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Overhead carrier and overhead carrying system

Abstract

An overhead transport vehicle includes: an article holding unit configured to hold an article; a linear drive unit configured to drive the article holding unit to move linearly; a pivoting drive unit configured to drive the article holding unit to pivot horizontally; and a control unit configured to control the pivoting drive unit in accordance with orientation of the article held by the article holding unit and orientation of a load port on which the article is placed.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is a National Stage Application under 35 U.S.C. § 371 and claims the benefit of International Application No. PCT/JP2021/005478, filed Feb. 15, 2021, which claims priority to JP Patent Application Serial No. 2020-078157, filed on Apr. 27, 2020. The entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

(2) An aspect of the present invention relates to an overhead transport vehicle and an overhead transport system.

BACKGROUND ART

(3) As a technology related to overhead transport vehicles, a rail-guided trolley described in Patent Literature 1, for example, is known.

(4) The rail-guided trolley described in Patent Literature 1 includes a body section configured to convey an article along a rail including a portion arranged in a grid pattern while holding it below the rail.

CITATION LIST

Patent Literature

(5) [Patent Literature 1] International Publication No. WO 2018/037762

SUMMARY OF INVENTION

Technical Problem

(6) In the overhead transport vehicle described above, depending on the orientation of an article held by an article holding unit, it may be difficult to transfer the article in a desired orientation to a load port.

(7) In view of this, it is an object of an aspect of the present invention to provide an overhead transport vehicle and an overhead transport system that can transfer an article in a desired orientation to a load port.

Solution to Problem

(8) An overhead transport vehicle according to an aspect of the present invention includes: an article holding unit configured to hold an article; a linear drive unit configured to drive the article holding unit to move linearly; a pivoting drive unit configured to drive the article holding unit to pivot horizontally; and a control unit configured to control the pivoting drive unit in accordance with orientation of the article held by the article holding unit and orientation of a load port on which the article is placed.

(9) With this overhead transport vehicle, regardless of the orientation of an article held by the article holding unit, the control unit controls the pivoting drive unit in accordance with the orientation of the article and the orientation of the load port, thereby being able to transfer the article in a desired orientation to the load port.

(10) In the overhead transport vehicle according to an aspect of the present invention, the linear drive unit may include a lifting drive unit configured to raise and lower the article holding unit and a slide drive unit configured to slide and move the lifting drive unit, and the pivoting drive unit may include a first pivoting drive unit configured to horizontally pivot the slide drive unit and a second pivoting drive unit configured to horizontally pivot the article holding unit or the lifting drive unit. By this configuration, the orientation of an article can be specifically controlled.

(11) The overhead transport vehicle according to an aspect of the present invention may be an overhead transport vehicle capable of traveling along a rail arranged at least partially in a grid pattern, and may include: a traveling wheel configured to roll on the rail; and a body section disposed below the rail and including the article holding unit, the linear drive unit, and the pivoting

drive unit. By this configuration, traveling paths for the overhead transport vehicle can be selected easily and flexibly, whereby traffic congestion can be prevented and conveyance efficiency can be improved.

(12) In the overhead transport vehicle according to an aspect of the present invention, the control unit may perform: a first control of horizontally pivoting the article holding unit by a first angle such that the orientation of the article and the orientation of the load port are in a certain relation; and a second control of horizontally pivoting the article holding unit by a second angle smaller than the first angle such that the orientation of the article is fine-tuned. By these controls, the article can be reliably transferred in the desired orientation to the load port.

(13) An overhead transport system according to an aspect of the present invention includes: a plurality of processing devices disposed so as to be aligned along a passage on each of one side and the other side of the passage; and the overhead transport vehicle described above. Each of the processing devices includes the load port disposed on a side of the processing device closer to the passage. The overhead transport system includes a traveling path, serving as a path along which the overhead transport vehicle travels, extending across the passage and allowing the overhead transport vehicle to pass through above a pair of the load ports.

(14) Generally, because the orientations of a pair of load ports facing each other with a passage interposed therebetween are opposite to each other, it is difficult to transfer an article between the pair of load ports such that the orientation of the article and the orientation of each load port are in the certain relation. To solve this problem, the overhead transport system according to this aspect of the present invention includes the traveling path extending across the passage and allowing the overhead transport vehicle to pass through above the pair of load ports (hereinafter also referred to as cross-traveling path) and the overhead transport vehicle described above. Even between the pair of load ports at the cross-traveling path, an article can be transferred in a desired orientation by appropriately controlling the pivoting drive unit by the control unit.

Advantageous Effects of Invention

(15) According to an aspect of the present invention, it is possible to provide the overhead transport vehicle and the overhead transport system that can transfer an article in a desired orientation to a load port.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. 1 is a side view illustrating an example of an overhead transport system according to an embodiment.

(2) FIG. 2 is a perspective view illustrating an overhead transport vehicle in FIG. 1.

(3) FIG. 3 is a perspective view illustrating the overhead transport system in FIG. 1.

(4) FIG. 4 is a diagram schematically illustrating the overhead transport vehicle in FIG. 1 when viewed from above.

(5) FIG. 5 is a plan view illustrating an example when an article is conveyed between load ports by the overhead transport vehicle in the overhead transport system in FIG. 1.

(6) FIG. 6 is a plan view illustrating a continuation of FIG. 5.

(7) FIG. 7 is a plan view illustrating a continuation of FIG. 6.

(8) FIG. 8 is a plan view illustrating a continuation of FIG. 7.

(9) FIG. 9 is a plan view illustrating a continuation of FIG. 8.

(10) FIG. 10 is a plan view illustrating a continuation of FIG. 9.

(11) FIG. 11 is a plan view illustrating a continuation of FIG. 10.

(12) FIG. 12 is a plan view illustrating cross-traveling paths that an overhead transport system according to a modification includes.

DESCRIPTION OF EMBODIMENTS

(13) An embodiment will now be described with reference to the drawings. In the drawings, in order to describe the embodiment, the scale is changed to be expressed appropriately by, for example, illustrating a part in an enlarged or emphasized manner. In each drawing, directions in the drawing are illustrated with the XYZ-coordinate system. In this XYZ-coordinate system, a plane parallel to the horizontal plane is defined as an XY plane. A linear direction along the XY plane is denoted as the X direction, and a direction orthogonal to the X direction is denoted as the Y direction. A direction in which an overhead transport vehicle **100** travels can be changed from a state illustrated in the drawing to other directions and, for example, it may travel in a curved direction. The direction perpendicular to the XY plane is denoted as the Z direction. Each of the X direction, the Y direction, and the Z direction is described on the assumption that the direction indicated by the arrow in the drawing is the +direction and the opposite direction is the -direction. The direction of rotation about the Z axis is denoted as θZ direction.

(14) As illustrated in FIG. 1, FIG. 2, and FIG. 3, an overhead transport system SYS is a system for conveying articles M by the overhead transport vehicle **100** in a clean room of a semiconductor manufacturing factory, for example. The overhead transport system SYS includes the overhead transport vehicle **100** and a system controller 5 to convey articles M to a plurality of processing devices 6. Examples of the articles M include a FOUP configured to accommodate semiconductor wafers or a reticle pod configured to accommodate reticles. Each article M has an orientation and, for example, a side opposite to a side of a lid Mb of the article M is the front orientation.

(15) Each processing device 6 is a device configured to perform processing on an article M. The processing device 6 is not limited to a particular one, and may be a device of various types. As illustrated in FIG. 5, the processing devices 6 are disposed so as to be aligned along a passage ST on each of one side and the other side of the passage ST. Each of the processing devices 6 includes a device body 61 and a load port 62. The load port 62 is disposed on a side closer to the passage ST, and an article M is placed thereon. The load port 62 has an orientation and, for example, a side of the load port 62 closer to the passage ST is defined as the front orientation thereof. The orientation of the load port 62 corresponds to the orientation of the article M to be placed thereon. For example, the article M is placed on the load port 62 such that the front of the load port 62 matches the front of the article M (such that the lid Mb of the article M faces the device body 61).

(16) As illustrated in FIG. 1, FIG. 2, and FIG. 3, the overhead transport vehicle **100** moves along a rail R of the overhead transport system SYS to convey an article M. The overhead transport vehicle **100** may be referred to as an overhead traveling vehicle because it travels near a ceiling of a building. The overhead transport vehicle **100** may be used in plurality, for example. Conveying articles M by the overhead transport vehicles **100** enables high-density conveyance, which can improve the efficiency of conveying articles M.

(17) The rail R is installed on a ceiling of a building such as a clean room or near the ceiling. The rail R is a grid-patterned rail including first rails R1, second rails R2, and intersection rails R3 (see FIG. 3). The rail R is arranged at least partially in a grid pattern. Hereafter, the rail R is referred to as the grid-patterned rail R. The first rails R1 are provided along the X direction (first direction D1). The second rails R2 are provided along the Y direction (second direction D2). In the present embodiment, the first direction D1 and the second direction D2 are orthogonal to each other, and the first rails R1 and the second rails R2 are provided along directions orthogonal to each other, but are provided so as not to directly intersect each other. The intersection rails R3 are disposed at intersections of the first rails R1 and the second rails R2. In the grid-patterned rail R, the first rails R1 and the second rails R2 are provided along orthogonal directions, whereby a plurality of cells C (compartments) are adjacent to each other in plan view. In FIG. 3, part of the grid-patterned rail R is illustrated, and the same configuration of the grid-patterned rail R is formed continuously in the first direction D1 (X direction) and the second direction D2 (Y direction) from the illustrated configuration.

(18) The first rails **R1**, the second rails **R2**, and the intersection rails **R3** are suspended and supported on a ceiling (not illustrated) by suspending members **H** (see FIG. 3). Each suspending member **H** has first portions **H1** for suspending first rails **R1**, second portions **H2** for suspending second rails **R2**, and a third portion **H3** for suspending an intersection rail **R3**. The first portions **H1** and the second portions **H2** are each formed at two locations with the third portion **H3** interposed therebetween.

(19) The first rails **R1**, the second rails **R2**, and the intersection rails **R3** have traveling surfaces **R1a**, **R2a**, and **R3a**, respectively, on which traveling wheels **21** (described later) of the overhead transport vehicle **100** travel. A gap **D** is formed each between each first rail **R1** and the corresponding intersection rail **R3** and between each second rail **R2** and the corresponding intersection rail **R3**. The gap **D** is a space through which a coupling section **30** described later, which is a part of an overhead transport vehicle **100**, passes when the overhead transport vehicle **100** travels on a first rail **R1** and crosses a second rail **R2**, or when it travels on a second rail **R2** and crosses a first rail **R1**. Thus, the gap **D** is formed in a width through which the coupling section **30** can pass. The first rails **R1**, the second rails **R2**, and the intersection rails **R3** are provided along the same or substantially the same horizontal plane. In the present embodiment, the traveling surfaces **R1a**, **R2a**, **R3a** of the first rails **R1**, the second rails **R2**, and the intersection rails **R3** are arranged on the same or substantially the same horizontal plane.

(20) As illustrated in FIG. 1 and FIG. 2, each overhead transport vehicle **100** is a carrier capable of traveling along the rail **R**, and includes a body section **10**, a traveling unit **20**, the coupling section **30**, and a vehicle controller (control unit) **50**.

(21) The body section **10** is disposed below (on the $-Z$ side) the grid-patterned rail **R**. The body section **10** is formed in a rectangular shape, for example, in plan view. The body section **10** is formed to have dimensions that fit into one cell **C** in the rail **R** in plan view. This allows the overhead transport vehicle **100** to pass another one traveling on the adjacent first rail **R1** or the adjacent second rail **R2**.

(22) The body section **10** includes an upper unit **17** and a transfer device **18**. The upper unit **17** is suspended and supported by the traveling unit **20** with the coupling section **30** interposed therebetween. The upper unit **17** is rectangular in plan view, for example, and has four corners on an upper surface **17a** thereof. On each of the four corners of the body section **10**, a traveling wheel **21**, the coupling section **30**, and a direction-changing mechanism **34** are provided.

(23) The transfer device **18** is provided below the upper unit **17**. The transfer device **18** can rotate about a first vertical axis **AX1** in the vertical direction. The transfer device **18** includes an article holding unit **13** configured to hold an article **M**, a lifting drive unit **14** configured to raise and lower the article holding unit **13** in the vertical direction, a slide drive unit **11** configured to slide and move the lifting drive unit **14** in a horizontal direction, a turning unit **12** configured to hold the slide drive unit **11**, a first pivoting drive unit **15** configured to horizontally pivot (rotationally drive) the slide drive unit **11** about the first vertical axis **AX1** with respect to the body section **10**, and a second pivoting drive unit **16** configured to horizontally pivot the lifting drive unit **14** about a second vertical axis **AX2** with respect to the slide drive unit **11**. The lifting drive unit **14** and the slide drive unit **11** constitute a linear drive unit configured to drive the article holding unit **13** to move linearly. The first pivoting drive unit **15** and the second pivoting drive unit **16** constitute a pivoting drive unit configured to drive the article holding unit **13** to horizontally pivot. Horizontally pivoting means pivoting about an axis along the vertical direction as the axis of rotation.

(24) The slide drive unit **11** includes a plurality of movable plates disposed in a manner stacked in the **Z** direction, for example. The movable plates are movable in the **Y** direction. To the lowermost movable plate, the second pivoting drive unit **16** is attached. The slide drive unit **11** can move the movable plates by a driving device (not illustrated), and slide and move the lifting drive unit **14** and the article holding unit **13** attached to the lowermost movable plate so as to protrude in one direction with respect to the traveling direction, that is, in one direction of linear directions. The

turning unit **12** is attached to the first pivoting drive unit **15** between the slide drive unit **11** and the upper unit **17**, and holds the slide drive unit **11**.

(25) The article holding unit **13** grips a flange **Ma** of an article **M**, thereby suspending and holding the article **M**. The article holding unit **13** is, for example, a chuck including claws **13a** that can move horizontally. By causing the claws **13a** to proceed to below the flange **Ma** of the article **M** and raising the article holding unit **13**, the article **M** is held. The article holding unit **13** is connected to suspending members **13b** such as wires or belts.

(26) The lifting drive unit **14** is attached to the second pivoting drive unit **16**. The lifting drive unit **14** is a hoist, for example, which lowers the article holding unit **13** by paying out the suspending members **13b**, and raises the article holding unit **13** by winding the suspending members **13b**. The lifting drive unit **14** is controlled by the vehicle controller **50** to lower or raise the article holding unit **13** at a predetermined speed. The lifting drive unit **14** is controlled by the vehicle controller **50** to hold the article holding unit **13** at a target height.

(27) The first pivoting drive unit **15**, for which an electric motor or the like is used, rotates the turning unit **12** about the first vertical axis **AX1**. The first pivoting drive unit **15** can rotate the turning unit **12** and also rotate the slide drive unit **11** about the first vertical axis **AX1**. When the slide drive unit **11** is rotated about the first vertical axis **AX1** by the first pivoting drive unit **15**, the second pivoting drive unit **16**, the lifting drive unit **14**, and the article holding unit **13** that are attached to the lower side of the slide drive unit **11** are rotated together about the first vertical axis **AX1**. The second pivoting drive unit **16**, for which an electric motor or the like is used, rotates the lifting drive unit **14** about the second vertical axis **AX2**.

(28) FIG. **4** is a diagram schematically illustrating the body section **10** when viewed from above. FIG. **4** illustrates an example of the rotational movement of the slide drive unit **11** and the lifting drive unit **14**. As illustrated in FIG. **4**, the first pivoting drive unit **15** can rotate the slide drive unit **11** within a range of 270 degrees about the first vertical axis **AX1** from a state in which the direction of sliding movement of the slide drive unit **11** is aligned in the first direction **D1** or the second direction **D2**. In this case, the article holding unit **13** can be slid and moved from the body section **10** stopped on the grid-patterned rail **R** to either direction of the first direction **D1** and the second direction **D2**. Furthermore, the article **M** can be placed in a desired orientation onto the load port **62**.

(29) The transfer device **18** can protrude the lifting drive unit **14** and the article holding unit **13** from a transfer position **P1** to any of protruding positions **P2a**, **P2b**, **P2c**, **P2d** by driving the slide drive unit **11**. The protruding position **P2a** is a protruding position when the lifting drive unit **14** and the article holding unit **13** have been slid and moved in the +Y direction by the slide drive unit **11**. The protruding position **P2b** is a protruding position when the slide drive unit **11** has been rotated 90 degrees (e.g., 90 degrees clockwise) about the first vertical axis **AX1** by the first pivoting drive unit **15** and then the lifting drive unit **14** and the article holding unit **13** have been slid and moved in the +X direction by the slide drive unit **11**. The protruding position **P2c** is a protruding position when the slide drive unit **11** has been rotated 180 degrees about the first vertical axis **AX1** by the first pivoting drive unit **15** and then the lifting drive unit **14** and the article holding unit **13** have been slid and moved in the -Y direction by the slide drive unit **11**. The protruding position **P2d** is a protruding position when the slide drive unit **11** has been rotated 270 degrees about the first vertical axis **AX1** by the first pivoting drive unit **15** and then the lifting drive unit **14** and the article holding unit **13** have been slid and moved in the -X direction by the slide drive unit **11**.

(30) As described above, the slide drive unit **11** is configured to slide and move the lifting drive unit **14** and the article holding unit **13** in one direction of the linear directions. However, by driving the first pivoting drive unit **15** to set the turning position of the slide drive unit **11** at intervals of 90 degrees, the lifting drive unit **14** and the article holding unit **13** can be slid and moved in each of four directions of the +X direction (first direction **D1**), the +Y direction (second direction **D2**), the -X direction (first direction **D1**), and -Y direction (second direction **D2**).

(31) The second pivoting drive unit **16**, for which an electric motor or the like is used, rotates the lifting drive unit **14** (the article holding unit **13**) within a range of at least 180 degrees about the second vertical axis AX2 with respect to the linear direction of sliding movement by the slide drive unit **11**. In FIG. 4, the lifting drive unit **14** (the article holding unit **13**) can be rotated 180 degrees about the second vertical axis AX2 within a range of the direction indicated by a dash-dotted line passing through the second vertical axis AX2 (direction orthogonal to the linear direction). In this case, the article M can be placed in the desired orientation onto the load port **62**. For example, by driving the second pivoting drive unit **16** to rotate the front side of the article M 180 degrees about the second vertical axis AX2 from a state of being oriented toward the +X direction, the front side of the article M can be oriented toward the -X direction (i.e., the opposite direction). For example, by driving the second pivoting drive unit **16**, the front side of the article M can be set from a state of being oriented toward the +X direction into a state of being oriented toward the +Y direction or the -Y direction.

(32) As illustrated in FIG. 1, FIG. 2, and FIG. 3, the traveling unit **20** includes the traveling wheels **21** and the auxiliary wheels **22**. The traveling wheels **21** are disposed at the respective four corners of the upper surface **17a** of the upper unit **17** (the body section **10**). Each traveling wheel **21** is attached to an axle (not illustrated) provided to the corresponding coupling section **30**. The axles are provided parallel or substantially parallel along the XY plane. Each traveling wheel **21** is rotationally driven by the driving force of a traveling drive unit **33** described later. Each traveling wheel **21** rolls on the grid-patterned rail R. The respective traveling wheels **21** roll on the traveling surfaces R1a, R2a, R3a of the first rails R1, the second rails R2, and the intersection rails R3 in the grid-patterned rail R, thereby causing the overhead transport vehicle **100** to travel. Herein, all of the four traveling wheels **21** do not necessarily have to be rotationally driven by the driving force of the traveling drive unit **33**, and some of the four traveling wheels **21** may be configured to be rotationally driven.

(33) Each traveling wheel **21** is provided to be able to pivot in the θZ direction about a pivot axis AX3. The traveling wheel **21** pivots in the θZ direction by the corresponding direction-changing mechanism **34** described later, and consequently can change the traveling direction of the overhead transport vehicle **100**. The auxiliary wheels **22** are disposed each in front of and rear of the traveling wheel **21** in the traveling direction. Each of the auxiliary wheels **22** can rotate in the θZ direction in the same manner as the traveling wheel **21**. The lower ends of the auxiliary wheels **22** are set higher than the lower end of the traveling wheel **21**. Thus, when the traveling wheel **21** is traveling on the traveling surfaces R1a, R2a, R3a, the auxiliary wheels **22** do not come into contact with the traveling surfaces R1a, R2a, R3a. When the traveling wheel **21** passes over a gap D (see FIG. 3), the auxiliary wheels **22** come into contact with the traveling surfaces R1a, R2a, R3a to prevent the traveling wheel **21** from falling. Herein, two auxiliary wheels **22** do not necessarily have to be provided to one traveling wheel **21**. For example, one auxiliary wheel **22** may be provided on one traveling wheel **21**, or no auxiliary wheel **22** may be provided.

(34) As illustrated in FIG. 1 and FIG. 2, a cover W may be provided to surround the transfer device **18** and the article M held by the transfer device **18**. The cover W has a shape that is open at the lower end thereof, and has such a shape that a portion thereof through which the movable plates of the slide drive unit **11** protrude (portion through which they slide and move) is recessed. The cover W, the upper end of which is attached to the turning unit **12**, turns about the first vertical axis AX1 as the turning unit **12** turns.

(35) The coupling sections **30** couple the upper unit **17** of the body section **10** to the traveling units **20**. The coupling sections **30** are provided at the respective four corners of the upper surface **17a** of the upper unit **17** (the body section **10**). By these coupling sections **30**, the body section **10** is suspended and disposed below the grid-patterned rail R. Each coupling section **30** includes a support member **31** and a connecting member **32**. The support member **31** rotatably supports the rotating shaft of the corresponding traveling wheel **21** and the rotating shafts of the corresponding

auxiliary wheels **22**. The support member **31** maintains the relative position between the traveling wheel **21** and the auxiliary wheels **22**. The support member **31** is formed in a plate-like shape, for example, and is formed to have a thickness capable of passing through each gap **D**.

(36) The connecting member **32** extends downward from the support member **31** and is coupled to the upper surface **17a** of the upper unit **17** to hold the upper unit **17**. The connecting member **32** includes inside a transmission mechanism configured to transmit the driving force of the traveling drive unit **33** described later to the traveling wheel **21**. This transmission mechanism may have a configuration using a chain or a belt, or may have a configuration using a gear train. The connecting member **32** is provided to be rotatable in the θZ direction about the pivot axis **AX3**. This connecting member **32** rotates about the pivot axis **AX3**, thereby being able to pivot the traveling wheel **21** in the θZ direction.

(37) Each coupling section **30** is provided with the traveling drive unit **33** and the direction-changing mechanism **34**. The traveling drive unit **33** is mounted on the corresponding connecting member **32**. The traveling drive unit **33** is a driving source configured to drive the traveling wheel **21** and, for example, an electric motor is used therefor. Each of the four traveling wheels **21** is driven by the corresponding traveling drive unit **33** to serve as a driving wheel. The four traveling wheels **21** are controlled by the vehicle controller **50** to have the same or substantially the same rotation speed. If any of the four traveling wheels **21** is not used as a driving wheel, the traveling drive unit **33** is not mounted on the corresponding connecting member **32**.

(38) The direction-changing mechanism **34** pivots the traveling wheel **21** in the direction θZ by pivoting the connecting member **32** of the coupling section **30** about the pivot axis **AX3** with respect to the body section **10**. By pivoting the traveling wheel **21** in the θZ direction, the overhead transport vehicle **100** can switch from a first state in which the traveling direction thereof is the first direction **D1** to a second state in which the traveling direction is the second direction **D2**, or from the second state in which the traveling direction is the second direction **D2** to the first state in which the traveling direction is the first direction **D1**.

(39) The direction-changing mechanism **34** includes a driving source **35**, a pinion gear **36**, and a rack **37**. The driving source **35** is attached on a side surface of the traveling drive unit **33** away from the pivot axis **AX3**. For the driving source **35**, for example, an electric motor is used. The pinion gear **36** is attached to a lower side of the driving source **35**, and is rotationally driven in the θZ direction by driving force generated by the driving source **35**. The pinion gear **36** is circular in plan view and has a plurality of teeth in the circumferential direction of its outer circumference. The rack **37** is fixed to the upper surface **17a** of the upper unit **17**. The rack **37** is provided at each of the four corners of the upper surface **17a** of the upper unit **17**, and is formed in an arc shape centered around the pivot axis **AX3** of the corresponding traveling wheel **21**. The rack **37** has a plurality of teeth, which mesh with the teeth of the pinion gear **36**, in the circumferential direction of its outer circumference.

(40) The pinion gear **36** and the rack **37** are disposed with their teeth meshing with each other. When the pinion gear **36** rotates in the θZ direction, the pinion gear **36** accordingly moves in the circumferential direction centered around the pivot axis **AX3** along the outer circumference of the rack **37**. By this movement of the pinion gear **36**, the connecting member **32** is pivoted, and the traveling drive unit **33** and the direction-changing mechanism **34** are pivoted in the circumferential direction centered around the pivot axis **AX3** together with the pinion gear **36**.

(41) By this pivoting of the direction-changing mechanism **34**, each of the traveling wheels **21** and the auxiliary wheels **22** disposed at the four corners of the upper surface **17a** is pivoted within a range of 90 degrees in the θZ direction about the pivot axis **AX3**. The driving of the direction-changing mechanism **34** is controlled by the vehicle controller **50**. The vehicle controller **50** may give an instruction to pivot the four traveling wheels **21** at the same timing, or may give an instruction to pivot them at different timings. By pivoting the traveling wheels **21** and the auxiliary wheels **22**, the traveling wheels **21** shift from a state of being in contact with one of the first rails

R1 and the second rails R2 to a state of being in contact with the other. This allows the overhead transport vehicle **100** to switch between the first state in which the traveling direction thereof is the first direction D1 (X direction) and the second state in which the traveling direction is the second direction D2 (Y direction).

(42) The vehicle controller **50** is a computer including a central processing unit (CPU), a read only memory (ROM), and a random access memory (RAM). The vehicle controller **50** can be configured, for example, as software such that a program stored in the ROM is loaded into the RAM to be executed by the CPU. The vehicle controller **50** may be configured as hardware such as an electronic circuit. The vehicle controller **50** may be configured with a single device, or may be configured with a plurality of devices. If it is configured with a plurality of devices, they are connected via a communication network such as the Internet or an intranet to logically construct a single vehicle controller **50**. The vehicle controller **50** is provided to the body section **10**, but may be provided outside the body section **10**.

(43) The vehicle controller **50** collectively controls operations of the respective components of the overhead transport vehicle **100**. The vehicle controller **50** controls traveling of the overhead transport vehicle **100** on the basis of conveyance instructions. The vehicle controller **50** controls the traveling of the overhead transport vehicle **100** by controlling the traveling drive unit **33** and the direction-changing mechanism **34**, for example. The vehicle controller **50** controls transfer operation of the overhead transport vehicle **100** on the basis of conveyance instructions. The vehicle controller **50** controls the transfer operation of the overhead transport vehicle **100** by controlling the transfer device **18**, for example. The vehicle controller **50** generates and updates status information (not illustrated) periodically. The vehicle controller **50** transmits the status information to the system controller **5**. The status information is, for example, information on the current position of the overhead transport vehicle **100**, information indicating the current status of the overhead transport vehicle **100** such as normal or abnormal, and information on the status (execution in progress, execution completed, or execution failed) of various instructions such as conveyance instructions executed by the overhead transport vehicle **100**.

(44) The system controller **5** is a computer including a CPU, a ROM, and a RAM. The system controller **5** can be configured, for example, as software such that a program stored in the ROM is loaded into the RAM to be executed by the CPU. The system controller **5** may be configured as hardware such as an electronic circuit. The system controller **5** may be configured with a single device or a plurality of devices. When it is configured with a plurality of devices, they are connected via a communication network such as the Internet or an intranet to logically construct a single system controller **5**.

(45) The system controller **5** generates a conveyance instruction. The system controller **5** selects any one of the overhead transport vehicles **100** that can convey an article M, and assigns the conveyance instruction to the selected overhead transport vehicle **100**. The conveyance instruction includes a traveling instruction to perform traveling to a load port **62** at a conveyance source, an instruction to grab an article M placed on this load port **62**, a traveling instruction to perform traveling to a load port **62** at a conveyance destination, and an instruction to unload the article M being held onto this load port **62**. Information on the conveyance source and the conveyance destination can be received from a host controller (not illustrated), for example. A traveling path to be followed when traveling to the load port **62** at the conveyance source on the grid-patterned rail R can be acquired by various known methods. A traveling path to be followed when traveling to the load port **62** at the conveyance destination on the grid-patterned rail R can be likewise acquired by various known methods.

(46) The system controller **5** stores load port information on the orientation of each of a plurality of the load ports **62** in advance. As an example, the system controller **5** stores load port information in which port numbers, locations, and orientations of the load ports **62** are associated with each other. The port numbers are identification numbers set for the respective load ports **62**. The system

controller **5** acquires the orientation of the load port **62** at the conveyance source and the orientation of the load port **62** at the conveyance destination in the conveyance instruction to be assigned, on the basis of the load port information. The system controller **5** transmits information on the orientation of the load port **62** at the conveyance source and the orientation of the load port **62** at the conveyance destination to the overhead transport vehicle **100** to which the conveyance instruction is to be assigned.

(47) In the present embodiment herein, the vehicle controller **50** controls at least one of the first pivoting drive unit **15** and the second pivoting drive unit **16** in accordance with the orientation of the article M held by the article holding unit **13** and the orientation of the load port **62** on which the article M is placed with respect to a position where the overhead transport vehicle **100** stops. For example, because the orientation of the article M placed on the load port **62** is in a certain relation with (herein, the same as) the orientation of the load port **62**, the orientation of the article M being held by the article holding unit **13** can be acquired based on the information on the orientation of the load port **62** at the conveyance source, which has been transmitted from the system controller **5**. The orientation of the load port **62** on which the article M is placed can be acquired based on the information on the orientation of the load port **62** at the conveyance destination, which has been transmitted from the system controller **5**.

(48) The vehicle controller **50** performs: a first control of horizontally pivoting the article holding unit **13** by a first angle such that the orientation of the article M and the orientation of the load port **62** are in the certain relation; and a second control of horizontally pivoting the article holding unit **13** by a second angle such that the orientation of the article M is fine-tuned. The first angle is an angle of horizontal pivoting that is required because the orientation of the load port **62** at the conveyance source and the orientation of the load port **62** at the conveyance destination are different. The first angle is an angle of 90° or more and 270° or less, for example. The second angle is an angle of horizontal pivoting required to compensate for unintended misalignment in orientation of the article M. The second angle is smaller than the first angle, and is an angle of 10° or less, for example.

(49) The following describes an example when an article M is conveyed between load ports **62** by the overhead transport vehicle **100** in the overhead transport system SYS.

(50) In this example, as illustrated in FIG. 5, three processing devices **6** are disposed so as to be aligned along a passage ST on each of one side and the other side of the passage ST. The passage ST extends straight linearly when viewed from above. The processing devices **6** on one side of the passage ST and the processing devices **6** on the other side of the passage ST are disposed so as to face each other. The orientation of the load port **62** is an orientation that defines a side thereof closer to the passage ST as the front thereof. In this example herein, an article M placed on a load port **62S** is transferred to a load port **62E** that faces the load port **62S** with the passage ST interposed therebetween. The orientation of the load port **62S** and the orientation of the load port **62E** are 180° opposite to each other.

(51) The overhead transport vehicle **100** is assigned a conveyance instruction from the system controller **5** and receives, from the system controller **5**, information on the respective orientations of the load ports **62S** and **62E** at a conveyance source and a conveyance destination based on the conveyance instruction. In response to this, the overhead transport vehicle **100** performs the following operations under the control of the vehicle controller **50**.

(52) More specifically, as illustrated in FIG. 6, the overhead transport vehicle **100** travels along a traveling path based on the conveyance instruction to a position where the article M can be transferred from the load port **62S** at the conveyance source. As illustrated in FIG. 7, the overhead transport vehicle **100** grabs the article M placed on the load port **62S** at the conveyance source. As illustrated in FIG. 8, the overhead transport vehicle **100** travels along the traveling path based on the conveyance instruction while grabbing the article M to a position where it can transfer the article M to the load port **62E** at the conveyance destination. During conveyance to the load port

62E, as illustrated in FIG. 9, the first control is performed to control at least one of the first pivoting drive unit 15 and the second pivoting drive unit 16 such that the orientation of the article M matches the orientation of the load port 62E at the conveyance destination (such that the front of the article M is oriented toward the front of the load port 62E), and the article holding unit 13 is horizontally pivoted by the first angle. In the illustrated example, the first angle is 180°.

(53) As illustrated in FIG. 10, the overhead transport vehicle 100 unloads the article M onto the load port 62E at the conveyance destination. At this time, the second control is performed such that the orientation of the article M is fine-tuned (such that the front of the article M is properly oriented toward the front of the load port 62E), and at least one of the first pivoting drive unit 15 and the second pivoting drive unit 16 is controlled to horizontally pivot the article holding unit 13 by the second angle. By the processes described above, transfer of the article M from the load port 62S to the load port 62E is completed. The overhead transport vehicle 100 is then assigned with another conveyance instruction, for example, and travels toward another load port 62 (see FIG. 11).

(54) As described above, with the overhead transport vehicle 100, regardless of the orientation of an article M held by the article holding unit 13, by controlling at least one of the first pivoting drive unit 15 and the second pivoting drive unit 16 in accordance with the orientation of the article M and a load port 62, the article M can be transferred in the desired orientation to the load port 62.

(55) The overhead transport vehicle 100 includes, as linear drive units, the lifting drive unit 14 configured to raise and lower the article holding unit 13 and a slide drive unit 11 configured to slide the lifting drive unit 14, and also includes, as pivoting drive units, the first pivoting drive unit 15 configured to horizontally pivot the slide drive unit 11 and the second pivoting drive unit 16 configured to horizontally pivot the lifting drive unit 14. By this configuration, the orientation of an article M can be specifically controlled.

(56) The overhead transport vehicle 100 is an overhead transport vehicle capable of traveling along the grid-patterned rail R, and includes the traveling wheels 21 configured to roll on the grid-patterned rail R and the body section 10 disposed below the grid-patterned rail R. By this configuration, traveling paths for the overhead transport vehicle 100 can be selected easily and flexibly, whereby traffic congestion can be prevented and conveyance efficiency can be improved.

(57) In the overhead transport vehicle 100, the vehicle controller 50 performs: the first control of horizontally pivoting the article holding unit 13 by the first angle such that the orientation of the article M and the orientation of the load port 62 are in the certain relation; and the second control of horizontally pivoting the article holding unit 13 by the second angle such that the orientation of the article M is fine-tuned. By these controls, the article M can be reliably transferred in the desired orientation to the load port 62.

(58) Although the embodiment has been described above, an aspect of the present invention is not limited to the embodiment, and various modifications may be made within the scope not departing from the gist of the invention.

(59) In the above embodiment, the traveling path for the overhead transport vehicle 100 in the grid-patterned rail R is set by the system controller 5 on the basis of a conveyance instruction upon generation of the conveyance instruction. However, the present invention is not limited to this. For example, as illustrated in FIG. 12, the overhead transport system SYS may include, as a traveling path 7 along which the overhead transport vehicle 100 travels, cross-traveling paths 70 each extending across the passage ST and allowing the overhead transport vehicle 100 to pass through above a pair of load ports 62.

(60) In an example illustrated in FIG. 12, the traveling path 7 is a predetermined one-way path. The traveling path 7 includes at least first inter-bay paths 71 and second inter-bay paths 72 in addition to the cross-traveling paths 70. The first inter-bay paths 71 are set in a pair, which are aligned parallel and traveling directions of which are opposite to each other. The second inter-bay paths 72 are set in a pair, which are aligned parallel and traveling directions of which are opposite to each other. The second inter-bay paths 72 connect the pair of first inter-bay paths 71. The second inter-

bay paths **72** extend in the direction along the passage ST. The cross-traveling paths **70** connect the pair of second inter-bay paths **72**. The cross-traveling paths **70** constitute an intra-bay path. The cross-traveling paths **70** are set in pairs, which are aligned parallel and traveling directions of which are opposite to each other. Herein, three pairs of cross-traveling paths **70** are set between the pair of second inter-bay paths **72**. The cross-traveling paths **70** are set to pass through above pairs of load ports **62** or their surroundings.

(61) Generally, the orientations of a pair of load ports **62** facing each other with the passage ST interposed therebetween are opposite to each other. Thus, it is difficult to transfer an article M between the pair of load ports **62** such that the orientation of the article M and the orientation of each load port **62** are in the certain relation. To solve this problem, the overhead transport system SYS includes the cross-traveling paths **70** and the overhead transport vehicle **100**. Even between a pair of load ports **62** at a cross-traveling path **70**, an article M can be transferred in the desired orientation by appropriately controlling at least one of the first pivoting drive unit **15** and the second pivoting drive unit **16**. Even if there is an overhead transport vehicle **100** performing transfer at the point A, traveling of an overhead transport vehicle **100** heading for each load port **62** to transfer an article M that is present in the area X will not be hindered because the article M in the area X is not present on the path passing through the point A. It is not necessary to provide a branching or merging point in the vicinity of load ports **62** (the area Y) available for transfer. Thus, congestion is less likely to occur near the load ports **62**.

(62) In the above embodiment, the overhead transport vehicle **100** acquires the orientation of an article M held in the article holding unit **13** on the basis of the information on the orientation of a load port **62** at a conveyance source, which has been transmitted from the system controller **5**. However, the method of acquiring the orientation of the article M is not limited to a particular one. For example, an additional sensor or camera may be used to recognize the orientation of the article M held by the article holding unit **13**. In the above embodiment, the overhead transport vehicle **100** acquires the orientation of a load port **62** at a conveyance destination on the basis of information on the orientation of the load port **62** at the conveyance destination, which has been transmitted from the system controller **5**. However, the method of acquiring the orientation of the load port **62** at the conveyance destination is not limited to a particular one. For example, an additional sensor or camera may be used to recognize the orientation of the load port **62** at the conveyance destination.

(63) In the above embodiment, the overhead transport vehicle **100** may be an overhead transport vehicle configured to travel along a rail that is not arranged in a grid pattern and carries one-way traffic. With such an overhead transport vehicle, to transfer an article M in a desired orientation to a load port **62**, a direction in which it approaches to the load port **62** may be restricted, and thus a traveling path to the load port **62** may be restricted. In this case, there is concern that the traffic of another overhead transport vehicle **100** will be obstructed, resulting in traffic congestion and reduced conveyance efficiency. In contrast to this, by appropriately controlling the pivoting drive unit by the vehicle controller **50**, the overhead transport vehicle **100** can deliver the article M in the desired orientation to the load port **62** regardless of the direction from which it has approached to the load port **62**. Consequently, the overhead transport vehicle can prevent its traveling path to a target load port **62** from being restricted, and thus can easily select a traveling path that does not obstruct the traffic of another overhead transport vehicle, for example. Thus, traffic congestion can be prevented and conveyance efficiency can be improved. In the case of the overhead transport vehicle configured to travel along a rail that is not arranged in a grid pattern and carries one-way traffic, at least one of the first pivoting drive unit **15** and the second pivoting drive unit **16** is controlled in accordance with the direction of an article M held by the article holding unit **13**, the orientation of a load port **62** at a conveyance destination, and the direction of approaching to a load port **62** at a conveyance destination.

(64) In the above embodiment, the lifting drive unit **14** is configured to be horizontally pivoted by the second pivoting drive unit **16**. However, the article holding unit **13** may be configured to be

horizontally pivoted by the second pivoting drive unit **16**. In the above embodiment, while the overhead transport vehicle **100** is traveling to a load port **62** at a conveyance destination, the first control of horizontally pivoting the article holding unit **13** is performed such that the orientation of an article M and the orientation of the load port **62** are in the certain relation. However, the timing of performing the first control is not limited to a particular one. For example, the first control may be performed while the article M is being unloaded onto a load port **62E** at a conveyance destination.

(65) The materials and shapes of the respective configurations in the embodiment and the modifications above are not limited to those described above, and various materials and shapes can be used. Each configuration in the embodiment or the modifications above may be optionally applied to each configuration in other embodiments or modifications. Some of the respective configurations in the embodiment or the modifications above may be omitted as appropriate within the scope not departing from the gist of an aspect of the present invention.

REFERENCE SIGNS LIST

(66) **6** . . . processing device **10** . . . body section **11** . . . slide drive unit (linear drive unit) **13** . . . article holding unit **14** . . . lifting drive unit (linear drive unit) **15** . . . first pivoting drive unit (pivoting drive unit) **16** . . . second pivoting drive unit (pivoting drive unit) **21** . . . traveling wheel **50** . . . vehicle controller (control unit) **62** . . . load port **70** . . . cross-traveling path (traveling path) **100** . . . overhead transport vehicle M . . . article R . . . grid-patterned rail (rail) ST . . . passage

Claims

1. An overhead transport vehicle capable of traveling along a rail arranged at least partially in a grid pattern, the overhead transport vehicle comprising: an article holding unit configured to hold an article; a linear drive unit configured to drive the article holding unit to move linearly; a pivoting drive unit configured to drive the article holding unit to pivot horizontally; a control unit configured to control the pivoting drive unit in accordance with orientation of the article held by the article holding unit and orientation of a load port on which the article is placed; a traveling wheel configured to roll on the rail; and a body section disposed below the rail and including the article holding unit, the linear drive unit, and the pivoting drive unit, wherein the linear drive unit includes a lifting drive unit configured to raise and lower the article holding unit and a slide drive unit configured to slide and move the lifting drive unit, the pivoting drive unit includes a first pivoting drive unit configured to horizontally pivot the slide drive unit and a second pivoting drive unit configured to horizontally pivot the article holding unit or the lifting drive unit, and when the slide drive unit is horizontally pivoted by the first pivoting drive unit, the second pivoting drive unit, the lifting drive unit, and the article holding unit that are attached to a lower side of the slide drive unit are horizontally pivoted together.
2. The overhead transport vehicle according to claim 1, wherein the first pivoting drive unit rotates the slide drive unit at intervals of 90 degrees, and the second pivoting drive unit rotates the lifting drive unit within a range of 180 degrees.
3. The overhead transport vehicle according to claim 1, wherein the control unit performs: a first control of horizontally pivoting the article holding unit by a first angle such that the orientation of the article and the orientation of the load port are in a certain relation; and a second control of horizontally pivoting the article holding unit by a second angle smaller than the first angle such that the orientation of the article is fine-tuned.
4. The overhead transport vehicle according to claim 3, wherein the control unit performs the first control during conveyance of the article to the load port, and performs the second control during unloading of the article onto the load port.
5. An overhead transport system comprising: a plurality of processing devices disposed so as to be aligned along a passage on each of one side and the other side of the passage; and an overhead

transport vehicle capable of traveling along a rail arranged at least partially in a grid pattern, the overhead transport vehicle comprising: an article holding unit configured to hold an article; a linear drive unit configured to drive the article holding unit to move linearly; a pivoting drive unit configured to drive the article holding unit to pivot horizontally; a control unit configured to control the pivoting drive unit in accordance with orientation of the article held by the article holding unit and orientation of a load port on which the article is placed; a traveling wheel configured to roll on the rail; and a body section disposed below the rail and including the article holding unit, the linear drive unit, and the pivoting drive unit, wherein the linear drive unit includes a lifting drive unit configured to raise and lower the article holding unit and a slide drive unit configured to slide and move the lifting drive unit, the pivoting drive unit includes a first pivoting drive unit configured to horizontally pivot the slide drive unit and a second pivoting drive unit configured to horizontally pivot the article holding unit or the lifting drive unit, and when the slide drive unit is horizontally pivoted by the first pivoting drive unit, the second pivoting drive unit, the lifting drive unit, and the article holding unit that are attached to a lower side of the slide drive unit are horizontally pivoted together, wherein each of the processing devices includes the load port disposed on a side of the processing device closer to the passage, and the overhead transport system includes a traveling path, serving as a path along which the overhead transport vehicle travels, extending across the passage and allowing the overhead transport vehicle to pass through above a pair of the load ports.
