

A LIFTING ARRANGEMENT

Field of the Invention

5 The present invention relates to a lifting arrangement and to a transportation vehicle including such a lifting arrangement, the transportation vehicle for a goods handling system of the type wherein goods are stored in and retrieved from a goods storage area in an at least partially automated way.

Background of the Invention

It is known to provide an at least partially automated goods handling system wherein goods stored in a goods storage area are transported between the goods storage area and operator stations using transportation vehicles, for example transportation robots.

15 With one such system, the transportation vehicles are navigated through the goods storage area, for example using machine detectable tape that is disposed on the floor of a warehouse along defined movement paths or by using lasers that interact with reflective material, for example disposed on walls of the warehouse. The transportation vehicles also include a lifting arrangement arranged to controllably lift a goods storage
20 rack relative to the ground so that the rack can be transported by the vehicle.

However, existing transportation vehicles include relatively unsophisticated lifting mechanisms.

Summary of the Invention

In accordance with a first aspect of the present invention, there is provided a lifting arrangement for raising and lowering a contact member, the lifting arrangement comprising:

30 a linear actuator arranged to controllably move the contact member between a lowered position and a first raised position;

wherein the lifting arrangement is arranged to move the contact member between the lowered position and the first raised position without rotating the contact member about a rotational axis parallel to the direction of linear movement of the contact
35 member; and

wherein the lifting arrangement includes a rotational engagement device arranged, when the contact member is in the first raised position, to permit rotational movement of the contact member about the rotational axis between the first raised

position and a second raised position whilst restricting linear movement of the contact member parallel to the rotational axis.

In accordance with a second aspect of the present invention, there is provided a transportation vehicle comprising a lifting arrangement for raising and lowering a contact member, the lifting arrangement comprising:

a linear actuator arranged to controllably move the contact member between a lowered position and a first raised position;

wherein the lifting arrangement is arranged to move the contact member between the lowered position and the first raised position without rotating the contact member about a rotational axis parallel to the direction of linear movement of the contact member.

In an embodiment, the linear actuator includes a screw portion and a nut portion threadably engaged with the screw portion. The linear actuator may include a ball screw arrangement or a lead screw arrangement.

In an embodiment, the lifting arrangement includes a linear engagement device including a linear first channel and a projection received in the first channel, wherein movement of the projection in a direction parallel to the first channel is permitted and movement of the projection in a direction perpendicular to the first channel is restricted.

In an embodiment, the projection is connected to and extends from the nut portion and the contact member is connected to the nut portion such that movement of the projection relative to the first channel effects linear movement of the contact member.

In an embodiment, the projection includes at least one bearing received in the first channel. The at least one bearing may be rotatably mounted on a shaft extending from the nut portion.

In an embodiment, the rotational engagement device is movable such that the distance between the lowered position and the first raised position is modifiable.

The linear engagement device may include a first portion and a second portion, the first portion engaged with and reciprocally movable relative to the second portion such that the length of the linear first channel is adjustable.

In an embodiment, the lifting arrangement comprises a rack and pinion arrangement for effecting controlled reciprocal movement of the first portion relative to the second portion.

- 5 The rotational engagement device may include a second channel arranged to receive the projection when the contact member is in the first raised position. The second channel may be substantially annular.

- 10 In an embodiment, the transportation vehicle is arranged such that rotation of the screw portion of the linear actuator effects rotation of the nut portion of the linear actuator when the contact member is located in or between the first and second raised positions and when linear movement of the contact member parallel to the rotational axis is restricted.

- 15 In an embodiment, the transportation vehicle includes a body portion, the lifting arrangement arranged to controllably move the contact member relative to the body portion.

- 20 In an embodiment, the transportation vehicle includes at least one movement motor arranged to effect rotation of the body portion about a vertical axis in a direction opposite to the direction of rotation of the contact member. The transportation vehicle may effect rotation of the body portion in a direction opposite to the direction of rotation of the contact member such that the absolute orientation of the contact member is substantially unchanged despite rotation of the contact member about the rotational axis.

- 25 In an embodiment, the transportation vehicle includes at least one position detector arranged to detect the linear and/or rotational position of the contact member. The transportation vehicle may include a motor arranged to effect linear movement and/or rotational movement of the contact member and the or each position detector may be used to control operation of the motor. The at least one position detector may include at
30 least one limit switch.

Brief Description of the Drawings

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic representation of a transportation vehicle in accordance with an embodiment of the present invention;

Figure 2 is a block diagram illustrating functional components of the transportation vehicle shown in Figure 1;

Figure 3 is a diagrammatic perspective view of a lifting arrangement of the transportation vehicle shown in Figures 1 and 2;

Figure 4 is a diagrammatic side view of the lifting arrangement shown in Figure 3;

Figure 5 is a diagrammatic cross-sectional view of the lifting arrangement shown in Figures 3 and 4, with a contact plate of the transportation vehicle shown in a lowered position;

Figure 6 is a diagrammatic cross-sectional view of the lifting arrangement shown in Figures 3 and 4, with the contact plate of the transportation vehicle shown in a first raised position;

Figure 7 is a diagrammatic cross-sectional view of the lifting arrangement shown in Figures 3 and 4, with the contact plate of the transportation vehicle shown between the first raised position and a second raised position;

Figure 8 is a diagrammatic first view of an alternative lifting arrangement; and

Figure 9 is a diagrammatic second view of the alternative lifting arrangement; shown in Figure 8.

Description of an Embodiment of the Invention

Referring to the drawings, Figure 1 shows a transportation vehicle 10, in this example in the form of a transportation robot, that transports goods racks (not shown) between a goods storage area in a warehouse and one or more operator stations at which orders are packed. Movement of the transportation vehicles 10 may be coordinated by a management system, for example located remotely and in communication with the transportation vehicle 10 through a wireless communication network.

During use, items to be stored in the goods storage area are transported between the operator stations and the goods storage area by several transportation vehicles 10, and orders are fulfilled by transporting racks containing items included in the order from the goods storage area to the operator stations.

The transportation vehicle 10 includes a body 12, wheels 14, at least some of which are individually controllable so as to control the speed and direction of movement of the transportation vehicle 10, and a contact member, in this example a contact plate 16, that during use contacts a rack. The contact plate 16 may be controllably raised or lowered
5 relative to the body 12 in order to raise or lower a rack disposed above the transportation vehicle 10, and thereby facilitate transport of the rack, for example between the goods storage area and an operator station.

Example functional components 20 of the transportation vehicle 10 are shown in Figure
10 2.

The functional components 20 include a network interface 22 arranged to facilitate networked communications, for example between the vehicle 10, the management system that manages movement of the vehicle 10 and the operator stations that facilitate
15 packing of orders by operators.

The functional components 20 also include a microcontroller 24 arranged to control and coordinate operations in the transportation vehicle 10, and in particular to implement a position determiner 34 arranged to determine the location of the vehicle 10 using one or
20 more sensors 36, and a direction controller 38 arranged to control movement of the vehicle 10.

The microcontroller 24 communicates with a motor driver 26 that controls movement motors 28 associated with the wheels 14, and in this way the speed and direction of the
25 vehicle 10 is controlled.

The functional components 20 also include a lifting arrangement 32 arranged to controllably raise or lower the contact plate 16 in response to instructions from the microcontroller 24.
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Referring to Figures 3 to 7, a lifting arrangement 32 is shown for controllably raising and lowering the contact plate 16 relative to the body 12 of the vehicle 10.

The lifting arrangement 32 includes a housing 50, a linear actuator arranged to controllably effect linear movement of the contact plate 16 between a lowered position
35 shown in Figure 5 and a first raised position shown in Figure 6. The linear actuator in this example includes a ball screw arrangement including a ball screw part 52 and an associated ball nut part 54, the ball screw arrangement configured to effect movement of the ball nut 54 in a linear direction parallel to the axis of rotation of the ball screw 52.

The contact plate 16 is connected to the ball nut 54 and accordingly linear movement and/or rotational movement of the ball screw effects corresponding linear movement and/or rotation of the contact plate 16.

5 The lifting arrangement 32 also includes a linear engagement device 62 arranged to restrain rotation of the ball nut 54 as the ball screw 52 rotates. As shown in Figures 5 to 7, the ball nut 54 includes ball bearings 56 that facilitate relatively low friction rotation of the ball screw 52 relative to the ball nut 54.

10 However, it will be understood that alternative linear actuators are envisaged, for example a lead screw, the operation of which is similar to the ball screw arrangement in that linear movement of a nut is effected in response to rotation of a screw.

15 The linear actuator is driven by a motor 58, in this example through a gearbox 60, the motor 58 effecting controlled rotation of the ball screw 52.

The linear engagement device 62 ensures that the contact plate 16 does not rotate as the contact plate 16 moves from the lowered position shown in Figure 5 to the first raised position shown in Figure 6.

20 In this example, the linear engagement device 62 is connected to the housing 50 and includes a first channel 64 that receives a projection 65 extending from the ball nut 54 and thereby restricts rotation of the ball nut 54 whilst allowing the ball nut 54 to move relative to the first channel 64 in a generally linear direction parallel to the axis of rotation of the ball nut 54. The projection 65 may include a low friction device, such as a bearing 25 66, and a shaft 68 on which the bearing 66 is rotatably mounted. The bearing 66 locates in the first channel 64 and in this way facilitates relatively low friction linear movement of the shaft 68 relative to the first channel 64.

30 In this example, one projection 65, one associated bearing 66 and one associated first channel 64 are provided, although it will be understood that multiple projections 65, bearings 66 and first channels 64 may be provided.

35 A lower end of the first channel 64 has a first position detector, in this example a first limit switch 70, arranged to detect when the projection 65 reaches a position relative to the first channel 64 corresponding to the contact plate lowered position shown in Figure 5, and a second position detector, in this example a second limit switch 72, arranged to detect when the projection reaches a position relative to the first channel 64

corresponding to the first raised position shown in Figure 6. However, any suitable position detector is envisaged, and for example the first and second position detectors may include proximity sensors.

5 The linear engagement device 62 in this example also includes a ledge portion 74 on which is supported a rotational engagement device 80, the rotational engagement device 80 including an annular member 82 in which an annular second channel 84 is formed. The second channel 84 receives the projection 65 from the first channel 64 when the contact plate 16 is in the first raised position shown in Figure 6, and thereby permits
10 rotational movement of the ball nut 54 relative to the housing 50 whilst restricting linear movement of the ball nut 54 relative to the housing 50 when the projection 65 is located in the second channel 84. It will however be understood that linear movement of the ball nut 54 is only restricted when the projection 65 is not aligned with the first channel 64, in which case the ball nut 54 is able to move downwards relative to the housing 50.

15 In an alternative embodiment, multiple annular members 82 may be provided at different heights so that the rotational movement of the ball nut 54 is permitted at different defined heights.

20 During use, as part of a goods handling system the transportation vehicle 10 is instructed to retrieve a selected rack from a good storage area in a warehouse, and the vehicle 10 moves to the selected rack in response to controls from the direction controller 38. When the transportation vehicle 10 arrives at a location under a rack, the lifting device 32, for example under control of the microcontroller 24, activates the motor
25 58 which causes the ball screw 52 to rotate. Since the ball nut 54 is restrained by the linear engagement device 62 from rotating relative to the housing 50, rotation of the ball screw 52 causes the ball nut 54 to move upwardly relative to the ball screw 52, and thereby the projection 65 to move upwardly in the first channel 64 and the contact plate 16 to move from the lowered position shown in Figure 5 to the first raised position shown
30 in Figure 6. In this way, rotation of the ball screw 52 causes the contact plate 16 to move upwards without causing the contact plate to rotate. This is important because rotation of a rack disposed above the contact plate 16 may be undesirable, for example because of the risk of collision with other racks or other nearby obstacles.

When the contact plate 16 reaches the first raised position shown in Figure 6, the second limit switch 72 is triggered, for example by contact with the projection 65, which causes deactivation of the lifting device motor 58 and rotation of the ball nut 52 to cease. At an upper end of the first channel 64, the first channel 64 extends into the second
5 channel 84, and therefore the projection moves from the first channel 64 to the second channel 84 as the contact plate 16 moves from the lowered position shown in Figure 5 to the first raised position shown in Figure 6.

The transportation vehicle 10 with supported rack can then be moved to the desired
10 destination, for example an operator station at which orders are packed.

If during movement of the rack it is desired to change the rotational position of the contact plate 16 and thereby the supported rack, the lifting device motor 58 is reactivated which causes the ball screw 52 to rotate. Since the projection 65 is located in the
15 second channel 84 instead of the first channel 64, the ball nut 54 is free to rotate relative to the housing 50. In addition, since the projection 65 is restricted from moving upwards relative to the ball screw 52 by contact with the second channel 84, rotation of the ball screw 52 also effects rotation of the ball nut 54. As a consequence, rotation of the ball screw 52 effects rotational movement of the projection 65 in the second channel 84 and
20 rotation of the contact plate 16 from the first raised position shown in Figure 6 to a second raised position. A third position detector, in this example a third limit switch 86, is disposed at a location corresponding to an end of the second channel 84 remote from the second limit switch 72, and is used to deactivate the motor 58 when the contact plate 16 has reached the second raised position. Figure 7 illustrates a rotational position of
25 the contact plate 16 between the first and second raised positions.

If during movement of the rack the transportation vehicle 10 is required to change direction, but without changing the rotational position of the contact plate 16 and thereby the supported rack, the transportation vehicle 10, in this example the direction controller
30 38 of the vehicle 10, is arranged to control the movement motors 28 so as to rotate the housing 50 in a direction opposite to the direction of rotation of the contact plate 16. In this way, by ensuring that the respective rotations of the contact plate 16 and the housing 50 are substantially equal and opposite, the direction of movement of the vehicle is changed without changing the absolute orientation of the contact plate 16 and
35 supported rack.

When the vehicle 10 reaches the desired location with the contact plate 16 is disposed in the first raised position, the lifting device 32, for example under control of the microcontroller 24, activates the motor 58 so as to cause the ball screw 52 to rotate in an opposite direction. This causes the ball nut 54 to move downwardly relative to the ball screw 52, and thereby the projection 65 to move downwardly in the first channel 64 and the contact plate 16 to move from the first raised position shown in Figure 6 to the lowered position shown in Figure 5.

If the contact plate 16 is disposed in the second raised position or between the first and second raised positions when the vehicle 10 reaches the desired location, the lifting device 32, for example under control of the microcontroller 24, also effects opposite rotational movement of the projection 65 in the second channel 84 and rotation of the contact plate 16 to the first raised position shown in Figure 6 prior to effecting linear movement of the contact plate from the first raised position to the lowered position.

Referring to Figures 8 and 9, an alternative lifting arrangement 90 is shown. Like and similar features are indicated with like reference numerals.

The lifting arrangement 90 includes an alternative linear engagement device 92 that has a first portion 94 engaged with and reciprocally movable relative to a second portion 96, the first and second portions together defining a first channel that receives the projection 65. It will be understood that since the first and second portions are reciprocally movable relative to each other, the length of the first channel is adjustable. In this way, since the first portion 94 is connected to the annular member 82, the height of the annular member 82 is adjustable and thereby the height of rotation of the contact plate 16.

In this example, reciprocal movement of the first portion 94 relative to the second portion 96 is effected by providing one of the first and second portions 94, 96 with a rack 100 and providing the other of the first and second portions with a pinion 102, although it will be understood that any suitable arrangement for effecting controlled movement of the first portion 94 relative to the second portion 96 is envisaged. A suitable motor (not shown) is also provided for effecting rotation of the pinion 102 and thereby linear movement of the rack 100 and expansion or contraction of the first channel.

Modifications and variations as would be apparent to a skilled addressee are deemed to be within the scope of the present invention.

CLAIMS

1. A lifting device (32) for raising and lowering a contact member (16), the lifting device comprising:

an actuator (52, 54, 58) configured to move the contact member between a lowered position and a raised position, wherein in a first mode of operation of the lifting device (32), the actuator (52, 54, 58) moves the contact member (16) from the lowered position to the raised position without rotating the contact member (16) about a reference axis, and characterized in that:

wherein in a second mode of operation of the lifting device (32), the actuator (52, 54, 58) permits rotational motion of the contact member (16) about the reference axis from the raised position to a modified raised position, and

the actuator (52, 54, 58) restricts linear movement of the contact member (16) in a direction that is parallel to the reference axis.

2. The lifting device (32) according to Claim 1, wherein the actuator (52, 54, 58) includes a screw portion (52) and a nut portion (54), the nut portion (54) being fastened to the screw portion (52) in a threaded fashion.

3. The lifting device (32) according to Claim 2, wherein in the first mode of operation of the lifting device (32), the actuator (52, 54, 58) permits rotational motion of the screw portion (52) and linear motion of the nut portion (54).

4. The lifting device (32) according to Claim 2 or 3, wherein in the second mode of operation of the lifting device (32), the actuator (52, 54, 58) permits only rotational motion of the screw portion (52) and the nut portion (54), or

in a third mode of operation of the lifting device (32), the actuator (52, 54, 58) is configured to rotate the screw portion (52) in a direction that is opposite of the rotational direction of the screw portion (52) in the first mode of operation of the lifting device, and wherein the actuator (52, 54, 58) is configured to move the nut (54) in a linearly downward direction.

5. The lifting device of any of claims 1 to 4, further comprising:

an engagement member (65) including a shaft (68) connected at a first end to a nut portion (54) of the actuator and having a bearing (66) rotatably mounted on a second end of the shaft (68), the second end of the shaft (68) being away from the first end and being disposed in a first channel (64) that permits in the first mode of operation of the lifting device (32), a movement of the shaft (68) along a length of the first channel (64) and restricts movement of the shaft (68) in a direction that is perpendicular to the length of the first channel (64).

6. The lifting device (32) according to Claim 5, wherein the contact member (16) is connected to the nut portion (54) of the actuator and a linear movement of the shaft (68) along the first channel (64) induces the linear movement of the contact member (16).

7. The lifting device (32) according to claim 5, further comprising:

a rotational member (80) that includes a second channel (84) designed to receive the shaft (68) from the first channel (64) when the contact member (16) is in the raised position.

8. The lifting device (31) of Claim 7, wherein the rotational member (80) permits only rotational movement of the shaft (68) about the reference axis, in the second mode of operation of the lifting device (32).

9. The lifting device (32) according to Claim 7 or Claim 8, wherein the rotational member (80) is substantially annular in structure and is affixed to the nut portion (54) of the actuator by a ledge (74).

10. The lifting device (32) of Claim 1, further comprising:
an engagement member (92) including a first portion (94) and a second portion (96), the first portion (94) being engaged with and reciprocally movable with respect to the second portion (96), such that a length of a first channel (64) formed by the first and second portions is adjustable.

11. The lifting device (32) of Claim 10, further comprising:
a rack (100) attached to the first portion (94) of the engagement member (92), and
a pinion (102) attached to the second portion (96) of the engagement member (92),
wherein a rotational motion of the pinion (102) induces a linear motion of the rack (100).

12. The lifting device (32) according to Claim 5, wherein the reference axis is substantially parallel to the length of the first channel (64).

13. A transportation vehicle (10) comprising:
a body portion (12); and
a lifting device (32) according to any of claims 1, 5-11, and 12 disposed on the body portion (12).

14. The transportation vehicle (10) of Claim 13, further comprising:

a motor (28) configured to rotate the body portion (12) of the transportation vehicle about the reference axis in a direction opposite to the direction of rotation of the contact member (16).

15. The transportation vehicle (10) of Claim 14, wherein rotating the body portion (12) of the transportation vehicle in the direction opposite to the direction of rotation of the contact member (16) does not change an absolute orientation of the contact member (16) with respect to the body portion (12) of the transportation vehicle.