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Method and device for determining the state of a rail stretch

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The invention relates to a method and a device for determining the state of a rail stretch according to the definition of the patent claims.

Guide rails serve for guidance of objects, for example guidance of lift cages. As a rule, several guide rails are connected to form a rail stretch. Lift cages are usually conveyed suspended at cables and guided by way of guide wheels along the rail stretch. In that case the rectilinearity of the rail stretch becomes significant, since travel comfort depends thereon. Departures from rectilinearity of the rail stretch lead to vibrations in the lift cage. Even with a long rail stretch and fast lift cages, for example in high dwellings, such vibrations are strongly noticeable and are perceived as disadvantageous by the passengers.

In order to determine the rectilinearity of the rail stretch in the installed state, measuring at the rail stretch is often with a plumb bob, for example by cord or by laser. However, these measurements are very time-consuming. For this reason the measuring points are reduced in most cases to the fastening locations of the guide rails. In addition, such measurements must be undertaken at times when the lift installation is not used, i.e. often at night, which requires night work with extra pay and makes maintenance of the lift installation expensive. An improvement is desired in this area.

A solution for that purpose is presented in the specification EP 0 905 080. According to this method, deviations from the rectilinearity of the rail stretch are determined by way of several travel pick-ups fastened to an elongate housing. Magnitudes and position of the deviations are thereupon calculated. The travel pick-ups are mechanical or optical in nature.

A disadvantage of this solution is the high cost of this device.

The object of the present invention is to provide a simple, quick and accurate method of determining the state of a rail stretch. This method and the corresponding device shall be compatible with proven techniques and standards of machine construction.

This object is met by the invention in accordance with the definition of the patent claims.

The present invention meets the object with the help of three or more transmitters and a receiver in order to determine the position of the receiver with respect to a rail stretch. For example, the transmitters are distributed in any manner in a lift shaft of the lift installation and locally fixed. Advantageously, the transmitters are arranged in the lift shaft at the greatest possible angular spacings from the receiver for a triangulation. The receiver is advantageously moved at a constant spacing with respect to a guide surface of the rail stretch. The surface along which the lift cage is conveyed on the rail stretch is termed guide surface. The receiver is placed on, for example, the guide surface of the installed rail stretch. The transmitters transmit radio signals to the receiver similarly to a GPS (Global Positioning System).

In advantageous forms of embodiment additional sensors detect freely selectable locations such as rail fastenings, rail straps, storey halting points or positions of the shaft doors, as soon as the receiver passes the level thereof in the lift shaft. Advantageously, an acceleration sensor for detection of acceleration forces in the lift cage is provided. This further detection advantageously takes place simultaneously with determination of the position of the guide surface.

In measuring operation the receiver detects, preferably continuously and whilst it is moved along the guide surface of the rail stretch over the entire length of the rail stretch, the spacings from the individual transmitters or in each instance the position of rail fastenings, rail straps and shaft doors with respect to the displacement path of the receiver. The receiver preferably ascertains spacing data, i.e. the instantaneous spacing from the transmitters, on the basis of the detected radio signals. These spacing data are ascertained, for example, incrementally per unit of length and unit of time.

The resulting spacing data are preferably passed on to the evaluating unit. The evaluating unit compares the spacing data with reference data of the spacing of the receiver from the transmitters. Such reference data are, for example, ascertained in a calibration process and stored. This comparison delivers, as the result, departures from the rectilinearity of the rail stretch. This result can be represented, for example, graphically as a curvature in three dimensions. An advantageous result of the evaluation is a correction protocol, in accordance with which the engineer can straighten the individual guide rails of the rail stretch. Equipped with precise diagrams, as also straightening proposals, the engineer

can concretely realign the rail stretch and thus rapidly achieve or maintain an optimum travel behaviour of the lift cage.

The invention is explained in detail in the following by way of exemplary embodiments in accordance with Figs. 1 to 4, in which:

- Fig. 1 shows a schematic illustration of a part of a first embodiment of a lift installation with three transmitters and a receiver,
- Fig. 2 shows a schematic illustration of a part of a second embodiment of a lift installation with sensors at rail fastenings, rail straps and shaft doors,
- Fig. 3 shows a schematic illustration of a part of a third embodiment of a lift installation with an acceleration sensor in the lift cage and
- Fig. 4 shows a block diagram of the detection, passing on and evaluation of spacing data or lift stroke data or additional spacing data or acceleration data.

Fig. 1 shows schematically a first exemplary embodiment of a device for determining the state of a rail stretch SS in a lift shaft with at least three transmitters S1, S2, S3 and a receiver E. The receiver E is movable with respect to the rail stretch SS, which is illustrated by an elongate double arrow. The transmitters S1, S2, S3 are distributed anywhere in the lift shaft and locally fixed. In order to increase measuring accuracy, the transmitters are preferably to be mounted so that a greatest possible angle relative to the receiver arises.

The straightening of the rail stretch in the lift shaft is advantageously carried out in five method steps:

1. Provisionally assembled guide rails to form a rail stretch
2. Position transmitters in the shaft and receiver at the rail stretch
3. Measurement of the rectilinearity of the rail stretch or pick-up of spacing data
4. Evaluation of the spacing data
5. Straightening of the rail stretch on the basis of the correction protocol.

With regard to the individual method steps:

In a first method step, guide rails FS are mounted one after the other over the entire stroke path of the lift cage in the lift shaft. The guide rails FS are, for example, T-beams of steel with known standard constructional dimensions. The length of the guide rails FS is known and amounts to, for example, 5 metres. Height and width of the guide rail amount to, for example, 88 mm and 16 mm respectively. According to Figs. 1 and 2 individual guide rails FS are connected together by way of connecting straps VL to form a rail stretch SS. In a first assembly, the rail stretch SS is, for example, fastened by means of rail fastenings SB by way of, for example, screws to a shaft wall and provisionally aligned.

In a second method step, transmitters S1, S2, S3 are mounted in the lift shaft. Any transmitters which transmit radio signals can be used. According to Fig. 1 a first transmitter S1 is fixed in a front region (front wall) at a base of the lift shaft, a second transmitter S2 is fixed centrally in a righthand region (side wall) of the lift shaft and a third transmitter S3 is fixed in a rearward region (back wall) to a ceiling of the lift shaft. The transmitters S1, S2, S3 are advantageously mounted at the greatest possible angular spacing relative to one another. In the case of large stroke heights or shaft heights, advantageously several groups of transmitters S1, S2, S3 can be mounted. For example, several groups of three are arranged in series one after the other over the entire shaft height. Starting out from a lift shaft with a large stroke height it is achieved by the arrangement of several part groups of transmitters that the individual transmitters of such groups adopt a large angular spacing relative to one another and thus an exact triangulation within the transmission range of the respective group of transmitters is ensured. The transition from one transmitter group to the adjoining transmitter group can be flagged by, for example, a stroke height signal picked up by the receiver E. For example, the stroke height signal is mechanically picked up by the receiver E or transmitted by the transmitters S1, S2, S3 to the receiver E. The first and second method steps relating to the mounting of the device for determining the state of a rail stretch can be undertaken, for example, in any sequence or simultaneously.

In the third method step, for measuring the rectilinearity of the rail stretch SS the receiver E is moved along the rail stretch SS by hand, by accompanying travel on a roof of the lift cage and/or, however, by letting down the receiver E by a cable or pulling it up. For

preference, and in order to avoid externally caused measurement inaccuracies, the receiver E is moved in controlled and reproducible manner and, for example, moved by way of a roller guide along a guide surface FF, whilst, for example, at least one magnet keeps the receiver E in constant contact with the rail stretch SS or at a constant spacing from the rail stretch SS.

In measuring operation the receiver E detects, preferably continuously, the spacings from the individual transmitters S1, S2, S3. The receiver E determines, on the basis of the detected radio signals, spacing data AD, i.e. the instantaneous spacing from the transmitters S1, S2, S3. These spacing data are advantageously ascertained incrementally per unit of length and unit of time.

Optionally, sensors S4, S5, S6 can be provided which, additionally to the receiver E, detect important features of the rail stretch SS. In the second exemplary embodiment of a device for determining the state of a rail stretch SS according to Fig. 2, there are detected by way of the sensors S4, S5, S6, respectively, the position of rail fastenings SB, the position of screws of connecting straps VL and the position of shaft doors ST. Advantageously, such a detection is carried out in that the sensors S4, S5, S6 are guided along the rail stretch SS simultaneously with the receiver and the positions of the rail fastenings SB or the connecting straps VL or the shaft doors ST in the lift shaft are localised. Through detection of the position of the rail fastenings SB, the screws of connecting straps VL and the shaft doors ST during passage of the receiver E, the spacing data AD of the receiver E relative to the transmitters S1, S2, S3 can be processed together with additional spacing data ZAD. Such additional sensors S4, S5, S6 determine additional spacing data ZAD. A first sensor S4 determines the position of the rail fastenings SB from the rail stretch SS, a second sensor S5 determines the position of the connecting strap or the screws thereof in the rail stretch SS and a third sensor S6 determines the spacing and the position of shaft doors ST relative to the rail stretch SS. These additional spacings data ZAD are preferably determined incrementally per unit of length and unit of time. The sensors S4, S5, S6 can be, for example, commercially available distance measuring devices of mechanical, electronic and/or optical kind.

It is optionally possible, during the ascertaining of the spacing data AD, to also determine preferably simultaneously the transverse acceleration in the lift cage AK by way of at least one acceleration sensor S7. In the third exemplary embodiment of a device for

determining the state of a rail stretch SS according to Fig. 3 a statement about the actual transverse accelerations transferred to the lift cage AK is thus carried out. These acceleration data BD are preferably determined incrementally per unit of length and unit of time. The acceleration sensor S7 determines acceleration data BD in dependence on travel and thus has an influence in substantially two forms on the evaluation of the rectilinearity of the rail stretch SS:

- On the basis of the acceleration data BD, regions of the rail stretch SS can be localised in which the rail stretch SS is mounted imprecisely in impermissible manner. The acceleration data BD then serves as a localisation aid for impermissible deviations. The engineer must then straighten the rail stretch SS only in such localised "conspicuous regions", which markedly reduces the assembly times or correction times.
- It is possible through the spacing data AD of the rail stretch SS on the one hand and through the acceleration data BD on the other hand to determine a transfer behaviour, which is characteristic for the lift installation, in dependence on the travel. The transfer behaviour can then be used for, for example, an active regulation out of rail inaccuracies, i.e. "active ride". Since the "critical regions" are known in the above-described manner in the form of the correction protocol, the respective location can be quickly and rapidly rediscovered with the help of the equipment for measuring the rectilinearity of the rail stretch SS, particularly with the help of the receiver E. For that purpose the engineer moves the receiver E along the rail stretch SS again and in that case tracks, for example, in real time the result of the triangulation, from which he can read off the instantaneous position of the receiver. In this manner he removes the receiver E until at the "critical location", which he can then straighten in correspondence with the correction protocol.

Fig. 4 shows a schematic block diagram of the detection, passing on and evaluation of spacing data AD, additional spacing data ZAD, stroke height data HD and acceleration data BD. Spacing data AD and stroke height data HD ascertained by the receiver E are passed on to the evaluating unit AE. Additional spacing data ZAD ascertained by sensors S4, S5, S6 are passed on to the evaluating unit AE. Acceleration data BD ascertained by the acceleration sensor S7 are passed on to the evaluating unit AE. The spacing data AD, additional spacing data ZAD, stroke height data HD and acceleration data BD are

communicated as signals, preferably as digital signals, by way of, for example, an electrical signal line or wirelessly by radio to the evaluating unit AE. The evaluating unit AE is advantageously a commercially available computer with a central computing unit and at least one memory, communications interfaces, etc.

In a fourth method step in advantageous manner initially a lowermost point of a reference curve R and an uppermost point of a reference curve R are computed starting out from previously ascertained spacing data AD, additional spacing data ZAD, stroke height data HD and acceleration data BD, which correspond with an actual course of the guide surface FF of the rail stretch SS. Between this lowermost point and uppermost point of a reference curve R the entire reference curve R together with reference data RD is, with advantage, computed with the help of analytical methods. This reference curve R represents the desired course of the guide surface FF of the rail stretch SS provided under respectively different optimised viewpoints. Three kinds of reference curves R can, by way of example, be computed as follows:

- a) a straight line which is laid by interpolation through the lowermost point and the uppermost point of the reference curve R.
- b) an interpolation which is adapted to the previously measured positions of the rail fastenings SB and/or fastening straps BL and/or shaft doors ST.
- c) a reference curve R dependent on the transverse accelerations.

In the determination of the reference curves R of the first to third kinds a) to c), optionally detected stroke height data HD serve for distinguishing individual transmitter groups, so that with advantage only one evaluating unit AE is needed for evaluating the spacing data AD.

In the case of determination of reference curves R of the second kind b), the interpolation extends to the regions between the individual rail fastenings SB, fastening straps BL and shaft doors ST. The optionally detected additional spacing data ZAD thus serve for preparation of the spacing data AD and the correction data in the evaluating unit AE. The spacing of the shaft door ST is of significance in the case of a correction of the rail stretch insofar as the spacing is defined in this region and need not be arbitrarily adjusted.

Corrections can be undertaken with the fastening straps BL and with the rail fastenings SB, but the spacing from the shaft doors ST need not be shifted out of the tolerance range.

In the case of determining reference curves R of the third kind c), the slope of the reference curve R, for example, is computed. A horizontal transverse acceleration, which is induced at the lift cage AK by the rail stretch SS, is computed from the slope of the reference curve R. In that case it is proposed to predetermine a maximum permissible acceleration range or a freely settable permissible acceleration interval and to so compute the course of the reference curve R that this moves within this acceleration interval. As soon as the reference data RD of the reference curve R exceeds the acceleration range, the rail stretch SS is straightened. It is thus achieved that on the one hand the rail stretch SS has to be straightened only as accurately as necessary and more expensive assembly time can be saved and on the other hand no vibrations prejudicing travel comfort are transferred from the rail stretch SS to the lift cage AK. The reference curve R as well as the reference data RD can be stored and can be called up. It is possible to store the reference data RD in a central data bank, for example in an archive, and to deliver them to the engineer, for example on interrogation as signals, preferably as digital signals, for example by way of an electrical signal line or wirelessly by radio. It is obviously also possible to store the reference data RD decentrally in an evaluating unit AE. With knowledge of the present invention, the expert has numerous possibilities of variation in storage and making available reference curves or reference data.

On the basis of a reference curve R and the reference data RD there can be computed, for each position of the rail stretch SS, the relative deviation of the actual course of the guide surface FF of the rail stretch SS with respect to the reference curve R. The obtained relative deviations are made available to the engineer who thereby obtains positionally-dependent information about the direction in which and amount by which the provisionally mounted guide rail FS must be straightened so that it corresponds with the selected reference curve R together with reference data RD.

In a fifth method step, localised non-rectilinearities of the rail stretch SS are straightened by the engineer according to, for example, a correction protocol on the basis of a reference curve R with reference data RD. The reference data enable precise diagrams as well as concrete straightening proposals, so that the engineer can accurately and quickly straighten the rail stretch SS. It is also possible to display the correction or the result of

the correction "on line", i.e. in real time, for example on a monitor M. In the embodiment according to Fig. 4, the monitor M is part of a portable computer, for example a hand-held computer, which obtains reference data by way of, for example, a signal cable or wirelessly by radio. In principle it is possible to realise the evaluating unit AE and the monitor M in a portable computer, for example in a hand-held computer. Overall, the quality of the straightening operation is thereby significantly increased.

By contrast to previously known methods and devices for measuring rail inaccuracies, the method proposed here offers the advantages:

- The rail stretch is detected with the help of transmitters, which are arranged in stationary location, in the lift shaft. This takes place in incremental steps and delivers absolute positions of the rail stretch. Non-rectilinearities of the rail stretch can thus be localised very precisely.
- By comparison with previously known laser adjusting devices, the alignment of the laser beam is redundant and no errors, which are caused by optical effects or by deflection, inadequate beam focussing or obstacles in the lift shaft, occur.
- Determining/ascertaining the transfer behaviour between rail stretch and lift cage in the case of embodiments with acceleration measurement in the lift cage.
- Straightening of the rail stretch is possible without lift cage, for example by lowering or pulling up the receiver along the rail stretch.
- Continuous detection of the non-rectilinearity of the rail stretch.
- Sensors detect the rail fastenings and rail straps. Thus, disturbance locations and, at the same time, locations where the rail stretch can be corrected are localised very precisely.
- Precise straightening of the rail stretch thanks to concrete statements in millimetres about where and how much correction must be made.

Reference symbol list

AD	spacing data
AE	evaluating unit
AK	lift cage
BD	acceleration data
BL	fastening straps
E	receiver
FF	guide surface
FS	guide rails
HD	stroke height data
M	monitor
R	reference curve
RD	reference data
SB	rail fastenings
SS	rail stretch
ST	shaft doors
S1, S2, S3	transmitters
S4, S5, S6	sensors
S7	acceleration sensor
ZAD	additional spacing data

Patent Claims

1. Method of determining the state of a rail stretch (SS) of a lift, characterised in that a receiver (E) is moved along the rail stretch (SS), that radio signals are transmitted by at least three, preferably stationary, transmitters (S1, S2, S3), that these radio signals are received by the receiver (E), that spacing data (AD) of the spacing of the receiver (E) from the transmitters (S1, S2, S3) are determined, preferably incrementally per unit of length and unit of time, from these radio signals, that these spacing data (AD) are compared by an evaluating unit (AE) with reference data (RD) of the spacing of the receiver (E) from the transmitters (S1, S2, S3) and that a result with respect to the state of the rail stretch (SS) is delivered therefrom.
2. Method according to claim 1, characterised in that several groups of transmitters (S1, S2, S3) are arranged and/or that the transmitters (S1, S2, S3) of a group are arranged at an angular spacing relative to one another and/or that a transition from one group of transmitters (S1, S2, S3) to an adjoining group of transmitters (S1, S2, S3) is flagged by stroke height data (HD) and that these stroke height data (HD) are passed on to an evaluating unit (AE).
3. Method according to one of claims 1 and 2, characterised in that the receiver (E) is moved by way of a guide system, for example a roller guide or a slide guide, along a guide surface (FF) and/or that the receiver (E) is held by at least one magnet at a constant spacing from the rail stretch (SS).
4. Method according to one of claims 1 to 3, characterised in that the position of rail fastenings (SB) in the rail stretch (SS) is determined by a first sensor (S4) and/or that the position of connecting straps (VL) relative to the rail stretch (SS) is determined by a second sensor (S5) and/or that the position of shaft doors (S2) relative to the rail stretch (SS) is determined by a third sensor (S6).
5. Method according to one of claims 1 to 4, characterised in that a transverse acceleration in a lift cage (AK) is determined, particularly incrementally per unit of length and unit of time, by way of at least one acceleration sensor (S7) and is delivered in the form of acceleration data (BD) and/or that these acceleration data (BD) are passed on to an evaluating unit (AE).

6. Method according to one of claims 1 to 5, characterised in that a reference curve (R) together with reference data (RD) is calculated in the evaluating unit (AE) starting from previously determined spacing data (AD), additional spacing data (ZAD), stroke height data (HD) and acceleration data (BD).
7. Method according to claim 6, characterised in that a lowermost point of the reference curve (R) and an uppermost point of the reference curve (R) are calculated from spacing data (AD) and that the entire reference curve (R) together with reference data (RD) is calculated between this lowermost point and uppermost point of the reference curve (R), wherein a straight line is laid through the lowermost point and the uppermost point of the reference curve (R) and/or a straight line through the lowermost point and the uppermost point of the reference curve (R) is adapted by additional spacing data (ZAD) and/or a straight line through the lowermost point and the uppermost point of the reference curve (R) is adapted by acceleration data (BD).
8. Method according to claim 7, characterised in that a maximum permissible acceleration range is predetermined and that the rail stretch (SS) is straightened as soon as the acceleration range is exceeded.
9. Device for determining the state of a rail stretch (SS) of a lift, characterised in that a receiver (E) is arranged to be movable along the rail stretch (SS), that at least three transmitters (S1, S2, S3) transmitting radio signals are provided, that the receiver (E) receives these radio signals, that spacing data (AD) from the receiver (E) to the transmitters (S1, S2, S3) can be determined from these radio signals, that an evaluating unit (AE) compares these spacing data (AD) with reference data (RD) of the spacing of the receiver (E) from the transmitters (S1, S2, S3) and delivers therefrom a result with respect to the state of the rail stretch (SS).
10. Device according to claim 9, characterised in that it comprises features of one of claims 2 to 8.