

# Apparatus Producing an Even Distribution of Strain into Carries

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**Abstract.** In many high-rise residential buildings or multi-storey warehouses, machinery, so called lifts, is used for the vertical transportation of people or weights between two or more altitudinally distant places. Carriers used for lifts are steel ropes or sprocket chains, on which a cage or a counterbalance is hinged. Apparatus of all carriers, attached to the hinge of the cage or counterbalance, should be even. This can be made only by hammer hinge. Fixed or spring hinge cannot be a perfect equalizing apparatus. This article describes an apparatus, which allows an even distribution of the strain into lift carriers, which use spring hinge of carrier ropes.

## 1. Introduction

Transported people or weights stand during the transportation on a platform, which is a supporting part of the cabin or the cage. The cage is carried on fixed ropes, which are attached to the lift shaft. The fixed ropes enable only one movement of the cage and that is a linear movement up and down. The cage is hinged on one or more carriers, which connects it to a kinetic hoisting device, so called elevator machine.

## 2. Entry prerequisites and the description of the pocket conveyer

A hinge is apparatus, through which the cage or counterbalance is attached to carriers. Each carrier must be attached to the hinge separately. The hinges are divided into three categories, according to their construction: fixed, hammer or spring.

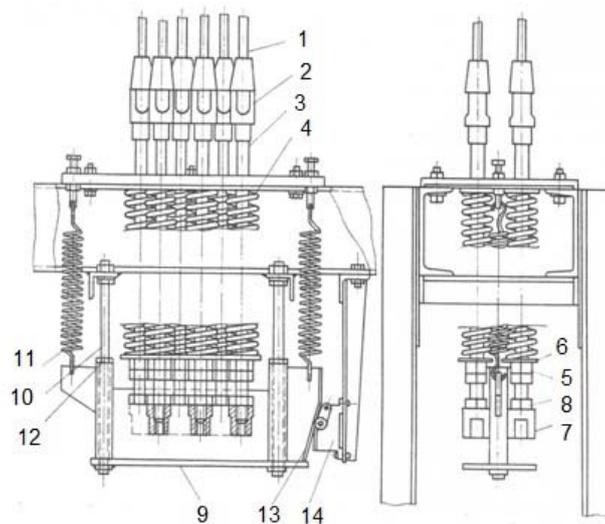
Each elevator must be equipped with a hinge switch, which turns off the control circuit and stops the elevator in case of excessive deformation, deinitialization or a breakdown of any carrier. The switching off must be forced and the switch must not automatically switch on when the carrier is strained again.

Fixed hinges, for more details see [3, p. 279] were formerly used mostly at counterbalances, cages of freight elevators without unaccompanied by persons and small freight elevators, they are currently used at personal elevators and freight elevators in combination with spring hinge at the counterbalance.

Hammer hinges, for more details see [3, p. 279] are formed by a lever system, which allows reciprocal turning of the levers and guarantees the even distribution of the overall apparatus on individual carrier. For elevators of bigger dimension, which require a bigger amount of carrier ropes [1], are hammer hinges significantly complex, as it turns out of the stated schemes of hinges. [3, p. 280].

Complex constructions of hammer hinges and possibilities of conferment of impulse to the action of the trapping device by so called speed limiter have led to the use of spring hinges [3], which are much simple when it comes to construction and have the advantage of a flexible mesh. If the constants are the same for all the springs, the same strain of all carrier ropes is guaranteed. The danger of vibration of the cage in the vertical direction is caused by a sharp mesh.



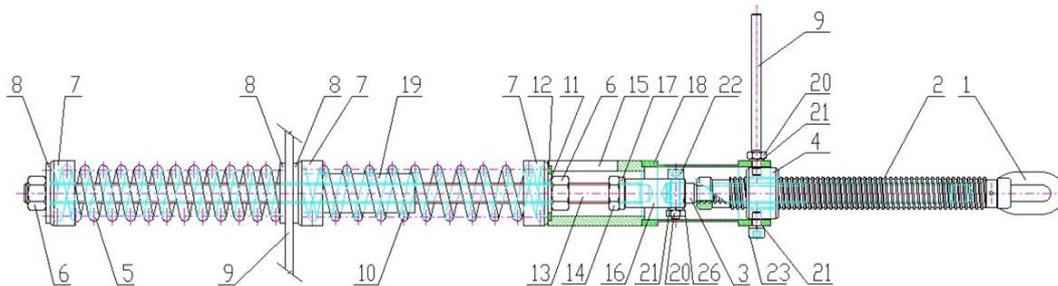


**Figure 1.** Spring hinge of carrying ropes

Picture Fig.1 shows six-rope hinge with the device for switching off the control circuit by the hinge switch at breakdown or excessive deformation of any rope. The ends of the rope **1** are embedded in the sleeves **2**, which are connected to the carrier bolts **3**. The bolts go through the aperture of the console of the hinge and are sprung. The springs **4** are possible to be adjusted by nuts **5**, which bear on the templates of the hinges **6**. Stops **7** are screwed on the lower end of the carrier bolts, which are secured by a nut **8** after the adjustment. At the extension of any rope, the stop touches the bearing base **9** and pushes it down. The bearing base is a part of a splinter bar vertically led by fixed interposer bars **10**, which is pushed by extension springs **11** in the basic position to bearing nuts of interposer bars **12**. The splinter bar bears with the inclined plane on the bar of the hinge switch **14** and at the movement down it switches the control circuit off through it. Between the stops **7** and the bearing base **9** there must be a sufficient clearance, so that at the vibration of the cage the automatical switch off of the control circuit would not happen.

### **3. Mechanical equalizer of tensile forces in the ropes of the elevator**

In the lift shaft of the relevant building, the free end of the carrying rope is mechanically attached to the eye of the suspension bolt with rope clamps [2]. Metric thread made on the suspension bolt, for more details see Figure 2, is laced through the aperture in the clamping console, so called baseplate, **9**. On the thread of the suspension bolt, above the level of the upper area of the clamping console, there is a bowl **7** mounted in the stated direction, to which one end of the wound compressive spring **10** is inserted. On the other end of the wound cylindrical spring there is a bowl **7** inserted, suspension bolt is equipped with a backplate **11** and a hexagonal nut **6** on its end. In this way the suspension bolt is detented against extrusion down in the direction of the lift shaft (by the influence of the tensile force in the carrying rope) through the aperture in the clamping console. If the inside diameter of the wound cylindrical spring **10** is significantly bigger than the inside diameter of the suspension bolt **13**, these two diameters are centred with the plastic centring insert **19**.



**Figure 2.** Engineering design of the apparatus for the detection of the tensile forces

The described apparatus, for more details see Figure 2, is made of the screw spindle **1**, which consists of double screw **2**, a simple screw **3** and a nut **4**.

Double screw **2** is equipped with trapezoidal isosceles simple thread and a trapezoidal isosceles simple thread, made on the inside longitudinal aperture, at the outer diameter of the cylindrical area. The simple screw **3** is equipped with trapezoidal isosceles simple thread on the outer cylindrical area. The cylindrical nut **4** is equipped with two apertures at the outer area, into which pins are inserted, which are made in the heelpiece of the cylindrical rod **9** and the screw with a cylindrical head with inside hexagon **23**. The pin on the end of the cylindrical rod **9** along with the pin on the end and the adjusting screw **23** mutually mechanically connect the cylindrical nut **4** to cylindrical object **18** of the apparatus for the detection of the tensile forces.

The simple screw **3** of the apparatus for the detection of the tensile forces is terminated with the cylindrical part, with the longitudinal aperture in the constructionally chosen distance of the axis of the aperture from the end of the cylindrical part. This cylindrical part of the simple screw **3** is inserted to the aperture of the flange **16**. The prevention of the mutual angular rotation of the cylindrical part of the simple screw **3** (of the telescopic spindle **1**) and the flange **16** is secured with the screw with the cylindrical head with inside hexagon **22**, flexible backplate **21** and hexagonal low nut **20**. To the aperture with an inside thread on the opposite part of the flange **16**, the metric thread of the threaded rod **13** (made on the outer cylindrical area) is screwed.

The outer metric thread of the threaded rod **13**, screwed on the inside metric thread of the hub **16**, is secured against release with the flexible backplate **17** and the hexagonal nut **14**. On the threaded rod **13**, there is the hexagonal nut **6** put on it in the relevant distance, which bears over the backplate **11** on the bowl **7**. The outer diameter of the backplate **11** centres, towards the inside diameter of the object of the apparatus for the detection of the tensile forces **15**, centering ring **12**.

The wound cylindrical spring **10** is placed in the bowls **7** by its both end cut fronts. The bowl **7** in the lower part (see the left bowl on the Figure 2 clutching the spring **10**) bears, over the backplate **8**, on the baseplate **9**. One cut front of the wound cylindrical spring bears over the backplate **8** against the opposite side of the area of the baseplate, its second cut front is placed in the bowl **7**. This bowl **7** is put on the threaded rod **13** and is secured against extrusion with the nut **6** over the backplate **8**.

#### 4. Description of the apparatus for the detection of the tensile forces

In the real practice, the suspension bolt is laced through the clamping console (here the baseplate **9**, see the Figure 2), to which eye (realized in the end part of the suspension bolt), one cross section of the carrying rope is attached by the rope clamps [2].

The suspension bolt is simulated by the threaded rod **13** (of the same diameter as the diameter of the suspension bolt). The tensile force affecting the axis of the suspension bolt (the tensile force is in the practice educed from the proportional nominal load, defined by the number of used carrying ropes and the way of used snubbing, in the appropriate branch of the carrying rope from the weight of the lift cabin or counterbalance) is at the described functional sample educed from the same size of the tensile force affecting in the axis of the threaded rod **13** through the force of the compression wound spring **5** in

tightened state. The compression wound spring **5** is pushed to the required force (desired tensile force affecting in the axis of the suspension bolt) through the nut **6**. In the moment of reaching the required axial force in one threaded rod **13**, the tensile force of a different size is educed in the same way in the axis of the second suspension bolt **13** of the apparatus for the detection of the tensile forces, see the Figure 3.

Different outcomes of the tensile forces educed from the different preloading of the wound compression cylindrical springs **5**, are scanned by a foil strain gauges **24**, which are attached to the area of the cylindrical object **18**. For the purpose of reaching the same size of the tension in steel ropes (here according to the Figure 1, in the threaded staff **13**), the double screw **2** of the partial screw spindle **1** is turned in the relevant direction, which causes the compression (release) of the partial wound compression spring **10**. The compression, eventually release (it is caused by the sense of turning the double screw **2** of the partial screw spindle **1**), of the partial wound compression spring **10** is caused by the engineering design of the mechanism for scanning and balancing the tensile forces, specifically by the fixed distance between placing the cylindrical nut **4** and the lower area of the object **15**.



**Figure 3.** Realization of the apparatus for the detection of the tensile forces

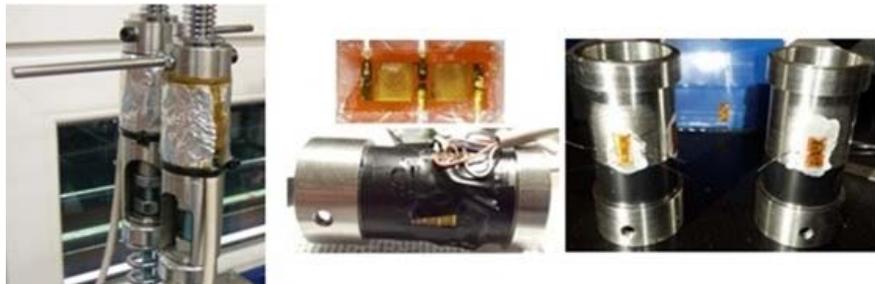
In the lower part of the object **15**, shoulder is realised, into which the centering ring **12** is inserted. The inside diameter of the centering ring **12** defines the clearance between the outer diameter of the backplate **11** and the inside diameter of the shoulder of the object **15**. In the moment of turning the double screw **2** of the partial screw spindle **1** in the stated direction, it comes into extension (shortening) of the mutual distance between the pins, in which the cylindrical nut **4** is placed and the centering ring **12**, which is inserted into the shoulder in the lower part of the object **15**. The centering ring **12** bears on the outer part of the surface of the bowl **7**. In the moment of turning the double screw **2** of the partial screw spindle **1** in the stated direction, the bowl **7** is pushed by the centering ring **12** (the distance between the cylindrical nut **4** and the surface of the bowl **7** is being prolonged) and it causes the compression of the wound compression spring **10** (while turning the double screw **2** of the partial screw spindle **1** in the opposite direction, the bowl **7** is being pushed to the centering ring **12** (because the direction between the pins of the cylindrical nut **4** and the surface of the bowl **7** is being shortened) and that causes the release of the wound compression spring **10**).

On the threaded rod **13** (in the practice called suspension bolt) above the bowl **7**, there is the backplate **11** put on and above it there is the hexagonal nut **6**. By tightening (releasing) the nut **6**, it is possible to fix the tightened (released) spring **10** in the required state. Regarding the fact that it is possible, by the foil strain gauges **24**, to continuously scan the results of the deformation in the partial cylindrical object **18**, which is the part of the apparatus for the detection of the tensile forces, and compare that to the results of the deformation in the other cylindrical object **18**, it is possible to reach the same results by the above stated process (to balance the tensile forces in partial carrying ropes) of the tensile forces educed from the threaded rods from the original different set results educed from the different preloading

of the wound compression cylindrical springs 5.

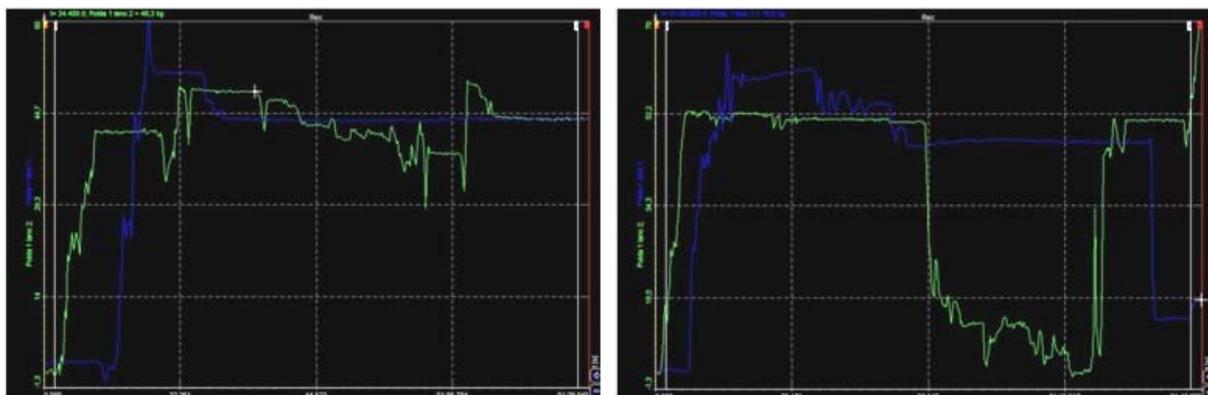
### 5. Activities of the apparatus for the detection of the tensile forces

The different results of the tensile forces educed from the different deforming energy of wound compression cylindrical springs are scanned by resistive biaxial strain gauges, attached to each of the two pieces of the upper part of the equalizer of tension of lift ropes, see Figure 4.



**Figure 4.** Mobile mechanical tension equalizer

The measured quantity (the pressure force educed by the deformation of the upper part of the tension equalizer of ropes of cable lifts from tensile forces in threaded screw) is scanned by resistive strain gauges. By mutual connection of the strain gauges into Wheatston bridge it comes at a change of load force to an elastic deformation of a deformation part (that is the upper part of the apparatus for the detection of the tensile forces) and consequently to the change of results of the resistances of each strain gauge, so called bridge ballancing. Wheatston bridge is powered from the measuring system by the direct current voltage and consequently the voltage is scanned on the signal side of the bridge. The measured voltage is transferred through 24bit A/D converter in modul BR4 into digital value, which is saved in the data system of the GATE unit. Here the value is calibrated according to the settings of the whole system, the required compensation of dislocation and amplification is added to it by the user. Consequently, the value is sent through Ethernet and connected AP (Access point) through Wi-Fi signal into the measuring computer, where it is saved. The control of the measuring system Dewetron is realised through DEWESoft software.



**Figure 5.** The process of the two tensile forces measured by the DEWESoft programme in the tension equalizers of ropes and rope lifts

The gained immediate values of the real sizes of the measured forces; along with the graphic process of changes of those values in the chosen time period and the record of the values; from the undertaken experimental tests (see the Figure 5) during checking the technology of tension equalizers of ropes of the rope lifts enables to conclude that the technology works and meets all the requirements imposed on it.

### 6. Conclusion

The possibility to measure the real value of the tensile force in the partial cross section of the carrying lift rope, to compare this to the value of the tensile force of the adjacent carrying rope and consequently, on the basis of the knowledge of difference of both (or more) values of tensile forces, to equalize both values in mechanical way (by turning the nut attached to the rope hinge or to the rod), it enables to use the described apparatus in practice to set the appropriate rope tension in multi-rope hinges.

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