US 20250263097A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2025/0263097 A1

Nishikawa et al. (43) Pub. Date: Aug. 21, 2025

(54) **TRANSPORT VEHICLE AND TRANSPORT FACILITY INCLUDING TRANSPORT VEHICLE**

(71) Applicant: **Daifuku Co., Ltd.**, Osaka-shi (JP)

(72) Inventors: **Tadashi Nishikawa**, Hinocho (JP); **Daichi Tomida**, Hinocho (JP); **Daisuke Ogawa**, Hinocho (JP); **Yoshitaka Deguchi**, Hinocho (JP); **Kenji Tamura**, Hinocho (JP)

(21) Appl. No.: **19/053,569**

(22) Filed: **Feb. 14, 2025**

(30) **Foreign Application Priority Data**

Feb. 16, 2024 (JP) 2024-022120

Publication Classification

(51) **Int. Cl.**

B61L 27/10	(2022.01)
B61B 5/00	(2006.01)
B61C 9/38	(2006.01)
B61C 17/06	(2006.01)
H01L 21/677	(2006.01)

(52) **U.S. Cl.**

CPC ***B61L 27/10*** (2022.01); ***B61B 5/00*** (2013.01); ***B61C 9/38*** (2013.01); ***B61C 17/06*** (2013.01); ***H01L 21/6773*** (2013.01); ***H01L 21/67733*** (2013.01); ***H01L 21/67736*** (2013.01)

(57) **ABSTRACT**

A holding unit of a transport vehicle is coupled to the travel unit via a coupling mechanism. The coupling mechanism is configured to be able to transition between a coupled state in which the travel unit and the holding unit are coupled to each other, and a separated state in which the travel unit and the holding unit are separated from each other. The travel unit executes both a coupled traveling mode of traveling while being coupled to the holding unit via the coupling mechanism and a separated traveling mode of traveling alone while being separated from the holding unit.

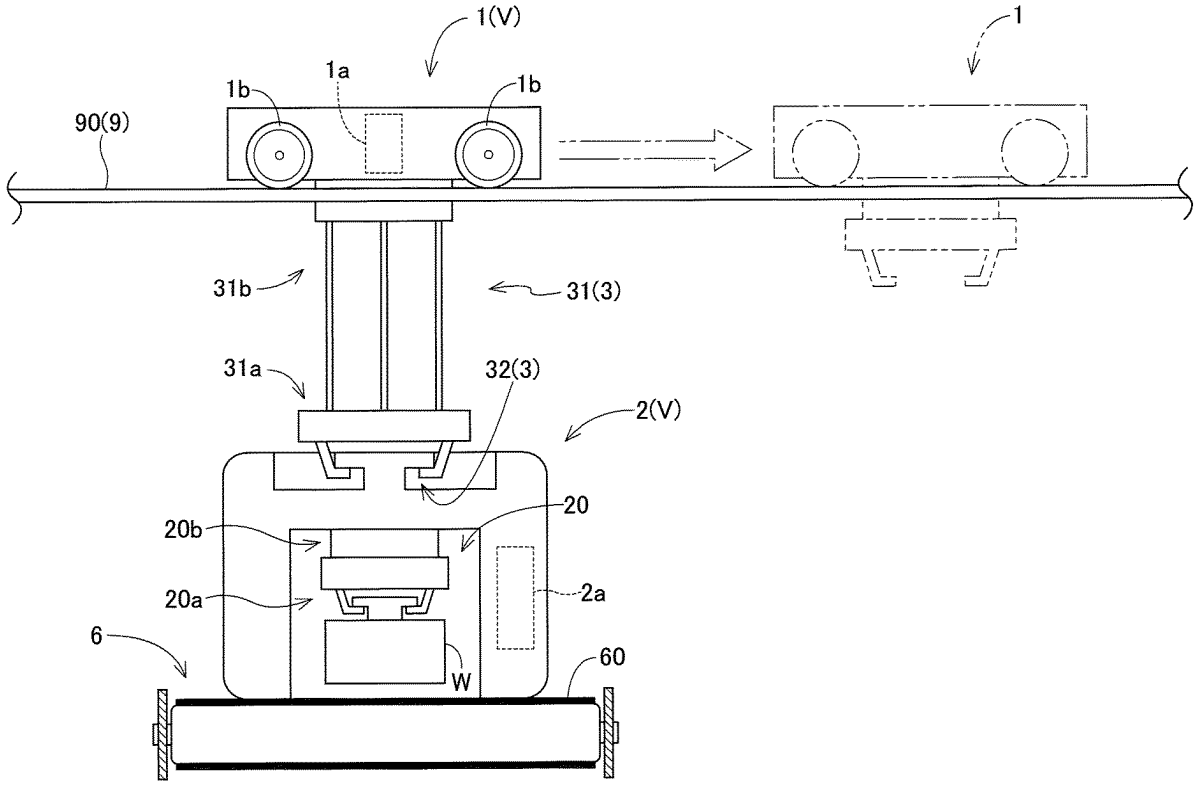


Fig.1

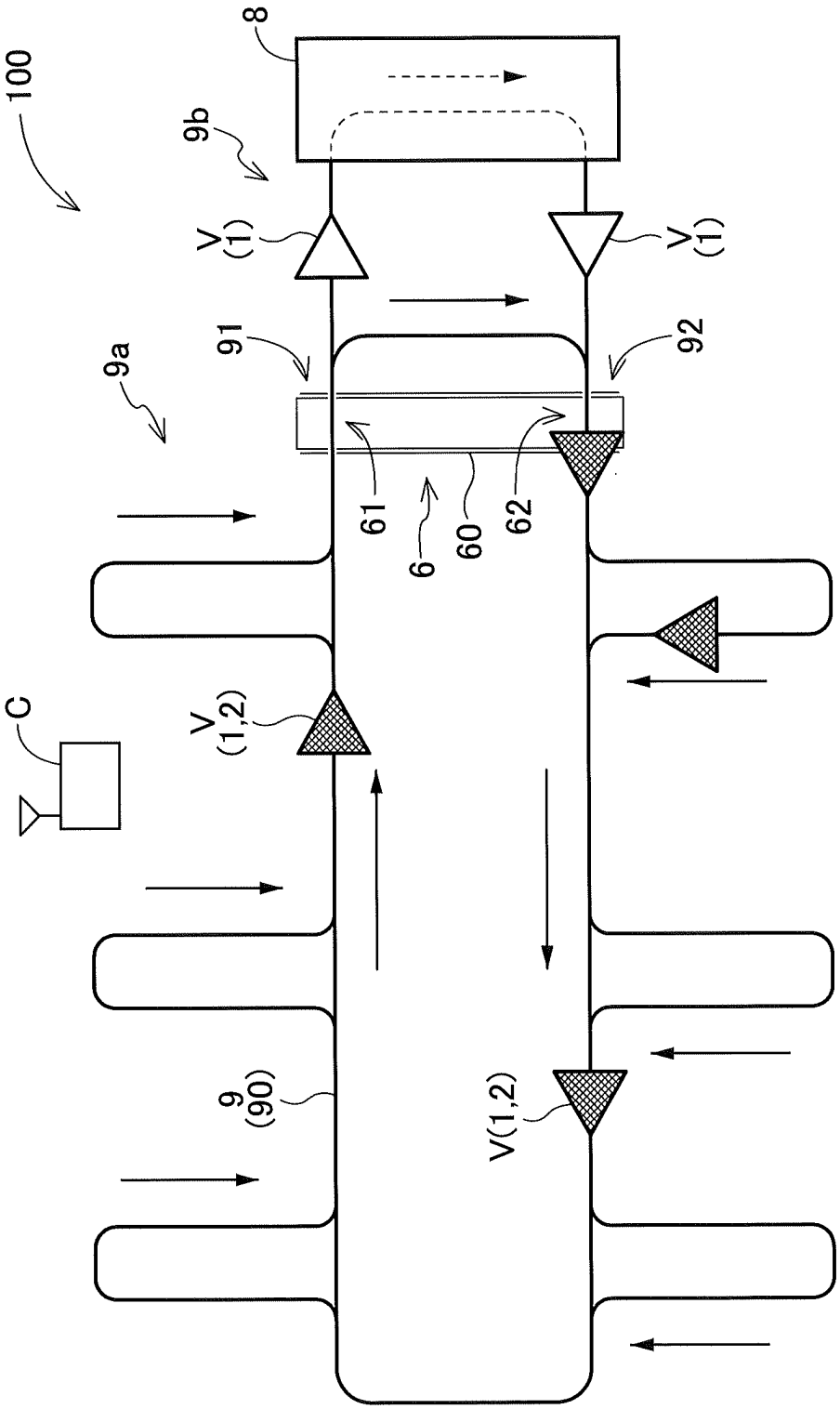


Fig.2

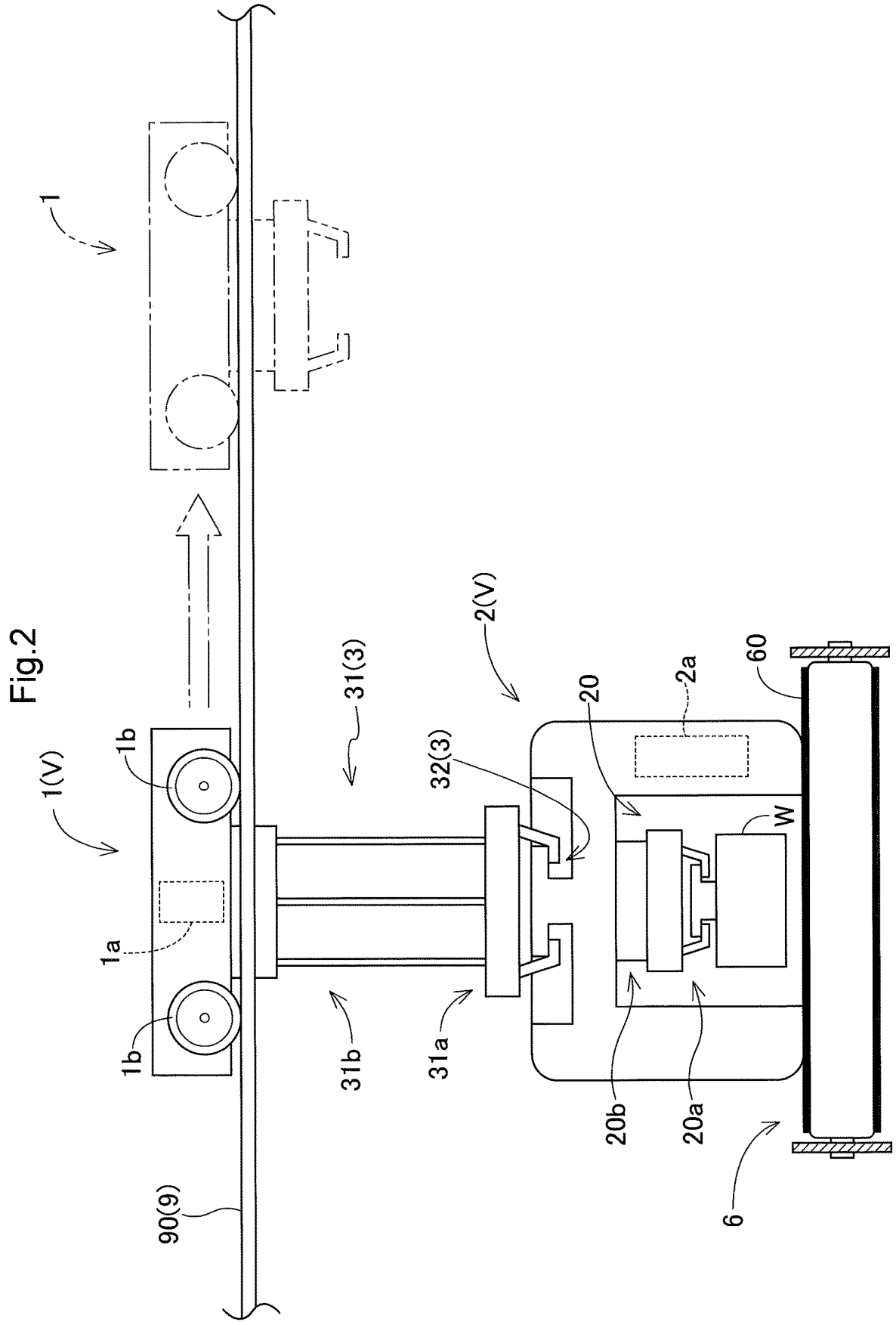


Fig.3

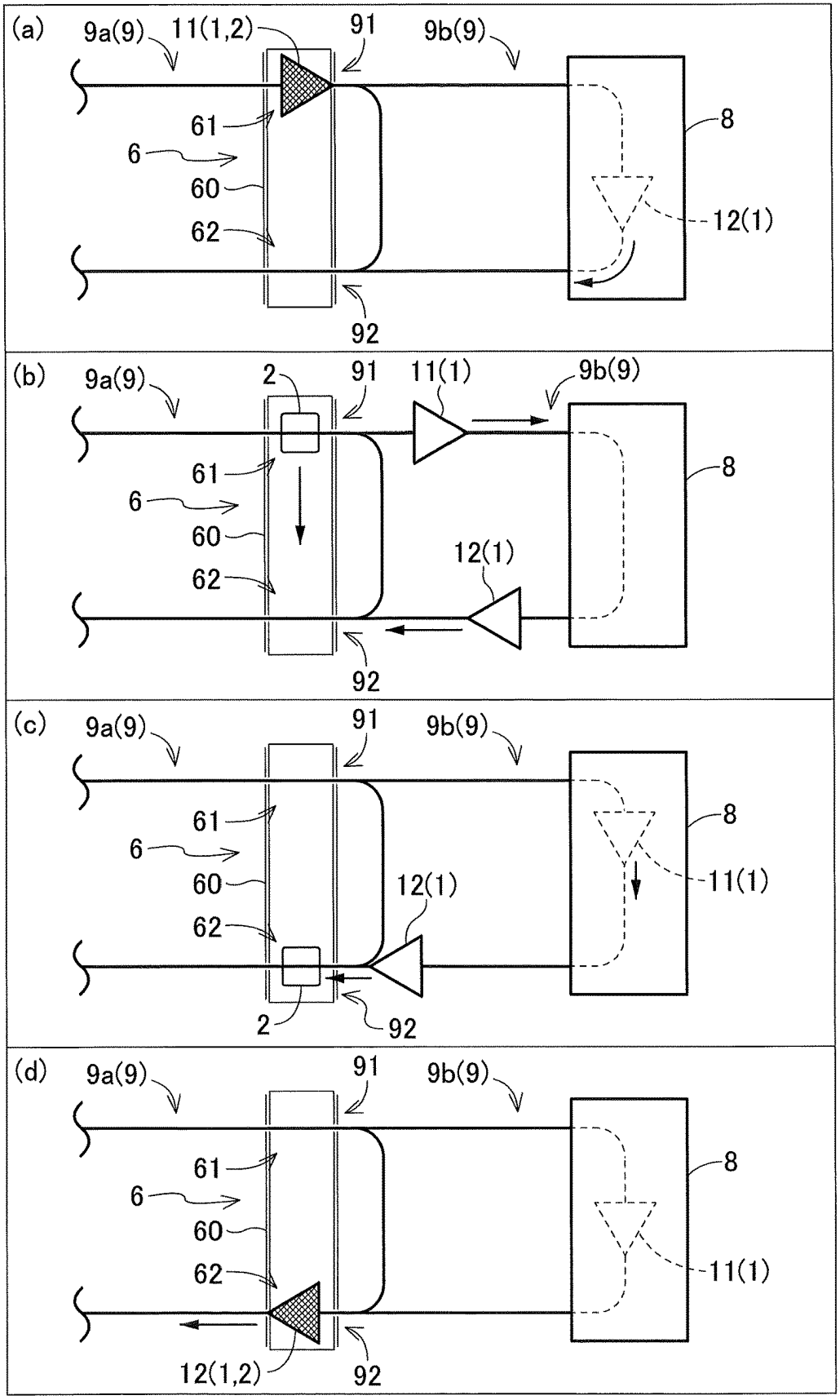

(a)
9a(9)
11(1,2)
91
9b(9)
61
6
60
62
8
12(1)
92
(b)
9a(9)
2
91
11(1)
9b(9)
61
6
60
62
8
12(1)
92
(c)
9a(9)
91
9b(9)
61
6
60
62
12(1)
8
11(1)
2
92
(d)
9a(9)
91
9b(9)
61
6
60
62
8
11(1)
12(1,2)
92

Fig.4

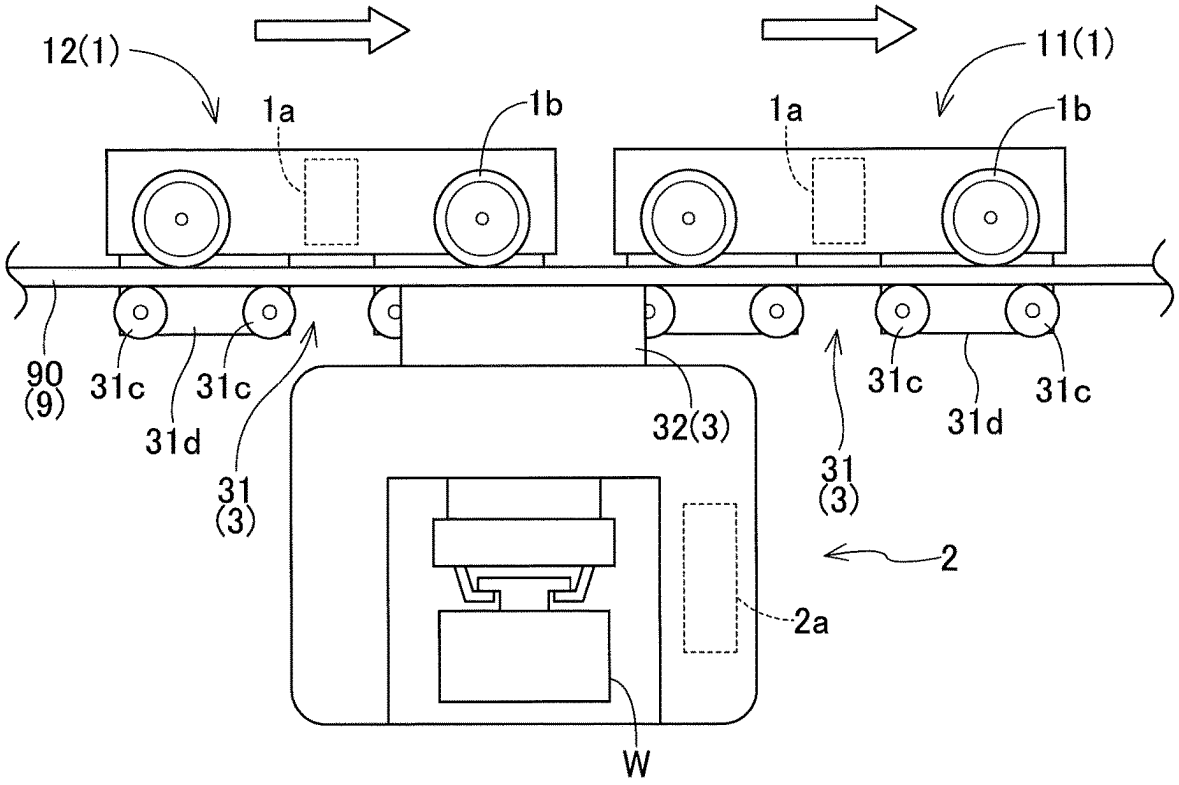

12(1)
11(1)
1a
1b
1a
1b
90
(9)
31c
31c
31d
31
(3)
32(3)
31c
31d
31c
31
(3)
2
2a
W

Fig.5

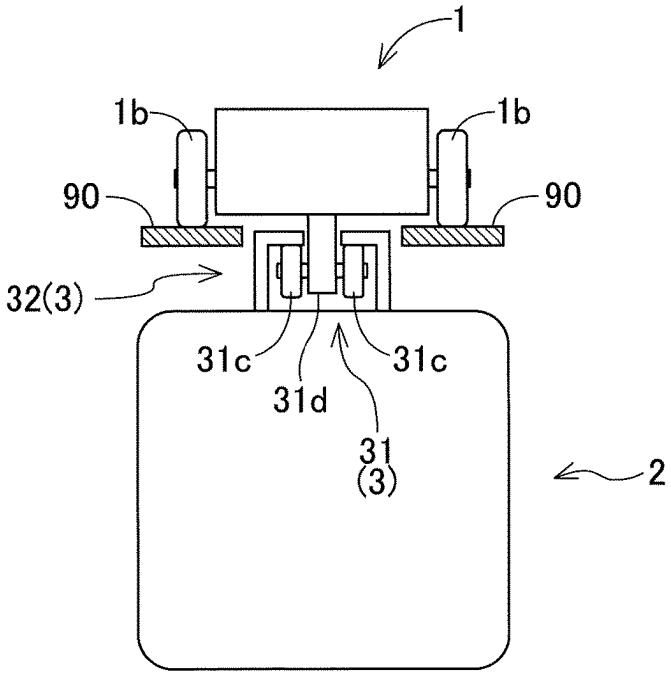

1
1b
1b
90
90
32(3)
31c
31c
31d
31
(3)
2

Fig.6

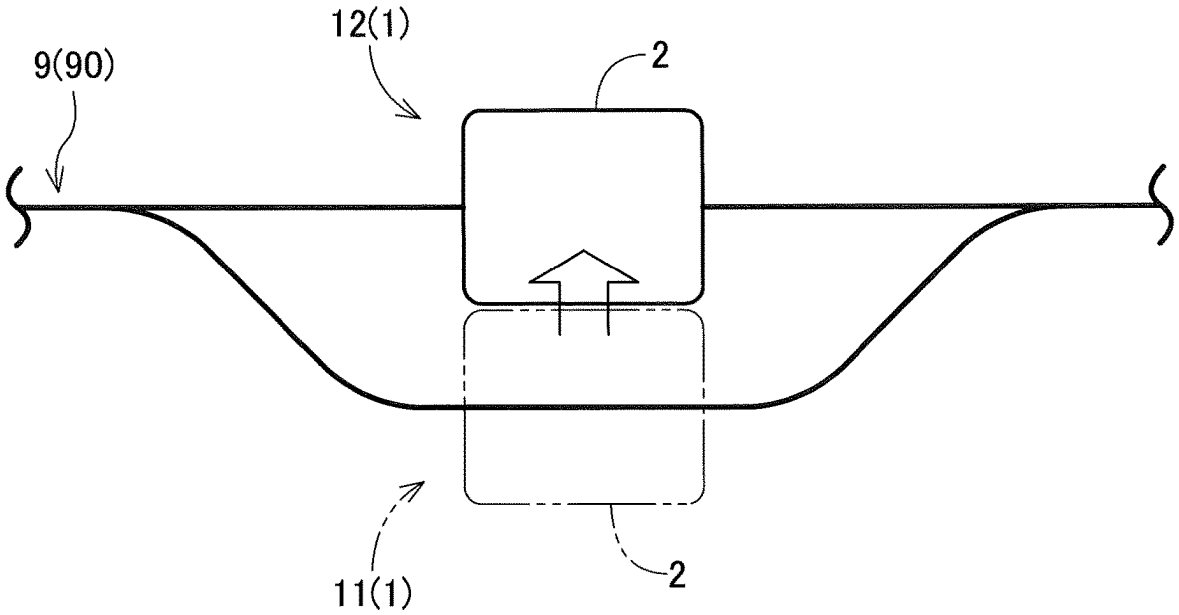


Fig.7

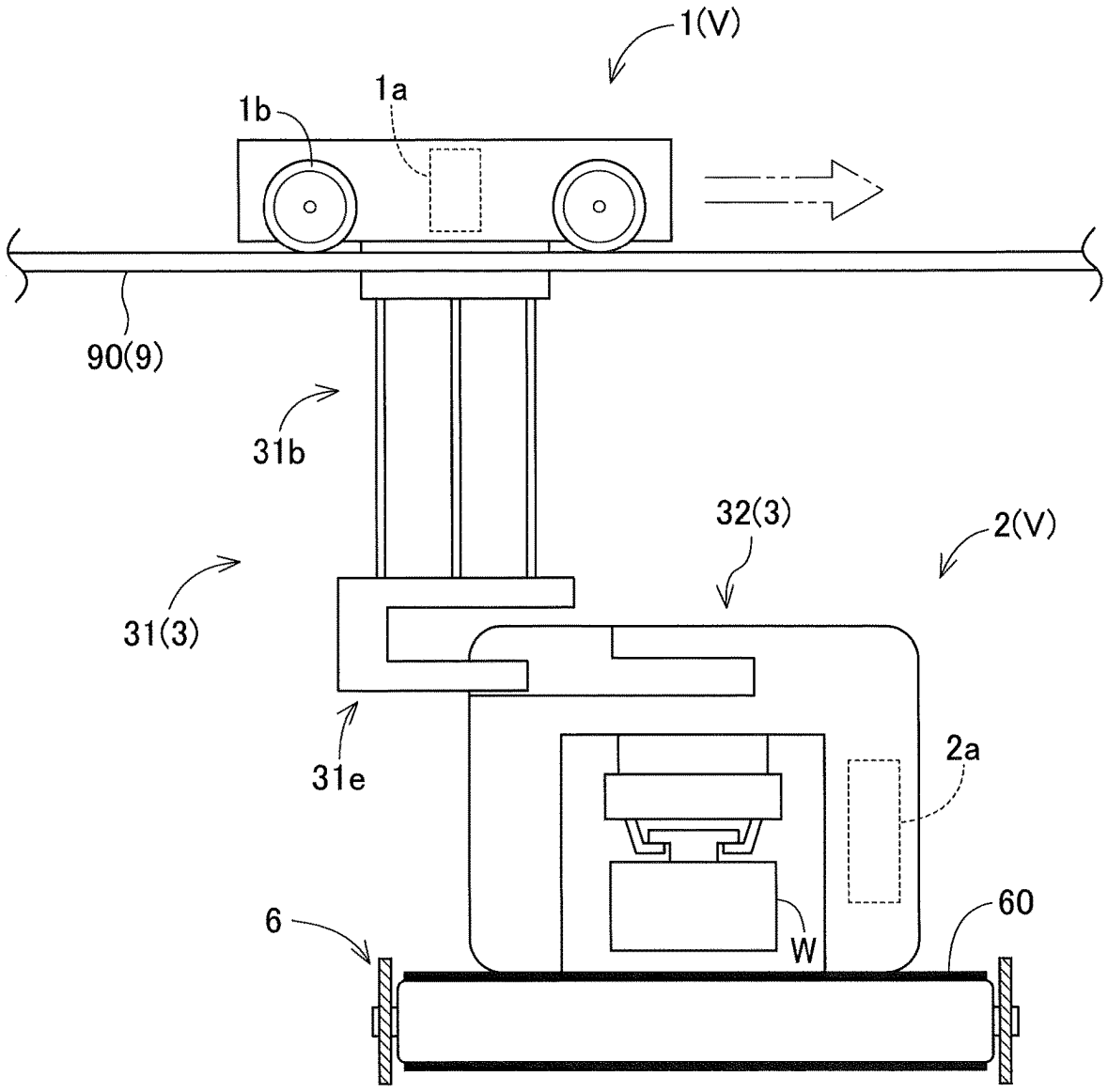
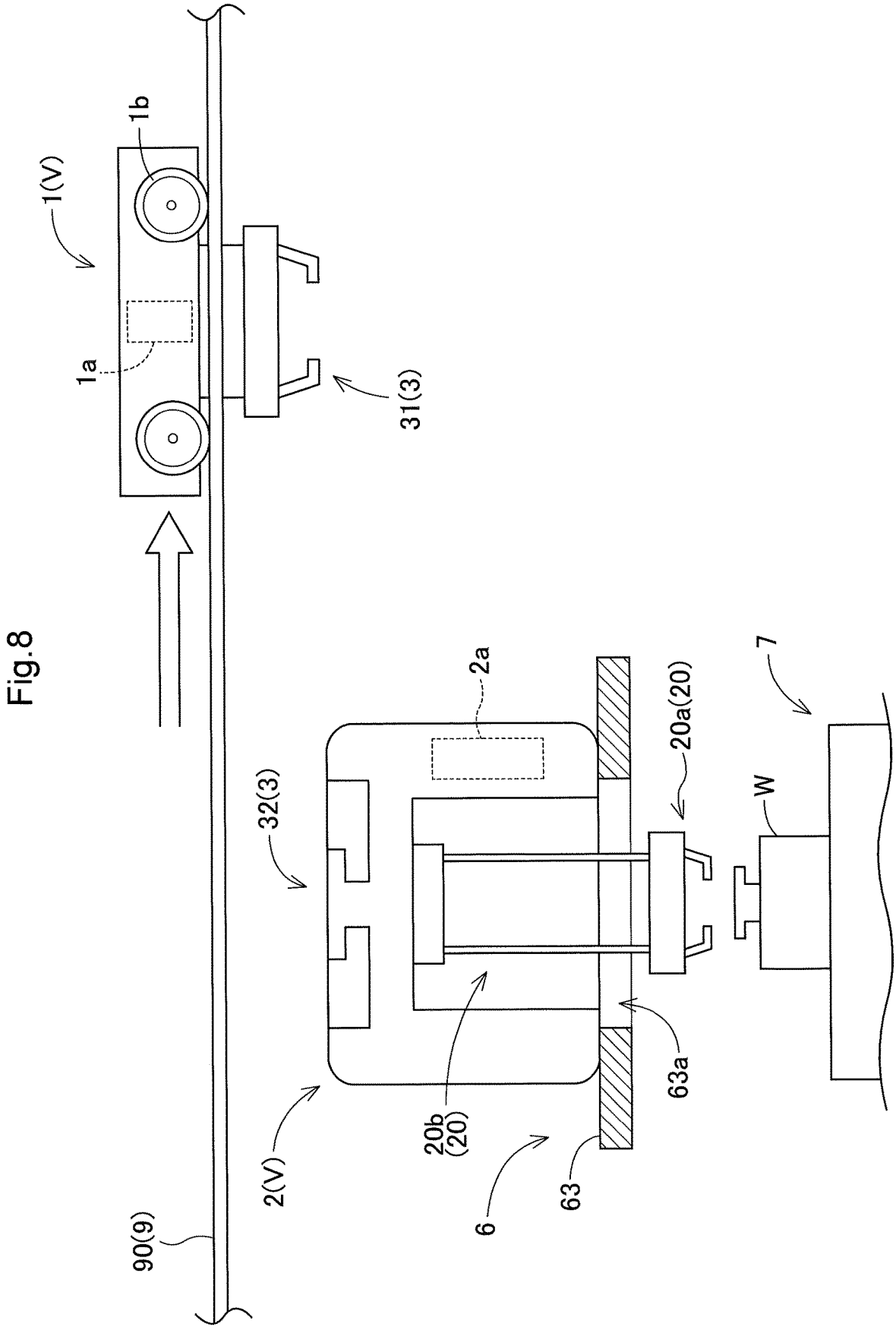


Fig.8



TRANSPORT VEHICLE AND TRANSPORT FACILITY INCLUDING TRANSPORT VEHICLE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-022120 filed Feb. 16, 2024, the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a transport vehicle and a transport facility including the transport vehicle.

Description of Related Art

[0003] For example, JP 2022-177495A discloses a transport vehicle (**1**) that transports a transport object (**200**) between processes.

[0004] The transport vehicle (**1**) is configured to travel along a route (**20**) while holding the transport object (**200**). In other words, the transport vehicle (**1**) has both the function of traveling a route and the function of holding the transport object (**200**).

[0005] In such a technical field, for example, in a case where some sort of problem occurs in a transport vehicle during transport of a transport object, the transport vehicle may be forced to head to a maintenance station while holding the transport object. Alternatively, if a transport vehicle uses a power storage device installed therein as a power source and the remaining power is running low, the transport vehicle may be forced to head to a charging station or the like while holding the transport object. In situations as described above, the transport of the transport object will be interrupted, which would interfere with the normal operation of the transport vehicle.

SUMMARY OF THE INVENTION

[0006] In view of the above-described circumstances, a technology that enables flexible operation of transport vehicles according to the situation is desired.

[0007] The technology to solve the foregoing problem is as follows.

[0008] A transport vehicle comprising:

[0009] a travel unit configured to travel along a rail; and

[0010] a holding unit configured to hold a transport object, the holding unit being configured to be coupled to the travel unit via a coupling mechanism,

[0011] the coupling mechanism being configured to transition between a coupled state in which the travel unit and the holding unit are coupled to each other, and a separated state in which the travel unit and the holding unit are separated from each other, and

[0012] the travel unit being configured to execute both a coupled traveling mode of traveling while being coupled to the holding unit via the coupling mechanism, and a separated traveling mode of traveling alone while being separated from the holding unit.

[0013] According to this configuration, by executing the coupled traveling mode, the travel unit can appropriately transport a transport object. Also, by executing the separated traveling mode, the travel unit can travel alone while separated from the holding unit. With this, during the execution of the separated traveling mode, the travel unit can perform another task at a location different from the location of the holding unit. Also, for example, if some sort of defect occurs only in the travel unit, the travel unit alone can take measures to resolve the defect, and the holding unit can be prevented from being involved. As described above, the present configuration enables flexible operation of the transport vehicle according to the situation.

[0014] Further features and advantages of the technology according to the present disclosure will become more apparent with the following illustrative and non-limiting description of embodiments, which will be described with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is a schematic plan view showing a transport facility.

[0016] FIG. **2** is a side view showing a transport vehicle.

[0017] FIG. **3** shows an example of a switching process.

[0018] FIG. **4** is a diagram showing Modification 1.

[0019] FIG. **5** is a diagram showing Modification 1.

[0020] FIG. **6** is a diagram showing Modification 2.

[0021] FIG. **7** is a diagram showing Modification 3.

[0022] FIG. **8** is a diagram showing Modification 4.

DESCRIPTION OF THE INVENTION

[0023] A transport vehicle and a transport facility including the transport vehicle, according to the present disclosure, can be used in semiconductor manufacturing plants, for example. In this case, examples of a transport object to be transported by the transport vehicle include a substrate container (so-called FOUP: Front Opening Unified Pod) that houses substrates (such as wafers and panels), and a reticle container (so-called reticle pod) that houses reticles. The following will describe embodiments of the transport vehicle and the transport facility including the transport vehicle, according to the present disclosure, with reference to the drawings.

[0024] As shown in FIG. **1**, a transport facility **100** includes transport vehicles V that travel on a travel path **9** and a control system C that controls the transport vehicles V. In the present embodiment, the transport facility **100** includes a plurality of transport vehicles V. The control system C is constituted by a high-level control device that manages the whole transport facility **100**. However, the control system C may also include control devices included in the respective transport vehicles V.

[0025] The travel path **9** is configured using a rail **90** (see FIG. **2**). In other words, the transport facility **100** includes the rail **90**. The transport vehicles V are configured as so-called overhead transport vehicles, which travel along the rail **90** installed in the vicinity of the ceiling.

[0026] In the present embodiment, the transport vehicles V are configured to travel on the travel path **9** in a predetermined direction. In other words, the travel path **9** is configured to allow only one-way travel of the transport vehicles V. However, temporary backward travel of the transport vehicles V may also be allowed on the travel path **9**.

[0027] As shown in FIG. **2**, each transport vehicle V includes a travel unit **1** that travels along the rail **90** and a

holding unit **2** that holds a transport object W. The holding unit **2** is coupled to the travel unit **1** via a coupling mechanism **3**. The moving route of the travel unit **1** traveling along the rail **90** and the moving route of the holding unit **2** coupled to the travel unit **1** do not overlap each other. In this example, the travel unit **1** is configured to move on the upper side of the rail **90**. The holding unit **2** is configured to move on the lower side of the rail **90**.

[0028] The coupling mechanism **3** is configured to be able to transition between a coupled state in which the travel unit **1** and the holding unit **2** are coupled to each other, and a separated state in which the travel unit **1** and the holding unit **2** are separated from each other.

[0029] The coupling mechanism **3** includes a travel unit-side coupling part **31** provided on the travel unit **1** and a holding unit-side coupling part **32** provided on the holding unit **2**. At least one of the travel unit-side coupling part **31** and the holding unit-side coupling part **32** includes a coupling drive unit for the state transition of the coupling mechanism **3** between the coupled state and the separated state. In the present embodiment, this coupling drive unit is provided on the travel unit-side coupling part **31**. Note however that a configuration is also possible in which the coupling drive unit is provided on the holding unit-side coupling part **32**.

[0030] In the present embodiment, the travel unit-side coupling part **31** includes a grip mechanism **31***a* that grips the holding unit **2**, and a lift mechanism **31***b* that moves the grip mechanism **31***a* up and down. The grip mechanism **31***a* constitutes at least a part of the above-mentioned coupling drive unit. For example, the grip mechanism **31***a* includes a pair of claws that move toward and away from each other, and a motor (not shown) that operates the pair of claws.

[0031] In the present embodiment, the holding unit-side coupling part **32** is a gripped part to be gripped by the grip mechanism **31***a* during the coupled state of the coupling mechanism **3**. The holding unit-side coupling part **32** has a shape corresponding to the grip mechanism **31***a*. In this example, the holding unit-side coupling part **32** is flange-shaped so that the pair of claws of the grip mechanism **31***a* can appropriately grip the holding unit-side coupling part **32**.

[0032] The travel unit **1** is configured to execute a coupled traveling mode of traveling while being coupled to the holding unit **2** via the coupling mechanism **3** and a separated traveling mode of traveling alone while being separated from the holding unit **2**. In FIG. **2**, the travel unit **1** executing the coupled traveling mode is indicated by solid lines, and the travel unit **1** executing the separated traveling mode is indicated by virtual lines.

[0033] In the present embodiment, the travel unit **1** includes a travel drive unit **1***b* and a power storage device **1***a* (hereinafter referred to as "travel unit-side power storage device **1***a*") serving as a drive source of the travel drive unit **1***b*. The travel drive unit **1***b* is configured to be driven by power stored in the travel unit-side power storage device **1***a*. The travel drive unit **1***b* includes wheels and a motor (not shown). Note however that the travel drive unit **1***b* may also be constituted by a linear motor. The travel unit-side power storage device **1***a* is constituted by a battery or a capacitor, or by both of them.

[0034] The holding unit **2** is configured to move along the travel path **9** while being coupled to the travel unit **1**. In other words, the holding unit **2** has a configuration such that it cannot travel alone while being separated from the travel unit **1**.

[0035] The holding unit **2** is configured to hold the transport object W. Various modes of the holding unit **2** holding the transport object W can include a chuck type, a fork type, a conveyor type, and a loading type, for example.

[0036] In the present embodiment, the holding unit **2** includes a transfer unit **20** that transfers the transport object W to and from a transfer destination/origin (not shown). Examples of the transfer destination/origin include a load port, a buffer, a loading conveyor for loading transport objects W to an automated warehouse, and a discharge conveyor for discharging transport objects W from the automatic warehouse.

[0037] In the present embodiment, the transfer unit **20** includes a transfer grip part **20***a* that grips the transport object W and a transfer lift part **20***b* that lifts and lowers the transfer grip part **20***a*. With this, the transfer unit **20** is configured to transfer the transport object W to and from the transfer destination/origin.

[0038] In the present embodiment, the holding unit **2** includes a power storage device **2***a* (hereinafter referred to as "holding unit-side power storage device **2***a*"). The above-described transfer unit **20** is configured to be driven by power stored in the holding unit-side power storage device **2***a* at least in a state where the holding unit **2** is separated from the travel unit **1**. The transfer unit **20** may be driven by power supplied from the travel unit **1** in a state where the holding unit **2** is coupled to the travel unit **1**.

[0039] As shown in FIG. **1**, in the present embodiment, the transport facility **100** includes a plurality of travel units **1**. The transport facility **100** also includes a plurality of holding units **2**. In this example, the number of travel units **1** present in the transport facility **100** is greater than the number of holding units **2**. Note however that the numbers of these units may be equal to each other. Note that the symbols shown by triangles in FIGS. **1** and **3** each indicate a transport vehicle V, and specifically, a hatched triangle indicates a travel unit **1** coupled to a holding unit **2**, and a white triangle indicates a single travel unit **1** separated from a holding unit **2**.

[0040] The transport facility **100** includes a support area **6** where the holding unit **2** separated from the travel unit **1** is supported, and a power replenishment area **8** where at least one of charging and replacement of the travel unit-side power storage device **1***a* is performed. The power replenishment area **8** is provided along the rail **90**.

[0041] The power replenishment area **8** includes at least one of a replacement device and a charging device. The replacement device is a device for replacing the travel unit-side power storage device **1***a* mounted on the travel unit **1**. In this case, the travel unit **1** whose travel unit-side power storage device **1***a* has been replaced in the power replenishment area **8** can leave the power replenishment area **8** promptly. The charging device is a device for charging the travel unit-side power storage device **1***a* mounted on the travel unit **1**. In this case, the travel unit **1** waits in the power replenishment area **8** until the travel unit-side power storage device **1***a* is completely charged. If a plurality of travel units **1** are being replenished with power in the power replenishment area **8**, the travel unit **1** that has been completely replenished with power exits the power replenishment area **8** in order.

[0042] In the present embodiment, a transport apparatus **60** that transports the holding unit **2** is provided in the support area **6**. In this example, the transport apparatus **60** is constituted by a conveyor that transports the holding unit **2** while supporting it from below. Note however that the transport apparatus **60** may be an AGV, a forklift, a crane, or the like.

[0043] The transport apparatus **60** is configured to transport the holding unit **2** between a receiving position **61**, which is located corresponding to a first position **91** in the travel path **9** for the travel unit **1** extending along the rail **90** and at which the transport apparatus **60** receives the holding unit **2** from the travel unit **1**, and a delivery position **62**, which is located corresponding to a second position **92** in the travel path **9** and at which the transport apparatus **60** delivers the holding unit **2** to the travel unit **1**.

[0044] In the present embodiment, the receiving position **61** is directly below the first position **91** in the travel path **9**. The delivery position **62** is directly below the second position **92** on the travel path **9**. In other words, the transport apparatus **60** receives the holding unit **2** from the travel unit **1** at the receiving position **61** while the travel unit **1** is located at the first position **91**. The transport apparatus **60** delivers the holding unit **2** to the travel unit **1** at the delivery position **62** while the travel unit **1** is located at the second position **92**. In other words, separation and coupling of the travel unit **1** and the holding unit **2** are performed in the support area **6**. Note that the positional relationship between the first position **91** and the receiving position **61**, and the positional relationship between the second position **92** and the delivery position **62** are not limited to the above-described positional relationships. These positional relationships need only be such that separation and coupling of the travel unit **1** and the holding unit **2** are possible.

[0045] In the present embodiment, the first position **91** is located upstream of the power replenishment area **8** along the travel path **9**. The second position **92** is located downstream of the power replenishment area **8** along the travel path **9**.

[0046] In the present embodiment, the travel path **9** includes a route **9***a* for transport along which the travel unit **1** travels to transport the transport object W, and a route **9***b* for replenishment that is a dedicated route for the travel unit **1** to travel for power replenishment. The above-described power replenishment area **8** is provided in the route **9***b* for replenishment. The route **9***b* for replenishment is branched off from the route **9***a* for transport and is merged into the route **9***a* for transport. In this example, the branching point at which the route **9***b* for replenishment is branched off from the route **9***a* for transport is located downstream of the first position **91**. The merging point at which the route **9***b* for replenishment is merged into the route **9***a* for transport is located upstream of the second position **92**.

[0047] As shown in FIG. **3**, in the present embodiment, if it is determined that the amount of power stored in the travel unit-side power storage device **1***a* is a predetermined threshold or less, the control system C brings the coupling mechanism **3** into the separated state in response to the transport vehicle V being located at the position (first position **91** in this example) corresponding to the support area **6**, so that the holding unit **2** is supported in the support area **6**, and the travel unit **1** travels to the power replenishment area **8** in the separated traveling mode. With this, the travel unit **1** separated from the holding unit **2** can travel alone to the power replenishment area **8**. Also, in the power replenishment area **8**, the travel unit-side power storage device **1***a* is replaced or charged. Note that the above-mentioned threshold can be determined based on a percentage with respect to the maximum capacity of the travel unit-side power storage device **1***a*, or can also be determined as an absolute value that is independent of the maximum capacity of the travel unit-side power storage device **1***a*.

[0048] In the present embodiment, while the transport vehicle V is located at the first position **91**, the control system C brings the coupling mechanism **3** into the separated state, so that the holding unit **2** is supported at the receiving position **61** by the transport apparatus **60**. The control system C causes the transport apparatus **60** to transport the holding unit **2** from the receiving position **61** to the delivery position **62**. In this way, the transport of the holding unit **2** is possible using a period of time for which the travel unit **1** is heading to the power replenishment area **8** alone, for example. The control system C brings the coupling mechanism **3** into the coupled state in response to the travel unit **1** being located at the second position **92**, so that the holding unit **2** is coupled to the travel unit **1** at the delivery position **62**. The travel unit **1** to which the holding unit **2** at the delivery position **62** is to be coupled may be the travel unit **1** that was previously separated from the holding unit **2** at the first position **91**, or may be another travel unit **1**.

[0049] The plurality of travel units **1** include a first travel unit **11** and a second travel unit **12**, which is a travel unit **1** different from the first travel unit **11**. In FIG. **3**(*a*), the travel unit **1** executing the coupled traveling mode is defined as the first travel unit **11**, and the other travel unit **1** preceding the first travel unit **11** is defined as the second travel unit **12**.

[0050] As shown in FIG. **3**(*a*), the travel unit **1** executing the coupled traveling mode, that is, the first travel unit **11** coupled to the holding unit **2**, is stopped at the first position **91** in the travel path **9**. In the shown example, the preceding second travel unit **12** is being replenished with power in the power replenishment area **8**.

[0051] As shown in FIG. **3**(*b*), the first travel unit **11** has separated from the holding unit **2** and has started the separated traveling mode. The first travel unit **11** having entered the route **9***b* for replenishment heads to the power replenishment area **8**. The transport apparatus **60** receives the holding unit **2** from the first travel unit **11** at the receiving position **61** and transports the received holding unit **2** toward the delivery position **62**. In the shown example, the second travel unit **12** has finished being replenished with power and has exited the power replenishment area **8**.

[0052] As shown in FIG. **3**(*c*), the holding unit **2** transported by the transport apparatus **60** reaches the delivery position **62**. The first travel unit **11** that was separated from the holding unit **2** and reached the power replenishment area **8** is replenished with power in the power replenishment area **8**. The second travel unit **12** travels in the vicinity of the second position **92** in the travel path **9**.

[0053] As shown in FIG. **3**(*d*), at the delivery position **62**, the transport apparatus **60** delivers the holding unit **2** to the second travel unit **12** located at the second position **92** in the travel path **9**. The second travel unit **12** is coupled to the holding unit **2** and starts the coupled traveling mode.

[0054] In the example shown in FIG. **3**, the holding unit **2** initially coupled to the first travel unit **11** is separated from the first travel unit **11** and then is coupled to the second travel

unit **12**. Thus, in the present embodiment, the control system C is configured to be able to execute a switching process of switching the coupling target to which the holding unit **2** is to be coupled from the first travel unit **11** to the second travel unit **12**. In the example shown in FIG. **3**, the switching process involves the transport of the holding unit **2** by the transport apparatus **60**.

[0055] Note however that the switching process is possible without the transport apparatus **60** transporting the holding unit **2**. In this case, the control system C may couple the holding unit **2** that was separated from the first travel unit **11** located at the first position **91** and is supported at the receiving position **61**, to the second travel unit **12** that is stopped at the first position **91** after the first travel unit **11** has left the first position **91**. If the second travel unit **12** is located behind the first travel unit **11**, the second travel unit **12** proceeds toward the first position **91**, and is coupled to the holding unit **2** supported in the support area **6**. On the other hand, if the second travel unit **12** is located ahead of the first travel unit **11**, the first travel unit **11** is separated from the holding unit **2** and then travels backward so as to leave the first position **91**, and the second travel unit **12** travels backward so as to be coupled to the holding unit **2** at the first position **91**.

[0056] If no switching process is performed, the first travel unit **11** separated from the holding unit **2** at the first position is replenished with power in the power replenishment area **8**, and after finishing the replenishment, the first travel unit **11** heads to the second position **92** and is coupled to the holding unit **2** at the second position **92**.

[0057] When a sufficient amount of power remains in the travel unit-side power storage device la mounted on the first travel unit **11**, the first travel unit **11** passes through the first position **91** and the second position **92** along the route **9***a* for transport, without heading to the power replenishment area **8**.

Modification 1

[0058] The following will describe Modification **1** with reference to FIGS. **4** and **5**.

[0059] As shown in FIGS. **4** and **5**, in Modification **1**, the coupling mechanism **3** includes drive rollers **31***c* and a roller support part **31***d* that supports the drive rollers **31***c* in a manner such that they are rotatable. In this example, a plurality of drive rollers **31***c* and a plurality of roller support parts **31***d* (two roller support parts **31***d* in the shown example) are included in the travel unit-side coupling part **31**.

[0060] In this example, the plurality of drive rollers **31***c* are aligned along the travel path **9**. The plurality of drive rollers **31***c* are supported by the roller support part **31***d* with the rotation axis of each of the drive rollers **31***c* extending in a direction orthogonal to the travel path **9** as viewed in an up-down direction.

[0061] The roller support part **31***d* protrudes downward from the body of the travel unit **1**. The plurality of drive rollers **31***c* are supported by the roller support part **31***d* below the rail **90**.

[0062] The holding unit-side coupling part **32** is supported by the plurality of drive rollers **31***c* while the coupling mechanism **3** is in the coupled state. In this example, the holding unit-side coupling part **32** protrudes upward from the body of the holding unit **2** and is in contact with the plurality of drive rollers **31***c* from above while the coupling mechanism **3** is in the coupled state. In other words, in this example, the holding unit-side coupling part **32** is configured to be supported by the plurality of drive rollers **31***c* from below while the coupling mechanism **3** is in the coupled state.

[0063] The plurality of drive rollers **31***c* are controlled so as to be fixed (so as not to rotate) while supporting the holding unit-side coupling part **32**.

[0064] In this example, in the switching process of switching the coupling target to which the holding unit **2** is to be coupled, the holding unit **2** is received and delivered between the travel unit-side coupling part **31** provided on the first travel unit **11** and the travel unit-side coupling part **31** provided on the second travel unit **12**. In other words, the holding unit **2** is directly received and delivered between the first travel unit **11** and the second travel unit **12** without temporarily being supported in the support area **6** or the like. Such a switching process can also be referred to as a "direct switching process".

[0065] In the direct switching process, the control system C positions the first travel unit **11** that is coupled to the holding unit **2** and is executing the coupled traveling mode, and the single second travel unit **12** that is executing the separated traveling mode, adjacent to each other on the travel path **9**.

[0066] The control system C progressively shifts the state of the coupling mechanism **3** on the first travel unit **11** from the coupled state to the separated state, and progressively shifts the state of the coupling mechanism **3** on the second travel unit **12** from the separated state to the coupled state. The control system C realizes the state transition of the coupling mechanism **3** by driving and rotating the drive rollers **31***c* of the travel units **1**.

[0067] In order for both the coupling mechanism **3** on the first travel unit **11** and the coupling mechanism **3** on the second travel unit **12** to make a state transition, the control system C causes the first travel unit **11** and the second travel unit **12** to travel in the same direction. For example, if the first travel unit **11** is located on the front side and the second travel unit **12** is behind the first travel unit **11**, both the first and second travel units **11** and **12** are caused to travel forward.

[0068] During the state transition, if both the coupling mechanism **3** on the first travel unit **11** and the coupling mechanism **3** on the second travel unit **12** have an element in the "coupled state", the holding unit-side coupling part **32** is supported by both the first travel unit **11** and the second travel unit **12** (the state shown in FIG. **4**). From here, the state transition of the coupling mechanisms **3** is further advanced in both the first travel unit **11** and the second travel unit **12**, and eventually the coupled state of the coupling mechanism **3** on the second travel unit **12** becomes dominant. Once the coupling mechanism **3** on the first travel unit **11** is completely separated and the coupling mechanism **3** on the second travel unit **12** is completely coupled, the direct switching process is complete.

[0069] Note that, in the description above, an example has been described in which the direct switching process is executed by moving the first travel unit **11** and the second travel unit **12** forward, but the direct switching process may also be executed by moving them backward.

[0070] Also, in the description above, an example has been described in which the direct switching process is executed by moving the first travel unit **11** and the second

travel unit **12** forward or backward, but the direct switching process may also be executed in a state in which the first travel unit **11** and the second travel unit **12** are stopped. In this case, only the drive rollers **31***c* of the first travel unit **11** and the second travel unit **12** are rotated. With this, only the holding unit **2** moves between the stopped first and second travel units **11** and **12**.

Modification 2

[0071] Next, Modification 2 will be described with reference to FIG. **6**.

[0072] As shown in FIG. **6**, in Modification **2**, the control system C positions, in the direct switching process, the first travel unit **11** executing the coupled traveling mode and the second travel unit **12** executing the separated traveling mode, side by side on separate travel paths **9** disposed adjacent to each other in a parallel manner. In other words, the first travel unit **11** and the second travel unit **12** are positioned adjacent to each other along a direction orthogonal to the travel paths **9** as viewed in the up-down direction. Then, the control system C shifts the state of the coupling mechanism **3** on the first travel unit **11** from the coupled state to the separated state, and shifts the state of the coupling mechanism **3** on the second travel unit **12** from the separated state to the coupled state.

[0073] In the direct switching process in this example, only the holding unit **2** moves from the position corresponding to the first travel unit **11** to the position corresponding to the second travel unit **12** with the positions of the first and second travel units **11** and **12** fixed. As a result, the holding unit **2** transitions from the state of being coupled to the first travel unit **11** to the state of being coupled to the second travel unit **12**, and then the direct switching process is complete.

[0074] Although detailed illustrations are omitted, in this example, the travel unit-side coupling part **31** on the second travel unit **12** includes a plurality of drive rollers **31***c* and a roller support part **31***d* that supports the plurality of drive rollers **31***c* in a manner such that they are rotatable, as in the above-described Modification 1. Note however that, in this example, the plurality of drive rollers **31***c* are aligned in a direction orthogonal to the travel path **9** as viewed in the up-down direction. Also, the plurality of drive rollers **31***c* are supported by the roller support part **31***d* with the rotation axis of each of the plurality of drive rollers **31***c* extending in a direction in which the travel path **9** extends. As a result, it is possible to move the holding unit **2** along a direction orthogonal to the travel path **9** as viewed in the up-down direction.

Modification 3

[0075] Next, Modification 3 will be described with reference to FIG. **7**.

[0076] As shown in FIG. **7**, in Modification 3, the travel unit-side coupling part **31** includes a hook **31***e* that engages with the holding unit-side coupling part **32**. The hook **31***e* is configured to be lifted and lowered by the lift mechanism **31***b*.

[0077] In this example, the holding unit-side coupling part **32** is an engaged part to be engaged by the hook **31***e* while the coupling mechanism **3** is in the coupled state. The holding unit-side coupling part **32** has a shape corresponding to the hook **31***e*.

[0078] In this example, the separated state/coupled state of the coupling mechanism **3** is realized by a combination of the lifting/lowering operation of the hook **31***e* by the lift mechanism **31***b* and the forward/backward movement of the hook **31***e* caused by the forward/backward movement of the travel unit **1**.

Modification 4

[0079] Next, Modification 4 will be described with reference to FIG. **8**.

[0080] In this example, the holding unit **2** is configured to be able to execute both a coupled transfer mode of transferring the transport object W to and from a transfer destination/origin **7** while being coupled to the travel unit **1**, and a separated transfer mode of transferring the transport object W to and from the transfer destination/origin **7** while being separated from the travel unit **1** and supported in the support area **6**. FIG. **8** shows a situation where the holding unit **2** is executing the separated transfer mode. As described above, the transfer destination/origin **7** may be a load port, a buffer, a loading conveyor, a discharge conveyor, or the like.

[0081] The support area **6** includes a support part **63** that supports the holding unit **2**. In this example, the support part **63** is constituted by a support platform that supports the holding unit **2** from below.

[0082] In this example, the support part **63** has an opening **63***a* through which the transport object W can pass in the up-down direction. The opening **63***a* may be a hole or a notch. Alternatively, if the support part **63** is constituted by a plurality of discontinuous members, e.g., a pair of plate members arranged at a distance from each other, a space between the pair of plate members may serve as the opening **63***a*.

[0083] In this example, the holding unit **2** executes the separated transfer mode while being supported by the support part **63**. The holding unit **2** executes the separated transfer mode using the holding unit-side power storage device **2***a* as a power source of transfer unit **20**. In the separated transfer mode, the holding unit **2** transfers the transport object W to and from the transfer destination/origin **7** located immediately below the support part **63** by lifting and lowering the transfer grip part **20***a* using the transfer lift part **20***b*. The transfer grip part **20***a* is passed through the opening **63***a* in the up-down direction, so as to be lifted and lowered over a range from the upper side of the support part **63** to the lower side of the support part **63**.

[0084] In the description above, an example has been described in which the transfer destination/origin **7** is located immediately below the support part **63**. However, the present invention is not limited to such an example, and the transfer destination/origin **7** and the support part **63** may be positioned in a manner such that they do not overlap with each other at least partially as viewed in a plan view. In this case, the transfer unit **20** may include, for example, a slide mechanism for moving the transport object W in a horizontal direction and a turning mechanism for changing the direction of the movement of the transport object W due to the slide mechanism. For example, the slide mechanism may include an arm or a fork.

[0085] In the description above, an example has been described in which the transfer unit **20** is powered by power stored in the holding unit-side power storage device **2***a*. However, the present invention is not limited to such an example, and a configuration is also possible in which, for

example, a power supply device is provided in the support part **63**, and the transfer unit **20** operates upon being supplied with power from this power supply device.

[0086] In the description above, an example has been described in which the support part **63** is configured to support the holding unit **2** from below. However, the present invention is not limited to such an example, and the support part **63** may be configured to suspend and support the holding unit **2** from above, for example. In this case, the above-mentioned opening **63***a* need not be formed in the support part **63**.

Other Modifications

[0087] In the description above, examples have been described in which the coupling mechanism **3** is of a gripping type, a roller type (Modifications 2 and 3), and a hook type (Modification 4), respectively. However, the coupling mechanism **3** may also employ other methods. For example, the coupling mechanism **3** may be of a magnet type. In this case, the travel unit-side coupling part **31** and the holding unit-side coupling part **32** are coupled to each other by the magnetic force of the magnet. Note that if the coupling mechanism **3** is of a magnet type, an electromagnet is preferably used. Accordingly, by controlling the state of a current flow through the electromagnet, the state transition between the separated state and the coupled state of the coupling mechanism **3** can be appropriately performed. Note that the coupling mechanism **3** may be constituted by a combination of some or all of the above-mentioned methods.

[0088] Note that the configurations disclosed in the above-described embodiments can be applied in combination with the configurations disclosed in other embodiments, as long as no contradiction arises. With respect to other configurations, the embodiments disclosed in the present specification are merely illustrative in all respects. Accordingly, various changes can be made as appropriate within the scope that does not depart from the gist of the present disclosure.

Overview of the Present Embodiment

[0089] Hereinafter, overviews of the present embodiment will be described.

[0090] A transport vehicle includes:

[0091] a travel unit configured to travel along a rail; and

[0092] a holding unit configured to hold a transport object,

[0093] the holding unit being configured to be coupled to the travel unit via a coupling mechanism,

[0094] the coupling mechanism being configured to transition between a coupled state in which the travel unit and the holding unit are coupled to each other, and a separated state in which the travel unit and the holding unit are separated from each other, and

[0095] the travel unit being configured to execute both a coupled traveling mode of traveling while being coupled to the holding unit via the coupling mechanism, and a separated traveling mode of traveling alone while being separated from the holding unit.

[0096] According to this configuration, by executing the coupled traveling mode, the travel unit can appropriately transport a transport object. Also, by executing the separated traveling mode, the travel unit can travel alone while separated from the holding unit. With this, during the execution of the separated traveling mode, the travel unit can perform another task at a location different from the location of the holding unit. Also, for example, if some sort of defect occurs only in the travel unit, the travel unit alone can take measures to resolve the defect, and the holding unit can be prevented from being involved. As described above, the present configuration enables flexible operation of the transport vehicle according to the situation.

[0097] Preferably, a moving route of the travel unit traveling along the rail and a moving route of the holding unit coupled to the travel unit do not overlap each other.

[0098] According to this configuration, the travel unit and the holding unit can be prevented from interfering with each other.

[0099] Preferably, a transport facility including the foregoing transport vehicle includes:

[0100] a rail;

[0101] a support area in which the holding unit separated from the travel unit is supported; and

[0102] a control system configured to control the transport vehicle,

[0103] the travel unit including a travel drive unit, and a power storage device serving as a drive source of the travel drive unit, and

[0104] the transport facility further including a power replenishment area in which at least one of charging and replacement of the power storage device is performed, the power replenishment area being located along the rail.

[0105] According to this configuration, for example, in a case where the amount of power stored in the power storage device is a predetermined threshold or less or in another case, the holding unit separated from the travel unit can be appropriately supported in the support area, and at the same time, the travel unit separated from the holding unit can travel to the power replenishment area, where at least one of charging and replacement of the power storage device can be performed as appropriate.

[0106] Preferably, the transport facility further includes a transport apparatus in the support area and configured to transport the holding unit,

[0107] wherein the transport apparatus is configured to transport the holding unit between a receiving position at which the transport apparatus receives the holding unit from the travel unit, and a delivery position at which the transport apparatus delivers the holding unit to the travel unit, the receiving position being located corresponding to a first position in a travel path for the travel unit extending along the rail, and the delivery position being located corresponding to a second position in the travel path, and

[0108] the control system is configured to:

[0109] bring the coupling mechanism into the separated state in response to the transport vehicle being located at the first position, so that the holding unit is supported at the receiving position by the transport apparatus;

[0110] cause the transport apparatus to transport the holding unit from the receiving position to the delivery position; and

[0111] bring the coupling mechanism into the coupled state in response to the travel unit being

located at the second position, so that the holding unit located at the delivery position is coupled to the travel unit.

[0112] According to this configuration, the holding unit coupled to the travel unit can move along the travel path for the travel unit, and the holding unit separated from the travel unit can be moved along a route different from the travel path for the travel unit by the transport device. Therefore, according to this configuration, it is easy to increase flexibility in the operation of the facility.

[0113] Preferably, the transport vehicle is configured to travel along the travel path in a predetermined direction,

[0114] the first position is upstream of the power replenishment area along the travel path, and

[0115] the second position is downstream of the power replenishment area along the travel path.

[0116] According to this configuration, it is easy to separate the holding unit from the travel unit before the travel unit heads to the power replenishment area and to couple the holding unit to the travel unit after the travel unit exits the power replenishment area. It is also easy to simplify the travel path for the travel unit to realize such a configuration.

[0117] Preferably, a transport facility including the foregoing transport vehicle includes:

[0118] a control system configured to control the transport vehicle; and

[0119] a plurality of the travel units,

[0120] the plurality of travel units including a first travel unit, and a second travel unit different from the first travel unit, and

[0121] the control system being configured to execute a switching process of switching a coupling target, to which the holding unit is to be coupled, from the first travel unit to the second travel unit.

[0122] According to this configuration, the same holding unit can be transported by different travel units. Therefore, according to this configuration, it is easy to increase flexibility in the operation of the facility.

[0123] Preferably, the coupling mechanism includes a travel unit-side coupling part provided on the travel unit and a holding unit-side coupling part provided on the holding unit, and

[0124] in the switching process, the holding unit is received and delivered between the travel unit-side coupling part provided on the first travel unit and the travel unit-side coupling part provided on the second travel unit.

[0125] According to this configuration, the holding unit can be received and delivered between different transport vehicles in the travel path, without being temporarily supported in the support area or the like.

[0126] Preferably, a transport facility including the foregoing transport vehicle includes:

[0127] a support area in which the holding unit separated from the travel unit is supported,

[0128] the holding unit including a transfer unit configured to transfer the transport object to and from a transfer destination/origin, and

[0129] the holding unit being configured to execute both a coupled transfer mode of transferring the transport object to and from the transfer destination/origin while being coupled to the travel unit, and a separated transfer mode of transferring the transport object to and from the transfer destination/origin while being separated from the travel unit and supported in the support area.

[0130] According to this configuration, by executing the separated transfer mode, the holding unit separated from the travel unit can transfer the transport object.

INDUSTRIAL APPLICABILITY

[0131] The technology according to the present disclosure is applicable to a transport vehicle and a transport facility including the transport vehicle.

What is claimed is:

1. A transport vehicle comprising:

a travel unit configured to travel along a rail; and

a holding unit configured to hold a transport object, and

wherein:

the holding unit is configured to be coupled to the travel unit via a coupling mechanism,

the coupling mechanism is configured to transition between a coupled state in which the travel unit and the holding unit are coupled to each other, and a separated state in which the travel unit and the holding unit are separated from each other, and

the travel unit is configured to execute both a coupled traveling mode of traveling while being coupled to the holding unit via the coupling mechanism, and a separated traveling mode of traveling alone while being separated from the holding unit.

2. The transport vehicle according to claim **1**,

wherein a moving route of the travel unit traveling along the rail and a moving route of the holding unit coupled to the travel unit do not overlap each other.

3. A transport facility including the transport vehicle according to claim **1**, the transport facility comprising:

a rail;

a support area in which the holding unit separated from the travel unit is supported; and

a control system configured to control the transport vehicle,

wherein the travel unit comprises a travel drive unit, and a power storage device serving as a drive source of the travel drive unit, and

wherein the transport facility further comprises a power replenishment area in which at least one of charging and replacement of the power storage device is performed, the power replenishment area located along the rail.

4. The transport facility according to claim **3**, further comprising:

a transport apparatus in the support area and configured to transport the holding unit,

wherein the transport apparatus is configured to transport the holding unit between a receiving position at which the transport apparatus receives the holding unit from the travel unit, and a delivery position at which the transport apparatus delivers the holding unit to the travel unit, the receiving position located corresponding to a first position in a travel path for the travel unit extending along the rail, and the delivery position located corresponding to a second position in the travel path, and

wherein the control system is configured to:

bring the coupling mechanism into the separated state in response to the transport vehicle being located at

the first position, so that the holding unit is supported at the receiving position by the transport apparatus;

cause the transport apparatus to transport the holding unit from the receiving position to the delivery position; and

bring the coupling mechanism into the coupled state in response to the travel unit being located at the second position, so that the holding unit located at the delivery position is coupled to the travel unit.

5. The transport facility according to claim **4**,

wherein the transport vehicle is configured to travel along the travel path in a predetermined direction,

wherein the first position is upstream of the power replenishment area along the travel path, and

wherein the second position is downstream of the power replenishment area along the travel path.

6. A transport facility including the transport vehicle according to claim **1**, the transport facility comprising:

a control system configured to control the transport vehicle; and

a plurality of the travel units,

wherein the plurality of travel units comprises a first travel unit, and a second travel unit different from the first travel unit, and

wherein the control system is configured to execute a switching process of switching a coupling target, to which the holding unit is to be coupled, from the first travel unit to the second travel unit.

7. The transport facility according to claim **6**,

wherein the coupling mechanism comprises a travel unit-side coupling part provided on the travel unit and a holding unit-side coupling part provided on the holding unit, and

wherein in the switching process, the holding unit is received and delivered between the travel unit-side coupling part provided on the first travel unit and the travel unit-side coupling part provided on the second travel unit.

8. A transport facility including the transport vehicle according to claim **1**, the transport facility comprising:

a support area wherein the holding unit separated from the travel unit is supported,

wherein the holding unit comprises a transfer unit configured to transfer the transport object to and from a transfer destination/origin, and

wherein the holding unit is configured to execute both a coupled transfer mode of transferring the transport object to and from the transfer destination/origin while being coupled to the travel unit, and a separated transfer mode of transferring the transport object to and from the transfer destination/origin while being separated from the travel unit and supported in the support area.

* * * * *