as rail thickness, brake plate wear or other areas of wear can be directly provided within the brake unit. Moreover, in the case of repair a replacement is possible in simple manner, since the characteristics, which are specific to brake unit, of the normal force regulation contained in the brake unit are directly, i.e. within the brake unit itself, detected and corrected.

The brake control unit 15 knows the current state of the lift installation 1 by way of the reports from a lift control 5 and/or a corresponding monitoring unit and/or from own measuring sensors 20, such as, for example, acceleration measuring sensor 21, speed measuring sensor 22 or travel measurement 23 and can undertake on the basis of this knowledge a suitable target presetting S_{Bi} of the normal force F_{N-soll} for the individual brake units 14. Thus, for example, the brake control unit increases the target preset S_{Bi} of the normal force F_{N-soll} near the shaft end so as to enable, if need be, shortened shaft ends. The brake control unit is advantageously arranged, as illustrated in Fig. 1, on the cage, if required in combination with further control or safety modules. Measuring and monitoring systems such as described in, for example, WO 03/004397 are advantageously integrated in a safety module of that kind.

This enables the provision of braking equipment 13 which can hold or brake, depending on the load case, by a corresponding braking force F_B , which is dependent on the effective normal force F_{N-eff} . The brake control unit 15 determines, with consideration of the instantaneous stage of the lift installation 1, the optimum use of the brake which is most appropriate to the user and the most sparing. Thus, a braking start value can be

calculated on the basis of state magnitudes ascertained by the measuring sensors 20, 21, 22 and 23, whereby a target value S_{BI} can be predetermined. The advantage of this braking equipment 13 according to the invention is to be seen in that a secure braking or holding, which is appropriate to need, of the lift cage 2 is made possible with minimal expenditure of energy.

According to the invention the brake unit 14, as illustrated in Figs. 4 and 5, has a locking device 17 which can lock the brake unit 14 in a set braking position corresponding with an effective normal force F_{N-eff} . On application of the normal force a movable brake plate 27 is adjusted. In that case the housing of the brake unit 14 is expanded in the elastic region. In the case of need the housing of the brake unit 14 can be provided with special resilient devices, for example with springs (not illustrated), which assist this expansion. The locking device 17 now locks this stressed braking position, for example by a locking pin 18, 18a as illustrated in Fig. 4 or 5. This locking makes it possible to ensure a sufficient holding or braking force F_B over a long standstill time with smallest or without expenditure of energy.

The advantage of this alternative or supplementing embodiment of a brake unit 14 is to be seen in that a secure braking or holding of the lift cage with minimal expenditure of energy is made possible and that by means of the locking device 17 not only a specific braking force setting can be locked, but substantially any set braking position and thus braking force level can be secured.

In a preferable embodiment of the locking device 17 of the brake unit 14 this locking device 17 is constructed in such a manner that a set braking position is maintained with interrupted energy feed. The locking pin 18 is, for example, brought by means of a control magnet 19 into its locking position or into its open setting. This embodiment is advantageous, since the brake unit 14 is thereby held in a secure holding position even in the case of an energy interruption of long duration. An energy interruption of long duration can arise not only unintentionally as a consequence of a supply fault, but can also be intentionally produced when, for example, individual lifts are shut down with buildings not fully occupied. The illustrated embodiment in that case has the advantage that it can be unlocked again only by means of an energy source, which increases security against incorrect operation.

Depending on the selected safety concept the locking, as illustrated in Fig. 5 in the case of an energy failure, takes place independently, wherein the last, instantaneous braking or holding position is secured. This takes place in the illustrated example in that the locking pin 18 is brought by means of spring force into its locking setting and held by means of a control magnet 19 in the open setting. Another safety concept proposes that, as apparent in Fig. 4, the self-securing locking pin 18a is held open by means of a spring and locked by means of a control magnet 19. This solution is advantageously designed in such a manner that the self-securing locking pin 18a in engaged state is locked by the brake counter-pressure and accordingly can be brought by the spring into the open setting only when a brake adjusting moment is present and the self-securing locking pin 18a correspondingly does not have to bear any locking force. The illustrated alternatives allow a selection, which is matched to the overall safety concept, of the appropriate embodiment.

In a further form of embodiment the effective normal force F_{N-eff} is established by means of measurement of the mechanical stress of the housing of the brake unit 14, for example by means of strain measuring gauges (SMG) 25 as illustrated in Figs. 4 and 5, or by a force measuring cell 24, as illustrated in Fig. 3, or by means of fixing a clamping path of the movable brake plate 27 of the brake unit 14 or of an energy value, such as current value or a pressure value, corresponding with the adjustment energy. The selection of the suitable normal force dimension F_{N-eff} is oriented inter alia to the form of embodiment of the brake unit 14. In the case of selection of an electromagnetic brake unit 14 the normal force F_N can be ascertained from the measurement of the electrical adjusting magnitudes, such as voltage and current, or in the case of use of a hydraulic brake unit 14 the pressure in the brake cylinder is a measurement magnitude for determination of the normal force F_{N-eff} . A favourable method for determination of the normal force F_{N-eff} can be used in dependence on construction.

Advantageously the brake control unit 15 takes into consideration an operational state of the lift installation 1, such as, for example, the acceleration, speed, loading and load distribution in the lift cage 2, the travel direction or the location of the lift cage 2, and/or a state of the brake unit 14, such as, for example, wear of brake plates 26, 27, and/or of the braking equipment 13, such as, for example, energy reserves or deviations of measuring magnitudes for determination of the target preset S_{Bi} of the target normal force F_{N-soll} . Thus, for example, in the case of a lift cage 2 which has strong eccentric loading the target

normal force F_{N-soll} can be increased or reduced for a specific brake unit 14. If merely a low braking force F_B is required, the braking of a brake unit 14 or a group of brake units 14 can be undertaken. In that case it is particularly advantageous that on the one hand a braking can be carried out appropriately to need and efficiently and that on the other hand, through selective distribution of the requisite braking forces, maximum braking situations referred to individual brake units 14 can be achieved. This increases the overall safety of the lift installation, since the functional capability of a brake unit 14 in continuous operation can be actively controlled. The risk of damage at standstill is thereby significantly reduced.

An embodiment of the braking equipment 13 proposes that the brake unit 14, as apparent in Figs. 2 to 5, comprises an adjusting regulation 28. The adjusting regulation sets, for example, a desired air gap 30 on the basis of a target preset S_{Bi} of the brake control unit 13. Moreover, the brake unit 14 comprises an adjustment control by means of which brake plate wear and/or departures from a normal behaviour of the brake unit 14 can be ascertained. This embodiment makes it possible for the brake unit 14 to be able to set a sufficiently large air play 30, whereby compensation can be provided for inaccuracies in the guide track 9 of the lift cage 2 - grazing noises of the brake plate 26, 27 with the guide tracks 9 are eliminated - and the brake unit 14 can selectively reduce the air gap 30 in advance of anticipated use of a brake - which enables rapid response of the brake unit 14 - as well as the exact point of brake use can be determined by establishing the rise in normal force, which makes it possible to establish the brake plate wear. The brake unit 14 reports the ascertained state magnitudes Z_{Bi} , adjustment travel and normal force rise to the brake control unit 15 and/or a corresponding safety module 44, which can thereby establish the correct function or which can define, if required, suitable corrective presets S_{Bi} . The safety and serviceability of the braking equipment 13 are improved.

A further embodiment of a brake unit 14 proposes that a movable brake plate 27 of the brake unit 14 is adjusted by means of an adjusting regulation 28 and the movable brake plate, as illustrated in Fig. 4, is retracted by means of a retraction system in correspondence with an adjustment position defined by the adjusting regulation 28. This is realised, for example, in that a spring mechanism 31 retracts the brake plate, i.e. draws it into open setting, and an adjusting drive 29 actuated by the adjusting regulation 28 adjusts the movable brake plate 27. This embodiment allows a simple and safe construction, since the adjusting drive 29 is always loaded in pressure. The force to be applied by the spring mechanism 31 is in that case small, since it merely has to overcome internal

frictional forces of the adjusting drive 29 and the brake plate guide. Alternatively, the movable brake plate 27 of the brake unit 14 is, as illustrated in Fig. 5, preloaded by means of brake compression springs 39. In the case of normal travel operation of the lift cage 2 the adjusting drive 29 holds the brake open against the adjusting force given by the brake compression springs 39. In the case of closing, the normal force (F_N) increases in correspondence with the force of the brake compression springs 39. This enables an increase in the braking force (F_B) of a brake unit 14 without the necessity of a stronger adjusting drive 29. The construction of the measuring of the effective and real normal force (F_{N-eff}) is also selected in dependence on the constructional execution of the adjusting drive.

Advantageously, the adjusting drive 29 moves the movable brake plate 27 directly perpendicularly to the brake surface, as apparent in Figs. 3 to 7. The application of force in that case directly enables an economic embodiment of a brake unit 14. Alternatively, the adjusting drive 29 moves the brake plate 27 indirectly by way of a wedge relative to the brake surface (not illustrated), wherein the wedge angle (α) used by the wedge is greater than the 'friction angle $\tan(\mu)$ '. The use of a wedge increases the normal force able to be applied by the adjusting drive 29. Since the wedge angle used by the wedge is greater than the friction angle, the adjusting drive 29 is always loaded in one direction and dragging in of the brake plate 26 is precluded. In a special form of embodiment the wedge angle changes over the adjusting travel. This embodiment enables, in particular, a rapid adjustment of the brake plate.

The adjusting drive is preferably an electromagnetic spindle drive 32. A spindle drive 32 enables, through the selection of the spindle shape and the spindle pitch, an optimum force amplification and an electric motor 33 can be used for application of the required actuating force. The electric motor 33 is preferably connected with the spindle by way of a gear stage 34, for example by way of the planetary gear, as apparent in Figs. 3 and 4. This form of embodiment is particularly reliable and robust, since proven functional elements are used and the drive moments at the motor 33 are kept small. In another example illustrated in Fig. 5, a spur wheel gear is used as gear stage 34. This enables, in particular, use of a very economic motor 33. The locking device 17 can be released particularly advantageously in the case of use of a spindle drive 32, since the adjusting position is locked in particularly simple manner by means of a locking of the spindle drive 32 or of the spindle nut.

A typical brake unit constructed in that manner has a weight of approximately 15 kg and the achievable normal force F_N amounts to approximately 25 kN. The necessary average power for actuation of a brake unit in that case amounts to less than 0.2 kW. The advantage of the power and weight saving relative to the state of the art is obvious, although incomparably higher normal forces and higher braking forces resulting therefrom can be achieved.

A further variant of embodiment proposes, as is illustrated in simplified form in Figs. 6 and 7, that a force measuring device 36, 37 measures the braking force or holding force F_B generated by the brake unit 14. The measurement is carried out by means of, for example, a force measuring cell 36 or a force measuring ring, which is integrated in the fastening of the brake unit to the cage 2, or the fastening is provided at a suitable place with a strain measuring device 37. The suitable place is determined on the basis of the force flow. In the case of a preferred solution, as illustrated in Fig. 6, the brake unit 14 is fastened to the cage 2 by means of a slide pin 38, wherein the slide pin 38 at the same time has integrated measuring cells 37 which measure the braking or holding force F_B . The slide pin 38 additionally makes it possible for the brake unit 14 to be able to be laterally aligned. The advantage of measuring the braking force or holding force F_B resides in the fact that departures from expected behaviour can be recognised and suitable measures can be taken. For example, an instantaneous coefficient of friction can be ascertained with knowledge of the braking force F_B and the effective normal force F_{N-eff} . A deviation of the friction value in the case of several brake units 14 allows the expectation that a change at the brake rail 9 has taken place (contamination, oil fouling, etc.), which initiates an appropriate control activity or cleaning. A deviation of the friction value in the case of an individual brake unit 14 signifies that contamination or wear of an individual brake lining 26, 27 is present. If a value of the adjusting regulation 28 is taken into consideration together with these evaluations there results a very accurate picture of a state of the brake unit 14, which improves maintenance possibilities and increases safety. Since these evaluations take place in the case of each use of braking, a fault can be recognised at an early point in time, which in turn increases the safety of the entire system for an emergency case. Moreover, measurement of the braking/holding force (F_B) at a stop enables, if need be with consideration of the location of the lift cage 2 in the shaft 4, determination of the loading of the lift cage.

In an advantageous development of the invention the deceleration or acceleration of the lift cage 2 is ascertained by an acceleration measuring sensor 21. This enables on the one hand establishing of an abnormal operational situation and moreover enables comfortable braking, which is suitable for the user, in the case of need. Moreover, measurement of the acceleration or deceleration of the lift cage together with measurements of the braking force measuring cell 35 and/or of the normal force measurement 24, 25 enables a plausibility check of the determined data, which enhances the reliability of the braking equipment.

The braking equipment 13 is usually, as apparent in Fig. 1, arranged at the lift cage 2, wherein the brake units 14 are installed below and/or laterally of and/or above a cage body. The location of the installation is determined with consideration of the constructional embodiment of the cage 2 as well as the number of necessary brake units 14. The brake units 14 act on the guide track 9 or a brake track or a brake cable.

Advantageously, the brake unit 14, as illustrated in Figs. 6 and 7, is attached to the cage 2 by means of a bracket 40, wherein the bracket 40 enables distribution of the air gap 30 to the brake surfaces and the connection of the bracket 40 to the brake unit 14 is effected by means of an element 41, which is resilient or freely movable in the direction of the air gap 30, and substantially rigid in the direction of the braking force. The element 41 is set in such a manner that a desired horizontal air gap 30 arises in the readiness setting of the brake unit 14.

In the case of lift installations 1 it is desired that the lift cage 2 moves with play relative to its guide tracks 9. This enables absorption of shocks or unevennesses of the guide tracks 9. The illustrated embodiment makes it possible to prevent, with little effort, contact of the brake plates 26, 27 with the guide tracks 9.

In an alternative or supplementing embodiment illustrated in Fig. 7 the brake unit 14 is guided by means of at least one horizontal guide element 42, which is arranged in the vicinity of the brake plate 26, 27, in such a manner that a small air gap 30 can be set, wherein the guide element 42 produces a horizontal displacement of the brake unit 14 relative to the bracket 40 and this displacement is made possible by the resilient or a freely movable element 42 and the horizontal guide element 42 is constructed either rigidly or resiliently. This embodiment permits a brake unit 14 which operates with minimum air

paths 30. The brake unit 40 can thereby react more quickly, since only small adjusting travels are required for braking, and at the same time the adjusting drive 29 can be of simpler construction, since smaller adjustment travels are required. The brake unit 14 is more economic and safety is increased. A quicker reaction of the brake unit enables shortening of the stopping travel of the lift cage, which is helpful particularly in the case of the use of shortened shaft ends.

In an alternative embodiment the brake control unit 13 controls in drive, independently of the operational state, all brake units 14 together or merely groups of brake units 14, wherein the allocation of a brake unit to a group is variable. This embodiment enables, even with a small requirement of braking force, individual brake units 14 to be strongly loaded and thus an active detection of function takes place, whereby the functional safety of the braking equipment 13 is increased. Moreover, this drive control is energy-conscious, since only the required number of brake units 14 is actuated. A further advantage of this solution is that the load cycles of the individual brake units 14 and, in particular, of the locking device 17 are reduced, which correspondingly prolongs the service life or the maintenance intervals of the entire braking equipment 13.

In a supplementing alternative the energy supply 43 of the braking equipment 13 consists of at least two separate energy stores and/or energy mains (redundant) and the energy store and/or energy mains form, together with groups of brake units 14, a multi-circuit braking system.

The energy stores can be provided in the form of, for example, accumulators or super-capacitors and the energy mains can be provided by the local mains or by local energy generators, such as emergency power apparatus, driven generators. The illustrated alternative enables arrangement of independently functioning brake units 14. Alternatively, the energy sources are connected together to form a secure energy mains which supplies all brake units 14 in common. The solutions enable selection of the most economic braking equipment 13, which is matched to the local energy situation and which is safe and reliable.

Advantageously, the braking equipment comprises a safety module 44, which safety module 44 monitors the correct functioning and/or the state of each brake unit 14 and/or of the brake control unit 13 and/or of the measuring sensors 20, 21, 22 and 23 and/or of the

energy supply 43, wherein the safety module 44 is a constituent of the brake control unit 15 or an own component. The safety module 44 ensures the functional readiness of the braking equipment 13 as well as efficient maintenance and fault diagnosis. The safety of the braking equipment 13 is increased.

The braking equipment 13 enables wide-ranging optimisations of a lift installation. Thus, for example, with use of this braking equipment 13 it is possible to substantially simplify a function test program. It is usual today to test a braking system with fully laden or overloaded cage 2. This is expensive and overloads the lift installation 1 beyond the normal. With the equipment according to the invention the function test program can be simplified. The braking equipment 13 allows, for example, establishing an effectively present coefficient of friction on the basis of a few tests with empty cage 2. With knowledge of the maximum allowed load the braking equipment 13 can calculate a required normal force F_N and the braking equipment 13 can check by means of the normal force measurement 24, 25 whether the required normal force F_N can be achieved with sufficient safety. This enables simplification of the test sequence.

Further refinements of the invention are possible. Thus, the braking force measurement can be used for determination of the load at a stop, a drive moment required for starting off can thereby be ascertained in simple manner or the braking force measurement can be used for determination of the instant of departure. Moreover, a gear stage 34 for driving the spindle can be, for example, a worm gear. Obviously, in the case of need the braking equipment 13 can also be used for protection of a counterweight or it can be arranged as a drive brake at the drive, for example at the drive pulley. The lift installation is vertically arranged in the regulating case. The braking equipment according to the invention can, however, also be installed at other kinds of transport devices, such as, for example, rail transport systems, horizontal transport systems such as cable railways or transport belts.

Patent Claims

1. Lift installation with a braking equipment, the lift installation comprises a lift cage which moves in vertical direction within guide tracks, the lift cage in the case of need is braked by the braking equipment or held at standstill, wherein the braking equipment consists of at least two brake units, characterised in that each brake unit comprises a normal force regulation, which regulates an effective normal force F_{N-eff} in correspondence with a target normal force F_{N-soll} determined by a brake control unit.
2. Lift installation according to claim 1, characterised in that the normal force regulation establishes the normal force F_{N-eff} by means of a measurement of the mechanical stress of the housing of the brake unit, or a brake measuring cell or a clamping travel of a brake plate of the brake unit or an energy value, such as a current value or a pressure value, corresponding with the adjusting energy.
3. Lift installation according to any one of the preceding claims, characterised in that the brake control unit takes into consideration at least one of an operational state of the lift installation, a state of the brake unit and a state of the braking equipment for determination of the target normal force F_{N-soll} .
4. Lift installation according to any one of the preceding claims, characterised in that the brake unit consists of electromagnetic components and comprises an adjusting regulation, by means of which an air gap predetermined by the brake control unit can be set, and the electromagnetic brake unit comprises an adjusting check, by means of which brake plate wear and/or departures from a normal behaviour of the brake unit can be ascertained.
5. Lift installation according to any one of the preceding claims, characterised in that the brake unit comprises at least one movable brake plate, which is adjusted by means of an adjusting regulation, and the brake unit comprises a retraction system, which in correspondence with the adjusting position defined by the adjusting regulation retracts the brake plate.
6. Lift installation according to any one of the preceding claims, characterised in that the movement of the movable brake plate is effected by an adjusting drive, which is

regulated by means of the adjusting regulation, and the adjusting drive moves the brake plate directly perpendicularly to the brake surface or the adjusting drive moves the brake plate indirectly by way of a wedge relative to the brake surface, wherein the wedge angle (α) used by the wedge is greater than the 'friction angle $\tan(\mu)$ ' and/or that the wedge angle (α) changes over the adjustment path.

7. Lift installation according to any one of the preceding claims, characterised in that the adjusting drive is an electromagnetic spindle drive, wherein the spindle if required is actuated by way of a gear stage.

8. Lift installation according to any one of the preceding claims, characterised in that the brake unit comprises a locking device, which in correspondence with an effective normal force $F_{N\text{-eff}}$ can lock the brake unit in a set braking position.

9. Lift installation according to claim 8, characterised in that the locking device locks the brake unit and maintains a set braking position in the case of interrupted supply of energy.

10. Lift installation according to claim 8 or 9, characterised in that the brake control unit takes into consideration at least one of an operational state of the lift installation, a state of the brake unit and a state of the braking equipment for actuation of the locking device.

11. Lift installation according to claim 8, 9 or 10, characterised in that the locking device consists of a locking pin, which can be brought by means of a control magnet and/or a spring into a locking position or into an open setting, wherein the locking pin in the locking position locks a stressed braking position of the braking unit.

12. Lift installation according to claim 8, 9, 10 or 11, characterised in that the locking pin is a self-securing locking pin, which is locked in the locking position by a brake counter-pressure and the locking pin can be brought into the open setting only when a brake adjusting force is present.

13. Lift installation according to any one of the preceding claims, characterised in that the braking equipment is arranged at the lift cage and that at least one of the brake units is installed either below a cage body or laterally the cage body or above the cage body.

14. Lift installation according to any one of the preceding claims, characterised in that the brake units act on the guide track or a brake track or a brake cable.

15. Lift installation according to any one of the preceding claims, characterised in that the brake control unit, depending on the operational state, controls all brake units together or controls groups of brake units, wherein the allocation of a brake unit to a group is variable.

16. Lift installation according to any one of the preceding claims, characterised in that the energy supply of the braking equipment consists of at least two redundant energy sources whereby each of the energy sources consists of an energy store or energy main.

17. Lift installation according to any one of the preceding claims, characterised in that each of the energy sources together with groups of brake units forms a multi-circuit braking system or
that the energy sources are connected together to form a secure energy main which supplies all brake units in common.

18. Lift installation according to any one of the preceding claims, characterised in that the braking equipment comprises a safety module, which safety module monitors at least one of the state of each brake unit, the state of the brake control unit, the state of the measuring sensors or the state of the energy supply.

19. Lift installation according to any one of the preceding claims, characterised in that, the safety module is a constituent of the brake control unit or an own component.

20. Method of braking and holding a lift installation with braking equipment, the lift installation comprises a lift cage which is moved in vertical direction within guide tracks, the lift cage is, if required, braked by the braking equipment or held at standstill, wherein the braking equipment consists of at least two brake units, characterised in that each brake unit comprises a normal force regulation, wherein an effective normal force (F_{N-eff}) is set in correspondence with a target normal force value (F_{N-soll}) determined by a brake control unit.

21. Method of braking and holding a lift installation according to claim 20 characterised in that the brake unit comprises a locking device, wherein the brake unit is locked in a set braking position corresponding with a set effective normal force (F_{N-eff}).