

**Catch device with an energy accumulator element**

The present invention relates to a safety brake device which is, for example, a component of a safety device for lift equipment. In this connection, the safety brake device serves for fixing a lift cage to a guide rail. Moreover, the present invention relates to a safety device with a corresponding safety brake device, to lift equipment with a corresponding safety device and to a method for actuating a safety brake device according to the invention.

Lift equipment usually comprises a lift cage and at least one counterweight, which are moved in opposite sense in a lift shaft. The lift cage and the at least one counterweight in this regard run in or along guide rails. For reasons of safety, lift equipment is usually equipped with a safety brake device which is part of a safety device. The safety brake device engages the guide rails of the lift cage and/or of the counterweight. The speed of movement of the lift cage or of the counterweight is thereby slowed down or reduced to zero by fixing of the safety brake device to the guide rail. Triggering of the brake or fixing is carried out by means of a speed limiter device which constantly monitors and limits the speed of the lift cage or of the counterweight.

This limitation of the speed is carried out, for example as disclosed in patent specification EP-B1-1 298 083, by coupling the lift cage or the counterweight with a limiter cable of the speed limiter by means of a linkage and lever mechanism. The limiter cable is guided in the shaft head over a cable pulley of the speed limiter and in the shaft pit over a return roller. During travel, the lift cage drives the limiter cable and the speed of the lift cage is monitored by the speed limiter via the limiter cable. In the case of excess speed of the lift cage the speed limiter blocks the cable pulley, in which case the lift cage drags the limiter cable over the cable pulley. By the friction at the cable pulley the limiter cable actuates the lever mechanism at the lift cage and engages the safety brake device in that the limiter cable exerts, by way of the linkage and lever mechanism, a tension on the safety brake device arranged at the lift cage. This tension in turn brings one or also two wedge-shaped and roller-mounted brake shoes of the safety brake device into a first (frictional) contact setting at the guide rail. A spring column, which is formed from plate springs and which is arranged opposite the brake shoes in a pincer-like double-lever construction, is thereby in turn activated. It is thus achieved that the tension force in the linkage and lever mechanism is not the actual braking force, but only the triggering force for the safety brake device. The effective braking force is exerted by, in particular, the spring column. The

same way of functioning applies to the counterweight. Monitoring of the cage speed can also be carried out, for example, electronically and the safety brake device triggered, for example, electromagnetically. The traditional mechanical speed limiter and the traditional limiter cable are redundant in this last-mentioned variant.

Patent specification US-2 581 297 discloses a safety device with a similarly constructed safety brake device, in which the braking force is generated by a spiral spring.

However, these known safety brake devices have the following disadvantages:

- The force store element, be it a spring column formed from individual plate springs as in EP-B1-1 209 083 or a helical spring as in US-2 581 297, has no safety reserves.
- Failure of this single force store element has the consequence of failure of the safety brake device.
- There are countries having safety regulations for safety-relevant parts in lift equipment which prescribe a safety reserve which would not be fulfilled by the two known safety brake devices.
- The manner of functioning of the safety brake device can be optimised with respect to preservation of material, the course of the braking force and thus the deceleration sensed by lift users in the lift cage.

According to the invention the mentioned disadvantages could be eliminated on the one hand by the arrangement of at least two force store elements instead of only one and on the other hand by optimisation of the overall path of the force/travel characteristic curve. Moreover, in correspondence with the invention the force store elements can be selected to be different in such a manner that the individual characteristic curves thereof are complementary in a specific manner. Beyond that, it is a feature of the invention that in the design of a safety brake device according to the invention a washer projecting beyond the outer diameter of the force store elements is arranged between the different force store elements. This washer, after a defined degree of compression of the first, weaker force store element, impinges on the end edge of a cylindrical housing which is open at one end and surrounds the weaker force store element. In accordance with the invention it is achieved in this mode and manner that the two force store elements are preserved, because they work only in a region allocated thereto. Moreover, the weaker force store element is no longer loaded to its maximum. A further advantage of the design according to the invention is a more comfortable, gentler response of the safety brake device. The

braking force builds up in steps and is not supplied, as in the past, with whole maximum force. In addition, failure of the (first, weaker) force store element means only loss of the just-described increase in comfort and material preservation and no longer automatically failure of the entire safety brake device.

All kinds of springs come into consideration as force storage elements. In this regard, they can be, in particular, plate springs which selectably form so-called spring columns with plate spring packets assembled in series or also in parallel. However, helical plate springs, spiral springs, leaf springs or gas pressure springs (usually pneumatic) or also hydraulic springs (for example valve chamber springs) or also combinations of all mentioned spring types also come into consideration.

Plate springs basically have a digressive characteristic curve, i.e. with increasing spring deflection the spring rate (spring constant or force storage rate) exponentially decreases. According to the invention plate spring arrangements or force store elements having a progressive characteristic curve (exponentially rising spring rate) are preferred. However, according to the invention the resulting characteristic curve of the force store element combination at least provides a preferably progressive, but at least wholly or even only partly linearly rising, characteristic curve.

The resulting characteristic curve of the force store element combination can be non-constant, i.e. from the point at which the end edge of the cylindrical housing impinges on the washer and thus stops further compression of the first, weaker force store element an abrupt decline in or also rise of the braking force value of the safety brake device can occur. However, a preferred design variant of a safety brake device according to the invention allows the second, stronger force store element to connect, by its characteristic curve, seamlessly with the characteristic curve of the first, weaker force store element so that a constant overall characteristic curve of the force store element combination results.

However, regardless of whether the overall characteristic curve has a non-constant or constant path, the relationship of the force store elements can be so selected that exclusively the first, weaker force store element comes into use in the case of, for example, a faulty control. The second, stronger element thereagainst comes into use only in the case of, for example, a support means breakage and the higher forces connected therewith. This inventive adaptation of the characteristic curves to the possible

disturbance situations opens up the possibility, for example in the case of recording the disturbance situations, of undertaking a more economic exchange or maintenance of only that force store element which was actually affected.

The constancy of the overall characteristic curve can be technically realised in that the second force store element has such a high spring rate that compression of this force store element is permitted only from the point of impinging of the end edge of the cylindrical housing on the washer. In other words, the absolute amount of the absorbed compression force - and thereby caused restoring spring force - at which the first store element drops out is identical with the start-off value of the second force store element. The constancy, but also an increasing monotony, of the overall characteristic curve (substitute spring characteristic curve) can, however, also be realised in that the working regions of the force store elements overlap at least partly so that the sum of the individual characteristic curves gives the desired resultant overall characteristic curve. Moreover, according to the invention influence on the overall characteristic curve is achievable in that the cylindrical housing and/or the washer is or are designed to be resilient.

The cylindrical housing can, moreover, optionally be formed from a disc and a tube. The disc can in this connection for reasons of cost be identical with the washer separating the two force store elements. The cylindrical housing or tube can, in addition, externally surround the force store element, but also be constructed internally as a spacer sleeve. For the weaker force store element it does not matter whether a travel limitation is provided internally or externally.

A further preferred embodiment of a safety brake device according to the invention comprises a biasing device for the force store elements. This can be realised, for example, in a simple and known manner by means of a screw in a threaded sleeve, which are so arranged at a spring pin that rotations of the screw compress or relax the force store elements displaceably mounted at the spring pin. However, this known biasing device in conjunction with the arrangement according to the invention of at least one weaker and at least one stronger force store element is accompanied by the fact that adjusting movements of the biasing device act exclusively or predominantly only on the weaker force store element. Biasing for the second, stronger force store element is - insofar as the force store elements have separate, mutually connected working ranges and do not overlap - possible only if the cylindrical housing impinges on the washer. As a

result in the case of the first, weaker force store element one is no longer in the realm of just any bias, but a bias over the maximum provided stroke.

In order, however, to also be able to bias the second, stronger force store element, a further preferred embodiment of a safety brake device according to the invention provides a spring pin featuring different outer diameters and thus abutments. It is possible with a corresponding biasing device, which separately engages and stresses only the second, stronger force store element, to subsequently achieve a desired amount of bias exclusively for this second, stronger force store element in that, for example, spacer washers are used. These spacer washers impinge on the abutment after release of the biasing device. The spacer washers thus limit or the abutment thus limits relaxation movements, but not compression movements, of the force store element. In order to be able to be subsequently mounted, the spacer washers are preferably formed to be crescent-shaped and can be plugged onto the respective outer diameter of the spring pin. The spacer washers are securable by an enclosure against unintended dropping off. The use in accordance with the invention of a biasing device additionally offers the advantage that in the event of possible disassembly the force store elements can be released from their bias in controlled manner.

The biasing of the first, weaker force store element is then carried out in known manner by actuation of the screw, which engages the spring pin, after biasing of the second, stronger force store element has been undertaken in the afore-described manner.

Instead of abutments the spring pin can optionally also be designed so that it has a continuous, identical outer diameter, but forms detent positions for the washer, into which the latter can be rotated in the manner of a bayonet coupling.

The axial adjustability of the washer along the longitudinal axis of the spring pin and/or, however, also an adjustability in the same direction as the cylindrical housing leads or lead to a further variant of embodiment in accordance with the invention of a safety brake device in which the spacing between the cylindrical housing and the washer can be adjusted. The stroke of the first force store element can thereby be set optionally in addition to the afore-described biasing by the screw.

A further variant of embodiment in accordance with the invention provides three different

force store elements. For separate, prior biasing of the then two stronger force store elements, corresponding biasing devices can optionally be provided and a spring pin, which then has three different outer diameters. In this connection it has to be noted that the weakest force store element is arranged on the largest outer diameter, the middle one on the middle outer diameter and the strongest force store element on the smallest outer diameter.

The safety brake device according to the invention preferably generates the braking force by means of a so-called spring column formed from individual plate springs lined up on the spring pin. In this connection, the plate springs can be arranged in series or in parallel or in double or triple arrangements in series or in parallel. The individual plate springs are preferably made of stainless and heat-resistant spring steels. Coming into consideration for that purpose are, for example, copper alloys (CuSn 8, CuBe 2) and nickel alloys (Nimonic, Inconel, Duratherm) or chromium-vanadium alloys or, however, also porcelain. In principle, according to the invention plate springs of Group 2 according DIN 2093 are preferred, but the use of plate springs of Group 1 or Group 3 is also possible. The surface roughness of the plate springs is preferably  $Ra < 6.3$ . These materials and values are stated by way of example and it is within the scope of the invention to achieve the assembly, in accordance with the invention, of at least one weaker and stronger force store element with different spring types, but also with different dimensions (outer diameter, inner diameter, thickness) and materials and material combinations.

As already mentioned, a safety brake device according to the invention can be arranged not only at the lift cage, but also at the counterweight. The safety brake device can for its part be placed on the lift cage or on the counterweight itself, for example at the underside thereof, but also at the upper side thereof.

The afore-described safety brake device has the advantage, by comparison with safety brake devices which act on the support means itself, that secure emergency braking can always be carried out irrespective of a support means breakage or irrespective of the point at which the support means breaks.

Further advantages offered by a safety brake device according to the invention are improved hysteresis characteristics and simplified disassembly when releasing the safety brake device after use or repair or maintenance operations, since a single travel range is

newly divided up into two or more travel ranges.

A safety brake device according to the invention can also be employed on inclined lifts, drilling apparatus, shelf stackers and other person or material conveying installations. Moreover, it is suitable for safety-braking not only of downward movements of the lift cage, but also upward movements, which can be caused by, for example, faulty controlling. For this purpose, a safety brake device according to the invention can also be attached - optionally additionally to the previously disclosed modes and locations of mounting - turned through 180 degrees at the roof of the lift cage.

The present application discloses at least two force store elements which are connected in series, such as, for example, spring columns formed from plate springs and lined up on a pin. The principle according to the invention can, however, also be realised by force store elements where one encloses the other. Thus, for example, the weaker or the stronger force store element can have an inner diameter which receives the other force store element.

Further or advantageous embodiments of the safety brake device according to the invention or of the correspondingly designed lift equipment form the subjects of the dependent claims.

The reference numeral list is a part of the disclosure.

The invention is explained in more detail symbolically and by way of example on the basis of figures.

The figures are described conjunctively and generally. The same reference numerals signify the same components and reference numerals with different indices indicate functionally equivalent or similar components.

In that case:

Fig. 1 shows a schematic sectional illustration of lift equipment with a safety device with a safety brake device, which corresponds with the current state of the art;

- Fig. 2 shows a schematic sectional illustration of a safety brake device which corresponds with the current state of the art;
- Fig. 3 shows a schematic sectional illustration of a part of a safety brake device according to the invention;
- Fig. 3a shows a preferred variant of embodiment of the safety brake device according to the invention of Fig. 3 at the time of assembly;
- Fig. 3b shows a crescent-shaped washer;
- Fig. 4a shows an illustration of a cumulative overall characteristic curve of the force store elements of the safety brake device of Fig. 3 with a non-constant and progressive course;
- Fig. 4b shows an illustration of the cumulative characteristic curve of the force store elements of the safety brake device of Fig. 3 with a constant and progressive course;
- Fig. 4c shows an illustration of the cumulative characteristic curve of the force store elements of the safety brake device of Fig. 3 with a constant and linear course;
- Fig. 5 shows a schematic sectional illustration of a part of a further safety brake device according to the invention;
- Fig. 5a shows a schematic sectional illustration of a part of another safety brake device according to the invention;
- Fig. 5b shows a schematic sectional illustration of a part of yet another variant of embodiment in accordance with the invention of a safety brake device; and
- Fig. 5c shows a sectional illustration along the section axis A-A of the part of the safety brake device of Fig. 5b.

Fig. 1 shows lift equipment 100 with a lift cage 2, which is movable in a lift shaft 1 and which is connected with a counterweight 4 by way of a support means 3. The support means is, in operation, driven by a drive pulley 5 of a drive unit 6. The lift cage 2 and the counterweight 4 are guided by means of guide rails 7a and 7b extending over the shaft height. The lift equipment has an uppermost storey with an uppermost storey door 8, a second-uppermost storey with a second-uppermost storey door 9, further storeys with further storey doors 10 and a lowermost storey with a lowermost storey door 11. The drive unit 6 and a speed limiter 13, which at a different speed stops the lift cage 2, are arranged in a shaft head 12. For this purpose a respective double lever 14a or 14b is arranged at each of two opposite sides of the lift cage 2 and is articulated to the lift cage 2 at a respective fulcrum 15a or 15b.

Moreover, the double lever 14a is fixedly connected with a limiter cable 19 of the speed limiter 13. The limiter cable 19 is guided in the shaft head 12 around a cable pulley 58 of the speed limiter 13 and in a shaft pit 20 around a return roller 21. During travel, the lift cage 2 drives the limiter cable 19 and the speed of the lift cage 2 is monitored by the speed sensor 13 via the limiter cable 19.

In the case of excess speed of the lift cage 2 the speed limiter 13 blocks the cable pulley 58, in which case the lift cage 2 drags the limiter cable 19 around the cable pulley 58. Due to the friction at the cable pulley 58 the limiter cable 19 exerts a tension force on the double lever 14a in upward direction in correspondence with the arrow direction 26. Thus actuated, the double lever 14a rotates about a fulcrum 15a. As a result, on the one hand a traction is transmitted in upward direction by way of a linkage 17a to a safety brake device 16a. On the other hand, however, insofar as the lift equipment 100 in accordance with a preferred embodiment - as illustrated - is equipped with a second safety brake device 16b coupled with the first safety brake device 16a, the double lever 14a additionally transmits a pressing movement to a connecting rod 18 by means of a rigid, approximately 90-degree angle arm which at its vertex is articulated at the fulcrum 15a to the lift cage 2. This connecting rod 18 in turn presses on the further, second double lever 14b, which similarly to the first double lever is formed from a rigid, approximately 90-degree angle arm articulated at its vertex at the fulcrum 15b to the lift cage 2. The pressure of the connecting rod 18 thus produces a rotation of the double lever 14b and this in turn is transmitted by a linkage 17b as a traction movement to the second safety brake device

16b.

The illustrated safety device 200 thus comprises the speed limiter 13 and at least one double lever 14, which triggers the safety brake device 16 by a traction force by means of the linkage 17. In principle, however, it is also possible to couple the traction movement of the limiter cable 19 with a lever arrangement which triggers the safety brake device 16 not by pulling, but by pushing.

The endless limiter cable 18 is tensioned by means of the return roller 21 arranged in the shaft pit 20, wherein a roller axle mount 22 is articulated at one end at a fulcrum 23 and carries a tensioning weight 24 at the other end. The support means 3, as also the limiter cable 19, can be a steel-wire cable or aramide cable, a belt or band or a V-belt or V-ribbed-belt.

Fig. 2 schematically shows, as a sectional illustration, a safety brake device 16 corresponding with the current state of the art. A force store element 27 is constructed as a spring column in that in each instance a pair of plate springs 34 in series and thus-formed plate spring pairs are then in turn lined up parallelly on a pin 33 with a longitudinal axis 55. The force store element 27 can be biased with the help of a biasing screw 35 in a threaded bush 36 and a washer 37. The pin 33 is mounted in eyes 32a, 32b of brake levers 29a, 29b, wherein the latter are mounted as a symmetrical pair respectively in rotary bearings 31a, 31b and are formed as double levers. A spreading force of the force store element 27 thus acts on the opposite lever ends of the double lever pair as a pressure force  $F$ , which is formed from the sum of the absolute amounts of the force vectors  $F_1$  and  $F_2$ . The pressure force  $F$  is the pressing pressure by which two brake shoes 28a, 28b with brake linings 38a, 38b grip the guide rail 7.

The brake shoes 28a and 28b are of wedge-shaped form, which is not apparent in this view, and are each mounted in a roller cage 39a or 39b. It is thereby achieved that the traction force or also pressure force, which is described in Fig. 1, of the linkage 17 suffices merely as a triggering, activation force for the safety brake device 16 in that one brake shoe or also both brake shoes is or are held in an initial braking position. The actual braking force  $F$  of the force store element 27 - as a spring-assisted reaction to its compression in accordance with Hooke's law - then builds up automatically due to the friction of the brake shoe 28 against the guide rail 7 and due to the wedging action of the

brake shoe 28.

Fig. 3 shows schematically, in a sectional illustration, an embodiment of a safety brake device 16c according to the invention. By contrast with the safety brake device 16 shown in Fig. 2 it comprises not a solitary, single-stage force store element 27, but a force store element combination 30, which is formed from a first force store element 27a and a second force store element 27b. The first store element 27a is a spring column consisting of plate springs 34 which are lined up as spring plate pairs parallelly on the pin 33.

The second force store element 27b forms a spring column of plate springs 34, which are lined up as several serial triple arrangements parallelly also on the pin 33. However, the most diverse arrangements of plate spring combinations lie within the scope of the invention, be it in series or parallel, or also the most diverse arrangements of force store elements, i.e. also other kinds of springs, for example spiral springs, leaf springs, screw-plate springs or gas pressure springs or combinations thereof also come into consideration. According to the invention the force store element combination 30 is formed from two or more force store elements 27, which differ from or complement one another with respect to the spring rate and characteristic curve thereof in a mode and manner according to the invention.

The first force store element 27a is encased by a cylindrical housing 40. After a defined degree of compression of this force store element 27a an end edge 41 of the cylindrical housing 40 presses on a washer 37a arranged between the force store elements 27a and 27b. As a result, with an increasing degree of compression of the force store element combination 30 a compression of the first store element 27a ceases and an exclusive compression of the second force store element 27b - which here, as illustrated, comprises a greater number of and stronger plate spring packets than the force store element 27a and thus also as a higher spring rate - begins.

A further variant of embodiment, which is not illustrated in more detail in this figure, but again in accordance with the invention, provides additionally to that previously described an adjustment possibility of the maximum compression of the first, weaker force store element 27a in that a spacing 42 between the end edge 41 of the cylindrical housing 40 and the washer 37a can be regulated. This can be carried out, independently of the bias by means of the screw 35 in the threaded housing 36, by a further screw adjustment for

the cylindrical housing 30. A further adjustment possibility of the spacing 42 can consist in that the washer 37a is so connected with the cylindrical housing by means of adjustable detent positions that a compression of the force store element 27a is possible, as before, up to a value of the spacing 42 equal to approximately zero, but not an increase in the value of the spacing 42 beyond the desired value of the bias of this force store element 27a.

Not only the biasing, which is known from the state of the art according to Fig. 2, by means of the screw 35, but also the afore-described adjustment possibility of the cylindrical housing 40 act - due to the fact that the safety brake device 16c according to the invention comprises a weaker force store element 27a and a stronger force store element 27b - exclusively or predominantly only on the weaker force store element. In other words, the stronger force store element 27b can no longer be biased without jumping over the preceding working range, which responds earlier, of the first force store element 27a.

In order to overcome this disadvantage, a further and preferred embodiment of a safety brake device according to the invention provides an adjustability of the washer 37a. According to the invention this adjustability is designed so that the washer 37a cannot move out to the left, towards the weaker force store element 27a, beyond defined and adjustable end positions. To the right, towards the eye 32b, the washer 37a, however, follows without hindrance pressure of an end face 44 of an outermost plate spring packet 43 of the force store elements 27a or - according to the respective design of the spring rate difference between the force store element 27a and the force store element 27b - the pressure of the end edge 41 of the cylindrical housing 40. It is achieved by this displaceability of the washer 37a to one side that the second, stronger force store element 27b, as seen by itself, can be biased, but as before can describe compression and expansion movements. However, the expansion movements do not exceed the set level of the bias.

Figures 3a and 3b show by way of example how the inventive feature of the separate capability of biasing the stronger force store element 27b can be technically realised. The pin 33a has along the length of the force store element 27b a smaller diameter than along the length of the force store element 27a and thus forms an abutment 47 for the washer 37a. By means of a biasing device 48, placed against the washer 37a and the eye 32b or, as illustrated, against the washer 37a and a pin end 46, it is possible at the time of

assembly of the second force store element 27b for its bias to be brought to a desired level and, as desired, for further washers 45, which are of crescent shape and are placed on the smaller diameter of the pin 33a, to be inserted. The biasing device 48 can subsequently be removed and the force store element 27b has, due to the thickness of the washer 37a, plus the thickness or thicknesses of the crescent-shaped washer 45 or crescent-shaped washers 45, the desired level of bias. This described technical embodiment has the consequence that the inner diameter of the first force store element 27a is greater than the inner diameter of the second force store element 27b. In order to safeguard against unintended dropping out, the crescent-shaped washers 45 together with the washer 37a can be encased.

Alternatively thereto the abutment 47 can also be formed in that the pin consists of two parts which can be screw-connected. In this case the washers 45 do not have to be formed to be crescent-shaped, but can be complete like the washer 37a. This can be of advantage with respect to a higher acceptance of the shear forces arising in the washers 37a and 45.

The sequence, which is shown in Figures 3 and 3a, of the arrangement with a centrally arranged weaker force store element 27a and an outwardly arranged stronger force store element 27b is by way of example. It can also be reversed, wherein experimental tests and practice will show whether, for example, it is of advantage if the stronger force store element 27b is centrally arranged and thus the compression movements of the weaker force store element 27a are performed more or less without involvement. Moreover, it is also conceivable that an arrangement of the cylindrical housing 40 at the outer edge, thus as close as possible to one of the eyes 32, is to be preferred for reasons of stability. Thus, for example, a ring 49b, which bears against the eye 32b, could equally directly deform the cylindrical housing 40.

An exemplifying composite characteristic curve of the force store element combination 30, i.e. the individual characteristic curves of the first force store element 27a and the second force store element 27b according to Fig. 3, are illustrated in the parts of Figure 4.

In Fig. 4a it is apparent at the outset that a travel  $s$  (compression) equal to zero does not also correspond with a pressure force  $F$  equal to zero. This initial force, which is necessary in order to excite a spring, is generally the so-called breakaway force.

However, in the present case it is a bias  $V$  which is superimposed thereon.

The characteristic curve of the force store element 27a assigns a rising value for the pressure force  $F$  to each rising value for the travel  $s$ . It is thus regarded as intrinsically constant. In addition, it is progressive, i.e. the pressure force increases not only linearly with the path covered, but in an over-proportionally (exponentially) increasing ratio. The characteristic curve is in this case a curve or a parabola.

The dashed line continuing the characteristic curve of the force store element 27a illustrates how the force store element would further behave if the end edge 41 of the cylindrical housing 40 were not to impinge on the washer 37a at the point  $s_1$ . The characteristic curve of the stronger force store element 27b is also regarded as intrinsically constant and progressive and would, without the prior action of the weaker force store element 27a up to the point  $s_1$ , begin with a higher pressure force in accordance with the dashed-line plot. From the point  $s_1$ , which corresponds with contact of the end edge 41 with the washer 37a, the pressure force  $F$  drops to a lower value than shortly beforehand. The overall characteristic curve for the force store element combination 30 is thus non-constant.

Fig. 4b thereagainst shows a constant course of the overall characteristic curve of a force store element combination 30'. As illustrated, this can be realised in that a characteristic curve 27a' and a characteristic curve 27b' intersect. This would in turn mean that, even before the cylindrical housing 40 ends the working range of a first force store element 27a', a second force store element 27b' begins its work. A common working range  $s_2 - s_1$  thus results. This can be technically realised, for example, in that the first force store element 27a' has a linear characteristic curve from the point  $s_2$  or in general has overall a linear characteristic curve. The characteristic curve of the second, stronger force store element 27b' can also be linear from the point  $s_2$  to the point  $s_1$ , but opposite to the linearity of the characteristic curve of the first force store element 27a', so that the sum of these two linear ranges gives a resultant characteristic curve in a desired range.

However, the constant characteristic curve can also be achieved in that the working range of the second force store element 27b' begins seamlessly where the working range of the force store element 27a' comes to an end, i.e. the force store elements are so precisely matched to one another by their spring rates that at the termination of the compression of

the first force store element 27a' by the cylindrical housing 40 the second force store element 27b' takes over the same amount of force. Represented graphically this would mean that the point  $s_2$  coincides with the point  $s_1$  on a continuous characteristic curve.

An overall characteristic curve of a force store element combination 30" composed respectively of a linear characteristic curve for the force store element 27a" and for the force store element 27b" is illustrated in Fig. 4c. The transition to the higher spring rate of the second force store element 27b" manifests itself as a kink of the overall characteristic curve at the point  $s_1$ . The dashed line illustrates the hysteresis curve of the force store element combination 30".

Fig. 5 schematically shows, in a sectional illustration, a further embodiment according to the invention of a safety brake device 16e in accordance with the invention. In this embodiment the force store element combination 30a is formed from a first force store element 27a, a second force store element 27b and a third force store element 27c. As can be seen at the symbolic illustration and arrangement of the plate springs 34, they form by pairs, which are each formed from a respective plate spring 34, the first, weakest force store element 27a. The second, middle force store element 27b is formed from a doubled arrangement and the third, strongest force store element 27c from a triple arrangement. For reasons of costs, exclusive use of the same plate springs 34 can be made in all three force store elements as illustrated. This is not a precondition of the invention, however, but only three force store elements 27a - 27c differing in their totality.

By contrast to the afore-described Fig. 3, the cylindrical housing 40 impinges not directly on the washer 37a, but initially on a further cylindrical housing 40a which surrounds the second force store element 27b. This further cylindrical housing 40a impinges on the washer 37a only with an increasing degree of compression.

The force/travel plot thus takes place in cascade manner and according to the invention in one of the modes shown in the parts of Figure 4, individually or combined, but expanded only by one further stage.

Fig. 5a shows schematically, in a sectional illustration, a further embodiment according to the invention of a safety brake device 16f in accordance with the invention. In this embodiment the force store element combination 30b is formed from a first force store

element 27d, a second force store element 27e and a third force store element 27f. As can be seen from the symbolic illustration and arrangement of the respective plate springs 34a - 34c, the force store element 27d is the weakest because it is formed from the smallest and thinnest plate springs 34a. The force store element 27f is the strongest, because the individual plate springs 34c are largest or thickest and at the same time are lined up in a triple arrangement on the pin 33b. The force store element 27e lies therebetween with respect to its characteristics and spring rate.

The arrangement of these three force store elements 27d - 27f is as desired. It is thus illustrated, by way of example, in this variant of embodiment that the weakest force store element 27d bears against the eye 32b or the ring 49b. The ring 49b forms at the same time the cylindrical housing 40b surrounding the first force store element 27d. Due to the fact that the weakest force store element 27d in the arrangement illustrated here is arranged on the (righthand) side towards to the eye 32b, by contrast with the previously illustrated variant of embodiment the compression movement of the entire force store element combination 30b also begins on this side.

From a defined degree of compression of the force store element 27d the end edge 41b of the cylindrical housing 40b presses on the cylindrical housing 40c surrounding the second, middle force store element 27e. The compression of the first, weakest force store element 27d thereby drops out and the compression of the second force store element 27e begins only now or even before, again depending on the design of the difference in the spring rates between the first force store element 27d and the second force store element 27e or depending on whether it is desired that the working ranges of the force store elements 27d and 27e overlap. In the same functional manner, a further stage in the force store element combination 30b takes place on contact of the end edge 41c of the cylindrical housing 40c with the washer 37a, again depending on the design of the force store elements 27e and 27f.

The safety brake device 16f illustrated here has, in addition, the pin 33b with a different diameter for each individual force store element 27d-f. It is possible in this mode and manner to achieve, by appropriate stressing devices and the selection of an appropriate thickness of a housing wall 50 of the cylindrical housing 40c or an appropriate thickness of the washer 37a, a bias for those force store elements (27e and 27f) which are stronger than the weakest force store element 27d.

As already described in Fig. 3, the biasing device 36 by means of the screw 35, which is known from the prior art (see there) and which acts on the entire force store element combination 30b, would, in fact, bias only or primarily the weakest force store element 27d. This known biasing device 36a shown in Fig. 3 is not illustrated in the present Fig. 5a, but it would preferentially be placed in front of the side of the pin 33b opposite the eye 32b. In any event its presence makes clear that each of the three force store elements 27d - 27f, even the weakest force store element 27d, can be biased. It is thus not necessary here to provide at the weakest force store element 27d a separate biasing possibility analogously to the embodiments with the stronger force store elements 27e and 27f.

As already demonstrated on the basis of possible characteristic curves of the individual force store elements, they can be designed so that initially the weakest force store element 27d describes its maximum travel and only then does the spring rate of the second force store element 27e allow compression or take-up of force. However, if this is not so and, as illustrated, the force store element consists of plate springs, then it can be the case that on compression of the first force store element 27d and, however, also simultaneous compression of the second, middle force store element 27e (overlapping characteristic curves as, for example, in Fig. 4b) the outermost plate spring 34a or also the adjoining plate spring or springs drops or drop out of the guide thereof in the sense that it or they falls or fall between a gap between an abutment 47a and the pressed-away end face of the cylindrical housing 50. In order to avoid this, spacers 51a or 51b which slide therewith can, as illustrated, be provided. They are slightly wider than the possible, above-described gap, which thus cannot even arise.

It is significant in any event that the largest diameter of the pin 33b has to be associated with the weakest force store element 27d and the smallest diameter of the pin 33b has to be associated with the strongest force store element 27f, otherwise the travels of the force store elements 27 are blocked by the abutments 47.

Fig. 5 shows a further variant of embodiment according to the invention of a safety brake device 16g, which comprises a pin 33c with groove profiles 52 extending along the longitudinal axis 55. Formed therebetween are web profiles 53 which as before correspond by an outer edge 56 with an outer diameter  $\varnothing$  of the pin 33c. As before, the plate spring 34a is guided on this outer edge 56 even when the washer 37b and a spacer

sleeve 57 (the previously cylindrical housing 40 is shown in this embodiment as a washer and a sleeve) move to the left due to the compression of the middle force store element 27e. An analogous construction, only with a deeper groove profile 52a, is provided between the middle force store element 27e and the strongest force store element 27f.

Fig. 5c shows a sectional illustration along the section axis A-A of Fig. 5b. The washer 37b forms, along its respective inner diameter, at least two, preferably four, approximately diametrically oppositely arranged segment members 57 which run along in the respective groove profile 52. The rearward end face of the segment member 54 is thus the contact surface for the respective abutment 47a or 47b, which in this form of embodiment is no longer formed over the full circumference, but only on a certain percentage of the full circumference. This further embodiment, in accordance with the invention, of the pin 33c with web profiles 53, groove profiles 52 and 52a and segment members 54 running therein has, by comparison with the solution shown in Fig. 5a, with respect to the dropping of the plate springs out of the guide the advantage that constructional length is saved, i.e. a greater proportion of the total travel of the force store element combination 30b is utilised.

The inventive features disclosed in Figures 3 to 5, although described only in relation to the respectively illustrated variants of embodiment, can be combined with one another. Thus, for example, the composite characteristic curve shown in the parts of Figure 4, which was illustrated there only in conjunction with a first and a second force store element in correspondence with Fig. 3, is optionally possible also for the second and third force store elements of the parts of Figure 5. Moreover, the adjustment possibility, which was described in connection with Fig. 3, of the spacing 42 can be readily realised even in the variants of embodiment according to the parts of Figure 5. In addition, the separate capability of biasing, which is shown in Fig. 3a, of the stronger force store element is - with appropriate stressing devices - disclosed to an expert for the variant of embodiment according to Fig. 5a.

**Reference numeral list**

|               |                                 |
|---------------|---------------------------------|
| 1             | lift shaft                      |
| 2             | lift cage                       |
| 3             | support means                   |
| 4             | counterweight                   |
| 5             | drive pulley                    |
| 6             | drive unit                      |
| 7             | guide rail, brake rail          |
| 8             | uppermost storey door           |
| 9             | second-uppermost storey door    |
| 10            | further storey door             |
| 11            | lowermost storey door           |
| 12            | shaft head                      |
| 13            | speed limiter                   |
| 14a, 14b      | double lever                    |
| 15a, 15b      | fulcrum                         |
| 16, 16a - 16g | safety brake device             |
| 17a, 17b      | linkage                         |
| 18            | connecting rod                  |
| 19            | limiter cable                   |
| 20            | shaft pit                       |
| 21            | return roller                   |
| 22            | roller axle mount               |
| 23            | fulcrum                         |
| 24            | tensioning weight               |
| 25            | buffer                          |
| 26            | tension direction of 19         |
| 27            | force store element             |
| 27a, 27d      | first force store element       |
| 27b, 27e      | second force store element      |
| 27c, 27f      | third force store element       |
| 28a, 28b      | brake shoe                      |
| 29a, 29b      | brake lever                     |
| 30, 30a, 30b  | force store element combination |

|               |                                                               |
|---------------|---------------------------------------------------------------|
| 31a, 31b      | rotary bearing                                                |
| 32a, 32b      | eye                                                           |
| 33, 33a - 33c | pin                                                           |
| 34, 34a - 34c | plate spring                                                  |
| 35            | biasing screw                                                 |
| 36            | threaded bush                                                 |
| 37, 37a - 37c | washer                                                        |
| 38a, 38b      | brake lining                                                  |
| 39a, 39b      | roller cage                                                   |
| 40, 40a, 40c  | cylindrical housing, outer or inner sleeve, travel limitation |
| 41, 41a - 41c | end edge of 40                                                |
| 42            | spacing between 41 and 37a                                    |
| 43            | outermost plate spring packet of 27a                          |
| 44            | end face of 43                                                |
| 45            | crescent-shaped washer                                        |
| 46            | pin end                                                       |
| 47, 47a, 47b  | abutment                                                      |
| 48            | biasing device                                                |
| 49a, 49b      | ring                                                          |
| 50            | housing wall                                                  |
| 51a, 51b      | spacer member                                                 |
| 52, 52a       | groove profile                                                |
| 53            | web profile                                                   |
| 54, 54a       | segment member                                                |
| 55            | longitudinal axis of 33                                       |
| 56            | outer circumference or outer edge                             |
| 57            | spacer sleeve                                                 |
| 58            | cable pulley                                                  |
| 100           | lift equipment                                                |
| 200           | safety device                                                 |
| F             | pressure force, braking force                                 |
| $F_1, F_2$    | force vector                                                  |
| s             | travel                                                        |

|               |                                                                 |
|---------------|-----------------------------------------------------------------|
| $s_1$         | travel corresponding with the contact of 41 with 37a            |
| $s_2$         | travel at which the force store elements begin to work together |
| $V$           | bias                                                            |
| $\varnothing$ | outer diameter of 33                                            |

**Patent claims**

1. Safety brake device (16) with a force store element (27), which by way of at least one brake lever (29) and at least one brake shoe (28) acting on a guide rail (7) generates a braking force (F) which stops a lift cage (2) and/or a counterweight (4), characterised in that the force store element (27) is a force store element combination (30) consisting of a first store element (27a) and at least one second force store element (27b) and that the force storage rate of the second force store element (27b) is higher than the force storage rate of the first force store element (27a).
2. Safety brake device (16) according to claim 1, characterised in that the force store elements (27) are separated by a washer (37a) at a pin (33) guiding the force store elements (27) and in the case of compression movements of the force store element combination (30) a travel limitation (40) for the first force store element (27a) impinges on the washer (37a).
3. Safety brake device (16) according to claim 2, characterised in that the travel limitation (40) and the washer (37a) form a spacing (42) which is adjustable by means of an axial adjustability of the travel limitation (40) along the longitudinal axis of the pin (33) or by means of an axial adjustability of the washer (37a) along the longitudinal axis of the pin (33) or by means of both capabilities of adjustment.
4. Safety brake device (16) according to claim 2, characterised in that the second force store element (27b) has a characteristic curve which connects at a travel point ( $s_1$ ) of the force store element combination (30) at which the travel of the first store element (27a) is limited by the travel limitation (40).
5. Safety brake device (16) according to any one of the preceding claims, characterised in that it comprises a first biasing device (36) for the first force store element (27a) and for the second force store element (27b).
6. Safety brake device (16) according to claim 5, characterised in that it comprises a second biasing device (48) exclusively for the at least one force store element (27b) with the higher force storage rate.

7. Safety brake device (16) according to claim 2, characterised in that the pin (33) has different outer diameters and thus abutments (47) for spacer washers (45).

8. Safety brake device (16) according to claim 2, characterised in that the pin (33) has a continuous outer diameter and detent positions at which spacer washers (45) are detentable.

9. Safety device (200) with at least one safety brake device (16) according to any one of the preceding claims 1 to 8.

10. Safety device (200) with at least one safety brake device (16) with at least one force store element (27a) and second force store element (27b) with different force storage rates, in lift equipment (100) with at least one lift cage (2) which runs along at least one guide rail (7), wherein the safety device (200) comprises at least one speed limiter (13) with a limiter cable (19) and wherein tension forces of the limiter cable (19) are transmissible to the at least one safety brake device (16) at the lift cage (2) so that at least one brake shoe (28) of the safety brake device (16) can be pressed against the guide rail (7) by the force of the first force store element (27a) up to a travel limitation (40) and by the force of the second force store element (27b) from the travel limitation (40).

11. Lift equipment (100) with at least one safety device (200) according to claim 9 or 10.

12. Use of a force store element combination (30) consisting of at least one force store element (27a) and second force store element (27b) with different force storage rates in a safety brake device (16c).

13. Method of actuating a safety brake device (16) with at least one force store element (27a) and second force store element (27b) with different force storage rates, wherein the force store elements (27) press at least one brake shoe (28) against a brake disc or brake rail (7) by means of at least one brake lever (29), comprising the following steps in the following sequence:

- triggering the safety brake device by bringing the at least one brake shoe (28) into frictional contact with the brake disc or brake rail (7);
- pressing at least one brake shoe (28) against the brake disc or the brake rail (7)

with the force of the first force store element (27a); and

- reaching a travel limitation (40) for the first force store element (27a) and thereupon taking the first force store element (27a) out of action and bringing the second force store element (27b) into action.

14. Method according to claim 13, characterised in that the bringing of the at least one brake shoe (28) into frictional contact with the brake disc or brake rail (7) is carried out by the tension of a limiter cable (19), which moves at lower speed than a lift cage (2), of a speed limiter (13) and the safety brake device (16) is thereby triggered.

15. Method according to claim 13, characterised in that the bringing of the at least one brake shoe (28) into frictional contact with the brake disc or brake rail (7) is carried out electromagnetically.