

Apparatus and Method for Controlling a Container Crane

5 The invention relates to an apparatus and a method for controlling a container crane.

10 A series of different types of crane are used for transloading containers. These include conventional ship unloading cranes, which are movable freely or on tracks, and gantry cranes or e.g. swinging cranes. Common to all of them is that they have a movable lifting device on which loading gear is suspended. The loading gear is so designed that it can grip and hold the current types of container.

15 There is a series of different transloading situations. The most common situation is that a container is picked up with an empty loading gear and transported to a target location. This target location can on the one hand be a suitable support surface, e.g. the loading surface of a lorry or goods vehicle or on the other hand a further container which serves as a stacking base.

20 Correctly controlling the loading gear between a starting point and a desired point is made more difficult by the following factors:

- 25 1. The loading gear hanging freely on the lifting device behaves like a pendulum and can be caused to oscillate undesirably by the movement of the lifting device or external influences, such as wind,
- 30 2. the point at which the loading gear or the container suspended from it is to be deposited is not always

optimally visible and

3. in the event that containers are being transloaded from a ship to shore or vice versa, current-induced movements of the ship need to be compensated for.

An additional factor is that when loading or unloading e.g. ships, the loading configuration (i.e. the height of the individual container stacks, which are possibly to be crossed over by the loading gear) continually changes and this must also be taken account of in order to avoid collisions.

At the present time, the movement of the loading gear along the transport path is controlled manually whilst being viewed by a crane driver. The crane driver generally works together with so-called guides who assist him, e.g. by radio, in the depositing of the empty or loaded loading gear at the target location.

It is clear that the crane driver, in particular, has a particularly responsible position which may only be filled with highly qualified personnel. However, even in this case there is always the danger of human error in which particularly the guides in the vicinity of the target location are at risk and furthermore the freight can also be damaged. Apart from this, the labour cost currently necessary when transloading containers is too high.

It is thus the object of the invention to provide an apparatus and a method with which the movement of the loading gear necessary when transloading containers may be controlled, at least partially, automatically.

The object is solved by means of an apparatus as claimed in Claim 1 and a method as claimed in Claim 9.

5 The apparatus in accordance with the method operates with at least one sensor secured to the crane which is in the position to scan surfaces situated within the lifting range of the loading gear and to survey at least one point on edges situated therein which have a minimum height drop. The minimum height drop is predetermined
10 having regard to the selected edge to be scanned so that the sensor specially recognises this edge and does not react to further, e.g. adjacent, edges of lower height.

15 The distance sensor can be e.g. a sensor which is described below and which scans a line or a surface in a predetermined angular region with a resolution which decreases with distance. The sensor is so aligned that it in any event surveys a point of a selected edge, particularly a horizontal edge, of the loading gear or a
20 point of a selected edge of the container carried in the loading gear. When approaching a container, which is to be picked up by the loading gear or serves as a stacking base for a container to be unloaded, a point of a selected edge of this target container is also surveyed.
25 The apparatus is so designed that it produces control signals for the crane drive to steer the loading gear into an engagement position with the target container from the measured data determined by the sensor based on the known dimensions of the loading gear or the container
30 carried therein.

The apparatus in accordance with the invention makes, in particular, automatic height control of the empty or loaded loading gear possible with respect to a target

container. It can be assumed that the target location for the loading gear is frequently a target container. It is, however, equally possible that a loaded loading gear is moved up to an empty setting down surface, e.g.
5 on a lorry or goods vehicle. Such setting down surfaces generally also have characteristic edges which can be surveyed by means of the sensor at at least one point. When the term target container is used in the context of this application, it always also includes those
10 (container-free) target locations which have at least one edge which may be detected with the sensor and unambiguously define the position of the setting down surface.

15 It is possible within the scope of the invention to survey edges of any orientation by means of the sensor. It is, however, sensible to select horizontally or substantially horizontally aligned edges for surveying purposes. Points on inclined, non-horizontal edges may
20 of course also be surveyed with increased processing capacity or the use of a plurality of sensors and related to one another. Thus it is e.g. assumed that a lorry generally has a gently inclined setting down surface with correspondingly extending edges to be surveyed. Even
25 target location configurations of this type may be detected and calculated with the apparatus in accordance with the invention.

Embodiments of the invention are protected in the
30 dependent claims with which a yet further automation of the loading gear control may be achieved.

These embodiments can be realised, in particular, in cranes which are movable as a whole parallel to one of

the horizontal edges of the target container and whose lifting device (travelling winch) is movable transversely thereto parallel to a further upper horizontal edge of the target container. In the case of a derrick, the crane can be moved on e.g. wheels or tracks parallel to the longitudinal edges of target containers stacked in transverse rows on a ship. The lifting device is movable in the direction of the transverse rows with the loading gear aligned parallel to the target containers. This type of crane is only described in so detailed a manner because it is commonly used for the transloading of relatively large quantities of container and due to the predetermined coordinate axes on which the crane and lifting device move, make sensor-controlled automation particularly simple. Regardless of this, every other crane, e.g. gantry or swinging crane, can, however, of course also be equipped with the apparatus in accordance with the invention. Merely a larger processing effort must be made with such cranes when converting the determined measurement data into control signals. In principle, sensor-controlled automation of the loading gear movement is, however, possible in this case also.

The problem was mentioned above that the empty or loaded loading gear suspended on the lifting device behaves like a dynamic system. It can be caused to perform undesired oscillations merely due to the movement of the lifting device but also as a consequence of e.g. wind. In theory, the amplitude of this pendulum oscillation may be determined by surveying a point, e.g. a selected edge of the loading gear or of the container carried therein, provided that the selected edge to be scanned is aligned and remains transverse to the plane of oscillation. The

pendulum motion to be expected can, however, of course not always be predicted. Particularly with pendulum movements on which rotation of the suspended loading gear is superimposed, e.g. when moving a container with a mass distribution, the measurement of an individual edge point can no longer be sufficient in order to determine the degree of possible deflection.

An advantageous embodiment in accordance with Claim 2 thus provides that two points are surveyed situated on parallel edges of the loading gear or a container carried therein by means of the sensor. With continuous measurement, the oscillatory movement can be determined from the measured values obtained (which permit a point statement about the deflection and angular position of the loading gear). Signals are then produced automatically in the apparatus which control the crane drive to damp the oscillation.

It is possible for the two parallel edges to be scanned with one sensor. Appropriate sensors with suitable viewing angles are available. However, the resolution of such sensors decreases with increasing viewing angle, for which reason a construction in accordance with Claim 3 is preferred which associates an individual sensor of higher resolution with each edge to be scanned. If these sensors are arranged, as proposed in Claim 4, in different axial positions with respect to the edges to be scanned, measured values are obtained from which the angular position and deflection of the loading gear may be determined with relatively little processing effort.

Particularly the last apparatus referred to also permits a relatively simple parallel alignment of the empty or

loaded loading gear with a target container. If the sensors are further, as proposed in Claim 5, arranged moved out laterally somewhat (so that they can look beneath the loading gear or a container carried therein),
5 the empty or loaded loading gear can then be moved automatically into a position in which it is disposed above the target container and aligned parallel thereto. The empty or loaded loading gear need only be further adjusted in the direction of the longitudinal axis of the
10 container for a "flush" engagement position.

With the embodiments described above of the apparatus in accordance with the invention, e.g. the longitudinal edges of a loading gear may be automatically aligned with
15 the longitudinal edges of a target container. The crane driver is thus relieved of several difficult control processes. In order to lower e.g. the loading gear aligned onto a target container, it is, however, additionally necessary that an alignment also be
20 performed with respect to the transverse edges. This alignment can e.g. be effected manually by the crane driver. Furthermore, in addition to the sensors scanning e.g. the longitudinal edges, further sensors can be provided which survey the points on the transverse edges.

25 Advantageously, however, in an embodiment in accordance with Claim 6, a sensor is provided which is mounted on the crane so as to be movable in the direction of the edge to be scanned. Such a sensor can be moved along the
30 edge to be scanned and survey its (or their) end points. With the knowledge of at least one end point of an edge of the target container to be scanned, the precise position thereof may be determined and the crane moved accordingly. Thus in this embodiment, the alignment of

the empty or loaded loading gear with the longitudinal and transverse edges of the target container may be controlled in the simplest case with a single sensor. It is generally sufficient to perform this measuring process once per transverse row of containers which is to be transloaded. However, if the containers are to be loaded e.g. onto a ship or lifted off from it, it is possible to determine the end points of the edges of the target container to be scanned (or containers situated in the same transverse row) at regular distances and optionally to compensate for movement of the ship caused by currents etc. by appropriately moving the crane. It is of course also possible simultaneously to determine the end points of the edges of the loading gear to be scanned and of a container optionally carried therein and of the edge of the target container to be scanned.

The sensor is advantageously connected directly to the lifting device in accordance with Claim 7. An optimum overview of the transport process by means of the sensor is made possible in this manner.

In accordance with Claim 8 the sensor can be constructed as a 2D distance image sensor. Such a sensor produces a measurement beam pivoting in a plane with constant determination of the transmission angle and the beam return time. The beam return time is to be understood as meaning the time which e.g. a light pulse requires after transmission to return to a receiver after being reflected at an object to be surveyed. The distance of an object from the sensor may be calculated from the beam return time. A common example of distance measurement of this type is e.g. radar measurement. The spatial coordinates of a surveyed point may be determined with

respect to the sensor by means of the data (angle, beam return time) determined by the 2D distance image sensor. A laser beam or a microwave beam, for instance, may serve as the measurement beam.

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If the scanning plane of the 2D distance image sensors described above is additionally pivoted, a surface scan is obtained which can give e.g. information about the positions of points on a longitudinal and a transverse edge of the target container. Such a sensor (3D distance image sensor) supplies all three coordinates of the surveyed points.

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As already mentioned above, the measured data determined by the sensors is converted in the apparatus in accordance with the invention into control signals. The calculating processes necessary for this purpose are part of the basic knowledge of the expert as also are their processor-controlled conversion into control signals for a crane drive. It should, however, also be pointed out that, particularly in the embodiment in which the sensor is movably arranged on the crane, its position is also maintained fixed with respect to the crane and incorporated into the positional calculations. It is ensured in this manner that the necessary control signals can be produced independently of the position of the sensor on the crane.

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The invention is not limited only to an apparatus for controlling container cranes. Instead, a corresponding method is also to be protected.

In this connection, reference is made to independent Claim 9. Advantageous embodiments of the method are

protected in dependent Claims 10 and 11.

5 The principle of the method in accordance with the invention resides in surveying at least one point on a respective selected, upper, particularly horizontal, edge of the loading gear, of a container possibly carried therein and, when approaching a target location, at least one point on a selected edge of this target location. With the knowledge of the measured values, the vertical position and also the lateral position of the edges with respect to one another can be determined and from the known dimensions of the loading gear and a container possibly carried therein the vertical and lateral difference to the target location (whose configuration is also known), which is yet to be covered, can be input into the crane processor or some other processing unit which controls the crane drive. A further reference is also made at this point to the fact that a target location can be represented not only e.g. by a target container which is to be picked up or serves as a stacking base but also by a support surface for containers, e.g. on a ship, goods vehicle or lorry. Of importance for the method in accordance with the invention is merely that there is a surveyable edge in the region of the target location which is in clear geometrical relationship with the target location configuration. In the event that the target location is a container this can be e.g. one of the upper horizontal edges of the container.

30 It is provided in an embodiment of the method in accordance with the invention that further points on further edges of the loading gear, of a container carried therein and optionally of the target location are

surveyed. The loading gear can be aligned with the target location in this manner not only with respect to its lifting height but also with respect to further geometrical axes.

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In order to avoid repetition, reference is made to the statements in this connection relating to the apparatus claims.

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The previously discussed principal fields of application of the process in accordance with the invention (and also of the apparatus) relate to the approach and alignment of the loading gear and of a container possibly carried therein with a target location and the automatic damping of possible oscillations of the loading gear. A further embodiment of the method will be discussed below which relates in particular to the transport path of the loading gear between the target locations. As already stated above, containers are placed particularly in transverse rows, e.g. on ships, and further containers are stacked onto these containers. The lifting device is moved over the container row whose height is to be increased or reduced. The height of the individual container stacks situated in the row changes continuously (in dependence on the loading plan) in the course of transloading. Care should be taken that the loading gear is moved over its transport path at a suitably safe distance above the upper containers in the row. Due to the continuously changing configuration of the row of container stacks which is to be increased or reduced, manual monitoring of the transport path necessitates a high degree of concentration. It is therefore provided in accordance with Claim 10 that at least one upper horizontal edge of each container which is passed over by

the loading gear is surveyed at at least one point. The same sensor can be used for this purpose as is also used to survey points on the loading gear, on a container possibly carried therein and on the target container. The sensor is conveniently secured to the lifting device and aligned to look substantially vertically downwardly.

With the aid of the measured values a surface profile of the loading configuration can be determined with a processing unit, e.g. in the crane processor, which can be taken account of when controlling the loading gear over the container stacks to be increased or reduced. The data input into the processor is updated each time the loading gear moves, whereby changes in the loading configuration during the transloading process, and also a change in the position of a ship caused by tidal lift when e.g. loading or unloading the ship, are taken account of.

The invention will be explained in more detail below with reference to a number of views which relate to the exemplary embodiments.

Fig. 1 is a schematic view of a container crane which is equipped with an embodiment of the apparatus in accordance with the invention.

Fig. 2 shows a further crane,

Fig. 3 is a schematic drawing which shows the approach of a transported container to a target container.

Fig. 1 shows a container crane 10 transloading containers

12 stacked in a transverse row 11. The container crane 10 has a bridge 14 which is movable on wheels 13 and carried on which is a lifting device 15, which is movable in the longitudinal direction of the bridge. Suspended on the lifting device 15 is a loading gear 16 with which the containers 12 may be grasped and held. The loading gear 16 can be moved by the lifting device 15 into any desired vertical position below the bridge 14.

10 The container crane 10 illustrated in Fig. 1 corresponds thus far to the prior art. However, in accordance with the invention, a series of sensors 17a, b, 18a, b are now disposed on the lifting device 15. The sensors 17a, b are so arranged that, as shown, they survey respective points 170a, b, offset in the longitudinal direction, on longitudinal edges 160a, b of the loading gear 16 and points 170a', b', which are also offset from one another, on horizontal longitudinal edges 120a, b on a container 120. As explained below in connection with Fig. 3, the height difference, in particular, between loading gear 16 and the surface of the container 20 can be easily calculated from the respective measured point values and furthermore a parallel alignment of the longitudinal axis of the loading gear 16 with the longitudinal axis of the container 120 can be checked. If, as in the present case, the bridge 14 is already aligned with the container row 11, the loading gear 16 can automatically be controlled without difficulty by means of the measured data determined by the sensors 17a, b into loading engagement with one of the containers 12, e.g. the container 120.

However, the alignment of the bridge 14 with the container row 11 can also be automated. This is effected

in the drawing by the sensors 18a, b, of which the sensor 18a sweeps across a line parallel to the container row 11 with its field of view 180a (the field of view of the sensor 18b is not shown for reasons of clarity). In order to align the crane 10, it can be moved e.g. far enough in the longitudinal direction of the containers 12 that the field of view 180a of the sensor 18a includes the end edge corner points of the containers 12. The position of the container row 11 with respect to the crane 10 can be unambiguously determined with the aid of these measured values. It is then sufficient to move the crane 10 until the loading gear 16 is disposed centrally above the row 11.

The alignment of the crane can, however, also be effected by means of the sensors 17a, b. For this purpose, the crane 10 must be moved in a direction until e.g. the sensor 17a reaches the closer end of the upper horizontal edge 120a scanned by it of the container 120. The position of the row 11 with respect to the crane 10 may then be determined and appropriately aligned from the known relationship of the loading gear 16 with the crane 10 and the measured value.

A further possibility, which is described above, would be to arrange the sensor or sensors 17a, b in the lifting device 15 so as to be movable in the direction of the scanned edge 120a, b. It would be sufficient in this case to move the sensor 17a (and not the entire crane 10) appropriately in order to detect the corner point of the scanned edge of the container 120.

Figure 2 shows a container crane 20 which is the same in principle as the crane 10 shown in Fig. 1. Provided in

this case also is a bridge 22, which is movable on wheels 21 and carried on which is a lifting device 23 which is movable in the longitudinal direction of the bridge 22. A driver's cab 50, which is associated with the lifting device 23 and is movable with it, is provided on the bridge 22. A crane driver can monitor the loading activity from the driver's cab 50. Suspended from the lifting device 23 is a vertically movable lifting gear 24 which is just in loading engagement with a container 25. The container 25 belongs to a whole series of further containers, which are also designated with the reference numeral 25, and which are arranged in adjacent stacks 27 in a transverse row 26. In the illustrated case, the containers 25 engaged by the loading gear 24 are to be transloaded onto a lorry 28.

In order to control the loading process, sensors 29a and 29b are provided which are arranged on the lifting device 23 and whose sensor regions 290b, 290a survey respective points on the upper horizontal longitudinal edges of the loading gear 24.

The empty loading gear 24 is firstly lowered positionally correctly onto the container 25 (illustrated state) with the aid of the sensors 29a, 29b. The loading gear 24 is now moved, loaded with the container 25, to the lorry 28, the surfaces of the container stack 27 additionally being swept over by means of the sensors 29a, 29b and a respective point on the longitudinal edges, bounding the surfaces, of the container 25 is surveyed. With the aid of the measured values, a profile of the surfaces defined by the container stack is produced in the crane processor which can be updated on each loading movement of the loading gear 24 or of the lifting device 23. The crane

processor can thus automatically predetermine a collision-free path to the desired destination, in this case the lorry 28, for the transport of each container.

5 The lorry, for its part, has upper horizontal edges 30, 31 which can be surveyed by the sensors 29a, 29b at at least one point. The container 25 picked up by the loading gear 24 can be lowered precisely onto the loading surface of the lorry 28 with the aid of the measured
10 values detected for the lorry.

Fig. 3 is a rough schematic view of a typical transloading situation in which a container 40 is to be deposited flush on a target container 41. All the other
15 components of the crane etc. transporting the container 40 have been omitted for reasons of clarity. Reference numerals 42 and 43 indicate points which were surveyed on one of the upper longitudinal edges of the container 40 and the container 41 by means of a sensor 60 secured to
20 the crane, which is not shown. A measuring beam 600 is rotated by the sensor 60 in a plane over an angular region 61 for the survey. The beam return time at each defined emission angle is determined. The distance between the sensor and a point which reflects the beam may be determined from the beam return time and from the
25 emission angle of the beam and its angular position with respect to the sensor. Coordinates, which define the vertical and horizontal position of the point in relation to the sensor, can be determined in this manner for each
30 point surveyed by the sensor. In the present case, points 42 and 43 on upper horizontal longitudinal edges of the containers 40 and 41 were surveyed by means of the measuring beam 600 at angular positions A_1 , A_2 . The vertical distance Δh and the horizontal distance ΔX

between the points 42 and 43 can be determined from the corresponding coordinates.

5 For the purpose of positionally correctly setting down,
the container 40 must be moved, and with it the measuring
point 42, until the value ΔX is zero and the value Δh is
equal to the known height of the container 40, ΔC . The
appropriate control signals for the crane actuator may be
10 produced without difficulties with the knowledge of the
continuously determined and checked position of the
measured values 42 and 43.

15 It will also be clear from the preceding description of
the sensor 60 that the minimum height of an edge to be
scanned can be predetermined without difficulty. It is
sufficient for this purpose to relate the individual
distance values of the measuring beam 600 emitted from
the sensor at different angular positions to one another.
If, e.g. a relatively large change in the distance occurs
20 with a small change in the angle, then an edge is
present. The relationship between change in angle and
the distance values determined may be adjusted as desired
so that the edge drop triggering a measurement can be
matched precisely to the selected edge to be scanned. It
25 can e.g. be ensured in this manner that the sensor
reliably detects an external horizontal edge of the
container and does not respond to e.g. relatively small
edges of reinforcing profiles on the container. One
could e.g. pre-program the sensor only to respond to
30 edges which have a drop of the height of the side wall of
the container. As stated above, there is absolute
freedom of choice in this connection.

**CLAIMS:**

1. Apparatus for controlling a container crane, which has a movable lifting device for a suspended loading gear, with which the containers can be picked up and held, characterised in that at least one sensor (17a, b; 18a, b; 29a, b; 60) is provided which is arranged above the loading gear (16, 24) and looks downwardly and which is in the position to scan surfaces disposed within the lifting range of the loading gear (16, 24) and, on edges (160a, b; 120a, b) situated therein, which have a minimum height drop, to survey at least one point (170a, b; 170a', b'; 42; 43) on the edge (160a, b; 120a, b) and which is so aligned that its scanning region sweeps over points (170a, b) on at least one edge (160a, b) of the loading gear (16, 24) or at least one upper edge of a container (25) carried in the loading gear (24) and, when approaching a target container (120) to be picked up or serving as a stack base, at least one upper edge (120a, b) of the target container (120), whereby the apparatus generates control signals, from the positions of the detected edge points (170a, b; 170a', b'; 42; 43) and from the known dimensions of the loading gear (16, 24) or of the containers (12, 120, 25, 40, 41), for the crane drive to steer the loading gear (16, 24) or a container connected thereto into an engagement position with the target container (120).
2. Apparatus as claimed in Claim 1, characterised in that the sensor sweeps over at least two selected, parallel edges of the loading gear or of the container carried therein.



3. Apparatus as claimed in Claims 1 or 2, characterised in that at least two sensors (17a, b; 29a, b) are provided which scan respective opposed, parallel edges (160a, b) of the loading gear (16) or a container carried in the loading gear.
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4. Apparatus as claimed in Claims 3 or 4, characterised in that the two sensors (17a, b) are offset from one another in the direction of the edges (160a, b) to be scanned.
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5. Apparatus as claimed in one of Claims 1 to 4, characterised in that the sensor (29a, b) is arranged outside the vertical projection of a container (25), carried in the loading gear (24), on the crane.
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6. Apparatus as claimed in one of the preceding claims, characterised in that the sensor is mounted to be movable in the direction of the selected, scanned edge.
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7. Apparatus as claimed in one of the preceding claims, characterised in that the sensor (17a, b; 18a, b; 29a, b) is mounted on the lifting device (15, 23).
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8. Apparatus as claimed in one of the preceding claims, characterised in that the sensors (17a, b; 18a, b; 29a, b; 60) are conventional 2D distance sensors which produce a beam (60) rotating in a plane with constant simultaneous determination of the beam angle and the beam return time.
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9. Method of controlling a container crane in which a



- loading gear for containers suspended on a movable lifting device is moved back and forth in the empty or loaded state between two alternating target locations, the target locations being represented substantially by a target container to be picked up or serving as a stack base or a receiving surface of characteristic configuration, characterised in that by means of at least one sensor (17a, b; 18a, b; 29a, b; 60) arranged on the crane (10, 20), at least one respective point (170a, b; 170a', b'; 42) of a selected upper edge (160a, b) of the loading gear (16) and/or a container (40) carried therein and, on approach to the target location (120, 28, 41), a point (170a', b'; 43) of a selected edge (120a, b; 30, 31) situated in the target location (120, 28) are surveyed, from the measurement results and the known dimensions of the loading gear (16, 24) and a container (40) possibly carried therein and the known target location configuration the height difference and the lateral difference between the loading gear (16, 24) and the target location (120, 28, 41) are determined and converted into control signals for the crane drive.
10. Method as claimed in Claim 9, characterised in that the sensor is moved in opposition to or together with the crane in the direction of the selected horizontal edge of the target location and at least one of the two corner points of the selected edge is thereby surveyed and the crane is moved in accordance with the determined measured value parallel to the scanned edge so that its loading gear is movable into the target location without further displacement in the direction of the scanned



edge.

11. Method as claimed in one of Claims 8 or 9, characterised in that at least one respective point of a respective horizontal edge of all the surfaces situated on the path between the starting and target locations are surveyed by means of the sensor and a profile of the surface crossed by the loading gear is calculated and supplemented from the measured values.

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