

ARTICLE TRANSPORT APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 [0001] The present invention relates to an article transport apparatus for transporting articles.

2. Description of the Related Art

10 [0002] For example, International Publication No. 2019/035286 (Patent Document 1) discloses a transport system. Hereinafter, in the description of this related art, names and symbols in Patent Document 1 will be cited in parentheses.

[0003] This transport system (SYS) includes an article transport apparatus (ceiling transport vehicle 10) that includes a movable body (traveling portion 11), a cover (main body 12), a transfer mechanism (transfer portion 13), and a control unit (14). The movable body (traveling portion 11) travels along a track, and the cover (main body 12) is attached to the movable body (traveling portion 11), and is configured to be able to accommodate an article (M). The transfer mechanism (transfer portion 13) includes a holding section (15) that holds the article (M), a turning section (rotation mechanism 19) that rotates the holding section (15) around a rotation axis (AX), and a moving section (moving mechanism 16) for moving the holding section (15) and the turning section (rotation mechanism 19) with respect to the cover (main body 12), and the control unit (14) controls the operation of the movable body (traveling portion 11) and each portion of the transfer mechanism (transfer portion 13). In the article transport apparatus (ceiling transport vehicle 10), rotation performed by the turning section (rotating mechanism 19) is allowed when the article (M) held by the holding section (15) is at an escape position of coming out of the cover (main body 12), and this prevents the article (M) from coming into contact with an inner wall (23a) of the cover (main body 12).

SUMMARY OF THE INVENTION

35 [0004] Here, when the article transport apparatus is to be maintained and inspected, when the article transport apparatus breaks down, or the like, the article transport apparatus is operated according to an operation command from an operation terminal operated by a worker in some cases. In addition,

some covers have protrusions that protrude toward the accommodation region on the inner surface facing the accommodation region for accommodating the object. In such a case, for example, if the transfer mechanism is operated in response to an operation command to shift to a predetermined orientation

5 while the holding section is accommodated in the accommodation region covered by the cover, the holding section may interfere with (come into contact with) the protruding portion depending on the turning angle of the holding section at the time when the operation command is issued.

[0005] In view of this, realization of an article transport apparatus capable of

10 appropriately operating the transfer mechanism while avoiding interference between the holding section and the protruding portion is desired.

[0006] In view of the above, a characteristic configuration of the article transport apparatus is

an article transport apparatus configured to transport an article, the

15 article transport apparatus including:

a movable body configured to move to transport the article;

a cover that is held by the movable body and that at least partially covers a lateral peripheral portion of an accommodation region in which accommodation region the article is accommodated while the article is

20 transported;

a transfer mechanism configured to hold the article and transfer the article to and from a transfer target location; and

a control unit configured to control the movable body and the transfer mechanism,

25 in which the transfer mechanism includes:

a holding section that is held by the movable body and that is capable of holding the article and releasing the article;

a turning section configured to turn the holding section around a vertical turning axis; and

30 an elevating section configured to raise and lower the holding section into and out of the accommodation region,

the cover includes an inner surface structure facing the accommodation region,

the inner surface structure includes a protruding portion protruding

35 toward the accommodation region at a specific location in an up-down direction, in response to an elevation height to which the holding section is raised

or lowered by the elevating section being within an interference height range, the transfer mechanism potentially interferes with the protruding portion due to the turning section turning the holding section, and in response to the elevation height of the holding section raised or lowered by the elevating
5 section being outside the interference height range, the transfer mechanism does not interfere with the inner surface structure even if the turning section turns the holding section,

the control unit has a maintenance mode, in which the control unit allows the transfer mechanism to be operated in accordance with a command
10 from an operation terminal operated by a worker, and

in the maintenance mode, in response to receiving an operation command for the transfer mechanism from the operation terminal, the control unit determines whether the elevation height is within the interference height range, and (i) in response to the elevation height being outside the interference
15 height range, the control unit allows the transfer mechanism to be operated in accordance with the operation command, and (ii) in response to the elevation height being within the interference height range, the control unit prohibits a turning operation of the holding section by the turning section among operations of the transfer mechanism performed in accordance with the
20 operation command.

[0007] According to this characteristic configuration, even if the worker issues an erroneous operation command for the transfer mechanism in the maintenance mode, if there is a possibility that the holding section will interfere with the protruding portion by performing a turning operation of the
25 holding section, it is possible to prevent the holding section from performing a turning operation, and in other cases, it is possible to allow the transfer mechanism to perform an operation in accordance with the operation command. As a result, the transfer mechanism can be appropriately operated in accordance with the operation command while avoiding interference between
30 the holding section and the protruding portion.

[0008] Further features and advantages of the technology according to the present disclosure will become apparent from the following description of exemplary and non-limiting embodiments described with reference to the
35 drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a diagram showing a usage mode of an article transport apparatus.

FIG. 2 is a side view of the article transport apparatus.

FIG. 3 is a diagram showing an interference height range.

5 FIG. 4 is a diagram showing the state of an article accommodated in the accommodation region.

FIG. 5 is a control block diagram relating to control of a transfer mechanism by a control unit.

10 FIG. 6 is a flow chart showing a procedure of control of the transfer mechanism by the control unit.

FIG. 7 is a diagram showing an example of notification in the case of interference.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

15 1. Embodiment of Article Transport Apparatus

[0010] An embodiment of an article transport apparatus will be described with reference to the drawings. As shown in FIG. 1, the article transport apparatus 1 transports an article W by moving along a movement route R provided between, for example, a plurality of transport target locations 90 in a factory or plant, and the orientation of the article W can be changed when the article W is transported.

[0011] In the following description, the direction in which the article transport apparatus 1 travels along the movement route R is referred to as “progression direction X”, and the direction perpendicular to the progression direction X in a plan view is referred to as “width direction Y”. Also, a direction perpendicular to both the progression direction X and the width direction Y will be described as “vertical direction Z”. Here, the frontward side in the progression direction X is referred to as “front side X1”, and the rearward side is referred to as “rear side X2”. Also, left and right are defined based on a state of facing the front side X1 in the progression direction X, and specifically, toward the front side X1 in the traveling direction X, the left side in the width direction Y is described as “left side Y1”, and the right side is described as “right side Y2”.

[0012] The article W corresponds to a transport target object to be transported by the article transport apparatus 1. In this embodiment, the article W is a container storing a semiconductor substrate, is in a cuboid shape, and can store

a plurality of semiconductor substrates in a plurality of levels. The upper surface and the bottom surface of the article W are closed, and in particular, the upper surface is provided with a flange W1 (see FIG. 2) that is gripped by the article transport apparatus 1 when the article W is transported. Also, one of the four side surfaces of the article W is provided with an opening for inserting and removing the semiconductor substrate. The remaining three sides of the article W are closed.

[0013] The transport target location 90 is a transport source or a transport destination of the article W. As shown in FIG. 1, transport target locations 90 are provided at a plurality of locations along the movement route R. At the transport target location 90, for example, the article W is processed. The transport target location 90 includes a processing apparatus 90a that processes a semiconductor substrate, and a delivery portion 90b for delivering an article W to and from the article transport apparatus 1. The delivery portion 90b is a so-called load port. When the semiconductor substrate stored in the article W received by the delivery portion 90b is retrieved by a retrieval device or the like included in the processing device 90a, the processing device 90a performs processing such as substrate cleaning, baking, and resist coating and stripping, for example.

[0014] The movement route R is a route along which the article transport apparatus 1 moves. In this embodiment, the movement route R is defined by a rail 99 (see FIG. 2) suspended from a ceiling of a building in which the article transport apparatus 1 is used. Accordingly, in this embodiment, the article transport apparatus 1 is configured as a so-called ceiling transport vehicle.

[0015] FIG. 2 is a side view of the article transport apparatus 1 transporting an article W. As shown in FIG. 2, the article transport apparatus 1 includes a movable body 2, a cover 3, a transfer mechanism 4, a control unit 5, and a height detection unit 15. The movable body 2 moves to transport the article W. In this embodiment, the movable body 2 is located above the rail 99 and has traveling motors 2M that drive wheels 2A. The wheels 2A are rotationally driven by the traveling motors 2M, whereby a driving force in the progression direction X is applied to the movable body 2. The movement for transporting the article W means travel along the movement route R from the transport source of the article W to the transport destination of the article W. Accordingly, the movable body 2 travels along the movement route R from the transport source of the article W to the transport destination of the article W.

[0016] The cover 3 is supported by the movable body 2 and at least partially covers a lateral surrounding area of an accommodation region S in which the article W being transported is accommodated. “Supported by the movable body 2” means that the cover 3 is coupled and fixed to the movable body 2 and moves together with the movement of the movable body 2. In this embodiment, the cover 3 is suspended from the movable body 2, below the rail 99. The accommodation region S in which the article W being transported is accommodated refers to a region of the article transport apparatus 1 in which the article W is disposed while the article W is being transported from the transport source of the article W to the transport destination of the article W along the movement route R, and the region being covered by the cover 3. The region in which such an article W is disposed is called the accommodation region S because it is covered from the sides by the cover 3. The accommodation region S may be covered by the cover 3 over the entire lateral side (entire peripheral portion) of the article W, or over part of the entire lateral side.

[0017] In the present embodiment, the cover 3 includes a pair of side covers 3B that cover the article W from the sides (horizontal direction) and an upper cover 3C that covers the article W from above. In the example of FIG. 2, each of the pair of side covers 3B and the upper cover 3C are coupled to each other to form the cover 3. Also, the side covers 3B extend downward from both ends of the upper cover 3C in the direction along the movement route R (progression direction X). As a result, the pair of side covers 3B cover the article W held by the holding section 10 from both sides in the progression direction X. Also, the cover 3 is in a shape in which both sides in the width direction Y and the lower side are open, and the cover 3 is in an angular inverted U shape in a view from the outside in the width direction Y. For this reason, the accommodation region S is in communication with the outside of the cover 3 on both sides in the width direction Y and the lower side.

[0018] The transfer mechanism 4 holds the article W and transfers the article W to and from the transport target location. Holding the article W means holding the article W so that the article W does not fall when the movable body 2 moves along the movement path R. For example, it is preferable to hold the article W by gripping the flange W1 provided on the article W. The transport target location corresponds to the transport source of the article W or the transport destination of the article W described above, that is, the transport

target location 90. The transfer of the article W corresponds to the delivery of the article W. Accordingly, when the movable body 2 moves along the movement route R, the transfer mechanism 4 grips the flange W1 provided on the article W from above so that the article W does not fall, and performs
5 delivery of the article W to and from a transport target location 90, which is the transport source or the transport destination of the article W.

[0019] In this embodiment, the transfer mechanism 4 includes a holding section 10, a turning section 20, an elevation section 31, and a sliding section 32. The holding section 10 is supported by the movable body 2 and can be
10 changed between a holding state in which the article W is held and a release state in which the article W is released. “Supported by the movable body 2” means that, similarly to the cover 3, the holding section 10 is coupled to the movable body 2 and moves according to the movement of the movable body 2. The holding state in which the article W is held refers to a state in which the
15 flange W1 provided on the article W described above is held. The release state in which the article W is released refers to a state in which the flange W1 provided on the article W is not gripped. In this embodiment, the holding section 10 has a gripping motor 10M and a pair of gripping claws 10C. The pair of gripping claws 10C can be driven by the gripping motor 10M to change
20 between a gripping orientation and a release orientation. The pair of gripping claws 10C enter the gripping orientation by moving toward each other, and enter the release orientation by moving away from each other. When the pair of gripping claws 10C grip the flange W1 of the article W in the gripping orientation, the holding section 10 enters a holding state in which the article
25 W is held, and when the pair of gripping claws 10C enter the release orientation from the state in which the flange W1 is gripped, the holding section 10 enters the release state in which the article W is released from being held. Since the holding section 10 holds the flange W1, the holding section 10 corresponds to a chuck.

[0020] The turning section 20 turns the holding section 10 around a turning
30 axis 4b extending along an up-down direction. In this embodiment, the turning section 20 changes the orientation of the article W by turning the article W around the turning axis 4b extending along the vertical direction Z. In this embodiment, the turning section 20 is provided with a turning shaft
35 (not shown) extending in the vertical direction Z and a turning motor 20M for driving the turning shaft. The turning shaft is coupled to the holding section

10, and is driven by the turning motor 20M to turn together with the holding section 10. As a result, the holding section 10 and the article W gripped by the holding section 10 can be turned around the turning axis 4b extending along the vertical direction Z.

5 [0021] The elevating section 31 raises and lowers the holding section 10 in and out of the accommodation region S. As described above, in the present embodiment, the accommodation region S is covered by the cover 3 while both sides in the width direction Y and the lower part are open. A position in this accommodation region S (that is, a position included in the accommodation
10 region S) corresponds to an internal position. Accordingly, the article W indicated by the solid line in FIG. 2 is supported at an internal position. On the other hand, a position outside of the accommodation region S (that is, a position not included in the accommodation region S) corresponds to an external position. As indicated by the broken line in FIG. 2, when the article
15 W is placed on the delivery portion 90b, the article W is supported at an external position. The elevating section 31 is able to raise and lower the holding section 10 (the article W held by the holding section 10) between such an internal position and an external position.

[0022] In this embodiment, according to the up and down movement of the
20 holding section 10 performed by the elevating section 31, the article W held by the holding section 10 is raised and lowered between an internal position in the accommodation region S and the position where the delivery portion 90b is provided. In this embodiment, the elevating section 31 has an elevating belt 30A coupled to the holding section 10, and an elevating motor 31M that drives
25 an elevating pulley (not shown) to wind or unwind the elevating belt 30A. As a result, by driving the elevating motor 31M, the article W held by the holding section 10 can be raised or lowered between the internal position in the accommodation region S and the delivery portion 90b. By moving the article W up and down by the elevating section 31, the article W can be transferred to
30 the transport target location 90 located at a different position in the up-down direction (the lower side in this example) with respect to the movement route R. Also, at this time, it is possible to adjust positional deviation of the holding section 10 with respect to the transport target location 90 in the vertical direction Z by adjusting the elevation height to which the holding section 10 is
35 raised or lowered the elevating section 31.

[0023] The sliding section 32 slides the holding section 10 along the horizontal

direction. In this embodiment, the article W held by the holding section 10 is slid according to the sliding movement of the holding section 10 by the sliding section 32. In this embodiment, the sliding section 32 is attached to the cover 3, and has a slide belt (not shown) and a sliding motor 32M that drives a slide pulley (not shown) to wind or unwind the slide belt. The sliding section 32 slides the holding section 10 and the article W held by the holding section 10 along the width direction Y as the sliding motor 32M is driven. By sliding the article W in the width direction Y with the sliding section 32, it is possible to adjust positional deviation in the width direction Y with respect to the transport target location 90 when the article W is transferred.

[0024] The control unit 5 controls the movable body 2 and the transfer mechanism 4. Controlling the moving object 2 means controlling traveling and stopping along the movement route R performed by the movable body 2. Controlling the transfer mechanism 4 means controlling the holding of the article W performed by the transfer mechanism 4 and the delivery of the article W from the transport source of the article W to the transport destination of the article W. Specifically, the control unit 5 controls the holding and release of the holding of the article W performed by the holding section 10, and controls the movement and turning of the article W performed by the turning section 20, the elevating section 31, and the sliding section 32 in such a manner as to perform delivery of the article W from the transport source to the transport destination. Although FIG. 2 shows that the control unit 5 is provided in the cover 3, the control unit 5 may be provided at another location different from the cover 3.

[0025] Here, as described above, the cover 3 forms the accommodation region S, and the cover 3 has an inner surface structure facing the accommodation region S. The “inner surface structure facing the accommodation region S” corresponds to a surface defining the outer edge of the accommodation region S. This inner surface structure includes an inner wall surface 3A of the cover 3 and all structures disposed on the accommodation region S side of the inner wall surface 3A. Specifically, the inner surface structure includes the inner wall surface 3A of the cover 3, a fall restricting section 6 for restricting downward falling of the article W, a swing restricting mechanism 7 for restricting swinging of the article W held by the holding section 10, a sensor provided in such a manner as to protrude in the accommodation region S, and the like.

[0026] The inner surface structure includes a protruding portion 8 formed so as to protrude toward the accommodation region S at a specific location in the up-down direction. The specific location in the up-down direction is below (a location below) the holding section 10 in the vertical direction Z (e.g., the holding section 10 in a later-described reference orientation) in the accommodation region S. Protruding toward the accommodation region S means protruding from the inner wall surface 3A of the cover 3 to the accommodation region S. Accordingly, the inner surface structure has a protruding portion 8 disposed so as to protrude from the inner wall surface 3A of the cover 3 toward the accommodation region S below the holding section 10 in the vertical direction Z in the accommodation region S. In this embodiment, the protruding portion 8 may be the fall restricting section 6.

[0027] The fall restricting section 6 is below the article W accommodated in the accommodation region S in the vertical direction Z and protrudes toward the accommodation region S from the inner wall surface 3A of the cover 3. The fall restricting section 6 is provided on a pair of side surfaces of the inner wall surface 3A of the cover 3 that face each other with the article W held by the holding section 10 interposed therebetween. Also, the fall restricting section 6 has a link mechanism (not shown), and enters a protruding orientation of protruding toward the accommodation region S due to a pair of regulating body driving portions 6M each operating the link mechanism while the article W held by the holding section 10 is accommodated in the accommodation region S. The fall restricting section 6 is disposed so that at least a part thereof overlaps with the article W in a view in the vertical direction Z when in the protruding orientation. As a result, even if the holding section 10 enters the release state while the article W is being transported, the fall regulating portion 6 supports the article W from below, and therefore, for example, it is possible to restrict falling of the article W to the floor. Also, the fall restricting section 6 assumes a retracted orientation when the transfer mechanism 4 moves the article W to an external position of the accommodation region S, such as when the article W is transferred. The fall restricting section 6 is arranged in such a manner as not to overlap with the article W in a view in the vertical direction Z when in the retracted orientation.

[0028] The swing restricting mechanism 7 includes supports 7A, contact portions 7B, and contact driving portions 7M. The supports 7A support the contact portions 7B. The swing restricting mechanism 7 is provided on a pair

of side surfaces of the inner wall surface 3A of the cover 3 that face each other with the article W held by the holding section 10 interposed therebetween. In this example, the swing restricting mechanism 7 is provided on each of the pair of side surfaces on which the fall restricting section 6 is provided. Also, in the present embodiment, due to the supports 7A being driven by the contact driving portions 7M, the orientation is changed to a protruding orientation in which the contact portions 7B protrude from the cover 3 toward the accommodation region S, and a retracted orientation in which the contact portions 7B are retracted toward the cover 3 relative to the protruding orientation. When the article W held by the holding section 10 is accommodated in the accommodation region S, due to the pair of contact portions 7B assuming the protruding orientation, the pair of contact portions 7B come into contact with the side surfaces of the article W from both sides. As a result, the article W is restricted from swinging when the article W is transported or transferred by the transfer mechanism 4. On the other hand, when the transfer mechanism 4 moves the article W to an external position outside the accommodation region S, such as when the article W is transferred, the pair of contact portions 7B enter the retracted orientation, whereby the pair of contact portions 7B are spaced apart from the article W. As a result, the article W can be moved appropriately.

[0029] Here, FIG. 3 is an illustrative diagram of an interference height range in this embodiment, and FIG. 4 is a diagram showing a state of the article W accommodated in the accommodation region S. When the elevation height to which the holding section 10 is raised or lowered by the elevating section 31 is out of the predetermined interference height range, the transfer mechanism 4 does not interfere with the inner surface structure even if the holding section 10 is turned by the turning section 20, but when the elevation height to which the holding section 10 is raised or lowered by the elevating section 31 is within the interference height range, the transfer mechanism 4 (e.g., the holding section 10) may interfere with the protruding portion 8 due to the turning section 20 turning the holding section 10. As described above, the holding section 10 is moved up and down along the vertical direction Z by the elevating section 31. Thus, the elevation height to which the holding section 10 is raised or lowered by the elevating section 31 corresponds to the height of the holding section 10 moved up and down by the elevating section 31. In FIG. 3, the lower surface of the holding section 10 that does not include the pair of gripping

claws 10C is indicated as a reference plane 10D, the position of the reference plane 10D of the holding section 10 when the holding section 10 is raised to the highest position in the vertical direction Z is indicated as a reference position RP, and the amount of downward movement from the reference position RP is indicated as the elevation height h. "The turning section 20 turning the holding section 10" corresponds to turning performed by the turning section 20 about the turning axis 4b extending in the vertical direction Z at a predetermined turning angle. In FIG. 4, such a turning angle is indicated as θ . The inner surface structure is a surface that forms the accommodation region S, and in this embodiment, the inner wall surface 3A of the cover 3, the fall restricting section 6, the swing restricting mechanism 7, a sensor provided so as to protrude in the accommodation region S, and the like correspond thereto. Interference means contact in this embodiment.

[0030] Here, as shown in FIG. 4, when a point that is at a position along the edge of the left side Y1 in the width direction Y and at the center in the progression direction X of the article W held by the transfer mechanism 4 is set as a point Q, and the turning center when the article W is subjected to a turning movement is set as a point O, the turning angle at which a line segment OQ is parallel to the width direction Y is defined as 0 degrees. Then, as shown in FIG. 3, the upper limit value of the interference height range is denoted as h1 and the lower limit value is denoted as h2. At this time, if the reference plane 10D of the holding section 10 is not included in the interference height range, that is, if the elevation height h is smaller than h1 (in this example, if the reference plane 10D of the holding section 10 is higher than h1), or if the elevation height h is greater than h2 (in this example, if the reference plane 10D of the holding section 10 is below h2), even if a turning movement performed by the turning section 20 on the article W (a movement of turning by θ from a turning angle of 0 degrees) or a sliding movement performed by the sliding section 32 on the article W is performed, the transfer mechanism 4 does not come into contact with the inner surface structure of the cover 3 (the inner wall surface 3A, the fall restricting section 6, the swing restricting mechanism 7, the sensor provided so as to protrude into the accommodation region S, etc.). However, if the reference plane 10D of the holding section 10 is included in the interference height range (in this example, if the reference plane 10D of the holding section 10 is between h1 and h2), the transfer mechanism 4 potentially comes into contact with the protruding portion 8 (in this example, the fall

restricting section 6) when a turning movement performed by the turning section on the article W is performed, as indicated by the two-dot chain line in FIG. 4. Similarly, if the reference surface 10D of the holding section 10 is included in the interference height range, when the article W is slid by the sliding section 32, the transfer mechanism 4 may come into contact with the protruding portion 8 (in this example, the fall restricting section 6), depending on the turning angle θ at that time.

[0031] The elevation height range in which the transfer mechanism 4 does not come into contact with the inner surface structure is outside the interference height range, and the elevation height range in which the transfer mechanism 4 may come into contact with the protruding portion 8 (fall restricting portion 6 in this example) is within the interference height range. Such an interference height range is shown in FIG. 3. As shown in FIG. 3, the interference height range is provided over a range of elevation height h from h_1 to h_2 with the reference position RP serving as a reference. Accordingly, if the elevation height of the reference plane 10D of the holding section 10 is smaller than h_1 or larger than h_2 , the transfer mechanism 4 does not interfere with the inner surface structure of the cover 3 even if the turning section 20 turns the article W or the sliding section 32 slides the article W.

[0032] The height of the holding section 10, that is, the elevation height of the holding section 10, can be detected by the height detection unit 15 (see FIGS. 2 and 3). If the height detection unit 15 directly detects the elevation height h of the holding section 10 from the reference position RP, for example, the height detection unit 15 can be constituted using a distance sensor that detects the distance from the reference position RP to the holding section 10. It is preferable to use the state where the reference plane 10D of the holding section 10 is at the reference position RP as a reference, and detect the amount of change in the detected value of the distance sensor from the reference as the elevation height h . Also, if the article transport apparatus 1 includes an encoder for detecting the rotation amount of the elevating motor 31M, the height detection unit 15 can perform detection by calculating the elevation height h of the holding section 10 from the reference position RP based on the detection result of the encoder. If the height detection unit 15 calculates the elevation height h using the rotation amount detected by the encoder, it is preferable to include a storage unit capable of continuously storing the rotation amount detected by the encoder even if the power supply to the encoder and

the height detection unit 15 is stopped. Here, "continuously storing" means that the rotation amount detected by the encoder stored without being lost even if the power supply to the encoder and the height detection unit 15 is stopped.

5 [0033] As shown in FIG. 5, the detection result (calculation result) of the elevation height to which the holding section 10 is raised or lowered by the height detection unit 15 is transmitted to the control unit 5. Accordingly, the control unit 5 can determine whether or not the elevation height is within the interference height range based on the detection result by the height detection
10 unit 15. Specifically, if the calculation result of the elevation height of the reference surface 10D of the holding section 10, which is the detection result by the height detection unit 15, is h_1 or more and h_2 or less, the control unit 5 determines that the holding section 10 is within the interference height range.

[0034] As shown in FIG. 5, in the article transport apparatus 1, the control
15 unit 5 can allow the transfer mechanism 4 to operate in accordance with a command from an operation terminal 100 operated by a worker. The worker is a person who performs management, maintenance, and the like of the article transport apparatus 1. The operation terminal 100 is a terminal that is connected to the control unit 5 by wire or wirelessly, and is capable of remotely
20 operating each functional unit of the above-described article transport apparatus 1 including the transfer mechanism 4. When performing maintenance and inspection of the article transport apparatus 1, when the article transport apparatus 1 malfunctions, or the like, the worker can operate the operation terminal 100 to issue an operation command, and thus can
25 operate the movable body 2 of the article transport apparatus 1 and the transfer mechanism 4 including the holding section 10, the turning section 20, the elevating section 31, and the sliding section 32. In particular, a mode in which the transfer mechanism 4 is operated in accordance with a command from the operation terminal 100 operated by the worker is called "maintenance
30 mode".

[0035] In such a maintenance mode, the control unit 5 determines whether or not the elevation height is within the interference height range upon receiving an operation command for the transfer mechanism 4 from the operation terminal 100. In this example, the operation command for the transfer
35 mechanism 4 is a command for a reference orientation return operation for setting the orientations of the turning section 20, the elevating section 31, and

the sliding section 32 to a predetermined reference orientation. The predetermined reference orientation is an orientation serving as a reference that is determined in advance. For example, the reference orientation of the turning section 20 is an orientation in which the above-described turning angle is 0 degrees. For example, the reference orientation of the elevating section 31 is an orientation in which the holding section 10 is positioned near the upper limit of the elevating movement range. For example, the reference orientation of the sliding section 32 is an orientation in which the holding section 10 is positioned near the center of the sliding movement range. Accordingly, in this example, when the turning section 20, the elevating section 31, and the sliding section 32 are all in the reference orientation, the entire article W held by the holding section 10 (the holding section 10 in the reference orientation) is accommodated in the accommodation region S. In this manner, the reference orientation is a so-called home position. An operation command for returning the orientations of the turning section 20, the elevating section 31, and the sliding section 32 to such a reference orientation corresponds to a reference orientation return operation command. Upon receiving a reference orientation return operation command from the operation terminal 100, the control unit 5 determines whether or not the elevation height of the holding section 10 is within the interference height range. Determination of the elevation height is performed based on the above-described detection result of the height detection unit 15.

[0036] If the elevation height of the holding section 10 is outside the interference height range, the transfer mechanism 4 does not come into contact with the inner surface structure of the cover 3 even if the turning section 20 turns the article W or the sliding section 32 slides the article W. In view of this, if it is detected that the elevation height of the holding unit 10 is outside the interference height range, the control unit 5 causes the transfer mechanism 4 to operate in accordance with the operation command from the operation terminal 100. Specifically, the control unit 5 drives each of the gripping motor 10M, the turning motor 20M, the elevating motor 31M, and the sliding motor 32M. As a result, the transfer mechanism 4 operates in accordance with the command of the worker operating the operation terminal 100.

[0037] On the other hand, if the elevation height of the holding section 10 is within the interference height range, the transfer mechanism 4 potentially comes into contact with the protruding portion 8 (in this example, the fall

restricting section 6) when the turning section 20 turns the article W or the sliding section 32 slides the article W. In view of this, if the elevation height of the holding section 10 is within the interference height range, the control unit 5 prohibits the turning operation performed by the turning section 20 on the holding section 10 among the operations of the transfer mechanism 4 performed in accordance with the operation command. Here, the case where the elevation height of the holding section 10 is within the interference height range is a case where it is determined that the elevation height of the holding section 10 is within the interference height range. The operation of the transfer mechanism 4 performed in accordance with the operation command is an operation of the movable body 2 of the article transport apparatus 1 and the transfer mechanism 4 (the transfer mechanism 4 including the holding section 10, the turning section 20, the elevating section 31, and the sliding section 32) performed in accordance with the operation command issued by the worker operating the operation terminal 100. For this reason, prohibiting the turning operation performed by the turning section 20 on the holding section 10 among the operations of the transfer mechanism 4 performed in accordance with the operation command means prohibiting the turning operation performed by the turning section 20 on the holding section 10 and allowing the operations of the holding section 10, the elevating section 31, and the sliding section 32 among the operations of the transfer mechanism 4 including the holding section 10, the turning section 20, the elevating section 31, and the sliding section 32.

[0038] In the present embodiment, when the control unit 5 receives an operation command for the transfer mechanism 4 from the operation terminal 100 in the maintenance mode, and the elevation height of the holding section 10 is within the interference height range, the control unit 5 prohibits the sliding operation performed by the sliding section 32 on the holding section 10 in addition to the turning operation performed by the turning section 20 on the holding section 10. In this case, the control unit 5 prohibits both the turning operation performed by the turning section 20 on the holding section 10 and the sliding operation performed by the sliding section 32 on the holding section 10 and allows the operations of the holding section 10 and the elevating section 31 among operations of the transfer mechanism 4 performed in accordance with the operation command (the operations of the transfer mechanism 4 including the holding section 10, the turning section 20, the elevating section

31, and the sliding section 32).

[0039] In this way, if there is a possibility that, in the current orientation of the transfer mechanism 4, the transfer mechanism 4 will come into contact with the inner surface structure of the cover 3 when the holding section 10 is moved, the control unit 5 prohibits the turning operation performed by the turning section 20 on the holding section 10 and the sliding operation performed by the sliding section 32 on the holding section 10. As a result, it is possible to prevent the holding section 10 from coming into contact with the inner surface structure of the cover 3 due to worker error or the like.

10 [0040] Also, in the maintenance mode, when the control unit 5 receives an operation command for the transfer mechanism 4 from the operation terminal 100 described above, and when the elevation height of the holding section 10 is within the interference height range, the control unit 5 can prohibit the turning operation performed by the turning section 20 on the holding section 10, execute the elevating operation performed by the elevating section 31 if the elevating operation is included in the operation command, and execute the turning operation performed by the turning section 20 on the holding section 10 as well in accordance with the operation command if the elevation height reaches a height outside the interference height range. The maintenance mode is a mode in which the transfer mechanism 4 is operated in accordance with a command from the operation terminal 100 operated by the worker. As described above, when the control unit 5 receives an operation command for the transfer mechanism 4 from the operation terminal 100 and the elevation height of the holding section 10 is within the interference height range, the control unit 5 prohibits the turning operation performed by the turning section 20 on the holding section 10. As a result, it is possible to prevent the holding section 10 from coming into contact with the inner surface structure of the cover 3. Then, if the operation command includes an elevating operation performed by the elevating section 31, first, the elevating operation of the elevating section 31 is executed so that the reference plane 10D of the holding section 10 is at a height outside the interference height range, and thereafter, the turning operation performed by the turning section 20 on the holding section 10 is executed in accordance with the operation command. As a result, it is possible to execute an operation in which the holding section 10 does not come into contact with the inner surface structure of the cover 3 even if the turning section 20 turns the holding section 10 in accordance with the

operation command.

[0041] FIG. 6 is a flow chart showing the above-described processing of the control unit 5. First, when the control unit 5 receives an operation command from the operation terminal 100 (step #10: Yes), processing is started. When
5 the control unit 5 receives an operation command from the operation terminal 100, the control unit 5 determines the elevation height of the holding section 10. If the elevation height of the holding section 10 is outside the interference height range (step #11: Yes), the control unit 5 operates the transfer mechanism 4 in accordance with the received operation command (step #12).
10 When the operation performed in accordance with the operation command is completed, the control unit 5 ends the processing.

[0042] In step #11, if the elevation height of the holding section 10 determined by the control unit 5 is not outside the interference height range (step #11: No), the control unit 5 prohibits the turning operation performed by the turning
15 section 20 on the holding section 10 (step #13). Furthermore, if the operation command received from the operation terminal 100 includes the sliding operation performed by the sliding section 32 on the holding section 10 (step #14: Yes), the control unit 5 also prohibits the sliding operation performed by the sliding section 32 on the holding section 10 (step #15).

[0043] In step #15, if the sliding operation by the sliding section 32 is prohibited (step #15), or in step #14, if the operation command received from the operation terminal 100 does not include the sliding operation performed by the sliding section 32 on the holding section 10 (step #14: No), it is determined
20 whether or not the operation command received from the operation terminal 100 includes the elevating operation performed by the elevating section 31 on the holding section 10 (step #16).
25

[0044] If the operation command received from the operation terminal 100 includes the elevating operation performed by the elevating section 31 on the holding section 10 (step #16: Yes), the control unit 5 allows the elevating section
30 31 to execute the elevating operation on the holding section 10 in accordance with the received operation command (step #17). This elevating operation is performed until the elevation height of the holding section 10 is outside the interference height range (step #18: No). When the elevation height of the holding section 10 is outside the interference height range (step #18: Yes), the
35 control section 5 terminates the elevating operation performed by the elevating section 31 on the holding section 10 (step #19). Subsequently, the control unit

5 causes the turning section 20 to execute the turning operation on the holding section 10 in accordance with the operation command received from the operation terminal 100 (step #20). Note that at this time, although not shown in the flow chart, in step #14, if the operation command received from the operation terminal 100 includes the sliding operation performed by the sliding section 32 on the holding section 10 (step #14: No), after the processing of step #20, it is preferable to execute the sliding operation performed by the sliding section 32 on the holding section 10 in accordance with the operation command received from the operation terminal 100. When the operation performed in accordance with the operation command is completed, the control unit 5 ends the processing.

[0045] On the other hand, in step #16, if the operation command received from the operation terminal 100 does not include the elevating operation performed by the elevating section 31 on the holding section 10 (step #16: No), the control unit 5 ends the processing without operating the transfer mechanism 4. At this time, as shown in FIG. 7, for example, the control unit 5 preferably displays a message such as "The elevation height (of the holding section 10) is within the interference height range" on the display screen 100A of the operation terminal 100, or displays a figure indicating that the holding section 10 is in an orientation that will or may potentially come into contact with the inner surface structure of the cover 3. Alternatively, it is preferable to output audio such as "The elevation height (of the holding section 10) is within the interference height range" from a speaker 100B of the operation terminal 100. Of course, display of other messages or output of audio is also possible. Also, if the article transport apparatus 1 includes a display device, it is possible to display the above-mentioned message on the display device, and if the article transport apparatus 1 includes a speaker, the above-mentioned audio may be output from the speaker.

[0046] If the elevation height of the holding section 10 is within the interference height range, the control unit 5 performs the elevating operation such that the elevation height of the holding section 10 is outside the interference height range, and then causes the turning section 20 to execute the turning operation on the holding section 10 and the sliding section 32 to perform the sliding operation on holding section 10, whereby the transfer mechanism 4 can be prevented from coming into contact with the inner surface structure of the cover 3, and the transfer mechanism 4 can be operated in

accordance with the operation command received from the operation terminal 100.

2. Other Embodiments of Article Transport Apparatus

5 [0047] Next, another embodiment of the article transport apparatus 1 will be described.

[0048] (1) In the above embodiment, the article transport apparatus 1 has been described as an example configured as a so-called ceiling transport vehicle. However, there is no limitation to such a configuration, and for example, the
10 article transport apparatus 1 may be various types of transport vehicles such as an unmanned transport vehicle and a track-guided cart. Alternatively, a transport device (e.g., a drone, etc.) that does not move along the rail 99 may be used.

[0049] (2) In the above embodiment, the protruding portion 8 was described
15 as being the fall restricting portion 6. However, there is no limitation to such a configuration, and the protruding portion 8 may also be the inner wall surface 3A of the cover 3, the swing restricting mechanism 7, a sensor provided so as to protrude in the accommodation region S, or the like.

[0050] (3) In the above embodiment, a case in which the transfer mechanism
20 4 includes the sliding section 32 was described as an example. However, there is no limitation to such a configuration, and the transfer mechanism 4 need not to include the sliding section 32. In this case, the control unit 5 preferably prohibits only the turning operation performed by the turning section 20 on the holding section 10 when the elevation height of the holding section 10 is
25 within the interference height range.

[0051] (4) In the above-described embodiment, the inner surface structure has been described as being a surface that forms the accommodation region S, and as corresponding to the inner wall surface 3A of the cover 3, the fall restricting section 6, the swing restricting mechanism 7, and the sensor provided so as to
30 protrude in the accommodation region S. However, the inner surface structure corresponds only to the inner wall surface 3A of the cover 3 if the fall restricting section 6, the swing control mechanism 7, the sensor provided so as to protrude into the accommodation region S, and the like are not provided.

[0052] (5) In the above embodiment, a description was given in which, when
35 the elevation height of the holding section 10 is within the interference height range, the control unit 5 prohibits the turning operation performed by the

turning section 20 on the holding section 10, executes the elevating operation performed by the elevating section 31 on the holding section 10 if the operation command includes the elevating operation, and executes the turning operation performed by the turning section 20 on the holding section 10 in accordance
5 with the operation command when the elevation height reaches a height outside the interference height range. However, there is no limitation to such a configuration, and the control unit 5 may also prohibit the turning operation performed by the turning section 20 on the holding section 10 and prohibit the elevating operation performed by the elevating section 31 on the holding
10 section 10 if the elevation height of the holding section 10 is within the interference height range.

[0053] (6) In the above embodiment, it was described that the position of the reference plane 10D of the holding section 10 when the holding section 10 is raised to the highest position in the vertical direction Z is the reference position
15 RP, and the amount of downward movement from the reference position RP is the elevation height h. However, there is no limitation to such a configuration, and for example, a position (e.g., the position of the upper surface of the holding section 10, etc.) that is different from the position of the reference plane 10D (the lower surface of the holding section 10 that does not include the pair of
20 gripping claws 10C) of the holding section 10 when the holding section 10 is raised to the highest position in the vertical direction Z may be the reference position RP, and the amount of movement downward from the reference position RP may be the elevation height h. Alternatively, a predetermined position (e.g., the position of the lower surface, the position of the upper surface,
25 etc.) of the holding section 10 when the holding section 10 is lowered to the lowest position in the vertical direction Z may be the reference position RP, and the amount of movement upward from the reference position RP may be the elevation height h. Furthermore, the elevation height may be the height from any one of the upper end, the center, the lower end, or the like of the
30 interference height range.

[0054] (7) In the above embodiment, a configuration was described as an illustrative example in which the height detection unit 15 can be constituted using a distance sensor, or the elevation height is determined based on the detection result of an encoder that detects the rotation amount of the elevation
35 motor 31M. However, there is no limitation to such a configuration, and for example, a capacitance sensor may be disposed along the movement direction

(vertical direction Z) of the holding section 10, and the elevation height of the holding section 10 may be detected based on the detection result of this capacitance sensor, or the elevation height of the holding section 10 may be detected based on a change in resistance or impedance.

5 [0055] (8) In the above-described embodiment, the operation command has been described as being a command for the reference orientation return operation for setting the orientations of the turning section 20, the elevating section 31, and the sliding section 32 to the predetermined reference orientation. However, there is no limitation to such a configuration, and the
10 operation command may be another orientation different from the predetermined reference orientation (e.g., an orientation that facilitates maintenance, etc.).

[0056] (9) Note that the configurations disclosed in the embodiments described above can also be applied in combination with the configurations
15 disclosed in other embodiments as long as there is no contradiction. Regarding other configurations as well, the embodiments disclosed in this specification are merely examples in all respects. Accordingly, various modifications can be made as appropriate without departing from the scope of the present disclosure.

20

[0057] 3. Overview of Above-Described Embodiment

[0058] An overview of the article transport apparatus described above will be described below.

[0059] The article transport apparatus is
25 an article transport apparatus configured to transport an article, the article transport apparatus including:

a movable body configured to move to transport the article;

a cover that is held by the movable body and that at least partially covers a lateral peripheral portion of an accommodation region in which
30 accommodation region the article is accommodated while the article is transported;

a transfer mechanism configured to hold the article and transfer the article to and from a transfer target location; and

a control unit configured to control the movable body and the transfer
35 mechanism,

in which the transfer mechanism includes:

a holding section that is held by the movable body and that is capable of holding the article and releasing the article;

a turning section configured to turn the holding section around a vertical turning axis; and

5 an elevating section configured to raise and lower the holding section into and out of the accommodation region,

the cover includes an inner surface structure facing the accommodation region,

10 the inner surface structure includes a protruding portion protruding toward the accommodation region at a specific location in an up-down direction,

in response to an elevation height to which the holding section is raised or lowered by the elevating section being within an interference height range, the transfer mechanism potentially interferes with the protruding portion due to the turning section turning the holding section, and in response to the
15 elevation height of the holding section raised or lowered by the elevating section being outside the interference height range, the transfer mechanism does not interfere with the inner surface structure even if the turning section turns the holding section,

the control unit has a maintenance mode, in which the control unit
20 allows the transfer mechanism to be operated in accordance with a command from an operation terminal operated by a worker, and

in the maintenance mode, in response to receiving an operation command for the transfer mechanism from the operation terminal, the control unit determines whether the elevation height is within the interference height
25 range, and (i) in response to the elevation height being outside the interference height range, the control unit allows the transfer mechanism to be operated in accordance with the operation command, and (ii) in response to the elevation height being within the interference height range, the control unit prohibits a turning operation of the holding section by the turning section among
30 operations of the transfer mechanism performed in accordance with the operation command.

[0060] According to this configuration, even if the worker issues an erroneous operation command for the transfer mechanism in the maintenance mode, it is possible to prevent a turning operation of the holding section from being
35 performed, and in other cases, it is possible to cause the transfer mechanism to perform an operation in accordance with the operation command. As a

result, the transfer mechanism can be appropriately operated in accordance with the operation command while avoiding interference between the holding section and the protruding portion.

[0061] Here,

5 it is preferable that in the maintenance mode, in response to (i) receiving the operation command for the transfer mechanism from the operation terminal and (ii) the elevation height being within the interference height range, the control unit prohibits the turning operation of the holding section by the turning section, in response to the operation command including
10 the elevation operation of the holding section by the elevating section, the control unit allows execution of the elevation operation, and in response to the elevation height reaching a height outside the interference height range, the control unit allows execution of the turning operation of the holding section by the turning section in accordance with the operation command.

15 [0062] According to this configuration, even if the worker issues an erroneous operation command for the transfer mechanism in the maintenance mode and the turning operation of the holding section is prohibited, the turning operation of the holding section is also executed in accordance with the operation command when an elevating operation is performed so that the holding section
20 reaches a height where it does not interfere with the protruding portion even if the holding section undergoes the turning operation. Accordingly, the transfer mechanism can be appropriately operated in accordance with the operation command while avoiding interference between the holding section and the protruding portion.

25 [0063] Also,

 it is preferable to further include a height detection unit configured to detect a height of the holding section,

 in which the control unit determines whether the elevation height is within the interference height range based on a detection result obtained by
30 the height detection unit.

[0064] According to this configuration, even if the control unit cannot determine the elevation height of the holding section based on the control results so far, for example, when power supply is started to the article transport apparatus that is not supplied with power, the elevation height can be
35 appropriately determined by providing the height detection unit.

[0065] Also,

it is preferable that the transfer mechanism further includes a sliding section,

the sliding section slides the holding section horizontally, and

in the maintenance mode, in response to (i) receiving the operation
5 command for the transfer mechanism from the operation terminal and (ii) the
elevation height being within the interference height range, the control unit
prohibits a sliding operation of the holding section by the sliding section in
addition to the turning operation of the holding section by the turning section.
[0066] In the article transport apparatus, even if a turning operation of the
10 holding section is not performed, the holding section and the protruding
portion may interfere with each other due to horizontal movement of the
holding section resulting from a sliding operation. In view of this, according
to this configuration, it is possible to appropriately avoid such interference as
well.

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Industrial Applicability

[0067] The technique according to the present disclosure can be used for an
article transport apparatus that transports an article.

20 DESCRIPTION OF REFERENCE SIGNS

[0068] 1 Article transport apparatus
2 Movable body
3 Cover
4 Transfer mechanism
25 4b Turning axis
5 Control unit
8 Protruding portion
10 Holding section
15 Height detection unit
30 20 Turning section
31 Elevating section
32 Sliding section
100 Operation terminal
S Accommodation region
35 W Article

What Is Claimed Is:

1. An article transport apparatus configured to transport an article, the article transport apparatus comprising:
 - 5 a movable body configured to move to transport the article;
a cover that is held by the movable body and that at least partially covers a lateral peripheral portion of an accommodation region in which accommodation region the article is accommodated while the article is transported;
 - 10 a transfer mechanism configured to hold the article and transfer the article to and from a transfer target location; and
a control unit configured to control the movable body and the transfer mechanism,
wherein the transfer mechanism includes:
 - 15 a holding section that is held by the movable body and that is capable of holding the article and releasing the article;
a turning section configured to turn the holding section around a vertical turning axis; and
an elevating section configured to raise and lower the holding
20 section into and out of the accommodation region,
the cover includes an inner surface structure facing the accommodation region,
the inner surface structure includes a protruding portion protruding toward the accommodation region at a specific location in an up-down direction,
25 in response to an elevation height to which the holding section is raised or lowered by the elevating section being within an interference height range, the transfer mechanism potentially interferes with the protruding portion due to the turning section turning the holding section, and in response to the elevation height of the holding section raised or lowered by the elevating
30 section being outside the interference height range, the transfer mechanism does not interfere with the inner surface structure even if the turning section turns the holding section,
the control unit has a maintenance mode, in which the control unit allows the transfer mechanism to be operated in accordance with a command
35 from an operation terminal operated by a worker, and
in the maintenance mode, in response to receiving an operation

command for the transfer mechanism from the operation terminal, the control unit determines whether the elevation height is within the interference height range, and (i) in response to the elevation height being outside the interference height range, the control unit allows the transfer mechanism to be operated in accordance with the operation command, and (ii) in response to the elevation height being within the interference height range, the control unit prohibits a turning operation of the holding section by the turning section among operations of the transfer mechanism performed in accordance with the operation command.

10

2. The article transport apparatus according to claim 1,
wherein in the maintenance mode, in response to (i) receiving the operation command for the transfer mechanism from the operation terminal and (ii) the elevation height being within the interference height range, the control unit prohibits the turning operation of the holding section by the turning section, in response to the operation command including the elevation operation of the holding section by the elevating section, the control unit allows execution of the elevation operation, and in response to the elevation height reaching a height outside the interference height range, the control unit allows execution of the turning operation of the holding section by the turning section in accordance with the operation command.

3. The article transport apparatus according to claim 1 or 2, further comprising

25 a height detection unit configured to detect a height of the holding section,

wherein the control unit determines whether the elevation height is within the interference height range based on a detection result obtained by the height detection unit.

30

4. The article transport apparatus according to any one of claims 1 to 3, wherein the transfer mechanism further includes a sliding section, the sliding section slides the holding section horizontally, and in the maintenance mode, in response to (i) receiving the operation command for the transfer mechanism from the operation terminal and (ii) the elevation height being within the interference height range, the control unit

prohibits a sliding operation of the holding section by the sliding section in addition to the turning operation of the holding section by the turning section.